INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA DISTRICT, KARNATAKA

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Funded by: Karnataka Biodiversity Board, Western Ghats Task Force (Forest, Ecology and Environment Department), GoK

Implemented by: Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

Investigators: Dr. T V Ramachandra, Dr. M D Subash Chandran and N V Joshi

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1.0 EXECUTIVE SUMMARY

Nature functions holistically. A great diversity of species, including the humans, has been associated with each other for long periods of time and co-evolution is at the centre of all ecosystems. The individual cannot live independently of the living environment and actions of individuals have an impact on the environment. On the contrary human societies are today overriding the holism of nature, shaking the very foundations of life itself to their detriment. For lasting wellbeing of human societies they need to necessarily learn more about the ecosystems, of which they form a part, assess their complexities and carrying capacity and modify or derive resources from them without straining their capacity to provide goods and services perpetually. The Uttara Kannada district, gifted with enormous natural resources potential, this dictum of sustainable development based on the foundation of carrying capacity studies, is yet to be a reality. Various developmental programmes, which proclaimed to be functioning on sustainability principle, on looking back, have been only fraying the complex web of life, disrupting ecosystems and causing decline in overall productivity. This is true in four major sectors such as forestry, fisheries, agriculture and hydrology.

The conservation and sustainable management of ecosystems are the vital components in the pursuit of development goals that are ecologically, economically and socially sustainable. This requires an understanding of the complex functioning of ecosystems, and recognition of the full range and diversity of resources, values and ecological services that they represent. In this regard, the current research envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. This process in due course will create an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government. Integrated Ecological carrying capacity study provides the regional planner in evolving appropriate conservation strategies for sustainable management particularly on a defined geographical area. Decision making on developmental activities, entail planning that depends upon the availability of reliable and accurate data. Data required for natural resource planning include spatial data such as, information of physiography of the area, land use, assets, etc. Geographic information system (GIS) with a capability of handling spatial data helps in the analysis and visualisation of results effectively, and aids decision making process.

The district is in need for ecologically sound development plans for sustainable productivity. For preparation of such a plan, the basic need is to have a fresh appraisal of the carrying capacity of the district, which has never been done before. The carrying capacity study, which involves detailed study on every aspect of ecology and human life in the region, will be the best guide and tool for both policy makers to choose appropriate developmental and other income generating projects which are in tune with the ecology of the district. The carrying capacity studies, if adapted to the village panchayat levels, can transform lives of people at grass-root level through better understanding of their surroundings, by adopting lifestyles having greater harmony with their environment, so as to reap maximum sustainable benefits.

Ecosystem carrying capacity can be defined as 'the maximum number of a species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation of the environment and without diminishing carrying capacity in the future. Carrying capacity thus refers to the maximum number of activities (biological, developmental, agricultural, and industrial, population) that can be supported over a period of time in the habitat without damaging the existing quality of life, balance of resources, ecology and productivity of the ecosystem. Ecological Carrying Capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. The aim of Environmental Carrying capacity is to adjust/increase the ability of the natural environment. Carrying capacity depends on

1) Resources (Biological or Non Biological) that influences on the number of species in the habitat based on the current condition.
2) Interaction(Physical, Chemical, Biological) between the resources and the processes involved in conversion/production of resource to a desired output with residuals and wastes in the environment
3) Habitat (Region), Human Choices, Living Standards, Time, technology
4) Economic Conditions, Growth Strategies and Policies;
5) Social-Cultural and Political Aspects

Carrying capacity research began, through inventorying, mapping and monitoring of the vegetation. Eventually this process was strengthened to cover the rest of the organisms, including the biodiversity of cultivated plants. Such a dynamic documentation process enabled the district to keep proper stock of its biological and ecosystem diversities and to supervise their judicious use for sustainable progress. Data required for natural resource planning included spatial data such as, information of physiography of the area, land use, assets, etc. The scope of a carrying capacity study has been extended to the analysis of supportive capacity in the region with respect to resource availability/utilisation, supply/demand, infrastructure/congestion and assimilative capacity/residuals. Hence, the carrying capacity is assessed as the ability to produce desired outputs (i.e., goods and services) from a limited resource base (i.e., inputs or resources) while at the same time maintaining desired quality levels in this resource base. The four dimensions that are relevant to the estimation of carrying capacity are:

(i) The stock of available resources to sustain rates of resource use in production.
(ii) The capacity of the environmental media to assimilate wastes and residuals from production and consumption.
(iii) The capacity of infrastructure resources (e.g., distribution and delivery systems) to handle the flow of goods and services and resources used in production.
(iv) The effect of both resource use and production outputs on quality of life.

Planning for development within the limits of carrying capacity recognises that humankind is dependent on the productive capacity of ecosystems, and therefore, a minimal level of ecosystem integrity is essential for human survival. Planning for sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of *supportive capacity* within its regenerative capacity and environmental quality within the *assimilative capacity* of regional ecosystem. The utilisation of carrying capacity, thus, requires a series of adjustments to reconcile competing operations in the developmental process through participation of various stakeholders.

Ecological carrying capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. Due to the increased scale of human activities, exploitation, demand of resources led to production of larger amount of goods and services with byproducts and wastes damaging the environment and the ecosystem at local, regional and global scales, effecting sustainable development in the region. Through carrying capacity investigations, it is possible to identify locations for conservation (ecologically sensitive) as well as development in the region as carrying capacity allows us to divide the region into various classes based on the different resource availability.

Uttara Kannada is one of the ecologically sensitive districts of Karnataka State. It is one of the districts with the higher vegetation cover in India. Being situated on the Western Ghats, which is now considered one of the mega biodiversity regions of global importance has all the three major landscape system of the state namely; the coastal region on the west, the high hill mountain region of Sahyadri in the middle and a Deccan plateau margin in the eastern side. Due to factors like growing population and mega developmental projects, much of its natural landscape and the natural resource are under severe pressure in Uttara Kannada district. Deforestation, encroachment, submergence, forest fragmentation, river pollution and degradation, seawater seepage to fresh water and so many other impacts are already being witnessed. Keeping this fragile situation in mind, people from across the society are urging the Government to take up an integrated ecological carrying capacity study of the district so that it becomes the guidelines for the future conservation and sustainable development works.

Realising the importance and necessity, the government of Karnataka through Karnataka Biodiversity Board, vide letter KBB/Misc/Western Ghats study/15/09-10/1314 dated. 29-06-2009, invited us to undertake a study on **'INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA'** (Ref: Letter No.FEE 49 ENV 2009, dated 22-05-2009 of the Secretary to the Government, Forest, Ecology & Environment, Bangalore).

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We have altogether submitted 38 **final reports** (Theme-wise), as and when the respective **themes/ topics** were completed since March 2012. Each one of these final reports, complete with summary and recommendations. Task-wise (as per objectives of the study) details of the report are listed in Table 3.1 (Page 114). The work was reviewed regularly under the Chairmanship of PS/ACS/CS, FEE, GoK and the details of the review meetings at FEE and KBB are provided in Table 1.1. All suggestions given during the review meeting have been implemented in the respective reports (theme wise).

Table 1.1: Details of the project review meetings at FEE or KBB

Sl.no	Review Meetings	Letter no. & Date
1.	12th November 2013	KBB/W.G.Studies/75/13-14/569, 08/11/2013
2.	8th November 2013	KBB/W.G.Studies/75/13-14/563, 05/11/2013
3.	28th October 2013	KBB/W.S.Studies/75/13-14/549, 28/10/2013
4.	31st August 2013	KBB/RFD/01/13-14/394, 23/08/2013
5.	14th May 2013	KBB/W.G.Studies/75/12-13/76, 14/05/2013
6.	21st January 2013	KBB/W.G.Studies/75/12-13/650, 8/01/2013
7.	30th May 2012	KBB/W.G.A/75/2010-11/113, 21/05/2012
8.	22nd May 2012	KBB/W.G.A/75/2010-11/94, 14/05/2012
9.	23rd June 2011	KBB/W.G.A/75/2010-11/80,16/06/2011
10.	19th November 2010	KBB/W.G.A/75/2010-11/638,12/11/2010
11.	26th May 2010	KBB/Bt.B/77/2010-11/177, 14/06/2010
12.	3rd November 2009	KBB/MISC/WG.Study/75/09-10/1647, 21/10/2009
13.	8th September 2009	KBB/12th B.M/09-10/1618, 06/10/2009
14.	6th August 2009	W.G.T.F

This report (SCR 41, ETR71) summarises the outcome of the research being carried out in Uttara Kannada district since 1st April 2010. The report consists of two sections. The first section outlines the purpose of the study with the significant recommendations. The second section discusses themewise outcome of the study, which includes brief introduction, method, significant results and recommendations for policy interventions.

1.1 CONSERVATION OF THREATENED BIODIVERSITY

Forests, especially evergreen forests, have high levels of threatened biodiversity, especially belonging to endemic species of plants and animals of Western Ghats. Within the forests the ancient kan forests, which are mostly dense evergreen forests, functioned as sacred forests of the local people. The kan forests are important watershed areas for perennial streams, springs and Myristica swamps. Such core evergreen forests have rare endemic mammals (eg. Lion-tailed macaque), high number of endemic amphibians (frogs and toads), endemic fishes etc. Therefore we recommend:

- Conservation of hydrologically important forests, with perennial streams, springs, and swamps. These areas have to be demarcated on forest management maps for inclusion in the working plans
- All forests where globally threatened species of plants and animals occur (figuring in IUCN Red List) should be demarcated along with their buffer zones, for maximum care
- As forests with more endemic tree species have more endemic fishes and frogs in their associated water bodies, conservation of such water bodies should include also their catchment area forests

1.1.1 FLORISTIC DIVERSITY IN UTTARA KANNADA DISTRICT

The forests are valuable resources on innumerable counts viz. as sources of various useful products to humans, for their environmental and ecosystem services (soil and water conservation, regulation of water flow, carbon sequestration, nutrient cycling, etc.) and as centres of biodiversity. Out of the total 329 million ha land area of India, 43% is under cropping and 23% classified as forests. The total area of forest cover in India, as per the latest assessment is about 692,027 km^2 or 21.05% of the total geographical area.

The Western Ghats range of hills, running close and parallel to the Arabian Sea along the western Peninsular India for about 1600 km from the south of Gujarat to Kanyakumari, covers an area of about 1,60,000 sq.km. This region harbours very rich flora and fauna and there are records of over 4,000 species of flowering plants (38% endemics). Western Ghats is among the 34 global biodiversity hotspots on account of exceptional plant endemism and serious levels of habitat degradation. The complex geography, wide variations in annual rainfall from 1000-6000 mm, and altitudinal decrease in temperature, coupled with anthropogenic factors, have produced a variety of vegetation types in the Western Ghats. While tropical evergreen forest is the natural climax vegetation of the more humid western slopes, along the rain-shadow region eastwards vegetation changes rapidly from semi-evergreen to moist and dry deciduous forests, the last one being characteristic of the semi-arid Deccan region as well. Lower temperature, especially in altitudes exceeding 1500 m, has produced a unique mosaic of montane 'shola' evergreen forests alternating with rolling grasslands, mainly in the Nilgiris and the Anamalais. All these types of natural vegetation are prone to or have already undergone degradations due to human impacts.

Uttara Kannada district with 76% of its 10,291 sq.km area covered with forests has the distinction of having highest forest area. This is the northernmost coastal district of Karnataka State (13.9220º N to 15.5252º N and 74.0852º E to 75.0999º E) has a geographical area of 10, 291 km^2. Topographically the district can be divided into three zones – the narrow and relatively flat to low hilly coastal along the west of Karwar, Ankola, Kumta, Honavar and Bhatkal taluks; the precipitously rising main range of Western Ghats towards the eastern interior of these taluks, the crestline zone composed of Sirsi, Siddpur Supa and Yellapur taluks and Haliyal and Mudgod taluks towards the north-east flattening and merging with the Deccan Plateau. The district can be divided broadly into five vegetation zones namely: Coastal, Northern evergreen, Southern evergreen, Moist deciduous and Dry deciduous. The evergreen to semi-evergreen forests form major portion of the district especially towards the more rainy western parts. Towards the eastern rain-shadow portion, the forests change rapidly into moist and dry deciduous types.

Whereas substantial areas of natural forests, through forestry practices over a period of more than one century, have been converted into monoculture tree plantations of teak, eucalypts (in the past) and into Acacia plantations in recent decades, there also remained in many places blocks of ancient patches of evergreens, known as *kans*, which were or still are sacred to the local people being the seats of village deities. These are relatively less impacted areas of climax evergreen forests, being sacred groves protected by the people through generations. Being preserved forests from ancient times these *kans* or their remains still might harbor rare species of plants, with high degree of Western Ghats endemism, and also endemic faunal elements. Eg. Asollikan (Ankola), Kathalekan (Siddapur), Karikan (Honavar) etc.

Slash and burn cultivation that prevailed almost till close of 19th century, especially in the heavy rainfall zone created considerable areas of secondary forests that replaced primary evergreen. Wherever clear felling has taken place in the past in the heavy rainfall belt, for shifting cultivation or under forestry operations, very sensitive evergreens and those without coppicing character tend to vanish. Old growth forests in stages of late secondary almost resemble the primary forests. But conspicuously absent in them are climax evergreen forest trees like *Dipterocarpus indicus, Vateria indica, Palaquium ellipticum*, and species confined to Myristica swamps like *Myristica fatua (M. magnifica),* etc. The forests bearing centuries of history is a grant mosaic of evergreen and semi-evergreen to secondary moist deciduous (in the high rainfall areas) to deciduous types. These are intermingled in many places with degraded stages like savannah, and scrub or entirely changed into grassy blanks used for cattle grazing, which within forest zone also have crucial role of supporting wild herbivores.

Karnataka has five National Parks and 21 Wildlife Sanctuaries. Uttara Kannada has mainly two important protected areas namely Anshi National Park and Dandeli Wildlife Sanctuary. These two PAs are brought together under Dandeli-Anshi Tiger Reserve with focus on tiger conservation. The DATR presently covers an area of 1365 sq.km. in the taluks Joida, Karwar and Haliyal. We could not carry out forest studies within the DATR due to want of permission from the Wildlife wing of Forest Department. However, prior to the imposition of restrictions on studies within Tiger Reserves we had carried out a study on the grassland resources within the Reserve. Recently (in 2011) Attivery Bird Sanctuary was declared in Mundgod taluk covering 2.23 sq.km area, mainly composed of a reservoir and its peripheral areas.

Conservation Reserves are a new concept within the framework of PAs under the Wildlife (Protection) Amendment Act of 2002. They seek to protect habitats that are under private ownership also, through active stakeholder participation. They are typically buffer zones or connectors and migration corridors between established national parks, wildlife sanctuaries and other RFs. They are designated as conservation reserves if they are uninhabited and completely owned by the government but used for subsistence by communities, and community reserves if part of the lands are privately owned. Administration of such reserves would be through joint participation of forest officials and local bodies like gram sabhas and gram panchayats. They do not involve any displacement and protect user rights of communities. In Uttara Kannada, four such Conservation Reserves were set up by the Government of Karnataka:

i. **Aghanashini LTM Conservation Reserve** (299.52 sq.km), to protect Lion tailed macaque and Myristica Swamps.
ii. **Bedthi Conservation Reserve** (59.07 sq.km) as Hornbill habitats and for medicinal plant species like *Coscinium fenestratum*.
iii. **Shalmala Riparian Eco-system Conservation Reserve** (4.89 sq.km) for conservation flora and fauna of a riverine ecosystem and
iv. **Hornbill Conservation Reserve** (52.5 sq.km) covering part of Kali River basin for specifically hornbill conservation.

The current study investigates floristic diversity associated with different forests and computes basal area, biomass and carbon sequestration in forests. Apart from this inventorying and mapping of endemic tree species has been done to find out areas of high endemism and congregations of threatened species. A set of criteria for holistic conservation of forest ecosystems, particularly of high endemism of Western Ghats has been prepared based on field investigation, interaction with stakeholders (researchers working in this region, forest officials, local people, subject experts)
Forests of all major kinds were studied using transect cum quadrat methods (altogether 116 transects, each transect with five quadrats of 400 sq.m each for tree vegetation, 10 sub-quadrats each of 25 sq.m for shrubs and tree saplings and 20 subquadrats of one sq.m for herb layer diversity. Out of 116 transects 8 were studied using point-centre quarter method). Altogether for tree vegetation 540 quadrats, each of 400 sq.m were studied. Necessary permission was, however, not granted for forest studies within the Dandeli-Anshi Tiger Reserve areas.

Altogether 1068 species of flowering plants were inventorised during the study period, through sample surveys and opportunistic surveys outside the transect zones. These species represented 138 families. Of these 278 were trees species (from 59 families), 285 shrubs species (73 families) and 505 herb species (55 families). Moraceae, the family of figs (*Ficus* spp.), keystone resources for animals, had maximum tree sp (18), followed by Euphorbiaceae (16 sp.), Leguminosae (15 sp.), Lauraceae (14 sp.), Anacardiaceae (13 sp.) and Rubiaceae (13 sp.). Shrub species richness was pronounced in Leguminosae (32 sp.), Rubiaceae (24 sp.) and Euphorbiaceae (24 sp.). Among herbs grasses (Poaceae) were most specious (77 sp.), followed by sedges (Cyperaceae) with 67 sp. Orchids (Orchidaceae) were in good number.

Tropical forests are major reservoirs of carbon in the terrestrial areas of the planet which is confronted with the prospects of imminent climatic change. World over all countries need to be alert to this major catastrophe. Apart from regulating pollution levels from various sources carbon sequestration in biomass has to be increased considerably. Our estimates on carbon sequestration based on tree biomass estimates from 116 forest samples show that the average carbon sequestration per hectare of forest (barren areas, scrub and grasslands excluded from sampling) was 154.251 ha.

It is a significant find that the sacred *kan* forests of pre-colonial era, despite their merger with state reserved forests, and subjection of most to timber extraction pressures in the post-independence era, continue to lead the chart of sites having some of the highest carbon sequestration per unit area. **Thus the *kan* forest adjoining the Karikanamman temple in Honavar taluk had the highest carbon sequestration at 363.07 t/ha in the tree biomass alone. This is followed by Tarkunde-Birgadde in Yellapur (357.67 t/ha), and some of the swamp-stream forest samples in Kathalekan (299.66 t/ha, 275.18 t/ha, 259.21 t/ha etc.). Likewise Kanmaski-Vanalli in Sirsi had 242.43 t/ha of carbon.**

The lowest carbon sequestered was found to be in the savannized forests, for obvious reasons of low to very low number of trees in them. These savannas whether they be in high evergreen forest belt (in Siddapur or Joida for instance) or be in drier zone of Haliyal or Mundgod have carbon storage of <50 t/ha in the tree biomass. Savannization was a necessity in the past for agricultural occupation of humans in the Western Ghats, for cattle grazing and slash and burn cultivation. Today the process is repeating to some extent still as forest encroachments have happened rampantly in all taluks increasing the porosity of otherwise in tact forests. Most bettalands allotted to arecanut orchard owners for exercising the privilege of leaf manure collection are in poor state of biomass and carbon sequestration (Eg. 14.19 t/ha in Gondsur-Sampekattu betta in Sirsi, Talekere betta in Siddapur 41.47 t/ha).

The report highlights the importance of conservation of riparian forests occurring along streams and swamps, not only from high species endemism but also for higher carbon sequestration. A very detailed study in Kathalekan involving nine samples of such forests versus nine samples away from such water courses reveal that the average carbon sequestration in the former was 225.506 t/ha against 165.541 t/ha in the latter. This is despite the fact both types occur within what is traditionally designated as a *kan* forest. We therefore recommend that forests adjoining or covering streams, swamps and riverbanks of the Western Ghats be considered sacrosanct and as critical areas for hydrology not only of the coast but of the entire Indian peninsula.

The report has paid substantial attention to the **evaluation of RET and endemic forest species,** from local, regional and global perspectives. As regards trees are concerned, in principle, **there are close associations between areas of rich tree endemism and occurrence of RET tree species. Forests with high tree endemism also tend to shelter endemic/RET non-tree species and fauna- especially fishes and amphibians- which are indicators of other such organisms as well. Tree species in danger of local or total extinction mainly exist in and closer to the Myristica swamps. These include *Syzygium travancoricum* (Critically Endangered), *Myristica fatua (M. magnifica)* (Endangered), *Gymnacranthera canarica* (Vulnerable), *Semecarpus kathalekanensis* (newly discovered), *Mastixia arborea* (rare endemic) etc. *Madhuca bourdillnoni,* a Critically Endangered tree, was not in our samples, but occurred very sparingly close to some Myristica swamps. The Kathalekan swamp forest sheltered at least 35 species of amphibians, most of them within a range of few hundred meters. While 26 species (74%) of them were Western Ghat endemics, one species *Philautus ponmudi* is Critically Endangered and five species each were Endangered and Vulnerable.** Scores of *Myristica* dominated forest swamps would have perished in the Western Ghats in past centuries having given way to human impacts, notably due to reclamation of primeval forest clad valleys for making rice fields and arecanut-spice orchards. The last remains are also under threat, mainly being looked upon for areca orchards by encroachers. Swamps being excellent sources of perennial streams we recommend tracing out all such swamps and potential swamps (of degraded vegetation or waters diverted for agriculture) for hydrological needs. The swamps along with their catchments, even if they have secondary forests, need to be safeguarded as prime areas of hydrological significance and as the last refugia of rain forests in the central Western Ghats.

Identification and prioritisation of `hotspots', is done for areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat. The focus is more on endemic species, rather than populations or other taxa, as the most prominent and readily recognizable form of biodiversity.

Using a grid system (preferably 1x1 km) of forest surveying we need to have a proper stock of the distribution of endemic tree species, and demarcate areas of high tree endemism for prioritization of conservation as such areas are also good for endemic faunal elements and for their hydrological importance.

Centres of high floristic endemism (of especially trees) are also the centres of endemic fishes in the streams draining them, in addition to amphibians and birds.

The role of man-made plantations needs a re-evaluation, in the light of high soil erosion, weed infestation, poor hydrology and poor associated faunal diversity as compared to natural forests. The teak plantation areas in general, despite the high value of teak timber, were found to have lower biomass and needs enrichment planting by NTFP species, nectar species for honey bee promotion, Soil erosion from forests and forest plantations is a matter of grave concern. As rains are often very high (upwards of 3000 mm/per annum) in most places, and so much of rains fall within a short period of mostly four months a dense forest cover is required to check soil erosion and increase infiltration into the ground water. Here we recommend eventual conversion of deciduous forests and their degradation stages (except grasslands or grassy blanks, critical resources for grazing ecosystems) in heavy rainfall zone into evergreen forests. Poor grade tree plantations with eroded soils need to be restored with natural forest species through planting of saplings and dibbling of seeds.

Forest restoration in the catchment areas of rivers will improve perennial nature of streams ensuring perpetual inflow of clear water into the storage dams of hydroelectric projects in Sharavathi and Kali rivers than bringing into them an onrush of water turbid with soils down the poorly vegetated terrain. The active monsoon period being of four months it is necessary to increase residency of water within the watershed soils than releasing it en mass into the reservoirs or other downstream areas as surface water, which eventually get lost through faster evaporation in the prevailing climatic conditions.

The species chosen for forest enrichment/afforestation should have strong bearing on a. increase in endemism; b. more of ecologically site specific NTFP species; c. benefit to birds and bats and other frugivorous animals and d. favour populations of wild bees and create employment opportunities through bee-keeping and enhance pollination services of both cultivated crops and forest plants.

Highest conservation values are more for forests towards the south from Sharavathi Valley (Kathalekan-Malemane-Gersopppa stretch to the Aghanashini valley in Siddapur and to a small extent in Sirsi). Incidentally this stretch of forests, having the northernmost populations in the Western Ghats of the endangered primate Lion-tailed macaque, of Myristica swamps and *Dipterocarpus* trees, has been already declared by the Government of Karnataka as Aghanashini LTM Conservation Reserve.

The study reveals that there is only a thin line difference between rain forests and deserts. Whereas the heavy rainfall of coast and malnadu taluks can potentially promote loftiest evergreen forests of Western Ghats many locations are characterized by poorer vegetation-poorer in biomass and in conservation ranking. The poorest savanna site exists on a hill top ironically in the Kathalekan forests of highest conservation value, dotted with Myristica swamps, by presence of lofty Dipterocarpus threatened and endemic plant and animal species (especially amphibians and LTM). Whereas the swamp forest samples of Kathalekan have average carbon sequestration of 225.506 t/ha the savanna patch has merely 5.06 t/ha. The land was savannized at least over 100 years ago by the shifting cultivators. Though today uninhabited the forest recovery has not taken place. Similar paradoxes exist between adjoining forest patches everywhere in the district.

Whereas in the earlier efforts towards conservation it was often the flagship species like elephant, tiger etc. and their habitats that captured major attention in the conservation priorities of the Government. Today, the Western Ghats, along with Sri Lanka constitute a hotspot of high endemism and significant threat of imminent extinctions. Therefore it has become necessary to evaluate and rank areas of high endemism, which we have attempted in this report through the application an objective method. Suggestions based on our sustained ecological research in Uttara Kannada district are:

- In the specter of climatic change that the planet is facing with its widespread implications especially on farming and biodiversity, the need has arisen to increase carbon sequestration in the forest areas. There are considerable areas of degraded forests in Uttara Kannada, the biomass of which has to be increased substantially through protection, enrichment and co-management.
- Inviolate forests should be identified range-wise for increased conservation efforts.
- Myristica swamps are among the oldest and original forest types of the Western Ghats. They have some of the highest degrees of floral and faunal endemism. Efforts should be made to make all out search for such swamps, record their locations and areas and conserve them along with their catchment area forests
- The *kan* forests and 'devarabanas' were **unique cultural identities** of bygone days. They still have portions harbouring deities and are seats of high endemism. As most of them got merged with state reserved forests they lost their pre-colonial identities as sacred groves from safety forests (except the smaller banas close to or in the middle of villages) Efforts should be made to trace them out and map and protect them.
- Conservation of Western Ghat endemism is important. High percentage of forest tree endemism even influences endemism among fishes in the streams that drain such forests.
- Biomass upgradation is an urgent necessity especially in the deciduous forest areas everywhere, especially in the maidan taluks of the district.
- Biomass and diversity are lower in the coastal minor forest tracts. Through consistent efforts involving local VFCs multiple species forests should be raised in such areas.
- Coastal lateritic hills were paid least attention so far; except for raising Acacia plantations no major activities were undertaken in them. Laterite plateaus also have great richness of monsoon herbs which flower gregariously and offer nectar for the survival of honey bees during the rainy season. Some ideal plateaus need to be conserved for their characteristic endemic flora.
- Regarding **scope for forestry based alternative development plan for enhancing the economic productivity of the region** we wish to state that **since** bulk of the lands in the district (over 70% area) being under the control of the Forest Department there

is very little scope for economic advancement of bulk of the local population beyond subsistence level. There is also not much scope for major developmental interventions due to the fragility of the terrain and the ecosystems. As economic growth gets stunted people, especially younger generation tend to migrate into the cities for better prospects. Such mass migrations from rural areas will strain the cities as well beyond their carrying capacities too- as it is happening in Bangalore. To reverse the trend as far as Uttara Kannada is concerned the following recommendations are made for creation of more of forestry based livelihoods without any major interventions into the ecosystems as such:

a. NTFP species should be widely raised
b. Bee keeping to be promoted as an important enterprise to benefit the people and forests (through pollination). Village peripheral forests and roadsides should be planted with numerous types of nectar plants used for foraging by honey bees (separate submitted on bee keeping0.
c. There is laxity among the arecanut garden owners as regards management of soppinbetta forests for fear of not getting the fruits of such improvement as the bettas are under Government ownership. It is recommended the betta owners be allowed certain tree rights if they adhere to certain norms like maintenance of the bettas to certain biomass levels, say like 30-35 sq.m of basal area/ha for trees.
d. The farmers require a helping hand from the Government in growing and marketing of medicinal plants and their primary products. Medicinal plants grown in VFC forests in home gardens or in fields, which also grow wild in the forest areas, should be procured by the Forest Department. This is to stop smuggling of medicinal plants from the forests, unauthorized exploitation by outside agencies and for betterment of local livelihoods.
e. Preparation of bio-pesticides, harmless to humans and domestic animals, may be promoted as a cottage industry using local plant resources, especially from village peripheral forests/VFC managed areas.
f. Vegetable dyes/or textiles coloured using such dyes, or for use as food colours are in increasing demand. Numerous plants in forests, mangroves and beaches are potential sources of such dyes. Village peripheral forests may be enriched using such plants to generate rural employment. Technology transfer is necessary.
g. Enormous scope for exploration of production and trade of plant based cosmetics and nutraceuticals (eg. from *Garcinias* and *Phyllanthus emblica* -amla) should be explored.
h. VFC managed sandalwood farms are recommended for the taluks of Haliyal, and Mundgod and for the eastern zone of Yellapur, Sirsi and Siddapur.
i. Being well forested district of hills and valleys, waterfalls, sea beaches and mangroves and for its cultural diversity Uttara Kannada has good scope for generating eco-friendly livelihoods through tourism promotion at grassroots level. This facet of development with the vision of upgrading livelihoods of grass root level people while also enriching forests, mangroves, sea beaches and coastal laterite plateaus has been successfully worked out by the Honavar Forest Division,

at Apsarakonda, Om Beach (Gokarna), Kasarkod, Bellangi etc. The State Government should liberalise the licensing policy on home stays and community managed cottages (through VFCs) to benefit growth of decentralized ecotourism in the district, to benefit both village communities and local ecology.

j. Decentralised systems of forest nurseries for generating women's employment and providing scope for application of indigenous farming techniques for forestry purposes.

- Village level biodiversity hotspots should be identified and protected through the involvement VFCs/local Biodiversity Management Committees. Eventually these, through succession and vegetational enrichment will turn out to be local hotspots of biodiversity.
- Realizing the fact that depletion of forests of food resources and human induced vegetational changes in forests have adverse consequences on wildlife while increasing crop raids by animals enrichment of secondary forests and poor grade tree plantations with food resources for forest herbivores is highly desirable.
- NTFP collection, that yields only minor revenue to the state, is being carried out in many forests with gay abandon causing destruction of the resource itself. We recommend that the VFCs and other forest dwellers in respective villages be organized and trained in scientific harvesting of NTFP which also serves as medicinal plants
- Rampant collection of poles, cane, fuel wood etc., has been taking a heavy toll on forest resources particularly in the village vicinities. Most of the easily accessible areas with many medicinal plants are more prone to exploitation and get converted into scrub and thickets. Even the semi-evergreen and evergreen forests higher up in more inaccessible areas are also being exploited for fuel wood, timber etc., due to which many of these forests have thorny thickets as under-growths. We recommend conduct of sustained programmes on biodiversity awareness. Also bamboo considered as 'poor man's timber' the villagers may be allowed to harvest it from designated areas for their own bonafide use, so that they will desist from pole cutting and stake removal from the forests which destroys lakhs of tree saplings and pole sized juveniles.

Conservationon of Terrestrial Ecosystems: Recommendations

1. **Forests towards carbon mitigation:** Carbon sequestration in any given forest is related to forest biomass. Basal area/ha is an index of the forest biomass. Higher carbon sequestration in stream course/swamp forests was a significant find of this study. In Kathalekan forests 9 forest samples along the water course-swamp parts had average carbon storage of 211.87 t/ha. In the nine samples from forest away from water course areas, carbon sequestration was lesse at 165.54 t/ha. On a hilltop savannized part, obviously due to shifting cultivation practice in the past, the carbon sequestration was very poor at 5.03 t/ha only. Numerous hill tops and wind exposed slopes of the district are in savannized state with poor biomass, demonstrating the fact clear felling of a rain forest

can bring in desertified conditions. Nevertheless, these grassy patches Considering forest as a place of tree growth, often also with undergrowth, the savannised forests and several secondary forest samples subjected to ongoing human impacts, or sytems recovering from past human impacts, had some of the least basal areas, irrespective of whether they fall in high, moderate or low rainfall areas. All the taluks have such forests, which are low in biomass. Altogether 3 out of 116 samples, as studied by transect cum quadrat method, had basal areas of < 10 sq.m, 10 transects had basal areas between 10-20 sq.m/ha and 17 had between 20-30 sq.m. To such degraded forest areas also belongs bulk of the Soppinbetta or leaf manure forests allotted to arecanut garden owners of mainly the malnadu areas, for exercising the traditional privileges, importantly leaf manure collection. Thus a betta inTalekere of Siddapur had only 10.12 sq.m basal area ha and Hartebailu betta in same taluk had only 17.80 sq.m/ha basal area. Gondsur-Sampekattu betta in Sirsi taluk had just 3.74 sq.m as the basal area. Hiresara bettaland in Yellapur was exceptional in having 41.73 sw.m basal area.

2. **Riparian forest protection:** River and stream bank forests, including inland swamp area forests are to be considered as endangered ecosystems for various reasons, including for their high accumulation of biomass and higher levels of carbon sequestration. Forest rangewise river-stream-swamp protection action plans, incorporating adequate amount of inviolate vegetation growth for protection of ecology of these vital water courses along with their rare and endemic species is critical. The maps and action plans prepared for special protection of such areas should be included in the forest working plans of every forest division. If such working plans are already prepared these should be still prepared as supplements. Timber extraction, conversion into monoculture plantations, or encroachments or any developmental activities should not be allowed affecting these inviolate forests.
3. **Protection of Myristica swamps:** These are remnants of the original primeval forests of the Western Ghats. The lineage of such forests could be traced to the supercontinent of Gondwanaland. The swamps, repositories of ancient and highly threatened rare biodiversity, are under various kinds of threats. They would have perished in large scale in early agricultural history of Western Ghats, being reclaimed for rice fields and betelnut gardens. Many of the last remaining fragments of swamps are also under threat from agricultural expansion. The swmaps should be demarcated in the forest working plans for the relevant areas and recommended for protection through preferably co-mamagement with the VFCs. The catchment areas for the swamps are to be protected from any kind of human disturbances being very important sources of hydrology. Kathalekan swamps in Siddapur taluk, being the most precious genepool of threatened plants and amphibains, among others, beng situated alongside the Honavar-Bangalore highway might get wiped out in case of road widening. The widening should not be permitted through any of the Myristica swamps or primary forest remnants.
4. **Conservation of unique forest related cultural identities:** The district abounds in forest related unique cultural identities like sacred groves and sacred trees. Sacred groves are known by various names like kans or devarabanas (often the presiding deities' names are added to respective banas-kans- such as Jatakabana, Choudibana, Kari-kanamman-bana,

Hulidevarukan, Naagarabana etc.). Numerous ancient trees, especially of genus *Ficus*, or several others like *Mimusops elengi, Mesua ferrea, Mangifera indica, Mammea suriga, Aegle marmelos* etc. are present dotting the landscapes of villages and towns signifying sacred locations of cultural value. Whereas the *kans* were traditionally large groves, of several hectares or even few sq.km in area (Kathalekan for eg.), the *banas* are smaller ones, mostly within an acre in area. While the former is associated often with other forests or wilderness the latter is often found closer to or within human settlements. The *kans* were places where tree cutting was not permitted under traditional management, but NTFPs could be taken care of and harvested (eg. Wild pepper, cinnamon, toddy and starch from *Caryota urens* etc.). The *kans* while protecting wild genepool amidst secondary, human impacted landscapes, also acted as safety forests, being fireproof systems due to their evergreenness and high humidity, as sources of perennial streams and springs and as sources of NTFP. The smaller groves the *banas*, were not traditionally violated for any form of bioresources. In short both *kans* and *banas* were unique cultural identitites of the region while they preserved the region's climax vegetation. With the process of forest settlement during the British period, most of the *kans* lost their original identity as village sacred groves from safety forests, and were treated not much different from other forests. The smaller sacred groves are under shrinkage too due to erosion of conservation ethics due to changing cultural worldviews of the local communities (Chandran, 1998; Chandran and Gadgil, 1993). A detailed survey of 86 villages gave details about the presence of 241 sacred groves. We strongly recommend that the Government through the Forest Department take immediate steps to revive the system of preservation of these ancient sacred groves however small they are,

5. **Identification and recouperation old *kan* forests:** *Kan* forests were sacred forests of local rural communities of central Western Ghats. They are known as *devarakadus* in Coorg district. Devarakadus of Coorg have official recognition as sacred forests to this day. The kans of Shimoga district were demarcated in maps and their areas were already listed from early British period. But the British did not recognize the sacredness of the *kans*. In Uttara Kannada many *kans* of Sirsi and Siddapur were demarcated villagewise in forest settlement reports. At the same time many other *kans* got merged with rest of the reserved forests without any special status conferred on them and subsequently it became difficult even to locate their boundaries. Such is the case of Kathalekan in Siddapur, Karikan in Honavar and Halsollikan in Ankola which we studied in detail. All these three *kans*, despite being reserved forest areas, are associated with sacred locations within them or in their vicinity, where local people continued the worship of deities. Interestingly all these places continued to maintain their distinctness as relics of primary evergreen forests embedded in a vast matrix of secondary forests. All these forests have *Dipterocarpus indicus*, a primary evergreen forest tree of South Indian Western Ghats. This species, though commoner in more southern forests, have isolated occurrences in Uttara Kannada mostly associated with *kan* forests. The presence of this Endangered evergreen tree has enhanced the conservation value of all these forests. Asollikan is a locality where we observed also the Critically Endangered tree *Madhuca bourdillonnii*. The discovery of this rarest species in Ankola taluk, once thought to be extinct and rediscovered in

southern Kerala Ghats in its original home range, is an instance of traditional, community based conservation practice. Presence of species like *Myristica magnifica* (Endangered), *Syzygium travancoricum* (Critically Endangered), *Gymnacranthera canarica* (Vulnerable) and *Semecarpus kathalekanensis* (newly described tree species from the Myristica swamps of Karikan, underscores the importance of surveying, demarcating and protecting the lost *kans* (sacred forests) of pre-colonial times, and demarcating them for more careful protection and restoration through natural regeneration. The *kan* forest areas, were considered during British period as hydrologically important areas, being associated with perennial streams and springs (Chandran and Gadgil, 1993). Even a small *kan* of just one ha, in the Mattigar village of Siddapur taluk has *Syzygium travancoricum* (Critically Endangered) and *Vateria indica* (Endangered). The *kans*, many of them in ruins, due to various reasons, should be salvaged and brought under a system of co-management involving the local VFCs, if they are closer to villages.

6. **Conservation and promotion of forest endemism:** High rainfall areas have high biodiversity values and higher conservation values. High rainfall areas of malnadu and coastal taluks are major seats of endmic biodiversity of both palnts and animals. Kathalekan studies in Siddapur taluk (by various investigators) reveal how the high endemism is associated with Myristica swamps, at least 35 species of amphibians, endemic hornbills and Imperial pigeon, Endangered primate Lion –tailed macaque etc. The very distribution of fresh water fishes is highly correlated to terrestrial landscape elements, of which quantity and quality of evergreen forests are more important. Of the 64 species of fresh water fishes reported from Sharavathi River, including in its catchment areas of Shimoga, 18 species were endemics to Western Ghats, including three new species *Batasio sharavathiensis, Schistura nagodiensis* and *S. sharavathiensis* and 24 species confined to Peninsular India (Bhat and Jairam, 2004; Sreekantha et al, 2007).
7. **Upgrading biomass in deciduous forests and secondary deciduous forests:** The quality and quantity of a deciduous forest stand is very much reflected in its total biomass of which basal area is an index. Eleven forests surveyed in the deciduous forest zone of Haliyal and Mundgod taluks reveal unsatisfactory biomass, estimated basal areas/ha being in ranges of 10-20 sq.m for three samples, 20-30 sq.m for five samples, 30-40 sq.m for just two samples and only one falls in 40-50 sq.m category (43.09 sq.m at Godnol in Mundgod). Forest fragmentation of high order, shifting cultivation practices in the past, massive conversions into monoculture plantations, clear felling and selection felling rampantly practiced in the past are some of the major causes for low basal areas. Compact stretches of forests especially in areas thinly populated by humans may be prioritised for developing ideal forests of high stuature through special protection and periodical monitoring of the progress of natural succession and tree growth. The forest management should aim at developing in the deciduous forest zone of Mundgod, Haliyal, in the drier eastern parts of especially Joida, Yellapur and Sirsi compact stands with basal areas exceeding 35 sq.m/ha.
8. **Increasing biomass and diversity in secondary deciduous forests of coastal taluks:** The secondary moist deciduous forests along the coastal taluks have been in impoverished state due to high density human impacts. Bulk of such forests constituted

the 'minor forests' meant for meeting the biomass needs of coastal people, including cattle grazing. Through special protection of promising forest patches using barbed wire fencing, and closing any kind of exploitation in such protected areas, natural regeneration can be promoted, for at least five year period. Thereafter these forests can be open for free movement of wildlife and more such selected blocks can be protected, using the mode of forest working plans.

9. **Demarcation of potential areas for conservation of congregation of endemic trees:** Our survey reveals there are special areas in the forests where species like *Myristica fatua, Dipterocarpus indicus, Syzygium travancoricum* etc. congregate. More such areas should be traced out through the involvement of forest guards and village people and earmarked for special conservation efforts.
10. **Importance of conservation of the native flora of coastal laterite hills and plateaus:** From ancient times the coastal hills and plateaus of Uttara Kannada, from Ankola to Bhatkal, presented a picture of a barren and desolate terrain with sparse growth of woody vegetation. As such these were demarcated as minor forests for meeting the biomass needs of the local population and for cattle grazing. Many have been used in the recent decades for raising monocultures of *Acacia auriculiformis*. Our studies reveal that during the rainy season, open lateritic areas get carpeted with tiny herbs, where billions of flowers bloom providing crucial off-season nectar resources for honey bees, which, especially the domesticated ones, are otherwise to be fed artificially using sugar/jiggery solutions. We have submitted in this regard a separate, detiled report with recommendations for conservation of such lateritc minor forest areas.
11. **Forest resources for improving economic conditions of local citizens:** Regarding scope for forestry based alternative development plan for enhancing the economic productivity of the region we wish to state that since bulk of the lands in the district (over 70% area) being under the control of the Forest Department there is very little scope for economic advancement of bulk of the local population beyond subsistence level unless suitable small scale enterprenureship complementary to forests and nature are nurtured in the district. This recommendation is made considering the least scope in the district for major developmental interventions due to the fragility of the terrain and the ecosystems. As economic growth gets stunted people, especially younger generation tend to migrate into the cities for better prospects. Such mass migrations from rural areas will be too exacting on the carrying capacities of cities- Bangalore, for instance is burgeoning with population and developmental activities with heavy toll on ecology the impacts far reaching even on ecology of Western Ghats. To reverse the trend as far as Uttara Kannada is concerned the following recommendations are made for creation of more of forestry based livelihoods without any major interventions into the ecosystems as such:
    i. ***Sustainable use of soppinbettas:*** Soppinbettas are forests allotted to arecanut garden owners of mainly the malnadu areas, for exercising the traditional privileges, importantly leaf manure collection. The farmers do not have tree rights in these bettas although in most bettas we observed trees are constantly lopped for leaf manure collection, apart from collection of leaf litter from the ground. Bettas sampled were understocked in tree biomass (a betta in Talekere of Siddapur had only 10.12 sq.m

basal area ha, in Hartebailu of same taluk a betta had only 17.80 sq.m/ha basal area and in Gondsur-Sampekattu betta in Sirsi taluk it was abysmally low 3.72 sq. m) Some farmers maintain bettalands in better conditions eg. Hiresara bettaland in Yellapur (basal area 41.73 sq.m/ha). One of the reasons for understocking and low biomass is that many farmers also use the bettas as tree savannas interspersed with grassy areas; as a result they are able to maintain improved cattle unlike the coastal farmers who are hard pressed for fodder grasses even to feed their diminutive indigenous cattle. The laxity in betta management is partly due to the general fear among the farmers that any improvement in the betta forests at their expenses will not be repaying for them as they do not enjoy absolute ownership over the betta lands or the trees. It is recommended here that the farmers be allowed to have rights on the trees (for timber and fuel) in the betta if they upgrade the tree biomass from present basal area indicator of less than <20 sq.m/ha to minimum of 30-35 sq.m/ha, which minimum limit the Forest Department may fix after examination of the condition of the betta on a case to case basis.

ii. ***Promotion of bee keeping:*** Uttara Kannada has ideal district for promotion of bee keeping. Bee keeping is complementary to forestry and farming because of pollination benefits. Uttara Kannada can reap enormous benefits through especially production of forest and farming based organic honey. Even roadsides and wastelands can be planted with nectar producing plant species. Although about 7000 sq.km area is under forest cover the district has achieved only very little progress in bee keeping. One of the key reasons is the inadequacy of bee forage plant species in the village peripheral forests which are often in degraded state, with scanty attention paid to enriching them with bee forage plants. Particularly nectar producing species, groups of them flowering in different times of the year, composed of a community of site specific flowering herbs, shrubs, climbers and trees are to be promoted to support apiculture in villages (A separate report on bee keeping is submitted). Even the landless and marginal farmers can involve in bee keeping depending on bee forage plants in forests, roadsides, mangroves and beaches. Through proper planning and implementation of 'forests for bee keeping' project, hypothetically, at the density of two bee colonies per ha of forest (not necessarily by placing bee boxes in every ha of forest, as the bees travel few km in search of forage plants; for eg. *Apis dorsata* has a foraging range of 3 km radius -Batra, 2001), at a modest estimate honey production based on 700,000 ha of forests at 40 kg/ha using native bees *Apis cerana,* and Rs.200/- kg rate at prevailing minimum rate, can yield 28,000 tons of honey worth Rs.560 crore. Honey is a good health food in demand nationally and internationally. Proper marketing as organic forest honey can fetch much more income (for eg. Soapnut tree based honey fetches upwards of Rs.700/- kg). Surplus honey can be used in the mid-day meal programmes for school students. To achieve such ambitious target we recommend that even a wing of Forest Department be made to promote apiculture related activities.

The bettaland farmers should be assisted in bee keeping activities aiming at a minimum of one bee box for every acre of betta. They are to be guided in enriching the bettalands with bee forage plants so that the vegetation of impoverished bettas are also improved. Improved vegetation and better ground cover can also improve local hydrological conditions. A single bee colony (in a bee box) can earn for the farmer Rs.4000/- extra money, through better management and vegetational enrichment. The farmers also stand to gain from increased farm productivity due to the pollination services from bees, and NTFPs from bee forage plants. The farmers need training in bee keeping related activities. Sirsi-Siddapur taluks, which have some of the highest forest fragmentation in the district, can also substantially improve the forest wealth through betta rehabilitation.

iii. ***Promotion of marketable medicinal plants*****:** The farmers require a helping hand in growing and marketing of medicinal plants and their products. The farmers would look forward to the Government/Forest Department, for acting as a purchasing agency for medicinal plants or their products. In this regard by undertaking the role of a facilitator between the producer and the purchaser (pharmaceutical companies) the Government/Forest Department would play a vital role in biodiversity conservation and enhancing the value of bettalands, minor forests, and even those who grow medicinal plants in their household gardens or private lands. The role of Forest Department as a purchasing agency while bettering local livelihoods can also stop smuggling of medicinal plants from the forests and other unauthorized exploitation by outside agencies

iv. ***Biopesticides from forest plants:*** Various plant species of the district viz. neem, *Pongamia, Vitex negundo* etc. are sources of biopesticides. Promotion of such plants in VFC managed forests and bettalands can further the cause of organic farming in the district while also earning extra income to the locals from production of marketable, homemade biopesticide formulations, under an assited programme from the Government. Neem based pesticide formulations are widely popular in the world. Azadirachtin, the main active principle of neem is also found in *Melia azedarach* (Hebbevu) of same family. However, use of such pesticides in India is making tardy progress, despite the fact that knowledge base for neem pesticidal properties is from India. Bark extract of *Acacia nilotica* has been found to provide complete protection to oranges from the blue mold fungus (Varma and Dubey, 1999). Leaf extract of *Clerodendron inerme*, a hedge plant and coastal shrub, is found effective against red spider mite. Use of *Lantana camara* extract to control cotton pests is a good example of agrass root level practice (Varshney, 2006). Strychnine from *Strychnos nux-vomica* is used as a rat poison. Pongamia leaves and bark are sources of traditional biopesticides, especially having insect deterrant properties (Kiruba et al., 2006). Seeds of the giant forest liana *Entada pursaetha* are used to control rats in the Garo Hills of North-East India.

v. ***Vegetable dyes from forest plants:*** World over, especially from developed countries, there is growing demand for textiles dyed using vegetable dyes. Total market for herbal dyes was estimated to be worth US$ one billion and growing annually at the rate of 12% (Gokhale et al., 2004). India has a wealth of traditional knowledge on production of plant based textile (for cotton, wool and silk) and leather dyes. The market demand for such dyes is yet unrealized in the absence of surveys. It is right time for Uttara Kannada district to capture this market using the enormous potential for growing plant sources of vegetable dyes in the VFC managed areas, including sea beaches and mangroves, under a sustained programme including training programmes for transfer of appropriate technology. Numerous plant species can be promoted for dye production in cottage industry level:

a). *Acacia catechu* (Khair): Catechin red from wood for dyeing silk, cotton and calico printing
b). *Acacia nilotica* (Jali): Catechin from wood for dyeing light yellow, dark grey, reddish brown
c). *Aegle marmelos* (Bilpatri): Marmalosin from fruit rind for yellow and gray
d). *Bauhinia purpurea* (Mandara): Chalcone and butein for dyeing and tanning purple
e). *Butea monosperma* (Muttaga): Dried flowers with several components for dyeing of silk brilliant yellow
f). *Caesalpinia sappan*: Brazilin from wood and pods for red and black
g). *Cassia fistula* (Kakkemara): Bark and sapwood for red
h). *Cassia tora* (Tagati): Rubrofusarin from seeds for tannin and dyeing blue
i). *Chukrasia tabularis* (Gnadhagarige): Leaves for red
j). *Dipterocarpus spp.* : Bark for brown and gray
k). *Madhuca indica* (Mahua): Bark for reddish yellow
l). *Mallotus phillippensis* (Kumkum): Fruits for dyeing silk red
m). *Mangifera indica* (Mango): Bark and leaves for dyeing silk yellow
n). *Morinda citrifolia* (Noni): Morindin from root and bark for dyeing silk dull red
o). *Pterocarpus marsupium* (Bet-honne): Epicatechin from bark for dyeing silk brownish red
p). *Rubia cordifolia* (Manishta): Manjistin and purpurin from stem and bark for reddish brown, light pink, light brown, gray
q). *Terminalia arjuna* (Holematti): Arjunic acid from bark for light brown
r). *Terminalia chebula* (Haritagi): Chebulinic acid from fruits for yellow and dark gray
s). *Tectona grandis* (Teak): For dyeing silk yellow
t). *Ventilago maderaspatana*: Ventilagin from root and bark for colouring cotton and tassar silk chocolate
u). *Woodfordia fruticosa:* Lawsone from leaves and flower for dyeing pink or red
v). *Zizyphus jujube* (Bora): Fruit as modant in dyeing silk

There are many more such plant sources of dyes. The important needs before implementation are:

- Documentation of traditional practices, study of local and global demands
- Improvisation of traditional techniques
- Commercial cultivation of wild sources
- Standardisation in dyeing practices

vi. ***Cosmetics and nutraceuticals from the wild:*** As such lot of authorised and unauthorised extraction of NTFP used for cosmetics and nutraceuticals are happening in the district, for instance from plants like *Garcinia* spp. Kokam fat from *Garcinia* seeds has global demand as is most sought after for preparing skin creams. Following in importance is seed fat from *Madhuca indica* (mahua tree). *Garcinia cambogea* and *Phyllanthus emblica* are few among several nutraceutical plants, the multiplication and sustainable harvests of which can generate considerable rural employment. The traditional Indian cosmetic products of India came from a variety of plants like Amla, Shikakai (Acacia concinna), neem, soapnut (Sapindus laurifolius),

vii. ***VFC managed sandal farms:*** Sandalwood (*Santalum album*) is perhaps the costliest of tree species in the world, Karnataka being its greatet production centre. The high cost of the wood has become baneful to the species, as the tree faces highest smuggling risks. Individual householders and farmers seldom dare to grow this valuable species due to their inability to safeguard it. Collective responsibility by village community seems to be the only course for the future of sandal. We therefore recommend the adoption of the species by VFCs in their respective jurisdiction especially in the taluks of Mundgod and Haliyal and eastern parts of Sirsi, Yellapur and Siddapur.

viii. ***VFC managed medicinal plant areas:*** Medicinal plant gardens of fast depleting and highly traded species may be promoted through VFCs for growing *Salacia chinensis, Nothopodytes foetida, Embelia spp., Coscinium fenestratum, Costus speciosus, Rauwolfia serpentine, Asparagus racemosus etc.* Many highly degraded forests, scrubs and thickets contain numerous medicinal plants particularly near coastal areas. These are to be mapped and brought under strict in situ conservation measures, so as to preserve the native medicinal gene pool.

ix. ***Forests for ecotourism:*** Natural and cultural heritage are primary attractants for tourism world over. Uttara Kannada is an idyllic district of valley villages of lush greenery merging with wooded hillsides and grasslands offering tremendous scope for development of eco-tourism and study tourism. Tourism flourishes especially in areas with more than two landscape elements meet – such as sandy seashore and beach forest (eg. Kasarkod), sea shore and hillscape (eg. Apsarakonda), waterfall and forest (eg. Jog, Unchalli and Magod waterfalls), pilgrimage and picnic trail through forest to cathedral rocks (eg. Yana, or to hilltop shrine of Karikanamma in the vicinity of *Dipterocarpus* sacred grove) and so on. In all these places and in many more areas, apart from National park and sanctuary, the Forest Department has demonstrated that tourism can be conducted successfully to benefit the local communities organized into VFCs. This facet of development with the vision of upgrading livelihoods of grass root level people while also enriching forests, mangroves, sea beaches and coastal laterite plateaus has been successfully worked out by the Honavar Forest Division, at Apsarakonda, Om Beach (Gokarna), Kasarkod, Bellangi etc. The potential should be developed so as to generate income to the locals through preservation of their local environment and local cultures without the need for migration into cities in search of employment. Key elements for successful development of eco-tourism are limiting growth within sustainable limits (Jog Falls, unfortunately, is a location where ecological norms are not adhered to creating considerable negative impact on environment), generating benefits to the local community (and not to major enterprises from outside), monitoring and mitigating ecological impacts (mostly not happening in our ecotourism areas, except in PAs). Partnership with local community/VFC is of great importance of success of ecotourism. We recommend that in all areas with ongoing, potential ecotourism training be imparted to especially local youth in successful management of tourism, in running forest trails, in bird watching, familiarisation with local flora and fauna etc. Liberal issuance of licenses for home stays and community/VFC managed cottages is necessary for ecotourism to benefit grassroot level people and environment.

x. ***NTFP species raising and utilisation*****:** For betterment of livelihoods at local level NTFP yielding species should be raised on a larger scale in VFC areas. Auctioning of NTFP to contractors is found to be injurious to forests due to overharvests, unscientific harvesting methods and for the poor returns of revenue to the State. The local VFCs, tribal societies, self-help groups of women etc should be prioritised for NTFP harvests.

xi. ***Decentralised systems of forest nurseries***: For generating women's employment in village areas and also providing scope for application of indigenous farming techniques for forestry purposes sets of local species may be raised in household nurseries.

12. **Village level biodiversity hotspots:** Our studies show that biodiversity conservation values are correlated to forest endemism. Although Western Ghats itself is part of a global biodiversity hotspot, the concept of village level biodiversity hotspots should be promoted through community participation. Such hotspots, which are especially centres of local level biodiversity, should be identified and special attention given to their protection through Biodiversity Management Committees/Village Forest Committees. Eventually these special patches should serve as local climax natural ecosystems also strengthening local hydrology.
13. **Decentralised systems of forest nurseries:** Villagers in close vicinity of forest areas may be commissioned to raise small scale nurseries of selected species flowering plants for replanting inn forest areas, roadsides etc. to reduce the load on the understaffed Forest Department which is required to spend considerable time and resources on large scale nurseries. This will increase rural employment, especially for women while also giving scope for application of indigenous planting techniques.
14. **Promoting food plants for wild animals:** Bulk of Uttara Kannada forests are of secondary nature, either old growth forests or forests, scrub and savannah in different stages of succession. As such these massive vegetational changes that have happened through centuries of human impacts, have adverse consequences on native fauna thinning the populations of many or causing their local extinctions. Leaving aside old growth forests, which should not be subjected to any kinds of tampering, the rest should be

enriched with food plants for various faunal elements, particularly birds and frugivorous bats, primates and other mammals. This enrichment is also necessary to reduce crop raiding by wild animals. Care should be take to preserve grassy blanks within forest areas, critical resources necessary for grazing wild animals. Such grassy blanks should not be subjected to afforestation.

15. **VFC based resource monitoring:** As villages are dispersed in Uttara Kannada all over forest areas it would make much sense to adopt a system of participatory resource estimation and monitoring within their respective areas- such as estimates of *Myristica*, cinnamon, gooseberry, *Garcinias* and other NTFP plants, key medicinal plants like *Nothapodytes*, *Cosicinim*, *Salacia*, *Embelia* and so on as well as of honey bee colonies within forests. This will strengthen bonds between the Forest Department and village communities while also getting a fair idea of the worth of forests at local level for the provisional goods they contain.
16. **Meeting the fuel needs:** Fuel extraction, both legal (especially removal of dead and fallen from interior forests) and illegal by local population is instrumental in degradation of many forests. Energy efficienct stoves, biogas, solar devices, use of agricultural wastes etc. are to be promoted as fuel in rural areas. At the same time adequate fuelwood/or other alternative fuels should be granted to cottage industries run by potters, lime makers etc.
17. **Selecting appropriate areas for tree plantations:** Raising monocultural/mixed tree plantations has to be site specific. Planting of *Acacia auriculiformis* has to be restricted to rocky or otherwise impoverished terrain and not in lands with good soil resources where native species are to be preferred.
18. **Dispensing with the practice of climber cutting:** Climber cutting is an archaic practice in forestry to promote tree growth. The Western Ghats harbour good diversity of climbers including endemic ones. The climber cutting practice has to be disbanded or restricted to tree plantations only as it would otherwise cause destruction of biodiversity including medicinal plants and entail adverse impacts on wildlife.

1.1.2 MEDICINAL PLANTS CULTIVATION AND VALUE ADDITION

Ayurvedic medicines and treatments now emerge as a most important scenario in world market. Health tourism is has flourishing prospects especially in South India. Uttara Kannada with coastal, malnadu and maidan zones is highly suitable for cultivation of various medicinal plants. There is however great risk in farmers growing medicinal plants for marketing fresh or without any processing, barring those which can be dried and sold. Bulk of the profit from medicinal plant trade goes not to the farmers but to the traders and wholesalers. This discourages farmers from undertaking any large scale cultivation of medicinal plants, unlike agricultural or horticultural products. The medicinal plant based industry, the drug manufacturing enterprises are growing by leaps and bounds, but the profits only trickle down to the growers and collectors. Therefore, to make medicinal plants cultivation a major enterprise and for discouraging collection in the wild we make following recommendations:

- Thousands of families in Uttara Kannada should be involved in medicinal plants cultivation for the sake of livelihood security and crop diversification.
- Training programmes should be arranged for growers of medicinal and aromatic plants.
- Training programmes should be arranged for value addition of medicinal plant products
- Government initiate production of Ayurvedic medicines on its own or through Government sponsored co-operatives and home industries production of standardised ayurvedic formulations or bases for such formulations.
- Grants should be made available to panchayats exclusively for medicinal plants cultivation and buy back of products.
- Saplings/seedlings and technology support for growing medicinal plant should be provided to needy growers
- Government should start procurement centres for buying the products from growers, and give support price if required.
- The assistance for medicinal plants growing should be made available to even marginal farmers through National Bank for Agriculture and Rural Development (NABARD), pharmaceutical companies etc. Groups of small growers should be formed for viability.
- Today organic farming is the most sought out way of medicinal plant cultivation as the plants produced through such methods possess all the natural qualities of the plants. Government make arrangements for organic certification
- Medicinal plant selection for cultivation should be based on market demand. The growers should be advised accordingly
- Bulk purchasers of medicinal plants should be made to declare the source of the plants so that the stock in the wild is not depleted
- Interests of primary producers should be protected by the Government
- Medicinal plants cultivation to be popularised in the economically and educationally backward villages of Supa, Haliyal and Yellapur villages, under buy-back schemes.
- The growers should be trained in simple techniques for value addition

An indicative list of plants that are suitable for various agroclimatic zones and names of medical formulations from them are given in the Table 1.2

Table 1.2: Notable medicinal plants for cultivation and trade in Uttara Kannada

Plant name & habit	Common names	Suitable habitats/zones	Formulations
Acorus calamus (herb)	Sweet flag (Eng); Bajje (Kan); Vacha (San)	Flooded fields, marshy places	Rhizomes for perfume; ayurvedic medicine
Aloe vera (herb)	Aloe; Kumari (San)	Dry, well drained soils	Leaf juice for sun burn, skin care, cosmetic, eczema, burns, acne, pimples, antioxidant, healthy hair, laxative, cancer cure
Alpinia calcarata (herb)	Galanga (San)	Malnadu	Tubers for throat ailments, digestion, blood purification and for good health
Asparagus racemosus (climber)	Shatavari (Kan; San)	Wild- for VFC areas; cultivation easy	Roots diuretic, antidysenteric; increased milk production and fertility. Many medicinal formulations
Coleus zeylanicus (herb)	Iruveli	Sandy and lateritic soils	Dried stem for vomiting, diarrhoea, leucoderma, fever, leucoderma; for iruveli kashayam, devashtagandha, snana choornam etc.
Curcuma aromatica (herb)	Vanaharidra	Well drained soils of coast and malnadu	Rhizome distilled for essential oil. For cosmetics, skin diseases, fever etc.
Emblica officinalis (tree)	Amla (San); Nellikai (Kan)	Maidan areas; good for VFC control	Fruits for pickles and numerous ayurvedic formulations
Garcinia indica (tree)	Kokum Murgila (kan)	Coastal taluks - VFC areas, home gardens	Fruit syrup cooling and refreshing; antidote to biliousness; seed fat for soaps, cosmetics; skin ailments, diarrhoea
Gloriosa superba (climbing herb)	Kalihari (San)	Raised from rhizome	Rhizome for gout, rheumatism, ulcers, Alkaloids for modern medicines
Indigofera tinctoria (shrub)	Neela amri (San)	Maidan taluks	Leaves reputed for hair growth & blackening; for 'Neelibhringadhi' oil
Kaempifera rotunda (herb)	Bhucampaka (San)	Wet shaded conditions	Rhizome for many ayurvedic formulations
Piper longum (creeping herb)	Hippali (Kan)	Intercrop in gardens	Dried spike for pickles, Chyavanaprash, respiratory diseases, muscular sprains, spasms etc.
Plumbago rosea (shrub)	Chitramoola (San)	Malnadu & maidan	Root tubers for leucoderma & skin diseases
Rauwolfia serpentina (herb)	Sarpagandha	Malnadu & coast; well drained fertile soils under irrigation;	Root derived drugs for hypertension, mental disorders, sleeplessness

1.1.3 PROTECTION OF CRITICALLY ENDANGERED HABITATS

The Anshi-Dandeli Tiger Reserve is a prime area in the Western Ghats for conservation of the Endangered Tiger. The Western Ghat's northernmost population of elephants, an Endangered mammal, constitutes an isolated herd or nearly 60 animals. Most (about 13) of the tigers of the district and the entire elephant population in addition to numerous other animals have ADTR as their main shelter. The elevation of ADTR into a haven for wildlife can generate good income from tourism and nature lovers and better the livelihoods of the most backward population of especially Joida and Haliyal taluks. For this purpose the ADTR management has to be fine-tuned towards meeting the habitat quality requirements of a variety of faunal elements. The major recommendations towards this are the following:

i. **Linking with sanctuaries of Goa:** Initiatives may be taken to increase the metapopulation of mammals like elephant and tiger by widening the habitat through linking Bhagavan Mahavir and Molem Sanctuaries of Goa. Such widening of the habitats will reduce human-wildlife conflicts which are on the increase.
ii. **Enrichment of grassland resources:** Grasses and herbs make the most important grazing resources for several wild mammals in the ADTR, such as elephants, barking, mouse and spotted deers and boar. The grazing animals, except elephants, constitute important prey stock for tiger and panther. The important grass resources grow in grassy blanks (which were early shifting cultivation areas), old walls and rocky surfaces, fallow fields, marshes and meadow etc. They are also associated with clearances under power lines. These grassy areas need to be preserved from competition from domestic cattle. The grassy blanks should not be brought under afforestation.
iii. Larger grassland areas such as Thayamaddi-Barpoli cross, Kaneri dam site, Terali, Burpali-Anshi, Kumbarwada-Diggi areas etc., are old grasslands having not only highly palatable, high yielding grass species but also good number of other fodder dicot species. They need to be spared from afforestation works.
iv. In ranges with less of open grasslands such as forested areas of Phansoli, Gund, Kulgi and Anshi areas permanent wetlands and water holes serve as a major source of fodder for wild life which are rich in grass species along with large number of dicot herb species with high fodder value. The integrity of these micro-habitats should not be altered.
v. If the phase wise rehabilitation of villages in the ADTR happens then the vast abandoned fields and other human used areas can make perfect grazing areas for wild animals under a proper management regime including sparing use of fire. The hill tops and slopes of Kumbarwada are covered with grasslands. Their integrity should be preserved.
vi. Cattle kills are more in the ADTR as 145 cattleheads were killed by carnivores during 1999-2000. This reflects the insufficiency of grasslands as well as the poorer qualities of many. The government schemes for rehabilitation of villages from the ADTR should be popularised among the people.

1.1.4 GRASSLANDS OF ANSHI-DANDELI TIGER RESERVE (ADTR)

Grasslands constitute a critical resource, as the grasses constitute bulk of the diet of herbivorous mammals, especially ungulates, which constitute bulk of the prey for the big cats, the tiger and the panther. Ecological history of the Western Ghats, especially of Uttara Kannada district, and the recent studies highlight that the number of tigers in any reserve is correlated to the number of prey animals and prey animals depends on grasslands. Therefore grasslands deserve prime attention in the management plans of ADTR. The work on grasses of ADTR is scanty and this work constitutes preliminary work which help in understanding grassland ecology. Tigers are part of a landscape of varied elements and grasslands cannot be treated in isolation, but in combination with forests, savanna, scrub, streams and rivers, gorges, ravines and cliff, which in a mosaic constitute homes for the deer, sambar, gaur and pig which are among the important preys of the tiger.

The grasslands in the district are mainly due to the forest clearance by humans carried out through centuries of shifting cultivation and cattle grazing. Specially maintained 'bena' grasslands of farmers as well as many grassy blanks within forests and closer to villages are the result of arresting the natural succession of forest vegetation because of periodic burning of woody growth by the people. Savanna vegetation is very common element of landscape in every taluk of the district. It is a mixture of isolated trees or clumps of dwarf trees amidst a general matrix of grasses. In the absence of fire these savannas often tend to progress towards forest, through recruitment of more trees, which shade the grasses, giving not much scope for their multiplication.

Recommendations

- The practice of afforestation of grassy blanks has to be discontinued unless there is need for recreation of resource patches (fruit trees and keystone plant resources favouring life of herbivores). These resource patches have to be in block planting or in linear forms facilitating corridors for movements, for animal movements. A combination of both may be also carried out, after planning and deliberations.
- Grassland enrichment is to be thought of for selected grasslands. Very degraded grasslands may be closed to grazing facilitating revival of the grasses.
- Afforestation of grassy blanks to be limited to very unproductive areas only. While selecting tree species for planting the animal community should be borne in mind. Patches have been observed where instead of raising natural vegetation the exotic industrial cum pulpwood species *Acacia auriculiformis* has been planted. For example Acacia was planted up in Thayamaddi-Barpoli Cross and few other places.
- Controlled fire to be used in grasslands in transition such as under dicot weeds and woody vegetation. Such grasslands to be divided into blocks and alternate blocks to be set on fire. Volunteers may be trained and their services used in meticulous use of fire so as to promote grasses

- Since legumes are nitrogen rich and good as fodder, leguminous fodder herbs may be planted in abandoned agricultural fields to promote wildlife. Herbaceous climbers of legumes, that provide forage for wildlife may be promoted experimentally in some of the poor grade mono-culture plantations.
- Natural succession inside monoculture plantations may be directed towards enhancing the food resources of the ADTR for wildlife.
- Herbaceous forage legumes may be considered experimentally for planting along the sides of some of the forest roads.
- Priority to be given for resettlement of villages with large number of cattle. Some of the good pastures of importance to wild herbivores need to be spared from grazing by domestic cattle. In the peripheral villages the concept of village fodder farms, to meet the fodder requirements of domestic cattle, needs to be promoted, so as to prevent those cattle from entering the ADTR.
- Tigers are sensitive to high levels of human disturbance. In landscape management programme large core areas are to be earmarked for strict protection. Relocation/rehabilitation of villages, preferably should begin with these identified core areas. The core areas may be identified by abundance of wildlife in general, good water resources and reasonably large sized elements in natural landscapes. Good grasslands need to be linked to large patches of multi-species forests and perennial water bodies.
- Core areas and corridors are to be identified on the basis of field studies, animal censuses/observations hitherto carried out and remote sensing data. Corridors to be devised and existing ones have to be strengthened/widened using suitable plant species.
- Buffer zone management is very critical in tiger conservation efforts. The buffer zone should not be one with intense human activities and grazing pressures from domestic cattle. The human activities here should be regulated and development guided towards complementing the objectives of ADTR. Activities suggested for the buffer zone are (i) Formation of Village Forest Committees and Biodiversity Management Committees among all the peripheral villages, (ii) Raising firewood and NTFP species to make peripheral villages self sufficient so as to take pressure of the ADTR core and buffer zones, (iii) Starting village fodder farms, under Social Forestry schemes, especially in villages having numerous cattle and insufficient fodder resources, (iv) Training enthusiastic youngsters as tourist guides, volunteers and communicators, (v) Fencing of small blocks of lands for three to five years from human impact and grazing by domestic cattle, will have very positive impact on forest succession and healthy growth of grasses in overgrazed areas. Once tall saplings are naturally established, the forest will flourish on its own. The protection may be shifted to other unprotected areas after the three to five year period. The forest lands thus protected may be named “Regeneration Blocks”. The vegetational succession in such blocks to be monitored and recorded, preferably by local volunteers. Seeds of suitable tree and shrub species may be disseminated in such areas to promote diversity.
- Application of GIS on wildlife distribution within ADTR is critical. Distribution data, to begin with, should cover primary and secondary reports on tigers, panthers and major herbivorous mammals. From existing and freshly collected data bird distribution details

can be prepared as well. Birds are also good indicators of habitat quality. From distribution maps thus prepared, areas of importance for tigers and their prey may be demarcated. This would help in understanding ecosystem processes for preparing guidelines of future management of the Reserve. As it is difficult to get exact details of the very few tigers reported from the ADTR, it is very important to track their associate species and use them as proxy for demarcating likely tiger preference habitats within the Reserve.

- **Grassland management -** It is necessary to maintain different kinds of grasslands within the Reserve as some grazing wild animals prefer short grass areas while others prefer tall grass areas. Mixed savanna-grasslands are favourites of yet others.
- **Controlled use of fire:** ADTR receives high to moderate rainfall and the natural climax vegetation here is forest. Gradual vegetational succession in grasslands towards forest would effectively reduce carrying capacity for grazing animals and thereby affect prey supply for the carnivores. Therefore maintenance and management of grasslands would play a crucial role in sustaining wild fauna. Fire has been an important tool in grassland management in the humid Western Ghat regions. In the grasslands fire burns down the harsh, fibrous old bases and promotes a flush of new growth of fodder grasses. As it is time consuming and expensive to manage the large areas and keep the ecosystems in a dynamic stage to sustain maximum of the tiger population, with the available staff of the Forest Department, trained volunteers, NGOs and wildlife enthusiasts may be used in grassland management with regulated use of fire according to specifically prepared, site-centred management plans. Fire is to be used with caution as repeated fires can dry out a habitat, cause soil erosion and destroy many sensitive species.
- Many tree species of food importance for herbivore prey animals of the tiger are associated with burnt savannas. These include *Acacia* spp., *Bombax ceiba, Careya arborea, Cordia* spp., *Dillenia pentagyna, Kydia calycina, Phyllanthus emblica* etc.
- **G**rassland within the Reserve, including fallow fields, should not be used for tree planting under normal conditions. The practice of raising block plantations in such grassy blanks is to be altogether dispensed with. Block plantations, and that too of fodder tree species and those trees that provide food for wildlife can be considered in rocky areas with scanty growth of grasses and other herbs. Providing designed corridors (using area specific trees and other life forms) for animal migration through such areas would be a good exercise for keeping the integrity of the ADTR by keeping the ecosystem processes alive.
- **Remove monoculture plantations -** Ever-since commercial forestry began in the ADTR region, over one hundred years ago, during the British period, raising of teak plantations became an accepted practice, almost in every block of forest, after clear-felling the natural tree growth. Teak plantations in general are low diversity areas, with scanty undergrowth of grass. The plantations are drier places than the natural forests, often subjected to soil erosion and ground fires. Despite the fact teak timber fetches fabulous market prices, there has been a moratorium on tree felling within the ADTR. With the objective of increasing the prey population of tigers, the food resources have to

be increased. Without in anyway tampering with good teak plantations, the others can be subjected to enrichment planting with various fruit and fodder species, mainly the trees.

- **Adopting landscape level approach:** In small and isolated protected areas the chances for long term survival of megafauna are slim, unless they are linked by natural habitat corridors to permit dispersal of tigers and their prey and are provided with buffer zones to minimize impacts from other land uses. Therefore landscape level approach is essential for tiger conservation, which requires Evaluation of habitat quality in different parts of the ADTR with their suitability for wildlife in general and tiger in particular needs to be carried out. In such evaluation grassland quality and connectivity with different other landscape elements are important. Management plans have to be prepared to upgrade landscape elements, particularly poor quality grasslands.
- Tiger in India is a symbol of pride, power and strength. In Indian tradition it is both feared and respected animal and treated at par with the lion. In the local cultures associated with the wooded highlands tiger has been a worshipped animal. This holds good for the hilly terrain of Karnataka as well. In the Uttara Kannada district most villages and even towns have icons of tigers or *Hulidevaru* inside sacred forests, under sacred trees or in recently constructed small shrines. Tiger is famed as the *vahana* of the goddess Kali/Durga and Lord Aiyappa. Such incredible sentimental attachment among the public towards this magnificent animal needs to be appropriately utilized for gaining public support for tiger conservation in ADTR. Such support has to come from not only from outside but more so from the people living within the ADTR and its peripheral villages. Volunteers from among the youth, especially from these villages have to be enlisted to work for activities related to tiger conservation, and to develop a positive attitude among the local population. As the too few staff of the Forest Department are insufficient to manage and maintain the ADTR, especially in fire control, regulated use of fire, in grassland maintenance, tree planting, nursery activities, awareness creation, as local guides etc. it will be ideal to have a core group of such volunteers to assist the Department. If trained in bird watching, plant identification, and in disseminating wildlife related information to the visitors, ADTR can gain much from this reposition of confidence in the local population.
- Pulses are leguminous herbs and climbers the seeds of a great variety of which have been used as protein rich food by humans from ancient times. Not only are the seeds rich in proteins but the forage also is rich in proteins, mainly because of the association of the roots of these plants with nitrogen fixing bacteria. The very growth of the legumes enriches soils with nitrogen and they are ideal for reclaiming impoverished soils. Dispersing the seeds of relatively low cost pulses selectively, especially along roadsides, as well as raising them in small protected patches, and in canopy gaps of plantations, underneath power lines etc., in due course can increase the stock of these useful plants, as wildlings in the ADTR. The plants will provide excellent forage for many herbivores which constitute the prey stock of tigers.

Conservation and Management Guidelines for Amphibians at ADTR: Conservation and management needs for Amphibians of the Western Ghats are discussed in length over the years. There is a need for guidelines on these issues, especially for the forest managers, who in fact have more access and accountability of the protected areas. This part of the document deals with conservation management guidelines, keeping amphibians as focal organism. Anthropogenic changes in land-use like habitat alteration, fragmentation and forest loss are considered to be the primary challenge in the conservation of amphibians. Human populations are ever expanding, needing more and more land for various activities at local scale leading to alteration, fragmentation and loss of pristine forest habitats. This is considered to be the primary issue for the decline of amphibian populations worldwide. A proactive approach for minimizing the impact of such activities and to improve upon existing habitat is the key for conservation of amphibians. These guidelines are not regulations, nor to limit or curtail the activities of forest officials.

Landscape approach based on hydrological regime of ADTR will help long term conservation and management of the amphibians. Anuran amphibians of ADTR use streams, wetlands, and forest habitats in a very complex manner for breeding, feeding and resting. In addition, majority of amphibians are highly seasonal, having their breeding span spread only in the rainy period. This calls for a better understanding of natural history of these animals, their seasonal movement between habitats, and the natural dynamics of the habitats themselves, which are quintessential in landscape based conservation effort. For amphibians, water bodies (lentic or lotic) play major role in breeding, egg laying (spawning), tadpole development and foraging, hiding place from predators and thermoregulations, whereas terrestrial habitats help in foraging, movement (dispersal), resting place and escape from floods. The following guidelines are suggested within ADTR for maintenance and enhancing habitat quality.

- Limit motorized vehicle transit within the ADTR during rainy seasons, specifically during monsoon. Amphibians are generally active during night and more so during rainy seasons when they breed. Limiting the motorized vehicle within ADTR, either in numbers or in speed would certainly decrease the number of road kills of amphibians in ADTR.
- Maintain native vegetation where ever possible (e.g., near Patoli cross, there is native evergreen patch, maintain this patch as it is) and where it is absent, restore native vegetation both in structure and composition. As far as possible avoid introducing/planting exotic species, if management regime permits, remove them and replace plantation of exotic species with native plant species. This is more pertinent to defunct mining areas, which are now planted with *Acacia*. It could have been better, if native tree species were planted here.
- Protect from expansion of roads, agriculture fields and any other developmental activity. These activities are disruptive to amphibians and they generally fragment, degrade and reduce habitats of amphibians.
- Amphibians are very much dependent on natural hydrology of an area, hence, maintain and restore natural hydrology. This allows natural evolution of stream dynamics and associated vegetation. Natural flood cycles are important for maintaining amphibian population as also their prey and predator populations too.

- There are agriculture fields within ADTR, hence there must a monitoring on the usage of fertilizers, herbicides and pesticides, which are proved to be detrimental amphibian population.
- Provide conservation related education MATERIALS to farmers, campers, hikers and people who frequent ADTR. Batracharium is one such area, where people can watch exclusive for frogs (detailed in Part I). Educating and creating awareness about amphibians among school children who are residing inside and nearby areas (Dandeli, Kulgi, Anshi, Joida, Ambikanagar etc), which can also be extended to all people in and around ADTR.
- Grass lands and defunct mining areas needs special attention and continued monitoring for amphibian diversity.
- Research on anuran amphibians over a long time period, with a proper objective, highlighting hydrology related issues must be supported and continued in future.

1.1.5 ROADSIDE VEGETATION

The district has 3645 km length of roads, which include National Highways, State highways and major district roads. Assuming that 50% of the total road length is available for planting, we may practically have 3645 km of roadsides for tree planting. By aiming to raise one NTP cum nectar producing tree, suitable for honey bee forage, at every 20 m length of roadside, we can altogether raise 182,250 trees. At the rate of 2 kgs of honey production per tree if the potential of these trees is fully used through bee keeping we may aim to collect altogether 364,500 kgs of honey/year worth Rs. 72,900,000. The selection of trees may be made in such manner so that along with honey the selected trees also yield other useful products. Few examples are shown in the table 1.3.

Table 1.3: Species recommended for roadside planting

Tree	Zone	Honey	Other products
Antawala (*Sapindus lauiolius*)	All	Early honey of the year; highly priced	Fruit medicinal; dye from seeds
Nerale (*Syzygium cumini*)	Moist roadsides-all zones	Major honey producer; amber coloured	Edible fruits; for preserves, squashes, jellies; for vinegar; seeds as fodder; plant parts medicinal
Tari (*Terminalia bellirica*)	Coast and malnadu	Good source of honey	Seeds medicinal
Amli, Huli (*Tamarindus indica*)	Maidan	Rich source of golden coloured honey	Fruit for food preparation; tartaric acid, tamarind concentrate, medicine; seed for sizing powder for textiles; leaves for medicine
Mavu; mango (*Mangifera indica*)	All zones	Good source of honey	Edible fruits
Xanthoxylum rhetsa	Roads through coastal laterite	Good source of honey	Fruit as spice

1.1.6 COASTAL LATERITE PLATEAUS AS 'CONSERVATION RESERVES'

Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected. Conservation Reserves can be declared by the State Governments in any area owned by the Government. Particularly stressed are areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with local communities.

Low altitude (<100 m) flat topped laterite hills and plateaus abutting part of Central Western Ghats, in the coastal district of Uttara Kannada in Karnataka, are often considered a harsh, infertile and barren terrain covered with mostly scrub or isolated clumps of bushes with hardy, dwarfish trees. All the while ignored was the rich seasonal life of rare herbal flora during the June to September period, when these plateaus on account of torrential rains turn into a network of seasonal pools and streams and meadows interspersed with exposed and darkened protrusions of laterite covered with slimy algae. The seasonal laterite wetlands and meadows, seldom ever studied, where surveyed from floristic and ecological angles during the rainy season of 2012. The infertility of the substratum is reflected in the predominance among the herbs of the insectivorous *Utricularia* spp. and to lesser extent *Drosera indica* and *D. burmanii.* Partial parasitic Scrophulariaceae herbs like *Ramphicarpa longiflora, Striga lutea, S. gesneroides, Sopubia delphinifolia* etc. also indicate the prevailing nutrient stress situation. The laterite expanses are notable for several endemic herbs such as *Eriocaulon fysonii, E. lanceolatum*, *E. cuspidatum, Rotala malampuzhensis*, rare grasses like *Danthonidium gammiei* and threatened endemic hydrophyte *Wisneria triandra,* and more such interesting species. Whereas pockets of soils amidst rocks have perennating tuberous herbs like *Ceropegia* spp., *Euphorbia fusiformis, Curculigo orchioides, Theriophonum dalzelli, Ophioglossum* spp. etc. hardy perennial herbs like *Lepidagathis prostrate* persist alive on eroded and porous boulders.

We propose two lateritic plateaus of coastal Uttara Kannada viz. 1).Bhatkal plateau in Bhatkal taluk and 2). Mugali plateau in Honavar taluk under the conservation category called **Conservation Reserves** under the provisions created by the Ministry of Environment and Forests. Details of the two plateaus are:

1. **Bhatkal laterite plateau:** The plateau proposed for Conservation Reserve covers part of Bhatkal forest beat and part of Kotkhanda forest beat in the Bhatkal range of Honavar Forest Division. The proposed plateau covers about 425 ha of area within lat.13.99915° -14.02062° N and long. 74.55929°-74.59044°E. The detailed study of the flora was carried out and the plateau can be considered one of the richest lateritic floristic provinces of Uttara Kannada, and hence worth of its conservation for the sake of ecology, biodiversity and posterity.
2. **Mugali laterite plateau:** The plateau proposed is also in Honavar Forest Division. It covers area of about 300 ha in the coastal villages of Mugali, Kelaginoor and

Apsarakonda villages. The proposed plateau is part of a much larger one and is situated between lat. 14.1977°-14.2437°N and long 74.4406°E-74.4806°E.

Both the proposed areas are, admittedly, not adjacent to National Parks and Sanctuaries, nor they link one PA with another. Yet they have very important reasons to be considered as such reserves for the following reasons:

- These Conservation Reserves are going to be, perhaps the first in the world, exclusively for lateritic ecosystems
- Laterite is a unique type of tropical sedimentary rock (basalt derived laterite of Maharashtra mountain tops excluded from its purview).
- Western Ghats constitute a global biodiversity hotspot, and several sites have been recently declared by UNESCO as World Heritage Sites. Unfortunately there has been never an effort to recognize the rare herbal vegetation of coastal laterite plateaus and hills, which have a good proportion of rare and endemic herbs.
- Rare animals like Pangolin and Monitor lizard can be conserved ideally in such reserves
- The laterite formations are aesthetically pleasing, and particularly so with the massive flowering of rainy season herbs. The terrain is ideal for tourism and scientific studies
- UNESCO Criterion 9 or declaration of a place as Heritage Site pertains to "**outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features".** The coastal laterite formation is a testimony to India's separation from Madagascar almost 90 million years ago, and the erosion that happened through several million years of the primeval Western Ghats, and deposition of such eroded materials along the coastline, which originally belonged to the Tethys Sea, before the Arabian Sea came into existence.
- The seasonal herbs constitute the main foraging sources for honey bees and various other pollinators during the peak of rainy season, when there is absolute scarcity of any feed for them. Hence such plants may be considered as 'keystone resources'.
- Moreover the declaration of Conservation Reserves is not going to affect the rights of the people living in the area. On the other hand community participation in management can earn revenue for them, especially from tourism
- The State Government can declare the Conservation Reserves.

1.17 STATE OF DOMESTICATED/SEMI-DOMESTICATED SPECIES/VARIETIES

Uttara Kannada has various ecological zones in the district and the cultivated diversity is different in each of these ecological zones. Uttara Kannada is somewhat representative of the state of Karnataka having the humid coastal region and the *Malenadu* or the hill region, and the drier eastern plains with rolling hills merging with the semi-arid to arid Deccan Plateau. These three regions are three different agro-climatic zones and account for the tremendous domesticated diversity of the district.

i. *Coastal region:* The coastal region where saline water intrusion is present with mangrove ecosystems is unique. In this region sustainable traditional prawn cultivation is done. In addition to this the farmers grow saline resistant paddy varieties known as *' Kagga'* Similarly the coastal Kumta town is well known for its coconuts. This is a special variety with aroma and taste.

ii. *Foot hills of Western Ghats:* The foothills in Bhatkal taluka are well known for cultivation of scented paddy variety. Similarly Yana village in Kumta region is well known for good quality of coconuts with good yield and size. The foothills are also the resource base of NTFP collectors.

iii. *Crestline region:* This region mainly consists of Sirsi, Siddapur and Yellapur taluks. While the evergreen forest belt of this region is rich in wild biodiversity, the small narrow valleys are cultivated by farmers with arecanut, spices and paddy. The cardamom, pepper, areca, nutmegs and cocoa are the crops of the spice gardens.

iv. *Edge of ghats and plains:* The eastern parts of the district on the edge of Western Ghats are unique for horticultural crops and rained paddy varieties. In horticultural crops, the Pala region is a famous for growing mangoes.

v. *Riverine forests:* The forests on the banks of the small streams/ rivers in the district produce a unique ecosystem with diverse plant spices. The special wild mango varieties used for pickles known as *appemidi* is found in this belt.

vi. *Livestock*: Livestock is an integral part of the agricultural system in the region. Farmers keep cattle for ploughing and to meet the demand of milk. The local *Malenad Gidda* varieties of oxen and cow are the indigenous stock of the region. In recent years the cross breeding with the jersey stock has resulted in evolution of a cross bred stock that is used as draught as well as for milk. The farmers also keep goat and poultry. The local varieties are popular in the region. The Gawli tribes are specialised in rearing the buffalo which is popularly known as 'Gawli Buffallo.' Very little is done on the indigenous poultry of the district.

vii. *Honey bees:* Bee keeping is one of the important components of cultivated diversity. Bees play major role in conservation of biodiversity through pollination of crops, especially horticultural crops such as areca, mango, guava etc. There are three major species of honeybees in Uttara Kannada, namely the Rock bee (*Apis dorsata*), Indian bee (*Apis cerana indica*) and sting less bees (*Apis florea*)

viii. Paddy, legumes and sugarcane are important agricultural crops of the district. There are traditional varieties as well as modern HYV (High Yielding Varieties) in each of these crops, which are adopted by the farmers. The diversity within each of these crops and several others is quite high though most of it is yet to be surveyed systematically. Despite small area under rice the local varieties grown are many, despite our incomplete documentation, as shown in Table 1.4

Numerous horticultural crops are important in the economy of the region. The spice gardens in the narrow valleys in the Ghats have played key role through ages in the prosperity of the district. The pepper varieties known to be cultivated in the district during the past and present times are *Dadiga, Giddakare, Kudrugutta*, Mallisara*, Tirpagare*, Waddakare.** The decline of the traditional varieties due to disease has made farmers resort to growing of hybrid pepper. The evergreen-semievergreen forests are rich in different species of wild pepper; although over the years, due to neglect and unplanned exploitation it is difficult to sight good yielding pepper in the wild. Banana is widely cultivated in the district. the notable varieties are *Boodibale, Chipsbale, Currybale(Anbale) Karibale, Mitka, Mysore mitka, Nenibale, Rasabale, Pachebale, Sakkarebale.* Some exotics and hybrids are also grown in the district. Over the last ten years also, mainly due to the "Bunchy-top disease" the bananas are on the decline.

Table 1.4: The traditional rice varieties of Uttara Kannada

Ajaga	Kannuru	Dasapatte	Rangoona
Arya	Karabele	Doddapandya	Ratnachooda
Aryahalaga	Karibatta	Gowri	Sannabatta
Aryakempi	Karichitka	Halaga	Sannamalaga
Banka	Koondooru	Halagempi	Sannamullarya
Bantavala	Kumbharjaddu	Hurutaga	Sannapandya
Bilibatta	Masakaai	Jaddikempi	Shetgi
Biliekka	Mottahalaga	Jadduhalaga, Jattu	Siddasali
Bilikabagga	Mugenbelaga	Kagga (both black and	Sundari
Chitka	Mullare	yellow husked)	Tebbal
Dasala	Pandya	Kanchutti Dasapatte	Theppadarya

Arecanut is a major crop in the district, being cultivated in nearly 10,000 ha. As paddy cultivation today is nearly unprofitable many farmers have taken to arecanut. As arecanut needs more water there has been, of late, a wave of encroachment into the forests, along the streamsides, to raise small-scale areca gardens, causing further decline and endangerment of the already threatened Myristica swamps and decline of the climax streamside vegetation. Watershed value of stream catchments are negatively affected too. The diversity of fruit trees in the region is high. They can be found in domesticated and wild ecosystems. Mention may be made of the wild *'appemidi' mango* variety, which is favourite for pickling. Similarly the jack fruit varieties are also many in the district. There are numerous varieties of wild fruits that are used by forest dwellers and children. These include wild mangoes, kokum, *uppage* jackfruits, jujube, black berries (*neerilu*), gooseberries etc. These are on the decline due to the decrease in forest diversity.

The Western Ghats has divided the district in to coastal, hilly, and north transition agro-climatic zone. Due to varied zones in the Uttara Kannada it has rich biodiversity. Apart for biodiversity other natural resource are also rich. This has attracted many players like hydle power stations, a nuclear power station, mining industries, paper industries are exploiting the natural resources and further disturbing the delicately balancing nature. The studies indicate that, in further if disturbance is avoided the evergreen species which are endemic to the region and which had depleted can come back increasing the richness in biodiversity. Every decision taken has to keep nature and the consequences of unnatural act.

1.2.0 ESTUARINE ECOLOGY

Tropical estuaries are very productive ecosystems. In Uttara Kannada important estuaries are of the rivers Kali, Gangavali, Aghanashini, Sharavathi and Venktapur.. Due to their high productivity estuarine villages and coastal towns closer to them such as Karwar, Ankola, Gokarna, Kumta, Honavar and Bhatkal are densely populated. Because of high diversity and productivity of fishes, prawns, clams and oysters, crabs etc. thousands of fishing families depended on estuaries for their livelihood. Shallow parts of estuarine areas were converted into *gazni* rice fields, coconut groves and human settlements. Estuaries play important roles as egg laying places and nurseries for many marine fishes. They also shelter, altogether over 120 species of birds due to the abundance of food and the shelter which the mangroves gave.

Recommendations

- As estuaries are used by many marine fishes most of which have narrow tolerances for physical and chemical conditions, drastic alterations in such conditions due to human interventions will have adverse consequences on fisheries. As is evident from Sharavathi and Kali estuaries, both of which are adversely affected in biodiversity and productivity due to hydroelectric projects, in future it is very necessary for protecting all the remaining estuaries from major developmental interventions so as to protect biodiversity, ecology and local livelihoods.
- As estuaries make one of the finest nurseries and breeding grounds for a number of commercially as well as ecologically important species of fish, prawn and other organisms, and as the life cycle of many marine fishes contains a stage in which the young ones of the species are concentrated in a specific area or nursery ground in the estuary, such areas, especially mangroves and mudflats need to be safeguarded carefully
- Estuarine ecological changes in coastal Karnataka are so rapid that many estuarine functions such as storing and recycling of nutrients, trapping of sediments are getting affected due to human interventions. Their capacities as detoxifiers of pollutants should not be challenged any further. We recommend that the future plantings should be more mixed using all the locally available species, in the interest of healthier estuarine ecosystems.
- Proposals for 'Biodiversity Heritage Sites' in accordance with the provisions of the Biodiversity Act, 2012 for Kali and Aghanashini estuaries are pending with the Biodiversity Board of Karnataka. The constitution of such heritage sites should be expedited through completion of due formalities required.
- Mangroves are known to produce good quality honey with high market demand. Mangrove planting should be also aimed at production of honey to raise supplementary income for the estuarine villagers.

1.2.1 ESTUARIES AND MANGROVES

Estuaries are meeting places of rivers with the sea. Here salt water and fresh water mix together and create unique environments with high biodiversity. The tropical estuaries, such as the estuaries of Karnataka, are basically highly productive ecosystems. Most of the coastal towns and densely populated villages are alongside estuaries. This is because of high food and water security and also due to availability of resources from land, estuary and the sea. Goods and services available are taken as free gifts from nature and very little efforts are made to conserve them or sustainably use the resources.

Our studies show that when major developmental projects affecting estuaries are implemented no concern was shown for protection of estuarine environment. When hydro-electric projects were implemented, when intensive shrimp farming activities were implemented through aquaculture farms, when shell mining permissions are given very little concern was shown for estuarine ecology, and people's livelihoods.

- ***Restoration of abandoned/unused prawn farms/gajnis**:* The Government may consider converting suitable parts of private, unused or abandoned prawn farms/*gajni* fields into mangrove areas through the involvement of the Forest Department/local Self Help Groups/Village Forest Committees so as to increase production of fish, prawns and crabs, in the natural way, and fodder from marsh grasses, apart from facilitating breeding of these organisms. Such steps will also improve nutrient flow in the estuaries and marine areas. Restoration will create healthy, functioning natural coastal ecosystems. The farmers can continue to hold fishing rights through the involvement of local fishermen, if necessary, eliminating contract system.
- ***Safeguarding fishery based employment**:* The four estuaries studied, altogether, constitute a very important employment sector, accounting for about 2,092,000 fishing days/year, benefiting altogether an estimated 3,086 families of estuarine fishermen, earning for them an income of Rs.66.55 crores annually. The four estuaries, together have 7,549 ha area, excluding the private fish/prawn farms and *gajni* rice field cum fishing areas. This works out to the fact that every hectare of estuarine area generates 277 days of fishing work per year and earns an income of Rs.88,157/- ha/year. This is all the more significant that so much of income is without any input from humans except on fishing efforts through human energy alone, as mechanized fishing is not practiced in the estuaries of the district.
- ***Income from edible bivalves (clams and oysters):*** The production of clams and oysters, widely used as food in coastal areas, has been the subject of another report. This is an informal sector of non-specialized fisheries, engaged in also by good number of women and children. When a detailed study was carried out in Aghanashini estuary it came to the light that about 22,000 tons of bivalves were collected in the year 2008-09. About 1738 males and 609 females were engaged in bivalve collection. Many women are involved in sorting of bivalves for sale in outside market. The local sales, including house to house sales are exclusively by women. With the current market value of Rs.30,000/- ton, at Rs.30/- kg. total pricing of the

output is estimated at Rs.66 crores annually. Considering the fact so much of produce comes from less than 250 ha of clam beds in Aghanashini, highlights that the annual productivity of one hectare of bivalve bed could be around 88 tons, worth Rs.26.4 lakh at current market prices. As the market value of bivalves, which was known as poor man's food, is steadily rising due to exports to distant markets, the collection is feared to be on a non-sustainable scale. The production of this magnitude is astounding, yet not improbable, as James et al., way back in 1972, had estimated production of 10 kg of clams/sq.m in stretches of estuaries up to one mile from the bar mouth and half that quantity up to 6 miles interior in some of the Dakshina Kannada estuaries. This works out to 100 tons of clams/ha nearer to the estuary mouth in Dakshina Kannada, supporting our estimate of 88 tons/ha especially towards estuary mouth of Aghanashini, and lesser quantities more interior. An estuarine clam collector in the Ashtamudi backwaters of Kerala was estimated to collect approximately 40-50 kg of clams within 3 to 4 hours of collection time per day, way back in 1980's (Appukuttan et al., 1985), which would have been worth at least Rs.1200 to Rs.1500/day if the resource remained to this day!

- ***Bivalve fishery crossing sustainable limits:*** Until some years ago bivalves were very cheap and abundantly available. According to James *et al*., (1972) the price of clams was 20 paise to 50 paise for hundred in Kundapur. As demand was more local the exploitation was limited to 500 to 1200 kg per day. Similar conditions prevailed in Uttara Kannada also. The situation changed drastically today as in Uttara Kannada bulk of the product is being sent to Goa and to other far away markets for higher prices. The clams are sold today in coastal Uttara Kannada markets for Rs.40-60 per hundred and in Goa for Rs.100 for the same number of clams. The exploitation is happening on a big commercial scale without adhering to any norms. This stresses the need for integrated, participatory ecosystem management of estuaries for judicious use of this great food resource.
- ***Reducing pressure on estuarine fishery***: Fish fauna was abundant some decades ago when fishing efforts were minimal and prices very low. Marine fishing had reached peak in 1980's all over Karnataka coast, when estuarine fish catch was within sustainable limits, as most of the fishing gear was directed towards marine fishing. According to James *et al*., (1972), in the peak estuarine fishing season in the then South Kanara district 400-600 kg of fish was caught from any estuary within two mile distance from the river mouth. The catch was obviously could have been lower to availability levels, as prices were very low ranging between 50 paise to one rupee per kg. Uttara Kannada situation was not much different then. Today the demand for estuarine fish has escalated as the demand is also from far and wide, and the prices have shot up ranging from minimum of Rs.120/- kg to about Rs.600/- kg. Fishing pressure is very high, so much so, estuarine capture fishery (of fin fishes, prawns and crabs) is passing through a critical phase. All the estuaries surveyed are being overfished, as evident from average fishing days/ha. There is not much scope currently to improve fisheries in the dam affected Sharavathi and Kali estuaries. Percentage of fishermen dependent on estuary partially or fully in Aghanashini and

Gangavali, unaffected by dams (marine fishermen of non-estuarine village of Belamber excluded from Gangavali estimate) were 71% and 59% respectively. In dam affected Kali and Sharavathi 57% and 21%, respectively, of fishermen from estuarine families fished in estuaries. The estuarine area available/ head for fishing was 0.56 ha in Gangavali and 0.46 ha in Aghanashini (both without hydel projects), 1.58 ha in Kali and a whopping 4.72 ha in Sharavathi (both impacted by hydel projects).

- ***One hectare water for a fisherman:*** Whereas small-scale cage culturing may be promoted in Kali and Sharavathi backwaters to improve fishing community livelihoods it is desirable to reduce fishing pressure in Aghanashini and Gangavali so as to ensure at least one ha of fishing waters/fisherman that could yield, on a simplistic calculation, approximately Rs.195,000/fisherman/year in Gangavali and Rs.154,000/fisherman/year in Aghanashini, from the current levels of Rs.109,265 from 0.56 ha in Gangavali and Rs.70,870 from 0.46 in Aghanashini.
- ***Enriching estuarine vegetation to aid fish breeding and protection of nursereis:*** Specific areas within the estuaries, especially marshes with vegetation and mangrove areas support much greater densities of organisms, mainly as nurseries, than unvegetated parts (Minello, 1999; Beck *et al*., 2001). Generally an area has been termed as "nursery" if it supports juvenile fish or invertebrates in higher densities, provides greater protection from predators, or grows faster than in other habitats (Beck *et al*., 2001). Identification of fish nurseries within estuaries, where young ones grow faster and in greater numbers than in other areas, is a task to be achieved expeditiously, for future protection through involvement of village communities.
- ***Self-help groups of bivalve collectors:*** Village-wise self-help groups, constituted through local environmental NGO groups, may be organized for evaluation and better sustainability of the resource.
- ***Bivalve collection holidays:*** A concept of two days per week of bivalve collection holidays may be enforced through SHGs' for voluntary acceptance. NGOs have to play key role in this.
- ***People as integral part of estuarine ecosystems:*** Modern concepts of ecosystem management try to consider people as parts of ecosystems. Estuaries of Uttara Kannada were reasonably well protected through generations by traditional communities, despite interventions for livelihoods, almost until late 1960's. The estuarine farmers grew salt tolerant rice in reclaimed portions, the *gajnis*, protected by earthen bunds and strengthened by growing mangroves alongside. Fishing was mainly by fisher-folks, even within *gajnis*. The catches were within sustainable limits as there was not much trade in it beyond the district's limits. Shell collection was mainly for lime making locally. Salt was prepared only in designated areas. Sand mining was in limited quantities to cater mostly for local needs. The situation changed when the Government built permanent embankments for *gajnis* replacing the traditional earthen ones. Mangrove destruction became widespread as they were not needed for strengthening bunds and to meet growing fuel demands. Farmers started auctioning to contractors fishing rights within *gajnis*, which turned out to be virtual shallow dams

for storing estuarine water after harvest of paddy, because of building of permanent bunds. Thus the role of fishermen in catching fish for livelihoods in the *gajnis*, a traditional practice through ages, was replaced with contract system. The fishing pressure thereafter is expected to have intensified in the open water areas of the estuary. The proliferation of ice factories and intensive prawn farming systems destroyed traditional community based management leading to exhaustive catches of fish in markets expanding beyond the district. Considering this background seriously we recommend awareness creation, and people's involvement in fishery management and declaration of parts of estuarine portions rich in mangroves and marsh vegetation as fish nurseries, to be protected through local fishing community involvement.

- **Need for integrative management:** Estuary is a multi-stake-holder based complex ecosystem and a hub of human activities like traditional fishing, edible bivalve harvesting, modern prawns and fish farming systems, cultivation of salt tolerant rice in *gajni* fields, sand mining, shell mining, water transport, salt making, port activities, tourism *etc*. all activities simultaneously going on. The Central Government has made Coastal Regulation Zone Notification applicable to the estuaries. Of the State departments concerned with estuaries in Karnataka are Public Works, Ports and Inland Water Transport, Forests (as regards mangrove afforestation and protection), Agriculture, Fisheries, Brackish Water Fisheries, MPEDA, Mines and Geology etc. Lack of co-ordination among these departments and conflicts with traditional, community based management systems have caused the collapse of the latter, which were more informal. Therefore to safeguard and sustainably use estuarine systems integrated, participatory management is immediate necessity. The Government should evolve an estuarine management policy for safeguarding and restoring integrity of these ecosystems so as to ensure continuity of ecosystem services and the tremendous livelihood support they provide, with practically very little inputs from humans. We need to ensure that estuarine ecosystems are unharmed so that such services are passed on undiminished to future generations as well. Our studies reveal that Sharavathi has nearly lost its estuarine nature and Kali is in the mid-course to its denigration due to upstream hydroelectric projects.
- ***Estuary management to be ecosystem based:*** The present management of estuaries, of which fisheries constitute a vital part, as already explained, is by multiple agencies without any co-ordination, disjointed and disoriented, keeping away the local people, thereby causing enormous harm to the estuarine health and productivity. Therefore, we wish to impress upon the State about evolving ecosystem-based management plans through people's involvement, to be implemented by a single agency. The major issues of such a management plan should be:
    i. Define the physical and functional domain of any estuary through scientific studies.
    ii. Identifying the key components of the given estuary, which need to be considered for upkeep or restoration of estuarine integrity. These components may be physical (salinity, bathymetry, tidal regimes, soils and hydrology)

biological, social (stakeholder analysis), natural resource estimate based while taking into account harvesting pressures.

iii. Analysis of estuarine potential for rendering ecosystem services and livelihood security, threats.

iv. Preparation of estuary-wise management plans through research, with specifically define management objectives encompassing hydrology, restoration of ecosystem, pollution control, identification and containment of threats, zoning for human uses (fishing, fish conservation and protection of breeding areas, bivalve collection, sand and shell mining, salt production, aquaculture, mangrove and bird conservation, ecotourism etc.) under principles of sustainability through people's participation.

v. Ongoing monitoring mechanism through research for measuring successes and failures, and estimating progress achieved in fulfilling management objectives.

vi. Monitoring agency should be able to set norms for extraction of estuarine goods fixing the quotas to be harvested/gathered based on sustainable outputs and should come out with periodical progress reports.

vii. Involvement of stakeholders is a necessity in designing management plan.

- ***Biodiversity Heritage Sites in estuaries:*** Using the provision of Biodiversity Act-2002, suitable areas within each estuary need to be declared as Biodiversity Heritage Sites, under local panchayat management, through specially constituted Biodiversity Management Committees as per the Act. We have already submitted a separate report depicting the most important mud flats close to Aghanashini village, known for prolific production of edible bivalves and a small island, surrounded by rich mangroves, in mid estuary as Aghanashini Biodiversity Heritage Site. A similar report was prepared and submitted by Dr.V.N. Nayak for portions of Kali estuary to be declared as Heritage Site. Such Heritage Sites are bound to be buffers against the strong exploitative forces operating today in the estuarine ecosystems. We urge that as the declaration of Heritage sites in estuaries will further the cause of fish breeding and enhancement of harvestable fish, such measures may be taken expeditiously after due consultations with local panchayats.

- ***Protecting estuaries from destructive developmental interventions:*** Estuaries are centres of biodiversity, especially supporting rich fisheries. Even several marine fish species are dependent on them for spawning and nursery purposes. At the same time they are constantly under threat of developmental projects, such as dams in upstream areas and industrial interventions. A good portion of Aghanashini estuarine fields were acquired from local farmers and given to an industry – BILT at Binaga in Karwar, in 1970's, for conversion into salt pans. Subsequently the industry abandoned this plan and returned the areas (1815 acres) to Government after conversion of part of the lands into salt pans, at the cost of ecology and fisheries, and depriving local farmers of their estuarine rice fields, as salt production was found to be uneconomic. Thereafter the same estuarine portion was considered for starting a coal-based ultra-mega thermal plant, a plan that was also abandoned under public pressure and reports of adverse environmental impacts. Any conversion of fishery and mangrove rich estuaries, which are also known for their bird fauna, into industrial hubs will be most unimaginative use of such vital places which provide sustenance to thousands of families. Considering the ecosystem collapse of Sharavathi estuary and impoverishment of Kali estuary, compelling scores of dependent people, particularly fishermen, to look for alternative employment, it is strongly recommended not to utilize estuarine areas, most of which fall within the domain of CRZ-I, for detrimental developmental interventions challenging the functional integrity of these unique ecosystems.

- **Sand mining associated problems:** Sand mining is rampantly happening in all the estuaries of Uttara Kannada. Increased demand for sand from far and wide, coupled with widespread unemployment in fishermen community along the estuarine villages, the resultant of overfishing and fishery collapse due to hydro-electric projects, have attracted many fishermen, having skills in boating and maneuvering in water to work with sand mining contractors and sand traders. This constitutes a well-organized work force in the coastal taluks, who along with main operators try to thwart any attempts to bring controls on sand mining. Whereas periodical sand removal might be necessary to clear the accumulated erosion from land, as a natural process, the present sand policies are being implemented without ascertaining sustainable extraction limits. Environmental problems occur when the rate of extraction of sand exceeds the rate at which natural processes generate these materials. Sand mining licenses are given on administrative terms without any consideration of ecosystem that is affected. Unrestrained sand removal can destroy the estuaries and therefore estuarine fishery and to some extent marine fishery on following counts:

  i. Estuarine bottom getting deepened causing subsidence of banks
  ii. Habitats of bottom-dwelling fishes, fish nurseries and of other benthic organisms like bivalves and crustaceans are destroyed through siltation. It is reported that intensive sand mining in the Chapora River at Kolvale, Goa, for the last three decades, has eliminated the edible black clam (Times of India, Goa, 17-2-2011).
  iii. As total load of suspended particles, which are too small to settle down, increases, light penetration is bound to be affected thereby affecting the photosynthetic phytoplankton and zooplankton which constitute foundation for food chains.
  iv. No studies are carried out yet in Uttara Kannada on radiation hazards to biological systems and humans because of sand mining.
  v. Adverse effect on ground water systems
  vi. Adverse impacts on fishery and fish breeding from oil slicks from boats and noise pollution

vii. Filter feeders like bivalves get clogged with siltation and death takes places in masses.

Recommendations on sand mining

i. Estimate annual sand deposit patterns in the estuarine areas
ii. Limit sand mining operations strictly to areas which have highest deposits and least impacts on physical and biological characters of estuaries
iii. Limit sand mining to sustainable limits (matching deposit and extraction)
iv. Movement of extracted sand for local uses should be limited to within the coastal zone of Uttara Kannada only (from Karwar to Bhatkal).
v. The Biodiversity Management Committees of local panchayats and the Village Forest Committees may be authorized to monitor and report any illegality in adhering to established norms.
vi. The parties transgressing the regulations should pay for mitigation costs and contribute to the welfare of fisher-folks and bivalve collectors of the respective areas damaged
vii. The mussel and clam beds of estuarine areas with peripheral buffer zones of at least one km radius are to be strictly protected under CRZ provisions.

- **Regulations on shell mining:** Rich deposits of bivalve shells, which have happened through millions of years, have already been mined for industrial purposes, on large scale, over the last few decades, from especially Aghanashini and Kali estuaries. Shell mining is in need of moratorium, pending critical ecological evaluation, through a transparent process, as the extraction of shell deposits from the bottom of the estuary creates ecological devastations with consequences on fisheries, edible bivalves and mangroves and plankton which are critical initiators of food chains in the estuary.
- **Alternative employment for fisher-folks:** To reduce pressure on fishing it is suggested to increase and create alternative venues for eco-friendly employment such as mangrove based bee-keeping, mangrove planting and protection (fishing folks to be preferred for employment), eco-tourism, value addition to fishes and edible bivalves and similar kinds of alternative employment.

Impact of developmental projects (hydro electric projects) on estuaries: The consequences in Uttara Kannada are severe in Sharavathi and Kali estuaries. Fisheries collapsed in Sharavathi, clams (bivalves and oysters) production became almost nil. Hundreds of fishermen go in search of jobs elsewhere. In Kali estuary fishing income has become very much lower than in Aghanashini, a river unaffected by hydro-electric projects. Because of intensive aquaculture all estuaries suffered decline of mangroves. During the last few years mangroves are being artificially being raised. Our main recommendations are the following:

- The remaining pristine estuaries of Aghanashini and Gangavali should be preserved for the posterity. Per unit area of estuary both have highly productive fisheries to the tune of few lakh rupees/hectare/year.

- No hydro-electric projects should be executed in the remaining rivers of Uttara Kannada. No major polluting industries should be planned alongside them
- We recommend a estuarine park in the Aghanashini estuary, covering nearly 1000 ha area, for biodiversity conservation cum local livelihood support through designated fish conservation area, fishing area, eco-tourism, mangrove conservation and study centre, bird studies etc., to mainly benefit student community, local livelihoods and nature lovers.
- As edible bivalve collection, to the tune of over 60 crore rupees worth annually, is going in Aghanashini estuary, more as a market based and unregulated activity, it is recommended that committee of bivalve collectors to be formed for limiting the collection to sustainable limits.
- Mangroves vegetation is being grown over the last one decade, quite successfully, in suitable estuarine locations. As only one or two species are given more importance, we recommend that the future plantings should be more mixed using all the locally available species, in the interest of healthier estuarine ecosystems.
- Proposals for 'Biodiversity Heritage Sites' in accordance with the provisions of the Biodiversity Act, 2012 for Kali and Aghanashini estuaries are pending with the Biodiversity Board of Karnataka. The constitution of such heritage sites should be expedited through completion of due formalities required.
- Mangroves are known to produce good quality honey with high market demand. Mangrove planting should be also aimed at production of honey to raise supplementary income for the estuarine villagers.

1.2.2 MANGROVE DOCUMENTATION AND MAPPING

Mangrove wetlands are a multiple use ecosystems that provide protective, productive and economic benefits to coastal communities. Mangroves contribute to the stabilization of the shoreline and prevention of shore erosion. They serve as a barrier against storms so as to lessen damage to coastal land and residents. The dense network of supporting roots and breathing roots give mechanical support to the tree and trap the sediments. Without mangroves, all silt will be carried into the sea, where turbid water might cause corals to die. Mangrove trees act as sinks, which concentrate pollutants such as sewage, toxic minerals, pesticide, herbicides, etc.

The Indian east coast has much larger estuaries with mangroves than the west coast which has smaller estuaries and relatively less mangroves, Gujarat state being an exception. As far as Karnataka is concerned the mangrove are and importance have been under-estimated. The Forest Survey of India estimated mangrove area in the entire State of Karnataka as making just two sq.km, in 2001. Any visual estimate of the estuaries will reveal the mangroves could be something more. Such underreporting the area could have been the cause for long times of neglect. Over the last one decade or so under various schemes mangrove planting got more importance and the area has been on the increase. However, in none of the estuaries was attempted any mapping of the mangroves.

Mapping of mangroves using high spatial resolution remote sensing data could be of great help to the Forest Department in mangrove management. Mangroves are classified under CRZ-I area and therefore mangrove maps could be used for delineating CRZ I areas.

- It is recommended that similar exercises be carried out in other estuaries of Karnataka as well, considering the tremendous ecological and economic uses of mangroves
- No more hydro-electric projects are to be executed in the west flowing rivers, because of their adverse impacts in terms of decline of mangroves and fisheries, destruction of food bivalves, reduction in livelihood opportunities for fishing communities and overall lesser availability of fish and other estuarine food especially for coastal people.
- In the mangrove afforestation programmes the dependence on one or two species should be changed and more number of mangrove species should be used to create mixed plantations, for the sake of estuarine biodiversity and productivity.
- As *Rhizophora mucronata* is the main species used for mangrove afforestation, such monoculturing has to be avoided in future giving way to fair mixing of other species. More importance should be given to *Avicennia* spp. and *Sonneratia* spp.
- The rare population of *Bruguiera gymnorrhiza* in Venktapur estuary should be protected and more number of seedlings should be introduced here from Kali or Kundapur estuaries, as local regeneration is poor.
- Many aquaculture ponds are abandoned due to losses suffered by shrimp farmers. They are also unfit for rice cultivation. Government may formulate a scheme to acquire such areas for planting with mangroves.
- Honey production in mangrove areas is a totally neglected economic activity in Honavar Division as well as in the entire coastal Karnataka. As mangrove honey with rare mix of salts can have greater value bee keeping experiments should be carried out in the estuarine areas.
- Mangrove based tourism for bird watching and for scenic enjoyment should be promoted as a good income generating activity for the local VFCs (Village Forest Committees). Appropriate training for local youth in arranging such mangrove tours will provide newer livelihood opportunites.

1.2.3 AN ESTUARINE PARK FOR AGHANASHINI ESTUARY, KUMTA

The Aghanashini estuary is one of the most pristine estuaries of the west coast, not impacted by any major developmental project and away from urban settlements. It has high diversity of fishes (about 90 species), at least five types of edible bivalves, mud crabs, several species of prawns and about 120 species of birds. It produces annually Rs.43 crores worth fishes (only from water spread area excluding privately owned aquaculture areas), about Rs. 66 crores worth edible bivalves, Rs.70 crore worth cultured prawns, Rs. 8 crores worth molluscan shells, Rs. 8 crores worth salt and agricultural products and sand etc.

The ecology of the region is enriched, the waterscape/landscape is exquisitely beautiful, the fisheries steadily improving and bird fauna (residents, local migrants, and migrants from far off lands) steadily increasing. The availability of different microhabitats like channels, creeks, gullies, mud flats and sand flats and nearness of the Arabian Sea and Western Ghats offer favourable settings for consideration of this area and adjoining places (together approximately about 1000 ha) for an estuarine park.

The importance of the estuarine park

The park will be centre for study, eco-tourism, productivity and conservation as highlighted below:

- It will facilitate visits to fish and shrimp farms for studies/observations, to estuarine fields growing salt tolerant rice etc.
- Visits by tourists to edible bivalve collection centres with amazing productivity
- Visit to bird and bat roosting areas and other estuarine bird diversity
- For observations artisanal fisheries in the estuary
- Mangrove studies and mangrove sight seeing
- Visits to salt making areas
- Biodiversity of mangrove swamps
- Mangrove fish breeding area (about 500 ha)
- Mangrove fishing area, including sport fishing facilities for tourists

It is proposed that the centre should have mangrove diversity conservation area, bird and fish museum helping in identification, coastal arts and culture display centres including an auditorium, a museum of traditional fisheries, traditional rice varieties etc.

The management of the estuarine park could be under the joint supervision of the Forest Department. It will be self sustaining and provide greater livelihood security and generate employment facilities for villagers while enriching environment

1.2.4 SAFEGUARDING COASTAL AREAS FROM SEA-LEVEL RISE

Global warming due to green house gases and deforestation is a major threat to the life on the Earth, including the humans. Threat from sea level rise is looming large globally due to increased green house gases in the atmosphere and consequent global warming. Carbon dioxide has already crossed more than 350 ppm, highest level in more than half million years. The planet is about 0.75 degree warmer than in the year 1875. The sea level is already more than 200 mm than in 1800, and is feared to rise to 500 mm more than present level by the end of 21st century. This is a major threat to all the low lying coastal areas, including of Karnataka. The threat from sea level rise along the west coast is about 1.5 mm/year. Sea erosion problems are on the increase and the under present schemes of defense main thrust is on building of sea walls along the beaches using stones. This is a multicrore rupees work, which is associated with several problems and is not a lasting solution. Small efforts are however under way, under the initiative of the Western Ghats Task Force and the Forest Department to raise more greenery on the sea beaches using appropriate herbs, creepers, shrubs and trees. The vegetation is expected to build up sand dunes , which in course of time will established natural defense system against rising sea.

Hundreds of crore rupees are being spent on coastal protection through building sea walls. Sea walls can have many adverse consequences as they are built to resist the shock of rising sea waves than absorbing the shock. As the result the walls may be breached, the beach level subsides and sea erosion problems will increase along unprotected beaches.

High deposits of sand, the sand dunes, stabilized by natural vegetation of specially adapted creepers, shrubs and trees used to be the main defense against sea erosion from time immemorial. Removal of sand and the conversion of sandy areas too close to the sea into fields and habitations have increased threats from rising sea levels and cyclonic winds. We recommend the following measures as a better, less costly, eco-friendly options:

Recommendations

- Bioshileding of the coast has to be widespread action plan to defend coastal lands and lives from the threats of rising sea level
- Restoration of shore vegetation with the involvement of local communities will create natural, stabilized and ever rising sand dunes, which will act as shock absorbers than resistors.
- The beaches have to be aesthetically planted to increase the tourism potential
- The sea beach management should be brought under the joint management of coastal VFCs and the Forest Department (Apsarakonda and Kasarkod models in Honavar Forest Division)
- Use of NTFP species including of bio-fuel importance like *Calophyllum* (Honne) and *Pongamia* (Honge) will benefit the local communities and biofuel production.
- Planting should be carefully done in beaches used for egg laying by marine turtles so that some good sandy areas are left without planting.
- Periodical monitoring and progress achieved in bio-shielding has to be carried out by independent agencies
- Local sea shore management communities should be formed for creation and protection of the green walls, for protection of turtles that lay eggs in the beaches, for sustainable management of the products from the shore vegetation, to benefit from eco-tourism and to keep the beaches pollution free.
- Coastal Regulation Zone (CRZ) provisions should be strictly implemented for better safety of coastal people and safety of ecosystems including mangroves and estuaries.

1.2.5 SUSTAINABLE MARINE FISHING AND COASTAL AQUACULTURE

The importance of coastal fishing is next only to farming as regards employment potential and livelihood opportunities are concerned. Fishing, as followed through generations, was sustainable and non-mechanized. Use of mechanized boats and different kinds of technically superior nets introduced from 1960's revolutionized the marine fishing sector. From less than 20,000 tons of annual catches in early 1960's the fish catches crossed 80,000 tons in mid 1980's, when the number of mechanized boats was between 1250 to1500. As no sustainable limit was set for marine fishing the number of mechanized boats crossed 2500 and is still increasing. Government records show that the fish production has crashed to less than 35000 tons per year with ever increasing efforts. The worst affected are the traditional artisanal fishermen and the consumers. Mechanized bots also have increased marine and coastal pollution. We recommend the following measures for greater security in fishing sector:

- Awareness programmes on responsible fishing
- Demarcate mangrove areas of high importance for marine fish breeding as fish breeding areas, and protect such areas from fishing through the involvement of community participation.
- Export of marine fishes to other countries should be restricted to save imminent fishing collapse in Karnataka and the west coast as a whole - Total fish production (marine and fresh water) rose in India from 800,000 tons in 1950 to 8 million tons in 2010. India is sixth largest exporter of fish in the world. It is recommended that the Government reduce marine fish exports to sustainable limits, and promote production more in inland, fresh water areas.
- Fish breeding areas and congregations of rare fishes (eg. Netrani island) should be closed to any form of fishing.
- Fish export from the region should be curtailed so as to limit the harvests until the stocks recover.
- Greater protection needed for sea turtle egg-laying areas in beaches through local beach and sea turtle protection committees
- Implementation of strict regulations on mesh size, especially for mechanized boats.
- Intensive aquaculturing for prawns creates pollution problems, salinity related problems in drinking water and destruction of mangroves. Aquacultural ponds should be devised for seminatural methods combining traditional rice farming, fishing and mangrove protection.
- Members of fishing communities should be attracted other forms of entrepreneurship such as coastal tourism etc.
- Moratorium on sanction of new mechanized boats for at least next five years. We recommend that the number of mechanized boats be limited to within 1500, through a gradual shift in licensing policy. There should be set a limit for one person or a single establishment having fishing monopoly by owning a fleet of boats. The limit to licensing of new mechanized boats (mainly purse seines

and trawlers) set rigidly in other coastal districts also for the sake of sustainable marine fishing. Priority and Government subsidies (including for fuel) should be limited to traditional fisherfolks only. Artisanal fishing and use of smaller motorized boats by traditional fishermen should not be curtailed.

- No new licenses should be issued for more mechanized boats, and mechanized fishing by non-fishing communities should be discouraged. There should be restrictions on numbers of mechanized boats licensed for individuals or undivided families.
- Periodic closing of some identified areas in the sea for fishing purposes making way for restocking of depleted fish resources. Voluntary marine conservation areas to be promoted
- Protection of estuarine ecology and increase in mangrove forests can promote breeding of many marine fish
- Regulation of plastic waste in the sea is very important
- Steps for reducing by-catches of non-target species. Discards at sea is up to 30%. Post harvest losses are up to 15%
- Strict vigilance on coastal and marine pollution
- The Government policy should be aimed at restricting the number of mechanized boats in Uttara Kannada to 1500. Similar measures to be adopted in other coastal districts also so as to achieve uniform sustainable limits
- The mesh restrictions for nets should be strictly followed so that the undersized fish are not caught.
- While restricting the number of boats care should be taken not to deprive the traditional fishermen of their fishing rights.

It is necessary to increase the contribution of marine fisheries to the food security, economies and the well-being of coastal communities. It requires effective management plans to rebuild overexploited stocks. Recommendations for the sustainability of marine fishery in a broader context of west coast and national fisheries are:

Strengthened governance and effective fisheries management: Promoting sustainable fishing and fish farming can provide incentives for wider ecosystem stewardship. This requires

1. **Adoption of an ecosystem approach to fisheries and aquaculture**
   - ***Ocean and linked coastal water bodies*** like estuaries, creeks, lagoons, salt marshes, mangrove areas etc. are to be considered as interconnected and valuable ecosystems producing rich food without practically any inputs from humans. These coastal and marine aquatic habitats need to be considered holistically for integrated management.
   - ***Pollution, reclamation, misuse or degradation*** of such ecosystems are to be strictly monitored and prevented.
   - ***Places of fish breeding*** within the marine areas and coastal backwaters are to be identified and demarcated as protected zones, in the interest of sustainability of marine fisheries.

- ***To promote the breeding stocks of fishes***, it is necessary to know the breeding months of various commercial fish species. Regulations should be imposed on capture especially of breeding stock of fish species by targeted fisheries sector. For instance peak spawning of mackerel was observed during July-August. The percentage of this fish with mature ovaries was 60% of the total in purse-seine operations in late August (Rohit and Gupta, 2004). The ban on mechanized fishing during this period will be helpful in stock recovery of mackerel and many other fishes. Stoppage of intake of such fishes by cold storage units for export purpose may be prevented so that adequate stocks remain. However, there need not be ban on artisanal fishery and capture by small mechanized crafts
- ***Estuarine integrity*** is very critical for several kinds of marine fishes and prawns which enter the estuaries for breeding or multitudes of their juveniles (fish and prawn seeds/larvae) enter the estuaries to feed and grow in the estuarine habitats like mangroves, sedge areas, mudflats, molluscan beds etc. Integrity of these habitats should be safeguarded through strict implementation of CRZ and considering such areas as ecologically sensitive areas. Involvement of local Village Forest Committees, Biodiversity Management Committees etc. will be of help in keeping vigilance at local level. These committees may be extended financial assistance under the existing forestry schemes or provisions of Biodiversity Act -2002. The Nushikote VFC in the Aghanashini estuary of Kumta, helping the Forest Department in planting and protection of mangroves, is a notable example.
- ***Multi-species mangrove vegetation*** need to be raised in all areas of estuaries suitable for the respective species combinations.
- ***Estuarine rice fields*** of Uttara Kannada, especially of Aghanashini estuary, where salt tolerant Kagga rice used to be grown, are locally well known as natural feeding grounds of marine shrimps and various marine/coastal fishes because the farmers used to harvest the tall paddy by cutting only the head portions leaving the rest in the field to degrade and become manure. The paddy stumps in post-harvest fields flooded with salt water are ideal places for juveniles of shrimps as anchoring places. These residues eventually become rich nutrients. However, because of intensification of aquaculture in recent decades many of these estuarine fields or *gaznis* are badly affected, and abandoned for cultivation. The Government should initiate steps to repair the *gazni* bunds and install sluice gates wherever damaged and desilt the *kodi* channels in the interest of not only marine and estuarine fishing but also for boosting the sagging production of rice.
- ***Destruction/degradation due to damming of rivers*** for power generation has severe adverse consequences on coastal fishery, including bivalve production through reduction in post-rainy season salinity. This has been noticed in Sharavathi and Kali estuaries, most severe collapse of fishery happening in the former where estuarine water has turned almost into fresh water with salinity less than 0.5 ppt.
- ***Likely diversion of rivers*** will have adverse consequences on estuarine salinity and ecology and on marine and estuarine fisheries.

- ***Need for removal of estuarine mouth siltation*** is necessary for Sharavathi, Aghanashini and Gangavali estuaries where siltation has affected the free movement of tides and therefore of marine fishes entering these estuaries for breeding/feeding.
- ***Regulation of sand and shell mining*** in the estuaries is very important for revival of estuarine and marine fishery. Shell extraction may be limited to the needs of local lime makers and large scale mining may be prohibited in the estuaries for at least the next ten years and the positive influence on coastal fishery studied throughout the period.

2. **Rebuilding collapsed/declining stocks:** The Government of India should adopt a dynamic marine fishing policy through prohibiting periodically export of any fish species the fishery of which is in collapsed/declined state (catches less than 5% of historical maximum), or those species which are seriously depleted or declining to less than 50% of their historical maximum catches, through a comprehensive evaluation system. Such ban may be lifted after the recovery of the stock of such populations to healthy levels. Fishery of all species with collapsed stocks has to be carefully monitored. In the interest of species survival and sustainability
3. **Need for more responsible fishing:** Consensus should prevail that fishing (aquaculture excluded) is not an industrial or business activity but more of an output of ecosystems, which need to be harvested strictly within sustainable limits. Fisher-folks, from time immemorial, depended on fishing for their livelihoods and over-exploitation never happened until commercial, mechanization dominated fishery in the recent times. Wild genetic stock of fish in the marine areas has to be maintained even for the success of aquaculture, where the cultured prawns and fishes are prone to diseases, pollution problems etc. for the surroundings including the marine areas.
4. **Impose uniform monsoon fishing ban in consultation with CMFRI**: The Government of India, through State Governments of respective maritime States, should implements a fishing ban during the monsoon every year, which is a peak season for breeding of many fishes. August is considered peak breeding season for Mackerels for which Karnataka coast is famous. The existing ban on fishing during monsoon by mechanized boats in Uttara Kannada by the State Government for 2013 is from June 15 to July 31, and in Dakshina Kannada from June 15 to August 10. According to CMFRI scientists Rohit and Gupta (2004) 60% of the total Mackerel catch in purse-seine operations during late August were with mature eggs; such catches are likely to have adverse effects on the future stocks. Although there could occur some variability in dates and duration of fishing ban in different states, disparities need to be reduced.

   The fishing ban lasts for 45-60 days with each State using a different time period or criteria such as advancement of monsoon as an indicator. Absence of a uniform ban period throughout the coastline has led to fishing trawlers of several States using this legal technicality to fish where fishing ban exists and land in an adjacent State where there is no ban. Fishermen in Goa, Karnataka and Maharashtra along the west coast, complained that the very essence of the fishing ban is flawed as vessels from neighbouring States continue to catch from one State's territorial waters and land in another, leading to low catches during the post ban period. With most of the coastal States having weak enforcement, due to huge gaps in allocated infrastructure, manpower and monetary resources, illegal fishing persists through domestic fishing vessels in inshore waters. Moreover, it also leads to problems in misreported catches where fish caught in one jurisdiction is reported as caught in another location.

To reduce such anomalies it is recommended that the fishing ban from Kerala to Gujarat should be during the same period, with maximum flexibility between any two neighbouring States not exceeding five days.

The artisan fisherman may be permitted to fish in near-shore waters during the fishing ban period, using their traditional fishing gadgets. Fishing concessions to a limited extent may be given to indigenous crafts with outboard engines within a five km distance from the shore.

5. **Strict regulations on mesh sizes of nets:** majority of the depleted and collapsed stocks of South-west India are those species which are mainly caught in trawls. As a first step for rebuilding stocks, trawl effort has to be reduced in both Kerala and Karnataka and strict implementation of the mesh restriction policy on trawl and purse-seine nets is very necessary. Serious thought should be given to revival of Cat fish population which is very badly affected by indiscriminate pure-seining using nets with small meshes where even eggs cannot escape. Karnataka Marine Fisheries Regulation Act requires all mechanized trawlers operating along the coast to use a cod end mesh size of at least 30 mm but, most of the trawlers use 10-15 mm cod end mesh size resulting in indiscriminate capture of juveniles of fish and shrimps. This has also contributed to substantial discards during the monsoon season.
6. **Reducing the carbon footprints of marine fishing boats:** Unrestrained mechanization of the Indian marine fishing sector has not only nearly destroyed traditional artisanal fishery and resulted in imminent collapse of numerous commercially exploited fishes but also caused the release of phenomenal quantities of CO_2 emission. This requires:
   - Improving fuel efficiency of marine fishing boats
   - Reducing the mechanized fleet size to half the present number, limiting to sustainable catches, in a gradual process through not giving new licenses until targets (sustained yields) are achieved
   - Strict enforcement of reserving about 5 km zone from the coastline for non-mechanized fishery and for operation of traditional *rampani* nets etc.
   - A shift from fuel-intensive active fishing methods such as trawling to passive methods such as seining, lining and gillnetting.
7. **Promotion of artisanal fisheries:** estimates indicate that illegal fish catches by trawlers in the inshore traditional zone resulting in annual loss of 1200 - 1950 tons. This loss, needless to say, affects the artisan fishers using canoes and plank built boat, cast nets, shore-seine nets and long lines. The operation of mechanized crafts in the inshore waters (5 km zone) needs to be prohibited to alleviate poverty and underemployment among artisanal fisherfolks.

8. **Reducing fishing by-catches/discards:** Introduction of modern fishing methods and targeted fisheries have resulted in wasteful by-catches of juvenile fishes, non-targeted species like turtles, other fishes, marine invertebrates etc. Such by-catches also have very serious food security implications on one billion people who depend on fish as their principal source of food. Results from this study shows that discards have increased for two main reasons. Firstly, the number of trawlers operating along the Indian coastline has increased over the past four decades. Secondly, the duration of fishing trips by multiday trawlers is in the order of 10-12 days, with trawlers along the Kerala, Karnataka and Maharashtra coastlines increasingly targeting deep sea stocks at 150-350 meters during most of the year. Increasingly, longer fishing trips in deeper waters means that non-commercial species of fish and shrimps are encountered in larger numbers. The operators of these trawlers cannot store trash fish from all the hauls during each trip, a good part of which are discarded into the sea. Gujarat has a more efficient trash fish collection as they are purchased for higher prices for fish meal factories. More and more landing of trash fish is reported to compensate for decline of commercial fishes. The following are recommendations to reduce by-catches:
    - From a sustainability point of view, limitation of fishery production to safe biological limits is necessary before seeking export markets for the products.
    - Given the dynamic complexity of marine ecosystems and the often inter-mingling of various types of species, the practical reality, however, is that selecting and catching only that which is managed will not be solved solely through selective fishing gear. Consequently, the most pressing priority for bycatch reduction and over-fishing, should be reducing the amount of fishing, to meet more the domestic needs than catering to the global demands.
    - Trawler fishing should be phased out to reach sustainable numbers by limiting licenses for new ones.
9. **Advisability of aquaculture:** The marine fishery resources are on the brink of collapse with most fishes and seafood in demand having already reached declined, depleted or collapsed states. Aquaculture, one of the fastest growing enterprises in the world, is considered as a strong solution to reducing pressure on marine fishery allowing for recovery of depleted stocks. A variety of chemicals used to inhibit the growth of other organisms may also affect other organisms. The fishing communities of Uttara Kannada coast have complained that the use of bleaching powder and lime in estuarine aquaculture ponds create massive deaths of juveniles of prawns and fishes.
10. ***Eco-friendly aquaculture:*** Government of India enacted the Coastal Aquaculture Authority Act, 2005, enabling the establishment of the Coastal Aquaculture Authority for enforcing proper regulatory measures for carrying out coastal aquaculture in a more sustainable and eco-friendly manner. The awareness levels of coastal shrimp farmers were inadequate and neither the State Government nor the farmers were geared to meet the challenges that were posed by issues such as pollution, viral diseases, etc. The National Fisheries Development Board (NFDB) has allocated funds for training, awareness and enhancing skills for coastal aquaculture, for shrimp and finfish farming.

There is a need to set up a dedicated Monitoring and Evaluation Cell in the Department of Fisheries to periodically monitor and evaluate activities implemented under the NFDB.

Bivalves

1. Regulating the shell and sand mining in the estuarine region will have positive impact on the diversity and distribution of edible bivalves.
2. The lessons from serious human impacts caused to Sharavathi estuary ecosystem, in the form of massive disappearance of edible molluscs, decline of high salinity tolerant mangrove species and dislocations in associated biodiversity etc., the implications of which are yet uncounted, should teach us to be more cautious in future in dealing with developmental projects especially affecting riverine systems. The role of estuary as breeding places and nurseries for several marine fishes of economic value has been totally ignored while executing such large river valley projects.
3. Maintenance of physico-chemical properties of estuaries need to be considered while executing any major river valley projects so that they can continue to be centres of diversity and productivity meeting the food and livelihood needs of thousands of families while also performing the vital ecological functions traditionally associated with estuaries.

1.2.6 CUMULATIVE ENVIRONMENTAL MANAGEMENT OF ESTUARIES

As there are no management criteria adopted for utilisation of estuarine resources, overharvesting and activites harmful to estuarine ecology have resulted. . Presently prawn aquacultuirng in specially created ponds have adversely affected traditional rice farming cum fish culturing. It has brought the salt tolerant Kagga rice variety towards the brink of extinction because of the sudden realization of higher income from prawns lot of estuarine areas are modifed into prawn farms. Prawn farming requires mangrove cutting to create aquaculture ponds. Addition of chemicals in the form of hormones, chemical feeds, algae destroying chemicals etc. have created pollution problems. Persistent storage of salt water in prawn growing areas is blamed as the cause for increasing salinity of drinking water wells. There are no norms for estuarine utilisation.

Mangrove destuction on large scale took place with building of permanent bunds for rice fislds, for local fuel wood demands and prawn farming. Introduction of contract system for prawn and fish harvests from privatelw owned gaznis is a relatively new practice which created wide spread unemployment among fishermen making them to overfish in the open part of estuaries. There are no norms for harvesting of freely available edible bivalves (*Belachu* and *Kalga*).

The execution of hydro-electric projects in Sharavathi River resulted in continuous release of fresh water after power generation reducing estuarine salinity, which has reached nearly fresh water conditions. This has caused total disappearnce of bivalves from Sharavathi estuary.

There has been major reduction in the area occupied by edible bivalves in dam affected Kali estuary also.

Carrying capacity of Sharavathi and Kali estuaries, in terms of fishereis support has substantially reduced. Whereas catches from Aghanashini estuary nearly amounts to Rs.43.51 crores annually, at current market prices, the total catch was worth only Rs.1.29 crore/year. In Kali it was better with about Rs.13 crores, but much lower compared to Aghanashini.

Aghanashini River without dams had 88 fishes in the estuary part. But Sharavathi with dams had only 43 fish species. Kali with dams had only 58 species in the estuary, although estuary is nearly as big as Aghanshini. Gangavali, without dams, has a smaller estuary than Sharavathi but 50 species of fish were recorded.

Shell mining in the Aghanashini estuary is a multi-crore rupees enterprise. The cumulative impact of this enterprise on the estuarine ecosystem and productivity is practically unstudied.

Recommendations

- No more hydro-electric projects are to be executed in the west flowing rivers, because of their adverse impacts in terms of decline of mangroves and fisheries, destruction of food bivalves, reduction in livelihood opportunities for fishing communities and overall lesser availability of fish and other estuarine food especially for coastal people.
- In the mangrove afforestation programmes the dependence on one or two species should be changed and more number of mangrove species should be used to create mixed plantations, for the sake of estuarine biodiversity and productivity.
- Because Aghanashini estuary is highly productive of fishes and food bivalves there has been overharvesting of these. Diversification is required in fishing commmunity employment and many youth should be trained in alternative forms of livelihood- for eg. tourism related activites.
- We have successfully mapped mangroves in the estuaries and creeks of Honavar forest Division. Mapping also includes areas suitable for mangrove planting, species distribution and location-wise suitable species for planting. As administrative beat wise mangrove mapping will be helpful for lower level field staff of forest department, it is recommended mangrove mapping be carried out in Karwar Forest Division and other coastal divisions of Karnataka.
- As the estuaries have immense potential for especially study and aestheitc tourism these areas should be developed to suit appropriate tourism to generate alternative employment preserving in tact the environment and culture. Tourism will create diversification in livelihoods and reduce fishing pressure on the estuaries.
- We wish to recall here that an area measuring 1819 acres in the Aghanashini estuary, acquired from farmers, and handed over to KIADB for salt production by an industry, and subsequently abandoned fot that purpose, has been converted by the Karnataka Forest Department into one of the best upcoming mangrove areas. Mangroves being

of high ecological and economic importance, and being automatically considered as CRZ-I areas, need to be preserved as such. As a local VFC is already involved in joint management with the Forest Department, and as the area falls closer to the tourst centre Gokarna, and NH-17, we recommend this area, and its adjoining areas to be brought under a park for mangrove conservation, eco-tourism and education centre. This will generate good income from tourism activity and will serve as fish breeding centre, bird watching and mangrove ecosystem study and recreation centre.

- We have already submitted a document for submission to the Karnataka Biodiversity Board, through the Forest Department some areas (229 ha) of high value for bivalve production, close to Aghanashini village, and another area of 67 ha towards the centre of the estuary, rich in mangroves, including a mangrove sacred forest, as a Biological Heritage Site, under the provisions of the Biodiversity-Act, 2002, of Government of India.
- The cumulative environmental impact of shell mining in the Aghanashini estuary, that has been going on for years, has to be studied for establishing sustainability limits. In other estuaries too such studies need to be carried out.
- Cumulative environmental impact of sand mining in the estuaries is to be studied for establishing sustainability norms.
- Salt tolerant Kagga rice is on the verge of extinction. To safeguard this rare variety farmers who cultivate them should be given subsidies for the in situ conservation efforts.

1.2.7 AGHANASHINI ESTUARY IN KUMTA TALUK, UTTARA KANNADA - BIOLOGICAL HERITAGE SITE

- Biological Heritage Site status under BIOLOGICAL DIVERSITY ACT 2002, Government of India for two locations in Aghnashini estuary in Uttara Kannada district of Karnataka is proposed for unique biodiversity and productivity. Although the estuary itself is unique in biodiversity and productivity, due to the practical problems that could arise in managing the entire estuary as one unit, two separate core areas are identified within it as Location-1 and Location-2, the former of tremendous importance in Molluscan (bivalves) productivity and the latter of importance for the mangrove ecosystem, which is the core area for biodiversity and productivity. As the estuary is one biologically integrated unit the two locations within it are to be brought under a single Heritage Site Management Committee.

1.3.0 AGRICULTURE, HORTICULURE AND LIVESTOCK DOMESTICATION

Unlike anywhere else along the flatlands of the maidan areas the traditional Uttara Kannada farming sector is a combination of rice fields, multicropping orchards of betelnut, betelvines, pepper, cardamom, nutmegs, bananas etc. and specially maintained leaf manure cum fodder growing forests called bettas. Cattle and buffaloes are essential parts of the system as producers of milk, manure and gobar gas. Farmyard manure of cattle dung and leaves is very critical for soil fertility, gradual release of nutrients and for soil protection from erosion in the heavy rainfall zone.

This ideal traditional system is changing drastically these days due to various reasons. The district used to be a great reservoir of hundreds of traditional rice varieties with wide array of qualities for the rice and the suitably of the varieties for different soils and water conditions. The tall straw provided much required dry season fodder for cattle. The widespread cultivation of dwarfish new varieties of rice in the recent decades has seriously affected cattle straw production. As a result, especially along the coastal taluks, particularly in Honavar, Bhatkal and Kumta taluks, where the cattle number is high (4 to more than 5 per hectare of sown area) fodder scarcity is very serious. The coastal hills and plateaus are of exposed laterite rocks with very little fodder production. Many farmers are compelled to purchase rice straw from other taluks, mostly from other districts, at high cost. This situation is compelling farmers to sell cattle or release cattle for free grazing as they cannot afford purchase of straw and other expensive feeds. The decline in cattle can create serious consequences on the farm sector, which has been by and large organically carried out. The decline of cattle has created scarcity of farmyard manure and most people are compelled to purchase packaged milk from elsewhere. To prevent the farm sector collapse we make the following recommendations:

- We have estimated that nearly 500 traditional rice varieties are likely to surviving in Uttara Kannada. About 100 have been already documented, many are extremely rare and on the verge of extinction. The Government should take steps to promote Uttara Kannada as a organic district, promote through subsidies in situ cultivation of traditional rice for the sake of cattle straw and for safeguarding the gene pool of rice.
- Farmers be given guidance and subsidies to grow suitable fodder grasses for own use and sale in the wastelands, benas and fallow fields.
- Panchayat level fodder farms should be started for helping manure and milk production especially by the landless.
- More than loans or subsidies for purchase of cattle such assistance be extended first for fodder production on priority.
- In the malnadu taluks farmers be encouraged in growing fodder plants in portions of bettas, for own use and sale.
- Dairying be promoted as an employment generating sector which is also crucial for supply of manure and for meeting village level energy needs through gobar gas.

1.3.1 LIVESTOCK: IMPORTANCE OF DEVELOPING FODDER FARMS

Uttara Kannada district experiences only five to six rainy months (>100 mm/month), remaining period having with scantier or no rains. During the dry months, mainly from November to May period grasses and herbal fodders dry up making the livestock keepers rely heavily on dry grass (karada) and paddy straw and small quantities of jowar straw in maidan taluks. During the rainy months, particularly June to September period, exceptionally heavy rainfall, from South-west Monsoon is experienced by especially coastal and malnadu taluks, where exposed soils and free grazing pasturelands tend to be eroded of top soils. The grasses start rapidly drying up from November onwards with practically nothing for foraging left for the cattle almost up to the end of May. During this long and difficult period the cattle are fed mainly with paddy straw and green grasses available, if at all, from fallow rice fields, and wetlands. The cattle keepers store straw for the lean period by purchasing or storing the straw from their own fields.

Importance of developing fodder farms: Cattle wealth is critical for agricultural economy for milk, manure, traction and bio-energy. Most of Uttara Kannada's agricultural soils, receiving torrential seasonal rains are prone to severe soil erosion and rapid nutrient losses in the absence of organic manure, bulk of which is traditionally composed of cattle manure. Cattle manure has become dearer these days compelling farmers to even neglecting farming operations. This will have serious implications on farming, and dairying, which together constitute largest sector of employment in the district. It is a dire necessity for dairy farmers to start growing green fodder (grass) if they desire to run their unit profitably. Mere distribution of milch animals by the Government is of no use to farmers. Along with the animals they must be also made aware of the importance of growing their own fodder for the animals. Buying several commercial feeds available in the markets today is not profitable for a small farmer. Green fodder production and sale by farmers has to be developed into a major enterprise. We also recommend that the government start fodder farms, particularly for production of green fodder, mainly grasses and leaves. Priority areas for fodder production, preferably panchayat-wise are Honavar, Bhatkal and Kumta taluks along the coast. Farmers of Siddapur, Sirsi and Yellapur may be assisted in fodder production especially in the bettas, which are under their control. Fodder farms may be started for user groups in these taluks and in Supa taluk, who do not have betta privileges, in common lands. Some of the promising grasses recommended for cultivation are Congo Signal, Guinea grass, Hybrid Napier like CO1, CO2 and CO3. Recently CO4 has become a much sought after, profitable, nutritive and productive grass in southern Kerala.

1.3.2 BEE KEEPING FOR BETTERMENT OF LIVELIHOODS

Beekeeping is a forest and agro-based industry. Whereas production of honey, bee-wax and other by-products are remunerative honey bees pollinate crop plants and increase production of fruits and seeds. Our studies show bee keeping is not well organized in Uttara Kannada, though the district is richest in forests in South India and well known for horticultural crops.

Honeybees provide a variety of goods (honey, wax, pollen, royal jelly, propolis etc) and services (pollination) to human society and ecosystem. Across the world the bees support millions of livelihoods while also enriching the ecosystem. Beekeeping is an important enterprise to rural communities and related to agricultural and horticultural production. Even though, Uttara Kannada district has over 60% of its lands under forest cover, and about 15% under farming, the honey production is far below its expected potential. The case study conducted highlights that beekeeping could be elevated into much more profitable venture requiring small investment of capital and skilled labor for realizing high yield in comparison to other rural employment and poverty reduction programmes. We have taken into account the static performance of the bee-keeping societies, which had in their earlier days played vital role in spreading awareness on scientific bee-keeping and its profitability and assisted people in setting up bee-keeping units in their homes and helped in marketing the products. Presently there are several individual entrepreneurs in the district who have realized the importance of bee-keeping, in a consumerist society where there is steady and rising market demand for honey as a health food, as medicine, for use in confectionaries, in pharmaceutical industry and so on.

Uttara Kannada, with about 70% of lands under forest cover, with its spice gardens and mangroves and predominantly organic farming, has high potential for growth of apiculture. The district can be transformed into one of the greatest centres of honey production for meeting domestic and export needs. Apiculture will be enriching forests and agriculture because of more fruit and seed production due to increased pollination. Whereas mixed honey from the forest plants or crop plants can fetch almost Rs.200/- kg honey from soapnut tree fetches Rs.600 to Rs. 800 easily. Yet no special efforts are made to promote apiculture.

Apart from utilizing roadsides for raising bee host plants degraded forests and blanks closer to villages may be planted with appropriate nectar producing plants. We recommend that every year about 500 ha of such forests and barren lands and roadsides may be planted with various honey bee host plants. The plantings are to preferably through gap filling than in the plantation mode. At the rate of 400 nectar producing trees per hectare, to cover 500 ha of suitable areas can carry about 2 lakh trees. Each of the five forest divisions in the district may raise annually bee forage plants in 100 ha area. Once the trees start flowering, from every year's plantations Rs. 4 crores worth honey production (about 4 lakh kgs) may be realized at current market prices. For fetching early income nectar producing and early flowering creepers, herbs and shrubs may also be introduced. So far people have no notion of production of mangrove honey that has high market value due to accumulation of rare salts in it. This requires

- Creation on awareness on scientific bee keeping
- Training traditional honey collectors in scientific bee keeping
- Demarcate suitable locations in forests near villages for keeping bee boxes seasonally
- Promote organic farming for healthy bee keeping
- Designing forest vegetation, near villages, to promote bee keeping
- Promote bee keeping in estuarine villages near especially mangrove forests

- Promote planting of honeybee host plants in village landscapes
- Honey from forest areas (entirely of organic nature and medicinal) should be specially marketed to improve livelihoods of people in interior villages
- Honey testing, packaging and marketing facilities to be made in the district

Recommendations: Some of the recommendations to improve the livelihood through beekeeping are:

1. Training programmes

a) ***Honey production*: *theory and awareness:*** There is large number of aspirants for apiculture in Uttara Kannada. If proper awareness and training programmes are conducted bee keeping can be a major income-generating activity especially in rural areas. Many people have interest; yet they are scary of bee stings or about gaining profits due to lack of encouragement and proper knowledge. By appointing adequate number of trainers, directly by the Government, or commissioning experienced bee keepers from the district itself as trainers, on honorary basis, the bee keepers' societies can still play key role in promoting this enterprise and bring it at par with China, the world's highest producer of honey. The trainers need to conduct the programmes at two levels. Using power point presentation, especially at panchayat level they can impress upon the village community on the importance of bee keeping. A selection can be made of prospective persons who can be given the second level of training with more practical components, including a series of visits to successful apicultural farms in the district and outside. Relevant literature on bee keeping theory and techniques should be provided to the trainees free of cost.

b) ***Using wild colonies from the jungles for domestication through traditional expertise:*** Many local villagers, especially belonging to the communities such as Halakkivokkals, Siddis, Kumri Marattis, Kunbis etc. have the knowledge of collecting wild bee colonies and transferring them to the bee-keeper's boxes. This is a much cheaper method, costing about Rs.300- Rs.500, per colony transfer. At the same time purchasing such a colony at market prices will cost anything between Rs.1200-Rs.1700, which many cannot afford. Caution is necessary regarding the timing of bee colony collection from the wild as the period from late March to early June is honey collection period from the forests. It is recommended strongly that for rearing purpose jungle colonies may be transferred to the brood chamber of the bee box during September and October. By February the box will be full of bees, all the seven to eight frames occupied by the bees through multiplication within the box itself. The bee box starts yielding honey from February to end of May. As this is the flowering season for most forest plants and horticultural crops, honey from the boxes can be collected at intervals of seven to 14 days.

c) ***Populating new boxes:*** A well maintained bee box can accommodate seven to eight frames of bees in the brood chamber. Each brood chamber is topped with a super chamber, from which alone honey has to be extracted as the brood chamber honey has to be kept in the reserve for the sake of the growth and functioning of the colony.

Once the newly trained bee-keeper, becomes successful in rearing honey bees, he needs training in developing new colonies for introducing in more boxes in his own farm. He can even trade surplus colonies to others. To develop a new colony the bee-keeper may remove four frames with honey bees to a new bee box where already four empty frames are fixed. The new bee box to be populated has to be kept as far away from the original colony so as to prevent the migration of the queen from the old box to the new.

d) ***Regulating the number of queen bees:*** Normally one bee box should have only a single queen bee. If an additional queen tends to develop by chance in a larger cell the worker bees will not provide royal jelly critically necessary for maturity of the queen bee. By mistake if an additional cell with developing larva gets stored with royal jelly one more queen develops in the same box. If more than one queen develops in a bee box it is likely to fly away from the parent box to establish a new colony elsewhere. Her flight is often accompanied by a horde of thousands of worker bees, deserting the parent colony, leading to its collapse, as less number of workers is left here to gather pollen and honey. The bee-keeper should keep an eye on such disorders in the colony and remove the extra queen cell itself or destroy the larva developing in the queen cell.

e) Screening for healthy queen bees: The setting up of a healthy colony depends on the quality of the queen bee. If the queen bee is undersized or unhealthy or infected with parasitic mites it will affect the egg laying capacity, or the eggs hatch into undersized bees etc. The bee keepers are to be guided to select every year a new queen for the colony as it has greater egg laying capacity leading to more number of healthy worker bees resulting in greater honey production.

f) ***Ideal time for setting up new colonies:*** Separation of a queen bee for setting up a new colony has to done before September, in the conditions of Uttara Kannada. After September with the beginning of overall flowering season the bees become active collecting nectar and pollen for brood development and therefore the worker force has to be maintained in the box.

g) ***Shifting bee boxes for greater production:*** An atmosphere of goodwill has to be created among the bee keepers and the general public so as to facilitate the bee keepers shifting the boxes of bee colonies to places with good amount of bee forage plants. Considering also the fact that bees are tremendous forces in pollinating horticultural crops and forest trees, various other medicinal plants etc., the farmers and foresters should welcome bee keepers to set up the bee boxes in their farms and forests respectively. In a small way however, 'nomadic' bee-keeping is happening in the district. For instance most of the soapnut trees (*Sapindus laurifolius*), the sources of the highly priced soapnut honey, are concentrated in the coastal taluks. Soapnut trees are the earliest to flower, November-December being their blooming period. Some of the bee keepers from the interior villages set up bee boxes in the coastal taluks on mutual understanding with the locals, so as to harvest soapnut honey, the first honey of the season. Likewise some of the coastal bee keepers also shift their bee boxes into interior hill ranges to derive benefit of the peak flowering season of a variety of wild plants.

h) ***Training in dis-infestation and disease control:*** Attack by mites, wax moth etc. and viral, bacterial and fungal diseases can have devastating effect on bee keeping. The bee keepers are scared of such outbreaks of pests and diseases and are often in the dark about how to deal with them. The bee keepers needs training in diagnosing the ailments of the bees and in adopting preventive and quarantine measures before greater expertise to deal with the problem is made available by the Government.

i) ***Protection from predators:*** Ants can be a menace on the bee colonies as honey in the hive is a great attraction for them. The use of water stored in containers around the legs of the box is the safest and most eco-friendly measure for keeping away the ants from access to bee colony. Awareness should be spread against the ill effects of chemical pesticides for that purpose. The attack by carpenter bees which capture and carry away honey bees to feed their young ones is almost an unsolvable problem that needs experts' attention.

j) ***Optional feeding during lean periods:*** The farmers need to be instructed about the importance of conservation of honey in the super chamber of the colony during the lean periods, especially the rainy season, when practically the bees do not get any food. There is the general practice among the bee keepers of providing sugar or jaggery solution as feed for the bees. Although the bees live feeding on such substances, these being mainly of sucrose, provide only calories and not the proteins vital for development of the larvae. Protein rich gram flour (from black gram, soybean, Bengal gram etc.) made into a paste with sugar and honey may be better option to provide vital nutrients to the adults and developing bees.

k) ***Awareness on pollination benefits:*** The great role of bees in pollination of especially horticultural crops need to be highlighted in the training programmes, through excursions to such farms with pronounced yield increase because of bees and through invited talks from such bee-keeper farmers. It is not merely extraction of honey for trade purpose that should motivate the farmers; the role of bees as pollinators to achieve higher yields and quality fruits and seeds is also very important. The bee keeping has to be ingrained as a culture among the farming community and even among the rural landless for the multiplicity of benefits that include income from honey, nutritional security and pollination of both cultivated and wild plants.

l) ***Awareness on organic farming:*** The widespread and indiscriminate use of pesticides in the agricultural sector can be detrimental to bee keeping. The evils of pesticide application can be far reaching on human health as well as of the various beings in the ecosystem. The honey bees are very susceptible to the toxic effects of pesticide use as organophosphates can be deadly neurotoxins on them. The pesticide use is becoming a widespread practice in the coastal areas than in the interior of the district where organic farming is more popular. During our survey, we came across a case of organophosphate application on sweet potato crop in Bijjur village of Gokarna panchayat that caused death of honey bees in five boxes in the vicinity.

2. Forests in support of beekeeping: In Uttara Kannada district most human settlements, barring some major towns, are dispersed among forest lands. These forest lands might be having already good vegetation, or may be poorly vegetated; for instance, the coastal minor forest belt is substantially barren or supports only scrub and Acacia plantations. These are not good places for healthy bee colonies, and naturally, there are less people on the coast having interest in apiculture. In the interior villages the forests may be rich or may be a combination of diverse landscape elements which include monoculture plantations (teak, Acacia etc.), scrub jungle, savanna, betta (leaf manure forests which are often heavily lopped). Our surveys and interviews with the bee keepers reveal that good vegetation with several species of nectar plants are very essential for enhancing honey production. Therefore we recommend the following:

a) ***Enrichment of coastal minor forests with bee forage plants:*** The ground in the coastal minor forests is very eroded, rocky and compact, often lateritic, or strewn with granitic boulders and fragments. The laterite formations of Kumta to Bhatkal have been destitute of good vegetation even before the British arrival in Uttara Kannada. Human impact seems to be the major reason for the general state of vegetational devastation of the coast. Once the original vegetation is destabilized through cutting and burning, for repeated cultivation or cattle grazing, the torrential monsoon rains erode the exposed soils and thereafter the hot sun bake the surface creating hard lateritic surfaces. These coastal hills and plateaus at the most could support scrub or savanna and some kind of stunted semi-evergreen forests where the soil conditions are better. During the last two to three decades a good lot of these areas have been brought under monoculture of *Acacia auriculiformis*. Apiculture in the coastal villages is not all that attractive proposition in the given situation, and the bee keepers are hard to find. Some of them carry their bee boxes into the interior forested villages once the early honey, mainly of soapnut plant origin is harvested. For instance K.B Gunaga from the coastal village of Alageri in Ankola moves into the interior villages of Hillur and Yana to fix his bee boxes, from mid-February of every year, after the soapnut honey season comes to an end as the coast does not have much to offer thereafter. Likewise some of the interior taluk bee-keepers take their bee boxes to the coastal areas to take benefit of the soapnut flowering.

b) ***The importance and profitability of soapnut tree:*** The soapnut tree (*Sapindus laurifolius*) is an excellent producer of high quality honey. It is one of the earliest to flower among the notable nectar plants, coming into bloom during November-December, soon after the rainy season. The honey, esteemed medicinally due to its slightly bitter taste and less sugar and other properties, was sold for about Rs.700/kg till a year ago and fetches these days a price exceeding Rs.1000/kg. Soapnut tree grows commonly along the coastal villages. It can be grown in a variety of soils including in lateritic areas and roadsides. Many bee-keepers demanded that soapnut tree be liberally planted by the forest department in all blank areas. On a modest estimate, if we succeed in raising 100,000 trees, at the average rate of three kg of honey per tree, each kg fetching Rs.1000/- at current market prices the potential income from one lakh soapnut trees could be Rs.30 crores. Apart from income from honey, the soapnut fruit is a non-timber forest produce used in production of soap and cosmetics. The tree will provide also a good cover for the open lands subjected to high degree of soil erosion.

c) ***Need for improving the betta forests:*** The bettas are forests allotted to arecanut gardeners for collection of dry leaves and lopped green leaves from trees as manure for their gardens. Betta allotment is highest in Sirsi, Siddapur and Yellapur taluks where horticulture is most important. Most of the bettas have today heavily lopped trees; they have open canopy and poor vegetation on the ground. Good bee-keepers shy away from keeping their bee boxes inside or closer to these bettas. Therefore, we suggest here that at least one third of the betta lands be enriched with bee forage plants, and the forest and horticulture departments should provide necessary guidance to the farmers and supply saplings of these bee forage plants.

3. Government assistance for bee-keepers: The Government may help bee-keepers with necessary equipments than with cash subsidies. The Government assistance may also include enrichment of bee flora in the village areas and the forests around, by planting such species along roadsides, public premises etc. Free guidance programmes should be taken up to help rural entrepreneurs to take up bee keeping, for purification and packaging honey and in disease prevention and control. Subsidies and loans are to be restricted to the functional boxes only so that Government aid is not misused.

4. Guidance for honey hunters: Honey hunting in the wild often happens to be destructive exercises. The bees are driven away with fire and smoke and the entire hive pulled down and squeezed to extract honey causing destruction of thousands of eggs, larvae and pupae. The honey hunting in the wild should be using sustainable methods. The Village Forest Committees and bonafide forest dwellers like Kunbis, Kumri Marattis, Karivokkaligas, Siddis etc. alone should extract honey on sustainable basis from only areas designated for the purpose by the Forest Department, leaving behind sufficient stock of untapped beehives so as not to decimate the genetic stock of wild bees very necessary for infusing resistance into the domestic bees, as the bee boxes are often colonized by capturing wild bees of the species *Apis cerana.* The Forest Department may periodically take stock of the situation and decide to close certain area of forests to honey collections, which are under threat from overharvests, until such areas recuperate well. The bonafide honey collectors may be provided with protective uniforms and awareness on scientific collection and processing techniques.

5. Bee colony heritage trees: The bees, especially *Apis dorsata,* prefer certain large trees such as *Tetrameles nudiflora* for establishing their colonies. Any such tree with more than ten colonies may be considered for declaration as a 'heritage tree' under the provisions of the Biodiversity Act-2002 of Government of India.

6. Prospects of beekeeping in mangroves: Mangroves play an essential role in maintaining a healthy coastal environment by providing protection for aquatic species, functioning as a habitat for a variety of terrestrial fauna, in improving coastal protection and acting as a source of nutrients that sustains many complex food chains. These swamp forest communities are often employed in promoting shrimp cultures.

The mangroves are good producers of honey. Forest Survey of India (1999) estimated about 487,100 ha area under mangroves in the country. The Sundarbans, which has largest area under mangroves, has been a major production centre for honey. It accounted for 111 tons of honey production, which was 90% of the total honey from mangrove areas of India. *Phoenix–Excoecaria* combination of trees associated with mangrove swamps offer ideal habitats for honey comb formation in the wild in the Sundarbans, accounting for maximum number of combs per unit area. *Rhizophora* and *Avicennia* (*A. alba* and *A.officinalis*) also accounted for good number of combs. *Aegiceras corniculatum* and several mangrove associates are useful for honey production. Area under mangroves is steadily under rise in Uttara Kannada during the recent years due to consistent efforts made by the forest department. If more attention is paid to the planting of nectar producing species more people from the coast will be benefited by bee keeping.

7. Importance of organic honey production: The demand for organic honey is on the rise in developed countries. Honey production from intensive agricultural landscapes, because of usage of chemical pesticides and fertilizers cannot be termed as organic. Bulk of Uttara Kannada's honey production probably would fall in the organic category on account of the cattle and forest dependent farming practices. The district needs to capitalize on this and intensify production of organic honey for export, supply to pharmaceutical companies and for domestic consumption.

The genera like *Syzygium, Terminalia, Strobilanthes*, *Holigarna*, *Sapindus, Vateria, Lagerstroemia, Phyllanthus, Areca*, *Cocos, Caryota, Crotalaria, Dalbergia, Pongamia, Pterocarpus, Xylia, Strychnos, Careya, and Vitex* are some of the very important genera as food sources for honeybees in Uttara Kannada. Honeybee species have their own preferences for plants as habitats. This host specificity is determined by branching pattern, flowering phenology and provision of holes and crevices in tree trunks. *Apis cerana* (cavity nesting bees) require cavities and hollows in big trees for nesting. *Apis cerana* are considered as photophobic bees and prefer shaded parts for colonization. In our study areas we could observe its nesting sites in trees like *Caryota urens, Careya arborea, Terminalia paniculata, Lagerstroemia microcarpa* and *Vitex altissima. Apis dorsata* is a more of a light loving bee and in our study area 21 tree species were associated with its colonies, in addition to the giant rock formations of Yana and some large buildings. *Tetrameles nudiflora*, a very gigantic soft wooded, deciduous tree is a preferred nesting site for this bee and several large sized hives are often seen on the same tree. *Trigona iridepennis,* the stingless small bees, a minor source of honey ('misri' honey of medicinal value) was associated with seven tree species in our study area. In addition it also occurs in the holes and cracks of old buildings.

We make here certain essential recommendations for promotion of bee-keeping:

I. Training programmes

a) To spread awareness on the importance of honeybees and bee-keeping
b) On using wild colonies from the jungles for domestication through traditional expertise.
c) On populating new boxes in potential beekeeping regions.
d) To regulate the number of queen bees per box and screening for healthy queen bees
e) For awareness on ideal time for setting up new colonies
f) On the importance of shifting bee boxes from one place to other, say for instance from the coast to the interior and *vice versa* so as to maximize production taking benefit of the different times of flowering.
g) Training in dis-infestation and disease control
h) Training in protection of bee-hives from predators
i) On the importance of providing supplementary food to bees during lean periods and on the composition of such supplementary food
j) Creating awareness on pollination benefits
k) To bring home the benefits of organic farming for healthy bee keeping, for health of humans and ecosystems and for enhancing market value of farm products.

II. The role of the Forest Department

The Forest Department, controlling over 60% of the land area of the district (>6000 sq.km) has to play major role if bee-keeping is to be nurtured as an important enterprise. The departmental involvement can be envisaged as:

a) Designing the vegetational composition of the forests in the immediate vicinity of villages so as to give premium to specially bee-forage plants
b) The department to take lead in raising bee forage plant species, particularly nectar trees (an indicated in the list included in this report) in its nurseries.
c) The coastal minor forest belt on lateritic terrain also to be enriched with bee forage plants
d) Soapnut trees (*Sapindus laurifolius*), indigenous to the region, needs to be raised in lakhs for planting in a variety of habitats, including household gardens, considering the high value of soapnut honey (Rs.700-1000/kg). The trees can come up even in degraded and rocky habitats and can also provide other benefits, such as shade, water and soil conservation, leaf litter for organic manure etc. in addition to the soapnut which has market value as NTFP.
e) Many species recommended for bee-keeping has also NTFP value - for eg: *Adhatoda vasica, Alangium salvifolium, Strychnos nux-vomica* (medicinal), *Mangifera indica, Spondias mangifera, Tamarindus indica* (food value), *Emblica officinalis* (food and medicine) *Canarium strictum, Vateria indica, Anogeissus latifolius, Acacia catechu* and *A. nilotica* (resins and gums), *Pongamia pinnata* (biofuel and pesticide) and so on.
f) Forest Department to permit bee keepers to keep their bee-boxes in the peripheral forests of villages and also allow them to shift their bee boxes to other similar forest

areas without affecting National Parks, Sanctuaries and other such specially protected areas.

g) The department to take lead in improving betta forests for furtherance of bee-keeping.
h) Certain special types of large trees such as *Tetrameles nudiflora*, on which numerous large bee-hives of *Apis dorsata* may be found to be declared as 'Heritage Trees' under the provisions of the Biodiversity Act 2002, or under any other suitable category to ensure their continued protection.
i) On realizing the potential of mangroves in production of rare kinds of honey it is recommended that the department increase the population of nectar producing mangroves like *Avicennia* spp. *Excoecaria agallocha* etc.

III. Government assistance for bee-keepers

a) People aspiring to take up bee-keeping may be given training and equipments at subsidized rates. On proper utilization of infrastructure granted the entrepreneurs of especially poorer class may be given more assistance.
b) Government to help the entrepreneurs with testing and certification of the genuineness of honey produced so as to fetch good market price for them.
c) Guidance for forest honey collectors on sustainable and safe harvesting methods.
d) Importance of organic honey production.
e) Government assistance for honey quality improvement through making available moisture reduction technique.
f) To make available ready expertise to deal with bee diseases.

IV. General recommendations

a. Honey being a nutritious food the local populace in the honey producing belt should get benefit of honey production. It is recommended that at least once a week, some sweetmeats prepared using honey, may be included in the mid-day meal programmes of the schools.
b. Contract system for collection of wild honey may be dispensed with as the contractors have only short term interest and look for maximization of profit using non-sustainable methods. The VFCs and forest dwelling traditional communities be empowered to do honey collection. The honey should be marketed as 'forest honey' after due purification and dehydration by the Government agencies such as the local beekeepers society. Reasonable price should be paid to the honey collectors by the societies.
c. Honey packaging to be done scientifically and in attractive cartons/bottles so as to fetch good returns for the producers/collectors. Honey from forested villages should be marketed as 'forest honey' so as to fetch better prices
d. Bee-keepers be trained in hygienic collection of royal jelly, bee-pollen, propolis etc. which have much higher value and demand in foreign countries, for pharmaceuticals and as health products.
e. Efforts should be made to preserve nesting sites of honey bees in the wild, as the wild bees constitute important germplasm for the domesticated ones. Branches of certain large trees in the forests and domestic gardens, tree holes, termite mounds etc. are used by bees for build their hives.

1.4.0 TOURISM PROMOTION FOR DISTRICT'S PROSPERITY

Uttara Kannada has enormous undertapped potential for tourism development. Tourism income can be raised manifold times through proper planning, without compromising the district's ecology, culture, history and lifestyles. The tourism policy should aim at essentially:

- ***Development of international tourism*** by opening opportunities for appreciation of Uttara Kannada's history, culture and environment in the background of Karnataka's, especially Western Ghat's history and culture.

- ***Developing understanding of other people's customs and cultures*** among the locals is very essential for success of international tourism

- ***Employment, income and foreign exchange generation*** are integral to tourism growth

- ***Helping diversification of economy*** can be achieved through tourism promotion while preserving near pristine conditions for varied ecosystems. Tourist attractions like forests, natural sceneries, waterfalls, sea beaches, mangroves, sanctuaries and national parks, ethnic cultures, arts and crafts, places of pilgrimage, indigenous health care and medicines etc., if judiciously utilized for tourism, both domestic and international, can benefit varied sections of the society.

- ***Redistribution of income*** especially from urban rich to the rural poor will be facilitated through promotion of nature studies, providing opportunities for understanding local cultures, history, arts and crafts, for treatments under local systems of medicine etc.

- ***Sensitizing local youth on the importance of conservation and appreciation*** of Uttara Kannada's scenic beaches, estuaries and mangroves, splendid waterfalls, sacred forests, sanctuaries and national parks, pristine rivers and springs, Myristica swamps, endangered plants and animals etc. can lead to tremendous opportunities for better livelihoods through tourism growth.

- ***Efforts required for betterment of roads, infrastructure:*** The poor state of major roads has adverse impact on tourism development.

- ***Need for short term research for preparing masterplan for developing thematic tourism*** is a critical necessity. Practically no studies are made about the interests of tourists visiting the district, whether they arrive to study about culture, archaeology and history, or appreciate nature, wildlife and birds, learn yoga, fine arts or music, or for pilgrimage or health promotion etc. No training programmes are arranged in details regarding food and accommodation of foreign visitors for especially small scale entrepreneurs; nor do we have any well trained tourist guides. Theme based tourism development can raise income for the district manifold while preserving its cultural and ecological integrity. We propose twelve months as the time required for preparing such a master plan for the district.

1.5.0 SUSTAINABLE ENERGY ALTERNATIVES

- **Solar Energy**: Abundant solar energy in Uttara Kannada can meet the regional lighting and heating energy requirements through decentralized solutions such as Rooftop solar PV system. It directly converts solar energy into electrical energy (DC) using photoelectric effect which can feed the lighting and heating sources of the household. Majority of the households require rooftop area less than 250 m^2 to meet the electric energy demand using solar PV system. Around 26% (350) of the places require rooftop area less than 100 m^2 and about 27% (363) places need rooftop area ranges from 100 to 250 m^2. Hence more than 54% of the places require rooftop area less than 250 m^2 to meet the current domestic electricity consumption. Solar potential analyses reveal that 5% of roof top is required to meet the domestic electricity demand and 10% of wasteland would meet the irrigation electricity demand.
- **Improved stoves**: End use efficiency experiments conducted in some households of Masur village (based on 4 days experiment) of Kumta taluk show that there is scope for saving 27–42% of energy by switching to improved devices, which are designed to maximise combustion rate (of fuel, ensuring the presence of sufficient oxygen), radiant heat transfer (from fire to vessels, keeping them as close to fire as possible), convection (to pass maximum hot gas over vessels, reducing drafts), conduction (heat is concentrated near the vessels by using insulating material for the stove) and user satisfaction (with user friendly design).
- Fuel wood required for domestic cooking and water heating is 1,202,615 tonnes, and the agriculture residues is about 367,861.44 tonnes (fuel wood equivalent). Thus, the total fuel wood required for the domestic sector is about 1,570,477.07 tonnes.
- **Energy plantations** raised on degraded lands will help in improving the ecological status of the region, provide biomass feedstock for rural bioenergy programmes and also help in meeting the domestic fuel wood demand. With appropriate species mixes, it also provides fodder for livestock, leaves for biogas and other valuable tree products. In the villages having higher bioresource potential, sustainable usage should be emphasized to maintain their status as the resource available is almost equivalent to the current demand. This has become imperative owing to the alarming population growth, mainly in the coastal zone. Active participation of the rural people in bioenergy programmes is required for its successful implementation. In the bioresource deficient zones (villages in the coastal, mundgod and Haliyal taluks), forest stocking can be improved by afforestation of the degraded lands, popularizing social and community forestry.
- **Biogas:** The livestock population of cattle, buffalo, sheep and goat were collected from the state veterinary department. The quantity of dung yield as per the field experiments, varies from region to region. It was taken as 12–15 kg/animal/day for buffalo, 3–7.5 kg/animal/day for cattle, 0.1 kg/animal/day for sheep and goat. The total dung produced annually was calculated by multiplication of the animal dung

production per year and the number of head of different animals taking animal residue yield for each village. Assuming 0.036–0.042 m^3 of biogas yield per kg of cattle/buffalo dung, the total quantity of gas available was estimated. The energy demand for cooking for each village was computed. Resources (animal residues) are available in 949 villages to implement biogas programmes successfully.

RECOMMENDATIONS FOR SUSTAINABLE ENERGY DURING 21ST CENTURY

Solar energy based generation seems promising and environmental friendly option to meet the growing demands. India is blessed with the good solar potential and harvesting this potential would minimize the environmental implications associated with the fossil fuels. Solar PV technology has the potential to meet the domestic and irrigation demands in the decentralized way. Appropriate policy incentives might help in the large scale deployment of solar devices at household levels. There is a need to focus on energy efficient decentralized electricity generation technologies with micro grid and smart grid architecture, which would go long way in meeting the energy demand. In this regard, suggestions are:

1. Electricity generation using SPV and CSP technologies would bridge the demand supply gap as India receives abundant solar energy of more than 5 kWh/m^2/day for about 300 days in a year. The adequate potential with mature technologies and apt policy incentives would help in meeting the electricity demand in a region. Few houses in Uttara Kannada has been using Solar PV for the last 4-5 years (Muroor Kalabe village, etc.)
2. Roof top based SPV would help in meeting the household energy demand in rural as well as urban households. Rural household require about 70-100 kWh per month and to meet this requirement 5-6 m^2 rooftop is adequate (at η=10%, and insolation of 5 kWh/m^2/day) and the average rooftop in rural locations in Karnataka is about 110 m^2 and about 115 m^2 in urban localities.
3. Adequate barren /waste land is available in Karnataka as the available waste land is about 7% of the total geographical area less than 1% area is sufficient to generate electricity required for irrigation and domestic sector through SPV installation.
4. SPV installation in waste/barren lands supports decentralized electricity generation and enables multi utilization of the area for activities such as grazing, livestock farming, etc. About 45 million households are still not electrified in India, which have potential to generate enough electricity from rooftop SPV installation; rooftop SPV installation would be the revolutionary method of rural electrification.
5. Rooftop SPV installation is the most adoptable technology in highly populous countries like India, where the monthly electricity consumption of a household ranges from 50 to 100 kWh. Encouragement for roof top SPV based electricity generation rather than centralized generation through incentives, financial aid for initial installation and tax holidays.

Supply of electricity to households in remote areas entails investment on infrastructure apart from transmission and distribution (T&D) loss of electricity. Assessment reveals that T&D loss in Karnataka is about 19.5% resulting in the loss of 7,210.16 GWh (annual demand is 36,975.2 GWh in 2010-11) of energy. Cost of energy loss ranges from Rs. 1,514.13 crores (@ Rs. 2.10/kWh) to Rs. 5,047.11 crores (@ Rs. 7/kWh) depending upon the tariff (in the respective state).

Decentralized generation of electricity through SPV would help in meeting the respective household's electricity demand apart from the removal of T&D losses. Generation based incentives (GBI) would herald the decentralized electricity generation, which would help in boosting the regional economy. Considering the current level of T & D losses in centralized system, inefficient and unreliable electricity supply, it is necessary to promote decentralized energy generation. Small capacity systems are efficient, economical and more importantly would meet the local electricity demand. The incentive could be

- Rs. 4.00 per unit for first five years (comparable to **subsidies granted to mini hydel projects, the power purchase at Rs 3.40)** and Rs. 3.50 for the next two years for the electricity generated from roof top solar PV.
- Buyback programmes for the electricity generated at household level and in micro grid - GBI of Rs. 5 to be provided for electricity generation (< 5 kW) feeding to the grid by SPV.
- Free solar home lighting (with LED lamps) under the Chief Minister's Solar Powered Green House Scheme (CMSPGHS), Government of Karnataka or JNNSM (Jawaharlal Nehru National Solar Mission, Government of India).
- All street lights and water Supply installations in local bodies to be energized through solar power (or hybrid mechanism) in a phased manner
- Install solar rooftops in all new government/local body buildings - implementation of solar rooftops could be in a phased manner in the existing government/local body buildings, etc.
- Exemption from payment of electricity tax to the extent of 100% on electricity generated from solar power projects used for self-consumption/sale to utility to be allowed for at least10 years.
- Fixing of standards for quality installation.

6. Commercial lighting in advertisement boards should only be from SPV panels. Complete ban on usage of grid electricity for these purposes.
7. Impetus to energy research through generous funding for the R and D activities to ensure further improvements in the grid, technologies, two way communication energy meters (to connect rooftop generation with existing grid), efficient luminaries' production, low cost wiring, switchgears, appliances, etc.
8. Energy education (focusing mainly on renewable energy technologies, end-use energy efficiency improvements, energy conservation) at all levels. School curriculum shall include renewable energy (RE) concepts.

9. Awareness about energy independence and the necessity of RE sources in the present gloomy energy scenario to the consumers
10. Education and awareness about applications and importance of renewable energy sources.
11. Capacity building of youth through technical education for installation and servicing of SPV panels.
12. Diploma /ITI courses with hand-on training on renewable energy technologies in all taluks
13. Setting up service centers in block development offices to meet the requirement of service support for RE technologies (Solar, biogas, energy efficient chulas, etc.).
14. Periodic revision of FIT structure and incentives to encourage the consumers.
15. Mandatory one week capacity building / training programmes to all bureaucrats and energy professionals at the initial stages of the career. This is essential as lack of awareness/knowledge among the bureaucrats is the major hurdle for successful dissemination of renewable energy technologies in India.

1.6.0 LAND USE AND LAND COVER

Land use analyses indicate that about 105782 ha. (10.29%) is released for various activities (Power projects, refugee camp, industry, etc.). Consequent to this, about 158253 hectares of forest land has decreased with the increase in built-ups, cropland, and plantation. This is evident from the reduction of evergreen-semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analysis reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (20.63 to 1.52). Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human–animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people.

1.6.1 IMPACT OF FOREST DEGRADATION/MINING/ QUARRYING: CASE STUDIES

Hilly terrain of rainy tropics is often very fragile. Deforestation, mining or quarrying can be very dangerous affecting hydrological conditions, soil and rocks. The management of the hilly terrain of Uttara Kannada has to be very carefully done due to following reasons:

Scenario-I

- The Western Ghats proper, in normal conditions, has normal rock/soil profiles; i.e. parent rock below transforming into fractured rocks above, which on continued weathering and interaction with the plant cover on surface, turn into smaller and smaller and fragments and ultimately into organic matter rich soil covered with forest.
- The removal of forest cover or major changes in forest cover exposes the soil to heavy seasonal rains creating severe erosion, leaving behind fragmented rocks, the soil remaining only in the crevices and gaps between them. These soil pockets may be covered with secondary vegetation of woody plants and seasonal herbs.
- Fire in secondary forests can destroy this vegetation also and expose the barren rock-soil surface to heavy rains and hot suns making it difficult for natural forests to re-establish.
- Higher the degree of slope on these hills more will be the the proneness to erosion and landslides.
- Continued human pressures including cutting of hill bases, quarrying for soil or rocks, road making etc. through deforested hilly lands can be disastrous because of the dangers from landslides especially during heavy rains.
- Such landslides take place due to slope failures when the exposed soil between fragmented and fractures rocks absorb water, and expand causing rupture of the hill and slide of rocks and soils down the slopes.

Most of the coastal hills of coastal Karwar belong to the above kind.

Scenario-II: When Western Ghats were formed about 88-90 million years ago, with the separation of Madagascar from Indian west coast, the western sides of the Ghats were high with more of vertical escarpments. Rainfall through millions of years would create considerable erosion of top soil and fragmented rock pieces from the top of the escarpments, these getting deposited along the west coast. These deposits were also carried down hill slopes by ancient west flowing rivers. In many places along the west coast these deposited material became secondary hills and plateaus, not exceeding 100 m in height anywhere. In the course of time, through millions of years, forests would develop on surface of these secondary formations creating stability for them. Such hills characterise part of the coast of Ankola, most of Kumta, Honavar and Bhatkal coastal terrain.

When agricultural communities settled along the coast, beginning around 3000 years ago forest clearances started along the coastal low hills and plateaus of deposited material for shifting cultivation and cattle grazing. The exposed soils would be washed off by seasonal rains leaving behind rock pieces cemented together by iron or aluminium oxides giving rise to the laterite. Less exposed laterite has cavities filled with soil. In more exposed laterite the trapped soil get washed off leaving behind large pores and tube like canals. This laterite of low coastal hills have become important building materials of present times in Uttara Kannada.

If the exposed coastal hills are covered with hardened lateritic surface there is stability from landslides. In places where laterite is not fully formed, due to such soil mounds situated within water bodies or surrounded by water bodies. If these hills are covered with forest vegetation there is no threat of their collapse or landslides. If the forests are cut the exposed soil of the hills, of clayey nature, absorb considerable quantity of water during heavy rains, expand and burst creating dangerous mudslides.

1.6.2 EFFECTS OF MEGA PROJECTS

Projects include hydel projects, Seabird Naval Base, Kaiga nuclear plant, Konkan Railway, Gersoppa dam, etc., which accounted to 26186 hectares. Additional 5508 ha of forests were used for accommodating displaced families. Apart from these, a colony was set up to accommodate Tibetan refugees, encroachment of forests for agriculture, mining have contributed towards the decline of forests. Encroachments of 2824.8 ha forest lands prior to 27.04.1978, were regularised subsequently (Forest Department, 2000-01). Decadal change analyses of forest cover reveals the decline of forest cover in the district by 1763 sq.km (during 1973-1989), 444 sq.km (during 1989-1999) and 1176 sq.km (1999-2010). Impacts due to the developmental projects (for example: hydro power projects) are:

- **Changes in land use and water availability in streams:** The land use and hydrological analyses show the linkage between land use pattern and hydrology in the basin. The catchment area with good evergreen to semi-evergreen vegetation cover shows a high stream discharge while the sub-basin with plantation and agricultural activities shows seasonal streams with low stream discharges. The stream flow results reveal that the tributaries in the catchment with evergreen to semi-evergreen vegetation discharge more water than the tributaries in the human altered catchment (with monoculture plantation, agriculture, etc.). Also, the streams are perennial in the former catchment compared to the later (seasonal streams). The rainfall data show significant variation with the changes in land cover in sub basins.
  This indicates that the land-use pattern in the watershed/catchment plays a major role in the health of the aquatic ecosystem, which is evident from the quantity of water yield in the catchment as well as quality (water and soil). The occurrences of perennial streams highlight a vital relationship between the ecology and hydrology. This result could be a pointer to the decision-makers considering a severe water stress faced in various parts of the Country. Hence, forest conservation and management activities should incorporate multifarious objectives of improving water production, both by quantity and quality through an appropriate land use planning involving the restoration of pristine forests.
- **Salinity changes in the estuary:** The most notable impact was lowered salinity in the estuary, which was less than 0.5 ppt in most parts of it indicating almost fresh water conditions. This is due to continuous release of fresh water after power generation from the hydel projects. In the Kali estuary also the salinity conditions are in the middle to low range because of continuous water releases from power projects. But

being bigger in size the salinity reduction in the estuary is not as much as in Sharavathi. What are the impacts of salinity dilution?

- ***Mangrove species decline:*** Most high salinity tolerant mangroves have almost entirely vanished. Medium salinity tolerant mangroves have declined. Very low salinity tolerant mangrove tree *Sonneratia caseolaris* was widely present.
- ***Fish species decline:*** Only 43 species of fishes were found in the estuary against nearly 90 species from Aghanashini estuary without any power projects. Kali estuary, next only to Aghanshini in area, had only 58 recorded fish species.
- ***Income reduction from fisheries:*** Whereas catches from Aghanashini estuary nearly amounts to Rs.43.51 crores annually, at current market prices, the total catch was worth only Rs.1.29 crore/year. In Kali it was better with about Rs.13 crores.
- ***Fishermen employment – reduced carrying capacity:*** Aghanashini had estimated 6139 fishermen, and 14,97,200 fishing days/year. Sharavthi estuary had only 283 fishermen and 41,420 fishing days/year. Sharavathi had only 31 fishing days/hectare/year against 527 days/ha in Aghanashini. In Kali estuary the situation was better than in Sharavathi (109 fishing days/ha). In Gangavali estuary, much smaller one fishing days/ha/year was 441. Obviously the hydro-electric projects in rivers can destroy estuarine productivity and reduce carrying capacity of estuarine ecosystem.
- ***Disappearance of edible bivalves from Sharavathi estuary:*** Edible bivalves (clams and oysters) were gathered from Sharavathi estuary until about three decades ago. Continuous release of fresh water from upstream dams caused all the edible bivalves to disappear. The livelihoods dependent upon bivalve harvesting, which employed large number of women, is no more existing presently. On the other hand in Aghanashini estuary about 22,000 tons of edible bivalves were collected in 2008, worth Rs. 66 crores at current market price. In the Kali estuary, even with dams the salinity was in the medium to low range, which made shift in bivalve area more towards the estuarine mouth and their occupation zone has also got reduced. Here too, obviously, bivalve quantity available would have reduced. Seven kinds of edible bivalves were noticed in Kali, Gangavali and Aghanashini estuaries. Sharavathihad only one species, *Polymesoda erosa*, tolerant of fresh water conditions.

Recommendations

Uttara Kannada, especially the rivers with hydro-electric projects, have suffered severely on account of salinity changes. The carrying capacity of the estuaries of those rivers, in terms of fish diversity and quantity and number of fishing days/year have reduced substantially creating widespread unemployment among the fisherfolks. The edible bivalve collection also suffered seriously in Kali and totally collapsed in Sharavathi. We therefore recommend to safeguard the remaining rivers and estuaries from further human impact due to execution of mega projects affecting their ecology. It should be borne in mind that the fisherfolks who lost livelihoods are not compensated in any way.

Region specific effective land use planning has been suggested to control fragmentation taking into consideration issues of deforestation. The suggested measures emphasise the regeneration of natural forest cover in the district across all divisions. This requires motivation, conviction, and commitment between two major stake-holders: the forest fringe dwellers as well as the officials at Forest Department. This needs building up an atmosphere of mutual trust and understanding between them for a strong intention of improving forests, which will in-turn improve quality of life of outlying population.

1. Building of solutions that are specific to address fragmentation on regional levels such as at watershed level. Restoration of forests with native species to enhance hydrological services and biodiversity.
2. Constitution of forest protection task force at each division with the representatives of all stakeholders. Forest task force shall have representatives of VFCs (Village Forest Committee).
3. The plantation of native species, which will enhance local ecology and hydrology. Non-timber forest products (NTFP) provide livelihood to the dependent forest population. Involvement of local people in forest activities – nursery development, afforestation, extraction of NTFP will also help in the forest conservation while providing employment to local rural youth.
4. The grazing lands should be demarcated for each village and the responsibility of maintainace should be given to VFCs.
5. Minimising grazing in natural forests would help in the regeneration and make natural cover out of disturbances.
6. Establishment of seed production areas; clonal propagation of improved planting stock and use of better management practices. The use of bio-fertilizers and compost is being encouraged for their environment friendly characters.
7. Clear felling should not be permitted in the intact primeval forests. Selective logging may be allowed by demarking the productive zones followed by reforestation. This approach helps in preserving the structure of an ecosystem with functional aspects and biodiversity.
8. Capacity building of local community in the conservation and management of forests. Local communities and local foresters joint management would help in curtailing illegal logging and encroachments.
9. Wildlife conservation and habitat improvement with eco-development activities in and around Protected Area is to be taken up.
10. The protection phase needs more attention and should be made more effective to avoid any damage to the existing plantation.
11. E-versions of forest boundaries in handheld devices (mobile) of forest guards would help in the effective protection.
12. Availability of geo-referenced forest boundaries of the defined jurisdictions on internet would also help NGO's taking prime role in the forest conservation, which would help in minimizing violations by vested individuals.
13. Management of forests through scientific research findings will strengthen conservation efforts. Operational protection and comprehensive implementation as per the site specific

plan (especially with reference to selection of site and nature of species) will ensure increased survival percentage and improvement in the condition of plantations.

14. Conservation of forest eco-systems and the environment of ecologically fragile zones with special emphasis on estuarine and the undulating lateritic tract of the coast should be taken up as early as possible. Socio-economic development of forest fringe population in for conservation of forest through available plans. The training should be given through VFCs on collection of NTFP (Non-timber Forest Products), application of bio-fertilizers. Employment generation for the disadvantaged section of the society, particularly women, SCs/STs and land less rural labors by implementation of Joint Forest Management of the forest patches.

1.7.0 NATURAL DISASTERS

Large scale landslides involving human casualties and notable losses to property were practically unknown in Uttara Kannada district situated towards the central Western Ghat-west coast region of Indian peninsula. A rethinking has set in, however, following a major disaster in early October, 2009, when following rainfalls of unprecedented intensity for the period, over 20 landslides happened during a single day in Karwar taluk, in which 19 people were buried alive in a single locality itself, and in other places the residents had providential escape due to marginal shifts in the actual locations of slope failures from human habitations. That the threat for future is at large can be deduced from the recurrence of a rockslide hitting a running train during the rains of 2010, killing one person and injuring others. Yet another hillside collapse happened in the outskirts of Kumta taluk, and the ground below being sparsely populated no casualties happened.

Development to be limited to carrying capacity: Karwar with several major projects such as India's largest naval base, Kaiga Atomic Plant, commercial port and a fisheries port, offices and several more establishments appears to be transgressing its ecological carrying capacity. The authors are presently engaged in a project estimating the ecological carrying capacity of Uttara Kannada district, and are expected to formulate specific measures for safeguarding ecological stability of the region as well as recommend developmental projects that are compatible with the rich biodiversity and ecological fragility of the region.

Recommendations

1. **Planting of native vegetation on hilltops and slopes.** The roots of the native vegetation, especially of certain specially chosen tree species, can act as good soil binders, thereby providing slope stability. The removal of trees (with deep tap roots) and subsequent taking over of secondary vegetation, planting of cashew trees on the Zariwada hill by removing earlier natural tree cover, most of them with shallow roots has reduced the soil binding properties.
2. **Restoration of natural drainage network.** Alteration in hydrological regime due to changes in drainage network consequent to deforestation - Inappropriate locations of human habitations on the first and second order streams in Kadwad has also hindered the water movement. Heavy pressure of rain water within the hill removed all the

blockages on the way – as evident from mudslide and collapse of houses (in Zariwada)

3. **Discouraging monoculture plantations**– the land given to cashew plantations in the Kadwad hills should be taken back and the afforestation has to be carried out with the native species of flora according to suitably designed planting programmes.
4. **Immediate banning of large scale illegal quarrying of granite stones and mineral mining** considering the hazards proneness of the region (Karwar) and presence of sensitive pockets (Naval base, Kaiga nuclear plant, eco sensitive Anshi-Dandeli tiger reserve). Weathered granites on the hills and weakening of soil due to excessive rains have triggered the landslides near Binaga, National Highway.
5. **Banning soil and rock mining on the hills-** Landslide prone areas should not be leased out for soil or stone removal. All illegal mining and quarrying have to be stopped
6. **Improving drainage connectivity.** The collective rainfall of many days has enhanced the pore water pressure. This with lateral pressure due to swelling of oversaturated clay rich horizon has set the driving force resulting in burial of houses and humans displacement and destruction of houses and loss of properties (at Zariwada, Kadwad).
7. **Need to investigate the suitability of human habitations in regions prone to landslides.**
    i. The Konkan Railway track connecting Karwar town with Goa and other places passes through this Zariwada paleo-river valley and also crosses the lineaments. The vibration generated by movement of trains is also suspected to have developed the cracks on hill tops resulting in the loosening of the soil (subsequent to soil mining reported to have taken place). Long spell of high intensity antecedent rainfall has triggered the mud slide.
    ii. Geomorphologically, the valley area was a paleo-river channel that formerly drained into the Kali River that flows in the north of Zariwada/Kadwad. The shift of the river course might have led to the formation of hills/mounds. Composition of this mound which is mainly of laterite clay further confirms the existence of paleo stream in this region. The paleo-river channel is still connected to the Kali River and the groundwater seepage into the channel increases or decreases rhythmically according to high and low tides in the River.
    iii. Soil formation for centuries on the hillocks and heavy rain might have led to the swelling of clay inside the hillocks resulting in the landslips.
8. **No large scale developmental projects particularly in Karwar taluk and ecologically fragile regions in Central western Ghats.** Considering the implementation of large number of mega projects in Karwar, it appears that the region has exceeded the carrying capacity and further implementation of any mega projects would prove detrimental to the local population. The region has already prone to hazards and could be categorized as hazard hotspot. This also emphasizes the need for carrying capacity study for Uttara Kannada district.

9. **Considering the hazard proneness of the region it is necessary to set up 'Disaster management centre (DMC)'** to assist in regional planning, management of disasters and also to assist the administration in rehabilitation measures in case of eventualities. Also, the region around 25 km radius of Karwar is seismically sensitive and also occurrence of lineaments further emphasizes the need for setting up a **seismic monitoring cell (within DMC)** in the district to assist the district administration in the predication and also mitigation measures. Disaster management centre shall house seismic monitoring cell, and shall have the state of the art gadgets to predict calamities due to natural as well as human induced causes.
10. **Naval authorities should be asked to remodel the protection wall** considering the natural drainages on priority. Construction of the protective wall by the naval authorities without any due consideration to natural drainage systems has resulted in large scale flooding of the region, which also has triggered series of landslides all along the Highway (NH 17). Removal of the protection walls at many locations during the floods, highlights the need for holistic approaches in planning and implementation of large scale projects. Many such projects have seriously impaired the ecology of the region, affected the livelihood of nature people and also have posed serious threats to the existence of local population.
11. **Shifting of all affected families** (located on the hill side) at Madibag/Zariwada to appropriate locations without affecting their current livelihood dependence.
12. **Afforestation with native vegetation** in the region considering the large scale deforestation in recent times. At present many hill tops are barren or with highly inadequate tree cover.
13. **Setting up special Uttara Kannada package to restore ecosystems –** The funding shall be from all developmental projects in the district. **Karwar taluk, in all probability, has transgressed its limits of growth, beyond the carrying capacity -** Series of landslides consequent human tragedies and property loss is the indication of the lack of integrated approaches in planning and the region has crossed the thresholds of carrying capacity. Large scale land cover changes has resulted in alterations in hydrological regimes evident from the conversion of perennial streams to seasonal streams, enhanced siltation in the catchment evident from increased sedimentation in reservoirs in recent years. The region being one among the global biodiversity hotspots call for immediate measures to restore the ecosystems. Large scale projects such as hydro power plants, project sea bird, Kaiga nuclear plants have played significant role in degradation the ecosystems which have also affected the livelihood of local people. **These projects shall also make provision to provide a recurring grant to sustain the proposed Disaster Management Centre at Karwar and also for Ecological Research in Karnataka part of Western Ghats.**
14. Considering the level of devastations in Karwar, **landslide susceptibility mapping should be carried out to delineate potential zones of instability**, particularly in areas where human lives and properties are involved. If any indication of slope instability is noticed in an area which has major risk elements, the fact should be shared with society in a proper way. This suggestion has two major implications.

i. First, with the increasing large scale environmentally unsound development activities in the region, the risk posed by natural hazard must also be evaluated. This is well-exemplified by a series of natural hazards (landslides) in the region. Considering rainfall-intensity and changes in climate / hydrologic regimes (due to global warming) stochastic relationships have to be developed to assess high-risk areas.
ii. Secondly, with the successful establishment of relationship between rainfall and landslide activity, analysis of palaeo landslides would provide insights based on the past variation in rainfall patterns. Equally, such relationships aid in predicting changes in mass movement activities based on modelled regional impacts of global climate change.

15. Apart from reforestation of barren hill slopes and hill tops, sealing of cracks, slope-grading, proper drainage measures, soil reinforcement using geo-grid and biotechnical measures have to be done. However, appropriate selection of these measures along with their design is only possible after an in-depth geological and geotechnical study of the slide area.

1.8.0 AQUATIC ECOSYSTEMS

Rivers of the central Western Ghats are unique in their geomorphology, due to the presence of ‘river capture’ in most of the rivers. When the Indian plate moved away from the Gondwana land, peninsular portion experienced an eastward tilt, which changed the pattern of drainage in many rivers. Among 4 major rivers , the western faulting led to 'river capture' and diversion of the easterly drainage to the west in Sharavathi and Kali rivers. There are abrupt drops as water falls such as Jog Falls, Unchalli, Magod through gorges and cascades of rivers flow along the upper reaches of the Western Ghats.Table 1.5 lists the threat faced by these rivers.

Table 1.5: Threats and Mitigation Measures

River Basin	Region	Problem	Remedial Measures
Kali	Dandeli	Paper mill effluent	Enforce effluent treatment by the industry (implementation of the control of water pollution, Polluter pays principle)
Kali	Ramnagar	Non-point source pollution in streams and rivers from Agriculture fields	Avoiding intense use of chemical fertilizers and pesticides
Kali	Honkon (Brackish)	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities
Bedthi	Sangdevarkoppa	Non-point source pollution	Avoiding intense use of chemical fertilizers and pesticides
Bedthi	Kalghatghi	Urban domestic sewage, non-point	Implementation of sewage treatment plant in Hubli town. Sewage should be

		source pollution	treated before letting in to the river.
Bedthi	Kalghatghi	Solid Waste Disposal in River	Setting up Solid waste disposal facility in outskirts of Hubli town.
	Manchikeri	Urban domestic sewage, non-point source pollution	Implementation of sewage treatment plant in Hubli town. Sewage should be treated before letting in to the river.
Sharavathi	Gerusoppa and downstream	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities

Recommendations:

- ***Enriching riparian vegetation*** with native species to prevent soil erosion in all river basins.
- ***Conserving the breeding areas:*** Shallow and stream joining areas are the breeding grounds of most of the fish species. In this connection, fishing activities should be totally restricted in shallow areas during June to September. The breeding area should be demarcated and these areas should be kept under continuous monitoring. Monsoon fishing should be allowed only at the central part and limited to harvest transplanted species by operating large mesh sized gill nets.
- ***Permanently stopping the fishermen migration*:** The Fisheries Department should reconsider its revenue-oriented approach in issuing the licenses to the fishermen. Licenses should be issued to the permanent fishermen residing near the reservoir, who are solely dependent on this reservoir for their livelihood. In order to reduce the fishing pressure, it is advisable to avoid migratory fishermen from fishing. Since their fishing period is monsoon, large quantities of breeding fishes are destroyed by over fishing. These fishermen are highly mobile in nature, which complicates the authorities in monitoring. This provides sufficiently large fishing ground to the permanent fishermen thereby considerably retarding the stress on the aquatic system.
- ***Strengthening the indigenous fish population***: Culture techniques for endangered species should be developed to protect and rehabilitate the endangered species taking into account the critical need to conserve genetic diversity. The native commercial fishes like *Tor khudree, Tor mussullah, Labeo kontius,* etc., have tremendous potential in commercial fishery and their population need to be strengthened by external input. Specifically in the central part of the reservoir most of the cyprinids have poor population indicating the immediate requirement of their culture.
- ***Proper introduction***: Presently it is necessary to translocate the gangetic carps to share the fishing stress on the native fishes. However there is a great ecological concern over the introduction of exotic species. In this regard, carrying capacity of aquatic environments should be well studied and the quantification of introduction should be made in order to eliminate the adverse effect on native fish fauna.

- ***Strict supervision***: Presently the department is lacking trained staff to strictly and properly supervise the fishing activity. They should be strengthened through increasing their number and proper training. This can enlighten the scientific approach in them towards fisheries management**.**
- ***Activating the Cooperative society***: It is another major necessity to activate the Cooperative Society, which is presently passive. All fishing activities should be carried out through the society. Frequent meetings among the fishermen, merchants and the departmental staff can strengthen the society. Here once again banning the temporary fishermen can simplify the task of activating the Cooperative society.
- ***Properly managed data***: There is no scientific location specific information available about fisheries. This severely affects the decision-making. Without any statistical data, it is impossible to maintain the fishery activity in healthy condition. Thus it is the prime importance to maintain at least the data pertaining to total yield statistics, species-wise yield, physicochemical analysis of reservoir water representing the entire water body, disease episodes which is very useful during any planning stage.
- ***Educating the local fishermen***: Fishermen should be properly educated about the importance of fish diversity. This can considerably decrease improper fishing practices by understanding their negative impacts on fish resources.

1.8.1 CARRYING CAPACITY OF RIVER BASINS CONSIDERING ECOLOGICAL AND SOCIAL DEMANDS

Carrying capacity refers to the maximum number of activities (biological, developmental, agricultural, and industrial, population) that can be supported over a period of time in the habitat without damaging the existing quality of life, balance of resources, ecology and productivity of the ecosystem. Ecological Carrying Capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. This provides theoretical basis with practical relevance for the sustainable development of a region. Carrying capacity of a river basin refers to the maximum amount of water available naturally as stream flow, soil moisture etc., to meet ecological and social (domestic, irrigation and livestock) demands in a river basin. Monthly monitoring of hydrological parameters reveal that stream in the catchments with good forest (evergreen to semi-evergreen and moist deciduous forests) cover have reduced runoff as compared to catchments with poor forest covers. Runoff and thus erosion from plantation forests was higher from that of natural forests. Forested catchment have higher rates of infiltration as soil are more permeable due to enhanced microbial activities with higher amounts of organic matter in the forest floor. Streams with good native forest cover in the catchment showed good amount of dry season flow for all 12 months. While strems in the catchment dominated by agricultural and monoculture plantations (of Eucalyptus sp. and *Acacia auriculiformis*) are sesonal with water availability ranging between 4-6 months. This highlights the impacts of land use changes in tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). This emphises the need for integrated watershed conservation approaches to ensure the sustained water yield in the streams. Assessment show that most Gram panchayats of Karwar and Bhatkal taluks, the Ghats of Supa, Ankola, Kumta, Honnawara, Siddapura, Sirsi and Yellapura have water for all 12 months (perennial). Gram panchayath in the coasts of Honnavara, Kumta and Ankola along with the Ghats of Siddapura, Sirsi, Yellapura and Supa towards the plains have water for 10 – 11 months, the plain regions of Haliyal and Mundgod taluks with part of Yellapura and Sirsi taluks show water availability for less than 9 months (intermittent and seasonal).

Quantification of silt yield highlights the linkage of silt yield with the land use in the respective sub-basin. Lower silt yield in sub-basins with good vegetation cover of thick forests, forest plantations, etc. The plains due to the higher lands under irrigation and are open lands, the silt yield is comparatively higher than that of other topographic regions. Strategies to regulate sand extraction are

- **Creation of No Development Zones (NDZ)**: Industries needs to be classified based on their type, and polices shall be amended upon which between 500 m to 10 km either sides of the river and CRZ 1 (Coastal Regulation Zone 1).
- **Fixing of time for silt removal**: Removal of sand be permitted between 7 AM and 4 PM
- **Fixing of sand removal location and quantity**: Based on category of river, sand removal shall be allowed only from the river bed, and no sand removal operation be allowed within 10 m of the river bank. No sand removal is allowed within 500 m from any bridge, irrigation project, pumping stations, retaining wall structures, religious places, etc. Quantity of sand extracted at particular location shall not exceed the quantity of silt yield per annum. Weighing bridges are to be fixed at identified locations to regulate the quantity of sand extracted during a year.
- **Fixing vehicle loading points**: Vehicles shall be parked at least 25 to 50 m away from the river banks, no vehicles shall be brought near the river bank. Erecting of pillars to demarcate vehicle restriction regions, beyond which vehicle should not be allowed
- **Restriction on mechanized removal**: No pole scooping or any method shall be carried out in sand removal operation
- **Restriction or ban on sand removal**: Sand shall not be removed from likely places where saline waters mixes with fresh water. Sand removal quantity per year based on scientific assessment and approval of on expert committee of district. Sustainable harvesting of sand considering the yield at point of extraction. Regions such as breeding habitat of fishes and other aquatic organisms, endemic species of riparian vegetation, and basins where ground water extraction is prevalent, are to be identified in the river basins for restricting sand mining. District collector may ban sand removal in any river or river stream during monsoons, based on the Expert Committee. Based on the acts, rules and orders made by the GOI/ state the expert committee shall prepare

river development plans for protection of river to keep up the biophysical environment along the river banks

- **Liability of District Collector**: Fifty percent of the amount collected by the local authorities shall be contributed as river management fund and shall be maintained by the district collector.
- **No construction between 500 m to 1 km from flood plain**: To protect life and property damages in cases of flash floods
- **Different stretch of rivers different regulations:** Rivers are dynamic, they come across different geomorphic, climatic, sociopolitical settings. Due to this different stretches of rivers faces different issues. Rivers where rivers originate, they are at the highest purity level which needs to be maintained as it is the source contributor for the downstream.
- **Flood Plain protection**: To protect against the damage that affects the floral and faunal diversity, intern maintaining the aesthetical and economic value of the river basins. No chemical based agriculture or fertilizers shall be used in the agricultural fields that affect the river channel polluting and affecting the ecosystem

1.9.0 VALUATION OF FOREST AND ESTUARINE ECOSYSTEMS

Forests provide various services classified as supporting services, provisioning services, regulating services and cultural services Most of these services are underestimated or not estimated and are thus undervalued in policy decisions. This paper is based on the quantification of various provisioning services from forests such as timber, fuel wood, fodder, green leaf manure, medicinal plants and NTFP. The area under different types of forest is derived from remote sensing data. Quantification of forest goods has been done based on the data compiled from the division offices of the Forest Department and micro level studies (productivity, etc.). Market prices were used for valuing the goods. The valuation of forest goods and services at micro level is expected to explore the possibilities for more effective micro level planning. This helps in integrating the environmental services with the economic goals of the region while ensuring the sustenance of natural resources and maintaining intergeneration equity.

Table 1.6: Total value of goods and services from forest ecosystem in Uttara Kannada

Services from forest Ecosystem	District Value per year (in Rs. crores)	Value of services per hectare per year (in Rs.)	Per cent share
Provisioning services	15,159	2,05,388	18.94
Regulating services	42,091	5,70,266	52.58
Cultural services	13,754	1,86,349	17.18
Supporting services	9,039	1,22,464	11.29
Total Value	80,043	10,84,466	

Gross District Domestic Product (GDDP) is about Rs. 5,978 crores with forests' goods of about Rs. 180 crores as per the district administration. The forest products included in the national income framework includes: (a) Industrial wood (timber, match and pulpwood) and fuelwood and (b) minor forest products. This includes only the recorded values by forest department and thus all other benefits from forests are unaccounted in the national income. Hence, GDDP values of the district are grossly undervalued evident from the the quantified provisioning services of Rs. 15,159 computed for forest ecosystem of the district. **This emphasizes relook at the current approach of computations of Gross domestic district product (GDDP), State Domestic Product (SDP) and Gross Domestic Product (GDP). Gross underestimation and non-accounting of natural resources and forest resources in particular are responsible for unsustainable exploitation of natural resources.**

VALUATION OF ESTUARINE ECOSYSTEMS: The provisioning services value of entire estuarine waters of Uttara Kannada is 6.85 billion Rs /year. Aghanashini make up the 79.5% (5.45 billion annually), followed by Kali 11.36 % (77.88 crores/year), Sharavathi 6.7% (45.91 Crores/year), Gangavali 2.24% (15.36 crores) and Venkatpura 0.2% (1.39 crores) respectively. The total value per hectare of estuary are Rs. 2,40,395 (Kali), Rs. 2,19,545 (Gangavali), Rs. 11,35,847 Rs(Aghanashini), 2,86,964 Rs (Sharavathi) and 55,707 (Venkatapura) respectively.

Table 1.7: Value (Rs/Ha/Yr) of the Goods and Services from estuaries in Uttara Kannada

ESTUARY	Provisioning Services	Regulating Services	Supporting Services	Information Services
Kali	2,40,395	1,839,037	369,435	122,531
Gangavali	2,19,545	2,055,250	348,256	53,210
Aghanashini	11,35,847	1,835,288	1,946,030	87,871
Sharavathi	2,86,964	1,828,300	267,706	70,541
Venkatpura	55,707	1,028,162	211,976	37,247

1.10.0 SOCIO-ECONOMIC WORTHINESS OF PEOPLE'S INSTITUTIONS AND ORGANIZATIONS

"except for cooperative sector, the Uttara Kannada district had not seen any progress because of lack of vision and willpower among the peoples' representatives" – G U Bhat

The quantitative performance of the co-operative movement of Karnataka is considered impressive compared to other states in the country. From the point of view of the number of societies, Karnataka occupies the 9th place among the states of India. In respect of working capital, it occupies the 6th place. In essence, both from the point of view of credit and non-credit co-operatives, the state of Karnataka is in a comfortable position compared with other co-operatively developed states of India.

Uttara Kannada being an environmentally sensitive and fragile district the arrival of some of the major developmental projects has created threats to ecosystems. The growth of Dandeli as an industrial town has witnessed rising pollution in Kali River. Setting up of Kaiga Atomic Plant has caused panic among the people regarding the health of local people and safety of Kali water. The hydro-electric projects in Sharavathi River, though non-polluting, have caused fall in salinity status of estuary resulting in death of many mangrove species and steep fall in fish diversity and quantity as well as total destruction of edible bivalves. Kali estuary is also affected by upstream hydro-electric projects, the results being glaring as far as edible bivalve decline is concerned. The Naval Base and Karwar Port along the shore of Karwar are expected to have adverse environmental impacts. Wetern Ghats being a biodiversity hot spot and Uttara Kannada being the most forested district in Indian peninsula the planners should aim at only non-polluting developmental programmes hereafter.

Uttara Kannada is a district endowed with tremendous natural resources, most overwhelming of which are forests and water resources, the latter in the form of Arabian Sea, estuaries and creeks, and rivers (mainly Kali, Gangavali, Aghanashini, Sharavathi and Venktapur). The interior of the district is rich in streams and springs. The maidan taluks of the district like Haliyal and Mundgod and relatively less hilly eastern portions of the taluks Yellapur, Sirsi and Siddapur are having numerous ponds and tanks. Despite the richness of natural resources the district's ecology is fragile and lands used for cultivation of seasonal crops (cereals, millets, legumes, sugarcane, vegetables, cotton etc.) and garden crops (arecanut, coconut, spices like pepper, nutmeg, cocoa, vanilla etc. and fruit crops like banana, mango, jackfruit, chikoo, papaya, pineapple etc.) constitute about 15% of the total geographical area of about 10,250 sq.km. Compared to the maidan districts of Karnataka, land under cultivation is very less and land holdings are too small. This situation has fostered through ages high degree of interdependence among the community paving the way for co-operative movement of later times. Traditional natural resource uses of people in the district were largely governed by various local community organization based regulations. People were bound by these regulations which were aimed at prudent utilization of natural resources. Adoption of the cluster (based on the availability of natural resources, networking of local institutions, etc.) approaches promotes decentralised economic development by improving the competitiveness among the sectors. Some of the industries/developmental projects suggested here as follows:

1. Agro-processing units (including cashew factories, fruit juices, jams etc.)
2. Readymade garments, Units for stitching of uniforms for police, fire service, industrial personnel, armed forces etc., Hosiery items, Units making bags, suitcases, purses, footware, belt, caps
3. IT and computer software units to be housed in multi-tier buildings on lease basis to minimise demands on land resources (Preferrably in Haliyal and Mundgod, closer to Hubli and Dharwad)
4. Dairying units for milk and milk products
5. Fibre glass moulding units
6. Cosmetics, hair oils, soaps, herbal toothpastes, tooth powder, herbal shampoos
7. Candles and agarbathis
8. Ice creams, bakerys, food processing units
9. Assembly of electronic equipments
10. Wrist watches, clocks
11. Handloom, khadi clothes; training centres for khadi to meet global standards
12. Bio-fertilizers, Cattle and poultry feeds
13. Repairs and assembly of vehicles and machinery
14. Coir products, furniture
15. Ayurvedic medicines
16. Tourism, entertainment, theatre, academies for fine arts
17. Fish canning units
18. Establishment of micro and small enterprises in villages with subsidised electricity
19. Industrial units to adopt vertical growth to minimise land requirements
20. Biotechnology units
21. Promotion of handicrafts and bamboo and cane weaving centres. Marketing support to ethnic handicrafts. Display cum sale centres for ethnic handicrafts in tourism areas
22. Nurseries for forestry species and medicinal plants for bulk supplies to even other States
23. Training institutes for skill development in various sectors
24. Training programmes for making innovative bamboo and palm leaves/ other ecofrieindly home stays for promotion of village level tourism
25. Manufacture of sports goods
26. Women run small scale units to be provided subsidiced electricity for better livelihood security
27. Educational/training institutions for all kinds of need based professional training. Vertical growth to be encouraged to minimise land requirements
28. Mangrove conservation, eco-tourism and education centre for Aghanashini estuary, Kumta
29. Government to encourage investments in employment rich, eco-friendly industries
30. No heavy industry should be set up in the district considering its ecological fragility
31. Solar energy utilisation to be made mandatory for all institutions, small, medium and large industries, government offices etc. to reduce dependence on conventional forms of energy

32. The shift in growth paradigm should be more towards service sector, predominantly eco-tourism, which has highest prospects for growth in the district.
33. Eco-friendly and study related tourism projects to be given priority clearances and subsidies
34. Waste management programmes, including energy from waste, recycling programmes to be paid greater attention
35. Implementation of strict compliances on medical waste disposal
36. Setting up of homes for care of elderly, especially in villages, by NGOs, philanthropists, service organizations etc. to be promoted by the Government
37. Centres for post-operative care, taluk-wise dialysis centres etc.
38. Setting up of physiotherapy units

RECOMMENDATIONS

- Community based forest management (**Village Forest Panchayat**) of Halkar in Kumta is found to be one of the most successful management system in the State. The Forest Department and Revenue Department should extend all possible co-operation to this VFP and project it as a model in the world.
- The formation of **Biodiversity Management Committees** is a sluggish process in the district. Wherever such BMCs are formed most do not know what the purpose is and therefore the tenure of the BMC gets past without even achieving the primary objective of preparing **People's Biodiversity Registers.** The State Biodiversity Board should prioritise villages for BMC formation and get the PBRs prepared through expert assistance, using simplified and theme-wise formats.
- Clusters of panchayats rich in indigenous varieties of cultivated crops may be brought under special attention for declaration of such areas are ***in situ*** **conservation areas** through proper subsidies to farmers organizations
- Milk producers, especially along the coast are facing challenges in getting cattle fodder which has to be brought from other areas at high cost. This situation is not conducive for making Uttara Kannada self-sufficient in milk production and in organic farming as getting farm manure for the purpose is becoming increasingly difficult. It is recommended to have village-wise fodder farms run by co-operatives of milk producers/farmers. As getting such lands are difficult wastelands, minor forests with poor vegetation etc. may be brought under **fodder production co-operatives** within the fold of **Joint Forest Management.** Unproductive/underproductive public lands are to be treated as wastelands and to be brought under community based fodder farming. More than providing loans for purchase of cows or buffaloes stress, in the present context, should be on fodder development.
- Gowli community is specialized cattle keepers, and major producers of milk and dairy products. Yet most of them are landless. The **Gowli co-operatives may be allowed open forest areas for fodder production** under joint forest management provisions.
- As honey production through beekeeping is lagging behind despite blooming prospects clusters of panchayats may be identified for integrated agriculture and apiculture development through local **co-operatives of beekeepers**. These clusters

may be aided with soft loans and subsidies for developing bee-flora, especially of trees and shrubs and seasonal herbs to promote honey production. Bottling and marketing assistance may be extended through existing co-operatives (like Kadamba for instance).

- VFC's should be assisted to promote more of NTFP species specially to provide **NTFP for processing and marketing by Women's SHGs.**
- **Kokam co-operative** may be established in the coast especially to promote kokam tree cultivation, scientific extraction of kokum fat from the seeds, purification and marketing of the same to meet the rising global demand.
- Considering the enormous potential of ecotourism development in the district **community, SHG and youth club based tourism management training** may be given for betterment of local livelihoods while also following better standards of natural resources management.
- As cooperatives, and other collective forms of economic and social enterprise, have shown themselves as distinctly beneficial to improving women's social and economic capacities. Therefore promoting cooperative organization among women is a worthy strategy for self-empowerment.
- **Revival of handloom co-operatives** is a necessity in Uttara Kannada to enhance employment opportunities especially for women. Training in handloom cloth production, garment stitching and marketing should be imparted to the local women especially in villages.
- **Promote self reliance** among co-operatives as a major step towards achieving autonomy.
- **Co-operative fish farming** in the tanks and reservoirs of specially malnadu and maidan taluks may be given serious consideration. Care should be taken not to introduce exotic fishes.
- **The clam beds of Aghanashini estuary** facing threats from over-exploitation may be brought under co-operative management of stakeholders.
- As fuel extraction from forests is a major activity in Uttara Kannada that is causing forest degradation, **clean energy initiatives through women's SHGs should be a priority activity**. This will save forests as well as ease the drudgery of especially women fuelwood collectors who are in thousands.
- Co-operatives of trained persons, especially women, for value added plant products such as **biopesticides and plant dyes**, need to be established. This is with an eye on blooming global market for organic products.
- Establishment of **solar based decentralized electricity generation with smart grids in villages under community management** will be a major step towards rural electrification

1.11.0 ECOLOGICALLY SENSITIVE REGIONS IN UTTARA KANNADA

Forests of the Western Ghats, one of the global biodiversity hotspots, have been steadily affected by human activities, especially since the introduction of agriculture. In traditional, community centered, pre-colonial land use, however, a sustainable balance was maintained between farmers and forests. This was facilitated through maintenance of a decentralized system of forest reserves, the sacred groves, in a mosaic of landscape elements which had shifting cultivation areas, secondary forests on fallows in different stages of vegetational succession, rice fields and spice gardens in valleys, and savannized lands as pastures. Network of natural water courses and swamps, covered with characteristic tree species of rarer kind would have been key feature of central Western Ghats. As historical records of Uttara Kannada testify, the pre and early colonial period up to mid-19th century was also one of richest wildlife as well. The many patches of sacred forests, often hundreds of hectares in extent, functioned as favorable pockets for persistence of several sensitive climax species of the Western Ghats, which could not easily re-colonize the fire burnt fallows and savannas. Flora and fauna distribution in Uttara Kannada is given below.

UTTARAKANNADA – HOTTEST HOTSPOT OF BIODIVERSITY: Field investigations at Kathalekan in Central Western Ghats, reveal that the forest is a mosaic of primary forest rich in relic trees like *Dipterocarpus* and *Palaquium* and a network of perennial streams and swamps sheltering *Semecarpus kathalekanensis*, *Syzygium travancoricum*, *Myristica magnifica*, *Gymnacranthera canarica* (the last three in threat categories of IUCN Red List). Persistence of these Western Ghat endemics, and relic species in this forest calls for serious attention from conservationists and forest managers to initiate programs immediately for recognizing and salvaging more fragments of such ancient forests that lie hidden amidst a sea of secondary forests. The fact that water course forests have not only rare species but also high biomass and greater carbon sequestration potential also calls for revision of forest management policies, as the innumerable stream courses of Western Ghats offer tremendous potential for carbon stocking per unit area while also bettering the hydrology of these mountains, which form the main watershed for the entire Indian Peninsula. Millions of subsistence farmers and other forest dwellers of Western Ghats can not only be partners in micro-level planning for prudent water use but also stand to gain in a big way from carbon credits for their new role as promoters and guardians of watershed vegetation. Rendering such service for mitigating global climatic change can also, same time, serve well the cause of relic forests and relic species in an otherwise much impacted biodiversity hotspot.

Ecologically Sensitive Regions (ESRs') are the 'ecological units' that may be easily affected or harmed. It is a bio-climatic unit (as demarcated by entire landscapes) wherein human impacts have locally caused irreversible changes in the structure of biological communities (as evident in number/ composition of species and their relative abundances) and their natural habitats' (Section 3 of the Environment (Protection) Act 1986 (EPA)). This approach of conservation or ecological planning considers spatially both ecological and social dimensions of environmental variables. Ecological sensitive regions with exceptional biotic and abiotic elements are being degraded or lost as a result of unplanned developmental activities. Landscapes sustainability as a basic goal for development requires comprehensive picture of the biophysical and socio-cultural information of a region and this approach provides an opportunities and constraints for decision-making and sustainable management of natural resources. Conservation by prioritisation of sensitive regions has been widely used to improve ecosystem by conservations practices. This study prioritises the regions at Panchayat levels in Uttara Kannada district, Central Western Ghats, considering attributes (biological, Geo climatic, Social, etc.) as ESR1(Regions of highest sensitivity or Ecologically Sensitive Region 1), ESR2 (Regions of higher sensitivity), ESR3 (Regions of high sensitivity) and ESR4 (Regions of moderate sensitivity).

The current research envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka –Uttara Kannada district. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. This process in due course will create an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government. Integrated Ecological carrying capacity study provides the regional planner in evolving appropriate conservation strategies for sustainable management particularly on a defined geographical area. Decision making on developmental activities, entail planning that depends upon the availability of reliable and accurate data. Data required for natural resource planning include spatial data such as, information of physiography of the area, land use, assets, etc. Geographic information system (GIS) with a capability of handling spatial data helps in the analysis and visualisation of results effectively, and aids decision making process.

Uttara Kannada district located in the central western Ghats lies between 13^0 55’ to 15^0 32‘N and 74^0 05’ to 75^0 05’E covering approximately an area of 10, 291 km^2. It forms arts of narrow Malabar where its location is almost central. The district extends N-S to maximum of 180 km and W-E to maximum width of 110 km. The Arabian sea border it on west creating a long continuous through narrow, coast line of 120km running N-S. Goa, Belgaum, Dharwad and Shimoga- Dakshina Kannada form Northern-Eastern and Southern boundaries respectively.

Western Ghats with a repository of endemic flora and fauna is one of the 34 hotspots of the world. The range of ancient hills that runs parallel to western coast of India form several ecological regions depending upon the altitude, latitude, rainfall and soil characteristics. The vegetation varies between the western escarpment, the crest with its lateritic plateaus and the drier eastern slopes. In few areas that are relatively undisturbed, the crest-line has isolated patches of unique tropical evergreen forest with open short grasslands. These forests are severely fragmented in the northern part of range, while in the south they still cover several larger stretches. The western slopes have a more moist vegetation patterns, whereas on eastern sides, drier vegetation merges into the scrubland of the Deccan-off shoots, such as Nilgiris, Annamalai in South India, form corridors between Western and Eastern Ghats. The southern ranges have higher rainfall, leading to some of the most lush evergreen forest tracks in the country. The forest of Western Ghats consists of evergreen forests, semi-evergreen forests and deciduous forests.

As a result of high variation in latitude, altitude and climate, the Western Ghats supports a wide variety of habitats and, thus, high overall biodiversity. Long periods of isolation from similar habitats elsewhere in the Indian sub-continent have led to the development of high levels of endemism, particularly within the region's moist deciduous and evergreen forests. Among vertebrate groups, amphibians exhibit the highest level of endemism (78 percent of species found in the region are endemic), followed by reptiles (62 percent), fish (53 percent), mammals (12 percent) and birds (4 percent). Of the 4,000 species of flowering plant found in the Western Ghats, 1,500 (38 percent) are endemic. The Western Ghats also contains numerous medicinal plants and important genetic resources, such as the wild relatives of various cereals (rice, barley, etc.), fruits (mango, banana, jackfruit, etc.), and spices (black pepper, cinnamon, cardamom and nutmeg). In addition to rich biodiversity, the Western Ghats is a home to diverse social, religious, and linguistic groups. The high cultural diversity of rituals, customs, and lifestyles has led to the establishment of several religious institutions that strongly influence public opinion and the political decision-making process. The presence of hundreds of sacred groves and sacred landscapes in the region bears testimony to society's commitment to conservation. The irreplaceable biodiversity and ecosystem service values of the Western Ghats are threatened by a variety of human pressures.

Biodiversity conservation, socio-economic development and sustainable management of natural resources requires information such as landscape dynamics, which helps in assessing threats as well as opportunities. Natural forest cover in the district is about 542,475 hectares, of which 25.62% are contiguous interior forests and standing biomass is about **113823** Gg. The region harbors variant rich flora, fauna and conservation habitats.

Uttara Kannada district was divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2. Grids are ranked based on an aggregate weightage metric score considering the information related to spatial extent of forest cover, extent of interior forests, occurrence of endemic flora and fauna, presence of conservation reserves, standing biomass, annual increment of biomass, geo-climatic parameters (slope, altitude, rainfall), estuarine diversity and productivity and presence of forest dwelling communities. Grids were ranked as ESR 1 to ESR 4 depending on the score. Ecological sensitive regions (ESR) at panchayat level / disaggregated levels suitable for local level planning (implementation of Biodiversity act, 2002) were delineated by overlaying spatial layer of panachayat. Uttara Kannada has 209 panchayats with the enactment of the 73rd Constitutional Amendment Act to strengthen the grassroots democratic processes. Among these, 102 panchayats are in ESR 1, while ESR 2 has 37 panchayat, ESR 3 has 33 and ESR 4 has 37 panchayats. ESR 1 and ESR 2 are most ecologically sensitive regions of the district. The degradation of these areas will have irreversible impact on the ecology, biodiversity and sustence of natural resources. Regions under ESR 1 and 2 are "***no go area***" for any developmental activities involving large scale land cover changes. ESR 2 have ecosensitiveness similar to ESR 1, and has scope to attain the status of ESR 1 with eco-restoration measures (as some pockets are degraded). ESR 4 are regions of moderate sensitivity, wherein sectors such as agro processing, information technology (IT), and such environment friendly sectors be permitted. Suggestions regarding ESR are:

1. Restrictions on large scale land cover changes;
2. Encouragement to organic farming;
3. No monoculture plantation of exotics like Eucalyptus, Acacia, etc.;
4. Extraction of medicinal plants only with strict regulations;
5. Ban on hazardous or toxic waste processing units;
6. Protection of high altitude valley swamps and water bodies;
7. Restoration of land cover through appropriate catchment area treatment plans of hydroelectric and major irrigation projects to improve their life span by reducing silt yield in the catchment;
8. Setting up fodder farms to support local livestock population;
9. Ban large scale mining;
10. Controlled quarrying and sustainable sand mining;
11. Involving education institutions to document biodiversity in the neighbourhood (village level);
12. Eco clubs at all schools and students to take part in environment monitoring (part of curriculum);
13. Environment profile indicators be worked out by Research institutions, NGOs along with local communities;
14. Setting up agro processing industries, cottage industries to support local livelihood;
15. Collection of NTFP through local people (complete removal of contract system);
16. Development of forest nurseries of local species through the active participation of local villagers;
17. Incentives to VFC's for conservation and protection of forests.
18. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada (Source: Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012)
19. Integrated clustering of villages for inclusive growth promoting eco-friendly, local resources, local skill and man-power based thematic developmental programmes through laying a stronger foundation for sustainable growth.
20. Micro-finance and revival of village centred enterprises and clustering of villages for thematic development programmes can greatly improve financial and livelihood security of rural homes, and could provide largest venues for women empowerment.

Recommendations/Guidelines for management or improving ecologically sensitive regions:

Delineating ESR at panchayat levels helps the local administration (and Biodiversity Management Committees (BMC's) as per Biodiversity act 2002) in implementing Biodiversity act 2002 and taking up appropriate conservation and development activities to improve and maintain sustainability of natural resources. The rules promulgated under Biodiversity Act, 2002 include the provision to constitute the BMCs in each panchayat. The mandate of the BMCs is conservation, sustainable use, documentation of biodiversity and chronicling of knowledge relating to biodiversity. Environment clearance of projects requires BMC's concurrence. BMC aid the local administration to approve applications either for access to biological resources or any activities that are likely to affect the sustainability of natural resouces.

Land use:

- Land use alteration should not permitted from forest to non-forest uses or agricultural to non-agricultural in ESR 1 and 2.
- Large scale sand mining in Uttara Kannada rivers, estuaries at larger scale has affected biodiversity and nearby ground water resources. CRZ regulations do not cover activities in the river bed. The sand removal from river beds is reported to choke the respiratory passages of the bottom dwelling clams (shell-fish). Suatainable sand mining (considering the silt yield per year) and tender allotment to be through panchayat, by imposing a proper time schedule (introduce sand mining holidays) for mining and strict implementation of ban on exporting sand outside of the district.
- The mining or mineral extraction activities in the district are leading to irreversible changes. The Bisgod mines of Yellapur has already caused irrepairable damage to the watershed. A large pond *Anekere* - 'elephant's pond'- (where historically elephants used to drink water) has been totally filled up with mining refuse. Moreover the tail-endings eroded the forested hill-slopes into a tributary of Kali river. Surface mining has impacted ground water resources in some places and partially buried plantations when amount of mine dump was washed down by torrential rains. Complete ban on mining in ESR 1 and 2 within 2 years and controlled mining be allowed in ESR 3 and 4 to meet only the district's requirement with appropriate regulatory mechanism.
- Commercial establishments and Special Economic Zones (SEZ) not allowed in ESR 1, 2 and 3 due to long lasting impacts of these sectors.
- From ancient times the coastal hills and plateaus of Uttara Kannada, from Ankola to Bhatkal, presented a picture of a barren and desolate terrain with sparse growth of woody vegetation. In the recent decades, these regions are used for raising monocultures of *Acacia auriculiformis* and open quarrying for brick making. During the rainy season, open lateritic (tropical sedimentary rock) areas get carpeted with tiny herbs, where billions of flowers bloom providing crucial off-season nectar resources for honey bees thus, immediate protection of these unique lateritic hills of coastal taluks as they are habitat for nectar plants during monsoon.

Forests:

- There are considerable areas of degraded forests in ESR-3, ESR-4 of Uttara Kannada, the biomass of which has to be increased substantially through protection, enrichment and co-management. This approach will increase carbon sequestration in the forest areas and mitigate climate change at locally as well as global. The forest management should aim at improving degraded patches of the deciduous forest zone in Mundgod, Haliyal and in the drier eastern parts Yellapura, Siddapur and Sirsi. These forests have ability to attain basal areas exceeding 35 sq.m/ha.

- The secondary moist deciduous forests along the coastal taluks have been in impoverished state due to high density human impacts. Bulk of such forests constituted the ‘minor forests’ meant for meeting the biomass needs of coastal people, including cattle grazing. Through special protection of promising forest patches using barbed wire fencing, and closing any kind of exploitation in such protected areas, natural regeneration can be promoted, for at least five year period. Thereafter these forests can be open for free movement of wildlife and more such selected blocks can be protected, using the mode of forest working plans.
- The exotic plantations in ESR-1, ESR-2 should completely phase-out within five years by planting location specific native species. Monoculture plantations lying adjacent to the water sources have to be taken on priority for enrichment through native vegetation. This programme should be integrated within the forest working plan of the respective division. Financial and technical supports need to be provided to the department and participatory agencies during the conversion period.
- The kan forests and ‘sacred grooves (devarabanas)’ were unique cultural identities of historic period. ‘kans’ are important sources of springs and streams, a fact even acknowledged by the Government of Bombay (1923) and many are located in ESR 1 & 2. The decline of the kans are due to tree felling (eastern Sirsi and Siddapur for fuelwood), in eastern Sirsi 769 ha of kans were converted into soppinbettas or leaf manure forests, overexploitation of the products of the kans by contractors, changes in the religious beliefs related to sacred forests (Chandran and Gadgil, 1993). Community based conservation is anticipated to be most effective solution for this problem. Efforts should be made to trace them out, map and protect them. The protection of these regions should be considered as a prime requirement by involving village forest committees (VFCs) for enrichment.
- The joint forest protection and management (JFPM) has been mostly assigned highly degraded parts of the forests for management. The range of issues dealt with by the JFPM in their micro plans include fodder development, raising of NTFP (Non-timber forest products) and fuel wood yielding plantations, use of energy saving devices, encroachment problems, and various other location specific issues. This practice is providing good results in the district especially Sirsi region. So this model is needed to be replicated in all taluks with active forest department involvement.
- Non-timber forest products (NTFP) collection should be done only by VFC’s, local communities rather than contractors in ESR 2, 3 & 4. The contractor is always associated with destructive extraction of forest produce, evident from the decline of forest produce such as peppar, cinnamon, mango, etc. The exploitation by the contractor is more opportunistic and without any thought on the regenerative capacity of the exploited resources. The contract system is associated with lopping the branches of wild nutmegs – “Rampatri” (*Myristica malabarica*), “Uppage” (*Garcinia cambogea*), nellikai (*Emblica officinalis*), stripping the cinnamon trees of bark, pulling down of pepper vines, cutting the branches of trees with bee-hives and so on.

- The opening of forest canopy following excessive industrial exploitation had created ideal conditions for Eupatorium to establish itself and it rapidly took over the forest floor from past four decades. The larger, shade tolerant, evergreen tree species were replaced by smaller, sun loving deciduous species and weedy plants like Eupatorium. The large biomass of the annual Eupatorium fuelled intense forest fires in the dry season, suppressing regeneration of trees. All these changes meant a drastic reduction in the availability of grazing for livestock. As the economic conditions of the herders deteriorated, they shifted from selling of butter, to selling of milk, and then to firewood extracted from forests. In parallel, there was substantial extraction of raw material for poly fiber and plywood industries as well, at highly subsidised rates, and at levels that were unsustainable. All of this meant far-reaching changes in the forest cover with a drastic reduction in the standing biomass of trees. So fodder depots should be maintained by forest department in connection with gram panchayat and more grass lands should be created in degraded forest patched available in ESR 3&4.
- Realizing the fact that depletion of forests of food resources and human induced vegetation changes in forests has adverse consequences on wildlife while increasing crop raids by animals enrichment of secondary forests and poor grade tree plantations with food resources for forest herbivores is highly desirable.

Agriculture:

- Farmers are to be encouraged by the Government, forest department in growing and marketing of medicinal plants and their primary products. Medicinal plants grown in forests by VFC, in home gardens or in fields, which also grow in wild, should be procured by the Forest Department. This would bring down the illegal practices associated with harvesting of medicinal plants from the forests, unauthorized exploitation by outside agencies and more importantly would better the local livelihood.
- The complete ban of pesticides, chemicals in agriculture/horticulture and monitoring is to be done by gram panchayats. The excessive use of chemicals in agriculture in the region has shown various adverse effects such as health problems to humans and domestic animals; adverse effects on soil quality (structure, porosity, soil organisms); pollution of water bodies; adverse effects on biodiversity- honey bees, butterflies, fishes, amphibians, birds, wild mammals etc.
- Excessive use of chemical fertilizers have contaminated soil and water. Need to regulate the use of chemical fertilisers and replacing with organic manure.
- Subsidies need to be provided for practicing organic farming, development of organic manure, crop rotation and raising green manure crops.
- Introduce incentive payments as conservation service charges to selected farmers for maintaining of traditional local varieties. More the local varieties of a crop, greater are the stability of agricultural sector. No genetically modified crops (GMOs) are encouraged in all ESR regions. Encourage participatory breeding programmes to improve productivity of traditional cultivators; encourage precision agricultural practices.
- Monoculture crops like rubber and banana plantations in steep slopes and heavy plowing has led to increased surface runoff along with loss of treasurable top soil. The

deforestation for areca nut, coffee and cardamom plantations located at higher altitudes (Siddapur, Sirsi taluks) has contributed to drying up of hill streams and swampy areas.

- The agriculture system should be ***mixed cropping*** systems rather than monoculture to poly culture. The food crops and edible fruiting trees should replace existing large extent of monoculture plantations such as rubber, coffee and cardamom to integrate more indigenous crops, which are suited to the locality. This approach will fetch greater amount of benefits to farmers as well as ecosystem by reducing soil erosion, enhance productivity and improve economic returns.
- Various plant species of the district viz. Neem, Pongamia, Vitex negundo etc. are sources of bio pesticides. Promotion of such plants in private lands, VFC managed forests and betta lands can further the cause of organic farming in the district while also earning extra income to the locals from production of marketable, homemade bio pesticide formulations, under an assisted programme from the Government. Forest department nurseries should provide saplings to interested groups by engaging nearby village unemployed women.

Fisheries:

- Absence of participatory management in fisheries sector is observed in the district. The present management of coastal and marine fisheries almost totally ignores the vast store of traditional knowledge among the fishing communities. The encouragement should be prompted to traditional fisherman and discourage mechanical boat usage by regulating licensing of fishing. The restrictions on fishing in specified areas such as breeding sites, and ban on monsoon fishing, should be implemented by more community participation.
- Establishment of fish sanctuaries in all the rivers and estuarine regions of district should be taken with local fisherman involvement and strengthen awareness programmes to ensure the sustainability and survival of fish resources.
- Information and maps regarding migration, breeding and spawning grounds of threatened fishes should be generated through extensive surveys and analysis. Such database is essential for both ex situ and in situ conservation of the endemic fish species of the district.
- Regulating the shell and sand mining in the river/estuarine regions will have positive impact on the diversity and distribution of fishes, edible bivalves.
- Maintenance of physico-chemical properties of rivers need to be considered with the help of school/college students so that they can continue to be centers of diversity and productivity meeting the food and livelihood needs of thousands of families while also performing the vital ecological functions.

Hydrology:

- River and stream bank forests, including inland swamp area forests are to be considered as endangered ecosystems for various reasons, including for their high accumulation of biomass and higher levels of carbon sequestration. Forest range wise river-stream-swamp protection action plans, incorporating adequate amount of inviolate vegetation growth for protection of ecology of these vital water courses along with their rare and endemic species is critical. The maps and action plans prepared for special protection of the riparian vegetation should be made available to all beats of forest divisions.

- The widespread vegetational changes, forest fragmentation is observed. Blocking of the rivers by building dams has enormously affected the input of organic litter from the forests into the coastal estuaries and the sea. They can heavily modify the magnitude (amount) of water flowing downstream, change the timing, frequency and duration of high and low flows. This has created loss in terms of production of fish and other economically important marine and estuarine organisms, loss of revenue to the State, financial losses to banks from poor recovery of fishing loans, and adverse effects on the fishing communities of coastal Uttara Kannada. So, further construction of dams and hydroelectric projects (Macro/mini/micro) should not be allowed in ESR-1 and 2. In ESR-3 the allotment should be considered only by more public requirements.
- Drinking water scarcity is on the rise in river bank panchayats of district in spite of being close to the river courses. The major amount is spent for providing drinking water in panchayats on river banks. The watershed based management plans afforestation, eco-restoration of catchments, rainwater recharging and harvesting, storm water drainage; water auditing, recycling and reuse etc. should be built into the plans by local self-government level management plans. These water management plans should integrate into basin level management plans.
- Panchayats should get river management funds that can be utilised for activities related to improve river health by riparian vegetation, watershed management programmes and not for construction or other developmental activities in the basin.
- The release of effluents in the Kali river rendering its water unfit for use by villagers and their cattle, and also resulted in fish kills. The release of untreated sewage from Dharwad district showing major impact on Bedthi river. Stringent waste management (solid & liquid) policies as per the water pollution act and also municiapl solid waste management rule 2000 are to be implemented to reduce the effect on riverine ecosystem.

Public participation:

- Greater interaction with local community, forest dwellers and involving them at all stages of planning and implementation of forestry programmes run by the Department, and supporting their own planning and implementation of community-based forestry programmes will ensure their resourceful economic and social development. This approach will lead to sustainable environment, protracted natural resource availability and holistic development of region.
- Environmental education can play a vital role in this effort by preparing well sensitised responsible citizenry, with a good understanding of various forces operating in the environment and their consequences. Local educational and research institutions should be encouraged to take up documentation of traditional practices, study of local and global demands of forest products, research projects to help forest department for enrich local ecology and farmers to shift from non-organic methods to organic farming.

- Energy efficient stoves, biogas, solar devices, use of agricultural wastes etc. are to be promoted as fuel in rural areas by creating awareness through schools and panchayats. Energy plantations raised on degraded lands providing right to public will help in improving the ecological status of the region, provide biomass feedstock for rural bioenergy programmes and also help in meeting fuel wood demand.

1.12.0 ECOLOGY INTEGRATED CLUSTERING FOR DEVELOPMENT OF LOCAL BODIES IN UTTARA KANNADA

Cluster-based economic development approach is considered an important aspect of a broader re-orientation of research and economic policy towards laying the foundations of a microeconomic approach for prosperity and growth. The past decades were under the spell of macroeconomics and the creation of market institutions in developing economies. While there is now fairly broad consensus on the type of macroeconomic and legal conditions necessary to achieve economic progress, it is also becoming clearer that these conditions are not sufficient. As a new approach to help economies reap the full potential of an improved macroeconomic and legal context cluster-based efforts have received a lot of attention. Clusters are groups of companies and institutions co-located in a specific geographic region and linked by interdependencies in providing a related group of products and/or services. Because of the proximity among them – both in terms of geography and of activities – cluster constituents enjoy the economic benefits of several types of positive location-specific externalities.

Cluster facilitators and need for institutional structure for implementation: Village panchayats form ideal units for implementation of cluster approach for integrated eco-friendly development. The success of cluster based development programmes will depend on the active participation of facilitators. The various Government departments, financial institutions and NGOs will have active roles to play for the success of the integrated cluster-base approach. In addition there is also need for district and taluk level facilitator committees for scrutinsation of developmental plans and review of progress achieved. The role of some facilitators, are indicated below:

Forests and wildlife departments: As forests constitute a major asset of the district the Forest Department need to be strengthened with adequate manpower at ground level.

- Development of nurseries involving local people. People be encouraged and guided to make nurseries of forest trees and medicinal plants (*Coscinium fenestratum, Nothapodytes nimmoniana, Asparagus racemosus, Emblica officinalis, Saraca indica, Terminalia bellirica, Adhatoda vasica, Rauwolfia serpentina, Tinospora cordifolia* etc)
- It is suggested to look into the feasibility of purchase of medicinal plants or their products by the Forest Department itself, or by the local VFCs from the producers at fair prices, and the sale/supply of these goods to pharmaceuticals to be undertaken by

the Forest Department itself. This recommendation is being made so as to stop rampant illegal collection and trade of medicinal plants from the wild.

- The local ayurvedic pharmaceuticals (within the district), and local people to be engaged in cultivation and value addition to medicinal plants be supplied with medicinal plants/products on priority basis to enrich the local economy and employment potential
- NTFP collection (removal of contract system of middle men) and value addition,
- Developing bee-keeping involving forests and mangroves. As bee-keeping is recommended as an important activity for almost all clusters, roadsides, common lands, under-stocked or degraded forest patches around villages be planted with appropriate nectar plant species.
- Contract system for collection of NTFP from forests found to be highly detrimental to forests and biodiversity and economic well being of local people be stopped forthwith and co-management system involving local people be adopted.
- Production of bamboo based products by local craftsman and effective utilization of bamboo for local development is important
- Use of alternative energy sources replacing firewood
- Development of bettas for tree farming, medicinal plants and fodder,
- Promoting backwater, mangrove, and beach tourism, development of rural tourism and home stays in the vicinity of forests and wildlife areas
- Regular conduct of training in bird-watching, wildlife studies, trekking trails, hygiene and solid waste management involving VFCs, local youth in forest and wildlife related tourism areas be arranged with view of generating eco-friendly employment potential.
- Utilization of weeds and harvestable trees/tree parts, bamboos, canes etc. from plantations or other designated areas for vegetable dyes, medicines, weaving, furniture, handmade paper, sports goods production
- Awareness creation and conservation of sacred groves, sacred kans, which are biodiversity and hydrology significant areas and still playing unique cultural roles in rural society.
- All hydrologically significant forest patches, as indicated, for instance, by high Western Ghats endemism among trees, be preserved both for the sake of perenniality of water courses and for the biodiversity content.
- The Department to consider pooling back good part of income from VFC managed areas into sustainable income generating activities in the cluster level

District Industries Centre (DIC): Main focus agency for promotion of small scale and cottage industries.

- Easy registration of small scale and cottage industries
- Infrastructure assistance, Investment subsidies
- Linking with Employment Generation programmes
- Entrepreneurship development programmes, Technical training
- Assisting in sale of products, buyer-seller meets

- No new red and orange category industries in malnadu and coastal taluks. Orange category may be considered under strict norms and social audit, away from biodiversity centres

Tourism Department: Integrated community based eco-tourism development is being conceptualised to benefit some clusters of adjoining local self government units as a strategy to address high incidence of poverty among the communities while such areas are teeming with tourism potential

- Developing integrated community based eco-tourism
- Assistance in building aesthetic cottages/rooms as part of home stays of bonafide locals or local VFCs. Local grass root level tourism related enterprises to be preferred against construction and commercial lobby.
- Developing tourism awareness in the appropriate panchayat clusters. Conducting programmes on safeguarding local cultures, performing arts and biodiversity.
- Training youth in tourism/homestay management.
- Fostering tourism related entrepreneurship among the local people so as to increase self employment opportunities in rural areas and small towns.
- Getting necessary registration/licenses for village home stays managed by individuals/VFCs/communities, and exhibiting details on location-wise home-stays through web pages

Horticulture Department

- Facilitate farming of desired crops only under insurance coverage
- Training in preservation of fruits and vegetables to women
- Promoting organic cultivation for exports and Indian markets

Financial institutions: Government financing and micro-financing institutions to step in to promote cluster level development programmes through local panchayats, VFCs, BMCs, NGOs, departments, societies etc. Financing from charitable and voluntary organizations and NGOs and not-for profit financiers to be considered and may be recommended by related departments. Crop insurance, preferably, in identified human-wildlife conflict zone is highly necessary for future of biodiversity conservation. Financial literacy is very critical for participatory development progrmmes envisaged.

Mining and Geology

- Mining in Western Ghats to be phased out. Mining for building stones/jelly be limited to meet local demands, and in any case not to be transported out of the district.
- Sand mining in west coast rivers and estuaries to be limited strictly for use within the district only.
- Considering coastal laterite as Gondwanaland soil/rock deposit, and its limited nature, its special ecosystem value sustaining rare and unique biodiversity, laterite quarrying from coastal hills be strictly limited to meeting local demands. Laterite transport to outside the needs to be banned

- Mining of stones/sand/shell etc. from VFC/BMC jurisdiction areas be limited to bonafide local use and in any case not to be transported outside local area/district as is deemed fit by the joint decision of VFC-BMC and Forest and Mining-Geology departments.

Education Department (Primary and Secondary): Our initiatives with high school students and teachers show, they are effective in documenting many aspects of biodiversity and related knowledge existing at village level. With a reasonable time, say one or two days spent on motivating them and familiarizing them with the concepts of biodiversity documentation and data collection formats, they could contribute substantially towards building up a dynamic database at village level ready for integration into the People's Biodiversity Registers. They are more effective in meeting and interviewing organic farmers, in noting down details on traditional cultivars, collecting details on sacred groves, major wildlife related details etc.

District administration/Zilla panchayat

- Thin plastic carry bags production and sale to be banned, so as to promote locally produced cloth and paper bags.
- Hoteliers and bulk purchasers of milk to purchase milk in larger containers, which the milk producers are to use mandatorily and need based
- Use of plastic disposable cups and plates to be banned so as to reduce environmental hazards and to provide market for locally produced biodegradable eco-friendly materials made up of say areca-spathe or washable utensils. Government institutions, offices, public sector undertakings, educational institutions, temples, hoteliers and roadside eateries, and bulk caterers to comply with such norms.
- Imposition of fines/cleaning charges be levied on polluters at all levels
- Toilet facility within reach of every household

1.13.0 INVOLVEMENT OF STUDENT COMMUNITY IN BIODIVERSITY DOCUMENTATION

Following the Biodiversity Act, 2002 of India, many State Biodiversity Boards were constituted which in turn are involved in formation of Biodiversity Management Committees (BMC) for "promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity." The **BMCs should prepare People's Biodiversity Register (PBR) containing local knowledge on biological resources and their usages. Nationwide preparation of PBRs,** is expected to be a mammoth exercise for India, a megadiversity country.

A decade is past since the Biodiversity Act, but only tardy progress made in relation to PBRs. Major hurdles hampering the process appeared to be concepts and formats unfriendly for grassroots level people, paucity of taxonomic expertise, low funding and lack of motivation and guidance. Model PBRs prepared were at enormous expenditure, and through the deployment of experts and not easily replicable. Looking for alternatives to current model of PBR preparation, we attempted under the aegis of the Integrated Ecological Carrying Capacity Project for Uttara Kannada the deployment of student community from high schools and colleges to document biodiversity under the banner 'My Village Biodiversity'. Simplified formats, as understood easily by high school students and village communities, were used for data collection, carried out during 2010-11 and 2011-12. The teachers were given orientation programmes about biodiversity, Biodiversity Act, and on formats to be used. Competitions were conducted for students and nominal rewards announced for the best reports and good presentations. No financing of the educational institutions was done to carry out this model of work. The objectives included:

a. ***Sensitisation of students:*** The very use of data formats were also aimed at sensitizing students to biodiversity related issues. Notable among data to be gathered included forest types, landscape and waterscape elements, plant and animal diversity as the village community understand, crop diversity, preparations and uses of bio-pesticides, organic farming, traditional storage methods, NTFP, management of village environment, community health, wildlife, human-wildlife conflicts, domestic animal diversity, production of honey and apiculture, energy sources, skilled and knowledgeable people in the villages, sacred groves etc.
b. ***Recording observations:*** The students were advised to read and understand data formats under the guidance of teachers
c. ***Vital information on crop diversity:*** Stress laid on documentation of local varieties of crops.
d. ***Low cost methods to assist PBR preparation:*** No money was paid to partner institutions and students except for meeting the travel expenses for attending workshops.
e. ***Creating ambassadors of goodwill:*** Students, with their unbiased minds were expected to merit greater acceptability in the households, as the villagers otherwise tend to be more reserved with outside agencies like NGOs engaged in such work.
f. ***Expertise in communication:*** Students were expected to gain good communication skills.

About 580 students from 116 high schools and 6 colleges representing the 11 taluks of Uttara Kannada took part in the two year exercise, in the course of the Carrying Capacity project work. Biodiversity documentation covered about 190 villages of the total of about 1200 villages in the district. Considering the sluggish scenario of PBR progress, with only 212 panchayats of Karnataka covered by 2008, comments on their merits pending, the cost was high for the Biodiversity Board in its infancy to bear, but at the same time funding considered small by the agencies catalyzing the PBRs at panchayat levels. Some schools fared poorly in their outputs on village biodiversity recordings, mainly on account of guiding teachers missing the orientation programmes. If the education departments, make suitable changes in the syllabi to incorporate biodiversity documentation, with due credits to the performers, the outcome would be more fascinating. The students in general found greater acceptability in the villages, got first hand learning opportunities and often turned out to be communicators of good order.

To highlight some results, notably, of 190 villages where rice cultivation was reviewed, 181 varieties were recorded; out of them 101 were native varieties. Sample survey with regression analysis gives expectation of finding around 492 native varieties in the district. Countrywide adoption of the method will benefit rapid documentation of traditional varieties, feared to have dwindled from around one lakh down to 8-10 thousand, mainly due to unregulated introduction of new varieties. Documentation also covered local varieties of banana, pepper, mango, jack, sugarcane, arecanut, coconut etc. The villages have rich wealth of traditional knowledge holders like herbal healers specialized in treating ailments like rheumatism, paralysis, migraine, kidney stones, bone fractures, eye and skin problems, jaundice, herpes, paralysis, infertility, epilepsy etc. and cattle diseases. Medicinal plants were exhibited during workshops and their uses documented. Information on persons with knowhow on biopesticides, earthworm manure, water divining, organic farming etc. also is available. Villagers gave good account of local wildlife, on occasional visiting animals like tiger, leopard, bear etc. Local names of fishes available in the fresh water bodies were recorded. The students provided indications on the presence of hundreds of sacred groves in the villages. They would be interesting places from biodiversity and cultural angles. On the whole pastoralism is on the decline due to fodder scarcity, and cattle manure, inevitable for high rainfall agricultural soils, is getting scarce. This can undermine the very farming system of the district. Our experiment shows the huge potential for harnessing the student power for documentation of the immense biodiversity of the country. Biodiversity awareness creation among the younger generation is a paramount necessity for the successful documentation. **The educational system has to be restructured to institutionalize biodiversity documentation, especially using student power from high school and undergraduate levels with due academic credits given to the participants.**

2.0 CARRYING CAPACITY: INTRODUCTION

Nature functions holistically. A great diversity of species, including the humans, have been associated with each other for long periods of time and co-evolution is at the centre of all ecosystems. The individual cannot live independently of the living environment and actions of individuals have an impact on the environment. On the contrary human societies are today overriding the holism of nature, shaking the very foundations of life itself to their detriment. For lasting wellbeing of human societies they need to necessarily learn more about the ecosystems, of which they form a part, assess their complexities and carrying capacity and modify or derive resources from them without straining their capacity to provide goods and services perpetually. The Uttara Kannada district, gifted with enormous natural resources potential, this dictum of sustainable development based on the foundation of carrying capacity studies, is yet to be a reality. Various developmental programmes, which proclaimed to be functioning on sustainability principle, on looking back, have been only fraying the complex web of life, disrupting ecosystems and causing decline in overall productivity. This is true in four major sectors such as forestry, fisheries, agriculture and hydrology.

The research work envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. This process in due course will create an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government. Integrated Ecological carrying capacity study provides the regional planner in evolving appropriate conservation strategies for sustainable management particularly on a defined geographical area. Decision making on developmental activities, entail planning that depends upon the availability of reliable and accurate data. Data required for natural resource planning include spatial data such as, information of physiography of the area, land use, assets, etc. Geographic information system (GIS) with a capability of handling spatial data helps in the analysis and visualisation of results effectively, and aids decision making process.

The district is in need for ecologically sound development plans for sustainable productivity. For preparation of such a plan, the basic need is to have a fresh appraisal of the carrying capacity of the district, which has never been done before. The carrying capacity study, which involves detailed study on every aspect of ecology and human life in the region, will be the best guide and tool for both policy makers to choose appropriate developmental and other income generating projects which are in tune with the ecology of the district. The carrying capacity studies, if adapted to the village panchayat level, can transform lives of people at grass-root level through better understanding of their surroundings, by adopting lifestyles having greater harmony with their environment, so as to reap maximum sustainable benefits.

2.1 BACKGROUND

Ecosystem carrying capacity can be defined as 'the maximum number of a species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation of the environment and without diminishing carrying capacity in the future. Carrying Capacity thus refers to the maximum number of activities (biological, developmental, agricultural, and industrial, population) that can be supported over a period of time in the habitat without damaging the existing quality of life, balance of resources, ecology and productivity of the ecosystem. Ecological Carrying Capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economical development in the region. The aim of Environmental Carrying capacity is to adjust/increase the ability of the natural environment.

Carrying capacity depends on

6) Resources (Biological or Non Biological) that influences on the number of species in the habitat based on the current condition.
7) Interaction(Physical, Chemical, Biological) between the resources and the processes involved in conversion/production of resource to a desired output with residuals and wastes in the environment
8) Habitat (Region), Human Choices, Living Standards, Time, technology
9) Economical Conditions, Growth Strategies and Policies
10) Social-Cultural and Political Aspects

Carrying capacity research began with the most critical area, through inventorying, mapping and monitoring of the higher plants. Eventually this process was strengthened to cover the rest of the organisms, including the biodiversity of cultivated plants. Such a dynamic documentation process would enable the district to keep proper stock of its biological and ecosystem diversities and to supervise their judicious use for sustainable progress. Data required for natural resource planning included spatial data such as, information of physiography of the area, land use, assets, etc. A Spatial visualisation of all the important assets, general physiography of the area, land use etc., based on a geo-database added support for effective decision making.

Carrying capacity of the region is assessed considering the maximum number of activities - like domestic, agriculture, transport, industries - that can be done continuously over a period of time without affecting: the existing quality of life (from the point of view of existing traditional practices, access to resources, health and pollution levels)

i. processes and functional capability of ecosystems
ii. biodiversity
iii. the balance of resources (renewability/regeneration is maintained)
iv. the fact that activities can be done on a sustainable manner
v. neighbouring systems
vi. existing ecological systems like coastal systems, forests etc.

The scope of a carrying capacity study has been extended to the analysis of supportive capacity in the region with respect to resource availability/utilisation, supply/demand, infrastructure/congestion and assimilative capacity/residuals. Hence, the carrying capacity is assessed as the ability to produce desired outputs (i.e., goods and services) from a limited resource base (i.e., inputs or resources) while at the same time maintaining desired quality levels in this resource base. The four dimensions that are relevant to the estimation of carrying capacity are:

(i) The stock of available resources to sustain rates of resource use in production.
(ii) The capacity of the environmental media to assimilate wastes and residuals from production and consumption.
(iii) The capacity of infrastructure resources (e.g., distribution and delivery systems) to handle the flow of goods and services and resources used in production.
(iv) The effect of both resource use and production outputs on quality of life.

Several indicators are integrated into a single index for more complex conditions or components (e.g., air quality index). Indices at an intermediate level of aggregation may, in turn, be integrated into still more general indices (e.g., quality of life). In these contexts, the term *index* represents a measurement of some environmental or social component for which there is more than one indicator. This provides a basis for evaluating the performance of development plans in terms of the changes in carrying capacity indices. In developing environmental management strategies for the urban region, planners and decision-makers must continually assess the social and environmental implications of various proposals. Recognising and establishing the limits of economic activity could provide decision-makers with a workable approach to assessing the environmental viability of developmental proposals.

To reiterate, planning for development within the limits of carrying capacity recognises that humankind is dependent on the productive capacity of ecosystems, and therefore, a minimal level of ecosystem integrity is essential for human survival. Planning for sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of *supportive capacity* within its regenerative capacity and environmental quality within the *assimilative capacity* of regional ecosystem. The utilisation of carrying capacity, thus, requires a series of adjustments to reconcile competing operations in the developmental process through participation of various stakeholders.

The supportive capacity of a region is the capacity of the ecosystems to provide resources for various anthropogenic activities, i.e., human settlements/industries. The resource base of a region could be categorised into ecological and economic resources, transformational resources, infrastructure and distributive resources and socio-cultural and amenity resources. Pragmatic utilisation of these resources warrants the establishment of functional relationships between the resources and their present level of usages. The carrying capacity of an ecosystem is greatly influenced by the availability of resources and the manner in which they are utilised. The availability of resources at any particular time is the result of the interactions amongst the physical occurrence of the resource, and the quantum of requirement, as also the technological and managerial means of their exploitation.

Assimilative capacity is the maximum amount of waste discharge that can be allowed in an environment without violating the designated use. In operational terms, assimilative capacity can be defined as ratio of observed level of pollutant and the environmental standard stipulated by the concerned authorities. Assimilative capacity is governed by dilution, dispersion, phase transformation, deposition and absorption phenomena. These phenomena are relatively local in nature. Assimilative capacity, therefore, needs to be worked out for a defined geographical area. The overall scope of work for estimating carrying capacity, thus, involves:

- Delineation of boundaries of the study region, taking into account the location of anthropogenic activities likely to affect estuarine ecology, boundaries of *talukas* and watersheds.
- Assessment of stock and demand for land, water, minerals, transformational (e.g., power generation and manufacturing), infrastructure (e.g., water supply and sanitation, health and education, transport and communication and socio-cultural resources).
- Assessment of environmental quality vis-à-vis standards for air, noise, water (both surface and ground), land, biology (both aquatic and terrestrial) components based on secondary data (including time-series, if available) supported by primary data.
- Assessment of residual assimilative capacity.
- Assessment of quality of life through questionnaire survey.
- Assessment of present activity levels in various sectors of economy, viz., forestry, fishery, agriculture, manufacturing, trade and commerce, transport, waste management, etc.
- Identification and quantification of sources of pollution.
- Short-listing of environmental and developmental concerns.
- Review of existing developmental plans prepared by concerned authorities.
- Prediction of business-as-usual scenario in terms of impact of developmental plans on demand for supportive capacity and determination of environmental quality.
- Identification of limiting resources.
- Assessment of developmental potential of the region.
- Recommendation of short-term and long-term policy/planning/technology interventions for enhancing carrying capacity.

In order to look at sustainability of a region, availabilities and consumptions of different resources were assessed. Major resources of relevance to Uttara Kannada district are the following:

i) Land - land use, land cover, quality of land - erosion due to sea.

ii) Water - rainfall, canals, wells, ground water - for several regions and seasons; quality of water.
iii) Biomass - fire wood, coconut/arecanut residues, agricultural residues.
iv) Biogas - from animal wastes, solid wastes, sewerages, industrial wastes etc,.
v) Food - from agriculture, imports
vi) Biodiversity – aquatic, terrestrial
vii) Fish - from ocean, surface waters
viii) Forests
ix) Coastal system - micro organisms to fish
x) Soil - enrichment, leaching, quality,

2.2 NEED FOR CARRYING CAPACITY:

Initially population was at a lower level. Activities were not many - society was dependent on agriculture. So the consumption of resources was at an acceptable level - mostly we used directly accessible, renewable resources. But with the advent of industrialization and development of energy/power generating units, the needs increased. Consumption of resources also increased, with tapping of non-renewable and non-regenerative resources. The outputs from industries polluted water, air and land resources degrading some resources. Consumption of energy resources destroyed some resources - deforestation. The effects of this are cumulative leading to a depletion of resources. So it became necessary to carefully nurture and manage resources used in our activities. Initially management of natural resources looked at alternative sources (like biomass in the place of coal, ethanol for petrol etc), and technological developments were initiated to improve efficiency of usage. Reuse and recycling of resources are being attempted now. Still, the increasing need for resources due to increases in population and wants of people may stress an area or region. Hence, it is desirable to conduct studies to obtain the limits on the availability of resources and their usage. Since different regions of a state may not be developing at the same level, there is normally a skewed level of development. Utilisation of resources will not be uniform in all regions. Patterns of development (based on perception, availability of infrastructure) may vary. But development is a continuous process. Hence, carrying capacity studies for different regions will allow us to divide the state into regions of different classes - highly resource stressed regions, normally stressed regions, low - stressed regions - for different resources. This can help us to identify locations for future development and to generate development plans for each region.

Before the process of Industrialization and Urbanization, pollution was at minimal levels, activities carried out were very less, and society used to depend upon agriculture. Consumption of resources was to the acceptable limits, most of the resources were directly used with little (or without) processing (renewable resources), most of the wastes and the residuals were recycled or used as a product. Due to increase on population growth, industrialization, development of units for power generation there is more and more consumption of renewable and nonrenewable resources, through which there is reduction in the resource. Due to production (conversion of resource) of a desired output, residuals and wastes are generated which intern pollutes resources such as land, water and air…*etc*. The need and consumption has led to deforestation/degradation and destruction of natural resources. To nurture and manage the resources based on the utilization, it is necessary to conduct studies to obtain the limits on the availability of resources.

Through carrying capacity investigations, it was possible to identify locations for conservation (ecologically sensitive) as well as development in the region as carrying capacity allows us to divide the region into various classes based on the different resource availability.

Resources: All the activities in our day to day life needs resources such as Land, Water, Air, Fuel, Food, Minerals, …*etc*. Resources can be divided as

1) Non Renewable Resources (Depleting Resources)
2) Renewable Resources (Regenerative Resources)
    a. Autonomous Regenerative Resources : Quality and Quantity regenerated doesn't depend upon human interaction/consumption Example: Sun light, Wind…*etc*
    b. Consumption Dependent Regenerative Resources: The Quantity of regeneration depends upon Human Consumption. Example: Production of Biomass depends upon the Harvest
3) Local and Non Local Resources: based on the availability in the region.
4) Primary Resource (Air, Water…*etc*) and Secondary Resource (Food Crops, Electricity…*etc*).
5) Producing Resource and Absorbing Resource.

Estimation of various Resource that are being consumed (Resource Consumption) is necessary to plan for developmental activities, to find sustainability of resources, to conduct carrying capacity studies. Resource Consumption is due to the Conversion of resource in the activities, some of them are:

1) Simple conversion producing resource (Burning of fuel emits gases such as CO_2, SO_2…)
2) Simple conversion with recoverable waste (Use of Detergents for washing with water produces waste water from which the chemical can be recovered)
3) Cascade usage (Cow dung is used as resource to produce biogas, which is further used for cooking)
4) Complex conversions: multiple input resources to multiple outputs (Land + Fertilizers + Pesticides+Water+Seeds…*etc* gives Food Crops+Biomass+Agricultural Residues+Waste Water…*etc*)

Estimation of Carrying Capacity

1) Assess the stock of the available Resources to sustain the rate at which the resources are being consumed

2) Capacity of the environmental media to assimilate the waste and the residuals/by-products due to a production process
3) Capacity of the Infrastructure Resources to handle the flow of resources, goods and services in production
4) Effect of the resources used on livelihood, quality of the environment.

In order to analyse and assess the Carrying capacity, it is necessary to assess resources over the spatial and temporal domains.

Spatial domain: Regional delineation for analysis of carrying capacity is based on consideration of the functional elements of three general types of regional space: Represents the physical space based on the ecology, economy and policies for demarcation of the boundaries. A study area for analysis of Carrying capacity w.r.t spatial domain should be

a) Easy to identify and separable from other surrounding regions
b) Capable of being modified with minimal or no effect on the surroundings
c) The boundary of the area should be within or as close as possible to the regional space
d) Movement of Resources, Goods and Services should be measurable along the boundary

Temporal domain: An important aspect of carrying capacity assessment is the problem of measuring the outputs of production processes. Production outputs are divided into two classes: goods and services, wastes and residuals. Measurements for the former, known as social indicators, are used to gauge the relative change in human needs and satisfaction levels. Measurements for the latter, known as environmental indicators, allow managers and decision-makers to determine how production activity affects the quality and assimilative and future productive capacity of the receiving environment. For analysis of Carrying Capacity of resources, it is necessary to consider time frame. As the technology advances with time, carrying capacity varies with time.

Measurement of output of production process is very important in measuring and assessing the Carrying Capacity. The production outputs are goods, services, waste and residues. Measurement using the socio-economic and environmental indicators allows measuring the relative change and helps in determining the effect of the product and the production activity on the Quality, Assimilative capacity, Supportive Capacity, Livelihood of the receiving environment. Many indicators can be used, merged to form a single measurable index that provides us a base for evaluating the performance of a developmental plan in terms of change in Carrying Capacity.

Planning for development in a region at least a minimal requires tradeoff between the Consumption levels and the Supportive capacity, Environmental Quality and Assimilative Capacity. Supportive Capacity of an ecosystem is the capacity of that ecosystem to provide resources for supporting anthropogenic activities. The resources can be ecological, economical, socio-cultural, infrastructural…*etc*. Assimilative Capacity is the maximum amount of wastes and residues discharge that can be accepted by the supporting environment. Assimilative capacity is the ratio of Discharged Pollution level to the acceptable pollution levels specified by the authorities for the region. Factors such as Dilution, Dispersion, Accumulation/Deposition, absorption..etc affects the accumulative capacity in the region.

Some of the Major Elements of works Carrying Capacity Include are:

1) Estimation of Supportive Capacity
2) Estimation of Assimilative Capacity
3) Assessment of Present Quality of Life, Plans and Policies
4) Development of Alternate Scenarios and strategies for Better Planning.

Some of the carrying capacities are:

1. Biomass production
2. Fuel usage and production (Fire wood)
3. Water storage and availability
4. Food production
5. Pollution load
6. Mineral availability
7. Fish production … *etc*

Computation of Carrying Capacity:

Human Carrying Capacity: Maximum population that can be supported based on the availability of resources such as water, food, land.

$$C_{food} = \frac{\text{Maximum Food Available}}{\text{Minimum Requirement per person}}$$

$$C_{water} = \frac{\text{Maximum Water Available}}{\text{Minimum Requirement per person}}$$

Human Carrying Capacity in the region is the minimum of (C_{food}, C_{water} …etc).

Land availability for any developmental activities is based on the net land availability and is can be calculated as

$$L_{NET} = L_{Total} - L_{Forest} - L_{Agriculture} - L_{Settlements} - L_{Essentials} - L_{Exisiting\ industries} - L_{Future\ essentials} - L_{Spare}$$

The following steps are necessary to calculate the Carrying capacity

1) From LULC maps , identifying the land available for development
2) Analysis of supply demand of water for the current period, modeling and predicting for future
3) Atmospheric studies
4) Establishing limits on pollution
5) Analysis of soil and solid wastes
6) In case of industries (objective functions and desired variables)
    a. Employment

b. Number of Industries
c. Risks associated
d. Pollution and Penalization for utilization of depletive resources

Uttara Kannada district of Karnataka State in central Western Ghats will be the main focus of the study. Some parts of Sagar and Hosanagara taluks of the adjoining Shimoga district, which form the main watershed for Sharavathi, one of the important west-flowing rivers of Karnataka also will be studied. Broadly, this study will be organized under the following themes so as to develop the integrated ecological carrying capacity and economic valuation.

This involves:

1. Land-use, land cover changes.
2. Inventorisation and mapping of biodiversity (terrestrial, aquatic-flora, fauna).
3. Inventorisation and mapping of domesticated biodiversity (agricultural, horticultural and livestock).
4. Understanding ecology, biodiversity and hydrology relationships.
5. Understanding cultural diversity in relation to conservation such as of sacred groves and sacred trees, sacred animals, totemic species, etc., traditional resource utilization and management, traditional skills and arts, traditional economic activities such as production of artifacts (wood and stone carving, bamboo and cane works, earthen artifacts, carpentry, etc.), skilled farm labour, etc. Identification of heritage and cultural sites.
6. Assessment of renewable energy potential (region-wise).
7. Assessment of carbon dynamics (sequestration potential, emission).
8. Assessment of ecosystem services and goods (ecosystem-wise).
9. Socio economic worthiness of people's institutions and organisations.
10. Identification and mapping of natural disaster prone regions, monitoring and mitigation measures through eco-restoration (eg. creation of green barriers to prevent sea erosion).
11. Global significance of the region (RET species, threatened ecosystems, protected areas, etc.).
12. River basin-wise, integrated holistic valuation (tangible and intangible) and assessment of ecological carrying capacity.
13. Impact of developmental projects (power, industry, monoculture plantation, etc.).
14. Formulation of ecologically sound developmental plan for sustainable productivity of the district.

The proposed framework for the environment and carrying capacity study would comprise the following components. All the parameters mentioned below should be studied in detail on long term basis in all the major river valley system *(Kali, Bedthi, Aghanashini and*

Sharavathi etc.) before drawing final picture. Only such in-depth study should guide the policy making process and developmental activity in any region of the district.

KARNATAKA BIODIVERSITY BOARD, vide letter KBB/Misc/Western Ghats study/15/09-10/1314 dated. 29-06-2009, ***invited the Principal Investigator to undertake a study on 'INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA'*** (Ref: Letter No.FEE 49 ENV 2009, dated 22-05-2009 of the Secretary to the Government, Forest, Ecology & Environment, Bangalore).

3.0 ORIGIN OF THE STUDY

Uttara Kannada is one of the ecologically sensitive districts of Karnataka State. It is one of the districts with high vegetation cover in the entire country itself and first among the districts in Karnataka State. Being situated on the Western Ghats, which is now considered one of the mega biodiversity regions of global importance has all the three major landscape system of the state namely; the coastal region on the west, the high hill mountain region of Sahyadri in the middle and a Deccan plateau margin in the eastern side. Because of this unique ecological system, Uttara Kannada has been identified as one of the ecologically sensitive region by many scientific studies for its role in ensuring the ecological and livelihood security of the entire peninsula.

However, due to factors like growing, population and mega developmental projects, much of its natural landscape and the natural resource are under severe pressure. Deforestation, encroachment, submergence, forest fragmentation, river pollution and degradation, seawater seepage to fresh water and so many other impacts are already being witnessed. Keeping this fragile situation in mind, people from across the society are urging the Government to take up an integrated ecological carrying capacity study of the district so that it becomes the guidelines for the future conservation and sustainable development works.

Ecological and socio economic significance of *Western Ghats (Sahyadri)* and Coastal region are well known in peninsular India because of their biodiversity, and ecological service values. However, these bio-geographic regions are being constantly destroyed over the years. Reasons may be many, but the lack of proper conservation and developmental plan for these ecologically unique regions emerges out as the major one. While industrialization, expansion of agriculture and urbanization taking place with rapid speed all over the country, the same is case here which may lead to long term impacts. Though, *Environmental Impact Assessment (EIA)* for any given major project is mandatory as per the *Environmental Protection Act, 1986,* often such studies end up without any-in-depth long-term studies. There is feeling that several projects, which have been through such assessment studies over the last decade in Sahyadri region, have ultimately caused considerable effects. There is an urgent need to redefining the objective and methodologies of such Environment Impact Assessment studies keeping the larger ecosystem and cumulative long term impacts in mind.

Such a model is now proposed for Uttara Kannada, since its conservation is having the national and global significance. Uttara Kannada district being considered as the forest district, for the fact it contributes much to whatever forest left in the state. It is home for four major perennial rivers which are the lifeline of millions of people having both Sahyadri and coastal regions along with the Deccan plateau region; this district is known for its richness in natural resources. Even after having so many mega developmental projects like hydroelectricity dams and nuclear power stations, this ecologically sensitive region is being subjected to further stress. Having experienced the lacuna of EIA procedure, which looks at the project in very minute scale and limited focus, an alternative and more reliable mode, is suggested. It should focus on keeping the ecology and socio-economic sustainability of the region in the long run. This is only a framework developed through intensive and detailed consultation with the scientists and experts who are working in this field and region. It is suggested that we should carry out a detailed and in-depth carrying capacity study of the region through this framework.

Realising the importance and necessity, the government of Karnataka through Karnataka Biodiversity Board, vide letter KBB/Misc/Western Ghats study/15/09-10/1314 dated. 29-06-2009, invited us to undertake a study on **'INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA'** (Ref: Letter No.FEE 49 ENV 2009, dated 22-05-2009 of the Secretary to the Government, Forest, Ecology & Environment, Bangalore). Details of the communication are provided below:

The proposed framework for the environment and carrying capacity study would comprise the following components. All the parameters mentioned below should be studied in detail on long term basis in all the major river valley system *(Kali, Bedthi, Aghanashini and Sharavathi etc.)* before drawing final picture. Only such in-depth study should guide the policy making process and developmental activity in any region of the district.

1. While calculating the value of forest or ecosystem region, mere counting of the value of standing resources is not enough. Measurement should also be taken into consideration for ecological services offered by the natural ecosystem in the long run. Such a **Holistic Net Present Value (HNPV)** should be done keeping a river basin or watershed as basic unit. *For example:* HNPV of Aghanashini river valley includes that of separate assessment in upland, Ghats and coastal regions, HNPV for Areca orchard system. HNPV for BETTA land, HNPV for mangrove region etc.
2. ***Economic values of ecological Services of forest and river ecosystems:*** Keeping the ecological services of Kali, Bedthi, Aghanashini and Sharavati river valleys like the watershed services, soil conservation, soil fertility maintenance, nutrient uploading for the down stream regions, etc. An empirical data generated for all

these factors can be extrapolated for the forest region and farm filed area, of the district. (Studies done by CES of Indian Institute of Science in Sharavati river valley could be a model for designing such studies. Ecosystem services are nothing but the ecological functions from which humanity get benefited like carbon mitigation, pollination, seed dispersal, water retention and percolation, soil erosion prevention, providing soil fertility, providing food, fodder, medicine etc, mitigating flood and so on).

3. ***Economic values of ecological services of coastal ecosystems:*** The ecological services of mangrove vegetation, mangrove fisheries, open sea fisheries, etc.
4. ***Economic values of biodiversity:*** The magnitude of the economic value of biodiversity in the current global context, if not the exact value. The diversity of plants, animals including RET and Endemic species, Geographic Indicator items like wild Pickle Mangoes etc in forest, river, bank, farmland, sea belt etc.
5. ***Tangible economic value of natural ecosystems and their significance in the global climate change context:*** Annual net productivity of natural ecosystems like forests, rivers and ocean in terms of timber, NTFP, medicinal plants, marine products, firewood, lime, sand, etc.
6. ***Tangible economic values of agricultural productivity:*** It comprises annual average yield in different crops, their current market worthiness.
7. ***Intangible economic values of agricultural productivity:*** Role of farm land in soil fertility, prevention of soil erosion, watershed development, conservation of agro-biodiversity, support for biodiversity like medicinal plants, insects and birds etc.
8. ***Tangible economic values of man made plantations (afforestation programmes) and their significance in the climate change context:*** It would be regarding assessing the existing plantations like that of Teak, Mangium, Eucalyptus, Caurina, Bamboo plants etc. It would also include the potential of a region in holding such plantations further, involving more local species diversity including that of RET, Endemic, NFTP etc.
9. ***Socio-economic worthiness of people's institutions and organizations:*** The co-operative institutions, schools, colleges, hospitals, etc. which are supported by farm economy.
10. ***Unique cultural identity:*** The uniqueness in cultural history for and type of their role in sustainable utilization of natural resources, value and type of traditional knowledge in conservation and sustainable utilization of biodiversity, traditional skills and arts innovation and practices of tribal and peasants, traditional economic activity like carpentry, fisheries, production artifacts, skilled farm labour etc. which are all basically supported by the farm economy and bioresources.
11. For any major industrial/developmental projects, where the impact would be beyond the threshold limits of given river valley system, the impact study should be taken up across the river valley systems of Uttara kannada.

12. Global significance of **Protected Areas (PAs), Critically Endangered Habitats, Wildlife and Endangered Species** in the region should be studied.
13. Cost-benefit analysis of current livelihood security value vs. proposed industrial output. (For example: The value of power generated by a dam vs. the impact on economy due to the loss of natural ecosystem and traditional livelihood opportunities)
14. ***Parameters for assessing the changes from various projects implemented in the region over last three decades:***
    - The effects of mega projects: The changes caused by mega projects in the district like hydro-electricity projects, paper industries, plywood industries, nuclear power stations, defense base, mining and quarry, encroachment etc in terms of permanent displacement of forest, wildlife and biodiversity, degradation of soil and water source, loss of watershed structure, human displacement, loss of livelihood etc.
    - The impact on natural environment and thereby traditional economic activity, for instance, fisheries.
15. ***Scope for development of alternative developmental plan for enhancing the economic productivity of the region.***
    - Scope for developing alternative energy resources: Like that of wind energy, tidal energy, bio-fuel, biogas, biomass energy units etc.
    - Scope for promoting agriculture and horticulture with value addition: Plantation crops (Areca, coconut, Banana etc), spices (cardamom, pepper, Coco, Vanilla etc) fruit crops (Jackfruits, Mango, Papaya, Sapota, Guava etc) and medicinal plants (Holy basil, Pachouli, Shatavari, Sarpagandha, Coleus etc).
    - Scope for promoting non-polluting industries like electronics industry, Knowledge Outsourcing Organizations (KPO) industries etc.
    - Scope for developing consultancy sector in the agriculture knowledge base.
    - Scope for promoting the sustainable eco-tourism based on the protected areas, organic farming, etc.
    - Eco-friendly industrial activities like that of Medicinal Plant based industry, organic farming products, sustainable inland fishery etc.
16. Assess the knowledge associated with Bioresources and their potential in livelihood of locals and society and prospects to derive economic benefit for Knowledge holders/communities for present and future.

In response to the above cited letter, the proposal was formulated and submitted to KBB for the financial assistance.

Definition of the problem: We are today in an age of rapid material progress that is out of tune with the harmony of nature, creating chronic strains in the web of life, polluting the environment with toxins, threatening the climatic regimes, severe loss of top soils, causing serious loss of biodiversity, including impoverishment of genetic diversity of crop plants and domesticated animals. To achieve sustainable development, therefore, the necessity has arisen to conduct region-wise carrying capacity studies.

Ecological and socio economic significance of *Western Ghats (Sahyadri)* and Coastal region are well known in peninsular India because of their biodiversity, and ecological service values. However, these bio-geographic regions are being constantly destroyed over the years. Reasons may be many, but the lack of proper conservation and developmental plans for these ecologically unique regions emerges out as the major one. Though, *Environmental Impact Assessment (EIA)* for any given major project is mandatory as per the *Environmental Protection Act, 1986,* often such studies end up without any-in-depth long-term studies. There is feeling that several projects, which have been through such assessment studies over the last decade in the Sahyadri region, have ultimately caused considerable effects. There is an urgent need to redefining the objectives and methodologies of such Environment Impact Assessment studies considering the larger ecosystem and cumulative long term impacts.

Despite Uttara Kannada district being identified as one of the ecologically sensitive regions by many scientific studies, for its role in ensuring the ecological and livelihood security of the entire peninsula, due to factors like growing population and various mega developmental projects, much of its natural landscape and the natural resources are under severe pressure. Deforestation, encroachment, submergence, forest fragmentation, river pollution and degradation, seawater seepage into fresh water and so many other impacts are already being witnessed. This necessitates an integrated ecological carrying capacity study of the district so that it becomes the guidelines for the future conservation and sustainable development works.

Proposed Research and Objectives: Uttara Kannada district of Karnataka State in central Western Ghats is the main focus of the study. Some parts of Sagar and Hosanagara taluks of the adjoining Shimoga district, which form the main watershed for Sharavathi, one of the important west-flowing rivers of Karnataka also will be studied. Broadly, this study will be organized under the following themes so as to develop the integrated ecological carrying capacity and economic valuation.

This involves:

1) Land-use, land cover changes.
2) Inventorisation and mapping of biodiversity (terrestrial, aquatic-flora, fauna).
3) Inventorisation and mapping of domesticated biodiversity (agricultural, horticultural and livestock).
4) Understanding ecology, biodiversity and hydrology relationships.

5) Understanding cultural diversity in relation to conservation such as of sacred groves and sacred trees, sacred animals, totemic species, etc., traditional resource utilization and management, traditional skills and arts, traditional economic activities such as production of artifacts (wood and stone carving, bamboo and cane works, earthen artifacts, carpentry, etc.), skilled farm labour, etc. Identification of heritage and cultural sites.
6) Assessment of renewable energy potential (region-wise).
7) Assessment of carbon dynamics (sequestration potential, emission).
8) Assessment of ecosystem services and goods (ecosystem-wise).
9) Socio economic worthiness of people's institutions and organisations.
10) Identification and mapping of natural disaster prone regions, monitoring and mitigation measures through eco-restoration (eg. creation of green barriers to prevent sea erosion).
11) Global significance of the region (RET species, threatened ecosystems, protected areas, etc.).
12) River basin-wise, integrated holistic valuation (tangible and intangible) and assessment of ecological carrying capacity.
13) Impact of developmental projects (power, industry, monoculture plantation, etc.).
14) Formulation of ecologically sound developmental plan for sustainable productivity of the district.

References:
Ministry of Environment and Forest, http://moef.nic.in/divisions/cltech/concept.htm
Ministry of Environment and Forest, http://moef.nic.in/divisions/cltech/sc.htm
Ministry of Environment and Forest, http://www.moef.nic.in/divisions/cltech/ac.htm
Subramanian D K, 1998, A framework for conducting Carrying Capacity Studies for Dakshina Kannada District
Vijay Kulkarni and T.V.Ramachandra, 2009, Environmental Management, TERI Press, New Delhi
XilianWang, 2010, Research Review of the Ecological Carrying Capacity, Journal of Sustainable Development

Submission of final reports (Theme-wise): We have altogether submitted 38 **final reports to KBB**, as and when such **themes/ topics** were completed since March 2012. Each one of these final reports are complete with summary and recommendations. Task-wise (as per objectives of the study) details of the report are listed in Table 3.1.

Table 3.1: Themes covered as per the objectives of the study

(Note: SCS – Sahyadri Conservation Series No., ETR – ENVIS Technical Report No)

	Task	SCS	ETR	Title of the final report	Pages
1).	**Land-use, land cover changes**	28	56	**1.** Land Use Land Cover (LULC) Dynamics in Uttara Kannada District, Central Western Ghats.	**35**
		29	57	**2.** Fragmentation of Uttara Kannada Forests	**270**

		31	61	**3.** Land use changes with the implementation of developmental projects in Uttara Kannada District.	**100**
2)	**Inventorisation and mapping of biodiversity (terrestrial, aquatic-flora, fauna).**	3	20	**4.** Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats.	**51**
		6	22	**5.** Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats.	**44**
		8	37	**6.** Anuran Diversity and Distribution in Dandeli Anshi Tiger Reserve	**28**
		11	35	**7.** Aghanashini Estuary in Kumta taluk, Uttara Kannada – Biological Heritage Site	**24**
		12	36	**8.** Grasslands of Anshi-Dandeli Tiger Reserve.	**114**
		-	43	**9.** Ecological Status of Dandeli Anshi Tiger Reserve.	**25**
		18	47	**10.** Amphibian Diversity and Distribution in Uttara Kannada District.	**30**
		20	50	**11.** Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats.	**165**
		21	51	**12.** Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada.	**25**
		-	CESTR:129	**13.** An Appraisal and Conservation Strategies for the Pteridophytes of Uttara Kannada.	**54**
		32	62	**14.** Floristic Diversity in Uttara Kannada District, Karnataka State, Central Western Ghats.	**175**
3).	**Inventorisation and mapping of domesticated biodiversity (agricultural, horticultural and livestock).**	13	39	**15.** Exploring Biodiversity and Ecology of the Central Western Ghats.	**303**
		16	42	**16.** Soil Quality across diverse landscapes in Central Western Ghats, India.	**76**
		19	49	**17.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
		34	64	**18.** Estuarine Fish Diversity and Livelihood in Uttara Kannada District, Karnataka State.	**100**
		38	68	**19.** Agro Biodiversity in Uttara Kannada.	**22**
		39	69	**20.** Status of Marine Fishery in Uttara Kannada.	**75**
4).	**Understanding ecology, biodiversity and hydrology**	4	21	**21.** Water, soil and sediment characterization: Sharavathi River Basin, Western Ghats.	**83**

	relationships.				
		14	40	**22.** Ecohydrology of Lotic ecosystems of Uttara Kannada, Central Western Ghats.	**69**
		16	42	**23.** Soil Quality across diverse landscapes in Central Western Ghats, India.	**76**
		22	52	**24.** Ecological Profile of Sharavathi River Basin.	**210**
		32	62	**25.** Floristic Diversity in Uttara Kannada District, Karnataka State, Central Western Ghats.	**175**
		35	65	**26.** Influence of Landscape Dynamics on Hydrological Regime in Central Western Ghats.	**153**
5)	**Understanding cultural diversity in relation to conservation such as of sacred groves and sacred trees, sacred animals, totemic species, etc., traditional resource utilization and management, traditional skills and arts, traditional economic activities such as production of artifacts skilled farm labour, etc. Identification of heritage and cultural sites.**	13	39	**27.** Exploring Biodiversity and Ecology of the Central Western Ghats.	**303**
		15	41	**28.** Ecology of sacred *KAN* forests in Central WesternGhats.	**122**
		19	49	**29.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
		20	50	**30.** Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats.	**165**
		21	51	**31.** Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada.	**25**
		32	62	**32.** Floristic Diversity in Uttara Kannada District, Karnataka State, Central Western Ghats.	**175**
6).	**Assessment of renewable energy potential (region-wise).**	26	58	**33.** Sustainable Energy Alternatives for Uttara Kannada.	**95**
7).	**Assessment of carbon dynamics (sequestration**	33	63	**34.** Carbon Sequestration in Uttara Kannada.	**124**

	potential, emission).				
		16	42	**35.** Soil Quality across diverse landscapes in Central Western Ghats, India.	**76**
8).	**Assessment of ecosystem services and goods (ecosystem-wise).**	9	30	Valuation of Bivalves* *based on the survey done earlier	**57**
		17	48	**36.** Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India.	**24**
		19	49	**37.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
		25	44	**38.** Valuation of Goods and Services from Forest Ecosystem of Uttara Kannada, Central Western Ghats.	**60**
		27	45	**39.** Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka.	**70**
9).	**Socio economic worthiness of people's institutions and organisations.**	40	70	**40.** Socio-economic worthiness of people's institutions and organizations	**72**
		19	49	**41.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
10).	**Identification and mapping of natural disaster prone regions, monitoring and mitigation measures through eco-restoration (eg. creation of green barriers to prevent sea erosion).**	7	28	**42.** Landslide susceptible zone mapping in Uttara Kannada, Central Western Ghats.	**131**
		10	34	**43.** Green walls for Karnataka Sea Coast.	**38**
11).	**Global significance of the region (RET species, threatened ecosystems, protected areas, etc.).**	3	20	**44.** Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats.	**51**
		6	22	**45.** Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats.	**44**
		8	37	**46.** Anuran Diversity and Distribution in Dandeli Anshi Tiger Reserve	**28**
		11	35	**47.** Aghanashini Estuary in Kumta taluk, Uttara Kannada – Biological Heritage Site	**24**
		12	36	**48.** Grasslands of Anshi-Dandeli Tiger Reserve.	**114**
		-	43	**49.** Ecological Status of Dandeli Anshi Tiger Reserve.	**25**
		18	47	**50.** Amphibian Diversity and Distribution in Uttara Kannada District.	**30**

		19	49	**51.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
		20	50	**52.** Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats.	**165**
		21	51	**53.** Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada.	**25**
		-	CESTR:129	**54.** An Appraisal and Conservation Strategies for the Pteridophytes of Uttara Kannada.	**54**
		22	52	**55.** Ecological Profile of Sharavathi River Basin.	**210**
		32	62	**56.** Floristic Diversity in Uttara Kannada District, Karnataka State, Central Western Ghats.	**175**
		37	67	**57.** Ecologically Sensitive Regions in Uttara Kannada.	**300**
12).	**River basin-wise, integrated holistic valuation (tangible and intangible) and assessment of ecological carrying capacity.**	36	66	**58.** Carrying Capacity of River Basins Considering Ecological and Social Demands	**97**
13).	**Impact of developmental projects (power, industry, monoculture plantation, etc.).**	31	61	**59.** Land use changes with the implementation of developmental projects in Uttara Kannada District.	**100**
14).	**Formulation of ecologically sound developmental plan for sustainable productivity of the district.**	30	60	**60.** Adopting Clustering Approaches – Ecology Integrated Sustainable Development of Uttara Kannada	**35**
		37	67	**61.** Ecologically Sensitive Regions in Uttara Kannada.	**300**
		41	71	**62.** Integrated Ecological Carrying Capacity of Uttara Kannada district	

Note: SCS – Sahyadri Conservation Series, ETR – ENVIS Technical report

Letter to the Member Secretary, Karnataka Biodiversity Board regarding the submission theme-wise final reports

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DR. T. V. RAMACHANDRA

CES/TVR/KBB/ 9560/2014
7th January 2014

The Member Secretary
Karnataka Biodiversity Board
(Forest, Ecology and Environment Department)
Government of Karnataka
Ground Floor, VANAVIKAS
18TH Cross, Malleshwaram. BANGALORE -03

Dear Sir

Sub: Regarding the Submission of report of the project "Integrated Ecological Carrying Capacity Study of Uttara Kannada District, Karnataka" reg.

Ref: a) letters from Karnataka Biodiversity Board
KBB/W.G.Studies/75/13-14/713 dated 13/12/13
KBB/W.G.Studies/75/13-14/569 dated 8/11/13
KBB/W.S.Studies/75/13-14/549 dated 28/10/13
KBB/RFD/01/13-14/394 dated 23/08/2013, your email, meeting of 27/06/2013
KBB/W.G.Studies/75/13-14/152 dated 5/06/2013
KBB/W.G.Studies/75/12-13/76 dated 14/05/2013
KBB/W.G.Study/75/2011-12, 21/12/2011
KBB/Western Ghats/75/2011-288, 19/10/2011,

b) **Our earlier letters**:
CES/TVR/KBB/9534/2013, dated 30th December 2013
CES/TVR/KBB/9533/2013, dated 27th December 2013
CES/TVR/KBB/9523/2013, dated 11th December 2013
CES/TVR/KBB/9511/2013, dated 6th December 2013
CES/TVR/KBB/9450/2013, dated 13th August 2013
CES/TVR/KBB/9399/2013, dated 27th June 2013
CES/TVR/KBB/9407/2013 dated 27th June 2013
CES/TVR/KBB/8981/2012 dated 4th May 2012
CES/TVR/KBB/8950/2012, dated 30th March 2012

CES/TVR/KBB/8631/2011, 27th June 2011 with CD containing the progress for the first year.
CES/TVR/KBB/8906/2012 dated 10th February 2012

Apropos the subject **Integrated Ecological Carrying Capacity Study of Uttara Kannada District, Karnataka** we wish to clarify that covering almost each one of the theme referred to us and even covering extra themes needed for completeness (for example Marine Fisheries of Uttara Kannada; unhealthy land use practices and landslides, conservation of laterite plateaus with rare ecosystems etc. which were not specifically referred to us), we have altogether submitted to your office **37 no of final reports** totaling **3632 pages**, as and when such **themes/ topics** were completed. Each one of these final reports, complete with summary and recommendations has been submitted since March 2012.

We have already submitted consolidated report on 28th November 2012 (letter reference CES/TVR/KBB/ 9194/2012), subsequently the board had arranged the review on 21st January 2013. You may note that based on some partial feedbacks received addressing sections given in the last review meeting held on 21st January 2013, and letter dated 28th January 13 (ref no KBB/W.G.Studies/75/12-13/679), we submitted 16 more reports (our letter 13th August 2013, 6th Dec, 11th Dec, .27th Dec 2013 and 30th Dec 13). Each one of these reports cost us extra time for field studies, associated research and reporting.

These reports were submitted in the hope that your office (Karnataka Biodiversity Board) - will take appropriate steps to circulate the reports to relevant departments/stakeholder agencies for scrutinizing and feedback. We learn from the departments like Forest, Fisheries, Mining and Geology (on report on landslides), Zilla Panchayat of Uttara Kannada etc. that none of our reports is passed on to them till to date for their scrutiny or implementation shows that proper co-ordination is amiss in this regard. We are once again appending herewith the list of final reports with dates of submission for earliest feedback.

Submission of reports of the project "Integrated Ecological Carrying Capacity Study of Uttara Kannada District"

Sl. No	Letter No. and Date	Report No.		Title of the Report	No. of Pages
		SCR	**ETR**		
1	CES/TVR/KBB/ 9534/2013, 30th December 2013	**40**	**70**	**1.** Socio Economic Worthiness of People's Institutions and Organizations.	**52**
2	CES/TVR/KBB/ 9533/2013, 27th December 2013	**36**	**66**	**2.** Carrying Capacity of River Basins considering Ecological and Social Demands	**97**
		37	**67**	**3.** Ecologically Sensitive Region in Uttara Kannada.	**300**
3	CES/TVR/KBB/ 9523/2013, 11th December 2013	**38**	**68**	**4.** Agro Biodiversity in Uttara Kannada.	**22**
		35	**65**	**5.** Influence of Landscape Dynamics on Hydrological Regime in Central Western Ghats.	**153**
4	CES/TVR/KBB/ 9511/2013, 6th December 2013	**39**	**69**	**6.** Status of Marine Fishery in Uttara Kannada.	**75**
		33	**63**	**7.** Carbon Sequestration in Uttara Kannada.	**124**
	CES/TVR/KBB/ 9450/2013, 13th August 2013	**34**	**64**	**8.** Estuarine Fish Diversity and Livelihood in Uttara Kannada District, Karnataka State.	**100**

		32	**62**	**9.** Floristic Diversity in Uttara Kannada District, Karnataka State, Central Western Ghats.	**175**
		31	**61**	**10.** Land use changes with the implementation of developmental projects in Uttara Kannada District.	**100**
		29	**57**	**11.** Fragmentation of Uttara Kannada Forests.	**270**
6	CES/TVR/KBB/ 9407/2013, 27th June 2013	**30**	**60**	**12.** Adopting Clustering Approaches – Ecology Integrated Sustainable Development of Uttara Kannada.	**35**
		26	**58**	**13.** Sustainable Energy Alternatives for Uttara Kannada.	**95**
		27	**45**	**14.** Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka.	**70**
		28	**56**	**15.** Land Use Land Cover (LULC) Dynamics in Uttara Kannada District, Central Western Ghats.	**35**
		25	**44**	**16.** Valuation of Goods and Services from Forest Ecosystem of Uttara Kannada, Central Western Ghats.	**60**
		CESTR:129		**17.** An Appraisal and Conservation Strategies for the Pteridophytes of Uttara Kannada.	**54**
7	CES/TVR/KBB/ 9194/2012, 28th November 2012	**-**	**-**	**18.** Integrated Ecological Carrying Capacity Study of Uttara Kannada District, Final Report Draft.	**107**
		21	**51**	**19.** Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada.	**25**
		22	**52**	**20.** Ecological Profile of Sharavathi River Basin.	**210**
8	CES/TVR/KBB/ 9152/2012, 17th November 2012	**20**	**50**	**21.** Conservation and Management of Mangrooves in Uttara Kannada, Central Western Ghats.	**165**
9	CES/TVR/KBB/ 9079/2012, 23rd August 2012	**19**	**49**	**22.** Beekeeping Sustainable Livelihood option in Uttara Kannada, Central Western Ghats.	**146**
		18	**47**	**23.** Amphibian Diversity and Distribution in Uttara Kannada District.	**30**
10	CES/TVR/KBB/ 8981/2012, 4th May 2012	**16**	**42**	**24.** Soil Quality across diverse landscapes in Central Western Ghats, India.	**76**
		17	**48**	**25.** Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India.	**24**
		15	**41**	**26.** Ecology of sacred *KAN* forests in Central WesternGhats.	**122**
		12	**36**	**27.** Grasslands of Anshi-Dandeli Tiger Reserve.	**114**
		4	**21**	**28.** Water, soil and sediment characterization: Sharavathi River Basin, Western Ghats.	**83**
		10	**34**	**29.** Green walls for Karnataka Sea Coast.	**38**

		11	**35**	**30.** Aghanashini Estuary in Kumta taluk, Uttara Kannada – Biological Heritage Site	**24**
		-	**43**	**31.** Ecological Status of Dandeli Anshi Tiger Reserve.	**25**
11	CES/TVR/KBB/ 8950/2012, 30th March 2012	**13**	**39**	**32.** Exploring Biodiversity and Ecology of the Central Western Ghats.	**303**
		14	**40**	**33.** Ecohydrology of Lotic ecosystems of Uttara Kannada, Central Western Ghats.	**69**
		7	**28**	**34.** Landslide susceptible zone mapping in Uttara Kannada, Central Western Ghats.	**131**

		8	**37**	**35.** Anuran Diversity and Distribution in Dandeli Anshi Tiger Reserve.	**28**
		6	**22**	**36.** Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats.	**44**
		3	**20**	**37.** Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats.	**51**

(**Note:** SCR – Sahyadri Conservation Series, ETR – ENVIS Technical report)

We handle numerous projects – national and international including various departments in Government of Karnataka. All funding agencies – various government departments in Karnataka, India and abroad write to the concerned Principal Investigator on issues related to the project. Frequent letters from KBB to the Registrar, IISc is contrary to the established norms and none of your letters have acknowledged or discussed theme wise reports submitted by us.

We are surprised to see your frequent letters to the Registrar, IISc despite regular submission of final reports (based on the themes). Outcome of our research should have reached para-state agencies, stakeholder organisations for implementing appropriate biodiversity conservation strategies. You may note that we have completed theme-wise submission of all final reports (with submission of ETR 66, 67 and 70 letter dated 27th and 30th Dec 2013) in the stipulated time as agreed by us during the review meetings. We look forward to early implementation of suggestions as per these reports. Our team has worked sincerely towards the completion of the task with a hope that our suggestions would help in the conservation and sustainable management of ecologically fragile Western Ghats.

Thank you,

Yours sincerely,
Sd-

(Dr. T.V. Ramachandra)

CC:

1. Dr. Sivasailam, IAS, Principal Secretary, GOK, Dept of Forest Ecology and Environment
2. APCCF and Member Secretary, Karnataka Biodiversity Board,
   Ground Floor, "Vanavikas", 18th Cross, Malleshwara.
3. The Registrar, Indian Institute of Science, Bangalore
4. Sri. Ananth Ashisar, Deputy Chairman, Karnataka Biodiversity Board
5. Prof. M D Subash Chandran , CES Field Station, IISc, Kumta
6. The Deputy Financial Controller, CSSP, IISc

4. STUDY AREA: UTTARA KANNADA DISTRICT, KARNATAKA STATE, INDIA

Karnataka state comprises of 30 districts, of which Uttara Kannada, Dakshina Kannada and Udupi are in the costal belt. Uttara Kannada (Figure 4.1) district is bounded between 13.769^o to 15.732^o north and 74.124^o to 75.169^o east. It encompasses an area of 10,291 sq km, which is 5.37% of the total area of the State. The district extends to about 328 km north south and 160 km east west. Most of the district is hilly and thickly wooded. The area of the district is 10,222.3 sq km. For administrative purpose, the district has 11 taluks. Supa taluk is the largest with an area of 1890.3 sq km and Bhatkal taluk the smallest in district with 348.9 sq km. The district is surrounded by state of Goa and Belgaum district in the north, Dharward and Haveri in the east; southern neighbours are Udipi and Shimoga districts, the Arabian Sea on the other side. This district takes away maximum portion of the shoreline, i.e., 120 km of 300 km of the total costal belt of Karnataka.

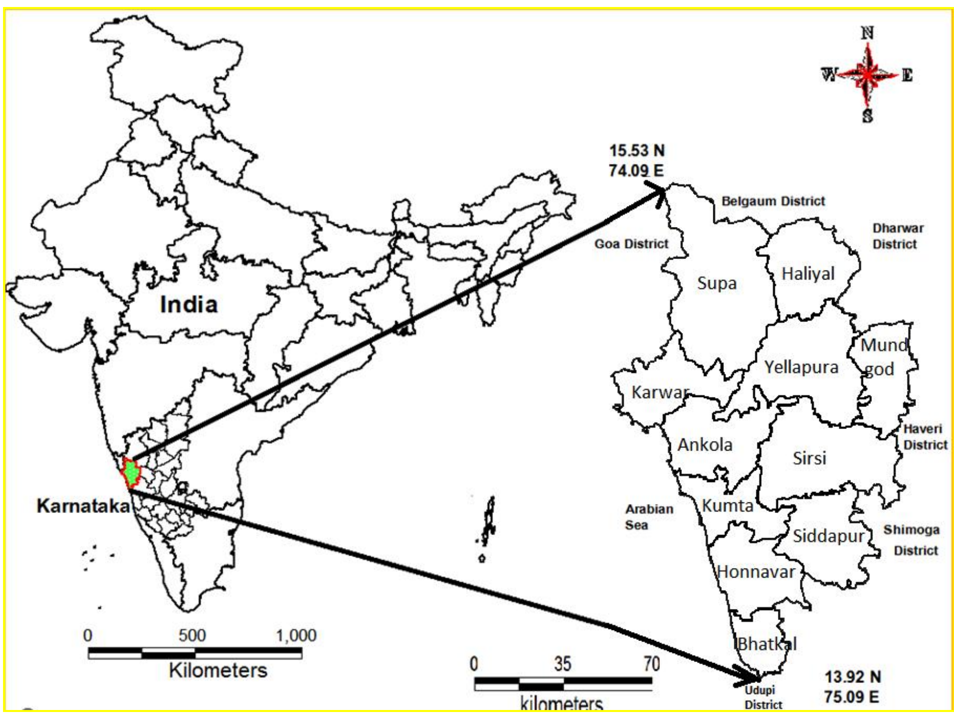


Figure 4.1: Geographic location of Uttara Kannada district

The west flowing rivers break the shoreline of Uttara Kannada by deep and wide mouthed estuaries. Kalinadi, Bedthi, Aganashini, Sharavathi, Venkatapur, Bhatkal, Belambar, Navgadde halla, Hattikeri halla and Belambar are west flowing rivers (Figure 4.2). Of these major rivers are Kalinadi, Bedthi, Aganashini, and Sharavathi River. The two east flowing rivers are Dharma and Varada. The rivers give raise to magnificent waterfalls in the district. The Jog fall in Sharavathi, Lushington falls, where the river Aghanashini drops 116 meters, Magod falls, where the Bedti river plunges 180 meters in two leaps, Shivganga falls, where the river Souda drops 74 meters, and Lalguli and Mailmane falls on the river Kali. The Kali river origins in Joida taluk flows through Karwar taluk, the Gangavali (Bedthi) origins in

Dharwad District flows through Yellapur and Ankola taluks. The Aghanashini river origins in Sirsi flows through Siddapur and Kumta taluks. Sharavati origins in Shimoga district, which forms the famous Jog Falls flows through Honnavar. The other rivers of the District are the Venktapur (origins in Bhatkal) and the Varada (origins in Sirsi). All the rivers flow from East to West, whereas Varada river flows eastwards. Uttara Kannada district has five reservoirs such as Supa reservoir, Tattihalla reservoir, Bommanahalli reservoir, Kodsalli reservoir & Kadra reservoir across Kali river and Gersoppa reservoir across Sharavathi river. Also, where these rivers meet the sea, there form some of the finest estuaries of the west coast. The district has varied Geographical features with thick forest, perennial rivers and abundant flora and fauna and a long coastal line of about 140 KM in length.

The study region included Uttara Kannada District (Figure 4.1, located at74^{0}05'13" - 75^{0}05'58" E and 13^{0}55'26" - 15^{0}31'23" N), some parts of Sagar and Hosanagara taluks of the adjoining Shimoga district, which form the main watershed for Sharavathi, one of the important west-flowing rivers of Karnataka.

Brief history: Uttara Kannada was under the rule of Kadambas from the 350 - 525CE, Banavasi was the capital. After the conquest of the Kadambas by the Chalukyas, the district came under successive rule of empires like Chalukyas, Rashtrakutas, Hoysalas and Vijayanagar Empire. Famous Arab traveler Ibn Battuta is said to have stayed for a time in the district under the protection of Nawayath Sultan Jamal al-Din at Hunnur. This place is presently known as Hosapattana and is located in the Honnavar taluk. The district came under the rule of Maratha Empire from around 1700 CE to 1800 CE. It was ceded to the British at the conclusion of the Third Anglo-Maratha War in 1818. The British established North Kanara district as a part of the Bombay Presidency. After India's independence in 1947, Bombay Presidency was reconstituted as Bombay state. In 1956 the southern portion of Bombay state was added to Mysore state, which was renamed as Karnataka in 1972.

The Uttara Kannada has rich diversity in the culture and languages. Languages of the district are Kannada, Konkani, Marathi, Tulu and Urdu. The population is predominantly Hindu comprising of many communities called as Bhandaris, Gramavokkaliga, Havyaka, Konkan Maratha, Goud Saraswat Brahmins, Daivajna Brahmins, Chitrapur Saraswat Brahmins, Vokkaligas, Sherugars, Namadhari naik, Nadavara and Vaishya (Vanis). Muslims in the district are mainly of Nawayath descent. They live mostly in taluks of Bhatkal and Honnavar and speak Nawayathi. The Konkani speaking people include Christians also. 90% of the population of this area speaks Kannada, Konkani and Marathi languages. The cultural pattern of people has thus been influenced both by Maharashtra and Karnataka.

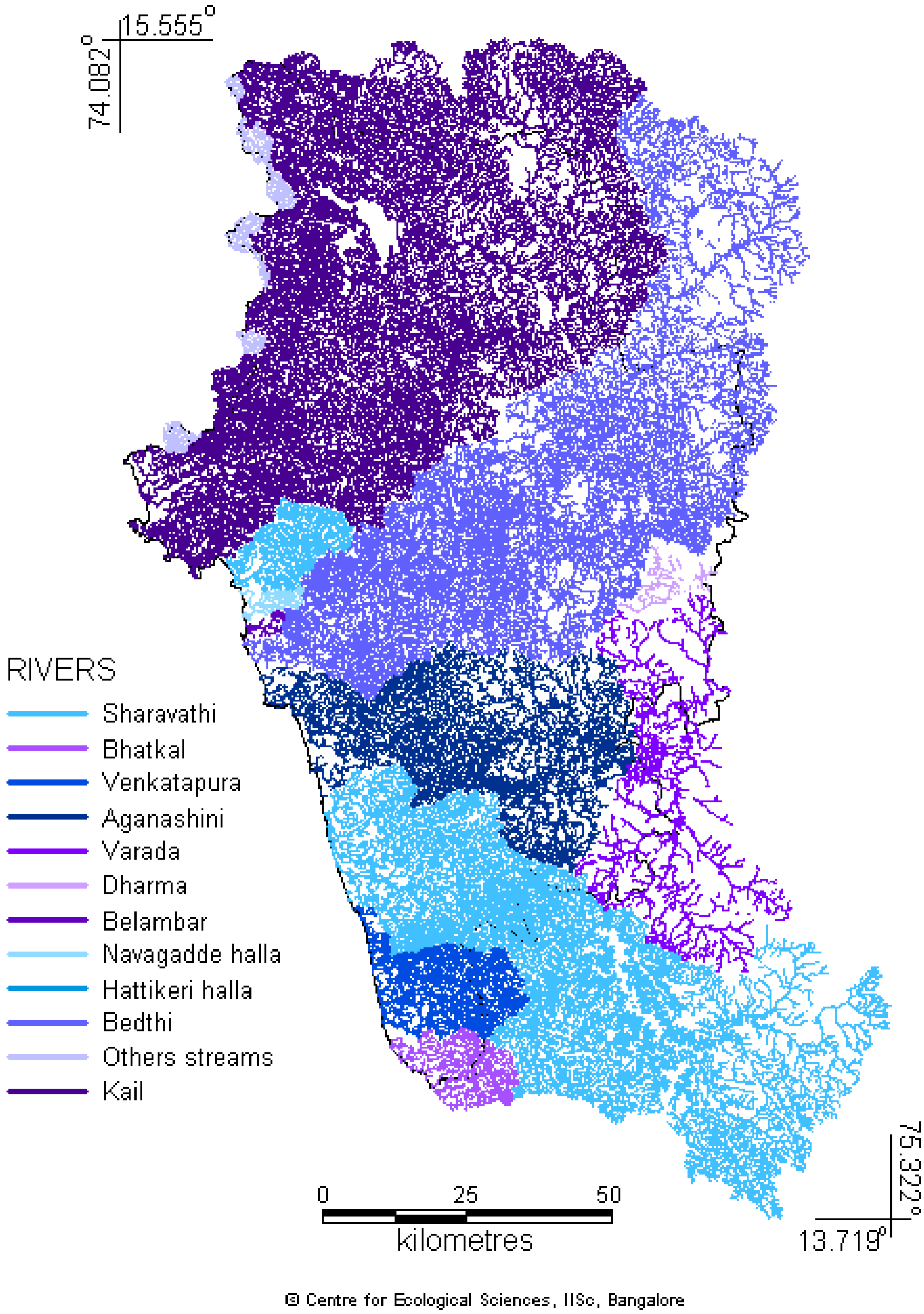


Figure 4.2: Drainage network in Uttara Kannada

4.1 ADMINISTRATIVE PROFILE:

The district is divided into 11 taluks (Figure 4.3). The district capital is at Karwar, the northernmost coastal taluk. The Deputy Commissioner is the administrative head of the district. The Chief Executive Officer of the Zilla Panchayat has also his office at Karwar. The Zilla Panchayat consists of the elected representatives of the people. The district has four Assistant Commissioners- at Karwar, Kumta, Bhatkal and Sirsi. The Tahasildar is the administrative head of the taluk. The villages are grouped under Village Panchayats, run by elected representatives. These 11 taluks have been divided into 1336 villages of which 1263 are inhabited and rest of the villages (73) is uninhabited.

The district, being the most forested one in the peninsular India, has a well-organised unit of the Forest Department. Named 'Kanara Circle' its administrative head is the Conservator of Forests. The Circle comprises of five territorial forest Divisions with the headquarters at Haliyal, Yellapur, Karwar, Honavar and Sirsi. Each Division is headed by a Deputy Conservator of Forests / Division Forest Officer (DFO). The entire forest area of the district is divided into 34 forest Ranges, each under a Range Forest Officer, and 131 forest Sections each under a Forester, and 425 Beats each under a Guard.

The Fisheries Department is under the Deputy Director of Fisheries. The department, with headquarters at Karwar, administers matters pertaining to marine, estuarine and inland fish resources. In addition Karwar also has the branch office of Central Marine Fisheries Research Institute (CMFRI), Cochin. Scientists here gather regular data on marine fisheries.

The Agriculture Department is headed by the Joint Director, whose office is at Karwar. The district is well known for horticultural biodiversity. Horticulture is under the jurisdiction of the District Horticultural Officer whose office is at Sirsi.

Senior Geologist heads Mines and Geology department which undertakes mineral investigation in the district. The district officers of the Groundwater Wing are under the administrative control of Zilla Panchayaths and technical guidance is provided by the Directorate.

The district groundwater officers are also carrying out micro watershed studies, studies of any specific groundwater problems identified in the district and also carry out construction of artificial recharge structures in their jurisdiction. They render technical advises for sinking of wells/bore wells and also for taking up rain water harvesting structures.

Karwar even has a Natural Resources Data Management System (NRDMS), launched by the Department of Science and Technology. This is National initiative aimed at developing and inducting such data based approach to planning.

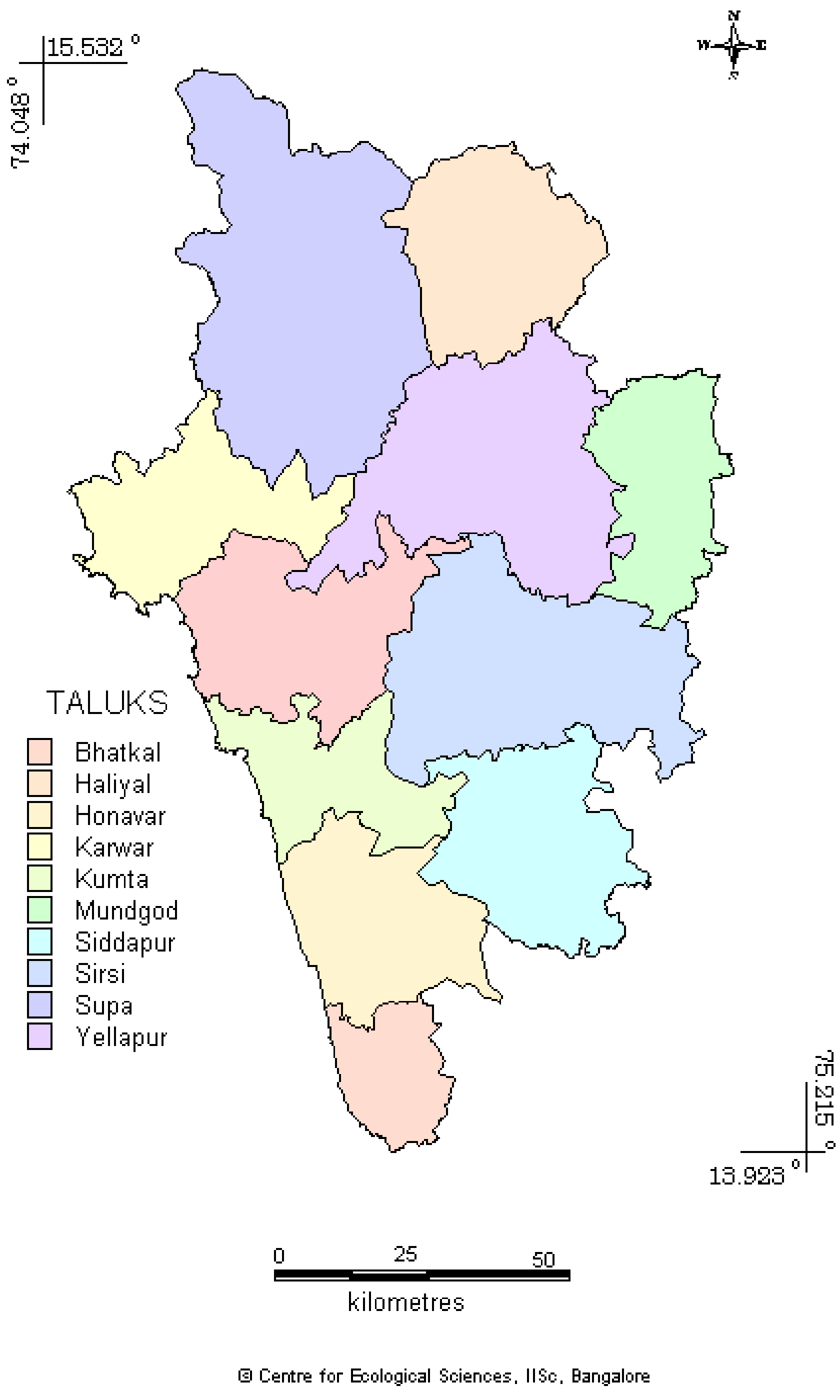


Figure 4.3: Taluks of Uttara Kannada district

4.2 POPULATION

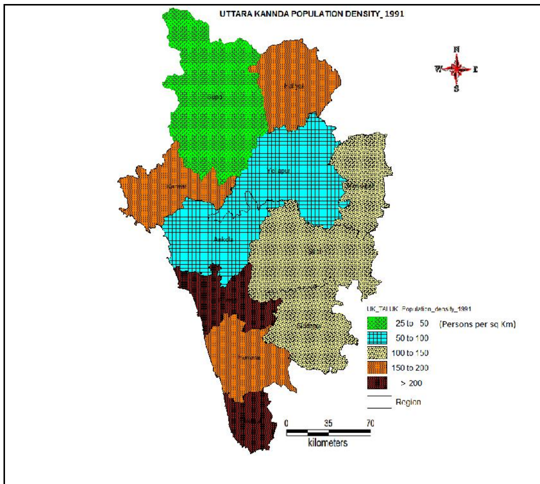
The population according to 2001 census data was 1,353,644 which amount to a population density of 132.42 per sq km implying a growth of 10.9 % in population data of 1991. The Bhatkal with the maximum and Supa minimum population density as can be seen in Table 4.1 (Figure 4.4.1 and 4.4.2). Figure 4.4.1 depicts talukwise population density, while Figure 4.4.2 depicts villagewise population density.

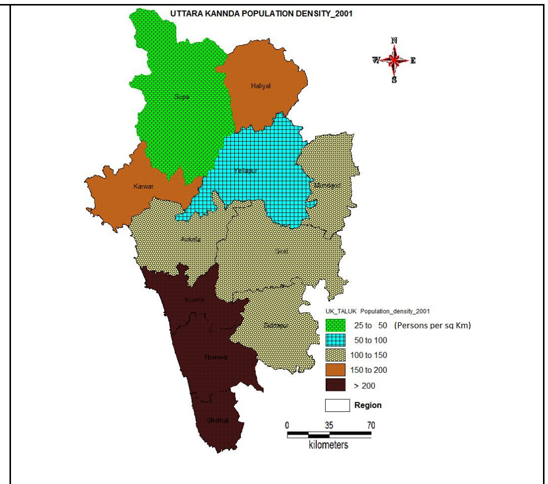
Nearly 75 % of the population of UK district lives in villages and remaining 25 % in small towns. It is estimated that about a fourth of the population lives below poverty line. In terms of gender related health indicators the situation in UK district is significantly better. The life expectancy at birth of females in UK district is 70.Thousands of people in the district have been displaced in the past due to hydel projects, Seabird Naval Base, Kaiga Atomic plant, Konkan Railway etc. (There are of 73 uninhabited villages 26 of the villages are evacuated during these construction activities). The displaced people were mostly resettled in forest lands. A total of at least 5508 ha of forests have been used since 1956 for resettlement of displaced people, which include even Tibetan refugees Forest encroachment is viewed as a serious problem. To regularise encroachments which have taken place before 27.04.1978, a total of 2824.8 ha have been released (Forest Department, 2000-01). Presently there are about 10,000 families of encroachers who are facing eviction. This is a haunting socio-economic and ecological problem.

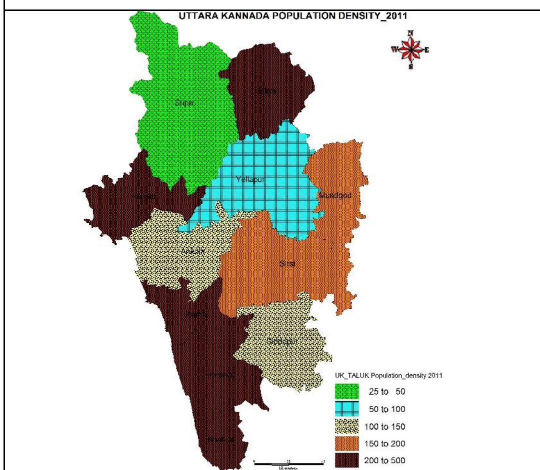
Table 4.1: **Taluk wise statistics of population, population density (persons/sq.km), number of villages and uninhabited villages.**

Taluk	Population 1991	Population 2001	Population _density_ 1991	Population _density_ 2001	Number of villages	Uninhabited villages (as per census 2001)
Ankola	91310	101549	97.87	108.84	86	1
Bhatkal	129017	149338	367.57	425.46	61	0
Haliyal	147064	159141	171.80	185.91	133	22
Honnavar	145842	160331	193.17	212.36	94	2
Karwar	140282	147890	188.05	198.24	58	6
Kumta	134144	145826	226.98	246.74	119	8
Mundgod	75046	90738	110.85	134.03	94	6
Siddapur	91646	100870	105.46	116.08	196	0
Sirsi	152935	175550	115.51	132.59	227	4
Supa	46818	48914	24.77	25.88	141	24
Yellapur	66156	73497	50.85	56.49	127	0
Total	**1220260**	**1353644**	**118.55**	**131.51**	**1336**	**73**

+ Without considering the population of taluk headquarters.

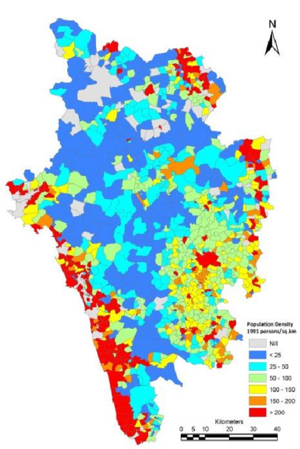




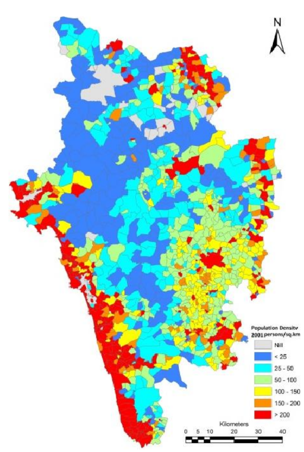


Taluk	Population -2011	Density persons/sq.km
Ankola	111449	119.954
Bhatkal	170417	487.455
Haliyal	172631	202.406
Honavar	172051	228.587
Karwar	153165	205.998
Kumta	159552	270.770
Mundgod	106952	158.670
Siddapur	111284	128.559
Sirsi	206225	156.470
Supa	54798	29.123
Yellapur	83930	64.005
Total	***1502454***	***146.329***

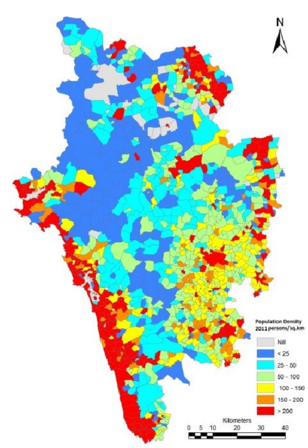
Figure 4.4.1: Population density distribution (1991 & 2001) across taluks



Population Density 1991



Population Density 2001



Population Density 2011

Figure 4.4.2: Villagewise population density 1991, 2001 and 2011

4.3 CLIMATE

Uttara Kannada has a tropical climate. It has a well-defined rainy season of about five months between June and November when the south west monsoon brings most of the rainfall and the climate remains hot and humid. The winds are predominantly south westerly during the summer monsoon and north easterly during the winter monsoon. The year may broadly be classified into four seasons. The dry season is from January to February with clear and bright weather. It is followed by hot weather from March to May. During this season thunderstorms are common in the month of May. The monsoon season is from June to September. The presence of Western Ghats in Uttara Kannada causes orographic precipitation (Mechanical lifting of moist air masses over natural barriers such as mountains cause orographic precipitation). The district falls under the Hilly agro climatic zone except for western parts of Karwar, Ankola, Kumta, Honnavar and Bhatkal taluks which fall under coastal agro climatic zone. The maximum rainfall is recorded in the coastal region and average rainfall toward the center of the basin and least rainfall toward the plains i.e., west to east. Bhatkal, which is a coastal region, receives high rainfall compared to other stations as can be seen in Figure 4.5. The mean annual rainfall is 4237 mm (Figure 4.6.1 to 4.6.8). Areal rainfall estimation and the analysis show that the land use dynamics has affected rainfall, mean annual rainfall was higher before the construction of reservoir. Average rainfall of 2108 mm was found in Kali river basin before the construction of Supa reservoir. After the construction the average rainfall reduced to 2019 mm. Daily rainfall data of 18 rain gauge stations since 1901 for 112 years (1901-2011) was collected from the Bureau of Economics and Statistics, Govt. of Karnataka. Table 4.2 lists the rain gauge stations and its location. Mean annual rainfall and the standard deviation were calculated for all the rain gauge stations to know annual variability and areal rainfall for the same was estimated using the kriging technique.

Table 4.2: Rain gauge stations and its location

RGS	District	Lat	Long	RGS	District	Lat	Long
Ankola	UK	14.69	74.30	Siddapura#	UK	14.30	74.89
Bhatkal#	UK	13.99	74.59	Sirsi	UK	14.60	74.79
Haliya*	UK	15.33	74.77	Hosanagara#	Shimoga	75.10	13.90
Honnavar#	UK	14.30	74.49	Sagara#	Shimoga	75.00	14.20
Joida*	UK	15.26	74.50	Shikaripura	Shimoga	75.40	14.30
Karwar*	UK	14.79	74.11	Soraba	Shimoga	75.00	14.40
Kumta#	UK	14.39	74.40	Dharwad*	Dharwad	75.00	15.50
Mundgod	UK	15.00	75.00	Kalghatgi	Dharwad	75.10	15.20
Yellapura*	UK	15.00	74.70	Kundgol	Dharwad	75.30	15.30

RGS: Rain gauge Stations, UK: Uttara Kannada, * (rain gauges in Kali river basin), # (rain gauges in Sharavathi river basin) - Stations chosen to analyse variations in rainfall with land-use dynamics with a well-defined rainy season between June and October, when the South-west Monsoon winds bring down on an average 2500 mm rainfall annually. The remaining part of the year has hardly any rains. Whereas the coastal and crest line taluks receive high rainfall, the north-eastern taluks, Haliyal and Mundgod have very low rainfall.

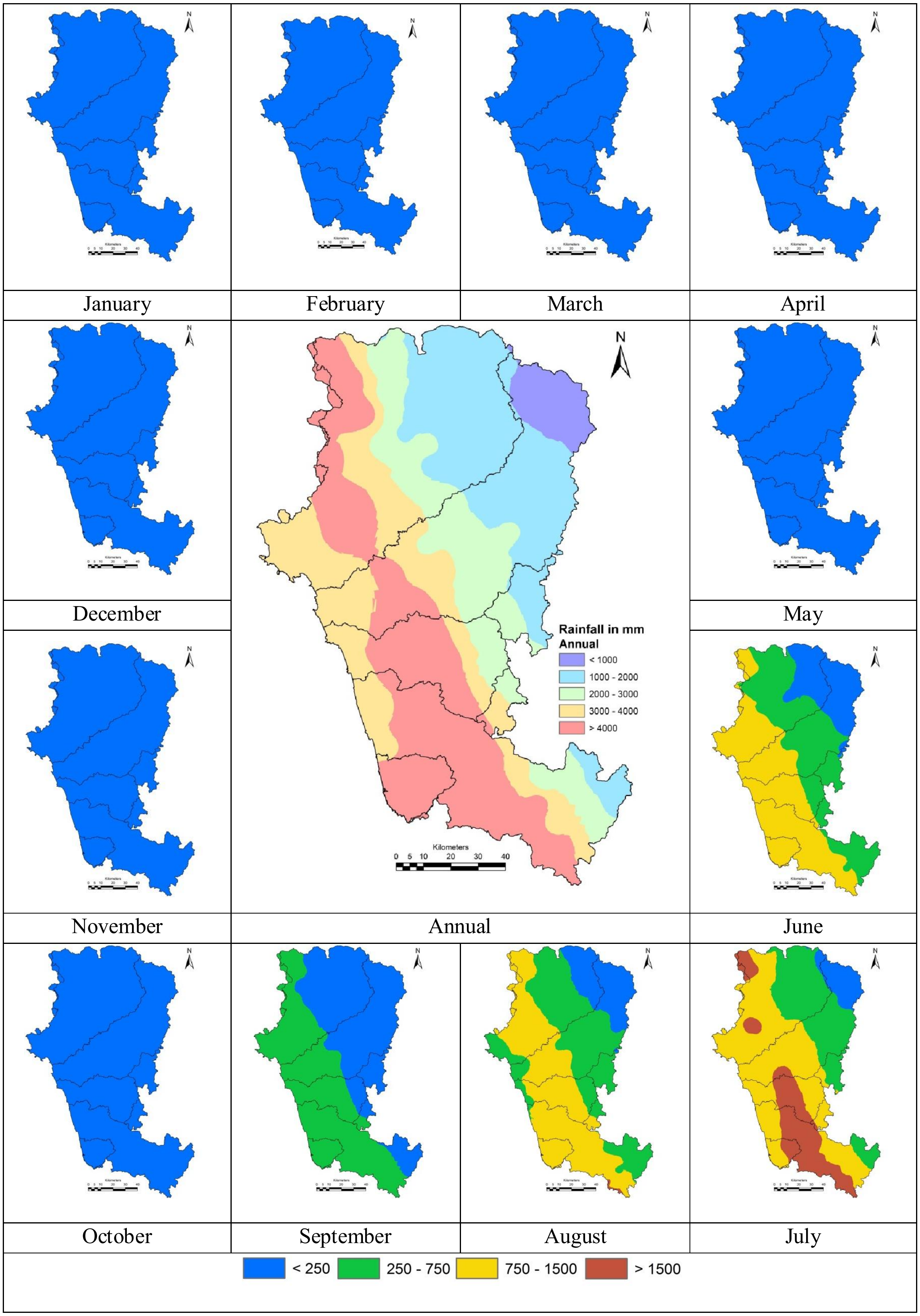


Figure 4.5: Rainfall (mm) distribution in Uttara Kannada

Ramachandra T.V., Subash Chandran M.D. and Joshi N.V., 2014. Integrated Ecological Carrying Capacity of Uttara Kannada district, Karnataka, Sahyadri Conservation Series 41, ENVIS Technical Report 71, CES, IISc,

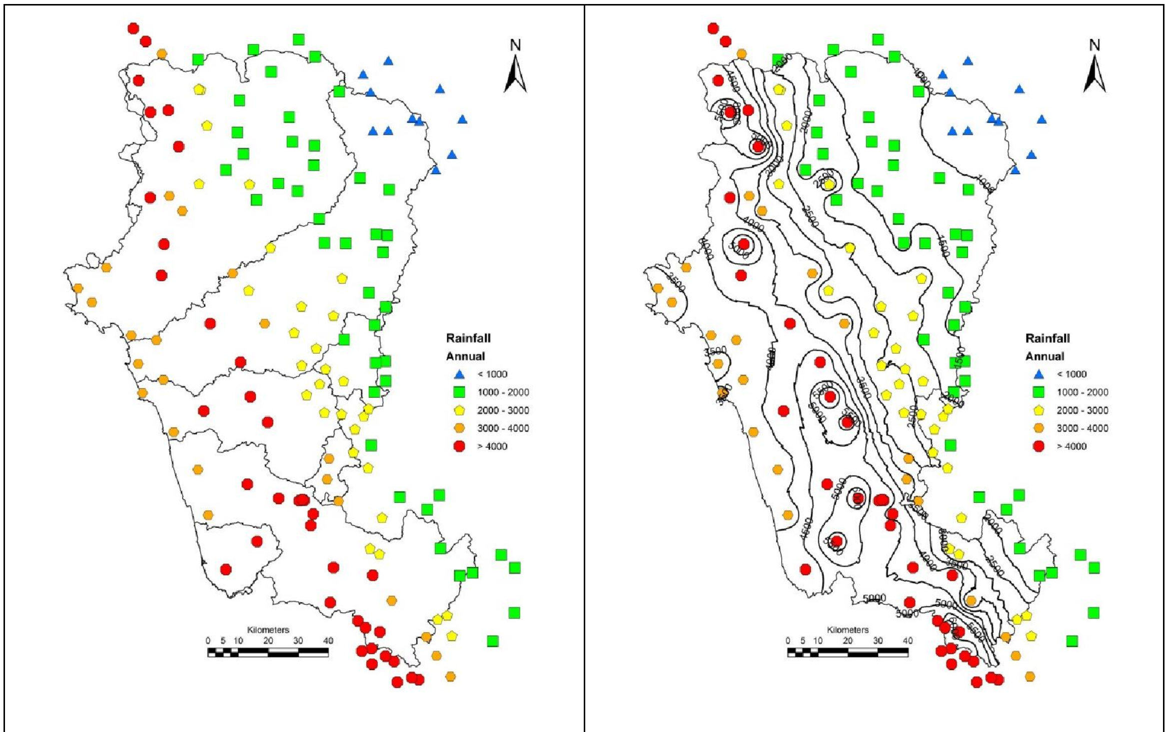


Figure 4.6.1: Annual Rainfall in mm

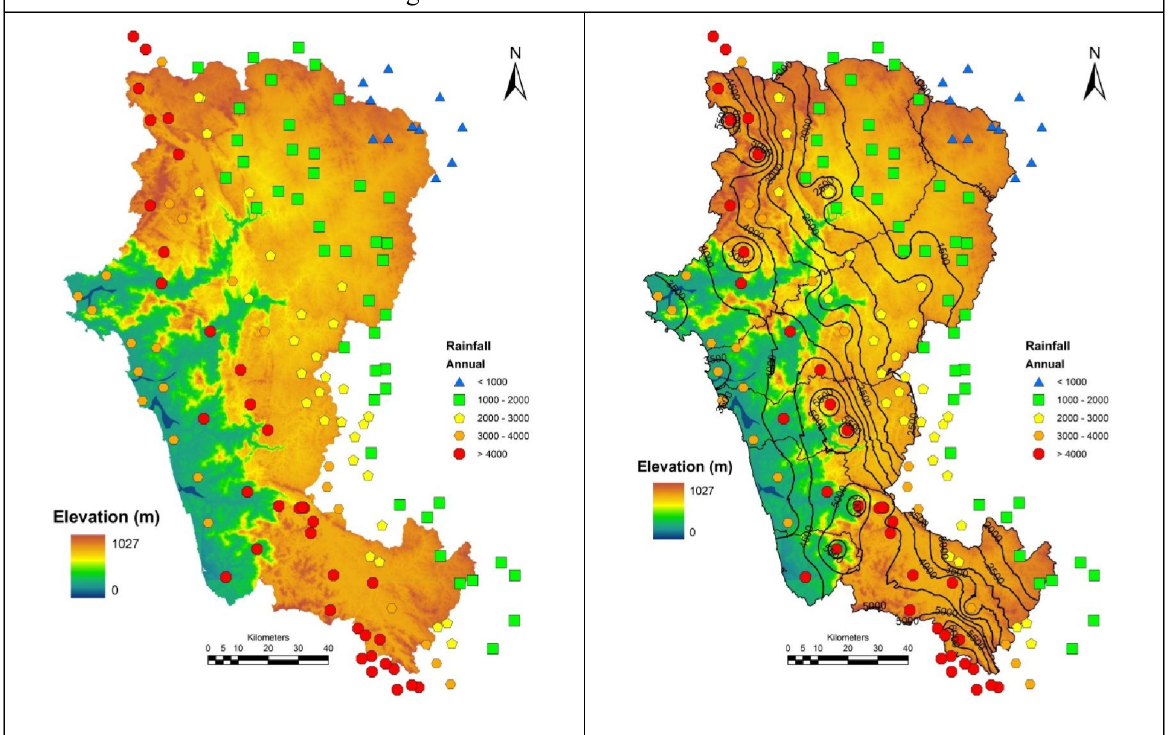


Figure 4.6.2: Annual Rainfall in mm overlaid on DEM

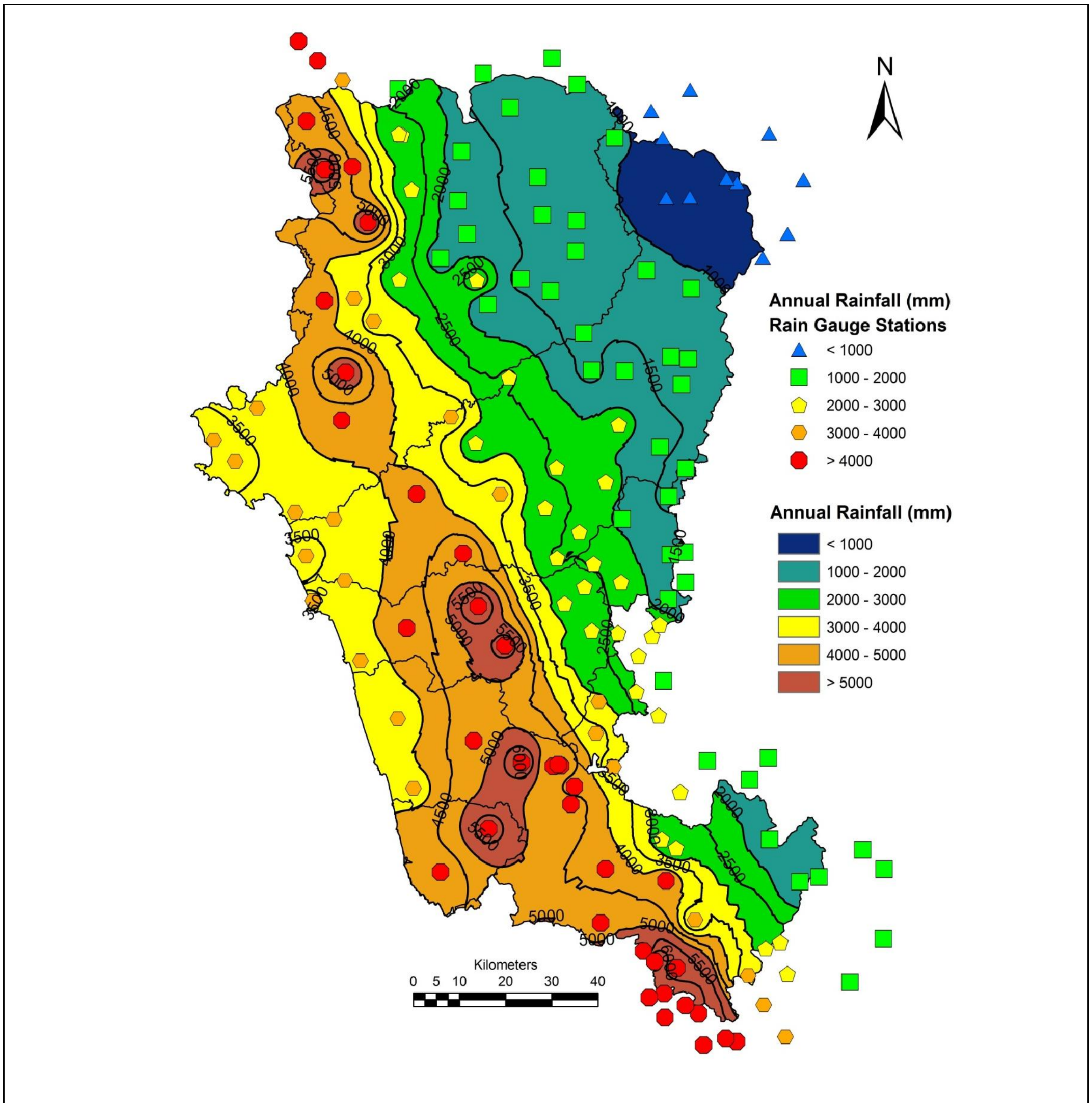


Figure 4.6.3: Annual Rainfall in mm Interpolated

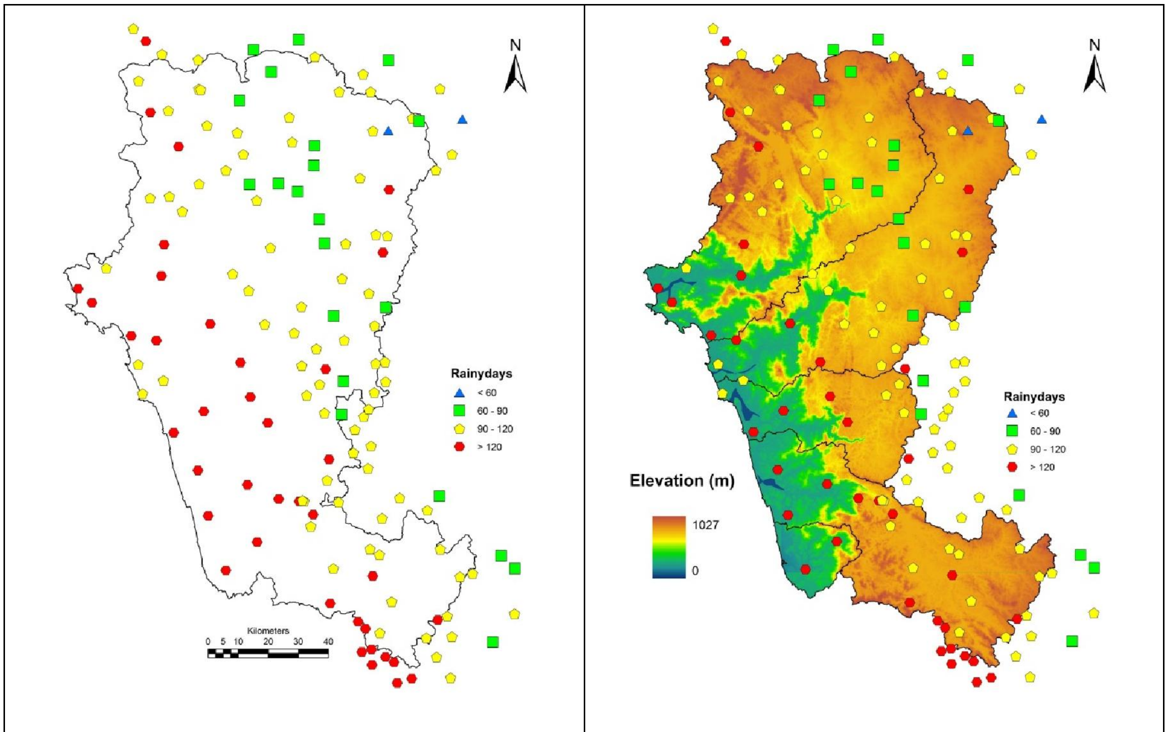


Figure 4.6.4: Number of Rainy day [Case I: Rainfall > 50 mm]

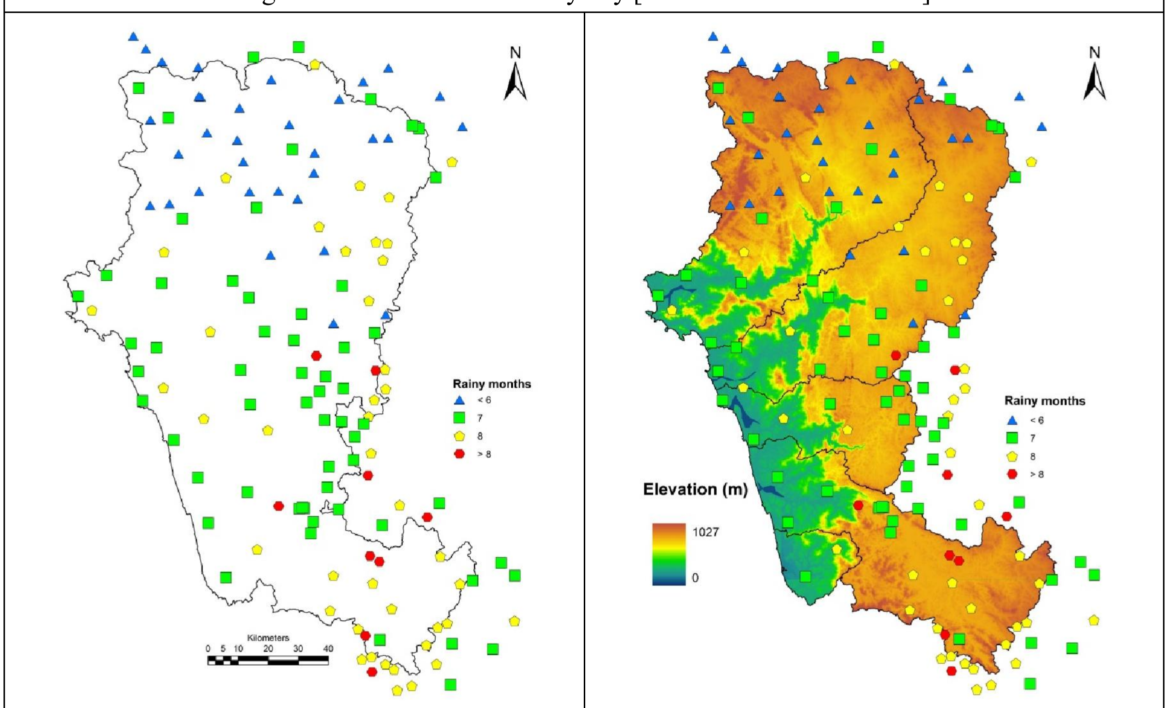


Figure 4.6.5: Number of Rainy Months [Case I: Rainfall > 50 mm]

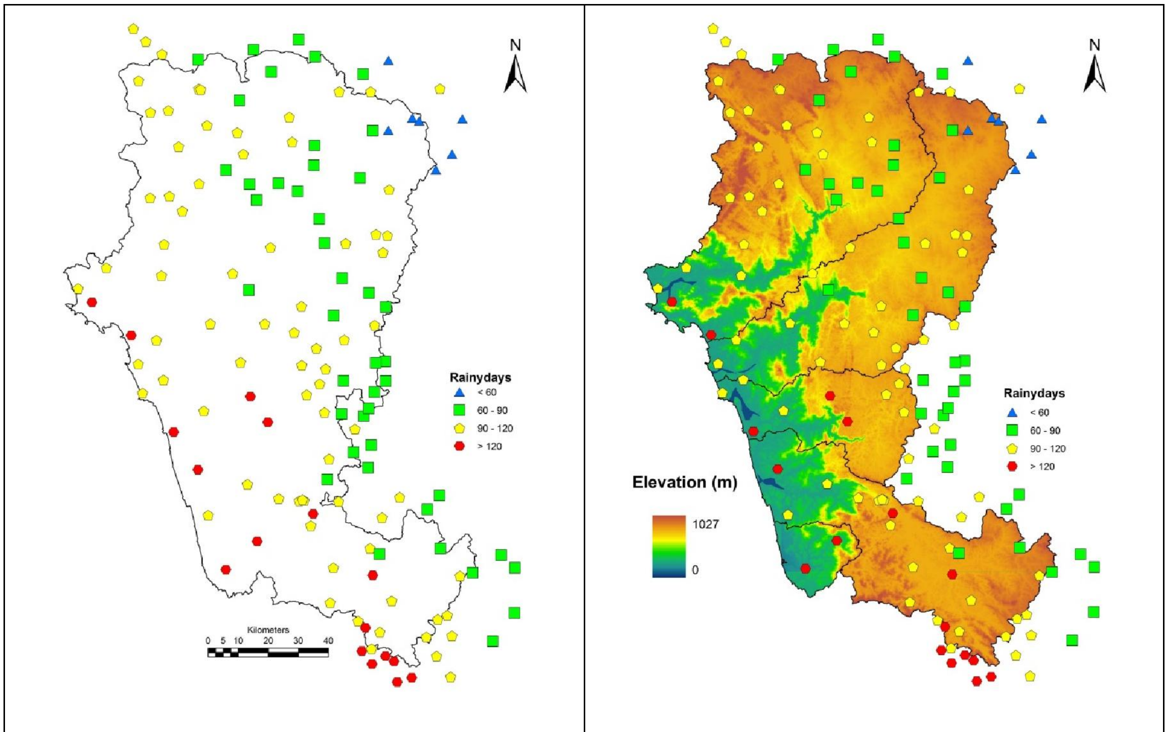


Figure 4.6.6:Number of Rainy day [Case II: Rainfall > 100 mm]

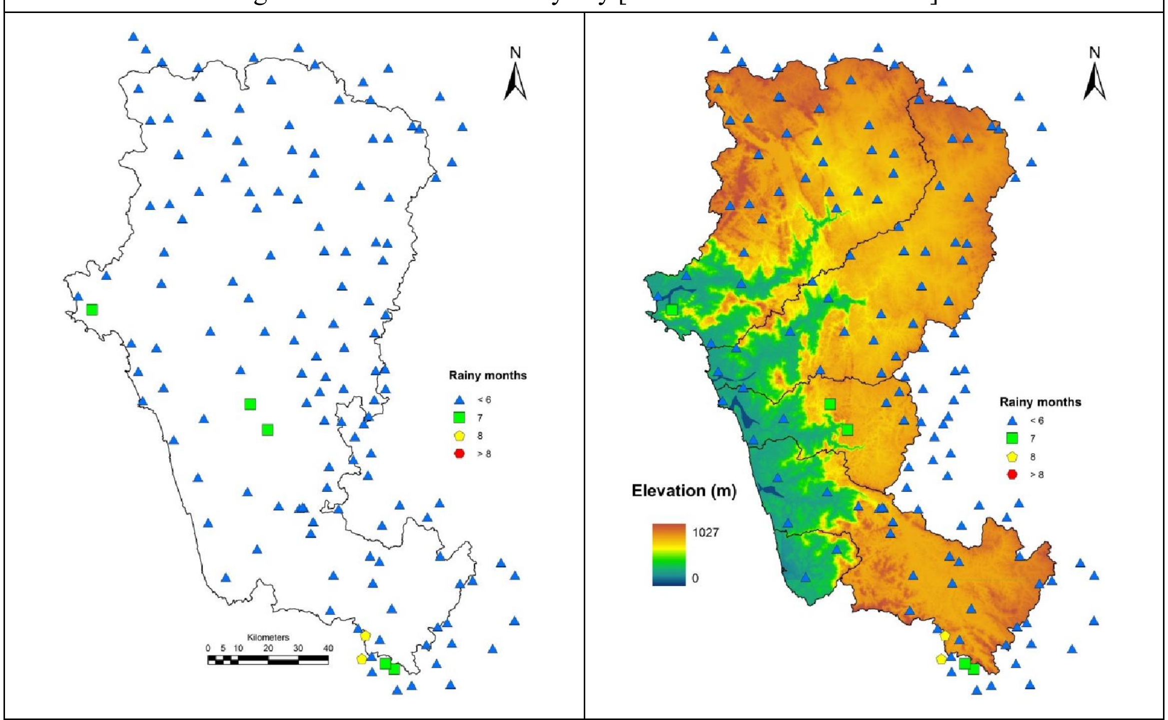


Figure 4.6.7: Number of Rainfall months [Case II: Rainfall > 100 mm]

4.4 TOPOGRAPHY:

The district is hilly and thickly wooded in most parts. Its major part is essentially highland, the lowland being restricted to the pockets along the course of rivers. Uttara Kannada is divided in to upland and low land by Sahyadri range (Figure 4.7.1 and 4.7.2). Uplands are the regions above the ghat with an area near of 7,770 sq km, and 600 to 700 meters above the sea level. Lowlands cover a region of 3,370 sq km. The district has three main and distinctive regions: the costal, the Sahyadrian interior and the eastern margin where the plateau begin. Relief and climate have introduced these regional differences.

- The coast of Uttara Kannada is almost straight line except at the shallow Karwar and Belekeri bay in the north. Karwar, Kumta, Honavar and Bhatkal regions are best developed with high economic development and a high density of population, as can be seen from the figure 4.4.1.
- The Sahyadrian region is mostly forested and only the road crossing the ghat sustains human activity, though the valley has special significance as belts of spice and areca gardens for which the district has been famous since yore.
- The eastern margin is undulating land, partly under forest and partly cleared for agriculture. It is a transitional zone between the forests and cultivated up lands of Dharwad district.

The costal tract being in the north form the village Majali on the Goa border and continues in the south up to the Udipi district boundary a little beyond the port of Bhatkal, till Gorte village. It varies from about 16 to 48 km depending upon the nature of estuaries and the intermediate tableland. Contrary to the general impression this is not a ‘plain’ but a succession of estuarine plains connected by narrow costal strips. Thus the tract in its northern extremity is a narrow coastal strip with large fishing village of Majali, focus of human activity.

A little to the south, Kali river joins the Arabian Sea, forming an estuary and supporting fishing activity. In the Kalinadi basin town of Karwar is located. The port of Karwar is always active as a result of mining activity in the district and nearby district. The Sea Bird project of navy has added one more dimension to this place. Further south of Kalinadi basin lies the Gangavali or Bedthi basin. These two basins are separated by small ghat known as Guddehalli-Baithkol range. This ghat forms horseshoe shape and some small rivers like Belambar, Navagadde and Hattikeri halla originate and join the sea (figure 4.2). In the catchment (basin) of Navagadde halla, Ankola is situated and is 20 km from Karwar. Bedthi merges in with sea at 3 km southwest of Ankola,.

Bedthi basin is separated from Aganashini or Thadri basin by a narrow range of hills. Kumta town is situated in this basin. South of Aganashini basin coastline is sandy and straight. The coastal line and coastal dunes has considerable influenced local agriculture. In the Sharavathi River basin, Honavar is located. The Sharavathi bridge and fisheries harbor, has contributed to the growth of Honavar. South of Sharavathi River basin, laterite assumes a more forbidden form and agricultural land is restricted to narrow strips along the coast. Bhatkal is at the southernmost tip of the district and a creek known as Bhatkal flows in the next to the town. In between Bhatkal and Sharavathi River, Venkatapur River flows (figure 4.2).

On the north, beyond the low level plateaus of the coastal region, lies the Malnadu of the North Karnataka. This is physically an extension of the Sahyadrian main range from Maharashtra in the north, and continues to the south in the districts of Shimoga and Hassan. From Chandgad border in the north to the border of the Siddapur taluk in the south, it has a length of about 110 km. As in the Maharashtra region the, the Sahyadris rise in a series of step from the costal lowlands, but the scrap face is not so bold as in the district of Kolhapur and Ratnagiri. In fact the geological composition gives a greater variety and a definite break which for a more favorable rainfall in the Dharwad district. The ‘rain shadow’ area is not so sharp and immediate in the northern Karnataka as it is in Maharashtra. Another interesting feature is the eastward shift of the watershed: the Kalinadi and Sharavathi Rivers drain a large the plateau area and through their captured course divert these water to Arabian Sea. Faulted topography is typical is typical of the western Sahyadris. This has given rise to the harnessing of hydropower. Central portion of the Sahyadris mainly consists of the crest line ridges and upper reaches of the rivers developing more mature valley forms before they plunge in to deeper chasms and gorges to join the coastal levels. The eastern margin has a rounded topography and the boarder valley features, which mark the transition from between the main Sahyadrian landscape and the drier plateau of the upghat regions. The three-fold division of Sahyadrian region persists in its features of the vegetation and is well reflected in its regional economy. In the western spurs which touch the low-level laterite plateaus, the red soil favours stunted vegetation, but in the higher terraces, vegetation improves in both density and quality to an astonishing degree. In the central belt, there is a mark of contrast between the hilltops and the backbone of ridges, which support a thinner vegetal cover and the river valleys where luxuriant deciduous growth is to be found. Evergreen strands are frequent features, but the riverbanks almost invariably carry the thickets of bamboo growth. In the eastern part of the Sahyadrian region, increasing dryness is the keynote in the landscape. It is a mellowed landscape with poorer types of forests having parkland scenery. Valleys open out toward the plateau margin of the Uttara Kannada district. Increasing cultivation and receding forest cover is a recurring pattern in the landscape (percentage change).

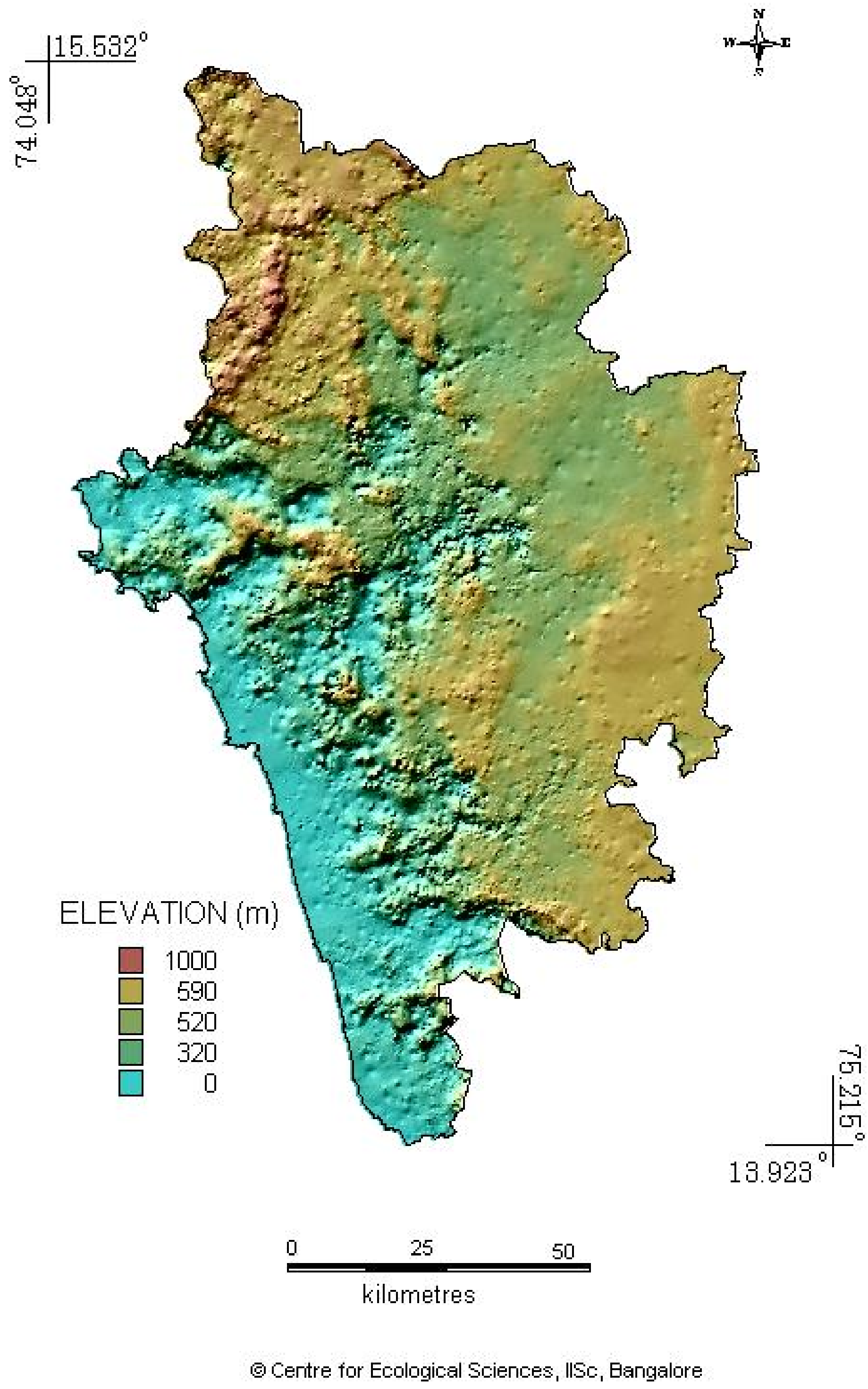


Figure 4.7.1: Shade relief map of Uttara Kannada district

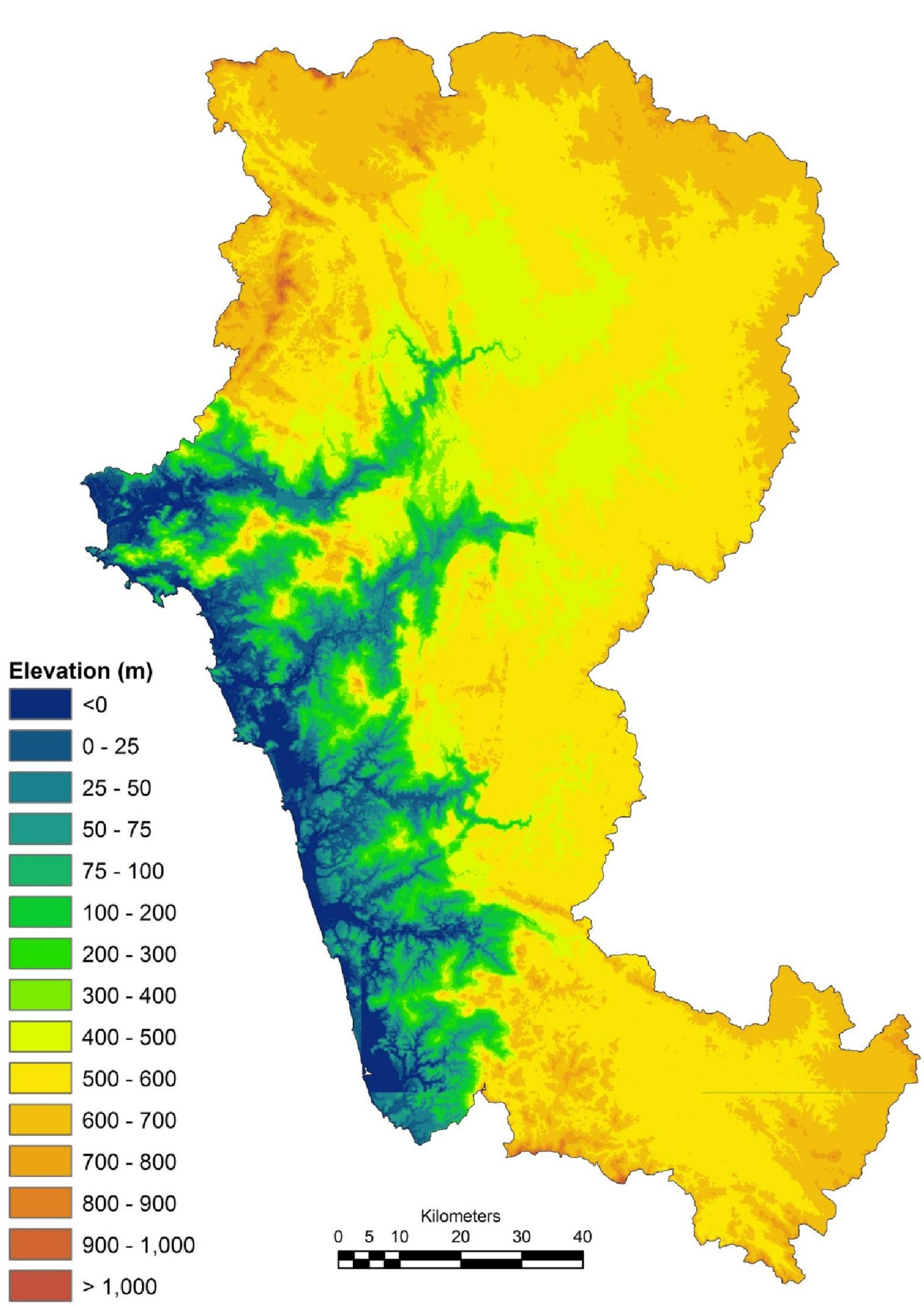


Figure 4.7.2: Digital elevation Model – DEM of Uttara Kannada district

Hills: The district is almost covered with hill, which may be arranged in to three groups:

- The bare flat –topped blocks of laterite from 60 to 90 meters high which roughen the coast belt,
- The westerly spurs from the central hills from 300 to 600 meters high stretch rugged and woody to the coast, and
- The main range and eastern spurs, of the central hills.

The west face of the Sahyadris in Uttara Kannada unlike the Sahyadris in Konkan does not rise in a single scarp, but is approached by numerous spurs and lower ridges. Locally the hills in the district are considered a break between two main ranges, the Sahyadris to the north that end at the Kalinadi near Karwar and the Malabar hills which stretches south from the Sharavathi River. Of the 11 peaks in the Sahyadris of the district, varying in height from 458 to 1050 meters, the Gudehalli and Shirvegudda are in Karwar taluk, the Bhedasgaon in Mundgod, the Menshingudda in Sirisi, the Hukali, Rakshasa and Mavinguddain Siddapur, Mothigudda, Kaltigudda, Darshanigudda and Nishanigudda are respectively in Ankola, Kumta, and Yellapur taluks. Suktale gudda and Sido Dongra gudda are the highest peaks with altitude of 1043 and 1049 meters in Supa taluk Darshanigudda in Supa (figure 4.8), about 1025 meters above the sea, rises near the meeting of the boundaries of Goa and Belgaum with Uttara Kannada.

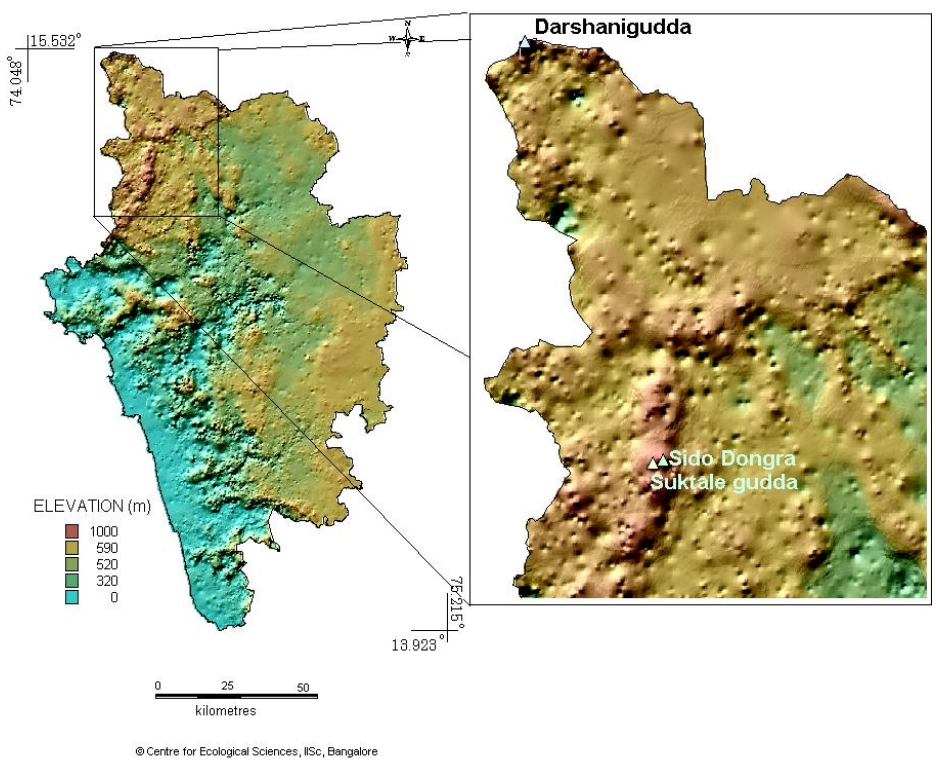


Figure 4.8: Highest peaks of Uttara Kannada district

4.5 RIVERS:

Kalinadi: The Kalinadi (figure 4.9) or Sadashivagad River originates near the village Diggi in the Supa taluk, and is known as Dagi in its upper reaches. It is also known as Karihole. Its total length is 184 km. To this river there are 6 major hydroelectric dams that have submerged over 32,000 acres of the rich forests area. The Supa Dam built in 1985 is one of the biggest dams across Kali. The other dams across Kalinadi: Kodasalli Dam, Kadra Dam, Kaneri Dam, Tattihalla Dam, Bommanahalli Dam. After winding in the southeastern course for about 55km, it takes a sharpe turn to the south-west near the village Devikop. Beyond this point, it flows 66 km till the village Kadra. From here, it takes an east-west course and falls into the sea, three km north of Karwar. Of the two branches of the main stream, the Pandri or Ujli originates in the extreme north. The two streams join at Supa, about 32 km south east of the source of Pandri, which is a larger stream. The banks of the Kalinadi are comparatively high and those of the Pandri are sloping. From Supa, under the name Kalinadi, it flows about 32 km south east till about 12 km north of Yellapur where it joined by left bank by the Tattihalla, a stream with a southerly course of about 56 km from the north of Haliyal. Near the confluences is the famous stepped Lalguli falls. The Kalinadi flows down to be joins by Kaneri and the Vaki are its two tributaries. Kaneri originates near the village Kundal in Supa taluk, and flowing mostly in the Supa taluk, taking a southeast direction and joins the kali to the south of Sannamaga village. Below the Kadra, for about 32 km, the Kalinadi is navigable by steamers. The mouth the river has a depth of about 4.5 meters at low water and 6.5 meters at high tide. Near Kadra, the Thananala, originating from Goa, joins the river.

Bedthi: The course of Bedthi River (figure 4.10) is 161 km long. The Bedthi is formed by confluence of two streams, Bedthi and Shamala. Bedthi originates in Hubli tank and Shamala has it origin near Someshwara temple, south of Dharwad. Two join near Kalghatgi and then, it is named Bedthi and it flows 25 km westwards and enters the Uttara Kannada district, and after a fairly straight south-westerly course of about 32 km, falls into the sea about 32 km south of Kalinadi. The Bedthi after joining Shamala passes along the border Uttara Kannada - Dharwad for about eight km before flowing 96 km in the district. Small streams, which join Bedthi River, are Mogaddehalla, Sonda River, Bill halla and Kaulgi halla. But none of them are notable feeders.

Aganashini (figure 4.11): This River rises at Manjuguni near Sirsi and after a course of 70 km merges with the sea. The streams, which join Aganashini River, are Kanasur hole, Soma nadi, Benne hole, and Chindrika nadi. Kanasur hole, which originates near Sirsi, joins Aganashini River near Mutthalli. Yana the famous rock structure is located in Benne hole catchment. At Uppinapattana, the Aganashini River meets the tide and from here no it winds southwest and then northwest about 13 km to Mirjan an old seat of trade. From Mirjan, it forms a lagoon or a backwater that runs parallel to the coast, about 13 km long and 2 to 6 km broad, cut from the sea by a belt of land with nearly uniform breadth of about a mile. The outlet to the sea is about five km from the north end of the lagoon. It is between two hills, one 91 and other 122 meters high.

Sharavathi: The Sharavathi River (figure 4.12) originates at Ambutirtha in Tirthalli taluk of Shimoga district. After northerly course of about 64 km from Nagar, it forms the southeast boundary of Uttara Kannada for about 13 km and it passes 32 km to west or 128 km in all to join the sea at Honavar. On the upper reaches of the Sharavati river is the large Linganmakki reservoir, which is the source of much of the hydroelectric power supply of the State of Karnataka. Apart from the Linganmakki dam, another dam across Sharavathi River is at Gersoppa. Badagani River rises in the peak of Kaltigudda, and flows west south, falling into the estuary of the Sharavathi River.

Other rivers: Beside the above four major rivers, there are many minor streams flowing in the district. Of the many, the Varada River, tributary to the Tungabhadra River, originating in the north–east part of Shimoga district and flowing north and east, is an east flowing river in the district and passes through a corner of Uttara Kannada near the town of Banavasi, which stands on its northern or left bank and finally joins the Tungabhadra at Galaganath in the Haveri taluk of Dharwad district. Another river, which flows east in the district, is Dharma River, which originates at Islur, Sirsi taluk, from a tank. It passes through Mundgod taluk and joins the Varada in Dharwad district. Hattikeri halla and Navagadde halla are limited to Ankola taluk. Hattrikeri halla is joined by two minor tributaries, joining it before the Shikliturli village on the northeast corner of the taluk. The town of Kumta is situated on the banks of a small stream Kumta. The Venkatapur River rises in the Sahyadris near the village of Kanti about 20 km near Venkatapur. Chitti and Katagari are its two tributaries, joining it from the north. This river merges in sea few kilometers north of Bhatkal Rivers merging in sea. The Bhatkal River is another westerly flowing river and town of Bhatkal is situated on its banks.

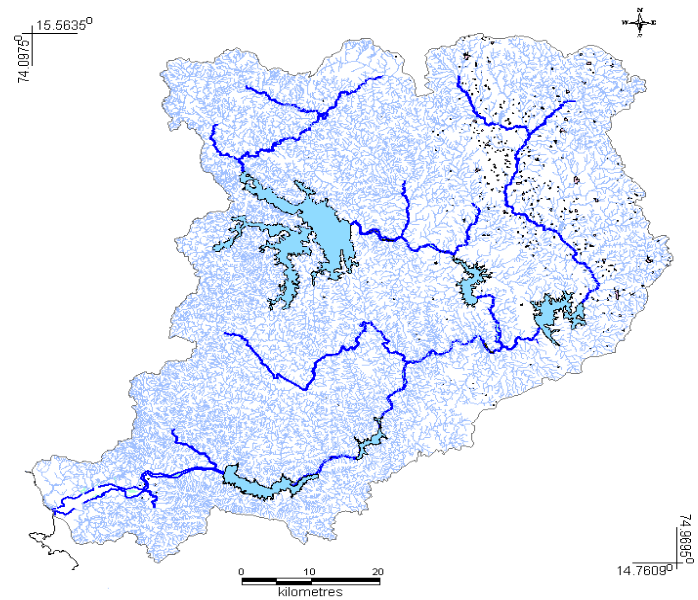


Figure 4.9: Drainage pattern of Kalinadi showing the reservoirs.

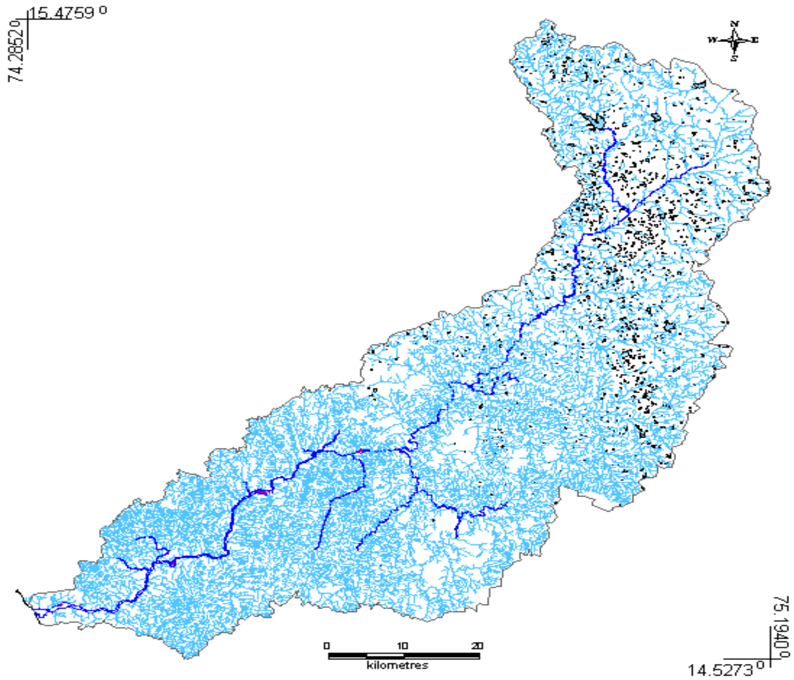


Figure 4.10: Drainage network of Bedthi River

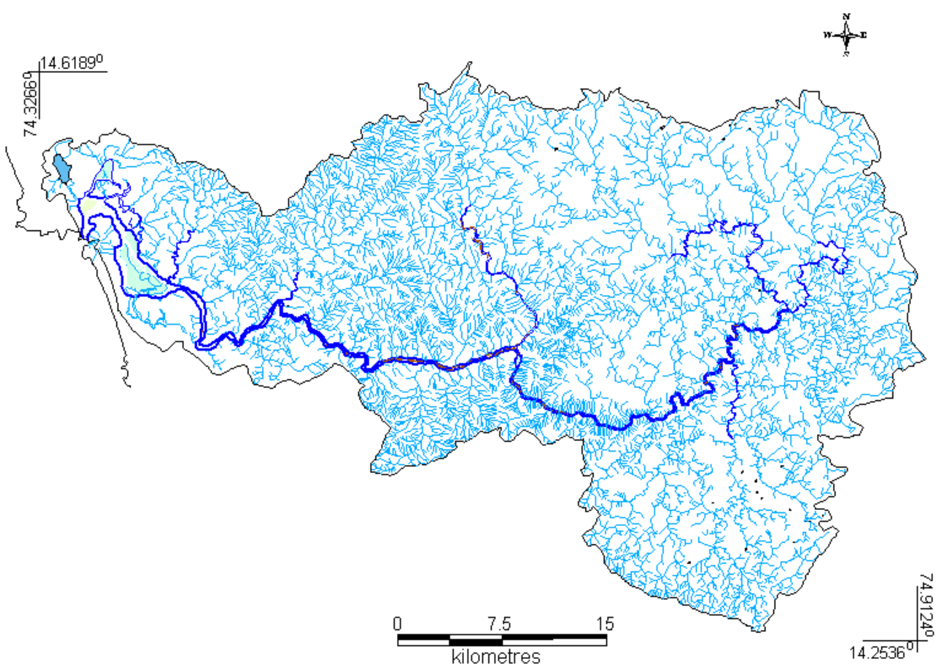


Figure 4.11: Drainage network of Aganashini River

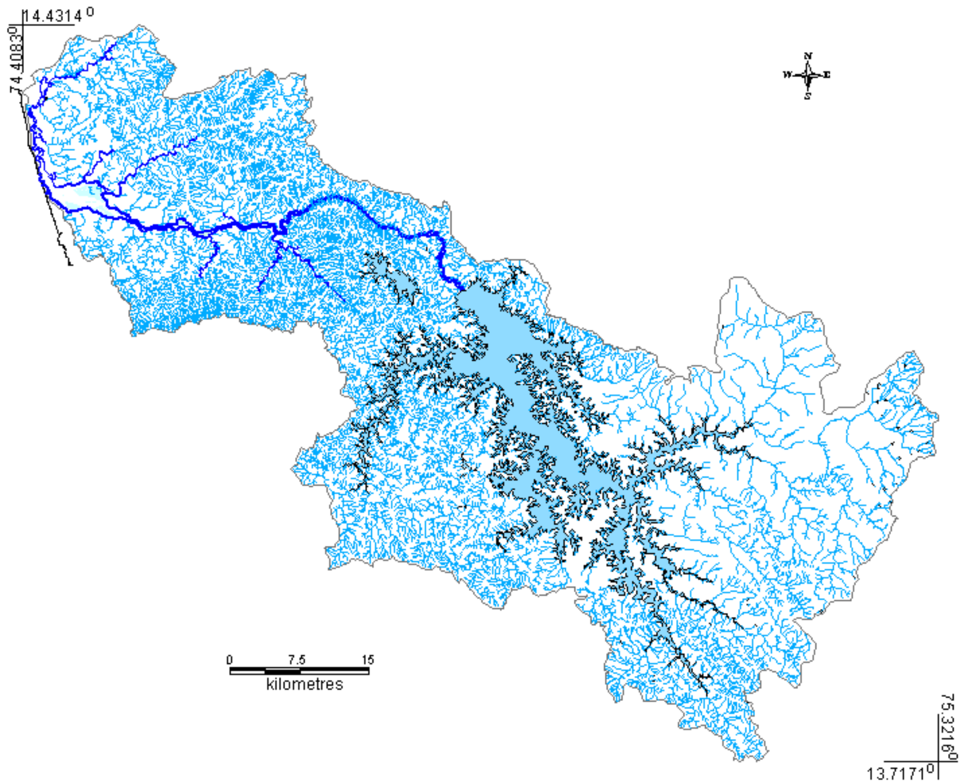


Figure 4.12: Drainage network of Sharavathi River with is reservoirs

4.6 GEOLOGY:

The district consists of rock formation of Archaean complex, the oldest rock of the earth crust. Rocks of the Archaean era occur over the whole of the district. They have not been submerged under the great lava flows known as the Deccan Traps, which have overspread most of the central India forming the great plateau with steep precipices. The district is characterized by a system of ridges and a plateau on the west descending rapidly to a narrow strip of low land covered by alluvium, which with the abundant annual rainfall supports cultivation. The low land appears to be the creation of later period than the upghat region. It emerged from the sea during the glacial and inter glacial period due to the changes in the sea level. The Archaean formations are divisible in to an older group of sediments and igulous viatrusives, all very highly metamorphosed, which are classified as the Dharwar system and a younger group of plutonic intrusive termed the peninsular geisses (figure 13). A capping of laterite, which is locally the source of iron and magnesium ores, frequently overlies both the Dharwar and the peninsular gneisses. In the western part of the district, nearly parallel to the coastline, there is a range of hills with several peaks over 700m high descending westwards gradually in broken country to the coast. This consists of varied assemblage of granite and schists. These ridges separate the Sahyadris, consisting of Dharwar schist in the south. Eastwards in the interior, the district is almost entirely hilly and consists of both the Dharwar and the Peninsular gneisses, the latter frequently occupying the low grounds. In this district

Ramachandra T.V., Subash Chandran M.D. and Joshi N.V., 2014. Integrated Ecological Carrying Capacity of Uttara Kannada district, Karnataka, Sahyadri Conservation Series 41, ENVIS Technical Report 71, CES, IISc,

the Dharwars are typically represented by chlorite-schists as opposed to the areas in the southern Karnataka where hornblende rocks predominate. The chloritic types are considered to be younger than the hornblend types. Other rock formations belonging to this system are quartzite, magnetic-quartzite, limestone-quartzite, senicite-quartz-schist, phyllite fine-grained grey limestone, dolomite, epidiorite and other basic igneous rocks. The Dharwar rocks generally out crop as narrow lenses and shingers, elongated nearly NS enclosed in the intrusive peninsular gneisses, which have invaded them after their folding. Most of the Dharwar are highly pilcated. Their folding is clearly seen in the limestone, which is thought to be the youngest in the Dharwar sequences. These limestones are well exposed as larger, highly contorted masses in the Nagjhari valley, south of Kulgi and in the valley of the river Kalinadi below its confluence with the Nagjhari. Dolomite bands are known to occur in the western parts of district (figure 4.13).

The peninsular gneisses consist mostly of the fine-grained granite-gneisses outcropping in the lower levels of the central and southern boundary of the district. The best exposure of these gneisses is near the southern boundary of the district where the Sharavathi River plunges down a vertical precipice in the magnificent Jog falls. They generally show a lower degree of metamorphism than the Dharwars, as they have been emplaced subsequent to the Dharwars folding. Usually there is great diversity of types amongst these rocks with frequent modification caused by assimilation of disintegrated Xenocrysts of the Dharwar stopped out during intrusion. There are, however, two main types of these rocks; one granitrid, highly crystalline, massive type and the other a schistose, less crystalline, highly foliated, distinctly banded type, but each group includes a number of distinct variations. It is not moreover quite certain if all these granitic rocks belong to the peninsular gneisses and granites characterize the lower levels of the north district. Highly granitoid types are reported to occur to the north Dharwar outcrops in the neighbourhood of Shinargaon and Kudalgaon, but their precise age is unknown.

The Archaean granites and gneisses with their sparse bounds of Dharwars are capped by laterite at many places in the district. They are typical tropical rocks resulting from the alteration under tropical condition of the basement rocks. They are found capping flat topped ridges and bluffs all along the coast of a hundred feet in thickness and occasionally show local enrichment of iron and manganese ore.

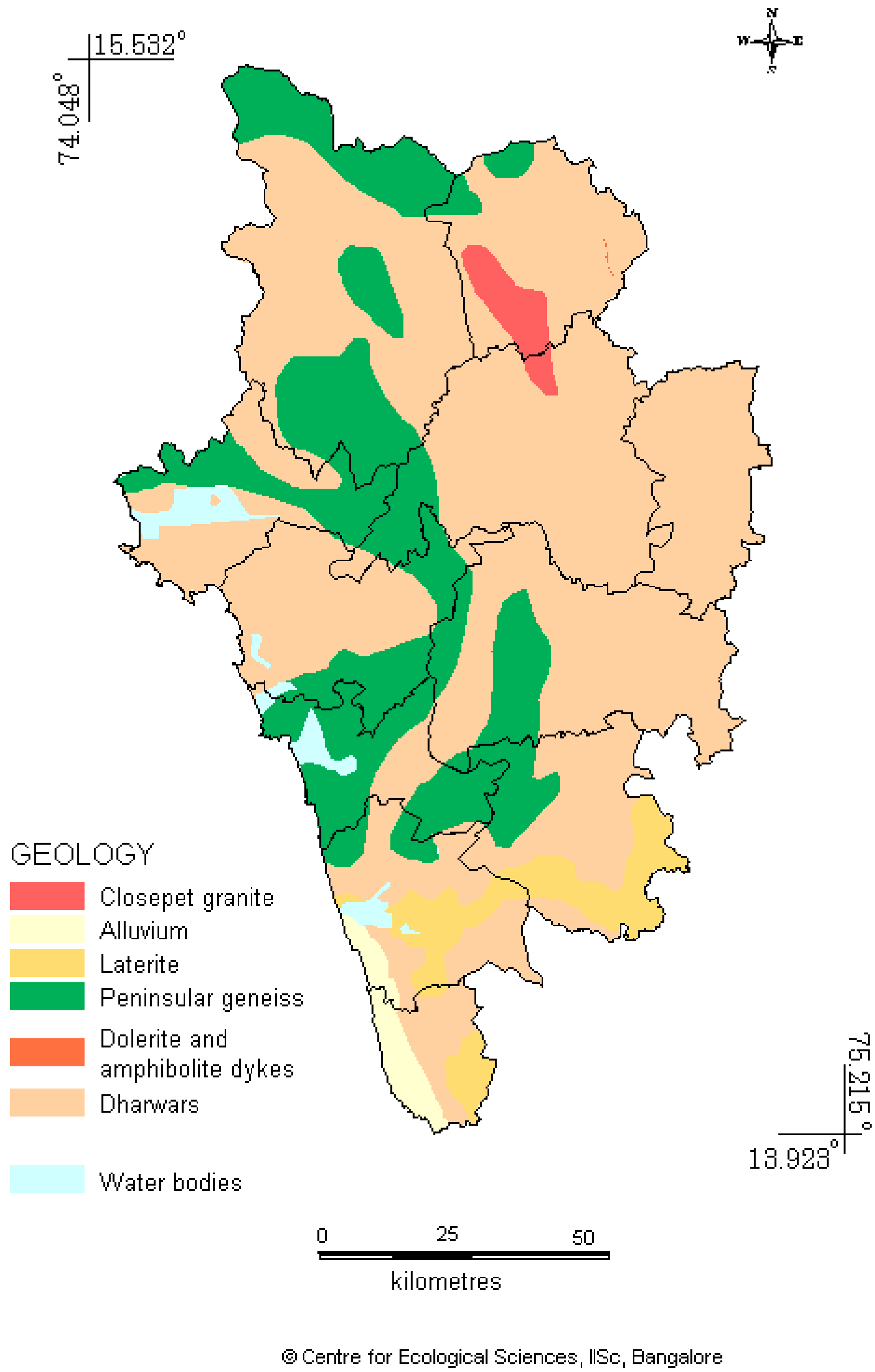


Figure 4.13: Geology of Uttara Kannada

4.7 SOILS:

The soils of UttaraKannada belong to six orders (figure 4.14). Of the total area of UttaraKannada Alfisols cover 51 percent, Ultisols 27 percent, Inceptisols another 8 percent, Mollisols 7 percent, Entisols 3 percent, and 0.2 percent of Vertisols.

Types of Soils seen in Uttara Kannada are basically divided into forest brownsoil, alluvial soil, coastal laterite soil, alluvial colluvio soil, laterial soil, and red soil. These have been further divided (figure 4.15). Red soil is divided into two i.e., gravelly clay soil and non-gravelly clay soil. Laterite is also divided into two gravelly clay soil and non-gravelly clay soil. Soil depth of the soil determines the effective rooting for plants and, in accordance with texture, mineralogy and gravel content, the capacity of the soil column to hold water. Figure 4.16 gives the understanding of how the soil depth is varying at different places. Surface soil texture (figure 4.17) indicates the relative proportion of the primary particles of sand, silt and clay. The textural class guides us to understand soil water retention availability, workability of the soil, infiltration and drainage conditions and crop suitability.

4.8 MINERALS AND ORES:

The district is rich in many minerals. Investigations have been conducted in the district by the Atomic Mineral Division of the Geological Survey of India and the State Department of Mines and Geology. Some investigations are yet to be completed. The economically important minerals available in the district are the iron ore, manganese ore, limestone, quartz, bauxite, limeshell, silica, sand and clays. The district is an important exploitation centre for iron, and manganese ores and it is second only to Bellary district in the State in the production of these minerals.

Iron Ore: Iron ore deposits are found in varying extents in the western half of the district, particularly in several places of Ankola, Honavar and Yellapur taluks. The ores are of different types, like haematite, limonite and litariferous iron ores. These deposits have been surveyed, mapped and prospected in detail by the Department of Mines and Geology of the State and the Geological Survey of India, has also conducted surveys in the district. These surveys have disclosed a reserve at 95.26 million tonnes of float and reef ore (about 58 to 65 per cent of Fe) in the district. In addition, there are several deposits of low to medium grade ores of content ranging from 44 to 54 per cent of Fe.

Manganese Ore: Manganese is one of the chief mineral of the district. The manganese ore of this district occurs associated with the shelf sedimentaries of rocks equivalent to Chitradurga group and is characterised by high Mn content with low phosphorous of low electro-negative elements. It is found in near Castle Rock region of Supa taluk and Yellapur, Sirsi, Kumta and Ankola also have deposit of Mn.

Limestone: Supa, Yellapur and Kumta taluks possess several band of limestone of varying extent and ranging in composition from high calcium to dolomitic types. A small band of high calcium limestone is exposed close to Kali River at about four km ESE of Supa and this deposit is not of much importance. High calcium type greyish crystalline lime stone is found in Yellapur. Kumta taluk has medium to coarse grained greyish limestone in discontinuously patches. Kankar limestone is another limestone present in Uttara Kannada.

Bauxite: Aluminous laterite with 42 per cent Aluminum oxide is found all along the coast line of the district. Bauxite containing more than 50 per cent alumina and low percentage of silica and titanium is found to occur in a reddish brown laterite covering an area of about 5.18 sq km at Mundolli and Talgod villages near Bhatkal. Small deposits are also found at (1) Swarnagudda, (2) Kumta plateau, (3) Haldipur and (4) Nirthadgi.

Copper: Copper is found in a small patch in Kaiga which is associated with ultramafics and meta-volcanics of Dharwar super-group.

Clay: Deposits of China clay (Kaolin) are reported to occur at the following places in the district: near Castle rock, Motigudda in Supa taluk, Hervatta extention in Kumta, near Hadinbal village in Honavar taluk and certain parts of Bhatkal taluk (sothern bank of Venkatapura river). Ankola also has deposit of clay which is slightly reddish in colour.

Mineral pigments: Among mineral pigments, only ochre of different grades occurs in the district. Yellow and red ochres are the two chief types that are commonly found. Ochres of fairly good quality have been reported to occur in the neighborhood of Castle Rock. The occurrence of yellow ochre of inferior quality is reported in Kallemane and Kumbaragadde villages in Ankola taluk.

Vanadium Ore: Titaniferous-Vanadiferous magnetite occurs as late magnetic deposits intimately associated with the ultramafic rocks like pyroxenite and peridotite. The important deposits are found at Santepet, Mulemane, Surya Kalyanigudda, Kanlal hill, Hiregutti, Madangeri, Motigudda, Sariyasigpdda, Angudibail, Kodemane, Kantgani, Kanchinkere and Achavegudda area.

Other ores: A small deposit of; asbestos associated with talc is reported to occur near Dhareshwar in Kumta taluk of the district and it is not of much economic importance. Partially developed rock crystals showing pyramidal termination at one end found encrushing the drusy cavities in a vein or reef of quartz in the .granite near Nidgod in the Siddapur taluk.

In Kumta taluk near Ramgundi, a band of good quality steatite is found, exposed for a length of about 75 m along the western flanks and on foot of the hill. Weathered and impure steatite is reported to occur as small bands near Karwar. The dolerite dyke rocks of coastal area of the district have made a name in Germany for its standard quality and for the nearness of ports. The deposits are reported from Aversa, Herwada Bagribail, Amdalli and Kodur. Granite gneisses and laterites are the chief building stones of the district. They are quarried at some places in the granitic regions and are being used as building stones. In the coastal belt of the district glass sand (medium grained white silica sand) and ilmenite sands is found. Ilmenite sand caontains ilmenite and zircon and also monazonite, rutile, apatite, haematite, amphibole, epidote and chlorite in much smaller proportion.

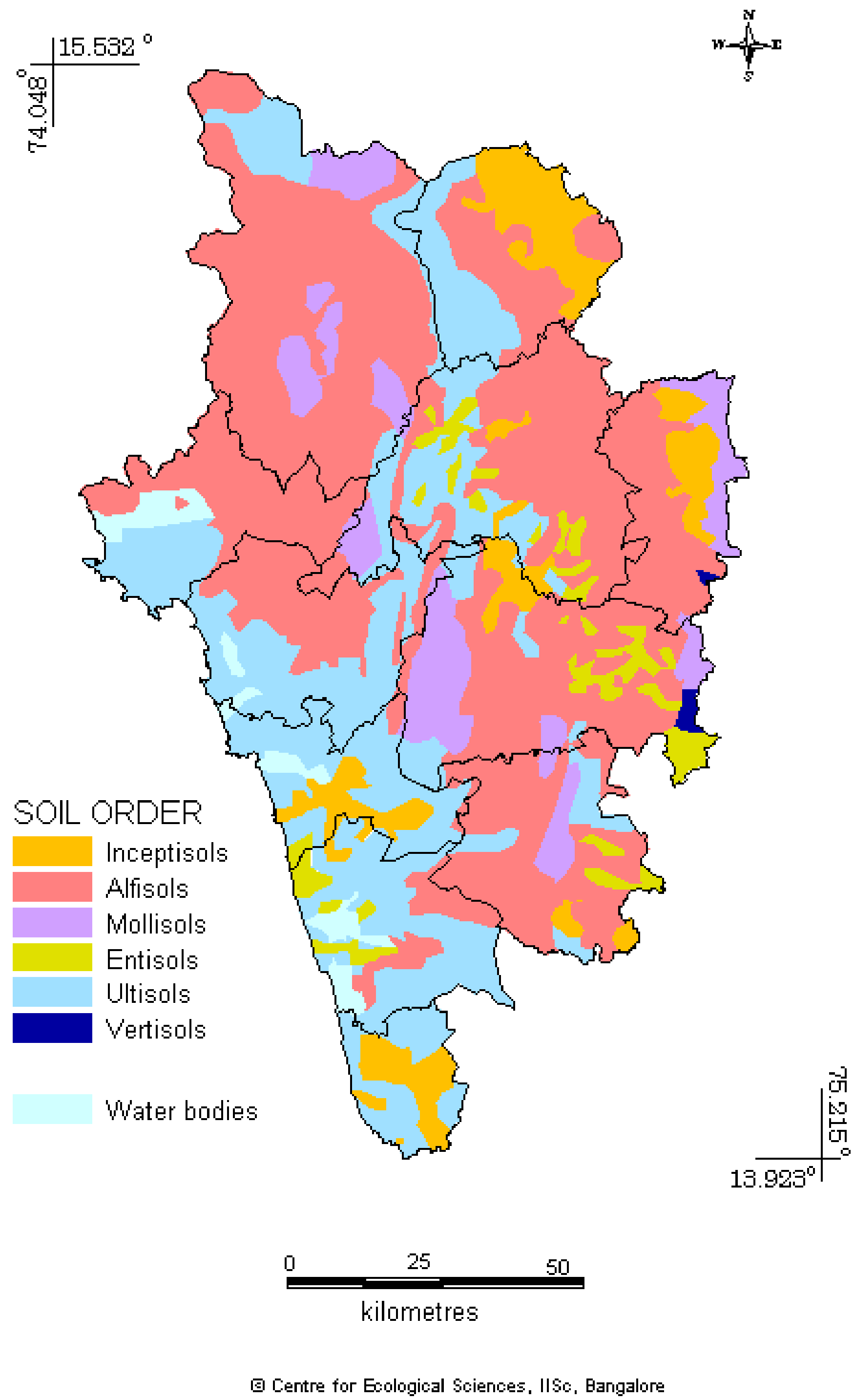


Figure 4.14: Soil order of Uttara Kannada

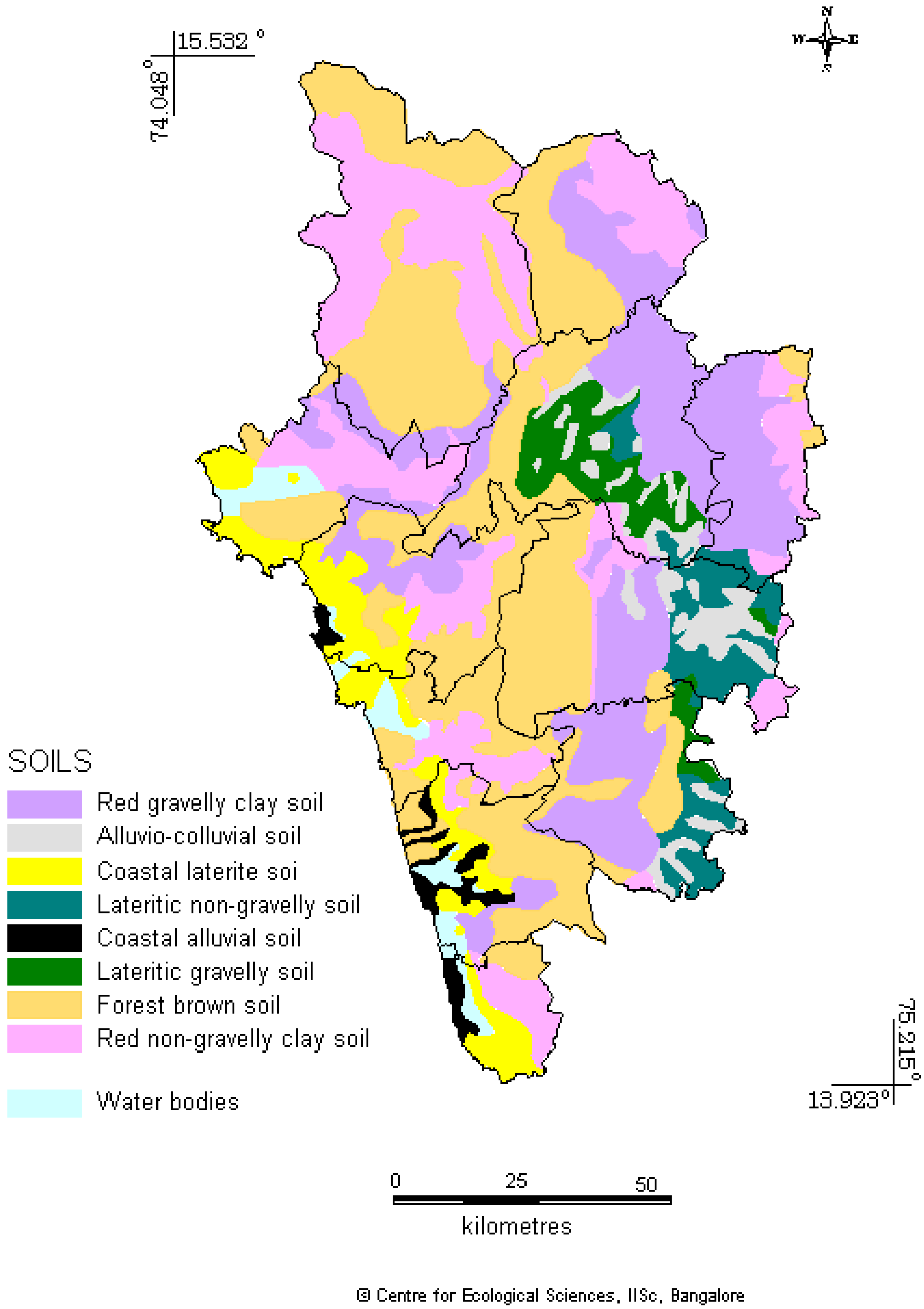


Figure 4.15: Soil of Uttara Kannada

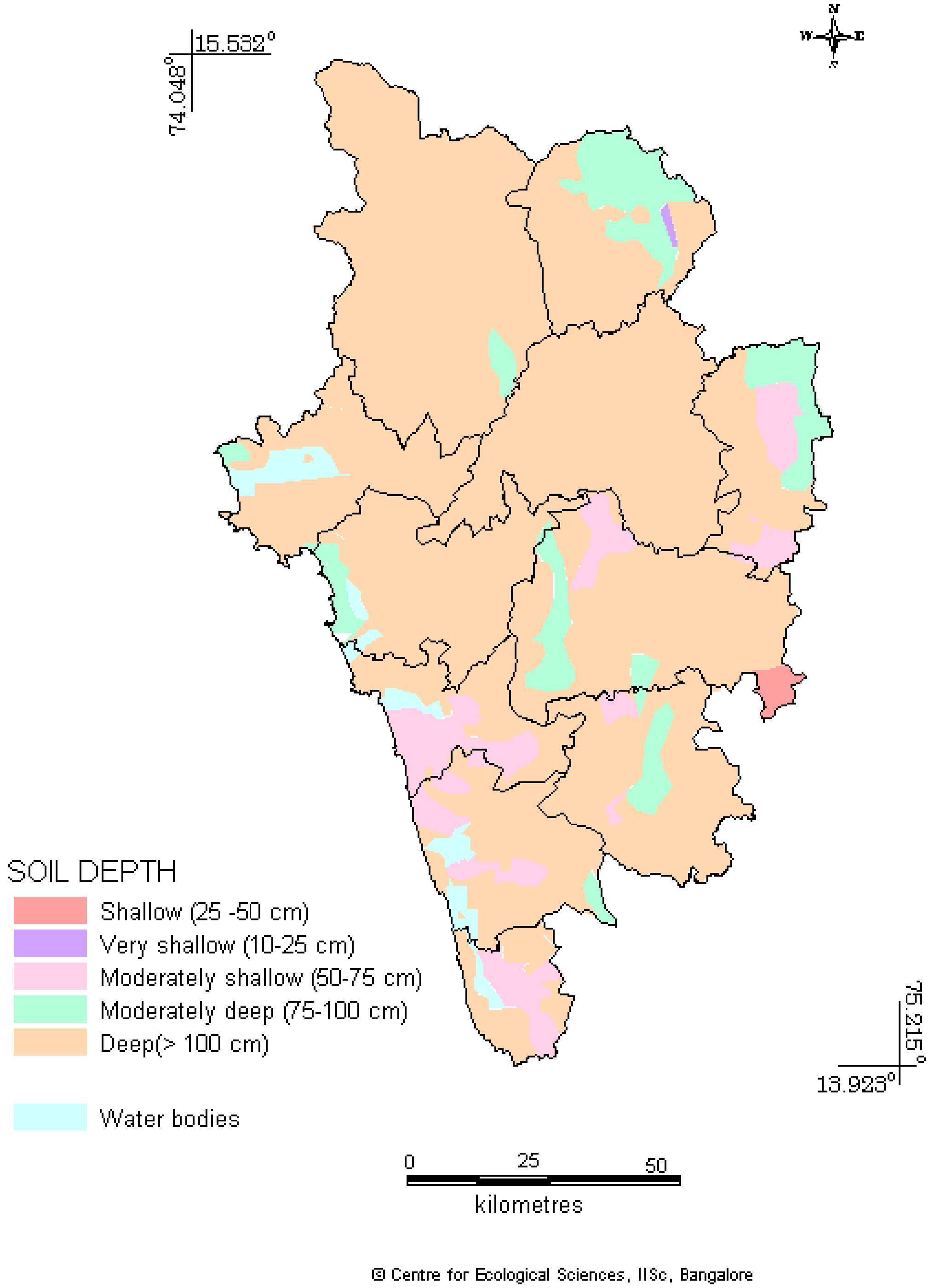


Figure 4.16: Soil depth of Uttara Kannada

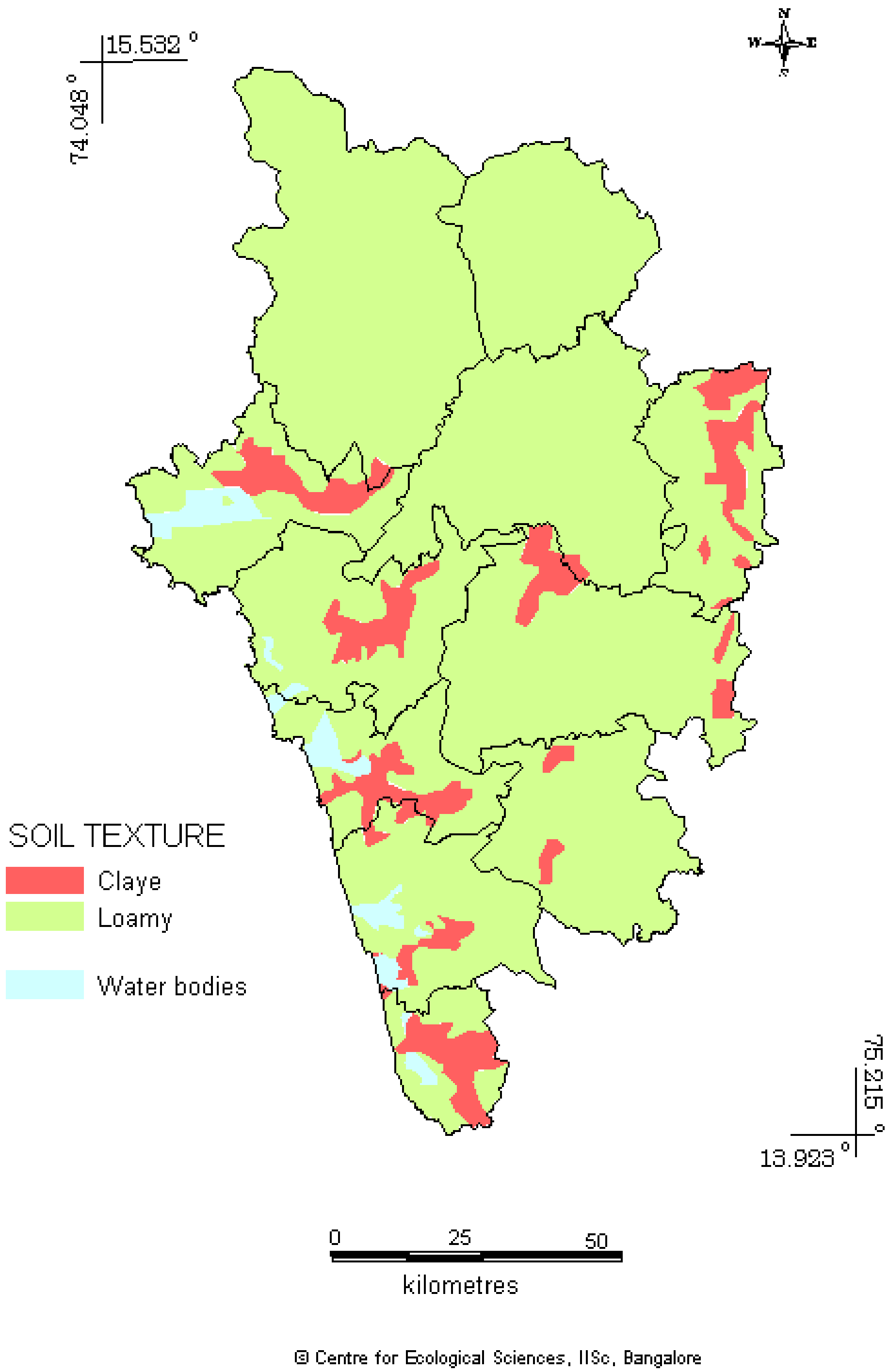


Figure 4.17: Soil texture of Uttara Kannada

The geomorphology of the Uttara Kannada (figure 4.18) is divided in to 30 categories considering the soil, topography, geology etc.

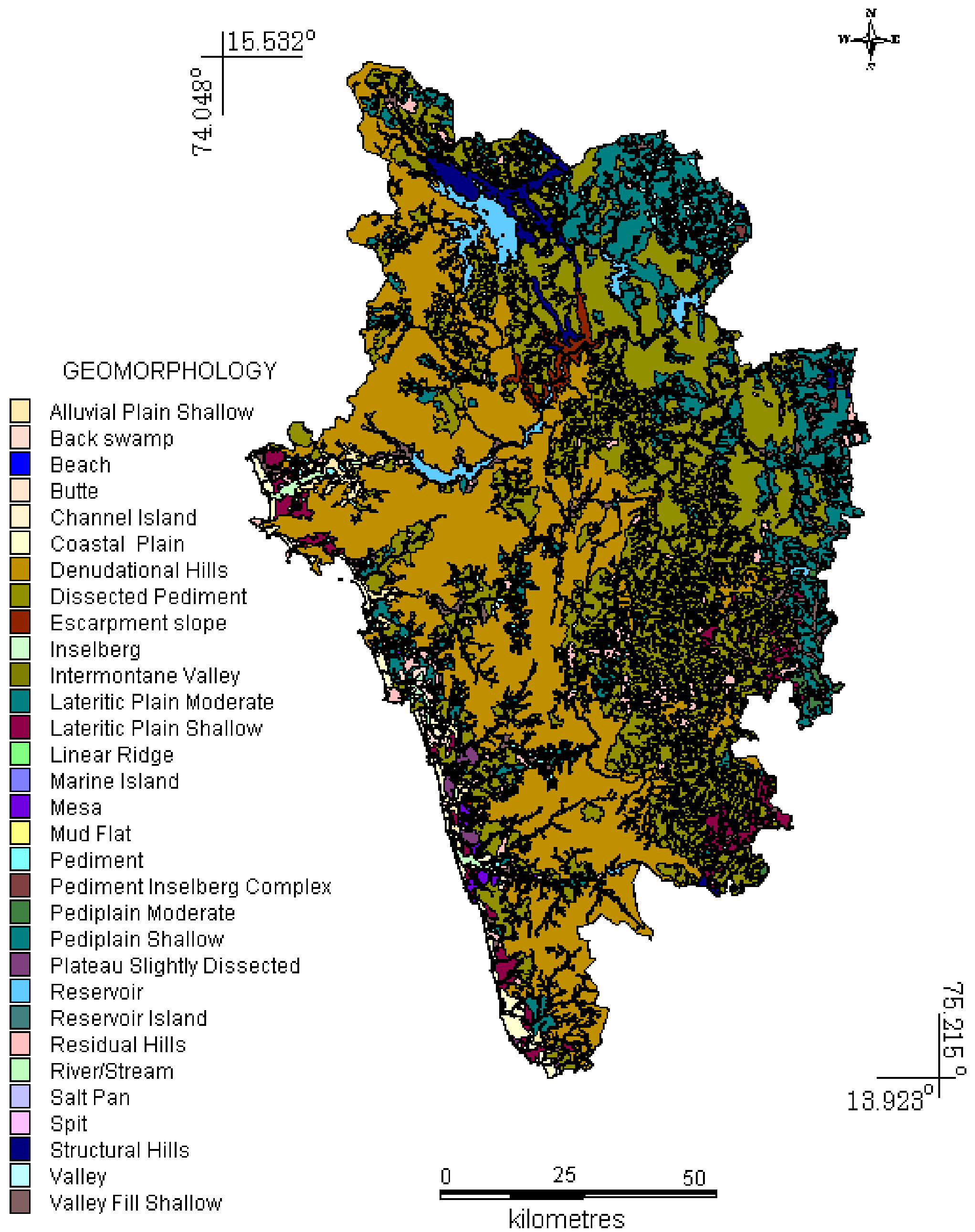


Figure 4.18: Geomorphology of Uttara Kannada

4.9 GROUND WATER:

Uttara Kannada district consists of rock formations of a system of ridges and a plateau on the west, main aquifers are weathered and fractured zones of metavolcanic, metasedimentary, granites and gneisses, laterites, along with the alluvial patches found along the major stream courses. Laterites occur overlying the schist and granites, and alluvium along the rivers and lagoons of the coast. Ground water in the above aquifer material generally occurs under unconfined to semi-confined and confined conditions, in the shallower zones under phreatic condition and under semi-confined and confined condition in the deeper zones. The ground water is being exploited from within the depth range of 3.00 to 31.00mbgl through dug wells and 30.00 to 200.00 mbgl through dug-cum-bore wells and Bore wells (CGWB, 2006). The area that drives ground water are under dugwells (7302 Ha), borewells (2090 Ha), lift (596 Ha) for agricultural activities. Ground water in the district occurs under water table conditions in the weathered mantle and jointed and fissured in bed rocks. Along the costal belt ground water occurs in the sandy alluvium. Major part of Uttara Kannada district is covered by a thick capping of laterite mantle on granites, schistose rocks and sand stones. These laterites are highly porous and hold and transmit good quantity of ground water. The ground water recharge is mainly a result of infiltration of rain water and little extent through seepage from streams, tanks, reservoirs and water applied for irrigation. It is discharged artificially by abstraction of water from dug wells. The fluctuation of water table varies in the district from 3 to 12 m for hard rock area and alluvium, the specific yield varies from 2 to 3 per cent (Table 4.3). The figure 4.19 shows the taluk wise ground water and its condition and potential areas for recharging. The district is almost under safe condition and there is a lot of scope for recharging areas.

Table 4.3: Ground Water level at taluk wise

SI. No	Taluk	Topography	Latitude (D M S)	Longitude (D M S)	Mean Sea Level (Mts)	Ground Water level (Mts)	
						Min	Max
1	Ankola	Coastal	$14^0$39'50"	$74^0$19’44”	17.34	11.4	0.8
2	Bhatkal	Coastal	$15^0$59'	$74^0$33'25"	12.24	4.27	0
3	Haliya	Hilly	$15^0$19'30"	$74^0$46'	540.63	13.25	7.5
4	Honnavar	Coastal	$14^0$18'30"	$74^0$28'30"	20.36	14.1	5.15
5	Karwar	Coastal	$14^0$48'25"	$74^0$07'54"	2.88	2.8	0.3
6	Kumta	Coastal	$14^0$25'30"	$74^0$24'40"	15.43	6.93	1.5
7	Mundgod	Plain	$14^0$58'10"	$75^0$02'30"	570.8	7.29	0.54
8	Siddapur	Hilly	$14^0$21'05"	$74^0$50'05"	598.69	11.73	9.28
9	Sirsi	Hilly	$14^0$37'05"	$74^0$50'05"	596.8	14.75	8.75
10	Supa	Hilly	$15^0$10'20"	$74^0$29'15"	591.7	6.1	1.72
11	Yellapura	Hilly	$14^0$54'45"	$74^0$39'45"	444.73	9.87	1.95

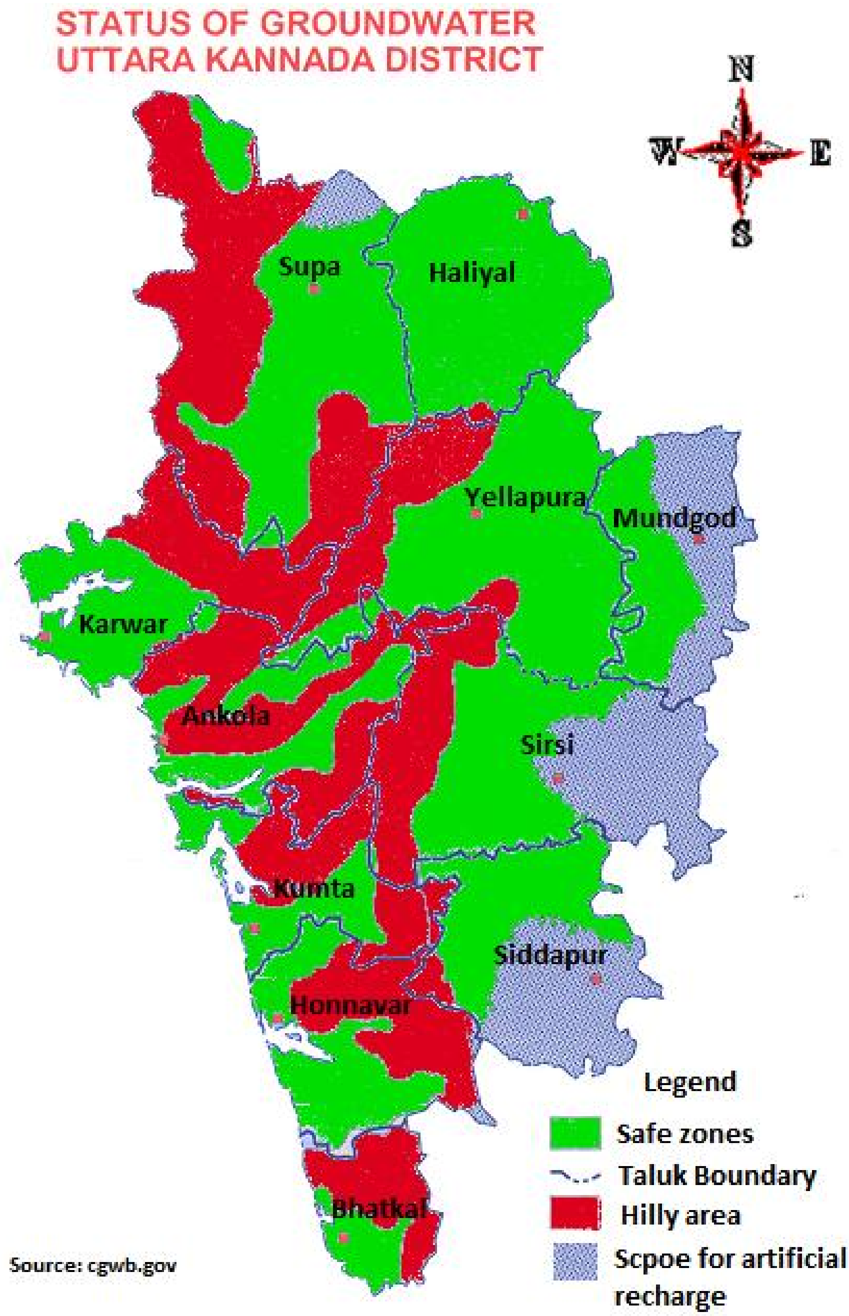


Figure 4.19: Ground water status and potential areas for recharge

4.10 VEGETATION

In the slopes of Western Ghats from north to south of Uttara Kannada district, there is beautiful cover of dense forests. The forests, stimulated by heavy rainfall, start growing within a few kilometers from the coast. They are generally lofty, dense and characteristics by large number of trees which occurs together with fine canopies of tree crowns and shrub growth. As one moves from coast from ghats, the forests are semi-evergreen with grassy banks along the coast, interspersed with stunted growth of secondary species and scrub and also Acacia catechu.

The evergreen forests are found in places where the rainfall is more than 225 cm and from a narrow strip along the Western Ghats (figure 4.20 and 4.21). The soil types of these evergreen forests are mostly laterite but along the river basin, it is alluvial. The semi-evergreen forests are in the places where the rainfall is from 150cm to 25cm. The deciduous forests are situated in the rainfall areas of 100 cm and more. In the areas where the rainfall is below 90 cm, the dry deciduous forests are found.

Uttara Kannada has 12 % of its land under cultivation and has happened because of hilly terrain. This rugged terrain is nurtures the forests. In Uttara Kannada both primary and secondary forests can be seen. Secondary forests has emerged because pre-colonial and early colonial period passed through phases of slash and burn cultivation by various local communities. This practice has cleared vast primary forest and now the secondary forest has come in to existence. This change from a cultivable land to forest occurs in various successions. The cultivable land first shows the sign of vegetation with the arrival of deciduous species. The deciduous specious are replaced over a period of time by evergreen trees. The study have shown that at many parts of Uttara Kannada evergreen have returned and the forests which were deciduous has become moist deciduous i.e., the percentage evergreen trees in the forest has increased over the time. Mangrove forests can be found in the river estuaries, and the sandy beaches are home to groves of Calophyllum inophyllum, coconut and screw pine (*Pandanus spp*.).The rocky beaches at Binaga, Arga, Belekeri, Tadadi, Ankola Keni, Kadle, Kumta, Dhareshwar, Kasarkod, Murdeshwar, Bhatkal and Belke of the district is rich with marine fauna diversity.

Apart from these types of forests, there are many places we can see monoculture plantation. These plantations without diversity have caused more harm to the eco system than the good. The best example is Acacia which has a thick leaf with a layer of thick cuticle which rebukes the rain water to infiltrate. This monoculture does not even invite or help flora or fauna to thriving in them. The district is also home to patches of savanna and degraded scrub jungles, which are often the result of over-use for logging or grazing. Much of the lowland has been cleared for agriculture. French Institute map (1985) show that about 7.1 thousand km² is under forest in various stages plus tree crops such as coconut and areca nut. Deducting from this 0.13 thousand km² under orchards, we are left with a figure of 6.9 thousand km² under some kind of vegetation, at least of scrub type (figure 4.20). It shows the regions of primeval forest patches and other types.

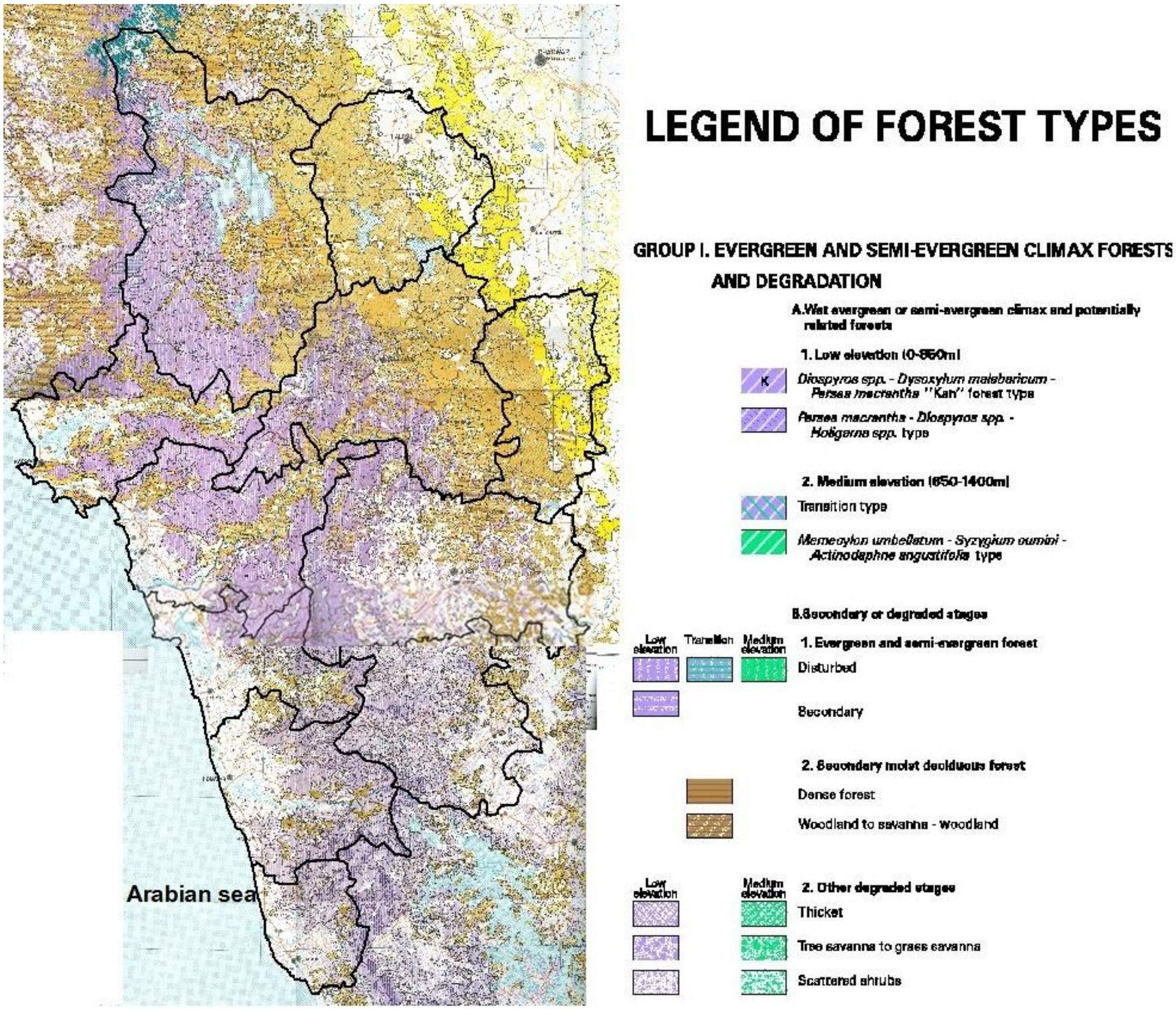


Figure 4.20: Vegtation (Source: French Institute, 1985) taluk wise distribution

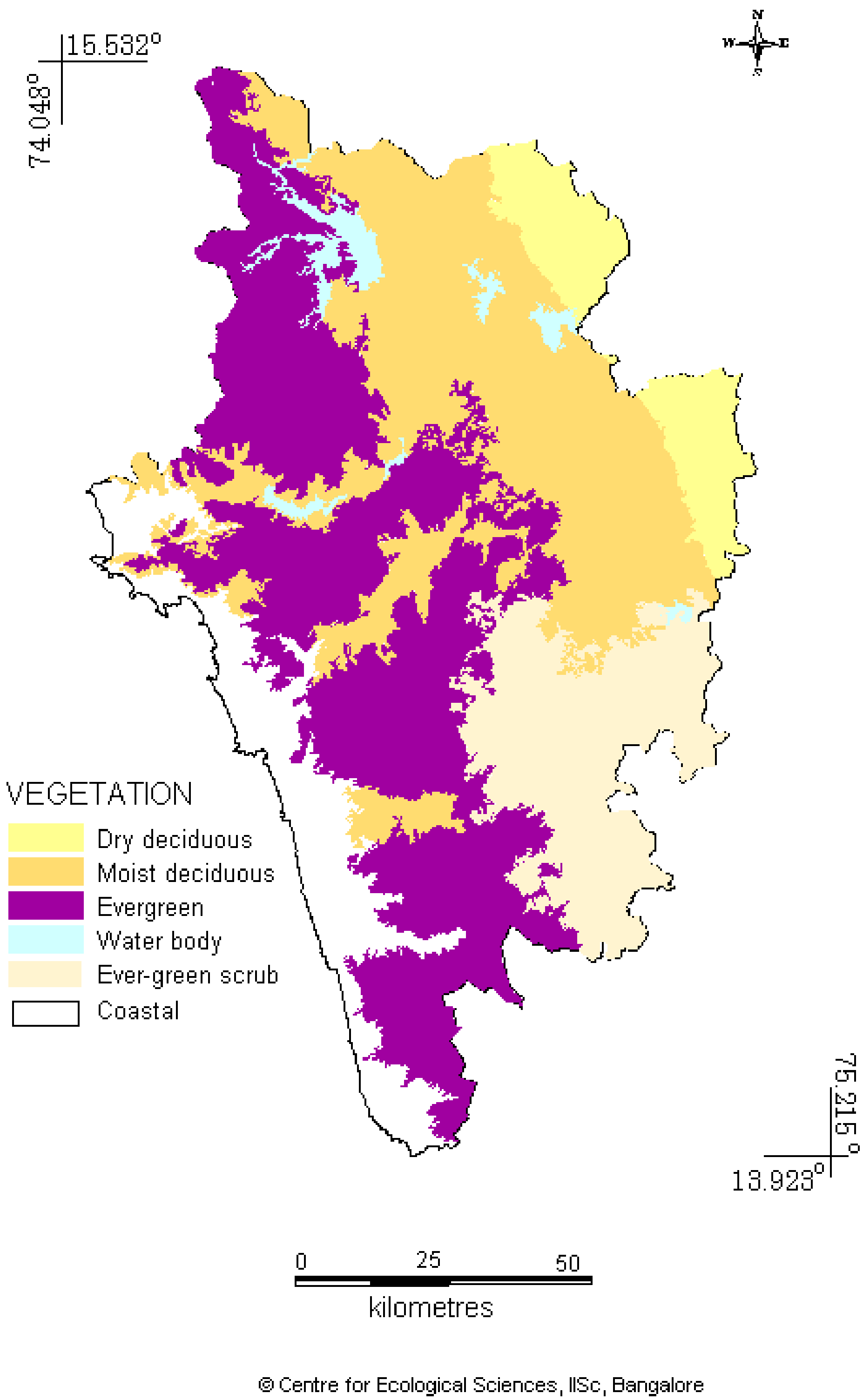


Figure 4.21: Vegetation distribution for Uttara Kannada District.

4.11 AGRO CLIMATIC ZONES:

Agro-climatic zoning is done on taking into consideration the rainfall pattern, quantum and distribution, soil types, texture, depth and physio-chemical properties, elevation, topography, major crops and type of vegetation. It helps in raising the production and productivity of the agricultural and livestock sector, and of arresting and reversing the deterioration of renewable natural resources involved in agricultural and livestock production and even comparative crop estimation.

Argo-climatic zones can correspond to two principal types-- general and specific--of agro climatic zoning. General types to agro-climatic zoning systems often refer to broad geographic regions (district, state, country, continent, or the entire world). The object is to identify zones of possible crops as related to the length of the vegetative cycles, the choice of crop and varieties, and the possibility of obtaining satisfactory levels of production. Specific types of agro-climatic zoning studies are done on a more detailed scale and refer to a particular crop. Specific requirements of the particular variety can be compared with existing climate conditions in each zone. Eventually, this type of zoning can narrow down to a single aspect of the crop: disease development, utilization of one cultivation technique, the demands of a particular phenological phase (term or period of photosynthesis, necessity of a dry period for maturation or of intense cold for germination, etc.). One of the most interesting tasks of agro-climatic zoning is the comparative analysis of productive ability of various ecosystems.

Uttara Kannada has three types of agro-climatic zones (figure 4.22), coastal and hilly. District contributes for 160817 lack tones or just 1.47% of the food grains production of the state for 2000-2001(Department of Agriculture, Govt. of Karnataka). Processing units are available for cashew, pineapple, coconut and vanilla. Long coastline, suitable agro climatic conditions and availability of water offer huge scope. The table 4.4 explains cropping pattern with respect to each taluk of the district. Major contribution is from Paddy cultivation followed by Groundnut. Sugar Cane and groundnut are major commercial crops grown in Uttara Kannada. Bengal gram, Green gram and Cowpea are the major pulses grown in the district. Groundnuts, Soyabean are major oilseeds.

Table 4.4: Cropping pattern (taluk wise)

Taluk	Cropping Pattern
Karwar, Ankola, Kumata, Honnavar, Bhatkal	Paddy, Paddy–Pulses, Paddy–Groundnut, Sugarcane
Sirsi and Yellapur	Paddy, Paddy-Pulses, Paddy-Groundnut. Cotton, Sugarcane
Siddapur and Joida	Paddy,Paddy-Pulses,Paddy-Groundnut, Sugarcane
Haliyal and Mundgod	Paddy, Paddy-Pulses, Maize, Cotton, Sugarcane

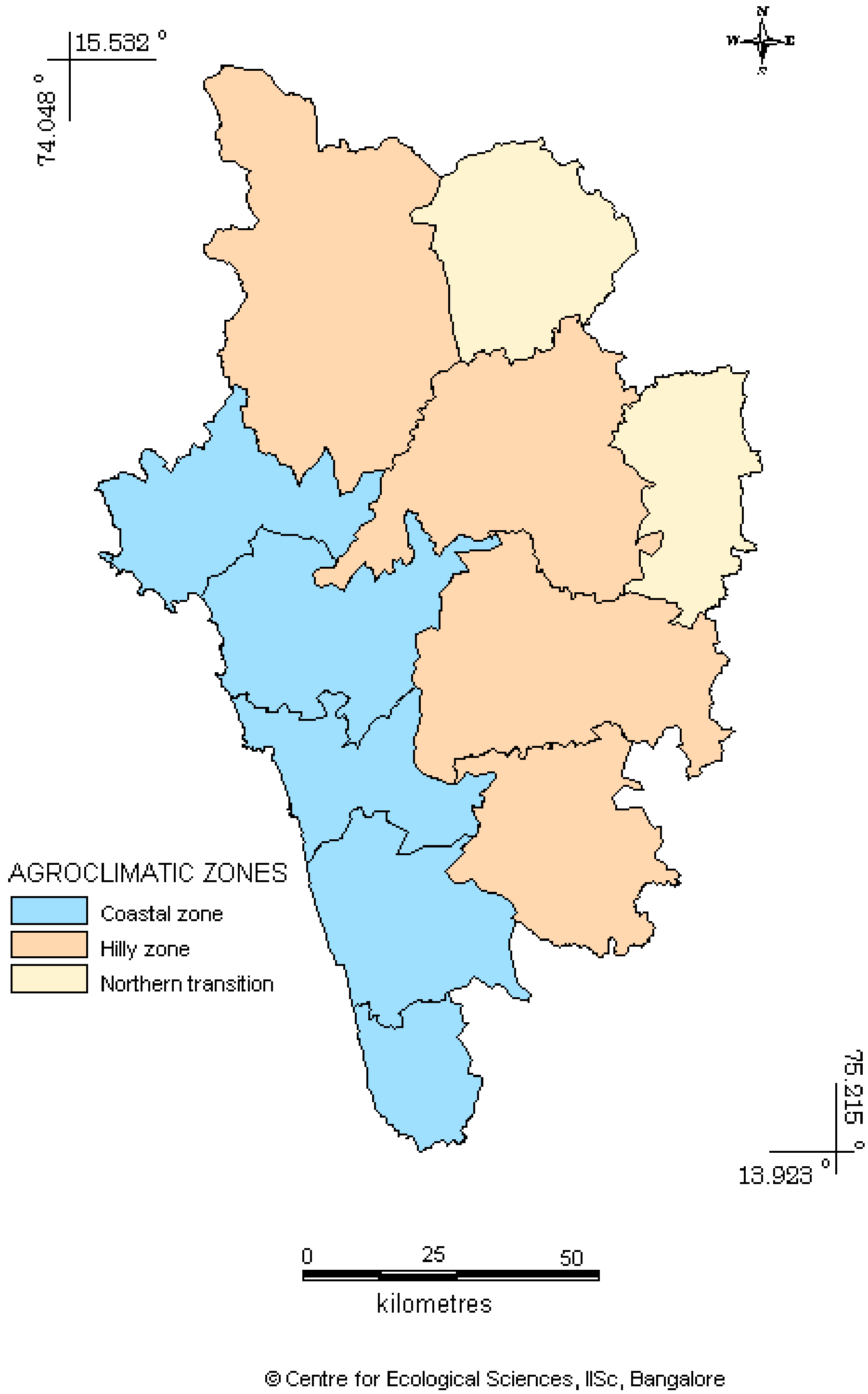


Figure 4.22: Agro-climatic zonation of Uttara Kannada district

4.12 INDUSTRIALISATION:

Apart from forest based industries already referred to other industries were established in the district, having ecological and socio-economic consequences. The district constitutes of 6 medium & large scale industries and 8 industrial estates. The district also has 9,154 MSME units (Micro, small, Medium Enterprise). The Ballarpur Industries Ltd., Binaga at Karwar was established in 1975. Nearly 1200 hectares of estuarine areas of Aghanashini river in Kumta taluk were allotted to the factory for producing salt to prepare caustic soda. This caused displacement of several families of estuarine farmers. Subsequently the factory found the lands not very suitable for salt making, and returned the lands to the Government. Since the farmers evacuated from these estuarine lands were already paid compensation by the Government, the latter refused to restore the lands to the farmers. It is alleged that the industry is discharging treated effluents of sodium tri-poly-phosphate and mercury into the Arabian Sea through a pipeline, causing marine pollution (Hegde, 1999).

The Uttara Kannada district is rich in minerals such as iron, lime-stone, quartz, manganese, bauxite, molluscan shells, silica etc. These minerals were exported since pre-independence days or used within the country itself. In 1955 the Dandeli Ferro Allies Pvt Ltd. was established. The factory uses manganese ore extracted from the forest belt for production of ferro alloys. By 1981, as many as 98 mining leases were given in the catchment area of Kali river itself, covering an area of 125.6 sq km. Total mining area within the district, mostly situated in the forests of Joida, Yellapur and Karwar taluks are reported to be 148.94 sq km. The mining operations cause various disturbances to the ecosystems. Erosion by runoff causes damage to forests, agriculture and rivers. The increased silt load in the river Kali was considered as detrimental to many aquatic organisms.

4.13 ROAD AND RAIL NETWORK:

Uttara Kannada is well connected with road network even though the terrain is rugged and hilly. Four National highways running across Uttara Kannada (figure 4.23). State highways connection different places of state connecting Uttara Kannada are five in number. State highways and National highway are connected with smaller towns with district road network of length 3645 km (table 4.6 and 4.7). The following are major National highways and State highways details in the district. NH 206 connecting Honnavar and Tumkur, NH 17 connection Panvel and Trichur, NH 63 Ankola to Gooty, and NH 4A between Panaji to Belgam. State highways are SH 69 Kumta with NH4 via Sirsi, Mundagod and Thadas. SH 48 Kumta with Pavagada via Siddapur, SH 6 Karwar with Hanumasagar-Il -Kaiga-Yellapur-Mundagod. Sh 93 Siddapur with Khanapur in NH 4A with Talaguappa via Haliyal Yellapur and Sirsi. SH 95 Khanapur with Sadasivagad via Londa and Supa.

Table 4.6: Road & Railways length of district

District details of Road length (As on 31-03-2010)				
Name Of The District	**Road Length (in Kms)**			**Total Road Length**
	National Highways	**State Highways**	**Major District Roads**	
Uttara Kannada	331	1246	2068	3645
State Total	**4490**	**20528**	**50436**	**75454**

Railways length (km)	
Konkan Railways	**130.6**
Belgaum to Goa	**20.71**
Dharwad to Haliyal	**24.39**

Table 4.7: Road length of district at taluk level

Taluk wise road length (in Km) as on 31-03-2010				
Taluk Name	**National Highways**	**State Highways**	**Major District Roads**	**Total**
Karwar	37	107	141	285
Ankola	70	38	161	269
Kumta	31	67	232	330
Honnavara	77	36	162	275
Bhatkal	25	27	158	210
Supa	16	223	138	377
Sirsi	0	229	263	492
Yallapura	49	91	170	310
Haliyala	0	108	152	260
Siddapura	26	230	338	594
Mundugodu	0	90	153	243
Uttara Kannada Dt	**331**	**1246**	**2068**	**3645**
State Total	**4490**	**20528**	**50436**	**75454**

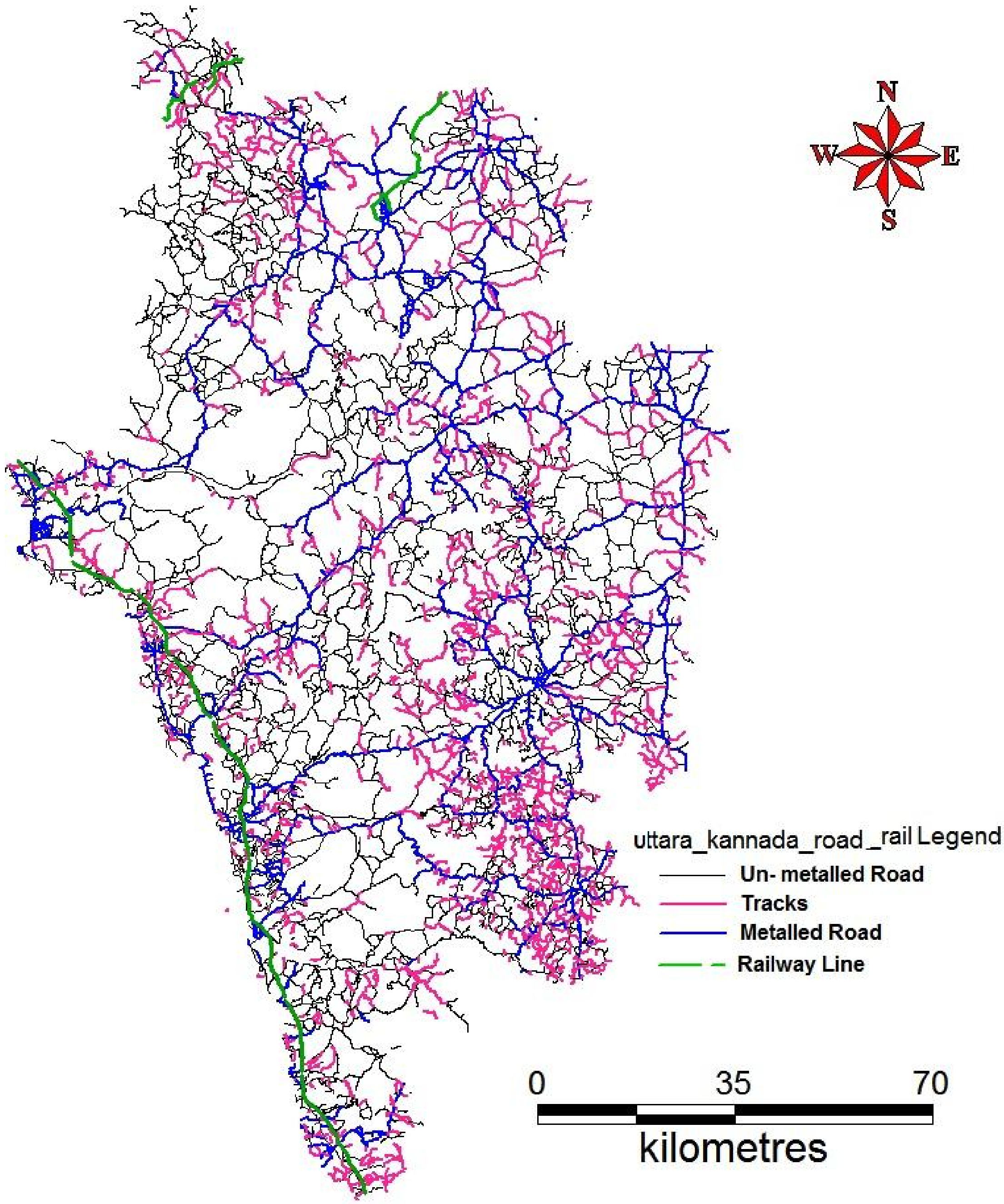


Figure 4.23: Road and rail network of Uttara Kannada district

5.0 EXPLORING BIODIVERSITY AND ECOLOGY OF CENTRAL WESTERN GHATS

Task: Review of literature
Reports Submitted 1) Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

Western Ghats is one of the important Biodiversity hotspots of the world passing through six different federal states in India and harbors a very rich diversity of flora and fauna. About 4000 flowering plant species occur in this region of which 1500 are endemics. The faunal diversity of this region is also very large with major percentage of endemism being in Amphibians (85% endemics) and reptiles (62% endemics). The complex geography, wide variations in annual rainfall from 1000-6000 mm, and altitudinal decrease in temperature, coupled with anthropogenic factors, have produced a variety of vegetation types in the Western Ghats.

The central Western Ghats passing through the state of Karnataka is blessed with a good percentage of this biodiversity hotspot and has a rich natural resource. The central Western Ghats encompasses the districts of Uttara Kannada, Shimoga, Chikmagalur, Hassan, Kodagu and parts of Dakshina Kannada. This region is bestowed with wide range of vegetation patterns and rich biodiversity including large proportion of endemic and RET species of flora and fauna. Many important conservation areas like Kudremukh National Park, Dandeli Wildlife Sanctuary, Anshi National Park, Bhadra Wildlife Sanctuary, Nagarhole National Park, Bandipur National Park, Brahmagiri and Pushpagiri Wildlife Sanctuaries, Bisale Reserve Forests and Dodabetta and Kattepura Reserve Forests are found to be occurring in this region. The important west flowing rivers harbouring biodiversity rich riverine ecosystems are Kali, Aghanashini, Bedthi (Gangavali), Sharavathi, Netravathi, Cauvery, Kumaradhara, Tunga, Bhadra and Hemavathi.

Many ecological and biodiversity investigations have been undertaken during the last three decades focusing on various aspects such as biodiversity, forest ecology, medicinal plants, riverine and coastal ecosystems, remote sensing and GIS applications, etc. Hence, in order to compile and review the vast collection of literatures spawning over different research aspects related to central Western Ghats (with a focus on Uttara Kannada district), frequent trips were made to the various universities and research institutions associated with the research work in this region. The libraries were browsed for collection of research reports, research papers and referring research thesis along with interaction sessions with the faculties/scientists associated with different departments. The broad research topics covered for literature review are listed as below:

1. Biodiversity
    a. Angiosperms

   b. Pteridophytes
   c. Fungi
   d. Phytoplanktons
   e. Mammals
   f. Fishes
   g. Amphibians
   h. Birds
   i. Insects
2. Forest related studies in central Western Ghats
3. Riverine ecosystems in central Western Ghats
4. Coastal ecosystems of Uttara Kannada
5. Biodiversity hotspots of Uttara Kannada
6. Sacred groves in central Western Ghats
7. Myristica swamps and Relic forests
8. Ethnobotany or Medicinal Plant wealth of Central Western Ghats
9. Biotechnological applications
10. Energy related studies in Karnataka
11. Remote sensing and GIS applications in central Western Ghats
12. Ecosystem goods and services from central Western Ghats

The literature collection and review process commenced in August 2010 and continued upto December 2011. The literature collected and reviewed involves a huge compendium of more than 300 research papers, about 60 thesises and many technical reports related to various research aspects of central Western Ghats. The details of Universities/ Institutions visited, their locations and period of visit is elaborated in Table 5.1.

Table 5.1: Universities/Research Institutions visited for literature collection

Sr. No.	NAME OF THE UNIVERSITY/INSTITUTION	LOCATION	TIME OF VISIT
1.	University of Mysore, Manasagangothri	Mysore	3rd August to 7th August, 2010
2.	Karnatak University	Dharwad	23rd August to 27th August, 2010
3.	Central Forest Library, Aranya Bhawan, Karnataka Forest Department	Bangalore	4th September to 10th September, 2010
4.	Kuvempu University, Shankarghatta	Shimoga	5th October to 8th October, 2010
5.	Mangalore University, Mangalaganothri	Mangalore	11th October to 16th October 2010
6.	Ashoka Trust for Research in Ecology and Environment (ATREE)	Bangalore	6th November to 10th November, 2010
7.	French Institute of Pondicherry	Pondicherry	5th December to 7th December,

			2010
8.	Centre for Ecological Economics and Natural Resources (CEENR), Institute for Social and Economic Change (ISEC)	Bangalore	15th January to 18th January, 2011
9.	College of Forestry, Sirsi	Uttara Kannada	13th April to 16th April, 2011
10.	Department of Marine Biology, Karnatak University	Karwar, Uttara Kannada	21st May to 25th May, 2011
11.	Centre for Ecological Sciences, IISc	Bangalore	1st June to 1st August, 2011

Besides visiting the Universities and institutions for literature collection, the internet was explored for published papers and reports. The following e-resources were referred to for information related to research aspects of central Western Ghats:

1. Energy and Wetlands Research Group - http://wgbis.ces.iisc.ernet.in/energy/
2. Sahyadri E-News - http://wgbis.ces.iisc.ernet.in/biodiversity/sahyadri_enews/newsletter/index1.htm
3. Nature Conservation Foundation - http://www.ncf-india.org
4. French Institute of Pondicherry - http://www.ifpindia.org/
5. Ashoka Trust for Research in Ecology and the Environment - http://www.atree.org/
6. Central Marine Fisheries Research Institute - http://www.cmfri.org.in/
7. UGC Digital Library Consortium - http://www.inflibnet.ac.in/econ/eresource.php
8. Oxford University Press - http://www.oxfordjournals.org
9. Taylor and Francis - http://www.informaworld.com/
10. Springerlink - http://www.springerlink.com/
11. JSTOR Publications - http://www.jstor.org/
12. Science Direct - http://www.sciencedirect.com/
13. International Union for Conservation of Nature - http://www.iucn.org/
14. Convention on International Trade in Endangered Species of Wild Flora and Fauna - http://www.cites.org/

Personal interactions and discussions (wherever possible) were also carried out with various researchers/experts in different research domains for obtaining information related to research done and probable research areas which need to be explored further.

6.0 LAND-USE, LAND COVER CHANGES

Task 1: Land-use, land cover changes
***Reports Submitted*:** 1. Ramachandra T V, Subash Chandran M D, Joshi N V, Bharath Setturu, 2013. Land Use Land Cover (LULC) dynamics in Uttara Kannada Central Western Ghats, Sahyadri Conservation Series 28, ENVIS Technical Report 56, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012 2. Ramachandra T V, Subash Chandran M D, Joshi N V, Bharath Setturu, 2013. Fragmentation of Uttara Kannada forests, Sahyadri Conservation Series 29, ENVIS Technical Report 57, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012 3. Ramachandra T.V., Subash Chandran M.D., Joshi N.V. and Bharath Setturu, 2013. Land use changes with the implementation of Developmental projects in Uttara Kannada district, Sahyadri Conservation Series 31, ENVIS Technical Report 61, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

6.1 LAND-USE, LAND COVER CHANGES

Land use Land cover (LULC) dynamics is a major concern, as the abrupt changes has a negative impact on ecology, climate, regional hydrology, and also people's livelihood in the region. LULC dynamics are specific to a region and vary from region to region. Land Cover refers to the observed physical cover on the earth's surface. Land cover essentially distinguishes the region under vegetation with that of non-vegetation. Land use refers to use of the land surface through modifications by humans and natural phenomena. Land use can be classified into various classes such as water bodies, built up, forests, agriculture, open lands, sand, soil, e*tc*. Land use modifications alter the structure of the landscape and hence the functional ability of the landscape. The modification includes conversion of forest lands, scrublands to agricultural fields, cultivation lands to built-up, construction of storage structures for water bodies leading to submergence of land features that may vary from small scale to large scale.

Land use and land cover patterns and their changes over time for Uttara Kannada district, Karnataka are quantified with the spatial data acquired through space borne sensors. Remote sensing data with synoptic repetitive coverage aids in understanding the landscape dynamics. The spatial data have been analysed using Geographic Information System (GIS). Changes in land use, land cover (LULC) have been analysed using temporal remote Sensing data with collateral data (field data, the Survey of India topographic maps, Google Earth data) through GIS. Vegetation cover (land cover) assessment was done by computing Normalised Difference Vegetation Index (NDVI) show the decline of vegetation cover from 92.87% (1973) to 83.44% (in 2013). Land use analysis reveal distressing trend of deforestation in the district, evident from the reduction of evergreen-semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analysis reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (20.63 to 1.52).

Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human–animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people. Main objective of the current study is to assess the spatial pattern of LULC changes in Uttara Kannada district, Central western Ghats in Karnataka. This involved i) land cover analysis, ii) land use analysis, iii) analysis of LULC dynamics, iv) understanding spatial patterns of LULC through spatial metrics

Measuring LULC changes: LULC changes in Uttara Kannada district is analysed using temporal remote sensing data with ancillary data and field data. The method followed for LULC analysis is represented in Figure 6.1 and details of datasets are summarized in Table 6.1.

Figure 6.1: Method followed in the study

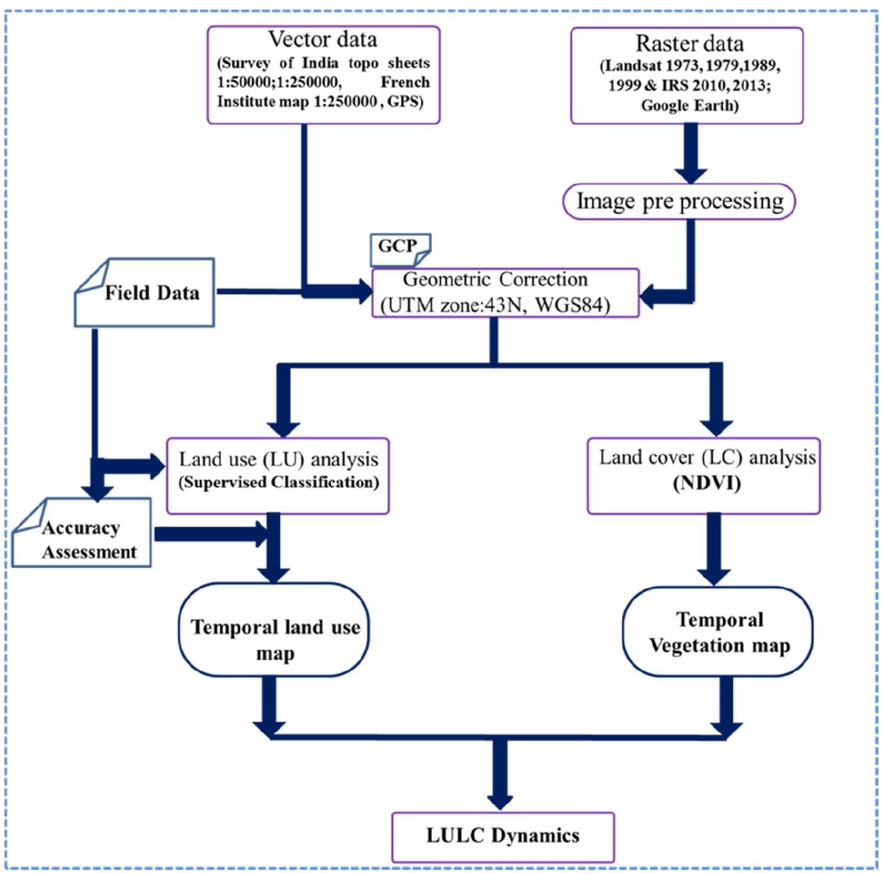


Table 6.1: Details of Remote sensing data

Year	Satellite	Sensor	Number of Bands	Resolution (M)
1973	Landsat	**Multi Spectral Scanner (MSS)**	4	57.5
1979	Landsat	**Multi Spectral Scanner (MSS)**	4	57.5
1989	Landsat	**Thematic Mapper (TM)**	7	28.5
1999	Landsat	**Thematic Mapper (TM)**	7	28.5
2010	IRS P6	**Liss 4 Multi spectral (L4MX)**	3	5
2013	Landsat	**Enhanced Thematic Mapper Plus (ETM$^+$)**	8	30

Ancillary data: Ancillary data include cadastral revenue maps (1:6000), the Survey of India (SOI) topographic maps (1:50000 and 1:250000 scales), vegetation map of South India developed by French Institute (1986) of scale 1:250000. Topographic maps provided ground control points (GCP's) to rectify remote sensing data and scanned paper maps. Vegetation map of South India (1986) of scale 1:250000 (Pascal, 1986) was digitized to identify various forest cover types and classify RS data of 1980's. Other ancillary data includes land cover maps, administration boundary data, transportation data (road network), etc. Pre-calibrated **GPS** (Global Positioning System - **Garmin GPS units)** were used for field data collection, which were used for RS data classification as well as for validation.

Land use analysis: Land use analysis involved (i) generation of False Color Composite (FCC) of remote sensing data (bands–green, red and NIR). This composite image helps in locating heterogeneous patches in the landscape, (ii) selection of training polygons by covering 15% of the study area (polygons are uniformly distributed over the entire study area) (iii) loading these training polygons co-ordinates into pre-calibrated GPS, (vi) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field, (iv) supplementing this information with Google Earth and (v) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment. The land use analysis was done using supervised classification technique based on Gaussian maximum likelihood algorithm with training data (collected from field using GPS).

Temporal remote sensing data have been classified through Gaussian Maximum Likelihood Classifier [GMLC]. Landsat data available in the public domain and IRS data (2010) corresponding to the study area were classified into eleven land use categories: Evergreen forest to semi evergreen forest, moist deciduous forest, Shrub lands/grass lands, Dry deciduous forest, Acacia/Eucalyptus/ other hardwood plantations, Teak/Bamboo/ other softwood plantations, Coconut/Areca nut plantations, Built-up, Water, Crop lands, Open fields. Table 6.2 lists land use details during 1973 to 2013. Figure 6.2 depicts land uses during 1973 to 2013 while land use category wise temporal changes is given in Figure 6.3. Comparative assessment of land use categories reveals the decline of vegetation cover in the district during 1973 to 2013. The reduction of area under evergreen forests from **67.73**% (1973) to **32.09**% (2013) due to anthropogenic activities involving the conversion of forest land to agricultural and horticultural activities, monoculture plantations and land releases for developmental projects.

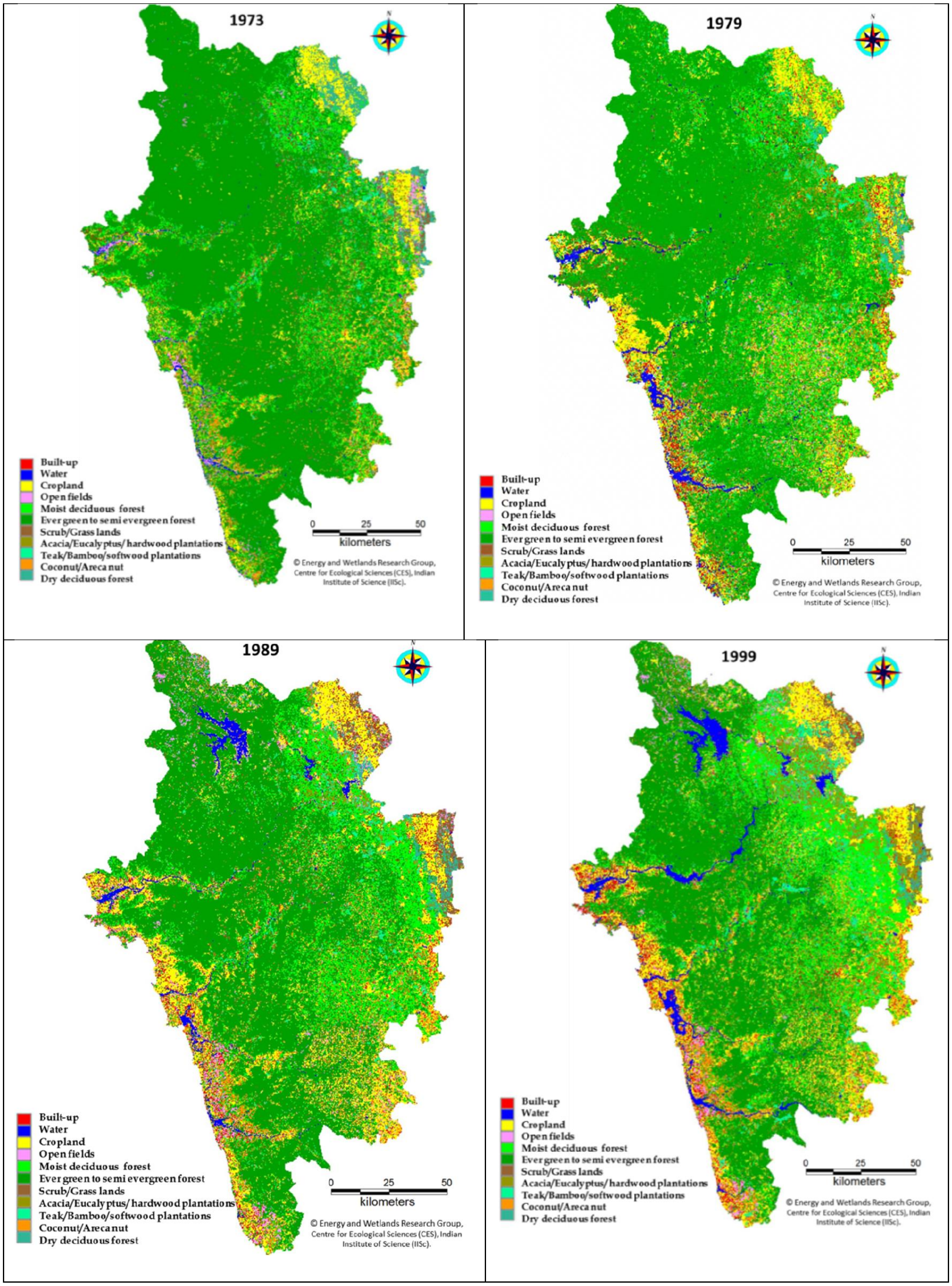
Transition of evergreen-semi evergreen forests to moist deciduous forests, and some have been converted into plantations (such as Teak, Areca nut, Acacia spp., etc.). Enhanced agricultural activities is evident from the increase of agricultural land use from **7.00 (1973) to 14.13 % (2013)** and the area under human habitations have increased during the last four decades, evident from the increase of built-up area from **0.38%** (1973) to **3.07%** (2013). Unplanned developmental activities coupled with the enhanced agriculture and horticultural activities have aided as prime drivers of deforestation, leading to the irreversible loss of forest cover with the reduction of ecosystem goods and services. The increase in plantation of exotic species has led to the removal of forest cover and also extinctions of species. *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus spp., and Tectona grandis* have been planted widely in the district. Acacia and Teak plantations constitute 12.04% and 6.60% respectively in the district. The dry deciduous forest cover is very less (0.96%) and is found mainly in the north eastern part of the district in Mundgod taluk and partly Haliyal taluk.

Table 6.2: land use variation from 1973 to 2013

Year / Category	1973		1979		1989		1999		2010		2013		Loss / Gain in area (1973-2013)
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	(Ha)
Built-up	3886	**0.38**	9738	0.95	12,982	1.26	21,635	2.10	28,491	2.77	31589	**3.07**	27703
Water	7,681	0.75	18527	1.80	16,604	1.61	32,983	3.21	26,119	2.54	28113	2.73	20432
Crop land	71,990	**7.00**	103163	10.02	121,167	11.77	138,458	13.45	148,187	14.40	145395	14.13	**73405**
Open fields	14071	1.37	15988	1.55	34,783	3.38	21,945	2.13	30,812	2.99	37660	3.66	23589
Moist deciduous forest	**95,357**	**9.27**	**102967**	**10.01**	**143,849**	**13.98**	**179,075**	**17.40**	**166,266**	**16.15**	**161,996**	**15.74**	66639
Evergreen to semi evergreen	**696,978**	**67.73**	**589762**	**57.31**	**531,872**	**51.68**	**423,062**	**41.11**	**367,064**	**35.66**	**330,204**	**32.08**	**-366774**
Scrub/grass	38,109	3.70	58936	5.73	44,123	4.29	47,366	4.60	35,158	3.42	40402	3.93	2293
Acacia/Eucalyptus/ hardwood plantations	40,905	**3.97**	50321	4.89	55,694	5.41	73,977	7.19	119,717	11.63	122927	**11.94**	82022
Teak/ Bamboo/ softwood plantations	13997	**1.36**	20896	2.03	21,937	2.13	38,588	3.75	44,794	4.35	67111	**6.52**	53114
Coconut/ Areca nut / Cashew nut plantations	20,702	**2.01**	29675	2.88	32,227	3.13	43,623	4.24	53,646	5.21	53,993	**5.25**	**33291**
Dry deciduous forest	25,410	2.47	29113	2.83	13,848	1.35	8374	0.81	9008	0.88	9873	0.96	-15537
Total	1029086												

The areas of each category were also compared with available administrative reports, statistical department data and forest division annual reports.

Figure 6.2: Uttara Kannada district land use change from 1973 to 2013
(a) 1973 (b) 1979 (c) 1989 (d) 1999 (e) 2010 (f) 2013



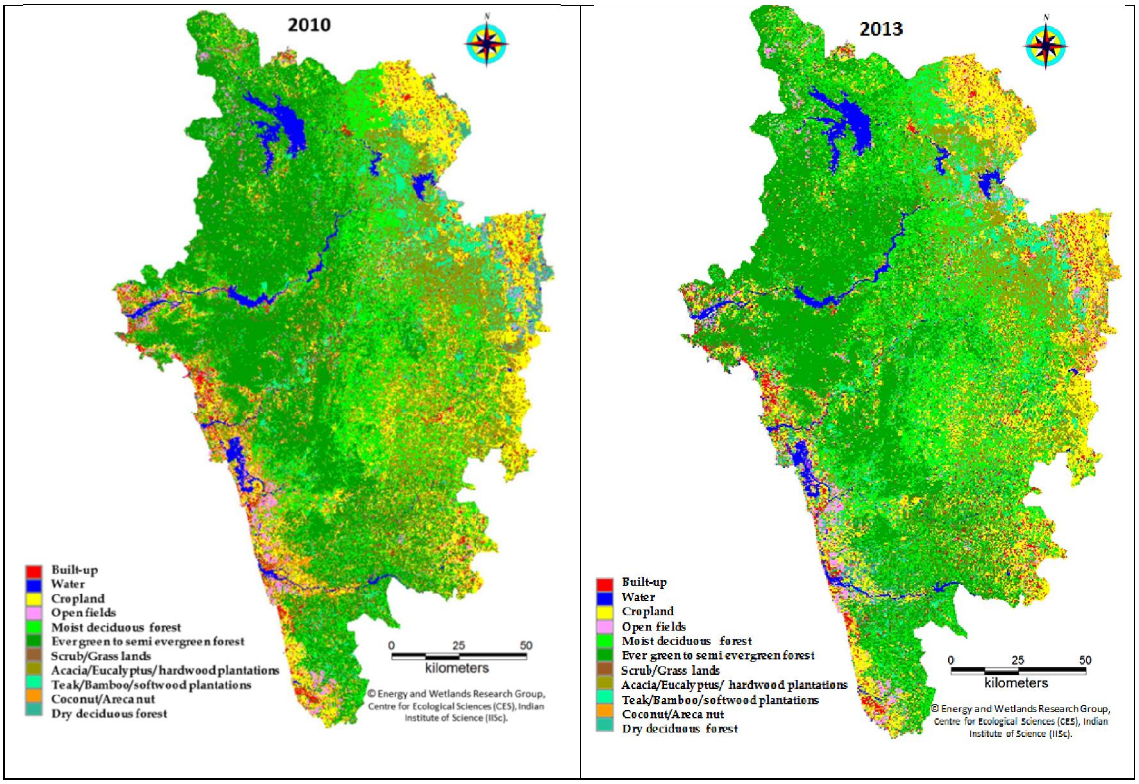
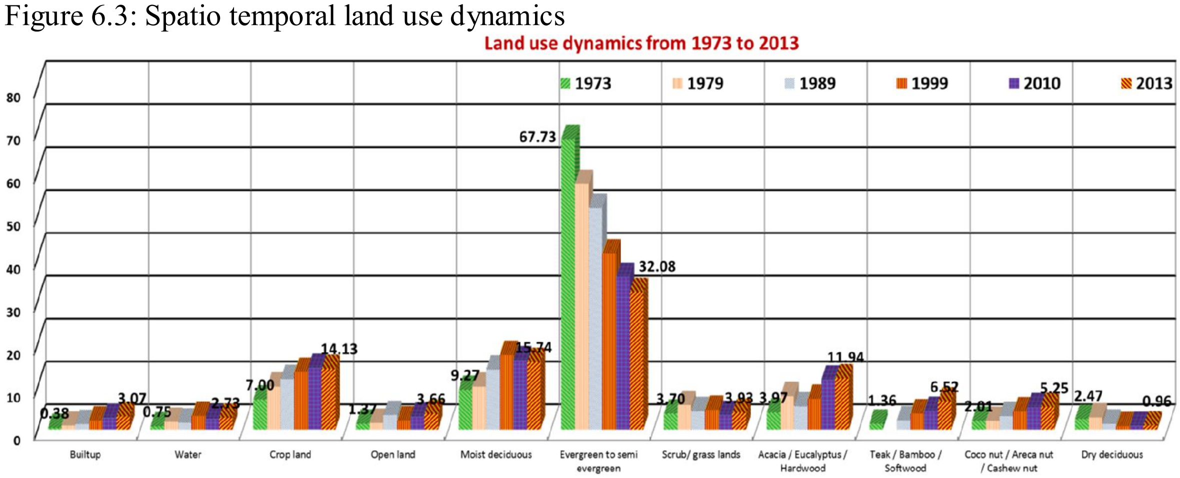


Figure 6.3: Spatio temporal land use dynamics



Category-wise rate of **land use changes were** computed to identify the categories which have undergone severe transformation. The annual rate of change at temporal scale provides landscape modification with respect to each period and category wise changes are listed in Table 6.3 and depicted in Figure 6.4. Higher changes are noticed during 1973-79 followed by 2010 to 2013. The built-up area shows as positive increase 15.31% y^{-1}(per year). The evergreen forest shows change of -2.78%y^{-1} (1973-1979) and -3.53%y^{-1} (2010-2013). Forest plantations and horticulture show an increase during 1973 to 2013, indicating market role in land conversions. The abrupt land use changes are due to large-scale developmental activities, change in agriculture practices and increase in population.

Figure 6.4: temporal variation of land use change rate from 1973 to 2013

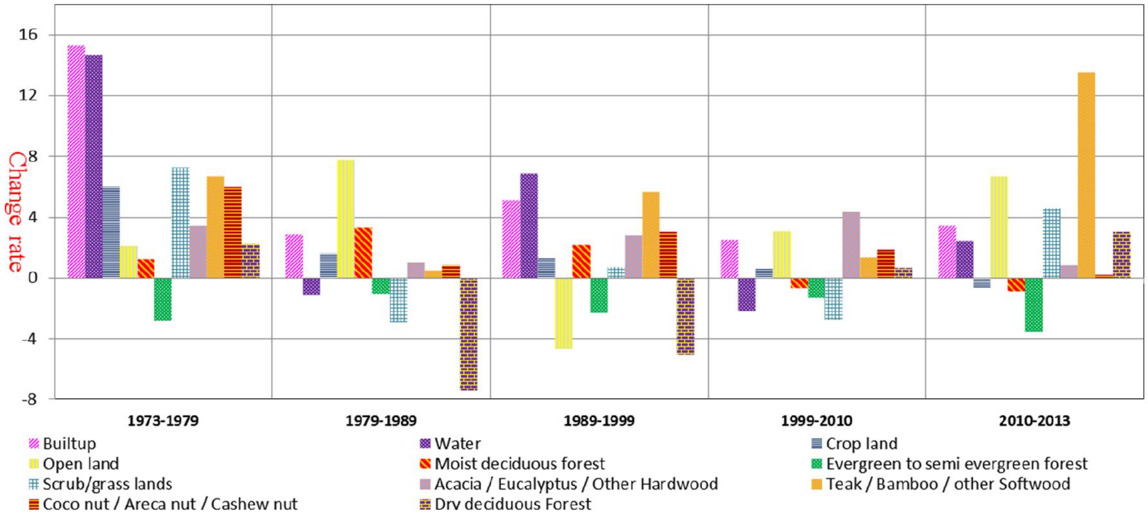


Table 6.3: land use change rate from 1973 to 2013

Rate of Change in land use categories (%)					
Category	Time period				
	1973-1979	1979-1989	1989-1999	1999-2010	2010-2013
Built-up	**15.31**	**2.88**	**5.11**	**2.50**	**3.44**
Water	14.67	-1.10	6.86	-2.12	2.45
Crop land	6.00	1.61	1.33	0.62	-0.63
Open spaces	2.13	7.77	-4.61	3.09	6.69
Moist deciduous forest	1.28	3.34	2.19	-0.67	-0.87
Evergreen to semi evergreen forest	**-2.78**	**-1.03**	**-2.29**	**-1.29**	**-3.53**
Scrub/grass lands	7.27	-2.89	0.71	-2.71	4.63
Acacia / Eucalyptus / Other Hardwood	3.45	1.01	2.84	4.38	0.88
Teak / Bamboo / other Softwood	6.68	0.49	5.65	1.36	13.48
Coconut / Areca nut / Cashew nut	6.00	0.82	3.03	1.88	0.21
Dry deciduous Forest	2.27	-7.43	-5.03	0.66	3.06

Changes in forest (evergreen–semi evergreen, moist deciduous, dry deciduous, scrub forest) and non-forest (built-up, crop land, open spaces, plantations) land uses for different time period is computed to understand the change dynamics. Table 6.4 lists category wise annual changes for different time period. Non-forest regions such as agriculture, built environments show an increasing trend in each time period, evident from an annual increase of 6.72% (during 1973 to1979), 2.07% (during 1979to 1989), 1.72 % (during 1989-1999), 0.95 (during 1999-2010) and 0.51% (during 2010-2013). In contrast to this, area under forests show a declining trend of -1.11% (1973 to 1979), -0.49% (1979 to 1989) and -0.21% (2010-2013).

Table 6.4: forest and non-forest land use change rate from 1973 to 2013

Land use category	1973-1979	1979-1989	1989-1999	1999-2010	2010-2013
FOREST	-1.11	-0.49	-0.52	-0.34	-0.21
NON-FOREST	6.72	2.07	1.72	0.95	0.51

Forest (Conservation) Act, 1980 and amendment 1988, National Board for Wildlife and State Boards for Wildlife for identification of future protected areas helped in effective management of forests in the region. The regulatory laws and protection measures were tried through formalization of national parks, wildlife sanctuaries, conservation reserves and community reserves. This approach helped to regenerate regions of disturbed forests. However, unplanned developmental activities such as construction of series of dams and encroachment of forests for non-forestry purposes led to the deforestation of forests. Compensatory afforestation has not yielded the desired results due to monoculture plantations and less prominence to the regeneration of forest patches through protection or appropriate conservation measures. Considering 1989 as base year, change analysis reveal declining trend of forests (Table 6.5). The evergreen forest cover has decline at -2.29% (1989-1999), -1.77% (1989-2010) and -2.27% (1989-2013). Due to infrastructure projects (roads, rail network), dams, project Seabird and Kaiga nuclear plant, built-up category show an increase of 5.11%, 3.74%, 4.23% respectively. Village forests were created to meet the needs of people and discourage exploitation from forests. Due to degradation of village forests, fuel wood for domestic purposes is being collected from forests.

Table 6.5: Computed change rate of land use by considering 1989 as a base year

Category	Time period (1989 as a base year)		
	1989-1999	1989-2010	1989-2013
Built-up	5.11	3.74	4.23
Water	6.86	2.16	2.51
Crop land	1.33	0.96	0.87
Open land	-4.61	-0.58	0.38
Moist deciduous forest	2.19	0.69	0.57
Evergreen to semi evergreen forest	-2.29	-1.77	-2.27
Scrub/grass lands	0.71	-1.08	-0.42
Acacia / Eucalyptus / Other Hardwood	2.84	3.64	3.77
Teak / Bamboo / Other Softwood	5.65	3.40	5.32
Coco nut / Areca nut / Cashew nut	3.03	2.43	2.46
Dry deciduous Forest	-5.03	-2.05	-1.61

Forests have declined considerably during 1973 to 2010, evident from Figure 6.5 and Table 6.6. Area under forests has been used for other purposes evident from the loss of forest cover by117645 hectares (during 1999-2010).

Figure 6.5: Changes in the forest cover in Uttara Kannada during 1973 to 2010

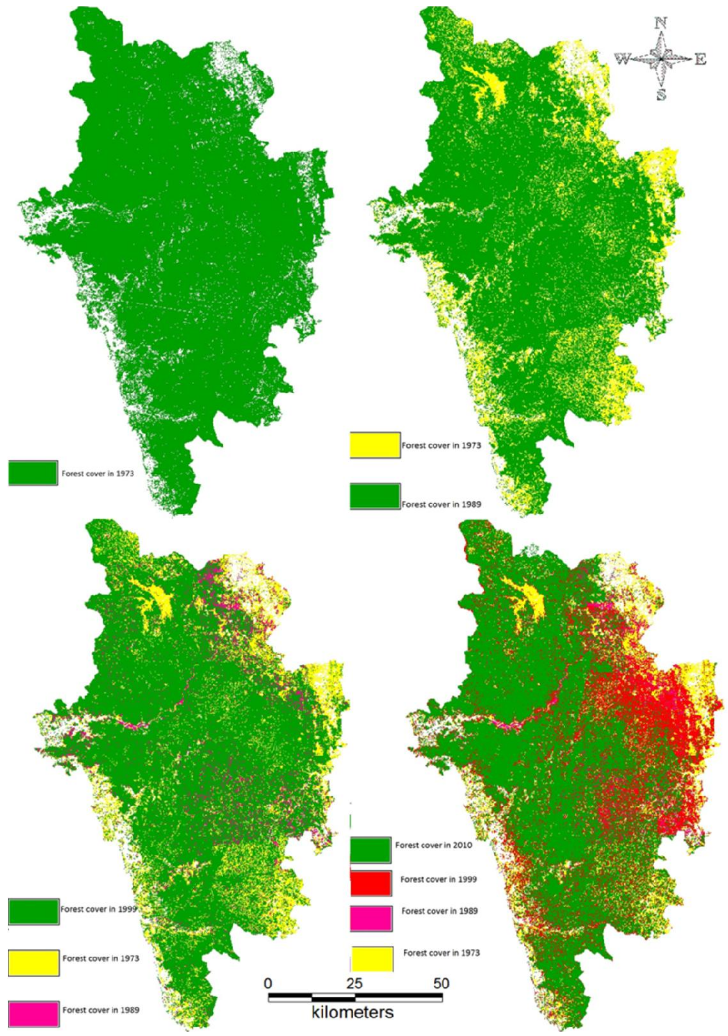


Table 6.6: Extent of forest loss

Year	Forest cover (Ha)	Forest loss (Ha)
1973	925466.26	
1989	749121.27	176344.99
1999	704668.88	44452.39
2010	587023.61	117645.27

7.0 FRAGMENTATION OF UTTARA KANNADA FORESTS

Landscapes are composed of interacting dynamic components with complex ecological, economic, and cultural qualities on which human and other life forms depend directly. Landscape is heterogeneous land area of interacting systems which forms an interconnected system called ecosystem. The functional aspects (interaction of spatial elements, cycling of water and nutrients, bio-geo-chemical cycles) of an ecosystem depends on its structure (size, shape, and configuration) and constituent's spatial patterns (linear, regular, aggregated). Large, contiguous forests are divided in a manner that leaves relatively small, isolated patches of forest (known as forest fragments or forest remnants), either by natural phenomenon or by anthropogenic activities involving construction of roads, clearing for agriculture, implementation of developmental projects or human habitations. Fragmentation of forests leads to the decline of biodiversity due to the inability of individual forest fragments to support viable populations, the local extinction of species due to inbreeding pressure, and edge effects altering the conditions of the outer areas of the fragment, greatly reducing the amount of true forest interior habitat.

Uttara Kannada district has the distinction of having highest forest cover among all districts of Karnataka. Land use analysis using temporal remote sensing data reveal distressing trend of deforestation in the district, evident from the reduction of evergreen - semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analysis reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (2063 to 1.52). Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human –animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people.

This highlights land use changes in the district, especially the conversion of forests to other categories. Fragmentation analysis considering the spatial extent of forests, reveal that contiguous forests (interior forests) has declined from 87.51 (1973) to 48.60% (2013). Forest fragmentation at landscape level show a decline of interior forest 72.95% (1973) to 25.62% (2013). Land use under non-forest categories (crop land, plantations, built-up, etc.) covers 47.29% of the landscape, while areas under natural forests constitute about 542,475 Ha. Mitigation of biodiversity loss in the district requires regeneration of forests through appropriate protection measures and also reforestation with native species of vegetation. Considering that the district has crossed the threshold of development, evident from the decline of forests, fragmentation of forests the focus should be on reforestation and regeneration of natural vegetation, which will ensure food and water security apart from the livelihood of local people. Forest management approaches need to be innovative with holistic approaches involving local people to attain sustainable use of resources, forest regeneration and minimizing the encroachment of forests.

Quantification of forest fragmentation: Fragmentation refers to the breaking of an ecosystem or habitat or land use type into small parcels of land inducing isolation. This transformation is driven by the human activities causing explicit changes in the landscape. It has effect in terms of patch size and shape, connectivity and causes changes in internal heterogeneity, thereby restricting the movement of species. It also create barrier to the normal route of species and thus limiting the potential of species for dispersal and colonization.

Fragmentation will result in spatial pattern changes making forests vulnerable with an increase in the number of patches, patch shape complexity and isolation. Determinants of fragmentation disturbance pattern are mainly spatial (size of area disturbed), temporal (period of disturbance) and severity. Fragmentation analyses provide insights to the configuration of individual landscape elements, e.g. the shape of individual patches, and characterises land-use changes impact on habitat topology and configuration. Spatial data acquired remotely through sensors mounted in satellite platform at regular intervals helps in assessing the temporal changes with spatial patterns. Geoinformatics is very effective in assessing the issues of ecological concern driven by changes in land uses with forest loss and fragmentation.

The forest transition and its associated fragmentation process throughout the study area were estimated based on the analysis of multi temporal landscape maps. Forest fragmentation analysis was done to quantify the type of forest in the study area-patch, transitional, edge, perforated, and interior based on the classified images. Forest fragmentation analysis spatially aids in visualizing the regions that require immediate attention to minimize landslides. Spatial fragmentation map depicts the type and extent of fragmentation. So there is a need for better understanding the role of disturbance regimes which helps in better informed management decisions, by gaining insight related to landscape dynamics and the historic range of variability in ecosystems. LULC changes in Uttara Kannada district is analysed using temporal remote sensing data with ancillary data and field data. The method followed for LULC and fragmentation analysis is represented in figure 7.1.

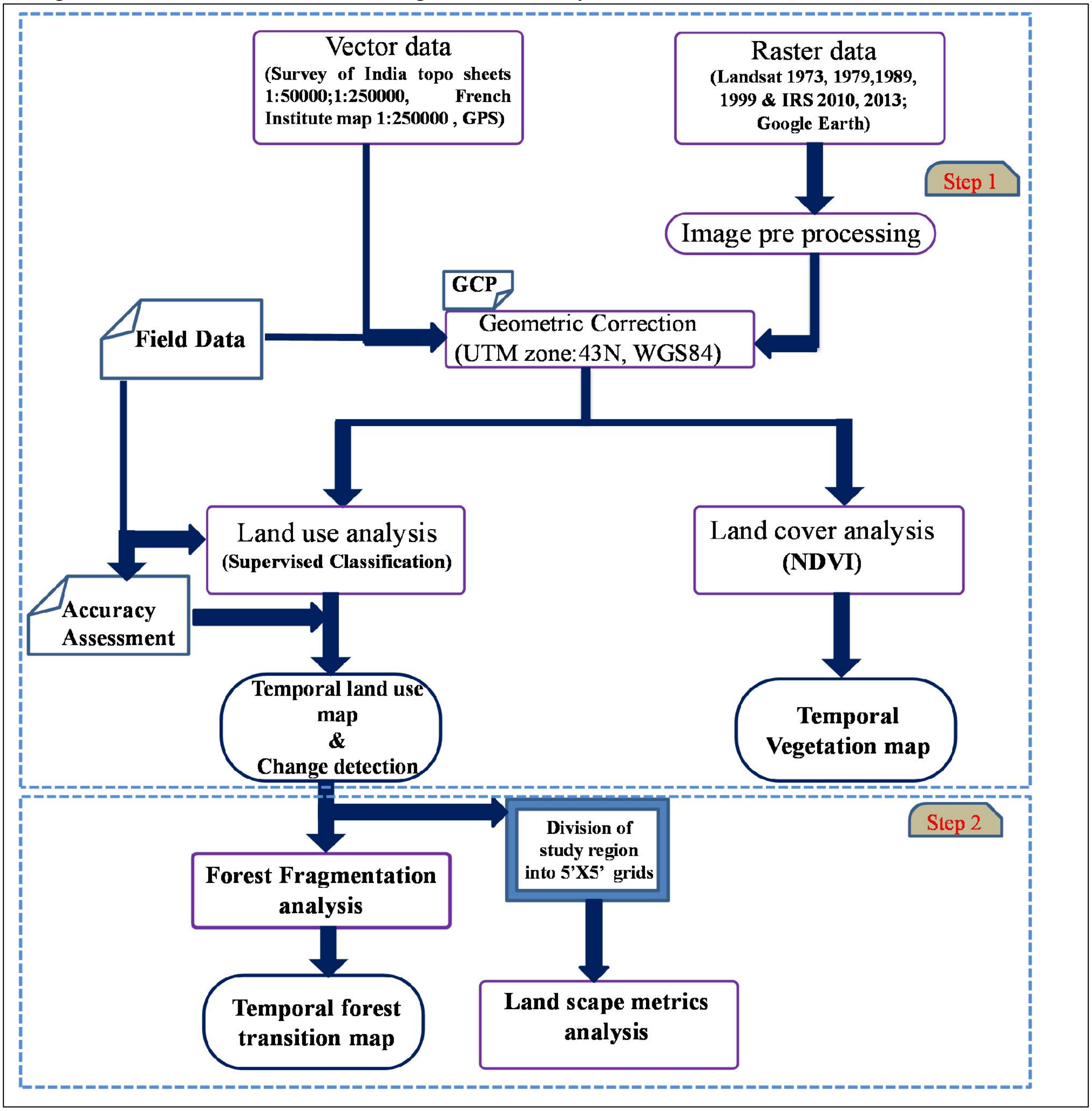
Forest fragmentation: Forest fragmentation category at pixel level is computed through Pf (the ratio of pixels that are forested to the total non-water pixels in the window) and Pff (the proportion of all adjacent (cardinal directions only) pixel pairs that include at least one forest pixel, for which both pixels are forested. In other words, The Pf is simply the proportion of non-missing pixels within the moving window with a specified size that are forest, and Pff is the ratio of the number of pixel pairs in cardinal directions that are both forest divided by the number of pixel pairs in cardinal directions where either one or both are forested. Pff estimates the conditional probability that given a pixel of forest, its neighbour is also forest. A moving window with the size of 5 X 5 pixels (figure 7.2) was used for the fragmentation analysis to maintain a fair representation of the proportion (Pf) of pixels in the window and to maintain interior forest at an appropriate level, due to the fact that the outcomes of the model are scale-dependent and threshold dependent. The spatial maps of forest fragmentation components thus derived by computing 'Pf' and 'Pff' using the sliding kernel (of size 5 x 5) based on the total extent of forest and its occurrence as adjacent pixels (Figure 7.3). A pixel is classified by the type of fragmentation and the result of the kernel is stored at the location of the center pixel (in the derived map), which represents between-pixel fragmentation around the corresponding forest location. Details of levels of fragmentation with discriminant criteria of the each component are listed in Table 7.1 based on two indices, Pf and Pff. Depending on these indices values, the analysis will derive different fragmentation components to assess the health of forest of a region. Forest pixels that comprise a small forested area surrounded by non-forested land cover refers to **Patch** forests. Forest pixels that define the boundary between interior forest and large non forested land cover features are **Edge** forests. **Perforated** forest refers to pixels that are the boundary between interior forest and relatively small clearings (perforations) within the forested landscape. **Interior** forest are the forest pixels that are reasonably far away from the forest-non forest boundary. Interior forested areas are surrounded by more thick forested areas. Transitional types are clearly depending on non-forest and edge pattern. These are in between edge type and non-forest types. If higher pixels are non-forest then they will be tending to non-forest cover with higher degree of edge. The water bodies or river coarse are considered as non-fragmenting features, because they act as natural corridors in forested landscape. Non-forested areas including buildings, roads, agricultural field, and barren land, along with developed land, are considered fragmenting features.

Table 7.1: Fragmentation components and their description:

Fragmentation component	Description
Interior	($P_f = 1$), All of the pixels surrounding the center pixel are forest
Patch	($P_f < 0.4$), Pixel is part of a forest patch on a non-forest background, such as a small wooded lot within a built-up region.
Perforated	($P_f > 0.6$ and $P_f - P_{ff} > 0$), Most of the pixels in the surrounding area are forested, but the center pixel appears to be part of the inside edge of a forest patch, such as would occur if a small clearing was made within a patch of forest.
Edge	($P_f > 0.6$ and $P_f - P_{ff} < 0$), Most of the pixels in the surrounding area are forested, but the center pixel appears to be part of the outside edge of forest, such as would occur along the boundary of a large built-up area, or agricultural field.
Transitional	($0.4 < P_f < 0.6$), About half of the cells in the surrounding area are forested and the center forest pixel may appear to be part of a patch, edge, or perforation depending on the local forest pattern

Computation of P_f and P_{ff} is explained considering a 5 x 5 kernel with 25 pixels shown in Figure 2. Forest pixels are shaded (15 pixels) and non-forest pixels are not shaded and Pf is 15/25=0. 6. Considering pairs of forest pixels in cardinal directions, the total number of adjacent pixel pairs is 40, and of these, 40 pairs include at least one forested pixel. Eight of those 40 pairs are **forest-forest** pairs, so Pff equals 8/40 = 0.2.

Figure 7.1: Method for LULC and fragmentation analysis



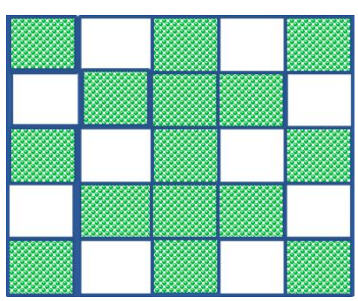


Figure 7.2: KERNEL (5x5) for computation of P_f, P_{ff} values

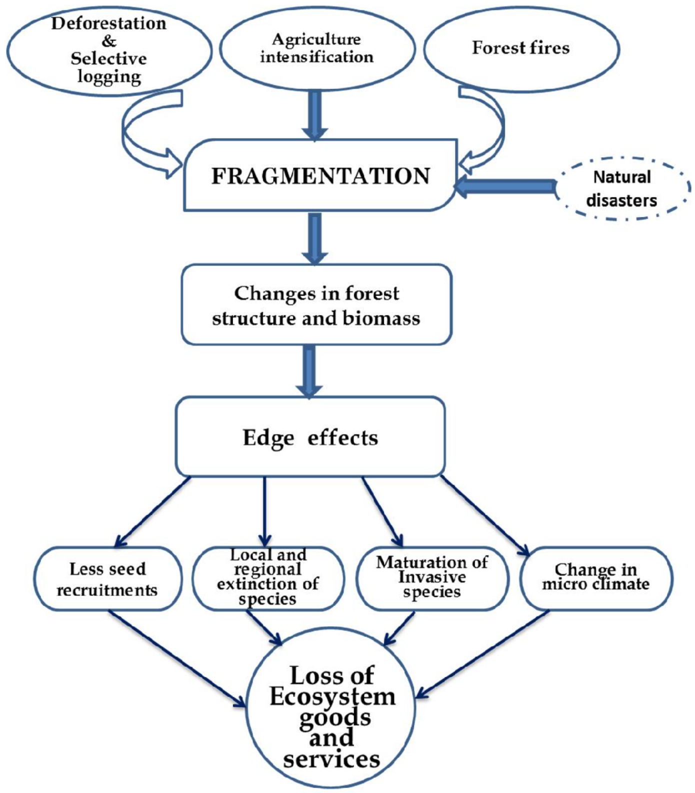


Figure 7.3: A theoretical frame work of Fragmentation

The analysis of forest fragmentation has been done to assess the spatial extent of interior forests, edge forest, etc. Temporal analyses of forest fragmentations reveal change transition with respect to all agents of influence. The fragmentation analysis was done in two stages. Stage 1 by considering only the forest cover of the region and stage 2 explains the fragmentation at landscape level. This information will provide more insights of forest cover in the region. Figure 4 (a, b,c,d,e,f) depicts the temporal pattern of forest fragmentation in Uttara Kannada district. Natural forest cover has declined from 83.17% (1973) to 52.71% (2013).

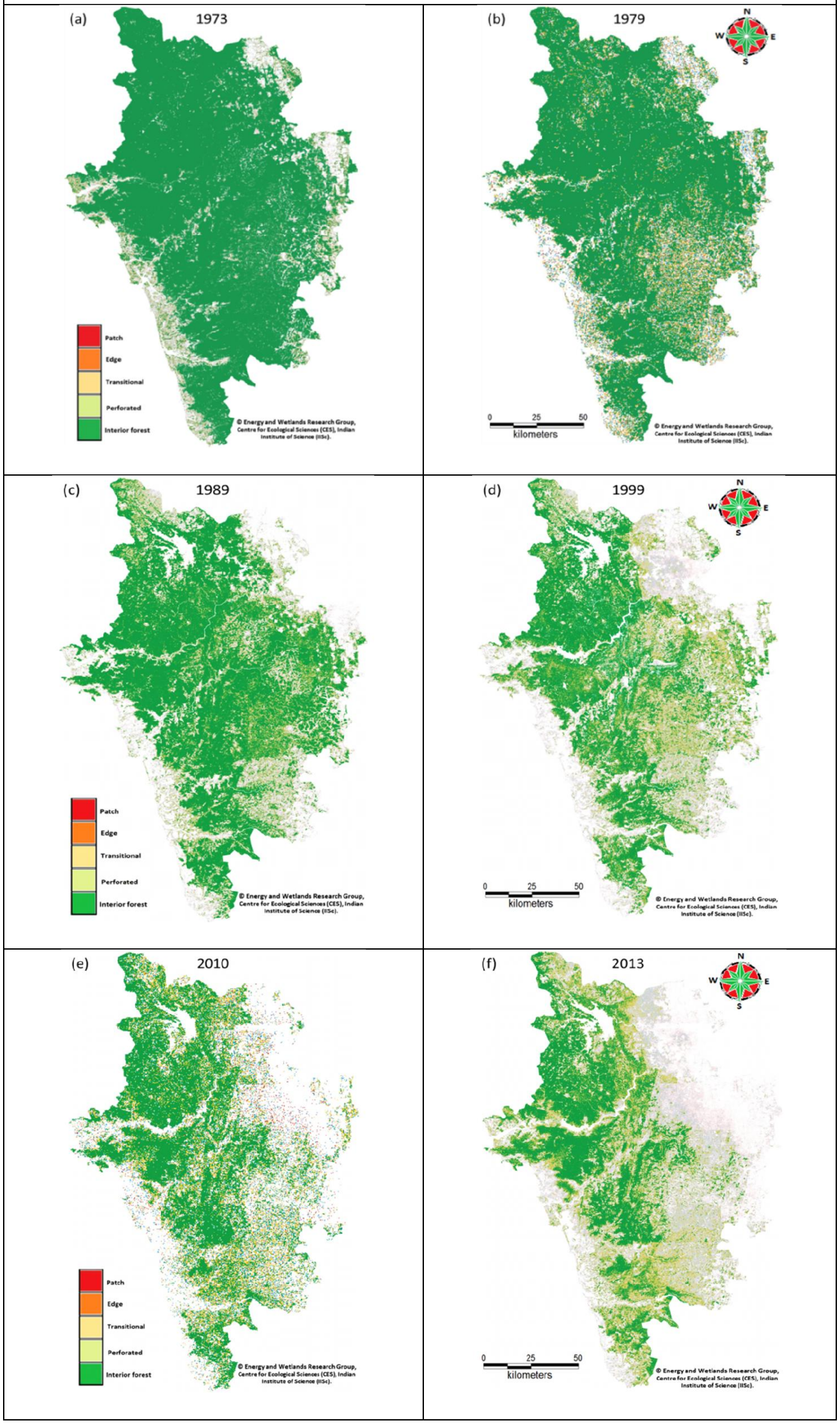
Table 7.2 lists the spatial extent of various types of fragments (interior, perforated, edge, transitional and patch forests) during 1973 to 2013. The analysis reveals the fragmentation evident from the decline of interior forests from 7507 sq km (1973) to 2636 sq.km (2013) and a considerable increase in other categories. Increase in the spatial extent of edge forests from 8.14% (1973) to 33.16% (2013) highlight the extent of fragmentations in the district. Figure 7.4(a) depicts the extent of forest fragmentation in 1973, the region was dominated by interior forest (87.51%) and edge forest (8.14%) was located along linear corridors, including roads, rivers and the boundary pixels of large forest patches. Patch forest is mainly located in the interfaces of forest intermixed with agriculture and urban classes over the small portions. The major disturbances noted in the forests in rural areas are due to the conversion of forest into agriculture and logging by forest based industries. The industrial sector's exploitation peaked up in 1950's due to industrialization and selective felling of trees in the evergreen forest reached peak in 1960's to 1980's period. The exploitation of wood in the evergreen forest has severely affected the forest ecosystem. The selective felling of large trees created many canopy gaps in the forest, leading to the spread of invasive exotic species adversely affecting the faunal species.

Table 7.2: temporal changes in forest fragmentation (stage 1) from 1973 to 2013

Year	1973		1979		1989		1999		2010		2013	
Fragment type	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Patch	3151.75	0.37	3711.73	0.48	13368.35	1.82	18043.33	2.74	15198	2.63	30618	5.64
Transitional	17282.89	2.01	20369.03	2.61	33833.24	4.61	40884.58	6.21	35135	6.08	59435	10.96
Edge	69841	8.14	75281.05	9.64	123490.4	16.83	168266.32	25.58	168084.9	29.11	179870	33.16
Perforated	16869.18	1.97	18517	2.37	14150.94	1.93	11434.67	1.74	9339	1.62	8909	1.64
Interior	750709.99	87.51	662909.2	84.90	548849.8	74.81	419248.5	63.73	349739.1	60.56	263643	48.60
Total area	857854.81		780788.01		733692.73		657877.4		577496		542475	

The figure 7.4 (b) shows the fragmentation status for year 1979. Interior forest has become 84.90% (1979) from 87.51% (1973) with increase in edge forests (9.64%). The major activities include industrialisation, infrastructure development, intensified agriculture, plantations. Supply of resources to industries at highly subsidised rates and permission to polluting industries in the ecologically sensitive regions has influenced the forest cover in the region. The major loss of interior forest cover and human induced disturbances to natural vegetation has become prominent during 1979 to 1989 (Figure 7.4(c)). Unplanned developmental activities such as large scale industrial and power projects - manganese mining, a ferromanganese plant, a paper mill, several irrigation projects and a series of major hydroelectric projects have led to the retreat of forest and the degradation were evident with barren hilltops. Large scale land use changes were witnessed during the period evident from the increase of paddy lands, coconut/areca nut plantations. These activities are aggravated due to the inaction of local administration and also due to regularizing encroachments. All these resulted in the reduction of interior forest cover by 10% (from 84.90% to 74.81%). The edges and transitional patches are created more which was reached to 16.31%, 4.61%. Figure 7.4 (d) shows the fragmentation status for the year 1999 of Uttara Kannada district. The region has lost major portion of interior forest and reached to 63.73% with the increase in edge forests to 25.58%. Drivers of these changes are implementation of series of hydroelectric projects, Kaiga NPH (Nuclear Power House), Project Sea Bird, national highways (NH), Konkan railway line and other infrastructure projects. Tree logging is banned in 1986 to minimize the environmental impacts. However, implementation of developmental projects influenced the forest cover changes. Edge forests have immense impact on interior forests due to changes in the composition of forest cover. The figure 7.4 (e & f) shows the status of forest for 2010, 2013. The region has 48.60% interior forest and 26.16% of edge forests. These interior forests are already protected wither in the form of sanctuaries, protected areas or sacred grooves. Increasing demand for fuelwood is contributing towards forest degradation and fragmentation.

Figure 7.4 (a, b, c, d, e, f): temporal forest fragmentation from 1973 to 2013



The region is rich in NTFP (non-timber forest produce) such as palms, bamboo grains and shoots, fruits like *Mangifera, Artocarpus, Garcinia, Phyllanthus emblica*, and *Syzygium cumini.* The edible fats are collected from the seeds as well as spices like pepper, cinnamon; honey, and mushroom. Apart from edible resources they are also extracting thatching, basket- and mat-weaving materials, fibers, medicinal plants, etc. The provision of roads to enable extraction of these resources have created more edges and have affected the biodiversity of the region.

Forest Divisionwise Fragmentation Analysis: Division wise fragmentation of forests have been analysed to understand the status of forests under different jurisdictions of Uttara Kannada. The total forest area of the district is 8296.45km^2, (as per the legal status) including areas released for various non-forestry activities and recent orders of regularization of encroachment. The total geographical area of the district is 10,291.00 km^2. The forest area under the control of the Forest Department is 7759.794 km^2. The forest area under revenue and other departments is 536.66 km^2. Uttara Kannada forest region is administered under Kanara circle. Kanara Circle comprises of 5 Territorial Forest Divisions (Table 7.4a), a Wild Life Division and one Social Forestry Division (Karwar Social Forestry division) (Figure 7.5). Each division is further divided into subdivisions for effective management.

Table 7.4a: taluks under various forest divisions in Kanara Circle

Forest Divisions	Taluks
Haliyal forest division	Haliyal, part of Supa taluk
Honnavar forest division	Ankola, Kumta, Honnavar, Bhatkal
Karwar division	part of Ankola, Karwar, part of Supa taluk
Sirsi division	Sirsi, Siddapura
Yellapur division	Yellapur, Mundgod taluks
Dandeli wild life division	major portion of Supa taluk

Table 7.4b: Forest cover in Uttara Kannada district as per legal status

Sl. No.	Department (as per legal status)	Type of Forest	Area (in Sq. Km)
1	**Forest**	Reserved Forest	7727.712
		Protected Forest	31.644
		Village Forest	----
		Un-classed	0.438
		Total	7759.794
2	**Revenue**	Reserved Forest	-----
		Protected Forest	510.485
		Village Forest	26.177
		Un-classed	----
		Total	536.662
Total			8296.456

Table 7.4b provides the spatial extent of each forest types as per legal status. These divisions harbours varitites of flaora and fauna. The minor forest areas are marked and left as a right and privilege for the people. Betta lands (lands alloted for open collection of resources for the farmers) are set apart to provide litter and other resources to support arecanut cultivation,. Betta lands are supposed to be managed through joint forest mangement framework, but present status depicts poor conditions in the district. Hakkals are areas set apart for shifting cultivation and shifting cultivation practice is no longer in vogue. The exotic plantations started in the forest area of this circle as back as 1865-66. The cumulative effect of these introduction visualised earlier in land use and fragmentation analysis at landscape level.

Figure 7.5: Forest division map of Uttara kannada district

Haliyal Forest Division: Haliyal forest division located between 14^0 58' 34" to 15^0 31' 16" N and 74^0 4' 52" to 74^0 29' 52" E comprising Haliyal, Bhagavati, Sambrani, Dandeli, Virnoli, Kulgi, Barchi, Jagalbet, Tinneghat and Gund Ranges. Forest types include broadly tropical wet evergreen forest to semi evergreen forests, moist deciduous forests, tropical dry deciduous forests. Figure 7.6(a and b) and Table 7.5 depicts the forest status during 1973 and 2013. The region had 77.78% of interior forests and only 14.31% area was under non-forest. The dense interior forests were lost due to construction of series of dams on river Kali and some area was replaced for plantaions. Current spatial extent of interior forests is about 18.8%, which is mostly concentrated in Supa taluk part and Kali river valley regions. In certain places of forest area, widening or creation of road works were noticed without obtaining clearance under FC Act 1980 (KFD, 2009). The Kaiga power grid lines have bisected thick tracts of intrior forests and formed additional edges. Cultivation areas grew up taking mainly dry forest areas which represent a general loss due to the changes to dry forest, grassland, and shrub-type vegetation. At the same time, abandonment of agricultural zones can be observed. These decreases can possibly be attributed to different socio-economic factors such as the limited availability of water resources, high production costs and migration.

Table 7.5: Haliyal Forest Division				
Year	1973		2013	
	Ha	%	Ha	%
Non-forest	21,306.25	14.31	88,503.14	59.44
Patch	176.27	0.12	5299.76	3.56
Transitional	2070.44	1.39	7841.99	5.27
Edge	2265.11	1.52	4094.17	2.75
Perforated	7259.46	4.88	15,159.10	10.18
Interior forest	115,816.97	77.78	27,996.34	18.80
Total	148,894.50			

Honavar Forest Division: This division with 1490 Km^2 forest area located between 13^0 56'15" to 14^0 41'15" N and 74^0 26'0" to 74^0 46'20" E on the west Coast with three sub divisions at Kumta, Honavar and Bhatkal. This division has thick evergreen forests, moist deciduous forests and many medicinal plants. Eventhough heavy human pressure exists, the region is still having rich biodiversity due to major rivers Gangavalli, Agnanashini, Sharavati and innumerable streams which flows from Ghats to Arabian sea. The region had 62.84% area under interior forests, 21.35% under non-forest cover (figure 7.6 (c, d)). The intensification of commercial plantations and exotic plantaions have led to the decline of inerior forests. Now the interior forests accounts to 23.14% with the increase in non-forest land and the current spatial extent constitute about 46.76% (table 7.6). Forest perforations (21.62%) highlight the conversion of forest to fram-lands or plantaions. The survival percentage of forest plantations is significantly lower due to weeds, bushes, vegetation and rocky out crops in certain regions. The rehabilitations of evacuees of Sharavathi and other dams has affected interior forests and created more edges and perforations. Effort by VFC's (Village forest committees) have contributed to the success of afforestation programmes.

Table 7.6: Honnavar Forest Division				
Year	1973		2013	
	Ha	%	Ha	%
Non-forest	41,098.01	21.35	90,019.05	46.76
Patch	992.86	0.52	4829.35	2.51
Transitional	7174.54	3.73	9406.11	4.89
Edge	5630.08	2.92	2084.55	1.08
Perforated	16,654.86	8.65	41,629.45	21.62
Interior forest	120,975.65	**62.84**	44,557.49	**23.14**
Total	192,526.00			

Karwar Division: Karwar division is located within 14^0 35'54" to 15^0 17'18" N and 74^0 5'10" to 74^0 42'18" E, with thearea under forets about 1446 Km^2. Karwar, is the district head quarter of Uttara Kannada having greater population pressure on forest for resources. The forests in the region are mainly evergreen to semi evergreen type, moistdeciduous cover also present in certain pockets. Like Honnavar forest division, this division also has coastal area and Ghats portion. High percentage of forest cover exists in the Sahyadri mountain ranges and also in the coastal areas. Most of the forests are under protected forests area status. The division had 79.99% of inerior forest and only 11% under non-forest cover (figure 7.6 (e, f)). The urbanisation followed by industrialisation led to loss of interior covrerage. The plantations also agravated the situation to reach interior forest by 48.07% in 2013 (table 7.7). The execution of series of dams, power plants, novel base projects are responsible for decline of inerior forests.

Table 7.7: Karwar Forest Division

Year	1973		2013	
	Ha	%	Ha	%
Non-forest	20,879.35	11.00	53,657.93	28.27
Patch	501.29	0.26	3225.48	1.70
Transitional	2658.93	1.40	6879.07	3.62
Edge	2601.77	1.37	2032.03	1.07
Perforated	11,340.16	5.97	32,782.59	17.27
Interior forest	151,827.20	79.99	91,231.60	48.07
Total	189,808.70			

Sirsi division is located between 14^0 12' and 14^0 51' N, 74^0 34' and 75^0 4' E and comprises of evergreen to semi evergreen, moist deciduous, dry deciduous forests cover type. The division is having topographically undulating terrain in the west and turn out to be plains on east. The forest division covers Sirsi, Siddapur towns and villages. This division is having unique feature among the other divisions, consisting Dharma and Varada rivers drain flowing towards the eastern region; Aghanashini, Bedthi, Sharavathi flowing towards the western region. About 40650 Hectare forest land is alloted as Betta land to support farmers for their garden requirements. The interior forest cover in 1973 was 72.5% and non-forest land use was only 13.5% (table 7.8). The market based agriculture practise encouraged the conversion of forest land for commercial plantrations, and the current (2013) spatial extent of area under non-forests is 52.12% (figure 7.6 (g, h)). The betta lands have degraded due to over exploitation and poor maintainence. Forest perforations (19.89%) are mainly due to conversion of forest to agriculture inside the interior forests. The diversion of streams also led to removal of trees in swampy regions of Siddapur taluk for agriculture and gardens worsen the situation in recent times. All these cumulative pressures are evident as the current spatial extent of interrior forests is about 13.83%.

Table 7.8: Sirsi Forest Division				
Year	**1973**		**2013**	
	Ha	**%**	**Ha**	**%**
Non-forest	29,600.06	13.50	114,256.96	52.12
Patch	688.52	0.31	9565.45	4.36
Transitional	3890.08	1.77	19,173.99	8.75
Edge	3818.55	1.74	2298.78	1.05
Perforated	22,100.44	10.08	43,598.78	19.89
Interior forest	159,122.87	72.59	30,326.56	13.83
Total	219,220.52			

Yellapur Division: Yellapur division lies between 14^0 44' to 15^0 7' N and 74^0 25' to 75^0 6' E with the geographical area of 187,304 Ha, is surrounded by Honnavar, Karwar and Sirsi divisions and on the eastern side by Dharwad Division. This division also also consisti of Betta lands of 1,65,458 Ha to encourage garden farmers like in Sirsi division. The intensified plantation activities and regularising of eearlier encrochments have affected the interior forests which has declined from 71.18 (1973) to 17.59% in 2013 (table 7.9). Non-forest land use cover has reached to 50.20% of landscape (figure 7.6 (i, j). The plantations of *Acacia auriculiformis; Tectona grandis* in moist deciduous and dry deciduous tracks of Mundgod and Kirwatti have registered high survival rate as compared to other ranges have encouraged the forest department to replace the natural regions like grassy blanks and open patches, irrespective of rainfall, depth of the soil by plantations. The dry forest areas were initially occupied by shrub-type vegetation, and grasslands which were converted to other land uses. The majority of changes have happened in the regions that are in contact with human habitations. This is major reason for loss of cooonctivity and shrinkage of interior forests. To cope up with the situation, efforts have been taken by the Forest Department to increase the forest and tree cover through promotion of social forestry, farm forestry, agro forestry, community forestry and afforestation on wasteland, panchayt land, private lands, etc. outside the notified Forest area.

Table 7.9: Yellapura Forest Division				
Year	**1973**		**2013**	
	Ha	**%**	**Ha**	**%**
Non-forest	29981.34	16.01	94,026.75	50.20
Patch	1035.09	0.55	6643.94	3.55
Transitional	3789.64	2.02	14,029.24	7.49
Edge	3387.05	1.81	2366.32	1.26
Perforated	15795.23	8.43	37,294.57	19.91
Interior forest	133315.65	**71.18**	32,943.18	**17.59**
Total	187,304.00			

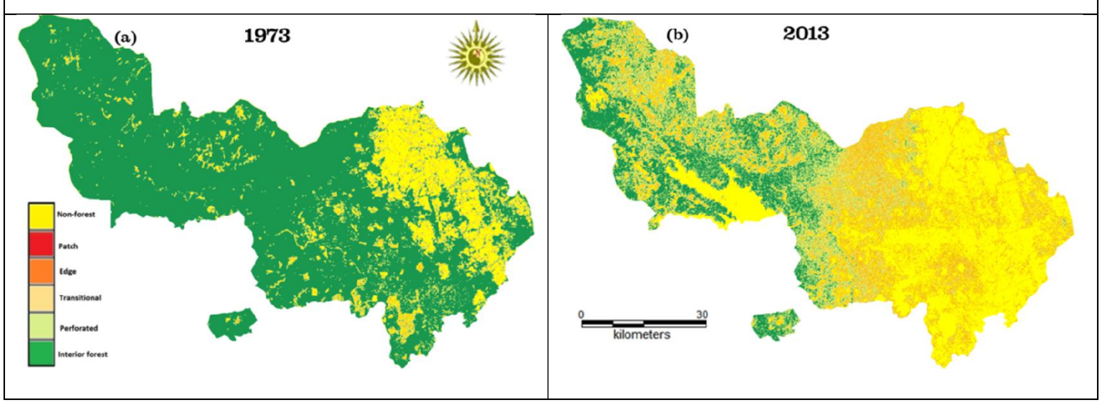
ADTR (**Anshi Dandeli Tiger Reserve)** wild life division consists of Dandeli Wild Life Sanctuary and Anashi National Park. The entire region has lush green cover and harbours rich and diverse flora and fauna. The forests of Dandeli Wild Life division area has mainly evergreen to semi evergreen and moist deciduous in nature. It is the only Wild Life division in Kanara Circle (declared in 4-01-2007). The revised management plan, for the period of 2008 to 2018 has now been prepared and is under implementation. The region had 94.05% area under interior cover (1973) and due to mangement plans of plantations the current interior cover is about 66.18% (table 7.10, Figure 7.6k, i). The easter part of ADTR has inflence of Haliyal taluk's villages. Plantations activities in protected area have altered the composition of species. Apart from continuous monitoring, socio-economic survey and bio-diversity survey are also required to be taken up at periodic intervals for knowing the impact of existing activities and status of conservation and development of the forest resources.

Table 7.10: ADTR wild life Division

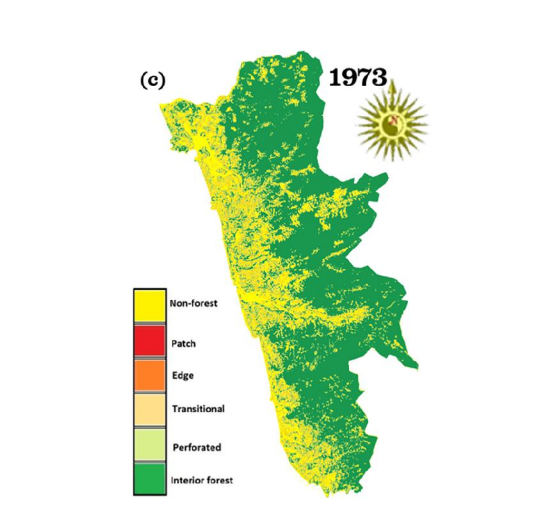
Year	1973		2013	
	Ha	%	Ha	%
Non-forest	2489.88	2.69	10,841.49	11.73
Patch	63.28	0.07	1086.2	1.17
Transitional	479.59	0.52	2854.44	3.09
Edge	371.4	0.40	613.72	0.66
Perforated	2096.97	2.27	15,869.59	17.17
Interior forest	86,950.00	94.05	61,185.68	66.18
Total	92451.12			

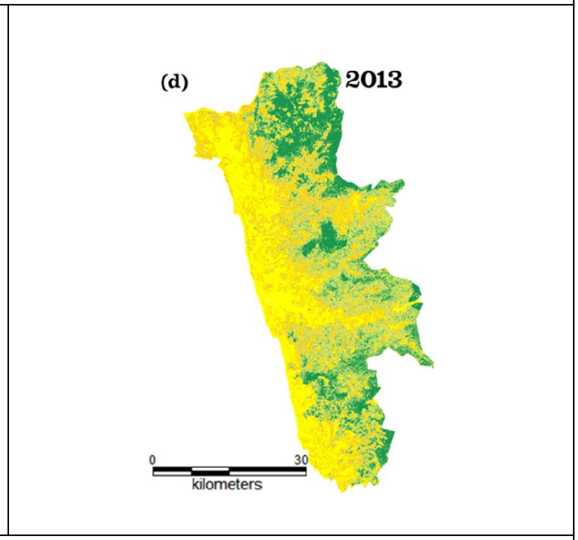
Figure 7.6 (a, b, c, d, e, f, g, h, i, j, k, l): Fragmentation status at division wise

Haliyal Forest Division

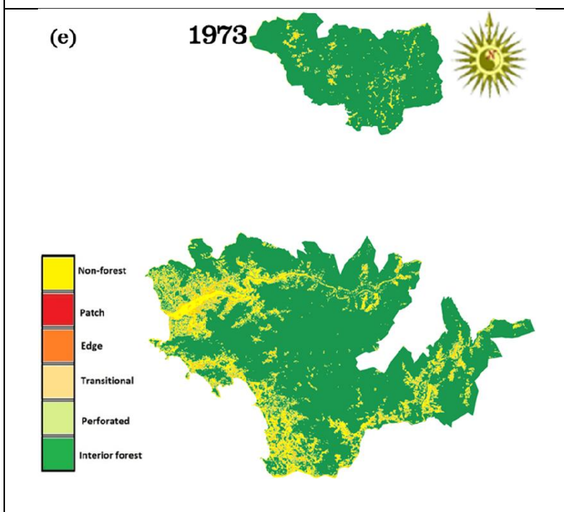


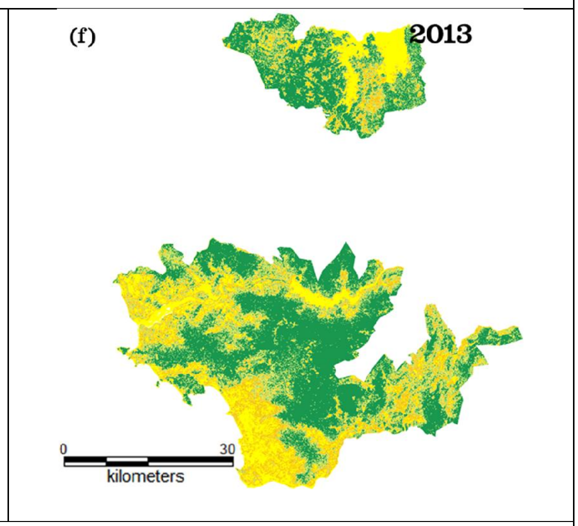
Honnavar Forest Division



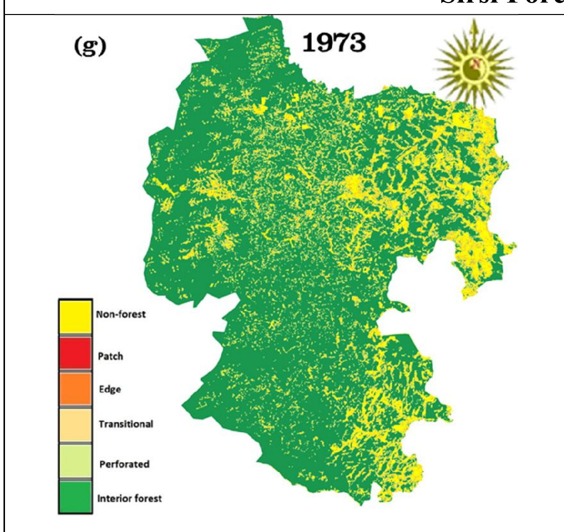


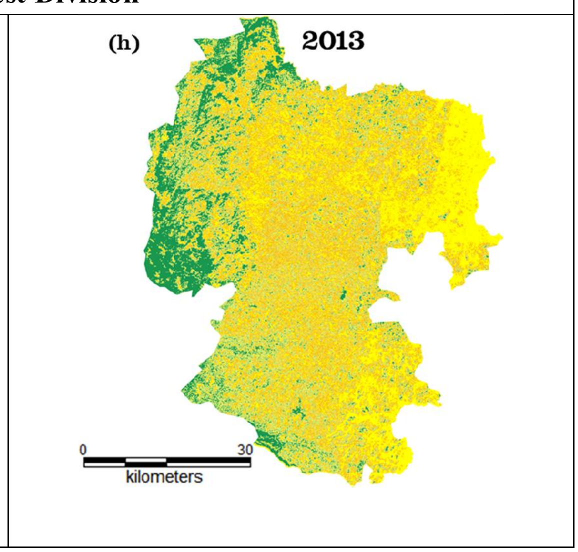
Karwar Forest Division



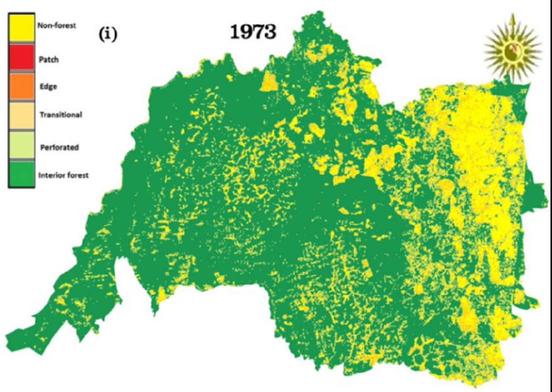


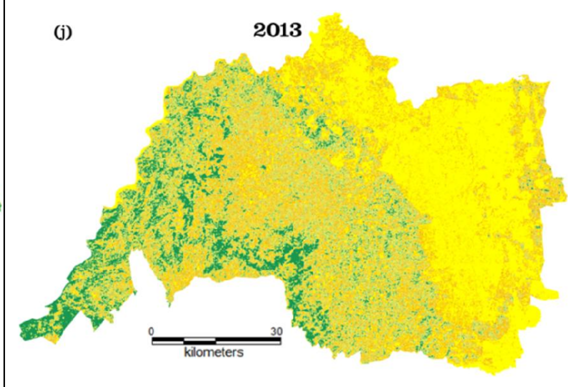
Sirsi Forest Division



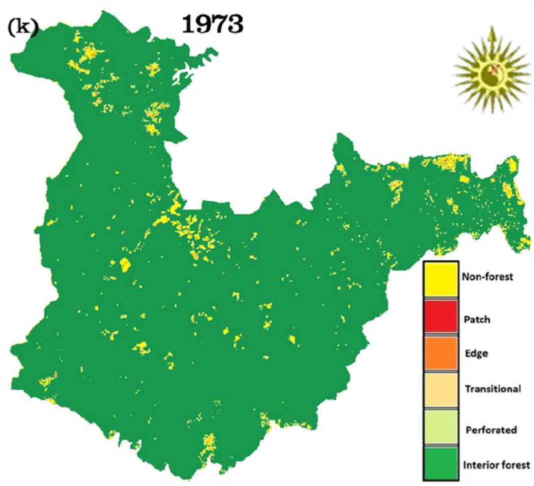


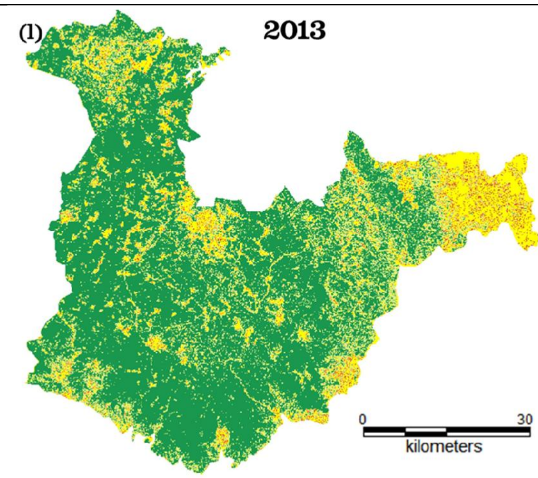
Yellapura Forest Division





ADTR (Anshi Dandeli Tiger Reserve) Wild Life Division





Encroachment of Forests: Encroachment of forest lands and conversion to other land uses is one of the prime drivers of forest fragmentation. The forest land encroachment is the major threat to biodiversity because it not only causes the habitat loss of species but also results in the more devastating effects through fragmentation. The factors responsible for large scale land conversions are due to unavailability of land to meet the growing population's demand; market based economic opportunities; unproductive land due to erosion of top soil with heavy rain fall, etc..

Forest division-wise encroachments are marked considering the latest forest administrative boundary map obtained from Karnataka Forest Department. The forest boundary map of the respective divisions are geometrically verified with ground control points (collected from field using calibrated GPS), the Survey of India topographic maps and online Google Earth (http://Googleearth.com). Forest boundary maps provide details according to forest type (evergreen, deciduous, plantations, etc.) at cadastral (village) level with land survey numbers. There is a clear distinction between forest land, revenue land and other features. These maps were overlaid on Google earth data, which provided land use transitions details. Visual interpretations coupled with random field verifications were adopted to delineate un-authorised transitions in the forest land uses in recent years. The area of each polygon corresponding to encroachment is marked and verified in the field as well as with cadastral maps and topographic maps.

Figure 7.7 illustrates the level of encroachment of forests in Uttara Kannada district and figure 7.8 details division wise forest area conversions. The district has five forest divisions one wild life division. Division-wise forest land changes have been analysed. Sirsi and Honnavar divisions have higher forest encroachments (3642 and 1852 hectares respectively) among all divisions due to conversion of forest land for agriculture, horticulture, etc. Even ecologically vital ecosystems such as swamps and sacred forests are being encroached in Sirsi, Honnavar divisions. The diversion of swamps and water channels to areca nut gardens in the upstream has deprived water to downstream habitations. Urban sprawl with encroachments of forests is noticed in the vicinity of towns - Sirsi, Honnavar, Bhatkal, Kumta town.

Figure 7.7: Forest encroachments in Uttar Kannada

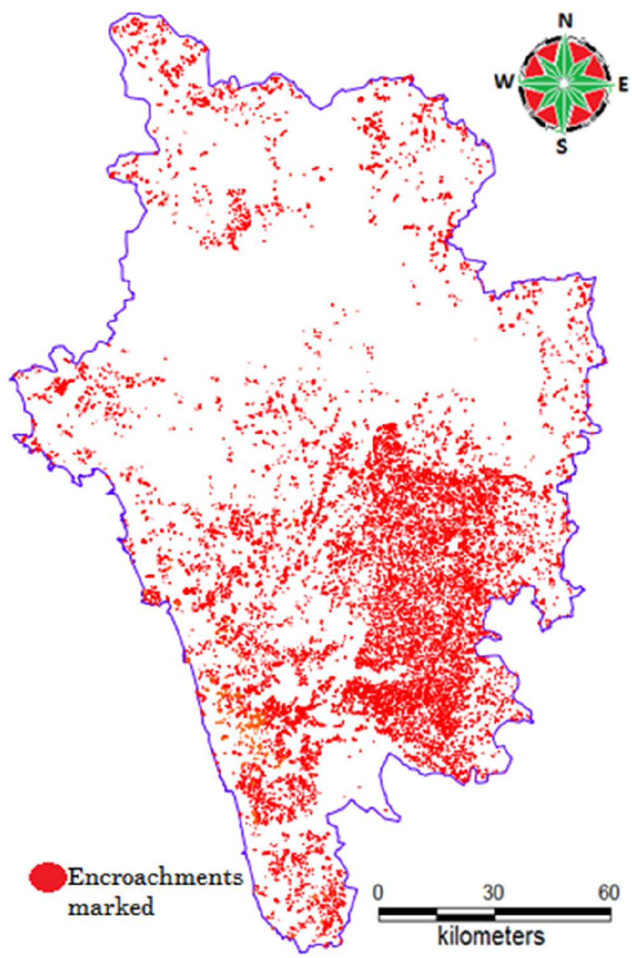


Figure 7.8 and Table 7.11 lists division and forest type wise land transitions, which indicates that major land use changes have happened in moist deciduous forests (3747.89 Ha) followed by evergreen to semi evergreen (1629.16 Ha). The Sirsi division has lost major tracts of forests in all categories. Honnavar division shows 402.07 Ha of lost in forest plantations (of Acacia). Conversion of Betta lands for other uses is observed in Sirsi division. Moist deciduous forests (383.71 Ha) mainly cleared for habitations and other associated developments in Karwar division. Figures 10 to 14 depicts the division wise encroachments marked and also marked in Google Earth.

Figure 7.8: Division wise forest encroachment

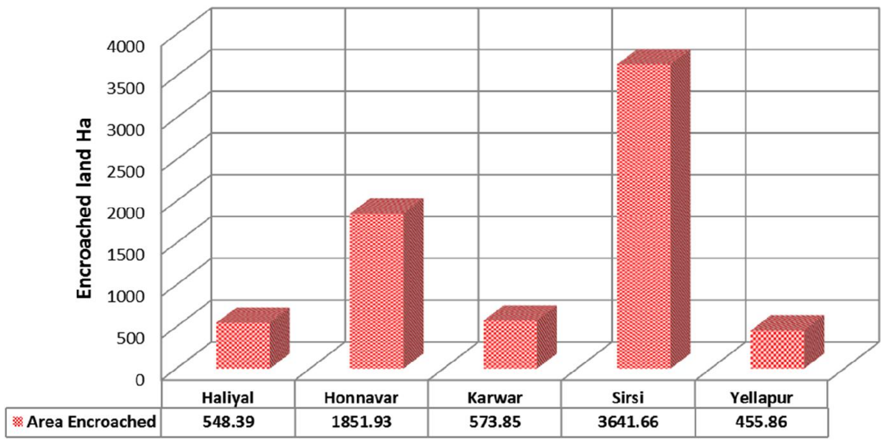


Table 7.11: Area of forest land encroached in different forest categories of five divisions (Ha)

Category	**Haliyal**	**Honnavar**	**Karwar**	**Sirsi**	**Yellapura**	**Total**
Acacia Plantation	4.59	402.07	45.44	159.52	3.51	615.13
Teak Plantation	14.12	144.89	44.43	25.62	0.00	229.06
Scrub forest/ Grassland	60.28	182.53	32.18	**208.61**	0.00	483.60
Evergreen to semi evergreen forest	31.39	714.22	68.09	**772.48**	33.98	**1620.16**
Moist deciduous forest	190.45	408.23	383.71	**2475.43**	290.07	**3747.89**
Dry deciduous forest	247.55	0.00	0.00	0.00	128.30	375.85
Total	**548.39**	**1851.94**	**573.85**	**3641.66**	**455.86**	**7071.69**

Figure 7.9: Forest type wise encroachments

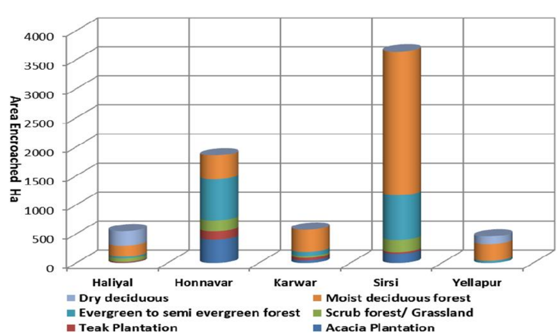


Figure 7.10: Encroachments in Haliyal division

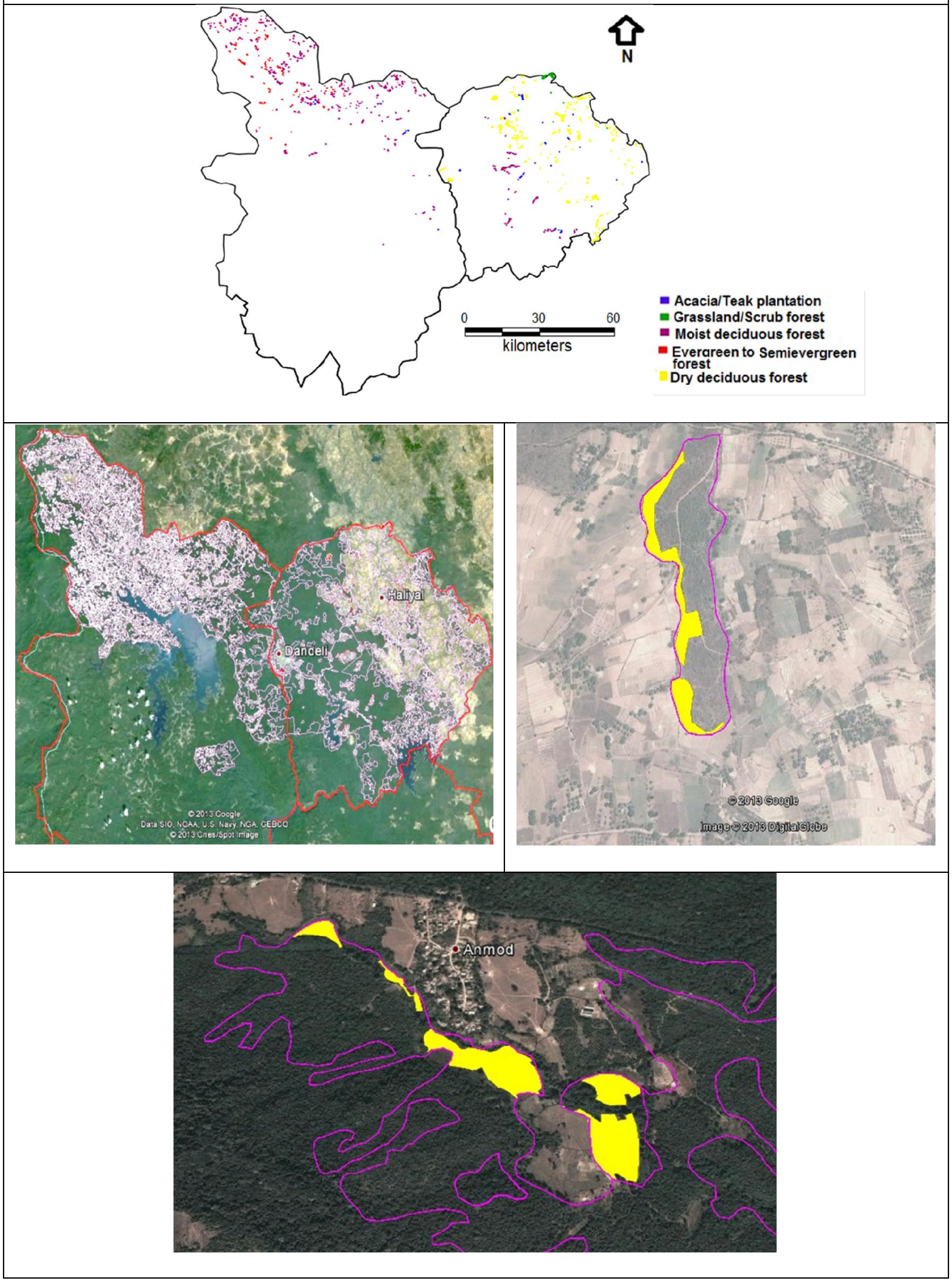


Figure 7.11: Encroachments in Honnavar division

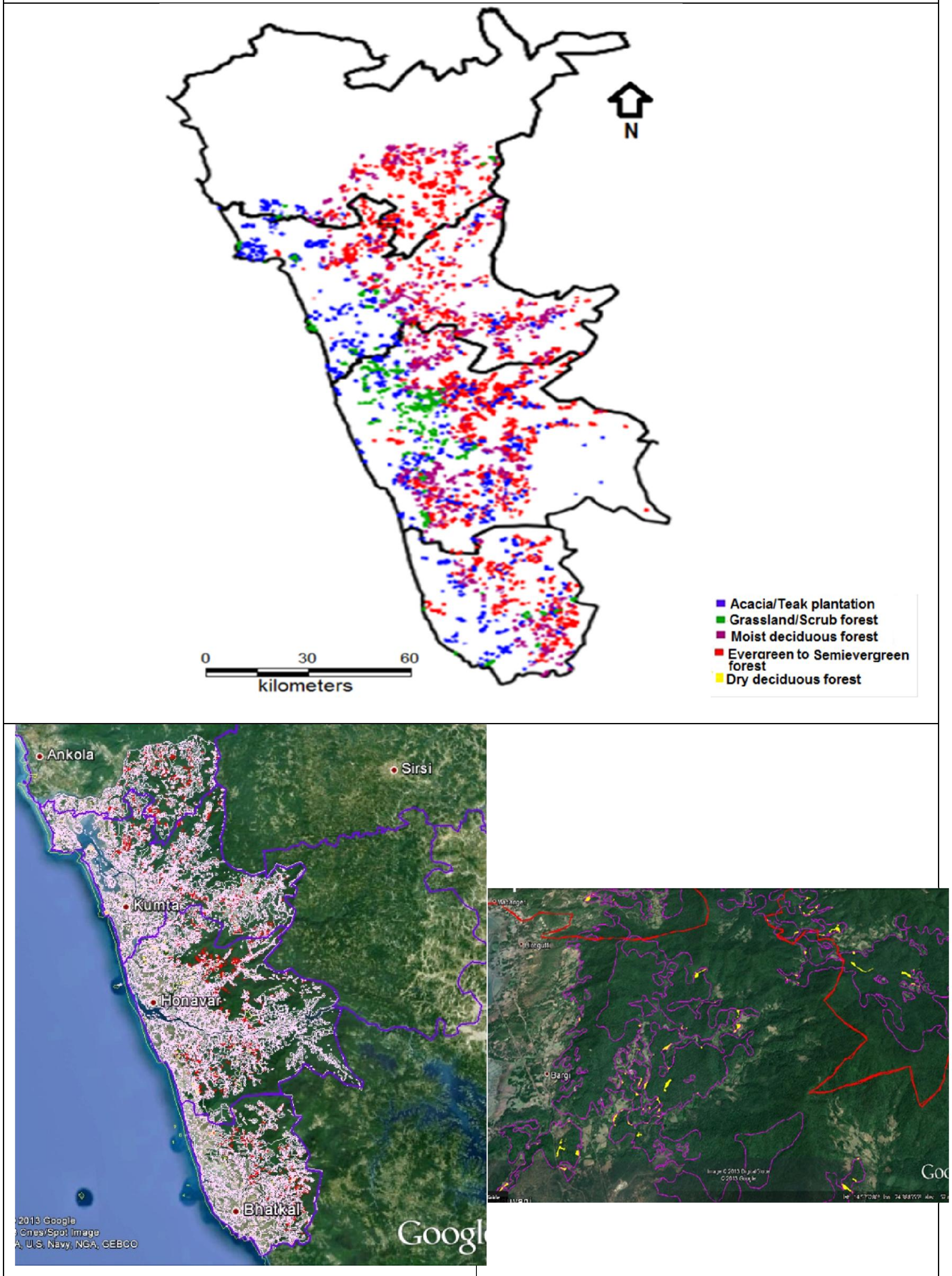


Figure 7.12: Encroachments in Karwar division

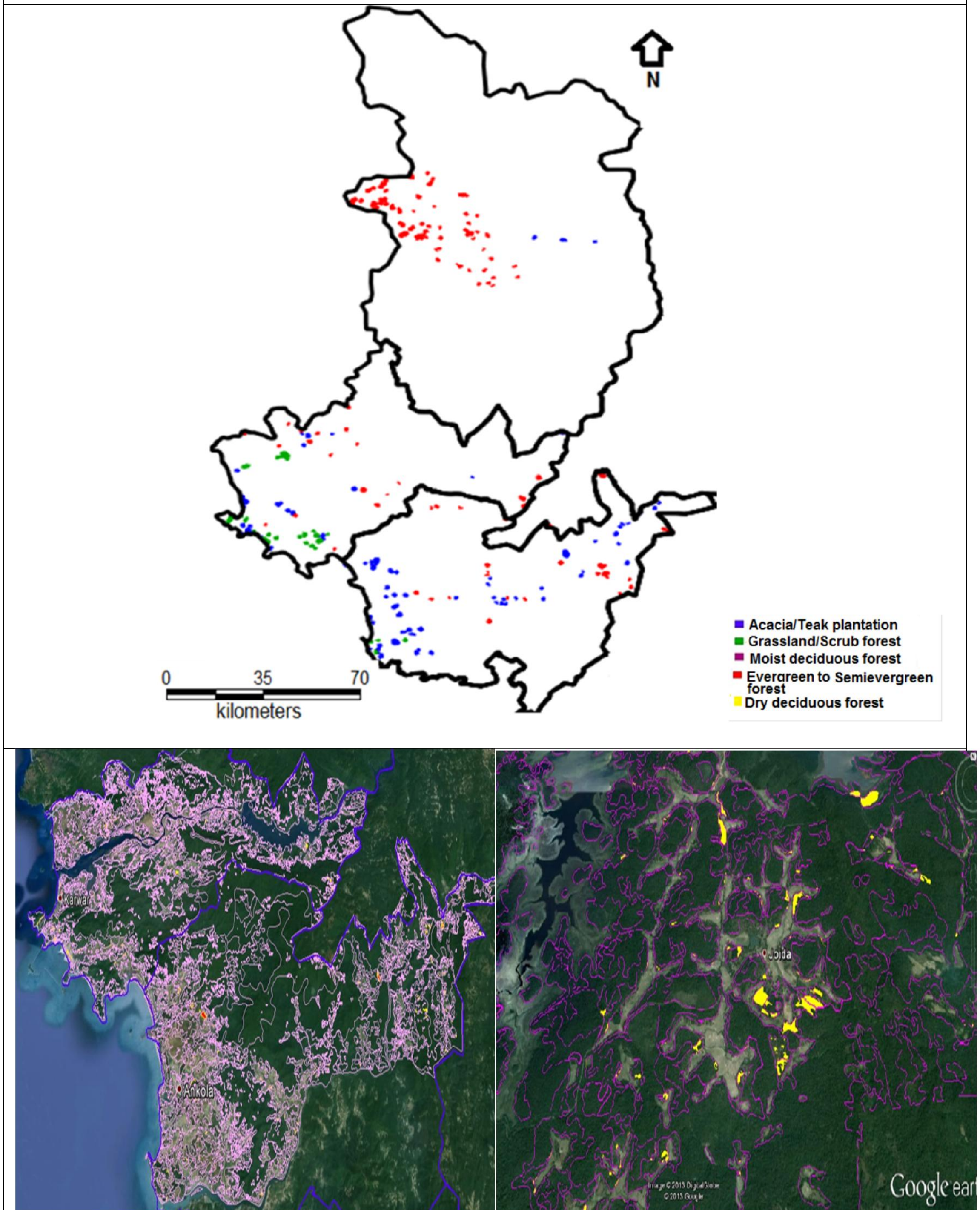


Figure 7.13: Encroachments in Sirsi division

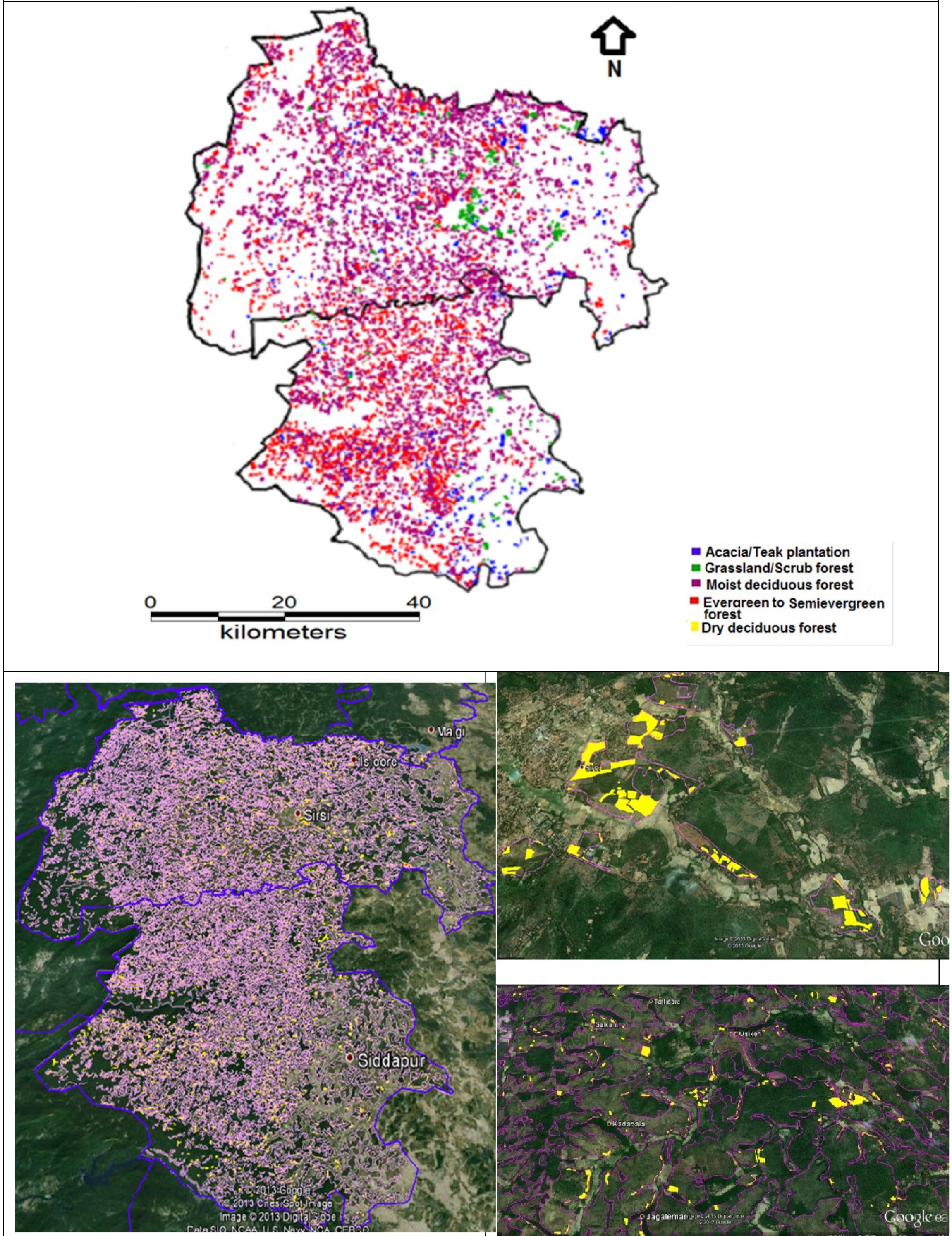
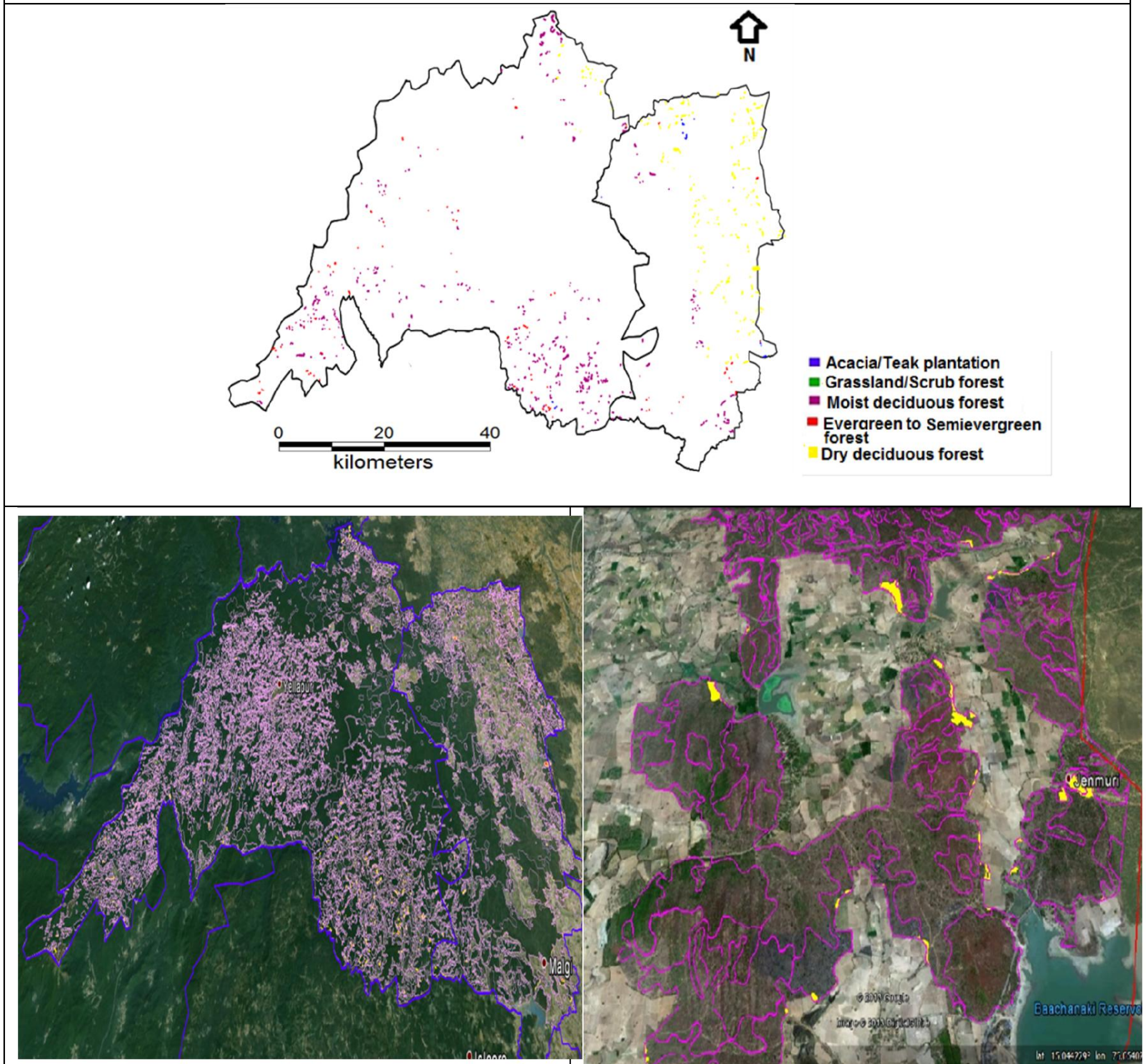


Figure 7.14: Encroachments in Yellapura division



Region specific effective land use planning being suggested to control fragmentation taking into consideration issues of deforestation. The suggested measures emphasise the regeneration of natural forest cover in the district across all divisions. This requires motivation, conviction, and commitment between two major stake-holders: the forest fringe dwellers as well as the officials at Forest Department. This needs building up an atmosphere of mutual trust and understanding between them for a strong intention of improving forests, which will in-turn improve quality of life of outlying population.

1. Building of solutions that are specific to address fragmentation on regional levels such as at watershed level. Restoration of forests with native species to enhance hydrological services and biodiversity.
2. Constitution of forest protection task force at each division with the representatives of all stakeholders. Forest task force shall have representatives of VFCs (Village Forest Committee).

3. The plantation of native species, which will enhance local ecology and hydrology. Non-timber forest products (NTFP) provide livelihood to the dependent forest population. Involvement of local people in forest activities – nursery development, afforestation, extraction of NTFP will also help in the forest conservation while providing employment to local rural youth.
4. The grazing lands should be demarcated for each village and maintainace should be given to VFCs.
5. Minimising grazing in natural forests would help in the regeneration and make natural cover out of disturbances.
6. Establishment of seed production areas; clonal propagation of improved planting stock and use of better management practices. The use of bio-fertilizers and compost is being encouraged for their environment friendly characters.
7. Clear felling should not be permitted in the intact primeval forests. Selective logging may be allowed by demarking the productive zones followed by reforestation. This approach helps in preserving the structure of an ecosystem with functional aspects and biodiversity.
8. Capacity building of local community in the conservation and management of forests. Local communities and local foresters joint management would help in curtailing illegal logging and encroachments.
9. Wildlife conservation and habitat improvement with eco-development activities in and around Protected Area is to be taken up.
10. The protection phase needs more attention and should be made more effective to avoid any damage to the existing plantation.
11. E-versions of forest boundaries in handheld devices (mobile) of forest guards would help in the effective protection.
12. Availability of geo-referenced forest boundaries of the defined jurisdictions on internet would also help NGO's taking prime role in the forest conservation, which would help in minimizing violations by vested individuals.
13. Management of forests through scientific research findings will strengthen conservation efforts. Operational protection and comprehensive implementation as per the site specific plan (especially with reference to selection of site and nature of species) will ensure increased survival percentage and improvement in the condition of plantations.
14. Conservation of forest eco-systems and the environment of ecologically fragile zones with special emphasis on estuarine and the undulating lateritic tract of the coast should be taken up as early as possible. Socio-economic development of forest fringe population in for conservation of forest through available plans. The training should be given through VFCs on collection of NTFP (Non-timber Forest Products), application of bio-fertilizers. Employment generation for the disadvantaged section of the society, particularly women, SCs/STs and land less rural labors by implementation of Joint Forest Management of the forest patches.

8.0 IMPACT OF DEVELOPMENTAL PROJECTS (POWER, INDUSTRY, MONOCULTURE PLANTATION, ETC.).

Task 1: MAJOR ANTHROPOGENIC ACTIVITIES IN THE DISTRICT
Reports Submitted: 1. Ramachandra T.V., Subash Chandran M.D., Joshi N.V. and Bharath Setturu, 2013. Land use changes with the implementation of Developmental projects in Uttara Kannada district, Sahyadri Conservation Series 31, ENVIS Technical Report 61, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

Interventions that led to the large scale land cover changes in the district are listed in Table 8.1 and depicted in Figure 8.1. Projects include hydel projects, Seabird Naval Base, Kaiga Atomic plant, Konkan Railway, Gersoppa dam, etc. A total of at least 5508 ha of forests have been used for accommodating displaced families. Apart from these projects, a colony was set up to accommodate Tibetan refugees, encroachment of forests for agriculture, mining have contributed towards the decline of forests. Encroachments of 2824.8 ha forest lands prior to 27.04.1978, were regularised subsequently (Forest Department, 2000-01).

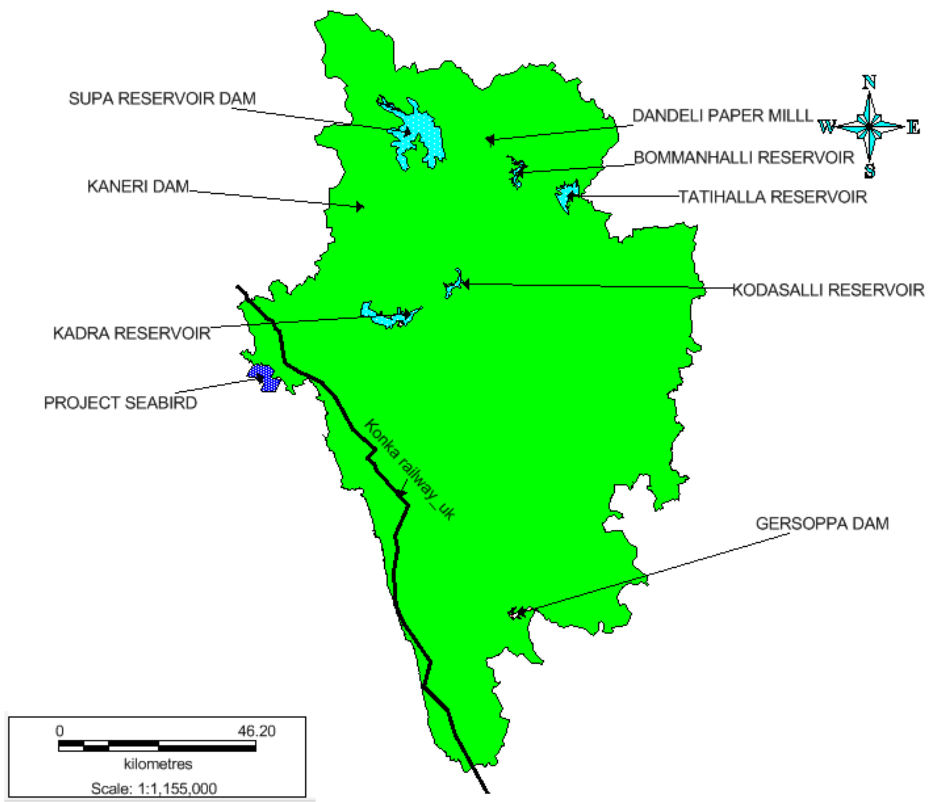


Figure 8.1: Developmental projects in Uttara Kannada district

8.1 LAND USE CHANGES WITH THE IMPLEMENTATION OF DEVELOPMENTAL PROJECTS IN UTTARA KANNADA DISTRICT

Forest ecosystems in Uttara Kannada district have witnessed major transformations during the post-independence. Uttara Kannada district has the distinction of having highest forest cover among all districts of Karnataka. Land use analysis using temporal remote sensing data reveal distressing trend of deforestation in the district, evident from the reduction of evergreen - semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analyses reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (2063 to 1.52). Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Implementation of developmental activities without taking into account the ecological significance of ecosystems, services provided by them in meeting the livelihood of local population has resulted in the degradation of forests. These changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human –animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people. About **62814.48 Ha** of forest land is diverted for various non-forestry activities during the post-independence period. About **7071.68 Ha** of forest area has been encroached for agriculture, horticulture activities, etc. Maximum encroachments of forest lands are in Sirsi, Honnavar forest divisions i.e., 3641.66 Ha and 1851.93 Ha respectively. An appropriate policy framework is required to prevent further encroachments of forest land and ensure sustainable management of natural resources. Table 8.1 lists the land allotments made for various developmental activities by the forest department due to the pressure from the State government since 1956. Figure 8.2 show the major developmental projects in the district (mapped on Google Earth). Temporal land use analyses have been done considering the project region with 1 km buffer to account for changes in the vicinity due to the implementation of the project. The length of railway line in the district is 176 km and for railway project buffer of 0.5 km was considered.

Figure 8.2: Developmental projects of Uttara Kannada district

Table 8.1: The extent of forest areas released for other purposes from 1956

S.No.	Particulars.	Area in Ha.
1	The forest area released for cultivation by 3 member committee from 1964 to 1969	6042.500
2	Forest area released as per special G.O.No.AFD.116 of 16/4/69.	11593.342
3	Forest area released as per G.O.No.AFD-282-FGL74 of 17/19-12-1974.	3399.400
4	Forest area released for long lease.	162.100
5	Hangami Lagan in Notified area.	8034.450
6	Extension of Gouthana.	390.400
7	Forest area released for township.	1096.900
8	Mining area leased & area actually in operation.	1591.250
9	Released to House sites to Houseless (1972-1979)	366.000
10	Rehabilitation of Tibetans displaced Ryots of Sharavathi Ghataprabha & Malaprabha, Gowli families etc.	4548.170
11	Area under submersion & other Project. 1. Kali Hydro Project. 2. Bedti Project (for colony) 3. Other irrigation tanks etc.	14602.000 300.000 303.365
12	Released to KSFIC for Napier Hybrid grass cultivation (Sirsi Division)	441.450
13	Released to KAMCO (Dairy & fruit processing Unit)	153.993
14	Released to KSFIC for Pineapple cultivation.	163.320
15	Karnataka State Veneers Ltd.	24.000
16	Power transmission lines.	677.979
17	For establishment of Industries.	95.000
18	Area released to Horticulture department (1969-70).	71.847
19	Released to Agricultural University, Dharwad.	214.000
20	Sharavathi Tail Race.	700.000
21	Kaiga Atomic Power Project.	732.000
22	Sea Bird Naval Base Project.	2259.000
23	Rehabilitation of Sea Bird out seas.	643.720
24	Area released for non-agriculture & other purposes.	394.870
25	Konkan Railway.	272.140
26	Area released for improvement & widening of Ankola-Hubli Road.	49.431
27	Area released for rehabilitation of displaced persons of KHEP & Kaiga Project.	316.410
28	Area released to regularise the encroachments, which have taken place before 27-04-1978.	2845.446
29	Area released to construction of 400 KVDC alternate transmission line between Kaiga NPP and 200 KV sub-station at Narendra in favour of M/s. P.G.C.I.L, Karnataka.	330.00
	TOTAL	**62814.483**

*Source: Forest working plan of Kanara circle (year 2009-10)

SUPA DAM: Supa Dam is the second largest dam in the state of Karnataka, built across the Kali river in Supa (Joida) Taluk of Uttara Kannada District in India. Supa Dam (figure 8.3 (a, b) is 101 Mtrs high and 332 Mtrs long concrete gravity dam for power generation. Land use analysis at Supa hydroelectric dam with buffer is shown in figure 8.4 and table 8.2. The Supa dam submerged thick evergreen forests which was covered 94.7% (1973) of region. The current cover remained is only 42.79%. The evergreen forest in 1km buffer of project area declined from 94.55% (1973) to 49.02% (2013). The land use analyses for the period 1973 and 2013 illustrate the increase in built-up area (human habitations) from

0.03% to 0.12% with the implementation of the project. The built-up area has increased in project area. Many small agglomerations for work force colonies can be seen in the buffer region.

Table 8. 2: Land use at Supa dam region from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**15.30**	**0.03**	**60.49**	**0.12**	**20.70**	**0.04**	**163.82**	**0.28**
Water	142.05	0.1	10126.05	20.57	52.48	0.09	10940.05	19.00
Agriculture	421.81	0.86	2101.20	4.27	594.27	1.03	2661.38	4.62
Open space	277.24	0.56	2169.70	4.41	341.33	0.59	2292.37	3.98
Moist deciduous forest	869.27	1.77	9100.07	18.49	992.05	1.72	11127.87	19.33
Evergreen to Semi evergreen forest	**46522.08**	**94.7**	**21063.30**	**42.79**	**54426.84**	**94.55**	**25216.00**	**43.80**
Scrub/Grass lands	530.09	1.08	1341.39	2.73	608.59	1.06	1466.80	2.55
Acacia/Eucalyptus plantations	275.08	0.56	1545.72	3.14	309.11	0.54	1698.85	2.95
Teak / Bamboo plantations	79.57	0.16	1072.34	2.18	102.44	0.18	1263.11	2.19
Coconut/Areca nut plantations	0.00	0	263.56	0.54	0.00	0	342.40	0.59
Dry deciduous forest	87.58	0.18	376.26	0.76	117.65	0.2	392.80	0.68
Total area	49220.08				57565.45			

Kaneri dam: Upper Kaneri reservoir (figure 8.5) is constructed across the Kaneri river, a tributary to Kali river near Kumbarwada village in Joida Taluk, Uttara Kannada District. The temporal land use analysis of Kaneri reservoir (figure 8.6 and table 8.3) shows that evergreen forest declined from 94.82% (1973) to 42.68%. In the buffer region, evergreen cover is about 63.83% (2013). It is also observed the plantation activities have increased from 1973 to 2013 and area under scrub lands have increased from 0.72% (1973) to 57.88% (2013).

Table 8.3: Land use in Kaneri reservoir region from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	0.00	0.00	12.25	**4.76**	0.00	0	23.86	**2.01**
Water	0.00	0.00	93.24	36.23	0.99	0.08	147.54	12.41
Agriculture	9.88	3.84	7.74	3.01	6.12	0.51	35.74	3.01
Open space	0.00	0.00	6.48	2.52	0.45	0.04	24.57	2.07
Moist deciduous forest	0.00	0.00	7.29	2.83	0.00	0	70.79	5.96
Evergreen to Semi evergreen forest	244.03	**94.82**	109.83	**42.68**	1171.89	**98.58**	758.73	**63.83**
Scrub/Grass lands	3.45	1.34	9.90	3.85	8.46	0.72	57.88	4.87
Acacia/Eucalyptus plantations	0.00	0.00	6.48	2.52	0.00	0	48.63	4.09
Teak / Bamboo plantations	0.00	0.00	1.08	0.42	0.00	0	11.62	0.98
Coconut/Areca nut plantations	0.00	0.00	2.88	1.12	0.00	0	6.93	0.58
Dry deciduous forest	0.00	0.00	0.18	0.07	0.81	0.07	2.43	0.20
Total area	257.36				1188.73			

Kodasalli dam: Kodasalli Dam was built across the Kali River (Kali nadi) in Yellapura taluk of Uttara Kannada district of Karnataka state, India (figure 8.7). The land use at Kodasalli dam region is given in figure 8.8 and table 8.4 for 1973 and 2013. Evergreen forest cover has declined from 97.6 (1973) to 30.95% (2013) and considering a buffer of 1 km the change is 97.57% (1973) to 52.91% (2013). The agricultural activities constitute 4.14% and plantations about 9.17% (2013).

Table 8.4: Land use at Kodasalli dam location in 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	0.72	0.01	11.07	0.2	0.72	0.01	7.74	0.23
Water	25.47	0.46	795.72	14.37	34.21	0.38	885.33	2.51
Agriculture	36.01	0.65	229.36	4.14	48.88	0.55	409.91	3.24
Open space	13.95	0.25	102.35	1.85	15.84	0.18	130.60	0.9
Moist deciduous forest	24.57	0.45	1555.26	28.08	47.35	0.53	1838.66	24.71
Evergreen to Semi evergreen forest	**5405.26**	**97.6**	**1714.23**	**30.95**	**8714.08**	**97.57**	**2595.33**	**52.91**
Scrub/Grass lands	7.83	0.14	267.97	4.84	22.05	0.25	2065.36	4.87
Acacia/Eucalyptus plantations	**13.68**	**0.26**	**507.77**	**9.17**	**26.10**	**0.29**	**538.22**	**5.9**
Teak / Bamboo plantations	9.63	0.17	189.57	3.42	19.98	0.22	219.63	3.53
Coconut/Areca nut plantations	0.00	0	163.74	2.96	0.00	0	240.06	1.18
Dry deciduous forest	0.81	0.01	0.90	0.02	2.16	0.02	0.54	0.02
Total area	5537.94				8931.38			

Kadra dam: Kadra power house commissioned in 1997 has been built on the left bank of the river Kali with an installed capacity of 150 MW. The Kadra Dam is an integral part of the Kaiga Project, provides adequate water to meet the total plant water requirement (figure 8.9). Land use at Kadra dam (figure 8.10 and table 8.5) region and buffer region show decline of evergreen forest from 69.92% (1973) to 50.98% (2013). The built-up area is increased from 0.63% (1973) to 1.51% (2013). Similar trends of increase from 0.48% to 2.23% (2013) are noticed in the buffer region due to construction of roads and infrastructure. This reservoir was constructed in 2000 mainly to provide enough water resources to Kaiga NPH project. There is intensive plantation activities observed in 2013. The evergreen forest has reached to 47.40% by 2013 at project location with 1km buffer.

Table 8.5: Land use at Kadra dam region during 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**72.55**	**0.63**	**172.56**	**1.51**	**80.02**	**0.48**	**371.65**	**2.23**
Water	112.16	0.98	2239.28	19.55	124.13	0.75	2961.79	17.81
Agriculture	225.85	1.97	322.34	2.81	335.12	2.01	644.94	3.88
Open space	47.26	0.42	303.71	2.65	65.17	0.39	409.26	2.46
Moist deciduous forest	1936.11	16.91	816.16	7.13	2377.54	14.3	1854.84	11.15
Evergreen to Semi evergreen forest	**8008.19**	**69.92**	**5839.40**	**50.98**	**12342.46**	**74.21**	**7882.77**	**47.40**
Scrub/Grass lands	542.25	4.73	809.41	7.07	660.88	3.97	989.23	5.95

Acacia/Eucalyptus plantations	222.52	1.94	359.88	3.14	303.71	1.83	687.16	4.13
Teak / Bamboo plantations	168.33	1.47	485.27	4.24	205.32	1.23	689.30	4.14
Coconut/Areca nut plantations	0.00	0	102.89	0.90	0.00	0	138.80	0.83
Dry deciduous forest	118.46	1.03	2.79	0.02	137.36	0.83	1.99	0.01
Total area	11453.66				16631.73			

Bommanalli reservoir: Bommanahalli pick-up reservoir built across the Kali River is situated in Haliyal taluk of Uttara Kannada District (figure 8.11). The land use analysis (figure 8.12 and table 8.6) at temporal scale with respect to Bommanalli pick up reservoir highlight the fragmentation of forests during 1973 to 2013. The crop land has increased from 2.21% to 6.22% by 2013. Deforestation is evident with the decline of evergreen forests from 41.18 to 2.90% (2013).

Table 8.6: Land use at Bommanalli reservoir region during 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	45.73	0.46	96.55	0.97	61.84	0.43	277.56	1.94
Water	49.24	0.49	1070.99	10.76	60.40	0.42	1179.99	8.24
Agriculture	246.73	2.48	822.73	8.27	316.31	2.21	994.34	6.94
Open space	58.42	0.59	213.37	2.14	92.63	0.65	256.62	1.79
Moist deciduous forest	4085.38	41.04	1007.08	10.12	5760.27	40.2	1006.06	7.02
Evergreen to Semi evergreen forest	3989.15	40.08	394.17	3.96	5900.24	41.18	428.37	2.99
Scrub/Grass lands	767.73	7.71	14.67	0.15	1094.12	7.64	5.40	0.04
Acacia/Eucalyptus plantations	109.46	1.10	4284.22	43.04	177.96	1.24	6680.02	46.62
Teak / Bamboo plantations	377.07	3.79	1919.19	19.28	592.47	4.14	3261.64	22.76
Coconut/Areca nut plantations	0.00	0.00	3.87	0.04	0.00	0	12.43	0.09
Dry deciduous forest	225.13	2.26	127.19	1.28	271.39	1.89	225.20	1.57
Total area	9954.03				14327.64			

Tattihala reservoir: Tattihala dam is constructed (figure 8.13) to divert the bulk of the monsoon flows of the river into the Bommanahalli Pick-up reservoir. The temporal land use analysis (figure 8.14 and table 8.7) in the locality of Tattihalla pick up reservoir indicates the forests in the region getting fragmented. The land use analysis in the region with 1km Buffer shows the loss of forest land and increase of area under agriculture and plantations. The crop land has increased from 4.29 (1973) to 11.96% in 2013 and human habitations constitute 2.98%.

Table 8.7: Land use at Tattihalla from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**20.08**	**0.25**	**123.49**	**1.56**	**34.39**	**0.31**	**334.30**	**2.98**
Water	67.02	0.85	1747.65	22.14	11.34	0.1	1869.00	0.03
Agriculture	**222.60**	**2.82**	**748.13**	**9.48**	**481.04**	**4.29**	**1192.81**	**11.96**
Open space	80.83	1.02	769.99	9.75	138.53	1.24	829.73	12.76

Moist deciduous forest	**2331.46**	**29.53**	**123.80**	**1.57**	**3069.39**	**27.36**	**247.26**	**4.37**
Evergreen to Semi evergreen forest	4117.54	52.16	11.08	0.14	5829.85	51.97	14.86	0.14
Scrub/Grass lands	336.56	4.26	86.50	1.10	499.85	4.46	215.84	0.47
Acacia/Eucalyptus plantations	**175.26**	**2.22**	**2615.27**	**33.13**	**224.32**	**2**	**3960.57**	**43.37**
Teak / Bamboo plantations	**134.66**	**1.71**	**1537.71**	**19.48**	**268.51**	**2.39**	**2370.10**	**23.73**
Coconut/Areca nut plantations	0.00	0.00	2.43	0.03	0.00	0	11.35	0.04
Dry deciduous forest	408.66	5.18	128.63	1.63	659.71	5.88	171.11	2.11
Total area	7894.69				11216.93			

Gerusoppa Dam: Gerusoppa dam (figure 8.15) was constructed across the river Sharavathi before entering Arabian Sea in Uttara Kannada District. Figure 8.16 and table 8.8 details land uses in Gerusoppa dam region, which shows the decline of evergreen forest from 87.15 (1973) to 43.17% (2013). Increase in built-up from 2.07% to 7.38% (dam region with 1km buffer) during 1973 to 2013. Cash crops like coconut have increased due to water availability in region. The current spatial extent of coconut plantation is 6.06% with in project area and 5.34% (the dam region with 1km buffer). Also a fraction of workforce of this project settled in the buffer region occupying forest lands.

Table 8.8: Land use analysis of Gerusoppa dam from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**0.00**	**0.00**	**48.79**	**1.67**	**4.30**	**0.10**	**138.51**	**3.13**
Water	59.41	2.03	529.28	18.12	99.52	2.25	686.27	15.49
Agriculture	61.32	2.10	153.94	5.27	91.92	2.07	326.75	7.38
Open space	9.45	0.32	32.95	1.13	89.46	2.02	137.18	3.10
Moist deciduous forest	72.33	2.48	247.65	8.48	297.35	6.71	644.75	14.55
Evergreen to Semi evergreen forest	**2545.06**	**87.15**	**1260.56**	**43.17**	**3565.06**	**80.47**	**1437.43**	**32.44**
Scrub/Grass lands	**16.92**	**0.58**	**217.95**	**7.46**	**96.92**	**2.19**	**380.75**	**8.59**
Acacia/Eucalyptus plantations	11.80	0.40	174.54	5.98	11.88	0.27	268.66	6.06
Teak / Bamboo plantations	14.85	0.51	77.68	2.66	44.85	1.01	173.36	3.91
Coconut/Areca nut plantations	**128.99**	**4.42**	**176.97**	**6.06**	**128.99**	**2.91**	**236.77**	**5.34**
Dry deciduous forest	0.18	0.00	0.00	0.00	0.18	0.00	0.00	0.00
Total area	2920.31				4430.43			

Kaiga Nuclear power plant: Kaiga Nuclear power (figure 8.17) generating station located on the branches of river Kali, in Uttar Kannada district of Karnataka, India. In 1999 and again in 2001, people of Sirsi and Yellapur taluks staged a protest against the laying of a high tension power line from Kaiga through the thick forest region. About 677 ha forest lands were cleared for power transmission lines. Now there is a proposal to establish two more units at the site. Villagers of Bare, Malavalli, Vajralli and Kalache in Yellapur taluk have reported more cancer cases after the establishment of the Kaiga project. Figure 8.18 and table 8.9 provides the picture of land use dynamics in the region due to Kaiga NPH. Evergreen forests have declined from

63.27 (1973) to 21.93%(2013) due to setting up of power house and employee quarters and associated developments (8.91%).

Table 8.9: Land use analysis of Kaiga NPH from 1973 to 2013

Land use Category \ Year	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**32.50**	**1.75**	**165.41**	**8.91**	**66.02**	**1.03**	**222.86**	**4.01**
Water	60.65	3.27	128.77	6.94	115.22	0.33	354.93	6.38
Agriculture	95.67	5.15	88.27	4.75	165.80	4.21	227.36	4.09
Open space	74.76	4.03	133.02	7.16	145.49	0.35	335.11	6.02
Moist deciduous forest	191.79	10.33	441.96	23.80	736.92	21.57	867.42	15.60
Evergreen to Semi evergreen forest	1174.72	63.27	407.23	21.93	3919.04	58.84	2615.07	47.02
Scrub/Grass lands	183.50	9.88	110.97	5.98	267.24	4.3	382.51	6.88
Acacia/Eucalyptus plantations	42.94	2.31	273.66	14.74	83.35	5.34	355.27	6.39
Teak / Bamboo plantations	0.00	0.00	0.00	0.00	48.07	3.08	88.89	1.60
Coconut/Areca nut plantations	0.00	0.00	107.30	5.78	0.00	0	112.15	2.02
Dry deciduous forest	0.09	0.00	0.00	0.00	14.76	0.95	0.36	0.01
Total area	1856.62				5561.92			

Konkan Railway: The construction of the Konkan Railway (figure 8.19) through the west coast, while revolutionising coastal transportation had also its own inevitable environmental impact in the form of landscape changes, diversion of agricultural and forest lands etc. Land use analysis of Konkan railway (figure 8.20 and table 8.10) show fragmentation of forests though it provides connectivity of many regions. In the buffer region (0.5km), built-up area has increased from 1.65% (1973) to 17.06% (2013). The increase in open fields (11.13%) is due to the clearance along the track. Moist deciduous forests in Konkan railway project region show a decline from from17.80 (1973) to 4.55% (2013). Cutting of the hills, removal of vegetation cover and vibrations due to frequent movement of trains have enhanced landslide susceptibility in the region.

Project Sea Bird: Indian Navy established a major Naval Base at Karwar (Karnataka), about 120 km south of Goa on the west coast of India under 'Project Seabird' also known as 'INS Kadamba' in 1986 (figure 8.21), for creation of infrastructure and facilities for the basing of ships/ submarines, with all associated operational/support facilities. Land use in the project Seabird region is given in table 8.11 and figure 8.22 show an increase of built-up area from 1.77% (1973) to 32.09% (2013) due to marine ship basements and port construction. Evergreen forests have declined from 34.63 (1973) to 5.22% (2013).

West Coast Paper Mills, Dandeli: Situated in the heart of thick forests on the banks of Kali river with the assured supply of raw materials, water from Kali river, power supply from the state grid; vicinity of rail and road linkages (figure 8.23). Land use (table 8.12 and figure 8.24) in region due to the implementation of paper mills show a decline of evergreen forests from 29.46 (1973) to 2.24% (2013). The region is turning to more moist deciduous forest from semi evergreen forest. Built-up has increased from 17.17(1973) to 44.04% in 2013.

Table 8.10: Land use analysis of Konkan railway line from 1973 to 2013

Year / Land use Category	Project area			
	1973		2013	
	Ha	%	Ha	%
Built-up	**214.23**	**1.65**	**2205.62**	**17.00**
Water	331.97	2.56	626.05	4.82
Agriculture	2619.86	20.19	4438.78	34.21
Open space	486.26	3.75	1444.28	11.13
Moist deciduous forest	**2310.03**	**17.80**	**589.77**	**4.55**
Evergreen to Semi evergreen forest	4142.00	31.92	942.09	7.26
Scrub/Grass lands	618.04	4.76	720.03	5.55
Acacia/Eucalyptus plantations	1240.57	9.56	486.44	3.75
Teak / Bamboo plantations	58.51	0.45	68.77	0.53
Coconut/Areca nut plantations	933.63	7.19	1452.92	11.20
Dry deciduous forest	21.16	0.16	1.53	0.01
Total area	12976.26			

Table 8.11: Land use analysis of Project Sea Bird from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**12.78**	**1.77**	**231.58**	**32.09**	**52.39**	**2.88**	**383.75**	**21.09**
Water	**110.16**	**15.26**	**6.77**	**0.94**	**130.15**	**7.15**	**63.94**	**3.51**
Agriculture	95.52	13.24	115.43	15.99	254.74	14.00	163.87	9.01
Open space	216.65	30.02	109.33	15.15	255.99	14.07	187.75	10.32
Moist deciduous forest	36.67	5.08	33.03	4.58	394.49	21.68	126.97	6.98
Evergreen to Semi evergreen forest	**249.93**	**34.63**	**37.64**	**5.22**	**586.87**	**32.26**	**408.73**	**22.47**
Scrub/Grass lands	0.00	0.00	116.56	16.15	35.38	1.94	290.08	15.94
Acacia/Eucalyptus plantations	0.00	0.00	19.83	2.75	104.84	5.76	88.53	4.87
Teak / Bamboo plantations	0.00	0.00	0.00	0.00	0.81	0.04	12.70	0.70
Coconut/Areca nut plantations	0.00	0.00	51.54	7.14	0.00	0.00	92.58	5.09
Dry deciduous forest	0.00	0.00	0.00	0.00	3.69	0.20	0.45	0.02
Total area	721.71				1819.35			

Table 8.12: Land use analysis of West Coast Paper Mills from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	30.42	17.17	78.04	44.04	40.33	3.96	175.27	17.21
Water	2.07	1.17	3.24	1.83	13.32	1.31	27.99	2.75
Agriculture	21.15	11.94	23.58	13.31	88.21	8.65	167.55	16.45
Open space	0.63	0.36	20.61	11.63	13.50	1.33	50.25	4.93
Moist deciduous forest	23.58	13.31	3.87	2.18	271.84	26.69	93.65	9.19
Evergreen to Semi evergreen forest	52.21	29.46	3.96	2.24	458.71	45.03	98.79	9.70
Scrub/Grass lands	4.68	2.64	19.53	11.02	30.06	2.95	24.05	2.36
Acacia/Eucalyptus plantations	14.50	8.18	19.86	11.21	24.48	2.4	246.28	24.18
Teak / Bamboo plantations	5.00	2.82	0.45	0.25	1.08	0.11	98.39	9.66
Coconut/Areca nut plantations	0.00	0.00	4.05	2.29	0.00	0	5.87	0.58

Dry deciduous forest	22.95	12.95	0.00	0.00	77.14	7.57	30.60	3.00
Total area	177.21				1018.69			

Figure 8.3: the location of Supa dam (a) Google Earth (b) Dam site

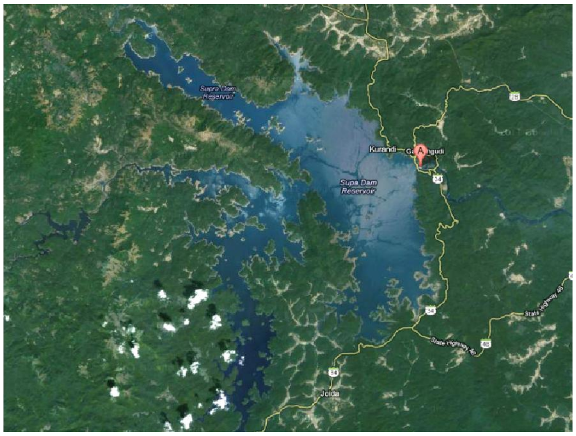
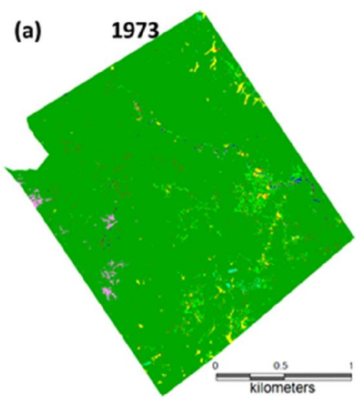


Figure 8.4 (a, b): Supa dam Project area



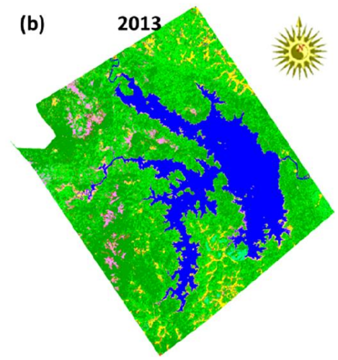
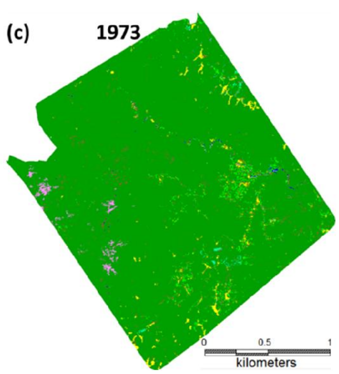
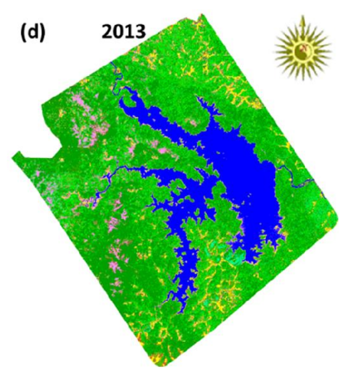


Figure 8.4 (c, d): Supa dam with 1km buffer





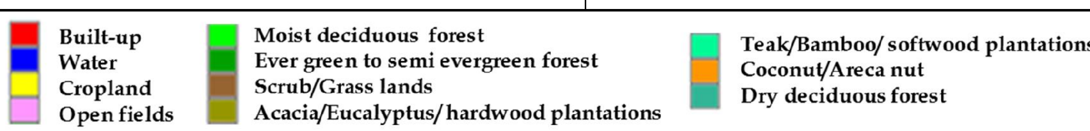


Figure 8.5: the location of Upper Kaneri dam as shown in Google Earth

Figure 8.6 (a, b): Kanei dam Project area

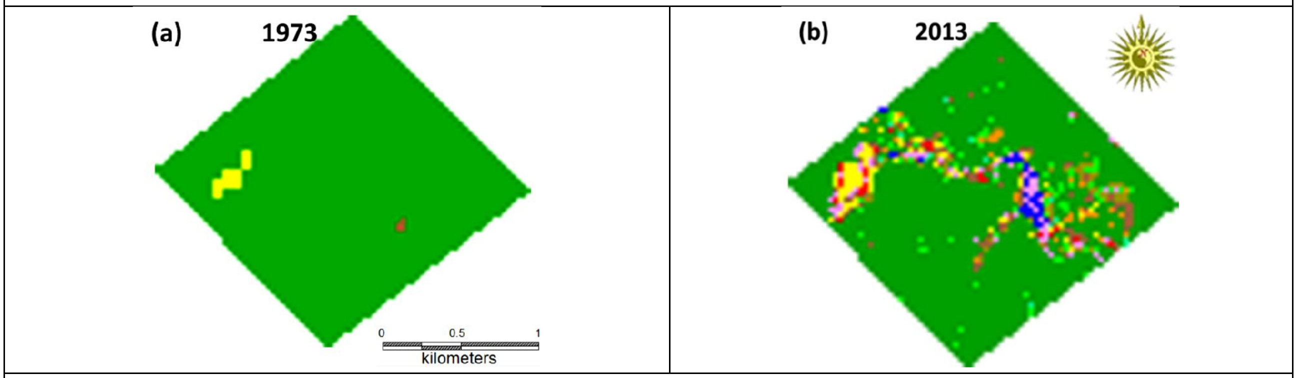


Figure 8.6 (c, d): Kaneri dam with 1km buffer

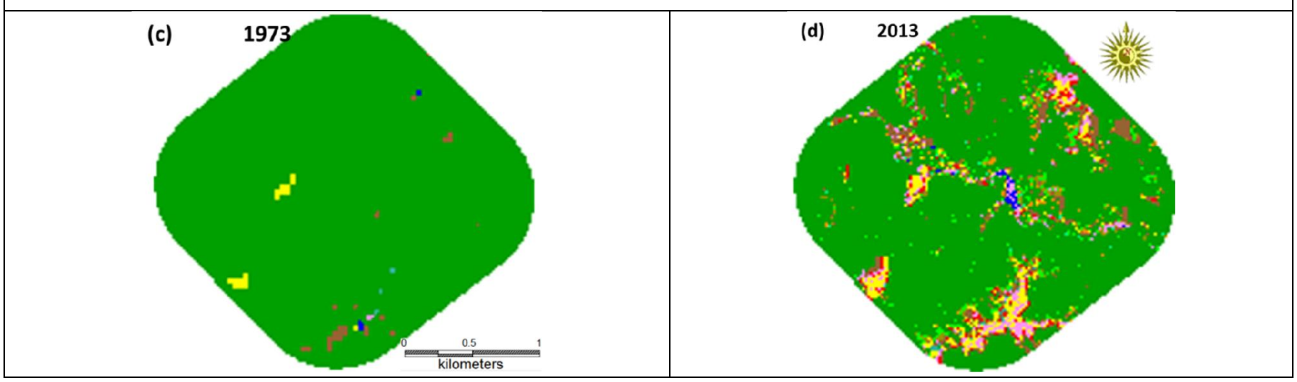


Figure 8.7: the location of Kodasalli dam as shown in Google Earth

Figure 8.8 (a, b): Kodasalli dam Project area

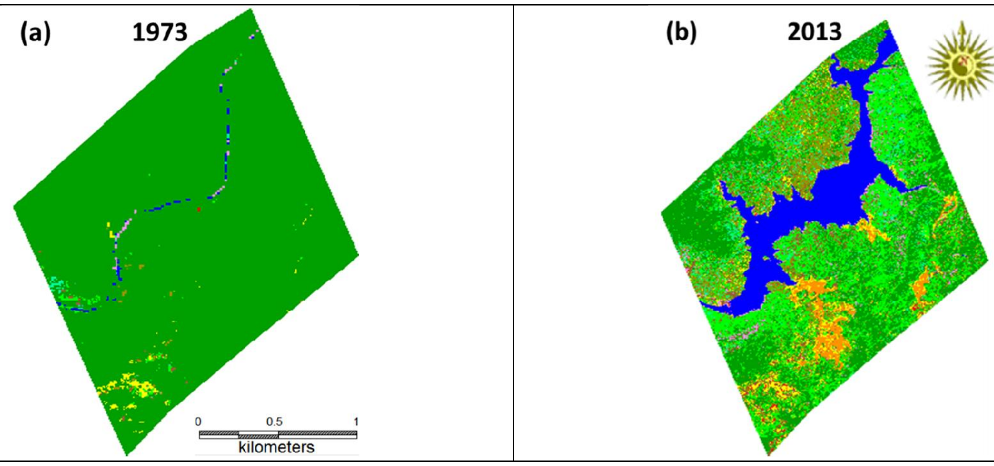


Figure 8.8 (c, d): Kodaslli dam with 1km buffer

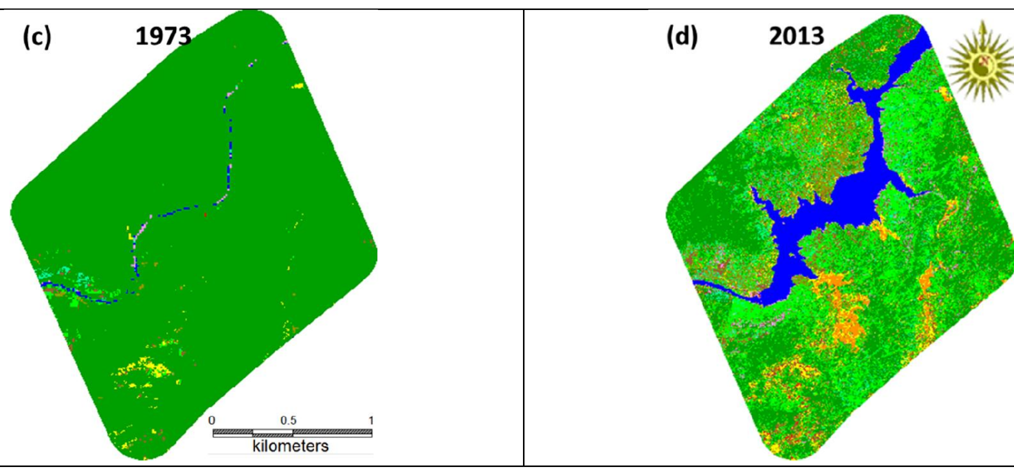


Figure 8.9: the location of Kadra dam as shown in Google Earth

Figure 8.10 (a, b): Kadra dam Project area

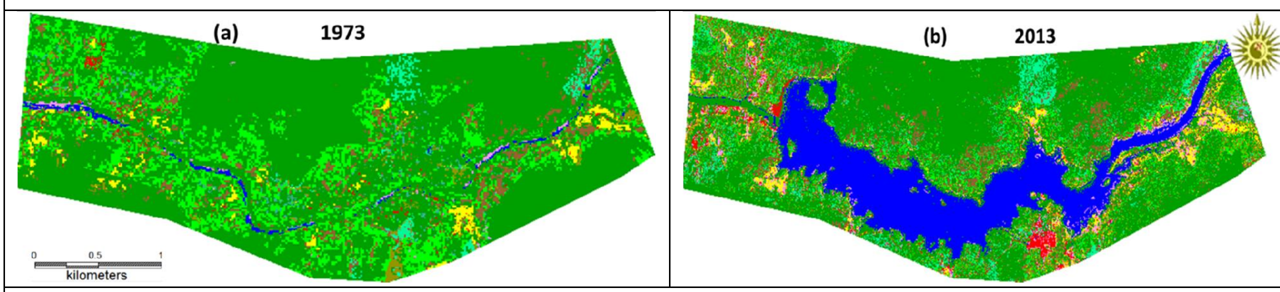


Figure 8.10 (c, d): Kadra dam with 1km buffer

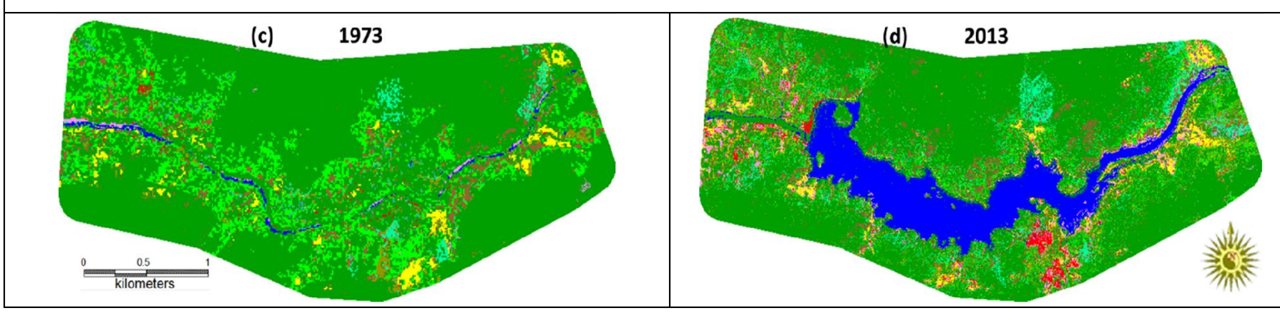


Figure 8.11: the location of Bommanalli reservoir as shown in Google Earth

Figure 8.12(a, b) : Bommanalli reservoir Project area

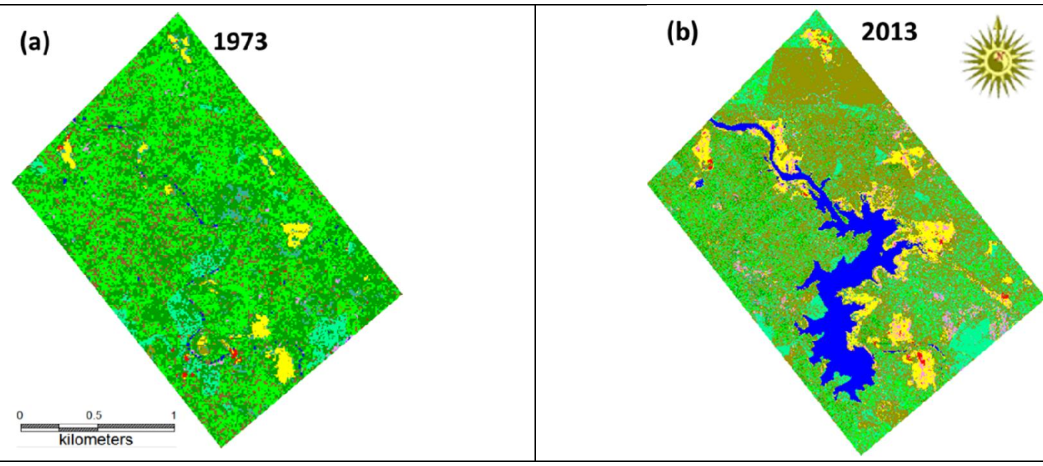


Figure 8.12 (c, d): Bommanahalli reservoir with 1km buffer

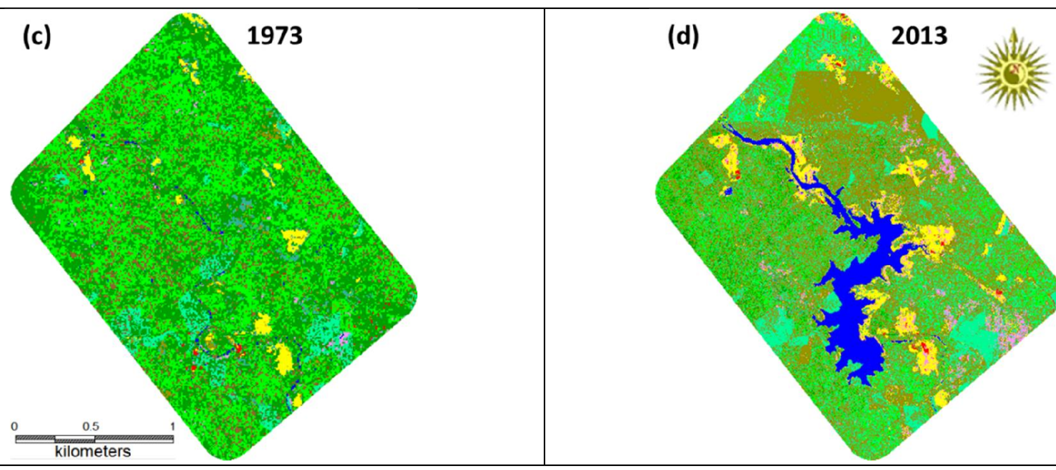


Figure 8.13: the location of Tattihalla reservoir as shown in Google Earth

Figure 8.14(a, b): Tattihalla reservoir Project area

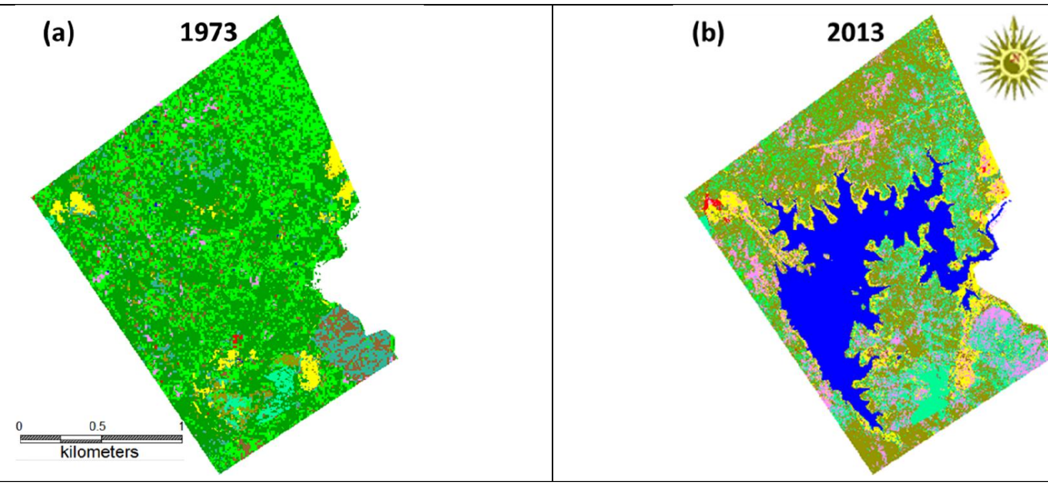


Figure 8.14 (c, d): Tattihalla reservoir with 1km buffer

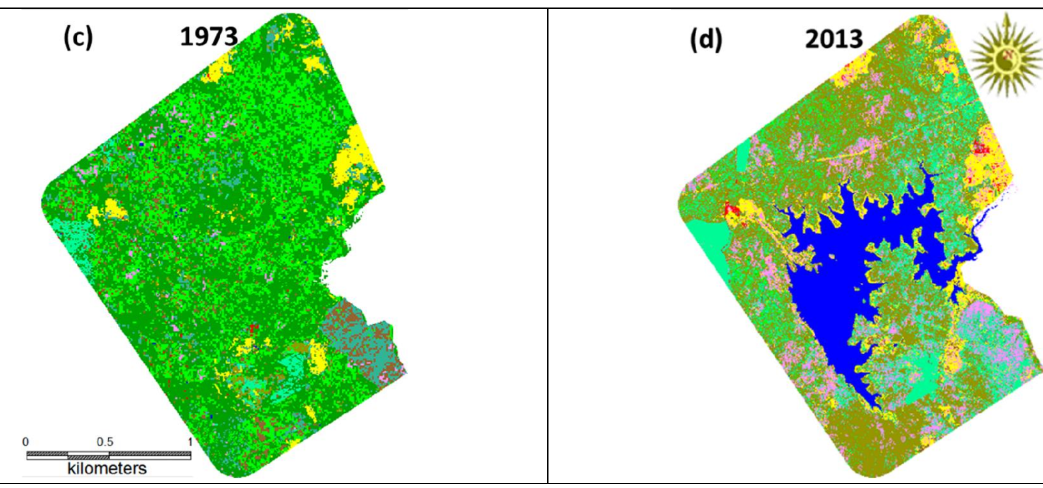


Figure 8.15: the location of Gerusoppa dam as shown in Google Earth

Figure 8.16(a, b): Gerusoppa dam Project area

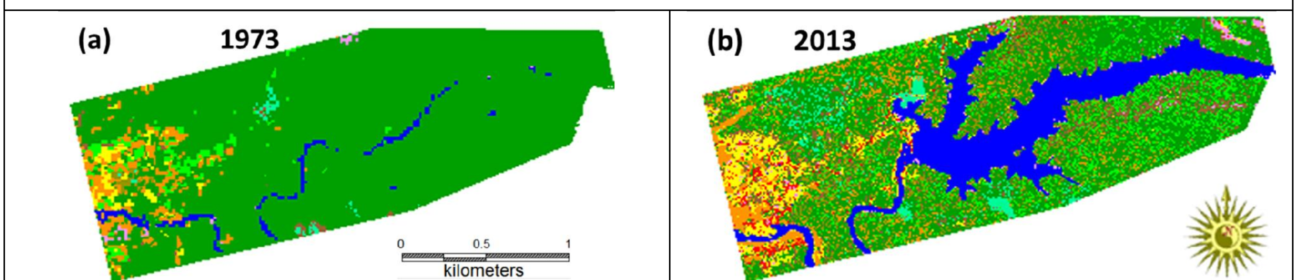


Figure 8.16(c, d): Gerucoppa dam with 1km buffer

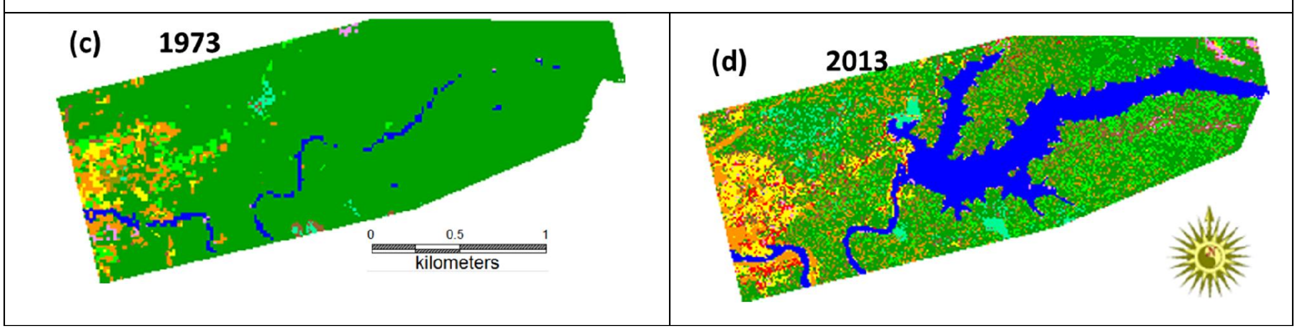
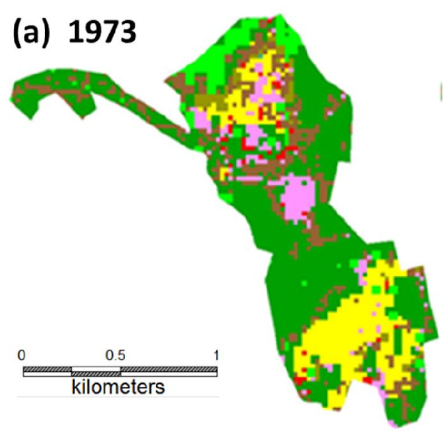


Figure 8.17: the location of Kaiga NPH as shown in Google Earth

Figure 8.18(a, b): Kaiga NPH Project area



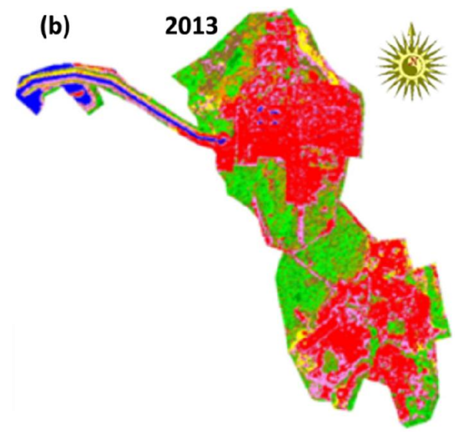
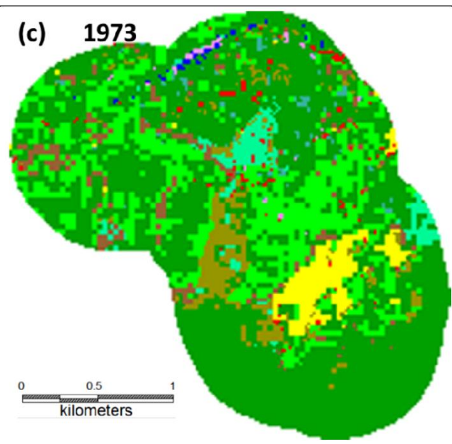


Figure 8.18(c, d) : with 1 km buffer



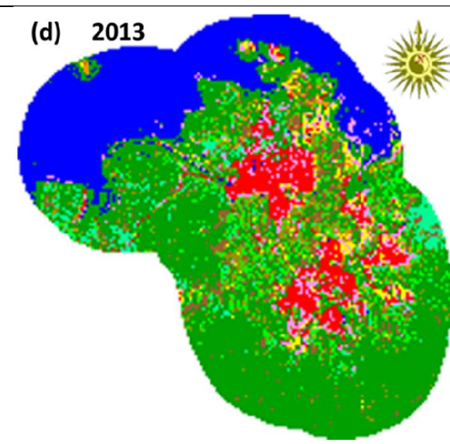


Figure 8.19: the location of Project seabird as shown in Google Earth and other

Birds eyes view of Project Seabird

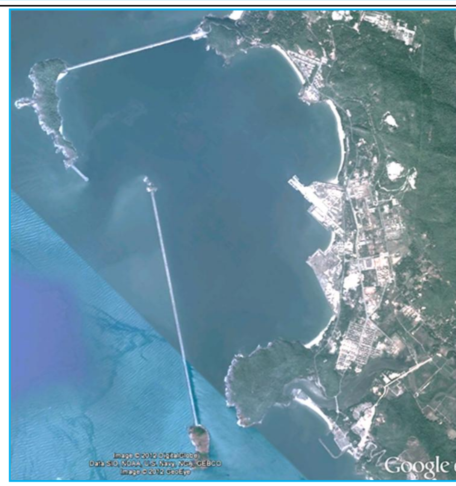


Figure 8.20(a, b): Project seabird area

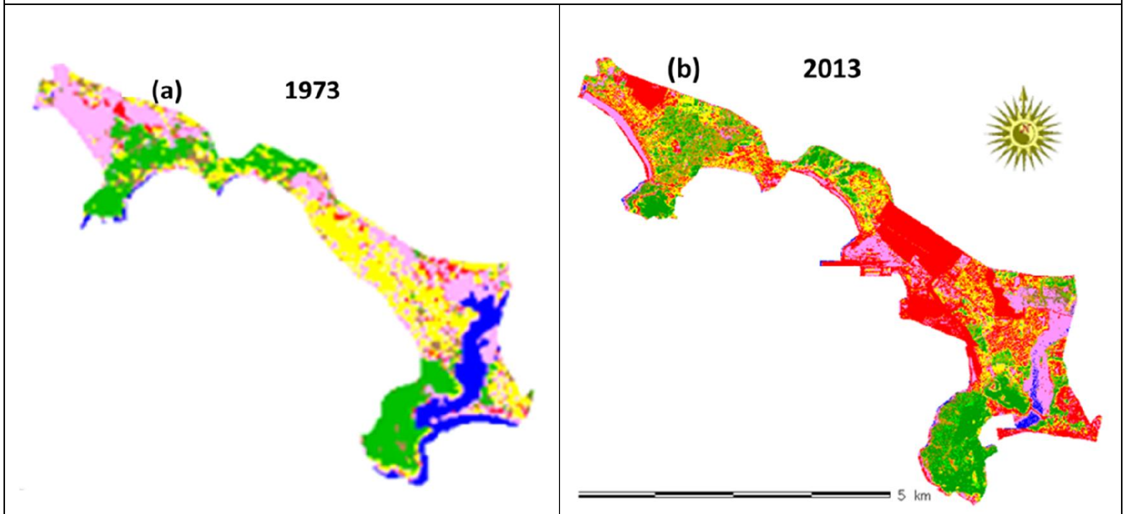


Figure 8.20(c, d): project Seabird with 1km buffer

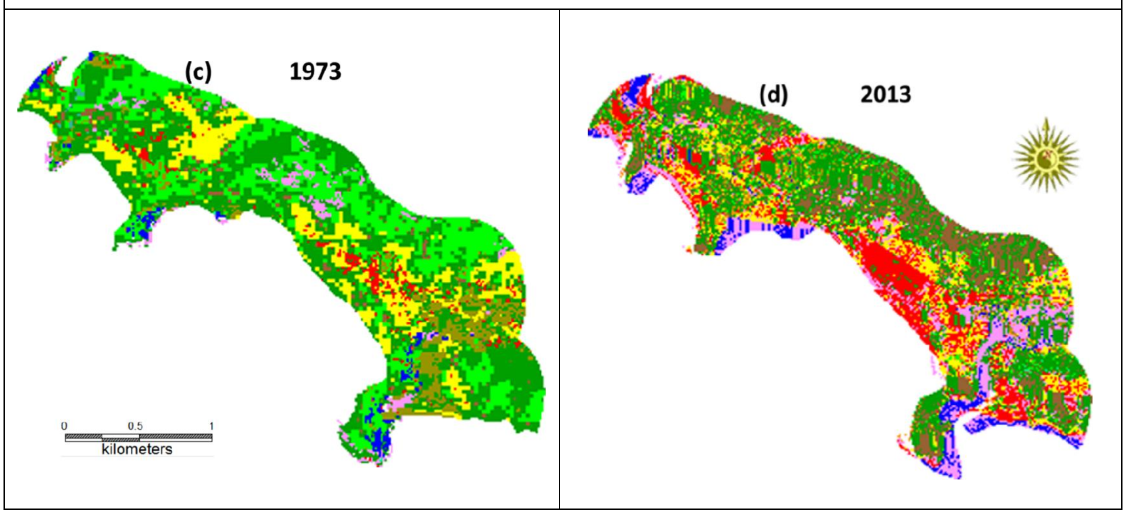


Figure 8.21: the location of West coast paper mills as shown in Google Earth and project site

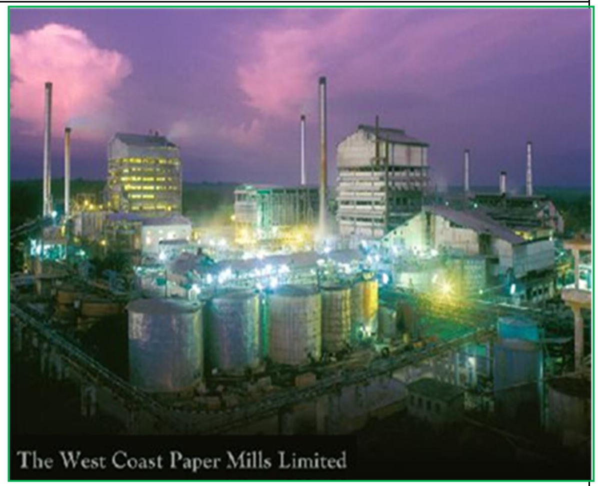
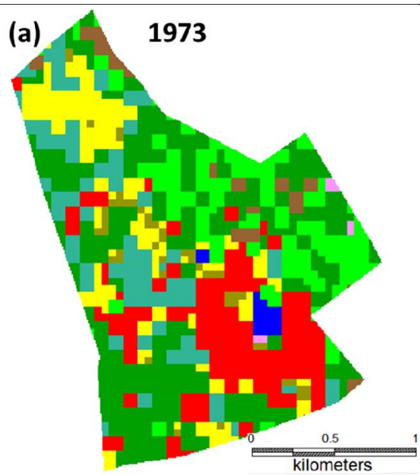


Figure 8.22(a, b): West coast paper mills area



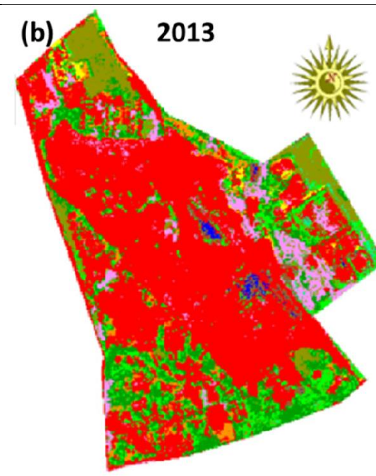
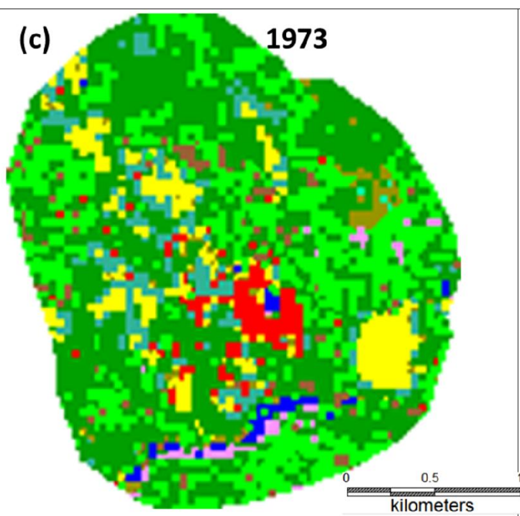


Figure 8.22(c, d): West coast paper mills with 1km buffer



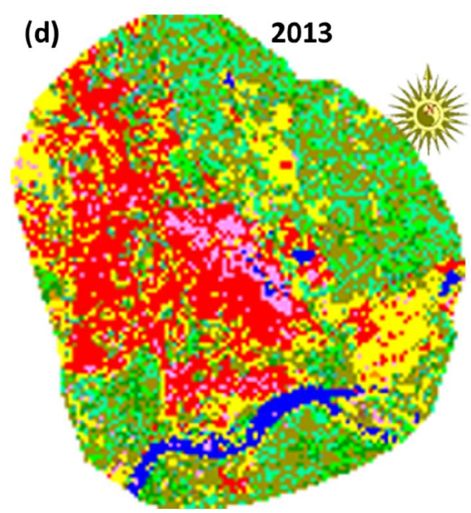


Figure 8.23: Rail way line of Konkan as seen in Google Earth

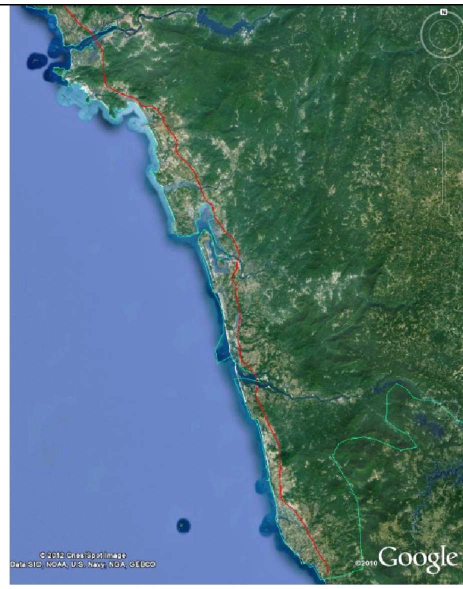
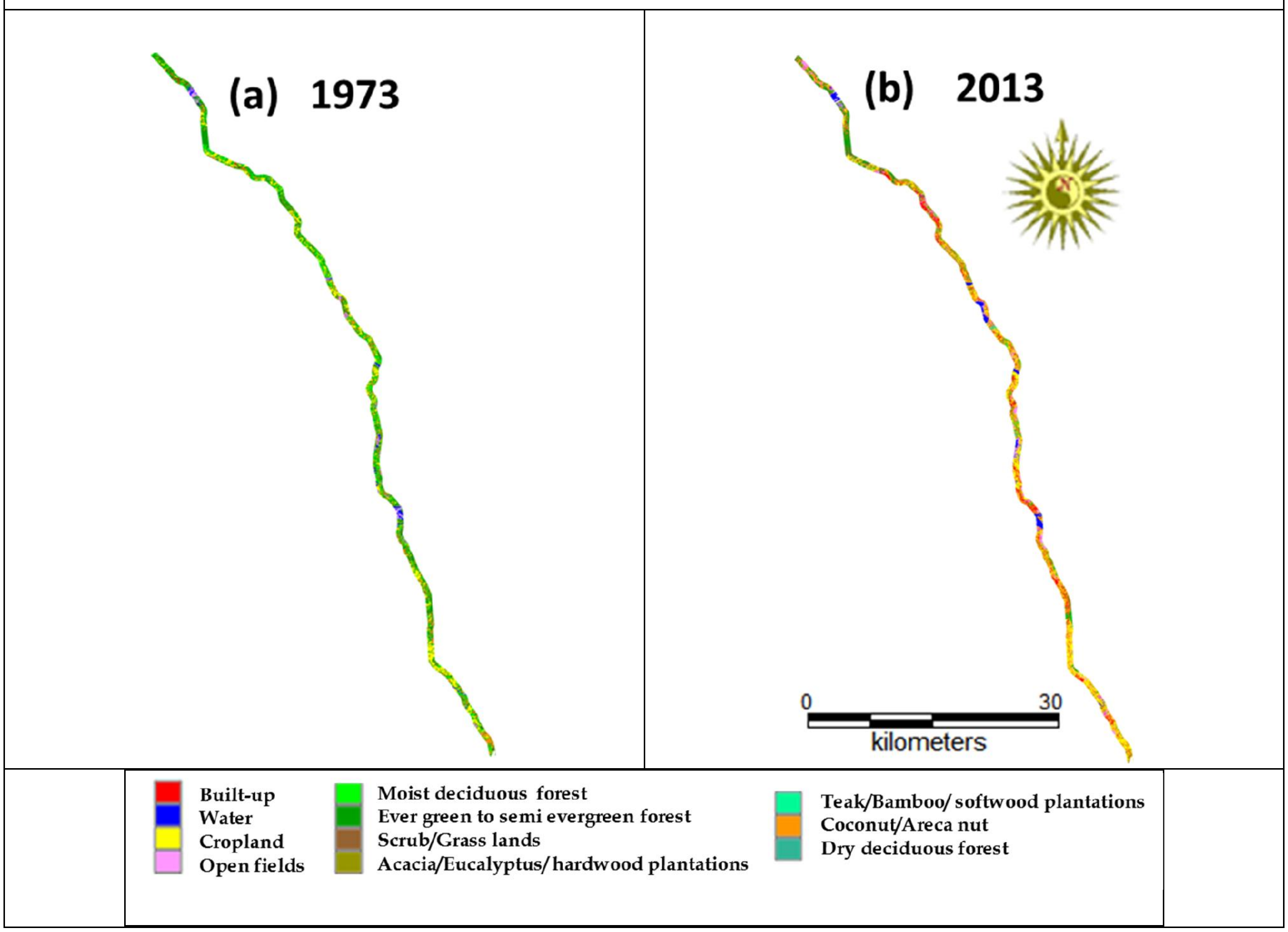


Figure 8.24(a, b): Konkan railway area



9.0 ASSESSMENT OF RENEWABLE ENERGY POTENTIAL

Task 6: Assessment of renewable energy potential (region-wise).
1) Ramachandra T V, Subash Chandran M D, Joshi N V, Ganesh Hegde, Gautham Krishnadas, 2013, Sustainable energy alternatives for Uttara Kannada, Sahyadri Conservation Series 26, ENVIS Technical Report 58, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

9.1 PROSPECTS OF SOLAR ENERGY IN UTTARA KANNADA

Energy is essential for economic and social development of a region. Dependence on fossil fuels has posed a serious threat due to greenhouse gas (GHG) emissions, dwindling stock of the fuel resource base. Among daily activities, about 80% of the mechanical work requires electrical energy. Dependence on the conventional energy resources for electricity generation is eroding the resources at faster rate. The process of electricity generation causes significant adverse effect on ecology by producing enormous quantity of byproducts including nuclear waste and carbon dioxide. Improving energy efficiency, switch over to renewable sources of energy and de-linking economic development from energy consumption (particularly of fossil fuels) is essential for sustainable development of a region. Green energy technologies have gained importance so that they are reliable and environmental friendly. Electrical energy harvesting from solar radiations is one such promising technology which uses photoelectric effect. Solar photovoltaic (SPV) modules directly convert solar radiations to direct current (DC) electrical power which can be used for various applications (or stored in battery) or can be sent to the existing grid. Uttara Kannada is located in the west coast of Karnataka, India, receives an average solar insolation of 5.42 kWh/m^2/day annually and has more than 300 clear sunny days. This solar potential can be utilized to meet the domestic and irrigation electricity demand. Domestic demand of the household in rural region is about 50 to 100 kWh per month and that in urban region is less than 150 kWh/month in Uttara Kannada. The solar potential assessment reveals that, domestic demand can be supplied by installing rooftop SPV modules, since less the 5% of the rooftop is required in majority of the houses and irrigation demand can be met by installing PV modules in wasteland where less than 3% of available wasteland area is sufficient. To estimate the fraction of rooftop required to generate sufficient electricity, rooftop area of a household in selected villages (chosen randomly, representative of agro-climatic zones) is digitized using Google earth image (http://googleearth.com). Electricity demand in households is estimated based on the sample household survey of 1700 households, which indicate the requirement of 50-100 units (kWh) per month per household. Computed rooftop area per household is used to extrapolate for all the villages in the district. Rooftop area required to install the PV module to meet the respective household's electricity demand is computed. The roof area required is less than 5% to meet the domestic demand of the respective household using rooftop PV system. In the similar manner the area required to generate electrical energy to meet the irrigation demand in the village is determined. In most of the villages in the district, less than 0.5% of the available wasteland is sufficient to meet the irrigation demand. The main objectives of the study is to i) assess the scope for solar energy considering the seasonal variability of solar radiation in Uttara Kannada, ii) estimation of household electricity demand, iii) extent of roof top available for deploying solar panel to meet the electricity demand of the respective households, iv) extent of land requirement to meet the demand of irrigation pump sets using solar PV and v) techno-economic analysis of rooftop PV system.

The study includes assessment of energy at supply side and demand side and is detailed in Figure 9.1. The supply side includes assessment of regional solar energy availability, spatial extent of rooftop (individual households) and waste land (in the respective villages). The demand side includes estimation of domestic electricity consumption in households and irrigation as well as the extent of rooftop/land area required for installing PV based systems to meet the decentralised demand.

Assessment of solar energy potential: Village-wise solar energy availability in Uttara Kannada was assessed using satellite-based high resolution global insolation data derived on prudent models. Two datasets collected were:

i. Surface Meteorology and Solar Energy (SSE) 1°x1° (~100 X 100 km) spatial resolution global horizontal insolation (GHI) data provided by National Aeronautics and Space Administration (NASA) based on satellite measurements of 22 years (July 1983 to June 2005) (Surface Meteorology and Solar Energy Release 6.0 Methodology, NASA, 2012);
ii. Higher spatial resolution 0.1° X 0.1° (~ 10 X 10 km) GHI data furnished by the National Renewable Energy Laboratory (NREL) based on satellite measurements of 7 years (January 2002 to December 2008) (NREL GHI data furnished by National Renewable energy Laboratory, 2010). These were compared and validated with long term surface GHI measurements based interpolation model for the region. Higher resolution NREL GHI data were used to study the seasonal availability and variability of village-wise solar energy in Uttara Kannada. Seasonal solar maps were generated using Geographic Information Systems (GIS) tools.

Estimation of the spatial extent of rooftops: Regional rooftop area availability for harvesting solar energy was calculated using remote sensing data through geo-informatics and statistical tools. Villages representing different agro-climatic zones of Uttara Kannada were randomly chosen and rooftop areas were mapped by manual digitisation of high resolution Google Earth satellite data (http://googleearth.com) with the support of geo-informatics tools. Roof types in towns and other urban areas were similar in most of the zones, one random sample was manually digitised for estimating the spatial extent of rooftops. The built-up areas for randomly sampled regions and manually digitized total rooftop areas were investigated using statistical tools.

Regional domestic electricity demand: Taluk wise electricity consumption data were collected from the respective government agencies. Apart from this, stratified random sampling of 1,700 households representing all agro-climatic zones yielded energy requirement per household. Based on this data, monthly electricity usage (in kWh) for household for purposes like lighting, heating etc, and irrigation pump sets were computed.

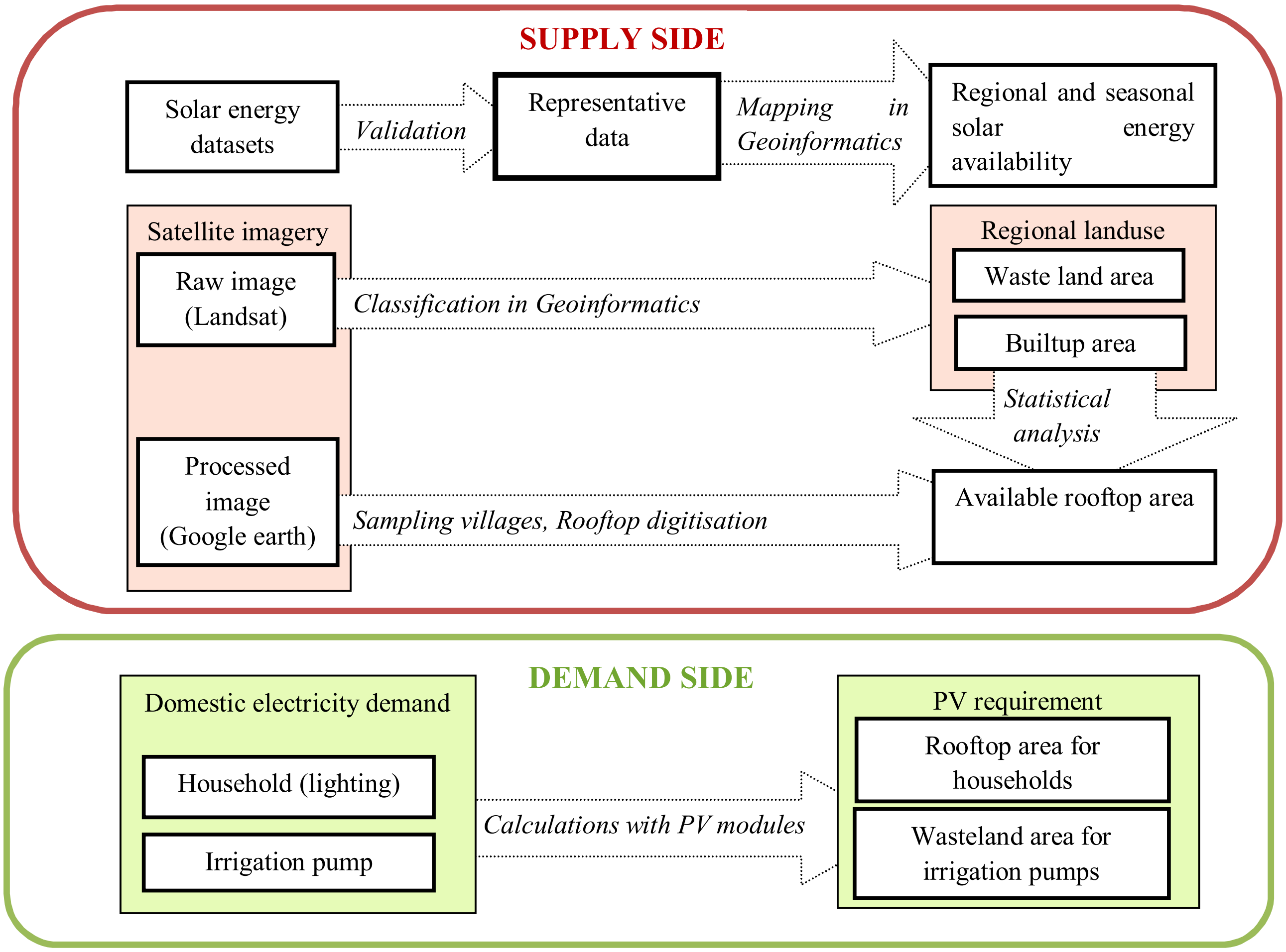


Figure 9.1: Assessment of electricity demand and solar potential

Figure 9.2 depicts the digitized rooftops in Lakolli village of Mundgod Taluk in Uttara Kannada. The polygons of exposed (available) rooftops in a village are manually digitised using Google Earth. Rooftops in 30 random regions (including one town) spread across four agro-climatic zones of Uttara Kannada were similarly digitised.

Figure 9.2: Rooftop digitisation in Lakolli village of Mundgod taluk, Uttara Kannada

Solar energy potential (Seasonal variations of solar insolation) assessment in Uttara Kannada: The monthly average GHI (Global Horizontal Irradiance) datasets from NASA and NREL were compared and validated with surface data based model. Figure 9.3 illustrates the monthly variability of solar radiation. The values indicate that adequate solar energy is available in the region. Higher resolution NREL GHI data were used to study the solar energy potential in Uttara Kannada. Solar maps generated for monsoon, winter and summer seasons, show seasonal availability and regional variability of GHI (Figure 4). The seasonal average GHI is highest in summer (6.65 – 6.95 kWh/m^2/day), moderate in winter (5.70 – 5.85 kWh/m^2/day) and lowest in monsoon (4.50 – 5.20 kWh/m^2/day). Annual average GHI values were considered for assessing the technical potential of solar energy in Uttara Kannada.

Figure 9.4 illustrates the seasonal variations of solar insolation in Uttara Kannada. Solar insolation ranges from 4.5 to 6.95 kWh/m^2/day in the districts throughout the year. During Monsoon season, district gets the insolation ranges from 4.5 to 5.2 kWh/m^2/day. Coastal and the eastern part of the central (moist deciduous) region receives insolation of 4.8-5 kWh/m^2/day. The central region (Evergreen) gets the lowest insolation ranges from 4.5 to 4.8 kWh/m^2/day during monsoon. Eastern most part (dry deciduous) receives higher insolation of 4.89-5.2 kWh/m^2/day.

In winter, insolation in the district ranges from 5.70 to 5.85 kWh/m^2/day. Most of the parts in the district receive insolation of 5.80-5.85 kWh/m^2/day. Eastern region of the district (dry deciduous) gets insolation ranges from 5.75 to 5.80 kWh/m^2/day. Some parts in this region receive insolation of 5.70-5.75 kWh/m^2/day also.

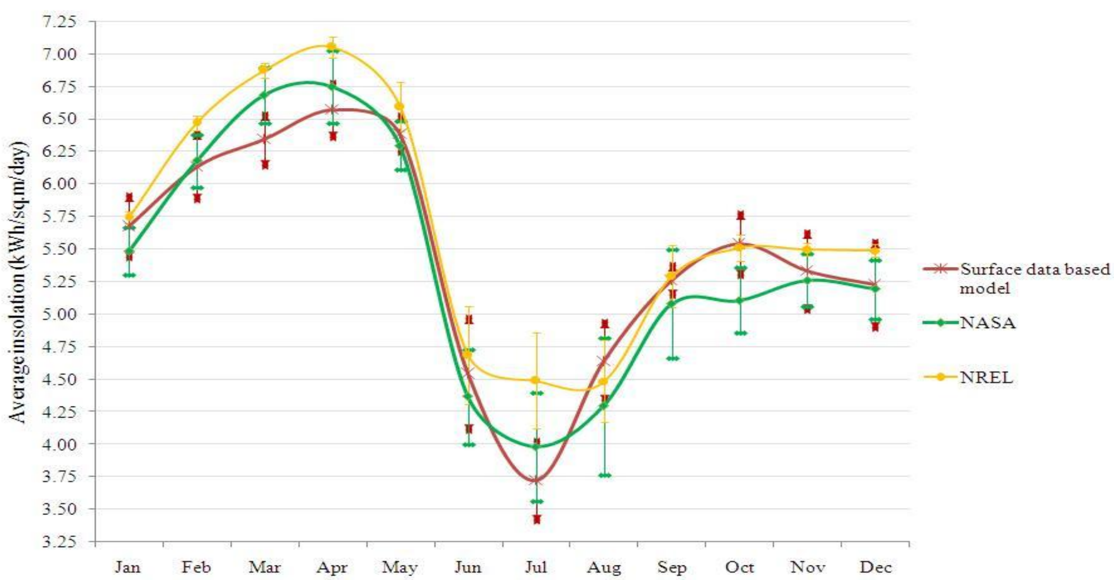


Figure 9.3: Comparison of different available solar data for Uttara Kannada

Uttara Kannada gets higher insolation ranges from 6.65 to 6.95 kWh/m^2/day in summer. Western part of the district receives insolation of 6.65-6.85 kWh/m^2/day. Most of the eastern part (central) gets insolation of 6.85-6.90 KWh/m^2/day. In summer, some parts of the district get higher insolation of 6.90-6.95 kWh/m^2/day.

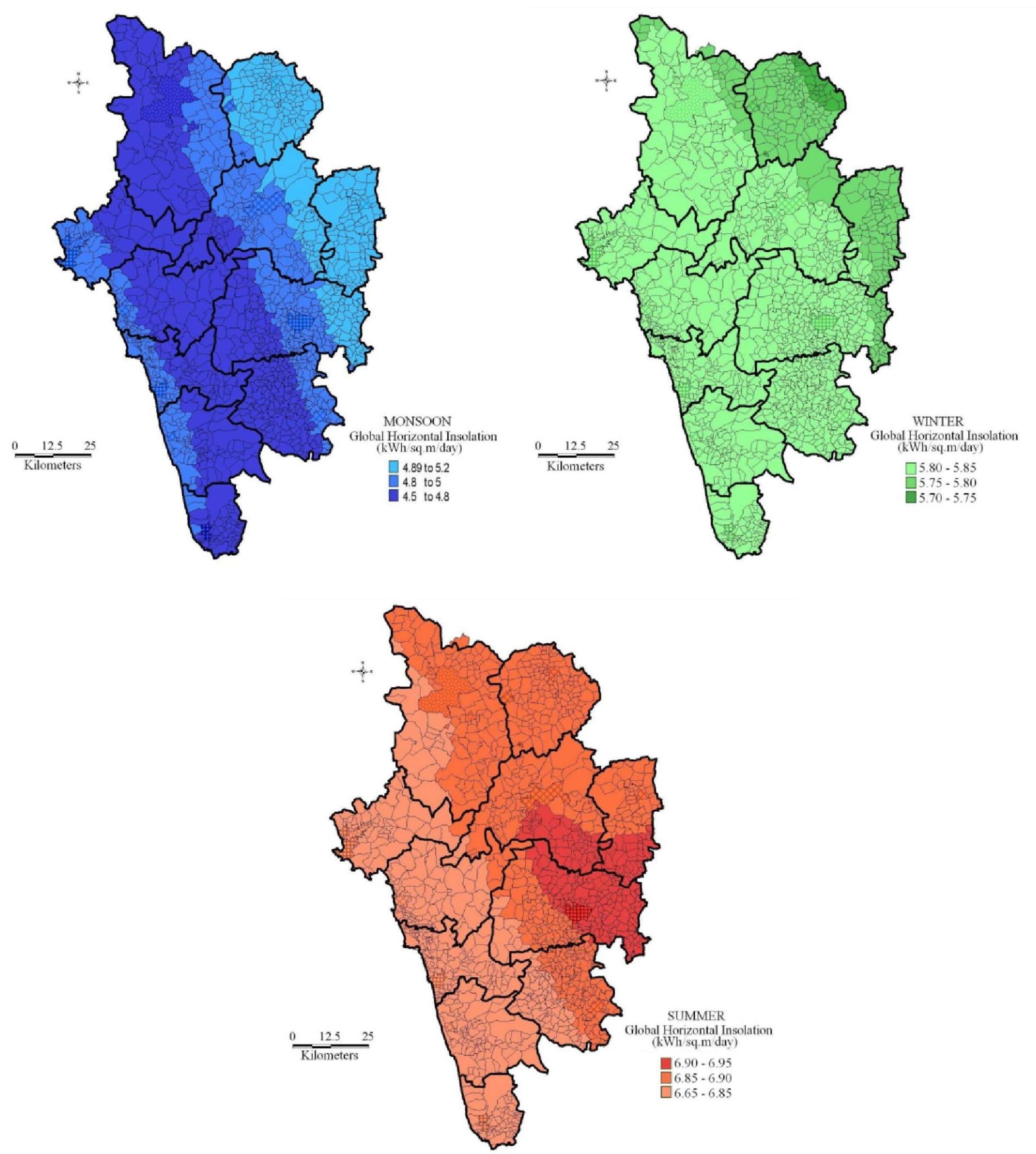


Figure 9.4: Seasonal variations of solar radiation in Uttara Kannada

Uttara Kannada has a good solar potential and can meet the energy demand in the domestic sector. Energy harvesting through PV based solar system mounted on rooftops of individual houses would help in meeting the respective house's energy demand while bringing down the dependency on the State's grid.

Domestic electricity consumption: Average monthly energy consumption of electricity for domestic purposes is about 34±8 kWh per month per household and irrigation requirement is about 3218±2412 kWh/hectare/year. Monthly domestic electricity consumption ranges from 23 (for Haliyal) to 44 (Honnavar) kWh. These values were used for calculating the region wise electricity demand for domestic and irrigation. Coastal taluks (Ankola, Kumta, Karwar, Bhatkal and Honnavar) have higher household electricity consumption. Siddapur and Sirsi taluks with vast extent of horticulture crops lead in the per hectare consumption of electricity for irrigation. A large part of Uttara Kannada except the coast is rainfed and hence do not rely on irrigation for agriculture. The electricity consumption ranges from 1,000 - 5,000 kWh/month. There are about 80 villages, which have the domestic consumption of 10,000 to 1,00,000 KWh of electricity in a month.

Scope for rooftop PV systems to meet domestic electricity demand: The monthly average electric energy consumption per household is about 50 to 100 kWh in Uttara Kannada. This electricity demand can be met through solar rooftop PV system, which ensures continuous supply of electricity compared to the current system of depending on grid with uncertainties. The rooftop area required to generate the electric energy using PV which will meet the domestic electricity demand in respective villages is given in Figure 12. Majority of the villages require rooftop area less than 250 m^2 to meet the electric energy demand using solar PV system. Around 26% (350) of the villages in the district require rooftop area less than 100 m^2 and about 27% (363) places need rooftop area ranges from 100 to 250 m^2. Hence more than 54% of the villages require rooftop area less than 250 m^2 to meet the current domestic electricity demand. In very few places total rooftop area required is 10,000 to 1,00,000 m^2 which are normally the city or town municipal corporations or census towns.

RECOMMENDATIONS FOR SUSTAINABLE ENERGY DURING 21ST CENTURY

Solar energy based generation seems promising and environmental friendly option to meet the growing demands. India is blessed with the good solar potential and harvesting this potential would minimize the environmental implications associated with the fossil fuels. Solar PV technology has the potential to meet the domestic and irrigation demands in the decentralized way. Appropriate policy incentives might help in the large scale deployment of solar devices at household levels. There is a need to focus on energy efficient decentralized electricity generation technologies with micro grid and smart grid architecture, which would go long way in meeting the energy demand. In this regard, suggestions are:

1. Electricity generation using SPV and CSP technologies would bridge the demand supply gap as India receives abundant solar energy of more than 5 kWh/m^2/day for about 300 days in a year. The adequate potential with mature technologies and apt policy incentives would help in meeting the electricity demand in a region. Few houses in Uttara Kannada has been using Solar PV for the last 4-5 years (Muroor Kalabe village, etc.)

2. Roof top based SPV would help in meeting the household energy demand in rural as well as urban households. Rural household require about 70-100 kWh per month and to meet this requirement 5-6 m^2 rooftop is adequate (at η=10%, and insolation of 5 kWh/m^2/day) and the average rooftop in rural locations in Karnataka is about 110 m^2 and about 115 m^2 in urban localities.
3. Adequate barren /waste land is available in Karnataka as the available waste land is about 7% of the total geographical area less than 1% area is sufficient to generate electricity required for irrigation and domestic sector through SPV installation.
4. SPV installation in waste/barren lands supports decentralized electricity generation and enables multi utilization of the area for activities such as grazing, livestock farming, etc. About 45 million households are still not electrified in India, which have potential to generate enough electricity from rooftop SPV installation; rooftop SPV installation would be the revolutionary method of rural electrification.
5. Rooftop SPV installation is the most adoptable technology in highly populous countries like India, where the monthly electricity consumption of a household ranges from 50 to 100 kWh. Encouragement for roof top SPV based electricity generation rather than centralized generation through incentives, financial aid for initial installation and tax holidays.

> Supply of electricity to households in remote areas entails investment on infrastructure apart from transmission and distribution (T&D) loss of electricity. Assessment reveals that T&D loss in Karnataka is about 19.5% resulting in the loss of 7,210.16 GWh (annual demand is 36,975.2 GWh in 2010-11) of energy. Cost of energy loss ranges from Rs. 1,514.13 crores (@ Rs. 2.10/kWh) to Rs. 5,047.11 crores (@ Rs. 7/kWh) depending upon the tariff (in the respective state).

Decentralized generation of electricity through SPV would help in meeting the respective household's electricity demand apart from the removal of T&D losses. Generation based incentives (GBI) would herald the decentralized electricity generation, which would help in boosting the regional economy. Considering the current level of T & D losses in centralized system, inefficient and unreliable electricity supply, it is necessary to promote decentralized energy generation. Small capacity systems are efficient, economical and more importantly would meet the local electricity demand. The incentive could be

- Rs. 4.00 per unit for first five years (comparable to **subsidies granted to mini hydel projects, the power purchase at Rs 3.40)** and Rs. 3.50 for the next two years for the electricity generated from roof top solar PV.
- Buyback programmes for the electricity generated at household level and in micro grid - GBI of Rs. 5 to be provided for electricity generation (< 5 kW) feeding to the grid by SPV.

- Free solar home lighting (with LED lamps) under the Chief Minister's Solar Powered Green House Scheme (CMSPGHS), Government of Karnataka or JNNSM (Jawaharlal Nehru National Solar Mission, Government of India).
- All street lights and water Supply installations in local bodies to be energized through solar power (or hybrid mechanism) in a phased manner
- Install solar rooftops in all new government/local body buildings - implementation of solar rooftops could be in a phased manner in the existing government/local body buildings, etc.
- Exemption from payment of electricity tax to the extent of 100% on electricity generated from solar power projects used for self-consumption/sale to utility to be allowed for at least10 years.
- Fixing of standards for quality installation.

6. Commercial lighting in advertisement boards should only be from SPV panels. Complete ban on usage of grid electricity for these purposes.
7. Impetus to energy research through generous funding for the R and D activities to ensure further improvements in the grid, technologies, two way communication energy meters (to connect rooftop generation with existing grid), efficient luminaries' production, low cost wiring, switchgears, appliances, etc.
8. Energy education (focusing mainly on renewable energy technologies, end-use energy efficiency improvements, energy conservation) at all levels. School curriculum shall include renewable energy (RE) concepts.
9. Awareness about energy independence and the necessity of RE sources in the present gloomy energy scenario to the consumers
10. Education and awareness about applications and importance of renewable energy sources.
11. Capacity building of youth through technical education for installation and servicing of SPV panels.
12. Diploma /ITI courses with hand-on training on renewable energy technologies in all taluks
13. Setting up service centers in block development offices to meet the requirement of service support for RE technologies (Solar, biogas, energy efficient chulas, etc.).
14. Periodic revision of FIT structure and incentives to encourage the consumers.
15. Mandatory one week capacity building / training programmes to all bureaucrats and energy professionals at the initial stages of the career. This is essential as lack of awareness/knowledge among the bureaucrats is the major hurdle for successful dissemination of renewable energy technologies in India.

9.2 OPPORTUNITIES FOR DECENTRALIZED WIND APPLICATIONS

Wind is one of the promising renewable sources which can substitute fast depleting fossil fuels sources. Windmills have been used for centuries to grind grain and pump water in rural areas. It has the advantage of being harnessed on a local basis for applications in rural areas and remote areas. Water pumping for agriculture and plantations is probably the most important application that contributes to the rural development through multiple cropping. Wind resource assessment is the primary step towards understanding the local wind dynamics of a region. Climatic average datasets of meteorological variables containing wind speed data for the period of 1961~1990 compiled from different sources I were used for the potential assessment of wind speed in the district. These were validated with the data of meteorological observatories at Karwar, Honnavar and Shirali obtained from the Indian Meteorological Department, Government of India, Pune. Analysis showed the seasonal variation of wind speed in the region. Wind speed varies from 1.9 m/s (6.84 km/hr.) to 3.93 m/s (14.15 km/hr.) throughout the year with minimum in October and maximum in June and July. District experiences annual average wind of 2.5 m/s to 3.0 m/s in all taluks indicating the prospects for WECS installation. Hybridizing wind energy systems with other locally available resources (solar, bioenergy) would assure the reliable energy supply to meet the energy demand at decentralized levels.

Wind resource assessment is the primary step towards understanding the local wind dynamics of a region. Wind flow developed due to the differential heating of earth is modified by its rotation and further influenced by local topography. This results in annual (year to year), seasonal, synoptic (passing weather), diurnal (day and night) and turbulent (second to second) changes in wind pattern. Increased heat energy generated due to industries and escalating population in urban areas result in heat islands which affects the wind flow as well. Objective of the present study is to assess the taluk wise annual wind potential in Uttara Kannada district and assess techno-economic feasibility of wind energy harvesting options, to meet the regional electricity demand.

Synthesised wind data: Synthesised wind data available from various sources provide preliminary understanding of the wind regime of a region. Depending on the physiographical features and climatic conditions, these data help assess wind potential in the region of interest validated by long term surface wind measurements. There many wind speed data sets are available of different time periods such as National Aeronautical and Space Agency (NASA) Surface Meteorology and Solar Energy (SSE), National Oceanic and Atmospheric Administration (NOAA-CIRES), Climate Research Unit (CRU) etc. However previous studies are evidently showed that CRU data are reliable and are closer to the Indian Meteorological Department (IMD) surface data and hence used in the present study. CRU at the University of East Anglia maintains climatic average datasets of meteorological variables which contains wind speed data for the period of 1961~1990 compiled from different sources. Further, inter and intra variable consistency checks are performed to minimize data consolidation errors. The Global Land One-km Base Elevation Project (GLOBE) data of the National Geophysical Data Center (NGDC) were re-sampled to 10'×10' (ten minute spatial resolution) elevation grids where every cell with more than 25% land surface (those below 25% being considered water bodies) represents the average elevation of 100~400 GLOBE elevation points. The climatic average of wind speeds measured at 2 to 20 m anemometer heights (assumed to be standardized during collection) collated from 3950 global meteorological stations together with the information on latitude, longitude and elevation were interpolated based on a geo-statistical technique called thin plate smoothing splines. Elevation as a co-predictor considers topographic influence on the wind speed and proximity of a region to the measuring station improves the reliability of the interpolated data. During interpolation inconsistent data were removed appropriately. This technique was identified to be steadfast in situations of data sparseness or irregularity. The 10’×10’ spatial resolution wind speed data as climatic averages were available for all global regions (excluding Antarctica) . Data from IMD stations located in the district are also acquired for respective locations and which gave the satisfactory results comparing with CRU data set. There are 4 IMD stations in the districts which are listed in Table 9.1. Cup counter anemometers with hemispherical cups measuring 7.62 cm in diameter were used in Indian Meteorological Department (IMD) observatories until 1973. During 1973-1979 these anemometers are replaced with 3 cup anemometers with 127 mm diameter conical cups, which are placed at l0 m above ground, over open terrain in conformity with international practice.

Table 9.1: IMD stations in Uttara Kannada

Location	Latitude	Longitude	Elevation (m)
Karwar	14° 47'	74° 08'	4
Kumta	14° 26'	74° 25'	8
Honnavar	14° 17'	74° 27'	26
Shirali	14° 05'	74° 32 '	45
Sirsi*	14° 62'	74° 85'	610

Data from the meteorological observatories at Karwar (for the period 1952-1989), Honnavar (for the period 1939-1989) and Shirali (for the period 1974-1989) obtained from the Indian Meteorological Department, Government of India, Pune, and daily wind data for the period 1990-1993 for these observatories, from the Indian Meteorology Department, Bangalore. The primary data obtained by installing a cup counter anemometer with mechanical counter fixed on 5 m tall guyed masts at Sirsi and Kumta. The anemometer readings were noted down every three hours during the day and mean wind speeds were obtained. Table 9.2 gives the month wise average wind speed in the respective locations. Figure 9.5 shows the comparison of mean wind speed in five IMD stations.

Table 9.2: Monthly variation in mean wind speed (km/hr)

Month	Karwar	Kumta	Honnavar	Shirali	Sirsi
January	5.96	5.95	5.95	6.78	6.92
February	6.55	7.76	6.00	6.87	6.88
March	8.15	9.09	6.10	7.03	7.20
April	9.65	9.42	6.20	7.25	8.38
May	11.82	9.87	7.21	7.84	9.09
June	12.01	11.83	7.50	8.30	11.19
July	15.27	13.03	7.72	8.50	18.17
August	11.98	11.54	6.66	7.64	14.19
September	7.44	6.71	4.87	5.56	11.14
October	5.41	6.59	4.55	5.42	8.39
November	4.75	6.29	5.04	6.76	7.72
December	5.04	7.73	6.00	9.51	8.42

Wind profile of Uttara Kannada: Wind speed is seasonal dependent which is normally at its maximum during monsoon season. Wind speed varies from 1.9 m/s (6.84 km/hr.) to 3.93 m/s (14.15 km/hr.) throughout the year resulting minimum in October and maximum in June and July. Annual average wind sped in the district ranges from 2.54 ± 0.04 m/s (9.144±0.144 km/hr.) in Haliyal taluk to 2.70 ± 0.05 m/s

(9.72±0.18 km/hr.) in Karwar taluk. Figure 9.6 gives the taluk wise annual average wind speed of the district. Ample amount of electrical energy can be generated using blowing wind through wind farms which could meet the major fraction of the current electricity demand of the district through decentralized generation.

Seasonal variation of wind speed: Speed of the wind is quite uncertain and dependent on ambient temperature and pressure, vegetation cover, elevation, topography of the site etc. Uttara Kannada has a mixed topography includes coastal belt, low and high elevation area with forest cover and also planes. From February to May district experiences summer with higher temperature in costal (Karwar, Honnavar, Kumta, Bhatkal and Ankola) and in planes (Mundgod and Haliyal) and comparatively lower temperature in taluks of higher altitudes (Sirsi, Siddapur, Yellapur and Supa). Figure 9.7 to 9.9 gives the mean wind speed variability in the district during summer, winter and monsoon months.

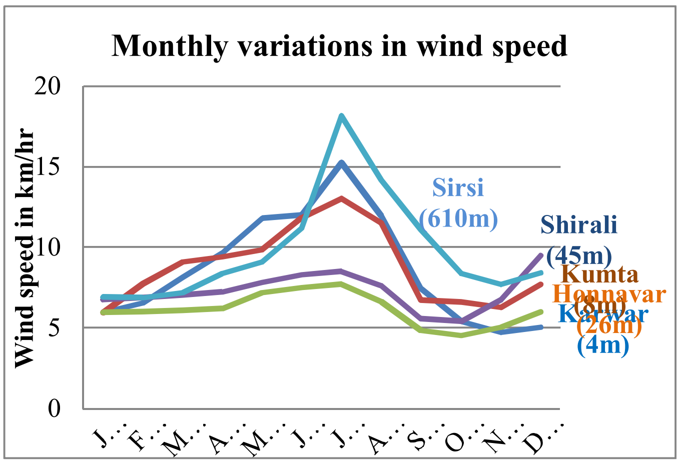


Figure 9.5: Monthly variation in wind speed

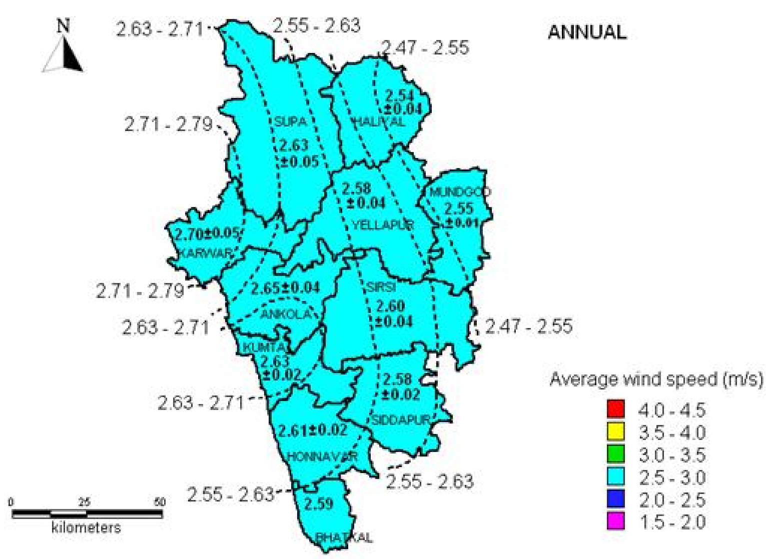


Figure 9.6: Average annual wind speed of Uttara Kannada

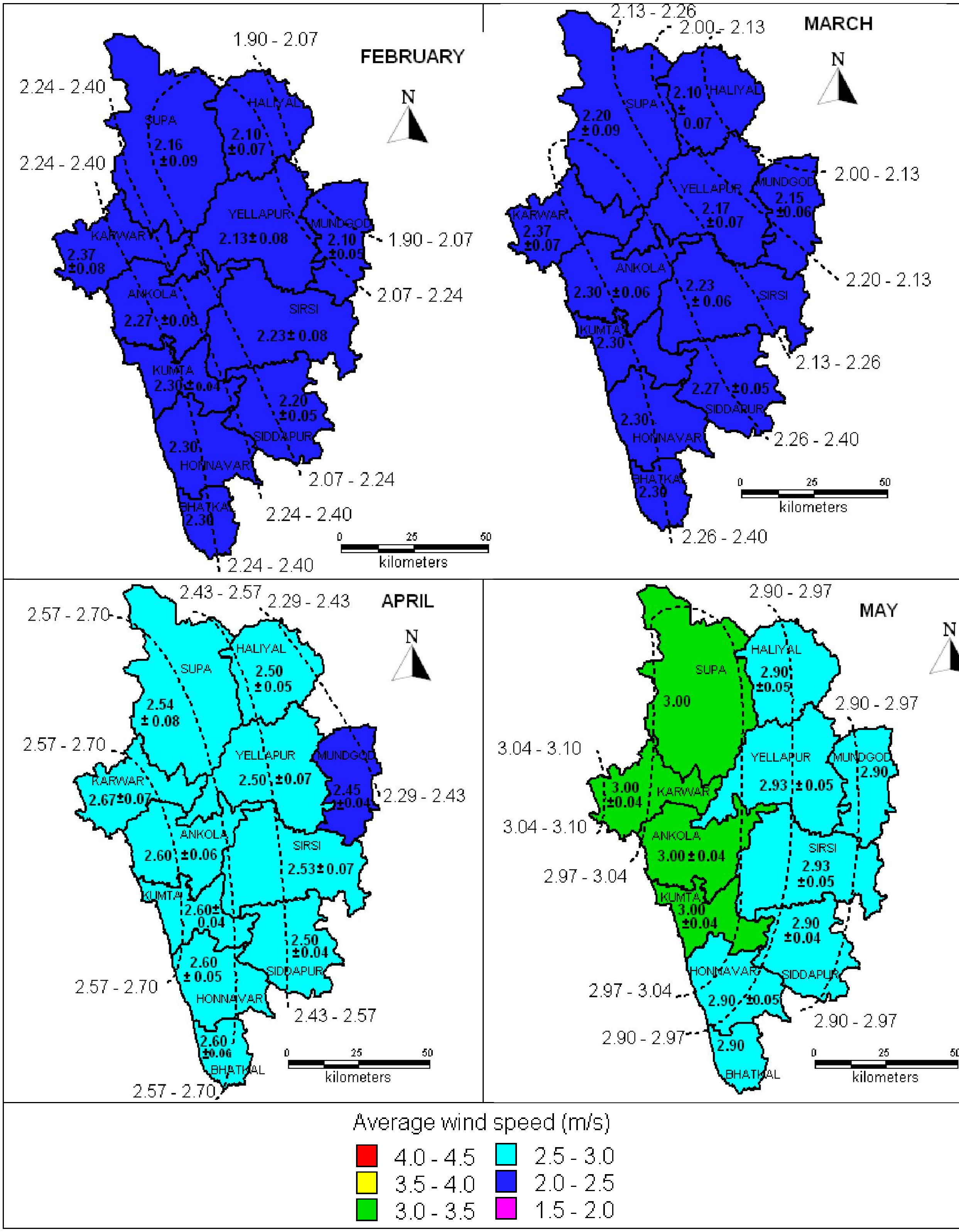


Figure 9.7: Wind speed variation during summer (m/s)

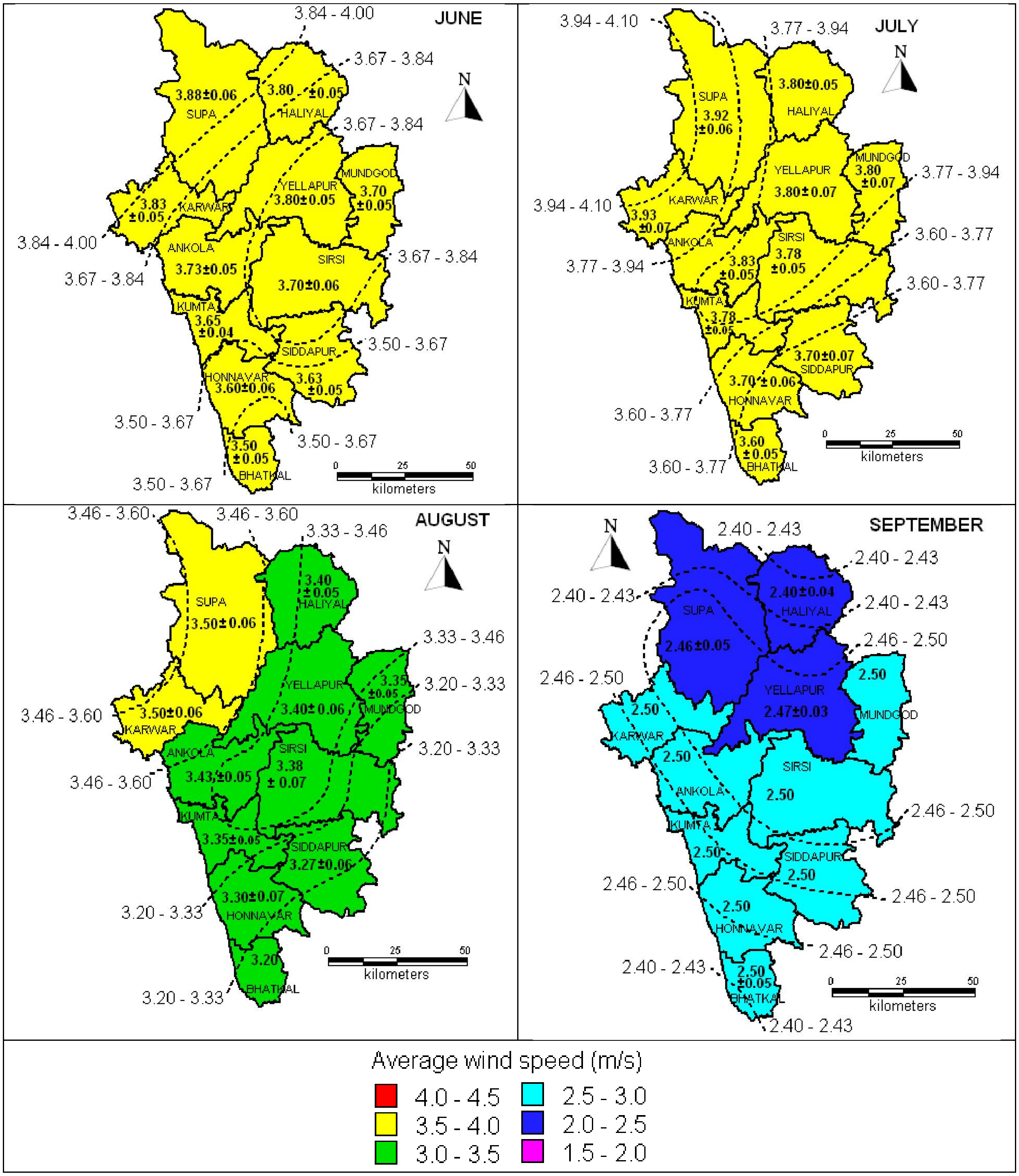


Figure 9.8: Wind speed variation during monsoon (m/s)

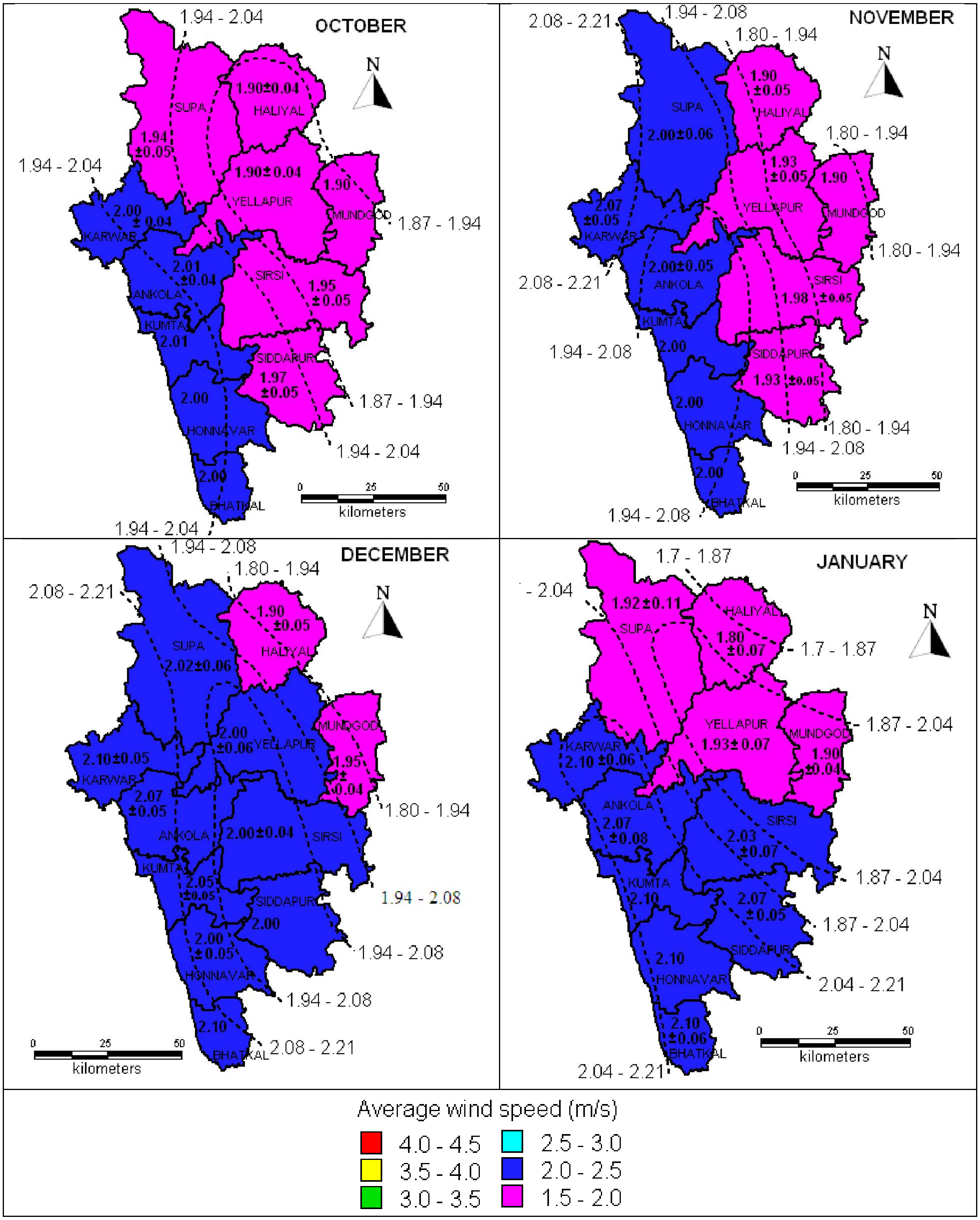


Figure 9.9: Wind speed variation during winter (m/s)

Wind Energy Conversion System (WECS): Wind Energy Conversion System (WECS) is used to extract energy from wind which in turn converted to mechanical and then electrical energy. Main components of WECS are blades, gears, turbine, generator and pillar to mount all the equipment at the required height. In almost all the taluk more than 45% of the wind speed is above 2.5 m/s except Honnavar (39.58%). Over 20% of the measured hours crossed 3.5 m/s wind speeds in Karwar, Kumta and Supa, in which Karwar being highest (27.38%). These findings along with relatively higher wind speeds (> 2 m/s in high elevation zone) observed in seasonal wind profiles (based on CRU data) are indicative of the prospects of small and medium scale wind applications in Uttara Kannada which are technically achievable and economically viable.

Wind is one of the promising renewable sources which can substitute fast depleting fossil fuels sources. Wind energy potential in the district could meet the electrical energy consumption in domestic through decentralized generation and wind turbine driven pumps can decrease the dependency on grid supply for irrigation. District experiences annual average wind of 2.5 m/s to 3.0 m/s in all the taluks which opens wide range prospects for WECS installation. Hybridizing wind energy systems with other locally available resources would assure the reliable energy supply for domestic and irrigation demand. Small and medium scale WEC systems are feasible for the community level installation which leads to abundant amount of carbon dioxide emission reduction.

9.3 PROSPECTS OF BIOENERGY IN UTTARA KANNADA DISTRICT

Rural population of India mostly depends on bio energy for cooking, space and water heating. Though most of the energy need is harvested from fossil fuels, 70% of the rural population depends on the bio energy for their domestic usage in the country. About 70% of the Indian population lives in rural area where 75% of the primary energy need is supplied by bio energy resources. Also, about 22% of the urban households depend on firewood, 22% on kerosene and 44% on LPG for cooking in the country. Bio energy resources are renewable in nature and combustion would not produce poisonous gases and ash with sufficient oxygen supply. A village level study on the present scenario of domestic energy consumption will help to assess the demand and supply of bio energy in the country. Uttara Kannada district in Karnataka state, India is chosen for bio energy assessment which has evergreen as well as moist and dry deciduous forest. In the district majority of the people live in rural area or in semi urban area, mostly dependent on forest, agricultural and livestock residues for domestic energy need.

Bioresource availability is computed based on the compilation of data on the area and productivity of agriculture and horticulture crops, forests and plantations. Sector-wise energy demand is computed based on the National Sample Survey Organisation (NSSO study) data, primary survey data and from the literature. Using the data of bioresource availability and demand, bioresource status is computed for all the agroclimatic zones. The ratio of bioresource availability to demand gives the bioresource status. The ratio greater than one indicates bioresource surplus zones, while a ratio less than one indicates scarcity. The supply/demand ratio in the district ranges from less than 0.5 to more the 2. If the ratio is less than 1 (demand > supply) then that place is fuel wood deficit place and where the ratio is more than 1 (supply > demand) then that place is referred as fuel wood surplus region. In Uttara Kannada, most of the Taluks with ever green forest cover (Sirsi, Siddapur, Yellapur, Supa and estern hilly ares of Kumta, Honnavar and Ankola) are fuel wood surplus regions where the supply/demand ratio is currently > 2 (compared to 8-9 in early 1990's). Dwindling resource base could be attributed to the decline in forest cover in the district.

A village level study on the present scenario of domestic energy consumption will help to assess the demand and supply of bio energy in the country. For bio energy assessment Uttara Kannada district in Karnataka state, India is chosen which has evergreen as well as moist and dry deciduous forest. In the district majority of the people live in rural area or in semi urban area, mostly dependent on forest, agricultural and livestock residues for domestic energy need. The primary objective of the study is to assess the bio energy status in Uttara Kannada district across the agroclimatic zones. This includes identification of the bioenergy surplus and deficit places in the district.

Bio resources from various sources (forests, agriculture, horticulture) is used for domestic applications (cooking, water heating) in the district. Fuel wood is mainly used for domestic cooking and water heating supplemented by horticultural and agricultural residues, forest biomass and biogas production from livestock. Majority of the fuel requirement for cooking, water and space heating is supplied by agricultural residues, animal matter or by forest in the district. More than 80% of the people are dependent on bio energy for their requirements such as food, fuel wood for traditional stoves, timber for houses and cattle sheds, poles for fencing and shelter construction, leaves to prepare manure and covering to control weed, wood to prepare all housing structures, ropes, herbal medicines and decorative articles. Study gives the village level details of supply and demand trend of bio energy in the district.

Supply and Demand trends of Bio energy in Uttara Kannada

Fuel wood: Fuel wood is one of the prominent forest by-products collected (normally by women and children) which is used for cooking and water heating through burning. Major domestic energy need is shared by fuel wood in the rural regions where the people collect it from nearby forest. The availability of the fuel wood for the consumers is depends on the closeness of the forest, type of the forest and methods of extraction. Figure 9.10 gives the availability of fuel wood in the districts annually. Since fuel wood is the cheapest primary energy source hence the demand will be high depending upon the availability. If the demand for the fuel wood increases then it may lead to deforestation or consumers may switch over to some other fuels such as LPG, electricity or kerosene due to the lack of availability. The annual fuel wood availability in the district ranges from less than 1,000 tonnes to 56.000 tonnes. In majority of the villages of Sirsi, Siddapur, Kumta and Honnavar Taluks, availability of fuel food ranges from 1,000 to 5,000 tonnes per annum. In northern villages of Haliyal and Supa Taluks availability of forest bio mass per annum is less than 1,000 tonnes to 5,000 tonnes. Availability of fuel wood is high in the central region of the district. In eastern part of Karwar and Ankola and southern part of Supa fuel wood availableness is 10,000 to 25,000 tonnes per annum. There are few villages Supa and Yellapur Taluks where the bio-mass availability is 25,000 to 56,000 tonnes in a year.

Figure 9.11 gives the supply to demand ratio of available forest bio mass (fuel wood) in the district. The supply/demand ratio in the district ranges from less than 0.5 to more the 2. If the ratio is less than 1 (supply < demand) then that place is fuel wood deficit place and where the ratio is more than 1 (supply > demand) then that place is fuel wood surplus region. In Uttara Kannada, most of the Taluks with ever green forest cover (Sirsi, Siddapur, Yellapur, Supa and estern hilly ares of Kumta, Honnavar and Ankola) are fuel wood surplus regions where the supply/demand ratio is more than 2. The villages with semi and moist deciduous forests (Western parts of Mundgod and Haliyal, Eastern parts of Bhatkal and Karwar) are also forest bio mass surplus places where the availability ratio is more than 1. The coastal and the extreme eastern part of the district (coastal villages of Karwar, Ankola, Kumta, Honnavar and Bhatkal with eastern part of Mundgod and Haliyal) are the fuel wood deficit places. The bioresource supply is dwindling in the district evident from the reduced bioresource supply to demand ratio from 8-9 to 2. This necessitates sustainable management approaches with augmentation of forest resources.

Bio-energy from Agricultural residues: Agricultural crops grown in the district include rice, ragi, jowar, bajra, maize and wheat. Paddy is the major crop in the district followed by jowar and maize. Net sown area in the district is about 1,12,946 ha which includes cereals, commercial crops and oilseeds.

a. Paddy residues: Paddy (Oryza sativa) is the widely grown crop in the district (78,073 ha, 69.12%). Rice husk and stalk are major constituents of the residue from paddy cultivation. The average higher calorific value of rice husk ranges from 2937.5 to 3461.31 kcals and lower value is from 2637.2 9 to 3161.2 5 kcals. The stalk is mainly used as fodder and husk is the main energy component in the residue.
b. Maize residues: Maize is one of the prominent crops in the district with a share of 3.68% of net sown area. Maize cobs are major residues from the crop which constitute about 30% of maize gain (Zea mays). Cobs are used to feed cattle or as fuel.
c. Bagasse: Sugarcane is an important cash crop in the district which is mainly used to prepare jaggery. Area used to grow sugarcane in the district is about 1,232 ha (1.09% of total sown area). Bagasse is a major residue from sugarcane which is left after extracting juice from it. The fibrous content in the sugarcane is the major contributor to the bagasse which is normally in the range of 30-32%. Bagasse is used as a fuel with wood in the process of producing jaggery from sugarcane juice which has a calorific value of 3500 kcals. Bagasse is also used to generate methane gas; 1 tonne of bagasse generates about 20 m^3 of combustible methane gas.
d. Oil seed: Ground nut is the most important and widely grown oil seed crop in the district followed by cotton. Ground nut is grown in 2949 ha (2.61%) where the total oil seed growing area is 3177 ha (2.81%). Sun flower is the other oil seed crop which is grown in the district (228 ha). About 1,878 ha (1.66% of net sown area) of area is under cotton which produces oil seeds. About 30% of the ground nut pod consists of shell which is used as residue has an average higher calorific value of about 4532.15 kcal/kg and the lower calorific value of about 4248.5 8 kcal/kg.

Figure 9.12 gives the annual energy available from agricultural residues in the district, which ranges from 250 million kWh to 90,000 million kWh per year. In majority of the villages (895 villages) of Yellapur, Supa, Siddapur, Sirsi and Kumta Taluks energy availability from agricultural residues is less than 250 million kWh per year. Some villages in Ankola, Sirsi, Siddapur and Haliyal Taluks get the annual energy from agricultural residues about 250 to 500 million kWh. Similarly, some villages in Karwar, Ankola and Haliyal Taluks have annual energy from agri-residues of 500 to 2,000 million kWh. In very few villages in the district (Mundgod taluk), energy from agricultural residues is more than 10,000 million kWh per year and the maximum availability is about 90,000 million kWh per annum.

Bio energy from Horticulture: Plantation crops (cash crops) such as areca (Areca catechu), coconut (Cocos nucifera), cashew (Anacardium occidentale), banana (Musa accuminata), cardamom (Elletaria cardamomum), cocoa (Theobroma cacao), pepper and spices are the major crops (32,953 ha, 29%) next to paddy in the district. There is an increasing trend in growing these crops in the district due to their commercial value. Coastal belt takes the major share in growing coconut crop and areca is grown in almost all the taluks. Area under areca crop is increasing with a higher rate in recent years which has become the crop of major income in Kumta, Honnavar, Ankola, Sirsi, Siddapur and part of Yellapur taluks. Cashew is a seasonal bearing plant which is normally grown in hilly or in waste land in the district. Cardamom, cocoa tree and spices are grown with areca and coconut plantations (1,675 ha) in the district which have higher trade value in the market. Horticulture crops are also the important source of residues which mainly contains combustible bio mass.

Horticulture residues

a. Areca residues: Areca is the most growing crop after paddy in the district. Fuel biomass extracted from areca is leaves, inflorescence, and husk and leaf sheath. Areca husk is the outer cover of areca fruit which accounts for 60-80% of the total volume (fresh weight consideration). It is normally used to cover the field or as mulch rather than used as fuel. It can be used in the manufacture of card boards, paper boards etc and properly composted husk can be good organic manure. On average 5-6 leaves can be obtained from each areca tree per year. It is used to prepare manure, to cover edges of cannels agricultural land, as fuel bio mass and to feed cattle. Used and throw (single use) plates and cups, hats and other decorative items manufactured by sheaths are getting attention of people in the district and state wide.

   Areca leaves are used as thatching materials and to cover areca gardens. These are the good source of manure and also combustible bio mass. Other residues such as inflorescence and trunk of the tree are used as fuel. Trunk is mainly used for construction and when it dries and become strength less it will be used as fuel.
b. Coconut residues: Coconut residues are mainly used for combustion (fuel bio mass) which are leaves, inflorescence, shells, husk and leaf sheath. Coconut husk is widely used for making coir, mats, rope and also used to cover coconut plantations. It is dried and used as main fuel for water heating during rainy season in the district. Shells are mainly used as fuel which has higher combustion value. Coconut shell charcoal production is gaining importance since it has a market value. Leave of coconut palms are used to cover houses and other plantation fields. Leaves are used to produce groom sticks which can be trade in the market.
c. Other residues: Other residues generated from horticulture crops are due to cashew cocoa and banana plantation. Cashew is one of widely grown cash crop in Uttara Kannada. Cashew shell husk is the major residue from the crop followed by the fuel wood from tree branches. Cocoa tree is sparsely grown in the district from which fuel wood and leaves are extracted as residues. Main Residue of banana plantation is leaves which are used instead of plates for serving the food and in cooking; also leaves are used to cover the plantation. However the banana tree will not produce any combustible residues.

Figure 9.13 gives the annual energy availability from horticultural residues in the district. In many taluks in the district namely Sirsi, Siddapur, Yellaour, Haliyal, Mundgod and Supa the annual availability of energy from horticultural residues is less than 250 million kWh per annum. Few villages (126) in the eastern part of Ankola taluk have 250 to 500 million kWh. In some villages of Honnavar and Karwar taluks, annual energy availability from horticultural residues ranges from 500 to 2,000 million kWh. Very few villages in the district have availability of energy from horticultural residues more than 10,000 million kWh.

Figure 9.14 gives the combined annual energy availability from agriculture and horticulture residues. In majority of the villages annual energy availability is less than 250 million kWh per annum. There are some villages in the district where energy availability rages from 250 to 500 million kWh (155 villages) and 500 to 2,000 million kWh (225 villages). In 159 villages of eastern part of Ankola, Mondgod and Haliyal energy from horticulture and agri residues in the range 2,000 to 10,000 million kWh. In nine villages, available energy is more than 10,000 million kWh which extends up to 90,000 million kWh.

Biogas resource status: Livestock a vital component of agrarian ecosystem, provides milk and manure. Other uses of livestock are for wool, for meat, transportation and for ploughing (or sowing). Animal residue from livestock aid in recharging the essential nutrients of soil. It also boosts the quality of the organic manure which increases the soil fertility.

Farmers in Uttara Kannada are very much dependent on livestock for their agriculture and horticulture practices. Animal residue is the main feedstock for the production of biogas as well as manure. There are about 3,66,949 cattle, 1,18,669 Buffaloes, 2,702 Sheep, 11,994 Goats in Uttara Kannada. Other members of livestock are Pigs (900), Dogs (93,403) and Rabbits (277). Total livestock population in the district is about 5,94,929 and poultry population is 3,61,351. Dung available from each cattle varies from 3-4 kg to 8-10 kg (from coastal to hilly region). Similarly average dung produced from a buffalo is 12-15 kg and from a hybrid one is 15-18 kg. By considering 3 kg dung production from a cattle in coastal area and 8 kg in hilly area, total dung production from cattle is about 6,32,058.46 tonnes per year. Similarly by considering the dung production per buffalo as 12 kg/day, total dung obtained is 5,19,770.22 tonnes per year. Assuming gas production of 0.036 m^3 per kg of dung, total biogas generated will be 41,465 thousand m^3 per year. National per capita natural gas consumption is about 54 m^3 per annum; then the biogas produced from livestock residue could meet the 50% of the gas demand in Uttara Kannada district. (100% dung produced is considered to generate biogas).

Figure 9.15 gives the annual biogas production from livestock residues in Uttara Kannada. It is evident that in majority of the villages in the district, annual biogas energy generated from biogas ranges from 0.1 to 0.5 million kWh. In 340 villages of Mundgod, Haliyal, Karwar and Siddapur taluks biogas energy generation is 0.5 to 1 million kWh. Few villages in Bhatkal, Honnavar and Mundgod taluk have biogas based energy production of 1-12 million kWh per annum.

Figure 9.16 gives the availability to demand ratio of biogas resource in the district. In more than 50% of the villages (625 villages) the availability is less than demand; which are called biogas energy deficit regions. In 334 villages of Siddapur, Yellapur and Supa taluks supply to demand ratio is between 1 and 2. There are 275 villages in Ankola, Mundgod and eastern Yellapur taluk, availability is more than twice of biogas demand. About 40% of the villages have adequate biogas potential to meet the domestic needs. These villages are to be considered for dissemination of biogas technology in the district.

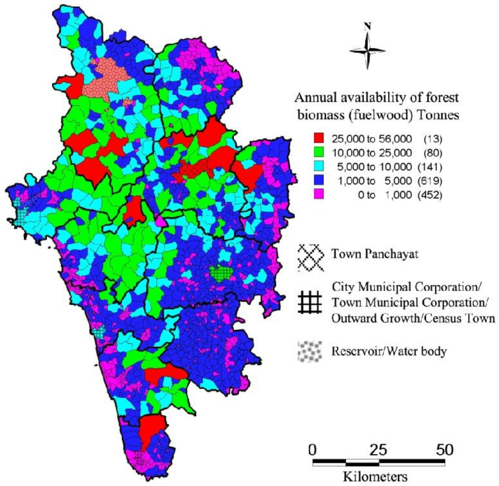


Figure 9.10: Availability of forest biomass (fuel wood) in tonnes/annum

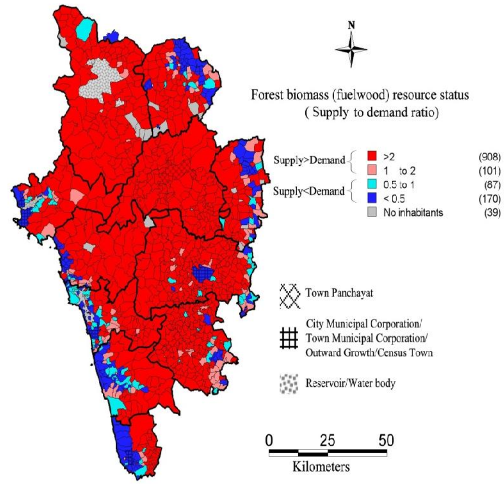


Figure 9.11: Fuel wood resource status (Supply to demand ratio)

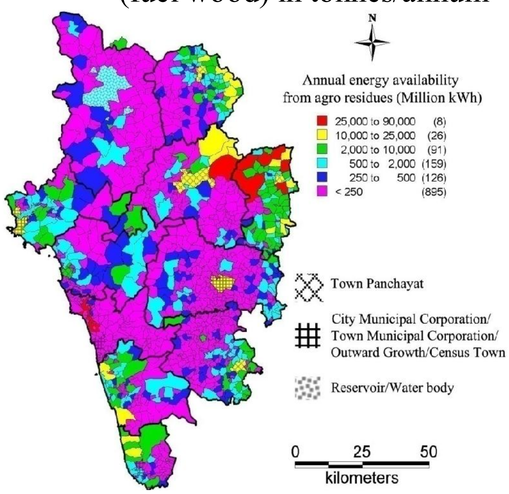


Figure 9.12: energy from agricultural residues

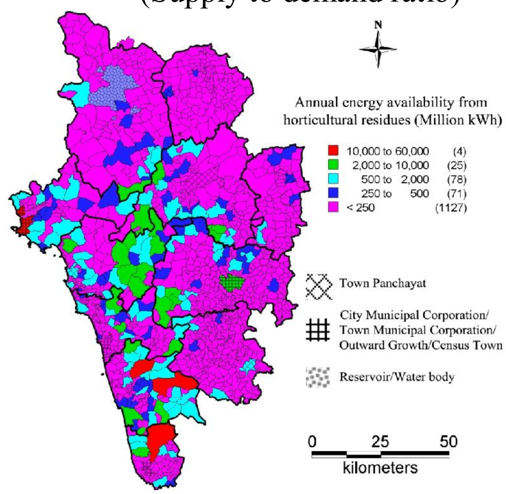


Figure 9.13: energy from horticultural residues

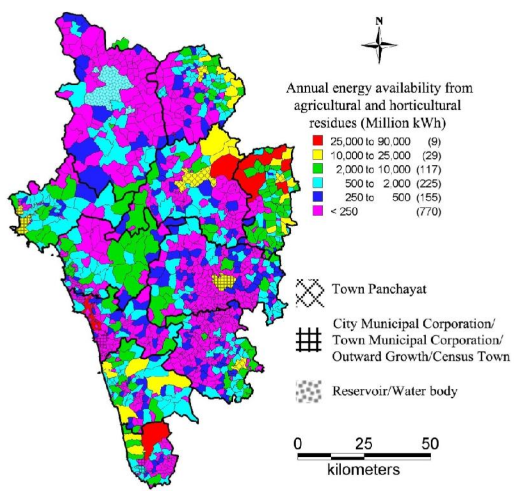


Figure 9.14: Annual energy availability from agricultural and horticultural residues

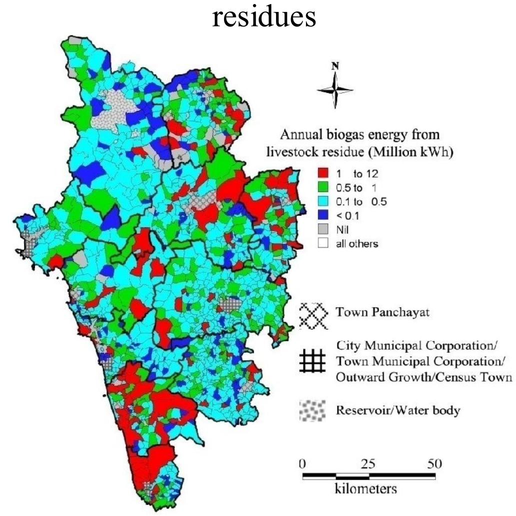


Figure 9.15: Annual biogas production from livestock residues in Uttara Kannada

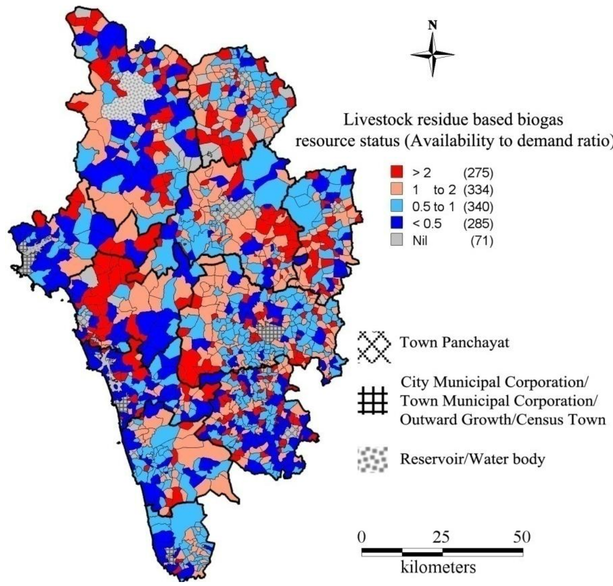


Figure 9.16: Biogas resource status (supply to demand ratio)

In Uttara Kannada district, bio energy meets the household energy demand. The supply/demand ratio of bioresources in the district ranges from less than 0.5 (Bioresource deficit) to more the 2. The coastal and the extreme eastern part of the district (coastal villages of Karwar, Ankola, Kumta, Honnavar and Bhatkal with eastern part of Mundgod and Haliyal) are the fuel wood deficit places. The bioresource supply is dwindling in the district evident from the reduced bioresource supply to demand ratio from 8-9 (in 1990's) to 2. This necessitates sustainable management approaches with augmentation of forest resources.

In coastal regions (Kumta, Honnavar, Ankola, Bhatkal, Karwar), availability of agro-horticultural residues is more than the current demand which has the potential to meet the rural household energy demand. Similarly in Sirsi, Siddapur and Yellapur taluks, forest biomass potential could meet the energy demand. In Mundagod, Haliyal and in coastal villages, availability of animal residues provides the scope for biogas production. About 40% of the villages have adequate biogas potential to meet the domestic needs. These villages are to be considered for dissemination of biogas technology in the district. Biogas can also be used for electricity generation and the byproduct, i.e. slurry is used for organic manure production which is a very good fertilizer.

10.0 INVENTORISATION AND MAPPING OF BIODIVERSITY (TERRESTRIAL, AQUATIC-FLORA, FAUNA)

Task 2: Inventorisation and mapping of biodiversity (terrestrial, aquatic-flora, fauna).

1. Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India
2. Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
3. Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 20, ENVIS Technical Report: 50, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
4. Ramachandra T V, Subash Chandran M D, Joshi N V, Gururaja K V, Sameer Ali and Vishnu Mukri, 2012. Amphibian Diversity and Distribution in Uttara Kannada District, Karnataka, Sahyadri Conservation Series 18, ENVIS Technical Report: 47, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
5. Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
6. Subash Chandran M. D., Rao G. R., Vishnu Mukri, Prakash Mesta and Ramachandra T V, 2011. Grasslands of Anshi-Dandeli Tiger Reserve, ENVIS Technical Report: 36, Sahyadri Conservation Series 12, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
7. Subash Chandran M. D., Prakash Mesta, Boominathan M., Rao G. R., Vishnu D.M. & Ramachandra T.V., 2011. Aghanashini Estuary in Kumta Taluk, Uttara Kannada - Biological Heritage Site, ENVIS Technical Report: 35, Sahyadri Conservation Series 11, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
8. Gururaja K V and Ramachandra T V, 2011. Anuran diversity and distribution in Dandeli Anshi Tiger Reserve, ENVIS Technical Report: 37, Sahyadri Conservation Series 8, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
9. Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, and Shalini Kumar, 2012. Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 6, ENVIS Technical Report : 22, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
10. Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, Ajay Narendra and Ali T.M., 2012. Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 3, ENVIS Technical Report : 20, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
11. Sumesh Dudani, Mahesh M K, Vishnu Mukri, Subash Chandran M D and Ramachandra T V, 2013. An appraisal and conservation strategies for the pteridophytes of Uttara Kannada, CES Technical Report 129, Centre for Ecological Sciences, IISc, Bangalore

10.1 **FLORISTIC DIVERSITY IN UTTARA KANNADA DISTRICT**

The forests are valuable resources on innumerable counts viz. as sources of various useful products to humans, for their environmental and ecosystem services (soil and water conservation, regulation of water flow, carbon sequestration, nutrient cycling, etc.) and as centres of biodiversity. Out of the total 329 million ha land area of India, 43% is under cropping and 23% classified as forests. The total area of forest cover in India, as per the latest assessment is about 692,027 km^2 or 21.05% of the total geographical area.

The Western Ghats range of hills, running close and parallel to the Arabian Sea along the western Peninsular India for about 1600 km from the south of Gujarat to Kanyakumari, covers an area of about 1,60,000 sq.km. This region harbours very rich flora and fauna and there are records of over 4,000 species of flowering plants (38% endemics). Western Ghats is among the 34 global biodiversity hotspots on account of exceptional plant endemism and serious levels of habitat degradation. The complex geography, wide variations in annual rainfall from 1000-6000 mm, and altitudinal decrease in temperature, coupled with anthropogenic factors, have produced a variety of vegetation types in the Western Ghats. While tropical evergreen forest is the natural climax vegetation of the more humid western slopes, along the rain-shadow region eastwards vegetation changes rapidly from semi-evergreen to moist and dry deciduous forests, the last one being characteristic of the semi-arid Deccan region as well. Lower temperature, especially in altitudes exceeding 1500 m, has produced a unique mosaic of montane 'shola' evergreen forests alternating with rolling grasslands, mainly in the Nilgiris and the Anamalais. All these types of natural vegetation are prone to or have already undergone degradations due to human impacts.

Uttara Kannada district with 76% of its 10,291 sq.km area covered with forests has the distinction of having highest forest area. This is the northernmost coastal district of Karnataka State (13.9220^o N to 15.5252^o N and 74.0852^o E to 75.0999^o E) has a geographical area of 10, 291 km^2. Topographically the district can be divided into three zones – the narrow and relatively flat to low hilly coastal along the west of Karwar, Ankola, Kumta, Honavar and Bhatkal taluks; the precipitously rising main range of Western Ghats towards the eastern interior of these taluks, the crestline zone composed of Sirsi, Siddpur Supa and Yellapur taluks and Haliyal and Mudgod taluks towards the north-east flattening and merging with the Deccan Plateau. The district can be divided broadly into five vegetation zones namely: Coastal, Northern evergreen, Southern evergreen, Moist deciduous and Dry deciduous. The evergreen to semi-evergreen forests form major portion of the district especially towards the more rainy western parts. Towards the eastern rain-shadow portion, the forests change rapidly into moist and dry deciduous types.

Whereas substantial areas of natural forests, through forestry practices over a period of more than one century, have been converted into monoculture tree plantations of teak, eucalypts (in the past) and into Acacia plantations in recent decades, there also remained in many places blocks of ancient patches of evergreens, known as *kans*, which were or still are sacred to the local people being the seats of village deities. These are relatively less impacted areas of climax evergreen forests, being sacred groves protected by the people through generations. Being preserved forests from ancient times these *kans* or their remains still might harbor rare species of plants, with high degree of Western Ghats endemism, and also endemic faunal elements. Eg. Asollikan (Ankola), Kathalekan (Siddapur), Karikan (Honavar) etc.

Slash and burn cultivation that prevailed almost till close of 19th century, especially in the heavy rainfall zone created considerable areas of secondary forests that replaced primary evergreen. Wherever clear felling has taken place in the past in the heavy rainfall belt, for shifting cultivation or under forestry operations, very sensitive evergreens and those without coppicing character tend to vanish. Old growth forests in stages of late secondary almost resemble the primary forests. But conspicuously absent in them are climax evergreen forest trees like *Dipterocarpus indicus, Vateria indica, Palaquium ellipticum*, and species confined to Myristica swamps like *Myristica fatua (M. magnifica),* etc. The forests bearing centuries of history is a grant mosaic of evergreen and semi-evergreen to secondary moist deciduous (in the high rainfall areas) to deciduous types. These are intermingled in many places with degraded stages like savannah, and scrub or entirely changed into grassy blanks used for cattle grazing, which within forest zone also have crucial role of supporting wild herbivores.

Karnataka has five National Parks and 21 Wildlife Sanctuaries. Uttara Kannada has mainly two important protected areas namely Anshi National Park and Dandeli Wildlife Sanctuary. These two PAs are brought together under Dandeli-Anshi Tiger Reserve with focus on tiger conservation. The DATR presently covers an area of 1365 sq.km. in the taluks Joida, Karwar and Haliyal. We could not carry out forest studies within the DATR due to want of permission from the Wildlife wing of Forest Department. However, prior to the imposition of restrictions on studies within Tiger Reserves we had carried out a study on the grassland resources within the Reserve. Recently (in 2011) Attivery Bird Sanctuary was declared in Mundgod taluk covering 2.23 sq.km area, mainly composed of a reservoir and its peripheral areas.

Conservation Reserves are a new concept within the framework of PAs under the Wildlife (Protection) Amendment Act of 2002. They seek to protect habitats that are under private ownership also, through active stakeholder participation. They are typically buffer zones or connectors and migration corridors between established national parks, wildlife sanctuaries and other RFs. They are designated as conservation reserves if they are uninhabited and completely owned by the government but used for subsistence by communities, and community reserves if part of the lands are privately owned. Administration of such reserves would be through joint participation of forest officials and local bodies like gram sabhas and gram panchayats. They do not involve any displacement and protect user rights of communities. In Uttara Kannada, four such Conservation Reserves were set up by the Government of Karnataka:

i. **Aghanashini LTM Conservation Reserve** (299.52 sq.km), to protect Lion tailed macaque and Myristica Swamps.
ii. **Bedthi Conservation Reserve** (59.07 sq.km) as Hornbill habitats and for medicinal plant species like *Coscinium fenestratum*.
iii. **Shalmala Riparian Eco-system Conservation Reserve** (4.89 sq.km) for conservation flora and fauna of a riverine ecosystem and
iv. **Hornbill Conservation Reserve** (52.5 sq.km) covering part of Kali River basin for specifically hornbill conservation.

The current study investigated f*loristic diversity associated with different forests and computes basal area, biomass and carbon sequestration in forests. Apart from this inventorying and mapping of endemic tree species has been done to find out areas of high endemism and congregations of threatened species. A set of criteria for holistic conservation of forest ecosystems, particularly of high endemism of Western Ghats*

has been prepared based on field investigation, interaction with stakeholders (researchers working in this region, forest officials, local people, subject experts)
Forests of all major kinds were studied using transect cum quadrat methods (altogether 116 transects, each transect with five quadrats of 400 sq.m each for tree vegetation, 10 sub-quadrats each of 25 sq.m for shrubs and tree saplings and 20 subquadrats of one sq.m for herb layer diversity. Out of 116 transects 8 were studied using point-centre quarter method). Altogether for tree vegetation 540 quadrats, each of 400 sq.m were studied. Necessary permission was, however, not granted for forest studies within the Dandeli-Anshi Tiger Reserve areas.

Altogether 1068 species of flowering plants were inventorised during the study period, through sample surveys and opportunistic surveys outside the transect zones. These species represented 138 families. Of these 278 were trees species (from 59 families), 285 shrubs species (73 families) and 505 herb species (55 families). Moraceae, the family of figs (*Ficus* spp.), keystone resources for animals, had maximum tree sp (18), followed by Euphorbiaceae (16 sp.), Leguminosae (15 sp.), Lauraceae (14 sp.), Anacardiaceae (13 sp.) and Rubiaceae (13 sp.). Shrub species richness was pronounced in Leguminosae (32 sp.), Rubiaceae (24 sp.) and Euphorbiaceae (24 sp.). Among herbs grasses (Poaceae) were most specious (77 sp.), followed by sedges (Cyperaceae) with 67 sp. Orchids (Orchidaceae) were in good number.

Tropical forests are major reservoirs of carbon in the terrestrial areas of the planet which is confronted with the prospects of imminent climatic change. World over all countries need to be alert to this major catastrophe. Apart from regulating pollution levels from various sources carbon sequestration in biomass has to be increased considerably. Our estimates on carbon sequestration based on tree biomass estimates from 116 forest samples show that the average carbon sequestration per hectare of forest (barren areas, scrub and grasslands excluded from sampling) was 154.251 ha.

It is a significant find that the sacred *kan* forests of pre-colonial era, despite their merger with state reserved forests, and subjection of most to timber extraction pressures in the post-independence era, continue to lead the chart of sites having some of the highest carbon sequestration per unit area. **Thus the *kan* forest adjoining the Karikanamman temple in Honavar taluk had the highest carbon sequestration at 363.07 t/ha in the tree biomass alone. This is followed by Tarkunde-Birgadde in Yellapur (357.67 t/ha), and some of the swamp-stream forest samples in Kathalekan (299.66 t/ha, 275.18 t/ha, 259.21 t/ha etc.). Likewise Kanmaski-Vanalli in Sirsi had 242.43 t/ha of carbon.**

The lowest carbon sequestered was found to be in the savannized forests, for obvious reasons of low to very low number of trees in them. These savannas whether they be in high evergreen forest belt (in Siddapur or Joida for instance) or be in drier zone of Haliyal or Mundgod have carbon storage of <50 t/ha in the tree biomass. Savannization was a necessity in the past for agricultural occupation of humans in the Western Ghats, for cattle grazing and slash and burn cultivation. Today the process is repeating to some extent still as forest encroachments have happened rampantly in all taluks increasing the porosity of otherwise in tact forests. Most bettalands allotted to arecanut orchard owners for exercising the privilege of leaf manure collection are in poor state of biomass and carbon sequestration (Eg. 14.19 t/ha in Gondsur-Sampekattu betta in Sirsi, Talekere betta in Siddapur 41.47 t/ha).

The report highlights the importance of conservation of riparian forests occurring along streams and swamps, not only from high species endemism but also for higher carbon sequestration. A very detailed study in Kathalekan involving nine samples of such forests versus nine samples away from such water courses reveal that the average carbon sequestration in the former was 225.506 t/ha against 165.541 t/ha in the latter. This is despite the fact both types occur within what is traditionally designated as a *kan* forest. We therefore recommend that forests adjoining or covering streams, swamps and riverbanks of the Western Ghats be considered sacrosanct and as critical areas for hydrology not only of the coast but of the entire Indian peninsula.

The report has paid substantial attention to the **evaluation of RET and endemic forest species,** from local, regional and global perspectives. As regards trees are concerned, in principle, **there are close associations between areas of rich tree endemism and occurrence of RET tree species. Forests with high tree endemism also tend to shelter endemic/RET non-tree species and fauna- especially fishes and amphibians- which are indicators of other such organisms as well. Tree species in danger of local or total extinction mainly exist in and closer to the Myristica swamps. These include *Syzygium travancoricum* (Critically Endangered), *Myristica fatua (M. magnifica)* (Endangered), *Gymnacranthera canarica* (Vulnerable), *Semecarpus kathalekanensis* (newly discovered), *Mastixia arborea* (rare endemic) etc. *Madhuca bourdillnoni,* a Critically Endangered tree, was not in our samples, but occurred very sparingly close to some Myristica swamps. The Kathalekan swamp forest sheltered at least 35 species of amphibians, most of them within a range of few hundred meters. While 26 species (74%) of them were Western Ghat endemics, one species *Philautus ponmudi* is Critically Endangered and five species each were Endangered and Vulnerable.** Scores of *Myristica* dominated forest swamps would have perished in the Western Ghats in past centuries having given way to human impacts, notably due to reclamation of primeval forest clad valleys for making rice fields and arecanut-spice orchards. The last remains are also under threat, mainly being looked upon for areca orchards by encroachers. Swamps being excellent sources of perennial streams we recommend tracing out all such swamps and potential swamps (of degraded vegetation or waters diverted for agriculture) for hydrological needs. The swamps along with their catchments, even if they have secondary forests, need to be safeguarded as prime areas of hydrological significance and as the last refugia of rain forests in the central Western Ghats.

Identification and prioritisation of `hotspots', is done for areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat. The focus is more on endemic species, rather than populations or other taxa, as the most prominent and readily recognizable form of biodiversity.

Using a grid system (preferably 1x1 km) of forest surveying we need to have a proper stock of the distribution of endemic tree species, and demarcate areas of high tree endemism for prioritization of conservation as such areas are also good for endemic faunal elements and for their hydrological importance.

Centres of high floristic endemism (of especially trees) are also the centres of endemic fishes in the streams draining them, in addition to amphibians and birds.

The role of man-made plantations needs a re-evaluation, in the light of high soil erosion, weed infestation, poor hydrology and poor associated faunal diversity as compared to natural forests. The teak plantation areas in general, despite the high value of teak timber, were found to have lower biomass and needs enrichment planting by NTFP species, nectar species for honey bee promotion, Soil erosion from forests and forest plantations is a matter of grave concern. As rains are often very high (upwards of 3000 mm/per annum) in most places, and so much of rains fall within a short period of mostly four months a dense forest cover is required to check soil erosion and increase infiltration into the ground water. Here we recommend eventual conversion of deciduous forests and their degradation stages (except grasslands or grassy blanks, critical resources for grazing ecosystems) in heavy rainfall zone into evergreen forests. Poor grade tree plantations with eroded soils need to be restored with natural forest species through planting of saplings and dibbling of seeds.

Forest restoration in the catchment areas of rivers will improve perennial nature of streams ensuring perpetual inflow of clear water into the storage dams of hydroelectric projects in Sharavathi and Kali rivers than bringing into them an onrush of water turbid with soils down the poorly vegetated terrain. The active monsoon period being of four months it is necessary to increase residency of water within the watershed soils than releasing it en mass into the reservoirs or other downstream areas as surface water, which eventually get lost through faster evaporation in the prevailing climatic conditions.

The species chosen for forest enrichment/afforestation should have strong bearing on a. increase in endemism; b. more of ecologically site specific NTFP species; c. benefit to birds and bats and other frugivorous animals and d. favour populations of wild bees and create employment opportunities through bee-keeping and enhance pollination services of both cultivated crops and forest plants.

A system for assigning conservation values to the forest patches based on characteristics of tree communities has been adopted here. **Assignment of conservation priorities is based mainly on five variables of forests namely: a). % evergreenness, b). % endemism, c). basal area, d). tree height and e). Shannon diversity index.** Principal component analysis based on the first four variables revealed that evergreenness of the forests is strongly linked to the presence of endemic trees. Higher the evergreen components more endemics congregate in such areas. Basal area and tree heights are linked to other two factors – but not so strongly as these two are subjected to rapid fluctuations depending on human impacts. Relative correlation between these five factors was obtained through application of Pearson correlation matrix. A composite conservation index is prepared for the 116 forest samples using scores allotted to the factors %endemism, mean canopy height, basal area and diversity index (Table 10.1 and 10.2). Additionally the presence of IUCN Red Listed trees (Table 10.3), if any, were given high conservation score- the actual score depending on the category of threat.

Table 10.1: Criteria for composite index for biodiversity conservation importance ranking in Uttara Kannada

Parameter		Score	Parameter		Score
Average height (m)	14-15	5	**Basal area (m²)**	20-30	5
	15-16	7		30-40	7
	16-17	9		40-50	9
	17-18	11		50-60	11
	18-19	13		60-70	13
	19-20	15		70-80	15
	20-21	17		80-90	17
Endemism%	20-30	5	**Threatened species**	Vulnerable	10
	30-40	10		Endangered	20
	40-50	15		Critically Endangered	30
	50-60	20		New species	30
	60-70	25			
	70-80	30			
	80-90	35			
Diversity index (Shannon)	1-2	5			
	2-3	7			
	3-4	9			
Add value for all transects		20			

Table 10.2. Composite conservation index, based on total site ranking score, for 116 forest samples

Tr. No.	Asolli-1 Asolli-2	**Taluk**	**Score for parameters**					**Add value**	**Total**
			Height	**Basal area**	**Endemism**	**Threatened sp**	**Diversity**		
1	Hosakere	Ankola	11	7	20	50	7	20	115
2	S1-Katangadde-Agasur	Ankola	13	7	30	50	7	20	127
3	S2-Balikoppa-Badgon	Ankola	9	7	20	20	7	20	83
4	S3-Hegdekoppa-Kasinmakki	Ankola			5		9	20	34
5	S4-Vajralli-Ramanguli	Ankola	5	5			7	20	37
6	Kachinabatti	Ankola	7	7			9	20	43
7	Maabagi	Ankola	5			20	7	20	52
8	Dakshinakoppa	Ankola	9				7	20	36
9	Gujmavu (semi evergreen)	Ankola	11	9	5	20	9	20	74
10	Hudil (evergreen)	Bhatkal	9	7			5	20	41
11	Hudil (semi evergreen)	Bhatkal	9	7	25	25	7	20	93
12	Golehalli	Bhatkal	13	7	35		5	20	80

13	Kudalgi-Tatigeri	Bhatkal	9	9	10		7	20	55
14	Magvad	Haliyal				7		20	27
15	Sambrani	Haliyal						20	20
16	Yadoga	Haliyal	7	5				20	32
17	Ambepal-1	Haliyal		7				20	27
18	Ambepal-2	Haliyal	7	5				20	32
19	Chaturmukhabasti	Honavar	15	7	15	40	7	20	104
20	Gersoppa	Honavar	17	9	25	40	9	20	120
21	Gundabala	Honavar	7	5	10		7	20	49
22	Hadageri-1	Honavar	13	7	20	20	9	20	89
23	Hadageri-2	Honavar	9	5	10	20	9	20	73
24	Halsolli	Honavar	17	11	20	40	7	20	115
25	Hessige-1	Honavar	17	9	20	40	7	20	113
26	Hessige-2	Honavar	17	7	30	30	5	20	109
27	Hessige-3	Honavar	13	9	15		7	20	64
28	Hessige-4	Honavar	11	9	15	20	7	20	82
29	Kadnir	Honavar	11	7	5	20	7	20	70
30	Karikan-lower slope	Honavar	13	11	10		9	20	63
31	Karikan-semievergreen	Honavar	9	7	25	20	7	20	88
32	Karikan-temple side-diptero patch	Honavar	5	9	25	40	7	20	106
33	Mahime	Honavar	7	7	25	40	7	20	106
34	Sharavathy-viewpoint	Honavar	13	17	30	40	7	20	127
35	Tulsani-1	Honavar	11	7	5		7	20	50
36	Tulsani-2	Honavar	13	7	25	20	7	20	92
37	Castlerock IB	Honavar	13	7	25	20	7	20	92
38	Castlerock-moist-dec.	Honavar	11	7	35	20	5	20	98
39	Castlerock-semi everg	Joida	9	11	30	20	9	20	99
40	Desaivada-Nandgadde	Joida					7	20	27
41	Gavni-Kangihole-Joida	Joida	9	5	5		7	20	46
42	Ivolli-Castlerock	Joida	11	7			5	20	43
43	Joida-deciduous	Joida	7	9	20		7	20	63
44	Kushavali	Joida	5	7	25		5	20	62
45	Shivpura	Joida	11	9			7	20	47
46	Gopishetta	Joida	11	15	10		7	20	63
47	Goyar-moist dec	Joida	9	11			5	20	45
48	Kalni-goyar	Karwar	7	7			7	20	41
49	Karwar-moist dec	Karwar	7	7			7	20	41
50	Devimane-Campsite	Karwar	13	9	25		7	20	74
51	Devimane-Sirsi side	Karwar					7	20	27
52	Devimane-temple	Kumta	11	9	25	20	9	20	94
53	Devimane-with myristicas	Kumta	7	9	20	20	7	20	83

54	Hulidevarakodlu	Kumta	7	9	20	20	7	20	83
55	Kalve	Kumta	7	9	30	20	7	20	93
56	Kalve-moist dec.	Kumta	13	9	20		7	20	69
57	Kandalli-Devimane	Kumta	9	5	25	20	7	20	86
58	Mastihalla-Devimane arch	Kumta	7	5			7	20	39
59	Mathali-Kandalli-Devimane	Kumta	9	9	30	20	7	20	95
60	Soppinahosalli	Kumta	9	9	25	20	7	20	90
61	Surjaddi	Kumta	9	9	25	20	7	20	90
62	Surjaddi-Morse	Kumta	7	5			7	20	39
63	Attiveri-teakmixed-dry dec	Kumta	13	7	25	20	7	20	92
64	Godnal	Kumta	11	7	25	20	7	20	90
65	Gunjavathi	Mundgod					7	20	27
66	Karekoppa-Gunjavathi	Mundgod	9	9			5	20	43
67	Katur	Mundgod	7	5			5	20	37
68	Katur to Gunjavati	Mundgod	11	7			5	20	43
69	G1-Kathalekan-nonswamp	Mundgod	11	5			5	20	41
70	G2-Kathalekan-nonswamp	Mundgod		5			7	20	32
71	G3-Kathalekan-nonswamp	Siddapur	7	7	20	40	9	20	103
72	G4-Kathalekan -nonswamp	Siddapur	9	7	25	50	9	20	120
73	G5-Kathalekan-nonswamp	Siddapur	9	9	25	40	9	20	112
74	Kathalekan-savanna	Siddapur	11	7	20	40	9	20	107
75	G6-Kathalekan-nonswamp	Siddapur	5	9	20	40	9	20	103
76	G7-Kathalekan-nonswamp	Siddapur					5	20	25
77	G8-Kathalekan- nonswamp	Siddapur	13	11	20	40	7	20	111
78	G9-Kathalekan-nonswamp	Siddapur	11	5	20	40	9	20	105
79	Hartebailu-soppinabetta	Siddapur	9	9	25	80	7	20	150
80	Hutgar	Siddapur	9	9	30	40	5	20	113
81	Joginmath-1	Siddapur			15		7	20	42
82	Joginmath_2-semievergreen	Siddapur	9	7	25		7	20	68
83	Kathalekan-1	Siddapur	11	7	5		9	20	52
84	Kathalekan-2	Siddapur	13	9	5		7	20	54
85	Kathalekan –swamp-1	Siddapur	11	5	20	20	9	20	85
86	Kathalekan –swamp-2	Siddapur	11	7	15	40	9	20	102
87	Kathalekan –swamp-3	Siddapur	11	9	30	80	9	20	159
88	Kathalekan –swamp-4	Siddapur	7	9	30	70	7	20	143
89	Kathalekan –swamp-5	Siddapur	9	15	30	70	9	20	153
90	Kathalekan –swamp-6	Siddapur	11	13	35	70	7	20	156
91	Kathalekan –swamp-7	Siddapur	9	9	30	100	7	20	175
92	Kathalekan –swamp-8	Siddapur	9	9	30	100	7	20	175
93	Kathalekan –swamp-9	Siddapur	9	7	20	70	7	20	133
94	Kathalekan-3	Siddapur	13	11	35	100	7	20	186

95	Malemane-1	Siddapur	15	13	25	70	9	20	152
96	Malemane-2	Siddapur	9	5	10	60	9	20	113
97	Malemane-3	Siddapur	11	7	15	40	9	20	102
98	Siddapur evergreen	Siddapur	15	7	25	40	9	20	116
99	Talekere	Siddapur	13	9	25	40	7	20	114
100	Bugadi-Bennehole	Siddapur	13	7	15	20	7	20	82
101	Gondsor-sampekattu	Siddapur			30	20	5	20	75
102	Hulekal-Sampegadde-Hebre	Sirsi	7	11	15		9	20	62
103	Kanmaski-Vanalli	Sirsi					7	20	27
104	Khurse	Sirsi	9	11	20		9	20	69
105	Masrukuli	Sirsi	7	11	20	20	7	20	85
106	Hiresara-bettaland	Sirsi		5		20	7	20	52
107	S5-Gidgar-Yemmalli	Sirsi	7	9			7	20	43
108	S6-Tarukunte-Birgadde	Yellapur		9		20	5	20	54
109	S7-Arlihonda-Nandvalli	Yellapur	15	9			9	20	53
110	S8-Yellapur-Mavalli	Yellapur	17	17	15		9	20	78
111	S9-Kiruvatti	Yellapur	9	7	5		9	20	50
112	Hasrapal-evergreen	Yellapur	13	7	10		9	20	59
113	Hulimundgi-semievergreen	Yellapur	11				5	20	36
114	Lalguli-moist-dec	Yellapur	15	7	20		7	20	69
115	Asolli-1	Yellapur	13	7	5		7	20	52
116	Asolli-2	Yellapur	11	9			7	20	47

Table 10.3: The IUCN Red listed tree species found in various transects

Red listed species	**Family**	**Category**	**Locations**	**Taluk**	**Remarks**
Gymnacranthera canarica	Myristicaceae	Vulnerable	Alsolli 1, Alsolli 2 Halsolli Kathalekan G1, G2 Kathalekan swamp T1, T2, T3, T4, T5, T6	Ankola Honavar Siddapur Siddapur	Confined to Myristica swamps only
Myristica fatua	Myristicaceae	Endangered	Halsolli Kathalekan swamps T1, T2, T5, T9	Honavar Siddapur	Confined to Myristica swamps only. In relics of primary forests
Dipterocarpus indicus	Dipterocarpaceae	Endangered	Alsolli 1, Alsolli 2 Ambepal 1, Ambepal 2	Ankola Honavar Honavar Siddapur	New reports for Ankola in relics of primary forests.

			Hadageri 1, Hadageri 2 Karikan lower slope Karikan s.evergreen Karikan templeside Kathalekan non-swamp grids G1, G2, G3, G4, G5, G6, G7, G8 Kathalekan swamp grids T1, T2, T3, T4, T5, T6, T7, T8, T9		Northward range extention in Western Ghats
Hopea Ponga	Dipterocarpaceae	Endangered	Widespread in evergreen forests Honavar, Kumta, Siddapur, Sirsi and Ankola and sparingly in Karwar and Yellapur	Honavar, Kumta, Siddapur, Sirsi, Ankola, Yellapur Karwar	
Vateria indica	Dipterocarpaceae	Endangered	Kathalekan 3	Siddapur	Planted widespread in the district; natural in Mattigar kan, Siddapur
Syzygium travancoricum	Myrtaceae	Critically Endangered	Kathalekan G8, Kathalekan swamp T3, T6, T8, T5	Siddapur	Also found very sparingly in Ankola Ghats. Range extention in Uttara Kannada reported for first time
Semecarpus kathalekanensis	Anacardiaceae	New tree species	Kathalekan swamps T1, T2	Siddapur	New tree species reported

Highest conservation values are more for forests towards the south from Sharavathi Valley (Kathalekan-Malemane-Gersopppa stretch to the Aghanashini valley in Siddapur and to a small extent in Sirsi). Incidentally this stretch of forests, having the northernmost populations in the Western Ghats of the Endangered primate Lion-tailed macaque, of Myristica swamps and *Dipterocarpus* trees, has been already declared by the Government of Karnataka as Aghanashini LTM Conservation Reserve.

The study reveals that there is only a thin line difference between rain forests and deserts. Whereas the heavy rainfall of coast and malnadu taluks can potentially promote loftiest evergreen forests of Western Ghats many locations are characterized by poorer vegetation- poorer in biomass and in conservation ranking. The poorest savanna site exists on a hill top ironically in the Kathalekan forests of highest conservation value, dotted with Myristica swamps, by presence of lofty Dipterocarpus threatened and endemic plant and animal species (especially amphibians and LTM). Whereas the swamp forest samples of Kathalekan have average carbon sequestration of 225.506 t/ha the savanna patch has merely 5.06 t/ha. The land was savannized at least over 100 years ago by the shifting cultivators. Though today uninhabited the forest recovery has not taken place. Similar paradoxes exist between adjoining forest patches everywhere in the district.

Conservation values assigned for forest areas for prioritisation of conservation, using the composite index is given in Figure 10.1.

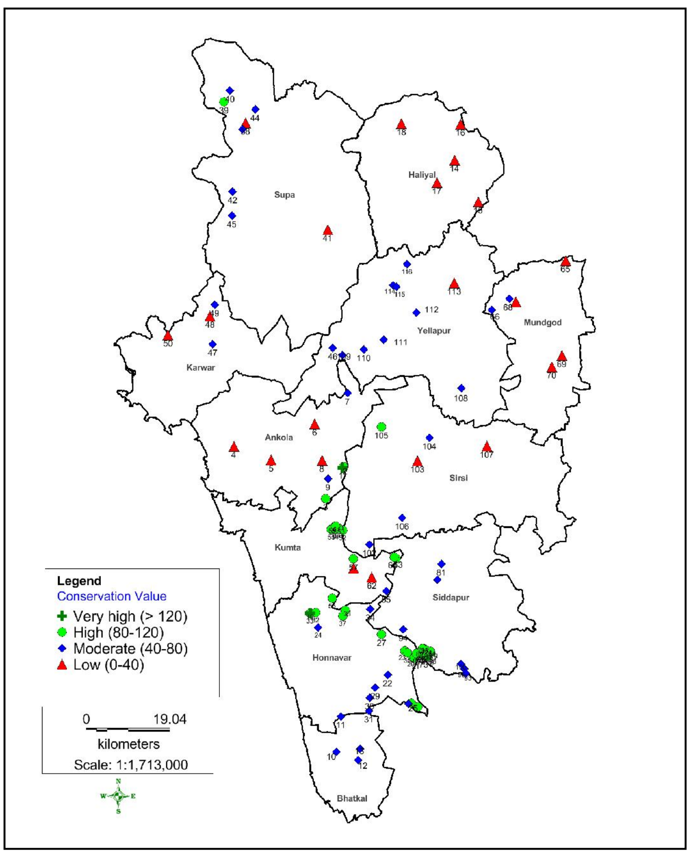


Figure 10.1. Tree diversity conservation values of forest stands in Uttara Kannada (for non-economic parameters)

Whereas in the earlier efforts towards conservation it was often the flagship species like elephant, tiger etc. and their habitats that captured major attention in the conservation priorities of the Government. Today, the Western Ghats, along with Sri Lanka constitute a hotspot of high endemism and significant threat of imminent extinctions. Therefore it has become necessary to evaluate and rank areas of high endemism, which we have attempted in this report through the application an objective method. Suggestions based on our sustained ecological research in Uttara Kannada district are:

- In the specter of climatic change that the planet is facing with its widespread implications especially on farming and biodiversity, the need has arisen to increase carbon sequestration in the forest areas. There are considerable areas of degraded forests in Uttara Kannada, the biomass of which has to be increased substantially through protection, enrichment and co-management.
- Inviolate forests should be identified range-wise for increased conservation efforts.
- Myristica swamps are among the oldest and original forest types of the Western Ghats. They have some of the highest degrees of floral and faunal endemism. Efforts should be made to make all out search for such swamps, record their locations and areas and conserve them along with their catchment area forests
- The *kan* forests and 'devarabanas' were **unique cultural identities** of bygone days. They still have portions harbouring deities and are seats of high endemism. As most of them got merged with state reserved forests they lost their pre-colonial identities as sacred groves from safety forests (except the smaller banas close to or in the middle of villages) Efforts should be made to trace them out and map and protect them.
- Conservation of Western Ghat endemism is important. High percentage of forest tree endemism even influences endemism among fishes in the streams that drain such forests.
- Biomass upgradation is an urgent necessity especially in the deciduous forest areas everywhere, especially in the maidan taluks of the district.
- Biomass and diversity are lower in the coastal minor forest tracts. Through consistent efforts involving local VFCs multiple species forests should be raised in such areas.
- Coastal lateritic hills were paid least attention so far; except for raising Acacia plantations no major activities were undertaken in them. Laterite plateaus also have great richness of monsoon herbs which flower gregariously and offer nectar for the survival of honey bees during the rainy season. Some ideal plateaus need to be conserved for their characteristic endemic flora.
- Regarding **scope for forestry based alternative development plan for enhancing the economic productivity of the region** we wish to state that **since** bulk of the lands in the district (over 70% area) being under the control of the Forest Department there is very little scope for economic advancement of bulk of the local population beyond subsistence level. There is also not much scope for major developmental interventions due to the fragility of the terrain and the ecosystems. As economic growth gets stunted people, especially younger generation tend to migrate into the cities for better prospects. Such mass migrations from rural areas will strain the cities as well beyond their carrying capacities too- as it is happening in Bangalore. To reverse the trend as far as Uttara Kannada is concerned the following recommendations are made for creation of more of forestry based livelihoods without any major interventions into the ecosystems as such:
    a. NTFP species should be widely raised

b. Bee keeping to be promoted as an important enterprise to benefit the people and forests (through pollination). Village peripheral forests and roadsides should be planted with numerous types of nectar plants used for foraging by honey bees (separate submitted on bee keeping0.
c. There is laxity among the arecanut garden owners as regards management of soppinbetta forests for fear of not getting the fruits of such improvement as the bettas are under Government ownership. It is recommended the betta owners be allowed certain tree rights if they adhere to certain norms like maintenance of the bettas to certain biomass levels, say like 30-35 sq.m of basal area/ha for trees.
d. The farmers require a helping hand from the Government in growing and marketing of medicinal plants and their primary products. Medicinal plants grown in VFC forests in home gardens or in fields, which also grow wild in the forest areas, should be procured by the Forest Department. This is to stop smuggling of medicinal plants from the forests, unauthorized exploitation by outside agencies and for betterment of local livelihoods.
e. Preparation of bio-pesticides, harmless to humans and domestic animals, may be promoted as a cottage industry using local plant resources, especially from village peripheral forests/VFC managed areas.
f. Vegetable dyes/or textiles coloured using such dyes, or for use as food colours are in increasing demand. Numerous plants in forests, mangroves and beaches are potential sources of such dyes. Village peripheral forests may be enriched using such plants to generate rural employment. Technology transfer is necessary.
g. Enormous scope for exploration of production and trade of plant based cosmetics and nutraceuticals (eg. from *Garcinias* and *Phyllanthus emblica* -amla) should be explored.
h. VFC managed sandalwood farms are recommended for the taluks of Haliyal, and Mundgod and for the eastern zone of Yellapur, Sirsi and Siddapur.
i. Being well forested district of hills and valleys, waterfalls, sea beaches and mangroves and for its cultural diversity Uttara Kannada has good scope for generating eco-friendly livelihoods through tourism promotion at grassroots level. This facet of development with the vision of upgrading livelihoods of grass root level people while also enriching forests, mangroves, sea beaches and coastal laterite plateaus has been successfully worked out by the Honavar Forest Division, at Apsarakonda, Om Beach (Gokarna), Kasarkod, Bellangi etc. The State Government should liberalise the licensing policy on home stays and community managed cottages (through VFCs) to benefit growth of decentralized ecotourism in the district, to benefit both village communities and local ecology.
j. Decentralised systems of forest nurseries for generating women's employment and providing scope for application of indigenous farming techniques for forestry purposes.

- Village level biodiversity hotspots should be identified and protected through the involvement VFCs/local Biodiversity Management Committees. Eventually these, through succession and vegetational enrichment will turn out to be local hotspots of biodiversity.
- Realizing the fact that depletion of forests of food resources and human induced vegetational changes in forests have adverse consequences on wildlife while increasing crop raids by animals enrichment of secondary forests and poor grade tree plantations with food resources for forest herbivores is highly desirable.

- NTFP collection, that yields only minor revenue to the state, is being carried out in many forests with gay abandon causing destruction of the resource itself. We recommend that the VFCs and other forest dwellers in respective villages be organized and trained in scientific harvesting of NTFP which also serves as medicinal plants
- Rampant collection of poles, cane, fuel wood etc., has been taking a heavy toll on forest resources particularly in the village vicinities. Most of the easily accessible areas with many medicinal plants are more prone to exploitation and get converted into scrub and thickets. Even the semi-evergreen and evergreen forests higher up in more inaccessible areas are also being exploited for fuel wood, timber etc., due to which many of these forests have thorny thickets as under-growths. We recommend conduct of sustained programmes on biodiversity awareness. Also bamboo considered as 'poor man's timber' the villagers may be allowed to harvest it from designated areas for their own bonafide use, so that they will desist from pole cutting and stake removal from the forests which destroys lakhs of tree saplings and pole sized juveniles.

RECOMMENDATIONS

1. **Forests towards carbon mitigation:** Carbon sequestration in any given forest is related to forest biomass. Basal area/ha is an index of the forest biomass. Higher carbon sequestration in stream course/swamp forests was a significant find of this study. In Kathalekan forests 9 forest samples along the water course-swamp parts had average carbon storage of 211.87 t/ha. In the nine samples from forest away from water course areas, carbon sequestration was lesse at 165.54 t/ha. On a hilltop savannized part, obviously due to shifting cultivation practice in the past, the carbon sequestration was very poor at 5.03 t/ha only. Numerous hill tops and wind exposed slopes of the district are in savannized state with poor biomass, demonstrating the fact clear felling of a rain forest can bring in desertified conditions. Nevertheless, these grassy patches Considering forest as a place of tree growth, often also with undergrowth, the savannised forests and several secondary forest samples subjected to ongoing human impacts, or sytems recovering from past human impacts, had some of the least basal areas, irrespective of whether they fall in high, moderate or low rainfall areas. All the taluks have such forests, which are low in biomass. Altogether 3 out of 116 samples, as studied by transect cum quadrat method, had basal areas of < 10 sq.m, 10 transects had basal areas between 10-20 sq.m/ha and 17 had between 20-30 sq.m. To such degraded forest areas also belongs bulk of the Soppinbetta or leaf manure forests allotted to arecanut garden owners of mainly the malnadu areas, for exercising the traditional privileges, importantly leaf manure collection. Thus a betta inTalekere of Siddapur had only 10.12 sq.m basal area ha and Hartebailu betta in same taluk had only 17.80 sq.m/ha basal area. Gondsur-Sampekattu betta in Sirsi taluk had just 3.74 sq.m as the basal area. Hiresara bettaland in Yellapur was exceptional in having 41.73 sw.m basal area.
2. **Riparian forest protection:** River and stream bank forests, including inland swamp area forests are to be considered as endangered ecosystems for various reasons, including for their high accumulation of biomass and higher levels of carbon sequestration. Forest rangewise river-stream-swamp protection action plans, incorporating adequate amount of inviolate vegetation growth for protection of ecology of these vital water courses along with their rare and endemic species is critical. The maps and action plans prepared for special protection of such areas should be included in the forest working plans of every forest division. If such working plans are already prepared these should be still prepared as

supplements. Timber extraction, conversion into monoculture plantations, or encroachments or any developmental activities should not be allowed affecting these inviolate forests.

3. **Protection of Myristica swamps:** These are remnants of the original primeval forests of the Western Ghats. The lineage of such forests could be traced to the supercontinent of Gondwanaland. The swamps, repositories of ancient and highly threatened rare biodiversity, are under various kinds of threats. They would have perished in large scale in early agricultural history of Western Ghats, being reclaimed for rice fields and betelnut gardens. Many of the last remaining fragments of swamps are also under threat from agricultural expansion. The swmaps should be demarcated in the forest working plans for the relevant areas and recommended for protection through preferably co-mamagement with the VFCs. The catchment areas for the swamps are to be protected from any kind of human disturbances being very important sources of hydrology. Kathalekan swamps in Siddapur taluk, being the most precious genepool of threatened plants and amphibains, among others, beng situated alongside the Honavar-Bangalore highway might get wiped out in case of road widening. The widening should not be permitted through any of the Myristica swamps or primary forest remnants.
4. **Conservation of unique forest related cultural identities:** The district abounds in forest related unique cultural identities like sacred groves and sacred trees. Sacred groves are known by various names like kans or devarabanas (often the presiding deities' names are added to respective banas-kans-such as Jatakabana, Choudibana, Kari-kanamman-bana, Hulidevarukan, Naagarabana etc.). Numerous ancient trees, especially of genus *Ficus*, or several others like *Mimusops elengi, Mesua ferrea, Mangifera indica, Mammea suriga, Aegle marmelos* etc. are present dotting the landscapes of villages and towns signifying sacred locations of cultural value. Whereas the *kans* were traditionally large groves, of several hectares or even few sq.km in area (Kathalekan for eg.), the *banas* are smaller ones, mostly within an acre in area. While the former is associated often with other forests or wilderness the latter is often found closer to or within human settlements. The *kans* were places where tree cutting was not permitted under traditional management, but NTFPs could be taken care of and harvested (eg. Wild pepper, cinnamon, toddy and starch from *Caryota urens* etc.). The *kans* while protecting wild genepool amidst secondary, human impacted landscapes, also acted as safety forests, being fireproof systems due to their evergreenness and high humidity, as sources of perennial streams and springs and as sources of NTFP. The smaller groves the *banas*, were not traditionally violated for any form of bioresources. In short both *kans* and *banas* were unique cultural identitites of the region while they preserved the region's climax vegetation. With the process of forest settlement during the British period, most of the *kans* lost their original identity as village sacred groves from safety forests, and were treated not much different from other forests. The smaller sacred groves are under shrinkage too due to erosion of conservation ethics due to changing cultural worldviews of the local communities (Chandran, 1998; Chandran and Gadgil, 1993). A detailed survey of 86 villages gave details about the presence of 241 sacred groves. We strongly recommend that the Government through the Forest Department take immediate steps to revive the system of preservation of these ancient sacred groves however small they are,
5. **Identification and recouperation old *kan* forests:** *Kan* forests were sacred forests of local rural communities of central Western Ghats. They are known as *devarakadus* in Coorg district. Devarakadus of Coorg have official recognition as sacred forests to this day. The kans of Shimoga district were demarcated in maps and their areas were already listed from early British period. But the British did not recognize the sacredness of the *kans.* In Uttara Kannada many *kans* of Sirsi and Siddapur were demarcated villagewise in forest settlement reports. At the same time many other *kans* got merged with

rest of the reserved forests without any special status conferred on them and subsequently it became difficult even to locate their boundaries. Such is the case of Kathalekan in Siddapur, Karikan in Honavar and Halsollikan in Ankola which we studied in detail. All these three *kans*, despite being reserved forest areas, are associated with sacred locations within them or in their vicinity, where local people continued the worship of deities. Interestingly all these places continued to maintain their distinctness as relics of primary evergreen forests embedded in a vast matrix of secondary forests. All these forests have *Dipterocarpus indicus*, a primary evergreen forest tree of South Indian Western Ghats. This species, though commoner in more southern forests, have isolated occurrences in Uttara Kannada mostly associated with *kan* forests. The presence of this Endangered evergreen tree has enhanced the conservation value of all these forests. Asollikan is a locality where we observed also the Critically Endangered tree *Madhuca bourdillonnii*. The discovery of this rarest species in Ankola taluk, once thought to be extinct and rediscovered in southern Kerala Ghats in its original home range, is an instance of traditional, community based conservation practice. Presence of species like *Myristica magnifica* (Endangered), *Syzygium travancoricum* (Critically Endangered), *Gymnacranthera canarica* (Vulnerable) and *Semecarpus kathalekanensis* (newly described tree species from the Myristica swamps of Karikan, underscores the importance of surveying, demarcating and protecting the lost *kans* (sacred forests) of pre-colonial times, and demarcating them for more careful protection and restoration through natural regeneration. The *kan* forest areas, were considered during British period as hydrologically important areas, being associated with perennial streams and springs (Chandran and Gadgil, 1993). Even a small *kan* of just one ha, in the Mattigar village of Siddapur taluk has *Syzygium travancoricum* (Critically Endangered) and *Vateria indica* (Endangered). The *kans*, many of them in ruins, due to various reasons, should be salvaged and brought under a system of co-management involving the local VFCs, if they are closer to villages.

6. **Conservation and promotion of forest endemism:** High rainfall areas have high biodiversity values and higher conservation values. High rainfall areas of malnadu and coastal taluks are major seats of endmic biodiversity of both palnts and animals. Kathalekan studies in Siddapur taluk (by various investigators) reveal how the high endemism is associated with Myristica swamps, at least 35 species of amphibians, endemic hornbills and Imperial pigeon, Endangered primate Lion –tailed macaque etc. The very distribution of fresh water fishes is highly correlated to terrestrial landscape elements, of which quantity and quality of evergreen forests are more important. Of the 64 species of fresh water fishes reported from Sharavathi River, including in its catchment areas of Shimoga, 18 species were endemics to Western Ghats, including three new species *Batasio sharavathiensis, Schistura nagodiensis* and *S. sharavathiensis* and 24 species confined to Peninsular India (Bhat and Jairam, 2004; Sreekantha et al, 2007).
7. **Upgrading biomass in deciduous forests and secondary deciduous forests:** The quality and quantity of a deciduous forest stand is very much reflected in its total biomass of which basal area is an index. Eleven forests surveyed in the deciduous forest zone of Haliyal and Mundgod taluks reveal unsatisfactory biomass, estimated basal areas/ha being in ranges of 10-20 sq.m for three samples, 20-30 sq.m for five samples, 30-40 sq.m for just two samples and only one falls in 40-50 sq.m category (43.09 sq.m at Godnol in Mundgod). Forest fragmentation of high order, shifting cultivation practices in the past, massive conversions into monoculture plantations, clear felling and selection felling rampantly practiced in the past are some of the major causes for low basal areas. Compact stretches of forests especially in areas thinly populated by humans may be prioritised for developing ideal forests of high stuature through special protection and periodical monitoring of the progress of natural

succession and tree growth. The forest management should aim at developing in the deciduous forest zone of Mundgod, Haliyal, in the drier eastern parts of especially Joida, Yellapur and Sirsi compact stands with basal areas exceeding 35 sq.m/ha.

8. **Increasing biomass and diversity in secondary deciduous forests of coastal taluks:** The secondary moist deciduous forests along the coastal taluks have been in impoverished state due to high density human impacts. Bulk of such forests constituted the 'minor forests' meant for meeting the biomass needs of coastal people, including cattle grazing. Through special protection of promising forest patches using barbed wire fencing, and closing any kind of exploitation in such protected areas, natural regeneration can be promoted, for at least five year period. Thereafter these forests can be open for free movement of wildlife and more such selected blocks can be protected, using the mode of forest working plans.
9. **Demarcation of potential areas for conservation of congregation of endemic trees:** Our survey reveals there are special areas in the forests where species like *Myristica fatua, Dipterocarpus indicus, Syzygium travancoricum* etc. congregate. More such areas should be traced out through the involvement of forest guards and village people and earmarked for special conservation efforts.
10. **Importance of conservation of the native flora of coastal laterite hills and plateaus:** From ancient times the coastal hills and plateaus of Uttara Kannada, from Ankola to Bhatkal, presented a picture of a barren and desolate terrain with sparse growth of woody vegetation. As such these were demarcated as minor forests for meeting the biomass needs of the local population and for cattle grazing. Many have been used in the recent decades for raising monocultures of *Acacia auriculiformis*. Our studies reveal that during the rainy season, open lateritic areas get carpeted with tiny herbs, where billions of flowers bloom providing crucial off-season nectar resources for honey bees, which, especially the domesticated ones, are otherwise to be fed artificially using sugar/jiggery solutions. We have submitted in this regard a separate, detiled report with recommendations for conservation of such lateritc minor forest areas.
11. **Forest resources for improving economic conditions of local citizens:** Regarding scope for forestry based alternative development plan for enhancing the economic productivity of the region we wish to state that since bulk of the lands in the district (over 70% area) being under the control of the Forest Department there is very little scope for economic advancement of bulk of the local population beyond subsistence level unless suitable small scale enterprenureship complementary to forests and nature are nurtured in the district. This recommendation is made considering the least scope in the district for major developmental interventions due to the fragility of the terrain and the ecosystems. As economic growth gets stunted people, especially younger generation tend to migrate into the cities for better prospects. Such mass migrations from rural areas will be too exacting on the carrying capacities of cities- Bangalore, for instance is burgeoning with population and developmental activities with heavy toll on ecology the impacts far reaching even on ecology of Western Ghats. To reverse the trend as far as Uttara Kannada is concerned the following recommendations are made for creation of more of forestry based livelihoods without any major interventions into the ecosystems as such:
    i. ***Sustainable use of soppinbettas:*** Soppinbettas are forests allotted to arecanut garden owners of mainly the malnadu areas, for exercising the traditional privileges, importantly leaf manure collection. The farmers do not have tree rights in these bettas although in most bettas we observed trees are constantly lopped for leaf manure collection, apart from collection of leaf litter from the ground. Bettas sampled were understocked in tree biomass (a betta in Talekere of Siddapur had only 10.12 sq.m basal area ha, in Hartebailu of same taluk a betta had only 17.80 sq.m/ha basal

area and in Gondsur-Sampekattu betta in Sirsi taluk it was abysmally low 3.72 sq. m) Some farmers maintain bettalands in better conditions eg. Hiresara bettaland in Yellapur (basal area 41.73 sq.m/ha). One of the reasons for understocking and low biomass is that many farmers also use the bettas as tree savannas interspersed with grassy areas; as a result they are able to maintain improved cattle unlike the coastal farmers who are hard pressed for fodder grasses even to feed their diminutive indigenous cattle. The laxity in betta management is partly due to the general fear among the farmers that any improvement in the betta forests at their expenses will not be repaying for them as they do not enjoy absolute ownership over the betta lands or the trees. It is recommended here that the farmers be allowed to have rights on the trees (for timber and fuel) in the betta if they upgrade the tree biomass from present basal area indicator of less than <20 sq.m/ha to minimum of 30-35 sq.m/ha, which minimum limit the Forest Department may fix after examination of the condition of the betta on a case to case basis.

ii. ***Promotion of bee keeping:*** Uttara Kannada has ideal district for promotion of bee keeping. Bee keeping is complementary to forestry and farming because of pollination benefits. Uttara Kannada can reap enormous benefits through especially production of forest and farming based organic honey. Even roadsides and wastelands can be planted with nectar producing plant species. Although about 7000 sq.km area is under forest cover the district has achieved only very little progress in bee keeping. One of the key reasons is the inadequacy of bee forage plant species in the village peripheral forests which are often in degraded state, with scanty attention paid to enriching them with bee forage plants. Particularly nectar producing species, groups of them flowering in different times of the year, composed of a community of site specific flowering herbs, shrubs, climbers and trees are to be promoted to support apiculture in villages (A separate report on bee keeping is submitted). Even the landless and marginal farmers can involve in bee keeping depending on bee forage plants in forests, roadsides, mangroves and beaches. Through proper planning and implementation of 'forests for bee keeping' project, hypothetically, at the density of two bee colonies per ha of forest (not necessarily by placing bee boxes in every ha of forest, as the bees travel few km in search of forage plants; for eg. *Apis dorsata* has a foraging range of 3 km radius - Batra, 2001), at a modest estimate honey production based on 700,000 ha of forests at 40 kg/ha using native bees *Apis cerana,* and Rs.200/- kg rate at prevailing minimum rate, can yield 28,000 tons of honey worth Rs.560 crore. Honey is a good health food in demand nationally and internationally. Proper marketing as organic forest honey can fetch much more income (for eg. Soapnut tree based honey fetches upwards of Rs.700/- kg). Surplus honey can be used in the mid-day meal programmes for school students. To achieve such ambitious target we recommend that even a wing of Forest Department be made to promote apiculture related activities.

The bettaland farmers should be assisted in bee keeping activities aiming at a minimum of one bee box for every acre of betta. They are to be guided in enriching the bettalands with bee forage plants so that the vegetation of impoverished bettas are also improved. Improved vegetation and better ground cover can also improve local hydrological conditions. A single bee colony (in a bee box) can earn for the farmer Rs.4000/- extra money, through better management and vegetational enrichment. The farmers also stand to gain from increased farm productivity due to the pollination services from bees, and NTFPs from bee forage plants. The farmers need training in bee keeping related activities. Sirsi-Siddapur taluks, which have some of the highest forest fragmentation in the district, can also substantially improve the forest wealth through betta rehabilitation.

iii. ***Promotion of marketable medicinal plants***: The farmers require a helping hand in growing and marketing of medicinal plants and their products. The farmers would look forward to the Government/Forest Department, for acting as a purchasing agency for medicinal plants or their products. In this regard by undertaking the role of a facilitator between the producer and the purchaser (pharmaceutical companies) the Government/Forest Department would play a vital role in biodiversity conservation and enhancing the value of bettalands, minor forests, and even those who grow medicinal plants in their household gardens or private lands. The role of Forest Department as a purchasing agency while bettering local livelihoods can also stop smuggling of medicinal plants from the forests and other unauthorized exploitation by outside agencies

iv. ***Biopesticides from forest plants:*** Various plant species of the district viz. neem, *Pongamia, Vitex negundo* etc. are sources of biopesticides. Promotion of such plants in VFC managed forests and bettalands can further the cause of organic farming in the district while also earning extra income to the locals from production of marketable, homemade biopesticide formulations, under an assited programme from the Government. Neem based pesticide formulations are widely popular in the world. Azadirachtin, the main active principle of neem is also found in *Melia azedarach* (Hebbevu) of same family. However, use of such pesticides in India is making tardy progress, despite the fact that knowledge base for neem pesticidal properties is from India. Bark extract of *Acacia nilotica* has been found to provide complete protection to oranges from the blue mold fungus (Varma and Dubey, 1999). Leaf extract of *Clerodendron inerme*, a hedge plant and coastal shrub, is found effective against red spider mite. Use of *Lantana camara* extract to control cotton pests is a good example of agrass root level practice (Varshney, 2006). Strychnine from *Strychnos nux-vomica* is used as a rat poison. Pongamia leaves and bark are sources of traditional biopesticides, especially having insect deterrant properties (Kiruba et al., 2006). Seeds of the giant forest liana *Entada pursaetha* are used to control rats in the Garo Hills of North-East India.

v. ***Vegetable dyes from forest plants:*** World over, especially from developed countries, there is growing demand for textiles dyed using vegetable dyes. Total market for herbal dyes was estimated to be worth US$ one billion and growing annually at the rate of 12% (Gokhale et al., 2004). India has a wealth of traditional knowledge on production of plant based textile (for cotton, wool and silk) and leather dyes. The market demand for such dyes is yet unrealized in the absence of surveys. It is right time for Uttara Kannada district to capture this market using the enormous potential for growing plant sources of vegetable dyes in the VFC managed areas, including sea beaches and mangroves, under a sustained programme including training programmes for transfer of appropriate technology. Numerous plant species can be promoted for dye production in cottage industry level:

a). *Acacia catechu* (Khair): Catechin red from wood for dyeing silk, cotton and calico printing
b). *Acacia nilotica* (Jali): Catechin from wood for dyeing light yellow, dark grey, reddish brown
c). *Aegle marmelos* (Bilpatri): Marmalosin from fruit rind for yellow and gray
d). *Bauhinia purpurea* (Mandara): Chalcone and butein for dyeing and tanning purple
e). *Butea monosperma* (Muttaga): Dried flowers with several components for dyeing of silk brilliant yellow
f). *Caesalpinia sappan*: Brazilin from wood and pods for red and black
g). *Cassia fistula* (Kakkemara): Bark and sapwood for red
h). *Cassia tora* (Tagati): Rubrofusarin from seeds for tannin and dyeing blue
i). *Chukrasia tabularis* (Gnadhagarige): Leaves for red

j). *Dipterocarpus spp.* : Bark for brown and gray
k). *Madhuca indica* (Mahua): Bark for reddish yellow
l). *Mallotus phillippensis* (Kumkum): Fruits for dyeing silk red
m). *Mangifera indica* (Mango): Bark and leaves for dyeing silk yellow
n). *Morinda citrifolia* (Noni): Morindin from root and bark for dyeing silk dull red
o). *Pterocarpus marsupium* (Bet-honne): Epicatechin from bark for dyeing silk brownish red
p). *Rubia cordifolia* (Manishta): Manjistin and purpurin from stem and bark for reddish brown, light pink, light brown, gray
q). *Terminalia arjuna* (Holematti): Arjunic acid from bark for light brown
r). *Terminalia chebula* (Haritagi): Chebulinic acid from fruits for yellow and dark gray
s). *Tectona grandis* (Teak): For dyeing silk yellow
t). *Ventilago maderaspatana*: Ventilagin from root and bark for colouring cotton and tassar silk chocolate
u). *Woodfordia fruticosa:* Lawsone from leaves and flower for dyeing pink or red
v). *Zizyphus jujube* (Bora): Fruit as modant in dyeing silk

There are many more such plant sources of dyes. The important needs before implementation are:

- Documentation of traditional practices, study of local and global demands
- Improvisation of traditional techniques
- Commercial cultivation of wild sources
- Standardisation in dyeing practices

vi. ***Cosmetics and nutraceuticals from the wild:*** As such lot of authorised and unauthorised extraction of NTFP used for cosmetics and nutraceuticals are happening in the district, for instance from plants like *Garcinia* spp. Kokam fat from *Garcinia* seeds has global demand as is most sought after for preparing skin creams. Following in importance is seed fat from *Madhuca indica* (mahua tree). *Garcinia cambogea* and *Phyllanthus emblica* are few among several nutraceutical plants, the multiplication and sustainable harvests of which can generate considerable rural employment. The traditional Indian cosmetic products of India came from a variety of plants like Amla, Shikakai (Acacia concinna), neem, soapnut (Sapindus laurifolius),

vii. ***VFC managed sandal farms:*** Sandalwood (*Santalum album*) is perhaps the costliest of tree species in the world, Karnataka being its greatet production centre. The high cost of the wood has become baneful to the species, as the tree faces highest smuggling risks. Individual householders and farmers seldom dare to grow this valuable species due to their inability to safeguard it. Collective responsibility by village community seems to be the only course for the future of sandal. We therefore recommend the adoption of the species by VFCs in their respective jurisdiction especially in the taluks of Mundgod and Haliyal and eastern parts of Sirsi, Yellapur and Siddapur.

viii. ***VFC managed medicinal plant areas:*** Medicinal plant gardens of fast depleting and highly traded species may be promoted through VFCs for growing *Salacia chinensis, Nothopodytes foetida, Embelia spp., Coscinium fenestratum, Costus speciosus, Rauwolfia serpentine, Asparagus racemosus etc.* Many highly degraded forests, scrubs and thickets contain numerous medicinal plants particularly near coastal areas. These are to be mapped and brought under strict in situ conservation measures, so as to preserve the native medicinal gene pool.

ix. ***Forests for ecotourism:*** Natural and cultural heritage are primary attractants for tourism world over. Uttara Kannada is an idyllic district of valley villages of lush greenery merging with wooded hillsides and grasslands offering tremendous scope for development of eco-tourism and study tourism. Tourism flourishes especially in areas with more than two landscape elements meet – such as sandy seashore and beach forest (eg. Kasarkod), sea shore and hillscape (eg. Apsarakonda), waterfall and forest (eg. Jog, Unchalli and Magod waterfalls), pilgrimage and picnic trail through forest to cathedral rocks (eg. Yana, or to hilltop shrine of Karikanamma in the vicinity of *Dipterocarpus* sacred grove) and so on. In all these places and in many more areas, apart from National park and sanctuary, the Forest Department has demonstrated that tourism can be conducted successfully to benefit the local communities organized into VFCs. This facet of development with the vision of upgrading livelihoods of grass root level people while also enriching forests, mangroves, sea beaches and coastal laterite plateaus has been successfully worked out by the Honavar Forest Division, at Apsarakonda, Om Beach (Gokarna), Kasarkod, Bellangi etc. The potential should be developed so as to generate income to the locals through preservation of their local environment and local cultures without the need for migration into cities in search of employment. Key elements for successful development of eco-tourism are limiting growth within sustainable limits (Jog Falls, unfortunately, is a location where ecological norms are not adhered to creating considerable negative impact on environment), generating benefits to the local community (and not to major enterprises from outside), monitoring and mitigating ecological impacts (mostly not happening in our ecotourism areas, except in PAs). Partnership with local community/VFC is of great importance of success of ecotourism. We recommend that in all areas with ongoing, potential ecotourism training be imparted to especially local youth in successful management of tourism, in running forest trails, in bird watching, familiarisation with local flora and fauna etc. Liberal issuance of licenses for home stays and community/VFC managed cottages is necessary for ecotourism to benefit grassroot level people and environment.

x. ***NTFP species raising and utilisation*****:** For betterment of livelihoods at local level NTFP yielding species should be raised on a larger scale in VFC areas. Auctioning of NTFP to contractors is found to be injurious to forests due to overharvests, unscientific harvesting methods and for the poor returns of revenue to the State. The local VFCs, tribal societies, self-help groups of women etc should be prioritised for NTFP harvests.

xi. ***Decentralised systems of forest nurseries***: For generating women's employment in village areas and also providing scope for application of indigenous farming techniques for forestry purposes sets of local species may be raised in household nurseries.

12. **Village level biodiversity hotspots:** Our studies show that biodiversity conservation values are correlated to forest endemism. Although Western Ghats itself is part of a global biodiversity hotspot, the concept of village level biodiversity hotspots should be promoted through community participation. Such hotspots, which are especially centres of local level biodiversity, should be identified and special attention given to their protection through Biodiversity Management Committees/Village Forest Committees. Eventually these special patches should serve as local climax natural ecosystems also strengthening local hydrology.
13. **Decentralised systems of forest nurseries:** Villagers in close vicinity of forest areas may be commissioned to raise small scale nurseries of selected species flowering plants for replanting inn forest areas, roadsides etc. to reduce the load on the understaffed Forest Department which is required to spend considerable time and resources on large scale nurseries. This will increase rural employment, especially for women while also giving scope for application of indigenous planting techniques.

14. **Promoting food plants for wild animals:** Bulk of Uttara Kannada forests are of secondary nature, either old growth forests or forests, scrub and savannah in different stages of succession. As such these massive vegetational changes that have happened through centuries of human impacts, have adverse consequences on native fauna thinning the populations of many or causing their local extinctions. Leaving aside old growth forests, which should not be subjected to any kinds of tampering, the rest should be enriched with food plants for various faunal elements, particularly birds and frugivorous bats, primates and other mammals. This enrichment is also necessary to reduce crop raiding by wild animals. Care should be take to preserve grassy blanks within forest areas, critical resources necessary for grazing wild animals. Such grassy blanks should not be subjected to afforestation.
15. **VFC based resource monitoring:** As villages are dispersed in Uttara Kannada all over forest areas it would make much sense to adopt a system of participatory resource estimation and monitoring within their respective areas- such as estimates of *Myristica*, cinnamon, gooseberry, *Garcinias* and other NTFP plants, key medicinal plants like *Nothapodytes*, *Cosicinim*, *Salacia*, *Embelia* and so on as well as of honey bee colonies within forests. This will strengthen bonds between the Forest Department and village communities while also getting a fair idea of the worth of forests at local level for the provisional goods they contain.
16. **Meeting the fuel needs:** Fuel extraction, both legal (especially removal of dead and fallen from interior forests) and illegal by local population is instrumental in degradation of many forests. Energy efficienct stoves, biogas, solar devices, use of agricultural wastes etc. are to be promoted as fuel in rural areas. At the same time adequate fuelwood/or other alternative fuels should be granted to cottage industries run by potters, lime makers etc.
17. **Selecting appropriate areas for tree plantations:** Raising monocultural/mixed tree plantations has to be site specific. Planting of *Acacia auriculiformis* has to be restricted to rocky or otherwise impoverished terrain and not in lands with good soil resources where native species are to be preferred.
18. **Dispensing with the practice of climber cutting:** Climber cutting is an archaic practice in forestry to promote tree growth. The Western Ghats harbour good diversity of climbers including endemic ones. The climber cutting practice has to be disbanded or restricted to tree plantations only as it would otherwise cause destruction of biodiversity including medicinal plants and entail adverse impacts on wildlife.

10.1 ECONOMIC VALUES OF BIODIVERSITY

Uttara Kannada is the most biodiversity rich district of Karnataka due to the following reasons:

1. It has topographically three regions: the Western Ghats, the Maidan areas and the sea coast, each with its own characteristic and exclusive species of plants and animals and the ecosystems with which they are associated
2. The district is a transition region being situated in the centre of the Western Ghats. The southern Western Ghats are more species rich than the northern regions in Maharashtra. Uttara Kannada is the northernmost refuge for several rare species characteristic of the south and some unique ones as well. Plant/animal species classified by IUCN under different threat categories like **Critically Endangered, Endangered and Vulnerable are**

priceless assets of the nature and mankind (**Table 10.1**), and hence cannot be monetarily evaluated.

Table 10.1: A list of some notable threatened species of plants and animals in Uttara Kannada

Ecosystems	Locations	Rare species/varieties	Remarks
Myristica swamps/ swampy forests	Siddapur, Sirsi and interior of Honavar taluks	*Myristica magnifica*	**Endangered** tree of nutmeg family
		Gymnacranthera canarica	**Vulnerable** tree of nutmeg family
		Semecarpus kathalekanensis	Newly discovered tree of mango family from Siddapur
		Syzygium travancoricum	**Critically Endangered** tree of jamun family, from Myristica swamps and sacred groves
Evergreen forests	Gersoppa, Ankola ghats	*Madhuca bourdilloni*	**Critically Endangered** tree of Sapota family
	Siddapur, Honavar, Ankola	*Dipterocarpus indicus*	**Endangered** tree of kan forests
Evergreen forests, swamps and streams	Siddapur evergreen forests, swamps, streams	*Hylarana aurantiaca*	**Vulnerable** amphibian- semi-aquatic in forests
		Micrixalis saxicola	**Vulnerable** aquatic amphibian
		Minervarya sahyadris	**Endangered** semiaquatic amphibian
		Nyctibatrachus aliciae	**Endangered** aquatic amphibian
		Nyctibatrachus humayuni	**Vulnerable** aquatic amphibian
		Nyctibatrachus major	**Vulnerable** aquatic amphibian
		Pedostibes tuberculosus	**Endangered** tree amphibian
		Philautus bombayensis	**Vulnerable** tree amphibian
		Philautus ponmudi	**Critically Endangered** tree amphibian

		Philautus wynaadensis	**Endangered** tree amphibian
		Philautus neelanethrus	**Endangered** tree amphibian
Evergreen forest streams	South & central Western Ghats	*Balitora mysorensis*	**Vulnerable** fish
		Carinotetradon travancoricus	**Vulnerable** fish
		Pterocryptis wynaadensis	**Endangered** fish
	Central Western Ghats	*Barilius canarensis*	**Endangered** fish
		Hemibagrus punctatus	**Critically Endangered** fish
		Puntius setnai	**Vulnerable** fish
	Uttara Kannada	*Puntius crescentus*	**Endangered** fish
	North Palghat Gap to Uttara Kannada	*Silurus wynaadensis*	**Endangered** fish
	Sharavathi River	*Batasio sharavatiensis*	**Endangered** fish discovered in Sharavathi River
Forest streams	Western Ghats	*Glyptothorax madraspatanus*	**Endangered** fish
		Hypselobarbus kolus	**Vulnerable** fish
		Hypselobarbus mussullah	**Endangered** fish
		Horabagrus brachysoma	**Vulnerable** fish
Evergreen forest streams	Sharavathi River tributaries	*Schistura nagodiensis*	**Newly discovered** fishes from catchment area streams of Sharavathi
		Schistura sharavathiensis	
Forests	India. Sparingly present in Uttara Kannada	*Panthera tigris tigris (Tiger)*	**Endangered** mammal. Anshi-Dandeli Tiger Reserve has notable presence
Forests		*Elephas maximus (Elephant)*	The northernmost population of this **Endangered** mammal lives in Anshi-Dandeli Tiger Resrve

10.2 **REDESIGNING ROADSIDE VEGETATION**

Roadsides have immense possibilities for more focused vegetation designing. The objectives of ideal roadside planting are to be stated as:

- Increase in green cover and biodiversity
- Roadside beautification
- Increase in availability of non-timber produce for the poor
- Increase in honey production

Taking for granted meeting of the first and second objectives are generally met by many species being already planted conventionally, we need to focus more on creation of more livelihood opportunities for the people aiming at fulfilling the latter two objectives.

Length of roadsides for planting: The district has 3645 km length of roads, which include National Highways, State highways and major district roads. Assuming that 50% of the total road length is available for planting, we may practically have 3645 km of roadsides for tree planting. By aiming to raise one NTP cum nectar producing tree, suitable for honey bee forage, at every 20 m length of roadside, we can altogether raise 182,250 trees. At the rate of 2 kgs of honey production per tree if the potential of these trees is fully used through bee keeping we may aim to collect altogether 364,500 kgs of honey/year worth Rs. 72,900,000. The selection of trees may be made in such manner so that along with honey the selected trees also yield other useful products. Few examples are shown in the table 1

Table 1: Species recommended for roadside planting

Tree	Zone	Honey	Other products
Antawala (*Sapindus lauiolius*)	All	Early honey of the year; highly priced	Fruit medicinal; dye from seeds
Nerale (*Syzygium cumini*)	Moist roadsides- all zones	Major honey producer; amber coloured	Edible fruits; for preserves, squashes, jellies; for vinegar; seeds as fodder; plant parts medicinal
Tari (*Terminalia bellirica*)	Coast and malnadu	Good source of honey	Seeds medicinal
Amli, Huli (*Tamarindus indica*)	Maidan	Rich source of golden coloured honey	Fruit for food preparation; tartaric acid, tamarind concentrate, medicine; seed for sizing powder for textiles; leaves for medicine
Mavu; mango (*Mangifera indica*)	All zones	Good source of honey	Edible fruits
Xanthoxylum rhetsa	Roads through coastal laterite	Good source of honey	Fruit as spice

11.0 PROTECTION OF GLOBALLY SIGNIFICANT PROTECTED AREAS, CRITICALLY ENDANGERED HABITATS, WILDLIFE AND ENDANGERED SPECIES

Task 11 : Global significance of the region (RET species, threatened ecosystems, protected areas, etc.).
1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, Rao G R., Prakash Mesta, 2013. Ecologically sensitive regions in Uttara Kannada, Sahyadri Conservation Series 37, ENVIS Technical Report 67, ENVIS, Centre for Ecological Sciences, Indian Institute of science, Bangalore 560012 2) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India 3) Sumesh Dudani, Mahesh M K, Vishnu Mukri, Subash Chandran M D and Ramachandra T V, 2013. An appraisal and conservation strategies for the pteridophytes of Uttara Kannada, CES Technical Report 129, Centre for Ecological Sciences, IISc, Bangalore 4) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V., Sreekantha, Raushan Kumar, Rajinikanth R., Desai S.R. and Subhash Babu, 2012. Ecological Profile of Sharavathi River Basin., Sahyadri Conservation Series 22, ENVIS Technical Report : 52, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012. 5) Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012. 6) Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 20, ENVIS Technical Report: 50, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 7) Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 19, ENVIS Technical Report: 49, ENVIS-Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

8) Ramachandra T V, Subash Chandran M D, Joshi N V, Gururaja K V, Sameer Ali and Vishnu Mukri, 2012. Amphibian Diversity and Distribution in Uttara Kannada District, Karnataka, Sahyadri Conservation Series 18, ENVIS Technical Report: 47, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
9) Ramachandra T V, Subash Chandran M D, Rao G R, Amit Yadav, Gururaja K V, Karthick B, Uttam Kumar, Durga Madhab Mahapatra and Vishnu Mukri, 2011, Ecological status of Dandeli-Anshi Tiger Reserve, ENVIS Technical Report: 43, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
10) Subash Chandran M. D., Rao G. R., Vishnu Mukri, Prakash Mesta and Ramachandra T V, 2011. Grasslands of Anshi-Dandeli Tiger Reserve, ENVIS Technical Report: 36, Sahyadri Conservation Series 12, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
11) Subash Chandran M. D., Prakash Mesta, Boominathan M., Rao G. R., Vishnu D.M. & Ramachandra T.V., 2011. Aghanashini Estuary in Kumta Taluk, Uttara Kannada - Biological Heritage Site, ENVIS Technical Report: 35, Sahyadri Conservation Series 11, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
12) Gururaja K V and Ramachandra T V, 2011. Anuran diversity and distribution in Dandeli Anshi Tiger Reserve, ENVIS Technical Report: 37, Sahyadri Conservation Series 8, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
13) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, Ajay Narendra and Ali T.M., 2012. Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 3, ENVIS Technical Report : 20, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
14) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, and Shalini Kumar, 2012. Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 6, ENVIS Technical Report : 22, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

The Anshi-Dandeli Tiger Reserve is a prime area in the Western Ghats for conservation of the Endangered Tiger. The Western Ghat's northernmost population of elephants, an Endangered mammal, constitutes an isolated herd or nearly 60 animals. Most (about 13) of the tigers of the district and the entire elephant population in addition to numerous other animals have ADTR as their main shelter. The elevation of ADTR into a haven for wildlife can generate good income from tourism and nature lovers and better the livelihoods of the most backward population of especially Joida and Haliyal taluks. For this purpose the ADTR management has to be fine-tuned towards meeting the habitat quality requirements of a variety of faunal elements. The major recommendations towards this are the following:

i. **Linking with sanctuaries of Goa:** Initiatives may be taken to increase the metapopulation of mammals like elephant and tiger by widening the habitat through linking Bhagavan Mahavir and Molem Sanctuaries of Goa. Such widening of the habitats will reduce human-wildlife conflicts which are on the increase.

ii. **Enrichment of grassland resources:** Grasses and herbs make the most important grazing resources for several wild mammals in the ADTR, such as elephants, barking, mouse and spotted deers and boar. The grazing animals, except elephants, constitute important prey stock for tiger and panther. The important grass resources grow in grassy blanks (which were early shifting cultivation areas), old walls and rocky surfaces, fallow fields, marshes and meadow etc. They are also associated with clearances under power lines. These grassy areas need to be preserved from competition from domestic cattle. The grassy blanks should not be brought under afforestation.

iii. Larger grassland areas such as Thayamaddi-Barpoli cross, Kaneri dam site, Terali, Burpali-Anshi, Kumbarwada-Diggi areas etc., are old grasslands having not only highly palatable, high yielding grass species but also good number of other fodder dicot species. They need to be spared from afforestation works.

iv. In ranges with less of open grasslands such as forested areas of Phansoli, Gund, Kulgi and Anshi areas permanent wetlands and water holes serve as a major source of fodder for wild life which are rich in grass species along with large number of dicot herb species with high fodder value. The integrity of these micro-habitats should not be altered.

v. If the phase wise rehabilitation of villages in the ADTR happens then the vast abandoned fields and other human used areas can make perfect grazing areas for wild animals under a proper management regime including sparing use of fire. The hill tops and slopes of Kumbarwada are covered with grasslands. Their integrity should be preserved.

vi. Cattle kills are more in the ADTR as 145 cattleheads were killed by carnivores during 1999-2000. This reflects the insufficiency of grasslands as well as the poorer qualities of many. The government schemes for rehabilitation of villages from the ADTR should be popularised among the people.

11.1 GRASSLANDS OF ANSHI-DANDELI TIGER RESERVE

During the last century, there were over 40,000 tigers in India. This number has dwindled to 1827 by 1972 due to poaching, illegal hunting, fragmentation and destruction of habitat, making them an endangered species. The Government of India started "Project Tiger" on April 1st, 1973 to protect the tigers from extinction. Uttara Kannada district was exceptionally rich in tigers almost until late 19th century. British chronicles show hundreds were hunted down in the district during late 19th century, and such hunting was even sponsored by the government. Presence of numerous tigers in the district until the close of 19th century highlights the richness of forests interspersed with grasslands, abundance of water resources and richness of wildlife in general, especially the grazing mammals, constituting the prey stock of the wild carnivores.

Dandeli Wildlife Sanctuary with the extent of 206.75 sq kms was first notified as Game Sanctuary in the year 1956 (vide Bombay Govt. Resolution WLP.1957 dated 10-05-1956). This was extended to 5729.07 sq kms (vide Government of Karnataka Notification No. AFD 52 FWL 74 dated 08-01-1975) and subsequently reduced to 834.157 sq kms (vide FFD 150 FWL 81 dated 01-09-1987) and 475.018 sq kms. (vide draft Notification no. FEE 172 FWL 93, on 29-04-1994), which was finally notified as Dandeli Wildlife Sanctuary (vide FEE 58 FWL 96/09-03-1998). The draft notification of Anshi National Park was done covering an area of 250 sq kms (vide AHFF 77 FWL 87 / 02-09-1987) and the final area notified is 339.866 sq kms (vide Notification No. FEE 221 FWL 99 dated 18.08.2003). Both the Protected Areas with the spatial extent of 814.884 sq km was declared as Tiger Reserve on 4th January 2007 (GO No. FEE 254 FWL 2006). This along with the Mahaveer Wildlife Sanctuary of Goa covers an area of over 2,000 sq.km.

The Anshi-Dandeli Tiger Reserve (ADTR) covers the hill ranges of northern Uttara Kannada district in the taluks of Joida and Haliyal. The western side of the Tiger Reserve, receive seasonal heavy rainfall from the South-West Monsoon to the tune of 3000-6000 mm. Tropical evergreen forest is the climax vegetation here. However, human factors through millennia have transformed bulk of these forests into semi-evergreen types, interspersed with savannas and agricultural areas. Progressive decline in rainfall towards the east, which gradually merges with the Deccan Plateau in the rain-shadow region, is responsible for moist and dry deciduous forests. Long history of forest burning in the past and wholesale transformations of the forests into teak plantations, beginning with the British period have acted as powerful factors that modified natural vegetation. Places such as Kumbarwada, Diggi, Terali, and Kundal have large expanse of grasslands, due to the slash and burn cultivation practices earlier by shifting cultivators consisting communities such as Kunbis and Kumri Marathis. *Gavli* pastoral tribes and *Siddi* forest dwellers live in this area. Many village settlements are present in the reserve and the surrounding areas where the wild animals move.

Grasslands are the grass-dominated areas with few trees. Global grasslands even though widespread are shrinking alarmingly and merit consideration as one of the most endangered ecosystems, even more so than tropical rainforests. Though the grasses form an easily identifiable natural group of plants they have remarkable diversity. The trailing habit of many grasses (e.g., *Cynodon dactylon, Oplismenus burmanii etc.*) helps them to withstand grazing pressure, trampling and even fires. Taller grasses tend to dominate areas where they have to compete with dicot herbs. Bamboos though woody and tree like are also grasses. For them the height is of advantage in competing with trees of the forest. Grasses are prolific seed producers. Their smaller seeds have enabled them to spread widely. Most grasses also reproduce vegetatively, so that even if their shoots are browsed by animals or destroyed in fire, they produce fresh shoots from underground rhizomes or from nodes at ground level. Some grass species can survive in diverse ecological conditions; for instance the Bermuda grass (*Cynodon dactylon*), commonly found in Anshi- Dandeli Tiger Reserve can grow in submerged habitats as well as on drier soils. Tiny, wind dispersed seeds of many grasses and their light loving nature enable them to be the pioneer colonizers of freshly created open habitats. Elasticity of grass internodes confer on them survival value in windy conditions and resist trampling. Another reason for the success of grasses is wind pollination and their non dependence on animals as pollinators. All such characters of grasses provide them with greater plasticity to grow in situations not favorable for many other flowering plants.

Grasslands constitute a critical resource, as the grasses constitute bulk of the diet of herbivorous mammals, especially ungulates, which constitute bulk of the prey for the big cats, the tiger and the panther. Ecological history of the Western Ghats, especially of Uttara Kannada district, and the recent studies highlight that the number of tigers in any reserve is correlated to the number of prey animals and prey animals depends on grasslands. Therefore grasslands deserve prime attention in the management plans of ADTR. The work on grasses of ADTR is scanty and this work constitutes preliminary work which help in understanding grassland ecology. Tigers are part of a landscape of varied elements and grasslands cannot be treated in isolation, but in combination with forests, savanna, scrub, streams and rivers, gorges, ravines and cliff, which in a mosaic constitute homes for the deer, sambar, gaur and pig which are among the important preys of the tiger.

The grasslands in the district are mainly due to the forest clearance by humans carried out through centuries of shifting cultivation and cattle grazing. Specially maintained 'bena' grasslands of farmers as well as many grassy blanks within forests and closer to villages are the result of arresting the natural succession of forest vegetation because of periodic burning of woody growth by the people. Savanna vegetation is very common element of landscape in every taluk of the district. It is a mixture of isolated trees or clumps of dwarf trees amidst a general matrix of grasses. In the absence of fire these savannas often tend to progress towards forest, through recruitment of more trees, which shade the grasses, giving not much scope for their multiplication.

Unlike lions or cheetah which need vast grasslands for their prey capture, tigers rely on surprising a prey and capturing it. Hence tigers prefer to inhabit mosaic kind of landscape elements such as dense forest, grasslands, scrub, ravines, wetlands etc. The tiger population largely vanished from Uttara Kannada itself mainly due to hunting (both tigers as well as its prey animals), and large scale conversion of forests into monoculture of mainly teak (about 1000 sq km of forests have been converted into teak plantations in the district) and other forms of intensified habitat degradation due to commercial working of forests for timber and industrial raw materials. Weeds like *Lantana* and *Eupatorium* proliferated in the canopy openings and inside the teak plantations adversely affecting native species, and therefore understandably, with adverse consequences on the rich wildlife that the region had once. Increase in human and cattle population, the growth of Dandeli as an industrial city, from an obscure village prior to independence and the execution of a chain of hydel projects in the river Kali and associated disturbances such as the setting up of new colonies for project employees at Ambikanagar and Ganeshgudi etc. would have obviously reduced wildlife areas and affected habitat quality. Evacuees from the submersion areas of Supa dam were resettled in the newly created Ramnagar township. Moreover several mining leases were given inside the forest areas damaging forests and grasslands as well as converting the region into a transportation hub. The stoppage of shifting cultivation in the late 19th century witnessed the erstwhile shifting cultivators like Kunbis, Kumri Marattis etc. taking to permanent cultivation. With settled cultivation these historically nomadic cultivators, who were earlier not associated with pastoralism, took to cattle rearing for manure and milk. Therefore, naturally, the pressure on the grazing resources from the domestic cattle would have increased substantially, with telling consequences on the ungulate preys of the tiger and panther. Shifting cultivation today is a thing of the past. Working of reserved forests for timber and firewood and industrial raw materials is no more in the reserved forests, from mid 1980's, and more so in the Protected Areas. There are strict rules regarding forest and wildlife conservation. As such we could expect an increase in the prey population favouring the multiplication of tigers.

Wildlife census was carried out in 1997 and 2002. The census covers only selected mammals. In due course more detailed and accurate census details may be expected. Latest census details are yet to be obtained. The data reveals that the tiger population had remained static at 13 during this period. Of these 13 tigers, 11 were reported from Dandeli Wildlife Sanctuary and only two from Anshi National Park. As the latest census report is awaited there is cause for concern. Most alarming is the decline of gaur (*Bos frontalis*) from 1817 in 1997 to 1376 in 2002. This could be due to sampling error, habitat destruction or poaching or a combination of these.

The decline of the spotted deer or chital (*Axis axis*) is still more alarming. Its number in the Dandeli Wildlife Sanctuary declined from 1667 in 1997 to 1252 in 2002. In 2002 the total number was 1429 because of adding the population of Anshi National park. The consolation, however, comes from the significant increase in sambar deer. However, for the sheer size of the ADTR the total estimated number of sambar deer at 722, is not satisfactory. Overall the census methods for the animals have to be streamlined to project reasonably good pictures. Although the pig (*Sus crofa*) is one of the notable preys of the tiger its enumeration has not been carried out, may be due to the understandable difficulties in counting this animal of varied habitats. The barking deer (*Muntiacus muntjac*), though an important prey, 6.4% of numbers killed in Chitwan, 34.8% in Huai Kha Khaeng Wildlife Sanctuary, Thailand and 8.4% in Nagarahole (Sunquist et al., 1999), the total estimated for ADTR is only 592.

Fodder needs: At a modest maintenance diet of 2610 kg meat/tiger/year the total meat requirement for 13 tigers would be 33930 kg/year. For meeting this requirement the tigers need to kill 518 prey animals of mean weight 65.5 kg. The meat requirement of a tigress feeding two large cubs is estimated to be 50% more. This meat would also come from pigs, and monkeys and other miscellaneous prey to a smaller extent. At the generally accepted energy flow models of 10% of biomass energy reaching successive levels of consumers in the food chain, to produce harvestable 33930 kg/year of harvestable meat for tigers the food needs of the herbivorous prey animals would be 3393000 kg/year (3393 tons of fodder). Considering the fact that there were only 4335 important prey animals (all deer spp. and gaur together) in the ADTR in 2002 the future of the tiger depends on how best we can increase the prey resources. We should also bear in mind that there are panthers, hyena, and some minor carnivores which have a share in the major and minor prey population of ADTR. As most of the ungulate prey mainly depends on grasslands for their fodder the management of these grasslands is of paramount importance.

Competition with domestic cattle: Good number of grasslands and savanna woodlands with grassy ground cover are in the vicinity of villages, where the wild animals will have to compete with them for fodder. At a modest rate of 10 kg of grass/other plant resources as fodder, the 6000 plus cattle would need annually about 22,000 tonnes of fodder. As ADTR has forest as climax vegetation, and large areas already covered with monoculture plantations. Many village grasslands grasslands are in eroded and poor state where again the cattle become competitors for wild herbivores. Unless this situation changes tiger population is not likely to improve significantly. Most of the deer and gaur usually come to grasslands only after dusk hours to escape humans. As villages, at least in the core areas, will be resettled outside the pressure from domestic cattle on these grasslands is bound to decline in the coming few years.

Traditional fodder management in hilly areas and wildlife fodder crisis: Different types of historical grassland management practices create different plant diversity patterns (Gustavsson, 2007). The open grasslands with long history of maintenance either by humans (by mowing, grazing by domestic animals, fire etc) or from wild animals (by grazing) tend to be more species rich with more fodder species. The grasslands in high rainfall hilly regions are exposed to varying levels of grazing such as in *benas* and *soppinabettas*. Some are temporarily fenced off and harvested by hand at the end of growing season. These management practices have co-evolved with the local agrarian system, which is a combination of Areca-spice orchards and paddy fields. Productivity depends critically on the continuous input of organic matter and nutrients in the form of livestock dung (along with leafy mater), and on the availability of draught animal power for ploughing. Milk is an important additional benefit. Livestock, almost all cattle and buffalo, are thus an integral part of the agrarian system. This has lead to the serious competition with wild life animals for natural grasslands as cattle population has increased. The grasslands areas are dwindling because of the need for land for housing, agriculture, roads and various other developmental activities

Fodder rich and poor areas in ADTR: Larger grassland areas such as Thayamaddi-Barpoli cross, Kaneri dam site, Terali, Burpali-Anshi, Kumbarwada-Diggi areas etc., are old grasslands having not only highly palatable, high yielding grass species but also good number of other fodder dicot species.

Most of the highly exploited, overgrazed, lands will have species very different from those they had earlier. Virnoli safari route forest grassland though showing high percentage grass individuals have only two low yielding fodder grasses (*Oplismenus burmanii* and *O.compositus*) dominating (Table 3). Same is the case with Goyar forest grassland which had also very low fodder value grass species. It also had low density of dicot herbs.

Areas underneath the forest canopy having low density dicot forage herbs along with sparsely occurring grasses as in the Virnolli-safari route, Goyar etc., cannot sustain any significant number of herbivores. On the other hand open grasslands interspersed with wetlands are more important in sustaining herbivores. In the ranges with dense forests and/or monoculture plantations such as at Anshi, Phansoli, Gund and Kulgi, the wildlife mostly depend on openings within the forest, on wetlands and on the sparse growth of grasses underneath the forest canopy. Hardly any grasses grow in the teak plantations and inside dense evergreen-semievergreen forests (as in Anshi Range) therefore these ranges do not have as much potential to support wildlife unlike Kumbarwada and Diggie Ranges. The entire forest region especially along the deciduous zone is dotted with teak plantations which are not congenial for grasses. Phansolli, and Kulgi forests are also largely planted with teak.

Recommendations

- Grassland enrichment is to be thought of for selected grasslands. Very degraded grasslands may be closed to grazing facilitating revival of the grasses.
- The practice of afforestation of grassy blanks has to be discontinued unless there is need for recreation of resource patches (fruit trees and keystone plant resources favouring life of herbivores). These resource patches have to be in block planting or in linear forms facilitating corridors for movements, for animal movements. A combination of both may be also carried out, after planning and deliberations.
- Afforestation of grassy blanks to be limited to very unproductive areas only. While selecting tree species for planting the animal community should be borne in mind. Patches have been observed where instead of raising natural vegetation the exotic industrial cum pulpwood species *Acacia auriculiformis* has been planted. For example Acacia was planted up in Thayamaddi-Barpoli Cross and few other places.
- Controlled fire to be used in grasslands in transition such as under dicot weeds and woody vegetation. Such grasslands to be divided into blocks and alternate blocks to be set on fire. Volunteers may be trained and their services used in meticulous use of fire so as to promote grasses
- Since legumes are nitrogen rich and good as fodder, leguminous fodder herbs may be planted in abandoned agricultural fields to promote wildlife. Herbaceous climbers of legumes, that provide forage for wildlife may be promoted experimentally in some of the poor grade mono-culture plantations.
- Natural succession inside monoculture plantations may be directed towards enhancing the food resources of the ADTR for wildlife.
- Herbaceous forage legumes may be considered experimentally for planting along the sides of some of the forest roads.
- Priority to be given for resettlement of villages with large number of cattle. Some of the good pastures of importance to wild herbivores need to be spared from grazing by domestic cattle. In the peripheral villages the concept of village fodder farms, to meet the fodder requirements of domestic cattle, needs to be promoted, so as to prevent those cattle from entering the ADTR.
- Tigers are sensitive to high levels of human disturbance. In landscape management programme large core areas are to be earmarked for strict protection. Relocation/rehabilitation of villages, preferably should begin with these identified core areas. The core areas may be identified by abundance of wildlife in general, good water resources and reasonably large sized elements in natural landscapes. Good grasslands need to be linked to large patches of multi-species forests and perennial water bodies.
- Core areas and corridors are to be identified on the basis of field studies, animal censuses/observations hitherto carried out and remote sensing data. Corridors to be devised and existing ones have to be strengthened/widened using suitable plant species.
- Buffer zone management is very critical in tiger conservation efforts. The buffer zone should not be one with intense human activities and grazing pressures from domestic cattle. The human activities here should be regulated and development guided towards complementing the objectives of ADTR. Activities suggested for the buffer zone are (i) Formation of Village Forest Committees and Biodiversity Management Committees among all the peripheral villages, (ii) Raising firewood and NTFP species to make peripheral villages self sufficient so as to take pressure of the ADTR core and buffer zones, (iii) Starting village fodder farms, under Social Forestry schemes, especially in villages having numerous cattle and insufficient fodder resources, (iv) Training enthusiastic youngsters as

tourist guides, volunteers and communicators, (v) Fencing of small blocks of lands for three to five years from human impact and grazing by domestic cattle, will have very positive impact on forest succession and healthy growth of grasses in overgrazed areas. Once tall saplings are naturally established, the forest will flourish on its own. The protection may be shifted to other unprotected areas after the three to five year period. The forest lands thus protected may be named "Regeneration Blocks". The vegetational succession in such blocks to be monitored and recorded, preferably by local volunteers. Seeds of suitable tree and shrub species may be disseminated in such areas to promote diversity.

- Application of GIS on wildlife distribution within ADTR is critical. Distribution data, to begin with, should cover primary and secondary reports on tigers, panthers and major herbivorous mammals. From existing and freshly collected data bird distribution details can be prepared as well. Birds are also good indicators of habitat quality. From distribution maps thus prepared, areas of importance for tigers and their prey may be demarcated. This would help in understanding ecosystem processes for preparing guidelines of future management of the Reserve. As it is difficult to get exact details of the very few tigers reported from the ADTR, it is very important to track their associate species and use them as proxy for demarcating likely tiger preference habitats within the Reserve.
- **Grassland management -** It is necessary to maintain different kinds of grasslands within the Reserve as some grazing wild animals prefer short grass areas while others prefer tall grass areas. Mixed savanna-grasslands are favourites of yet others.
- **Controlled use of fire:** ADTR receives high to moderate rainfall and the natural climax vegetation here is forest. Gradual vegetational succession in grasslands towards forest would effectively reduce carrying capacity for grazing animals and thereby affect prey supply for the carnivores. Therefore maintenance and management of grasslands would play a crucial role in sustaining wild fauna. Fire has been an important tool in grassland management in the humid Western Ghat regions. In the grasslands fire burns down the harsh, fibrous old bases and promotes a flush of new growth of fodder grasses. As it is time consuming and expensive to manage the large areas and keep the ecosystems in a dynamic stage to sustain maximum of the tiger population, with the available staff of the Forest Department, trained volunteers, NGOs and wildlife enthusiasts may be used in grassland management with regulated use of fire according to specifically prepared, site-centred management plans. Fire is to be used with caution as repeated fires can dry out a habitat, cause soil erosion and destroy many sensitive species.
- Many tree species of food importance for herbivore prey animals of the tiger are associated with burnt savannas. These include *Acacia* spp., *Bombax ceiba, Careya arborea, Cordia* spp., *Dillenia pentagyna, Kydia calycina, Phyllanthus emblica* etc.
- **G**rassland within the Reserve, including fallow fields, should not be used for tree planting under normal conditions. The practice of raising block plantations in such grassy blanks is to be altogether dispensed with. Block plantations, and that too of fodder tree species and those trees that provide food for wildlife can be considered in rocky areas with scanty growth of grasses and other herbs. Providing designed corridors (using area specific trees and other life forms) for animal migration through such areas would be a good exercise for keeping the integrity of the ADTR by keeping the ecosystem processes alive.
- **Remove monoculture plantations -** Ever-since commercial forestry began in the ADTR region, over one hundred years ago, during the British period, raising of teak plantations became an accepted practice, almost in every block of forest, after clear-felling the natural tree growth. Teak plantations

in general are low diversity areas, with scanty undergrowth of grass. The plantations are drier places than the natural forests, often subjected to soil erosion and ground fires. Despite the fact teak timber fetches fabulous market prices, there has been a moratorium on tree felling within the ADTR. With the objective of increasing the prey population of tigers, the food resources have to be increased. Without in anyway tampering with good teak plantations, the others can be subjected to enrichment planting with various fruit and fodder species, mainly the trees.

- **Adopting landscape level approach:** In small and isolated protected areas the chances for long term survival of megafauna are slim, unless they are linked by natural habitat corridors to permit dispersal of tigers and their prey and are provided with buffer zones to minimize impacts from other land uses. Therefore landscape level approach is essential for tiger conservation, which requires Evaluation of habitat quality in different parts of the ADTR with their suitability for wildlife in general and tiger in particular needs to be carried out. In such evaluation grassland quality and connectivity with different other landscape elements are important. Management plans have to be prepared to upgrade landscape elements, particularly poor quality grasslands.
- Tiger in India is a symbol of pride, power and strength. In Indian tradition it is both feared and respected animal and treated at par with the lion. In the local cultures associated with the wooded highlands tiger has been a worshipped animal. This holds good for the hilly terrain of Karnataka as well. In the Uttara Kannada district most villages and even towns have icons of tigers or *Hulidevaru* inside sacred forests, under sacred trees or in recently constructed small shrines. Tiger is famed as the *vahana* of the goddess Kali/Durga and Lord Aiyappa. Such incredible sentimental attachment among the public towards this magnificent animal needs to be appropriately utilized for gaining public support for tiger conservation in ADTR. Such support has to come from not only from outside but more so from the people living within the ADTR and its peripheral villages. Volunteers from among the youth, especially from these villages have to be enlisted to work for activities related to tiger conservation, and to develop a positive attitude among the local population. As the too few staff of the Forest Department are insufficient to manage and maintain the ADTR, especially in fire control, regulated use of fire, in grassland maintenance, tree planting, nursery activities, awareness creation, as local guides etc. it will be ideal to have a core group of such volunteers to assist the Department. If trained in bird watching, plant identification, and in disseminating wildlife related information to the visitors, ADTR can gain much from this reposition of confidence in the local population.
- Pulses are leguminous herbs and climbers the seeds of a great variety of which have been used as protein rich food by humans from ancient times. Not only are the seeds rich in proteins but the forage also is rich in proteins, mainly because of the association of the roots of these plants with nitrogen fixing bacteria. The very growth of the legumes enriches soils with nitrogen and they are ideal for reclaiming impoverished soils. Dispersing the seeds of relatively low cost pulses selectively, especially along roadsides, as well as raising them in small protected patches, and in canopy gaps of plantations, underneath power lines etc., in due course can increase the stock of these useful plants, as wildlings in the ADTR. The plants will provide excellent forage for many herbivores which constitute the prey stock of tigers.

11.2 ANURAN DIVERSITY AND DISTRIBUTON IN DANDELI ANSHI TIGER RESERVE

Anshi Dandeli Tiger Reserve (ADTR) is one of among the protected areas along the Western Ghats and so far no systematic studies on anurans are carried out in ADTR. Hence the present study was carried out with following objectives

- Systematic study on the anuran diversity in the region
- Anuran distribution maps, with comprehensive account on species rich regions within the ADTR.
- Monitoring protocols for the region

Twenty nine species of anurans were recorded from this region belonging to seven families and eighteen genera. This is nearly 19% of Western Ghats amphibians and 10% of Indian amphibians recorded till date. Twenty species among the total of twenty nine species (69%) are endemic (Endemism is categorized into species exclusive to the Western Ghats and Western Ghats-Sri Lanka hotspot). There are four endangered species recorded from ADTR.

Considering number of species in each family, Dicroglossidae represents maximum of 10 species, followed by Rhacophoridae and Microhylidae with six and four species respectively. Nyctibatrachidae is represented by only one species. All species in Nyctibatrachidae, Ranidae and Ranixalidae families are endemics. Dicroglossidae and Microhylidae, even though have more species, but have only 50% of them as endemics.

Euphlyctis cyanophlyctis is the most abundant and most frequently encountered species. According to IUCN red list (2009), it is least concerned in threat status. Similarly, *Nyctibatrachus petraeus*, also a least concerned species is the second most abundant species at ADTR. Most abundant species, in this study, *Euphlyctis cyanophlyctis,* inhabits in almost all study localities, while rarer species like *Pedostibes tuberculosus* and *Rhacophorus malabaricus* are found in particular habitats of very few localities.

Land-cover analysis based on NDVI show that the eastern part of the ADTR, especially near Ambikanagar, Kulgi, Bhagavati, BP dam areas are relatively poor in vegetation. Such non-vegetated areas are also on Kumbarvada Joida section, Gund, Ulvi and Anshi area, attributed mainly to agriculture clearings and dry river beds.

Land-use analysis of ADTR based on fuzzy supervised classification show nearly 98% of the region is covered with vegetation, among this; dense forest occupies nearly 57% followed by spare forest 26.5%. Plantation including Acacia/Areca/Coconut, etc., has 8.69% cover in ADTR. Built-up occupies 0.5% of the area, indicating that ADTR still has not been invaded by human habitation. It is also evident with almost 1% of area under agriculture. Hence, ADTR is one of potential protected area in the northern Western Ghats for conservation priority. On careful examination, eastern part of ADTR is predominant with sparse forest (logged/teak plantation). This is due to selective logging and teak plantation in the region in early 1980's. Anshi, Ulvi, Gund, Ambikanagar, Kulgi, and places near Kumbarwada have agriculture areas. West, South, North-western and south-western parts are among the very less disturbed regions in ADTR.

It is a very good initiative from Forest Department, Government of Karnataka, to include regions up to Kadra in south and up to Diggi in North, which are also of less disturbed forested areas in the vicinity. ***Batracharium*** - a unique concept for conservation of amphibians is proposed here, where in few localities inside ADTR are identified, habitats are marked and provisions are made for frog watch with sign boards indicating the species to look for, kind of habitat and regular monitoring programmes are scheduled. First such batracharium can be at Nagazhari pond in front of the Kulgi nature camp. This particular pond, proposed for batracharium would have two signboards (15cmx60cm), one indicating it as "Batracharium-stop to watch frogs" and other with 5-10 commonly available amphibian species in that particular locality, along with their images, pointer showing specific colors and/or parts to look out.

Conservation and Management Guidelines for Amphibians at ADTR: Conservation and management needs for Amphibians of the Western Ghats are discussed in length over the years. There is a need for guidelines on these issues, especially for the forest managers, who in fact have more access and accountability of the protected areas. This part of the document deals with conservation management guidelines, keeping amphibians as focal organism.

Anthropogenic changes in land-use like habitat alteration, fragmentation and forest loss are considered to be the primary challenge in the conservation of amphibians. Human populations are ever expanding, needing more and more land for various activities at local scale leading to alteration, fragmentation and loss of pristine forest habitats. This is considered to be the primary issue for the decline of amphibian populations worldwide. A proactive approach for minimizing the impact of such activities and to improve upon existing habitat is the key for conservation of amphibians. These guidelines are not regulations, nor to limit or curtail the activities of forest officials. Landscape approach based on hydrological regime of ADTR will help long term conservation and management of the amphibians. Anuran amphibians of ADTR use streams, wetlands, and forest habitats in a very complex manner for breeding, feeding and resting. In addition, majority of amphibians are highly seasonal, having their breeding span spread only in the rainy period. This calls for a better understanding of natural history of these animals, their seasonal movement between habitats, and the natural dynamics of the habitats themselves, which are quintessential in landscape based conservation effort.

For amphibians, water bodies (lentic or lotic) play major role in breeding, egg laying (spawning), tadpole development and foraging, hiding place from predators and thermoregulations, whereas terrestrial habitats help in foraging, movement (dispersal), resting place and escape from floods.

The following guidelines are suggested within ADTR for maintenance and enhancing habitat quality

- Limit motorized vehicle transit within the ADTR during rainy seasons, specifically during monsoon. Amphibians are generally active during night and more so during rainy seasons when they breed. Limiting the motorized vehicle within ADTR, either in numbers or in speed would certainly decrease the number of road kills of amphibians in ADTR.
- Maintain native vegetation where ever possible (e.g., near Patoli cross, there is native evergreen patch, maintain this patch as it is) and where it is absent, restore native vegetation both in structure and composition. As far as possible avoid introducing/planting exotic species, if management regime permits, remove them and replace plantation of exotic species with native plant species.

This is more pertinent to defunct mining areas, which are now planted with *Acacia*. It could have been better, if native tree species were planted here.

- Protect from expansion of roads, agriculture fields and any other developmental activity. These activities are disruptive to amphibians and they generally fragment, degrade and reduce habitats of amphibians.
- Amphibians are very much dependent on natural hydrology of an area, hence, maintain and restore natural hydrology. This allows natural evolution of stream dynamics and associated vegetation. Natural flood cycles are important for maintaining amphibian population as also their prey and predator populations too.
- There are agriculture fields within ADTR, hence there must a monitoring on the usage of fertilizers, herbicides and pesticides, which are proved to be detrimental amphibian population.
- Provide conservation related education MATERIALS to farmers, campers, hikers and people who frequent ADTR. Batracharium is one such area, where people can watch exclusive for frogs (detailed in Part I). Educating and creating awareness about amphibians among school children who are residing inside and nearby areas (Dandeli, Kulgi, Anshi, Joida, Ambikanagar etc), which can also be extended to all people in and around ADTR.
- Grass lands and defunct mining areas needs special attention and continued monitoring for amphibian diversity.
- Research on anuran amphibians over a long time period, with a proper objective, highlighting hydrology related issues must be supported and continued in future.

11.3 CONSERVATION OF ENDANGERED FAUNA

The rare lion tailed macaque (Macaca silenus) is an endangered species endemic to Western Ghats of South India in the tropical evergreen and semi evergreen forests. It is a taxonomically distinctive species. Special reasons for conserving this unusual monkey relate to its singular role as the only exclusively arboreal forest –dwelling macaque. The fragmentation of habitat is one of the threats to Lion tailed macaque (LTM) in Western Ghats. Other threats are clear felling, selective-felling, habitation and access roads, hunting and non-availability of food (due to legal and unauthorised collection of minor forest produce like Artocarpus, Ficus fruits which are its most important foods). The Lion tailed Macaque is on the verge of extinction due to extensive and widespread destruction of its habitat, even though it is secondary to its hunting. A study has been carried out in the Sharavathi river basin for a period of four months to explore the status of LTM's threats and conservation. Loss of habitat due to increasing anthropogenic activities is the primary threat to these animals. Fragmentation of habitats due to encroachments and unplanned developmental activities are converting the contiguous habitat into remnants which are unsuitable for LTM's as they are exposed to predation, hunting and also to inbreeding. During the field survey, a troop of LTM was spotted at the north bank of the Sharavathi River below Jog Falls. The region is fragmented by Honavar-Belgaum road along which forest encroachment for agriculture and horticulture is extensive. A severe decline in numbers of monkeys is reported since selective-felling operation began in early 60's. High forests lie between 200 to 500 m elevation and are transitional between semi-evergreens and evergreens. Since, this is now probably the north most limit of M.silenus, and also the habitat differs markedly from *Cullenia*-dominant and *Dipterocarpus*-dominant forests in south Western Ghats. Careful protection and management has to be adopted through restoration of forests to conserve the endangered endemic species.

Threats and Mitigation

Mitigation measures that are to be undertaken in order to overcome devastating effects of fragmentation for conservation of biodiversity in the Sharavathi river basin. These include

- Fragmentation caused by the submersion of vast areas and also due to biotic pressures [increasing settlement, agricultural fields, quarrying, fuel wood, fodder and NTFP (Non timber forest product) collection, encroachment, roads in reserve forests, etc.]. Land uses in the catchment were monitored for changes using temporal satellite imageries (IRS 1C data) and ground surveys.
- Lopping of branches for fuel wood and collection of leaves for fodder deprives animals of their food. Joint Forest Management (JFM) committees involving local people are to be formed in the catchment area and they should be associated with future management of forest in respective village territories.
- Overgrazing in the region has resulted in scarcity of resources for wild animals. Village fodder farms are to be initiated and managed to meet the needs of soil and water conservation and for other ecosystem needs.
- Conversion of forests into monoculture in vast areas for commercial purposes has affected the free movement of wild animals and deprived them of food and habitat. Monoculture plantations only serve either small mammals or agricultural pests as hiding places. An action plan needs to be prepared urgently for reducing area under monoculture by introducing forest species. Moreover, conversion of plantation into natural forests is necessary for meeting other ecological requirements including enhancement of watershed value.
- Fire, within limits, has an ecological role to play in the Western Ghats. But unregulated and frequent forest fires, accidental as well as intentional, have detrimental effects on the flora and fauna, and ecosystems as such. This necessitates appropriate management strategies such as creation of fire lines, restoration of evergreens, which provide greater fire immunity to the forests, adoption of a village centred fire management strategy, etc.
- Theft of forest products and poaching of animals have also affected the faunal diversity. Strengthening of JFMs, creation of nature clubs in the villages, and spread of awareness can go a lopping way in controlling hunting menace. The nature club helps in the ecological and nature conservation/ awareness movements. The village based nature clubs may be associated with animal census activities and other conservation centred activities.
- Regressive and intrusive forest fragmentation processes occurring in the region is to be controlled by removing all encroachments surrounding the interior forests and within core areas.
- Threats due to divisive type of fragmentation due to roads (which are inevitable) could be overcome by planting trees, which are likely to have wide canopy on either side of the road, and by providing ladders for animals to cross from one side of the habitat to another side (bifurcated due to a road).

11.4 ANT SPECIES COMPOSITION AND DIVERSITY

Insects form a major part of the animal biomass in the ecosystem and in recent times they have been used as indicator species. Ants represent a unique focal group, to be monitored, due to their ability to navigate across all trophic levels, along with their sensitivity to any changes in the environment. Endemism in ant species suggest that their occurrence and their absence could be due to certain specific reasons. In the Indian scenario, *Lasius* species of ants are present only at the base of Himalayas, *Harpegnathos saltator* only in the southern India, while *H.venator* occupies the northern regions of India. Species of *Strumigenys* are present in forests prominent of thick leaf litter, while *Tapinoma melanocephalum* is present in human interfered systems. This definitely shows in a small way, that ant fauna does vary geographically, across latitudes. To understand the diversity and the stability of an ecosystem, hence, it becomes important to study the species composition changes that occur due to variations in microclimate and habitat. This would help in biodiversity conservation endeavor as it aids in inventorying and mapping of biodiversity and also in demarcating the most seriously threatened ecosystems. With global remote sensing land cover data sets being nowadays increasingly available at high temporal resolutions, it becomes imperative to combine with it field surveys to provide powerful tools for biological resource assessments.

The study carried out at the Sharavathi river basin, Shimoga, Western Ghats, aims to determine the species composition and assemblages of ant fauna, across the varying landscape elements. GIS and Remote sensing have been used to derive information about the land cover and land use patterns, which are the niches for ants. This study has revealed that ant species composition varies drastically across vegetation types. Dominance of certain species increases while others decrease, with variation in habitat. Species that have highly specific requirements remain absent from disturbed habitats. This work has resulted in identifying certain biological indicators such as *Polyrhachis mayri* and *Oecophylla smaragdina* as species thriving in undisturbed evergreen- semievergreen forests and moist deciduous forests respectively, while *Anoplolepis longipes* has been identified as an invasive species. This study reveals the tremendous human pressure exerted towards the northern and eastern region of the river basin while contiguous forests were present only towards the western region (devoid of invasive species) of the study area.

Most of the ants have either a direct or an indirect relationship with vegetation. Some of these are highly specific to the habitat in which they occur, depending on the maximum benefits they attain for nesting, mating and food availability. Their preferences of microhabitat due to the above mentioned criteria were investigated by sampling ant fauna in various habitats along with mapping the vegetation using remote sensing and GIS (macro level analyses) to provide a detailed idea of the distribution of ant fauna, endemism and changes in patterns with habitat. By further determination of spatial distribution of certain indicator ant species the degree of stress and disturbance for prioritising conservation strategies for this section of the Western Ghats was analysed.

Ant species composition and their diversity patterns in different forest types at the Sharavathi river basin have been analysed in this study. This study emphasises the dominancy exhibited by the subfamily *Myrmicinae* within the ant communities, due to their ability to adapt to different niches with a variety of feeding habits. Dominancy exhibited by *Ponerinae* and *Formicinae* subfamilies in only certain habitats has been related to their very specific niche and food requirements. Habitats providing these specific niches were less frequently present. Results showed that the usually considered *species deficient* monocultures as acacia and pine plantations harbored certain ant species unique to their habitat, while truly arboreal ants were absent. Ants causing high diversity in such monocultures were those that are more generalistic in behavior. Behavioral data being sparse for ants represented by very few individuals, limits discussions. However, the absence of ants that thrived in moist deciduous and evergreen forests, which were specialists, suggests the lacking niches in plantations, dry deciduous forests and scrub jungles. The west radian, presents to the ants, larger number of niches than the others, suggesting, that though the western region was fragmented there still existed certain contiguous patches providing more niches for the ants (of all groups) to thrive, resulting in high species richness. Also, absence of certain species has revealed that the western region of the study area is under less degree of human stress compared to the other regions. We conclude by emphasising in classifying ants on the basis of their behavior than taxonomically, to pave way for further conservation and management programs. Further work in cataloguing the needs and requirements of different ant species to understand ant geography is in progress.

11.5 **AMPHIBIAN DIVERSITY AND DISTRIBUTION IN UTTARA KANNADA**

Amphibians are considered as biological indicators for their susceptibility to even very small changes in the surrounding environment and their habitats typically spread across the interface between terrestrial and aquatic habitats. They are the only vertebrate group with dual life stages (*i.e.,* tadpoles and adults) and perform vital ecological functions. Semi-permeable skin, anamniotic eggs and biphasic life style make them particularly vulnerable to changes and contamination of their habitats on land and in water. Habitat destruction and overexploitation are the major threat for amphibians, apart from *Chytrid* fungus and other synergistic effects of human induced changes. Presence of a diverse population of amphibians in a region is indication of a healthy environment. They are being used as surrogates in conservation and management practices. Monitoring amphibian diversity and their distribution would provide insights to the prevailing conditions of an ecosystem and its health, which in turn helps in prioritizing the region for conservation and management action in the Western Ghats.

River basins/catchments are topographically and hydrologically well defined unit of space and the present study has been carried out in five river basins namely Sharavathi, Aghanashini, Bedti and Kali of Uttara Kannada district using amphibians as biological indicators to arrive at conservation priority regions in the district.

Forty seven species of amphibians were recorded from Uttara Kannada district. This is nearly 30% of observed amphibians from the Western Ghats (157 species). These species belonged to two orders, nine families and 20 genera. Two families, namely, Nyctibatrachidae and Micrixalidae are among the oldest frog families found in the Western Ghats and are Gondwanan relicts. Of the 46 species recorded, 67% of them are endemic to the Western Ghats (31 species). Family Dicroglossidae has highest species (15) followed by Rhacophoridae with 10 species. Least species were recorded in Ranixalidae and Ichthyophiidae with two each. Kathalekan of Sharavathi river with 34 species of which 24 of are endemic, is an apt candidate for the status of heritage site of biological diversity as per biodiversity act 2002 (Chapter IX, Biodiversity heritage sites).River basin wise diversity of Amphibians: **There were 45 species from Sharavathi, 32 from Aghanashini, 29 each from Bedti and Kali river basins and five species in Venkatapura river.**

Sharavathi river basin: Majority of the species recorded for the entire Uttara Kannada district is known from Sharavathi river basin, except for *Raorchestes bombayensis*. Sharavathi harbours nearly 69% of endemic species of the Western Ghats. The species rich sites (> 10 species) are Kathalekan (34 species), Watehalla and Muppane (14 species each), Hurli (12 species) and Niluvase (11 species). Kathalekan is a well known Myristica swamp having ancient origin provides habitat for uniquely breeding species. It also has highest number of endemic species (24). *Raorchestes ponmudi*, an endangered species is also recorded from this site.

Aghanashini river basin: Thirty two species are recorded from Aghanashini river basin. None of the caecilians were recorded in this river basin. Kathagal with 17 species is species rich site in Aghanashini followed by Sapurthi (15 species) and Baillalli (13 species). Sapurthi harbours higher endemic species in the entire river basin.

Bedti river basin: Twenty nine species were recorded from Bedti river basin. Species rich regions are Makkigadde (13 species), Devnalli (12 species), Kelginkeri and Daanandi (10 species each). Endemism is highest is Makkigadde and Devnalli (8 species each). It is interesting note that Yerebail has no endemic species despite having 6 species.

Kali river basin: Kali river basin has 29 species. Castle rock, Virnolli and Ulvi are species rich (13 species each) followed Gowliwada (10 species). Castle rock leads with higher endemism than Ulvi (6 endmic species) Virnolli (9 endemic species). The species recorded from Deriye were all endemic to Western Ghats.

Recommendations: River basin based studies provide insights on species distribution and diversity as catchments are topographically and hydrologically well defined. Among five rivers, Venkatapura is least rich in terms of amphibians, which could be attributed to its smaller catchment. Among the other four river basins, Sharavathi is species rich and also endemics. One of the sampling site, Kathalekan, a very well known Myristica swamp, harbours 34 species, attributed to the vegetation and seasonality of stream. This site certainly needs immediate attention from decision makers as surrounding areas are used for agriculture purpose and there are instances of human activities inside the region. Muppane also has higher richness, but is already inside Sharavathi valley wildlife sanctuary. As one proceeds further north in Uttara Kannada district, the vegetation also changes to semi-evergreen to deciduous, which could be the reason of less diversity in Kali and Bedti river (29 species each). Kathagal in Aghanashini river basin is relatively closer to coast among the sites is an example for ‘refugia’ concept, where in amphibian species were found despite a small area surrounded by agricultural activities. Bailalli and Sapurthi also harbor higher species in Aghanashini. In Bedthi, Makkigadde and Kelginkeri are the sites with high amphibian richness and endemism. Similarly, Castlerock, Virnolli, Ulvi and Gowliwad are in Kali with amphibian richness and endemism. However, all these sites with high richness and endemism in all the river basin face the threat, directly are indirectly from human activities such as diversion of streams, encroachment for agriculture, illegal felling and collection of forest yields. Kathalekan in Uttara Kannada district is an ideal heritage sites from Biodiversity perspective. The other sites mentioned needs the attention of forest managers for better conservation and management of biodiversity in Uttara Kannada district.

11.5 NEED TO CONSERVE LATERITC PLATEAU ECOSYSTEMS OF COASTAL UTTARA KANNADA

> *According to the Ministry of Environment and Forests, Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat.* ***The rights of people living inside a Conservation Reserve are not affected.*** *This is unlike in National Parks and Sanctuaries where there are many stringent regulations regarding people living within them and on community rights and privileges. The PAs are constituted and governed under the provisions of the Wild Life (Protection) Act, 1972, which has been amended from time to time, with the changing ground realities concerning wildlife.*

Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected. Conservation Reserves can be declared by the State Governments in any area owned by the Government. Particularly stressed are areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with local communities.

In the cases proposed here of the two lateritic plateaus as Conservation Areas, it needs to be admitted that these are not adjacent to National Parks and Sanctuaries, nor they link one PA with another. We recommend these areas strongly for protection because of their uniqueness in flora, and to some extent in fauna, their ancient geological ages, the formation beginning 88-90 Mya.

The coastal landscapes of Uttara Kannada, mainly from parts of Ankola taluk in the north to Bhatkal taluk in the south, are notable for spectacular formations of low level laterite hills and plateaus. The valleys in between them are good water yielding places, perhaps were ancient water courses through which greater volumes of waters flowed, before they were reduced, as are today, into a network of green veins running through an otherwise bleak spectacle of denuded low hills and plateaus. These coastal lateritic formations, in all probability lost most of their surface soils during the last three millennia of history of shifting cultivation and savannization for domestic cattle and to keep away predatory wild animals for safety of humans and livestock. Surface laterisation process, as was already explained earlier, resulted in formation of hardened, indurated mantle. These lateritic formations, most of which is under the control of the Forest Department, have been naturally considered as one of the most unproductive terrain, from early British times.

The woody vegetation on such hills was mostly composed of stunted trees and shrubs such as *Sapium insigne, Strychnos nux-vomica, Zizyphus mauritiana, Plectronia parviflora, Grewia microcos, Flacourtia Montana, Ficus arnottiana, Memecylon edule, Syzygium corymbosa, Aglaia roxburgiana* etc. The wetter valleys in between have more evergreen species which are also found in the Western Ghats further interior. Many sparsely populated villages and hamlets, along with their spice gardens and rice fields are situated in these valleys. The village cattle would be seen grazing in these hills, with of course poor forage for them, except in protected portions under private control, where grows tall *karada* grasses, cut and stored by farmers after the end of the rainy season, when these grasses start drying up.

What was often overlooked was the fact that during the period of torrential rains, especially from June to almost the close of September, most of these apparently barren hills turn into altogether a different kind of seasonal ecosystem of wet rocks, shallow bogs and marshes and temporary streams, teeming with numerous herbs in myriad flowers of varied hues which attract a variety of insects, especially bees and butterflies.

These laterite ecosystems have scores of species of herbs, many of them endemic to the Western Ghats west coast regions. The scarcity of nutrients in the rocky substratum favour here a flourish of insectivorous herbs, the bladderworts (*Utriculalria* spp.) and sundews (*Drosera* spp). These make up for t nitrogen deficiency in the medium by resorting to trapping of tiny insects and digesting them using specially modified leaves. Yet another group of plants are some members of the family of Scrophulariaceae, like *Striga, Sopubia* and *Rhamphicarpa* specialized in root parasitism. Some legumes here have root nodules with nitrogen fixing bacteria in them.

The general consideration of these lateritic formations as of not much utility to humans made the government to give concessions to local people to gather biomass from these hills for fuel, manure and fodder. Further, quarrying for laterite bricks, the most common building blocks of the district has been a rampant activity disfiguring the hills and causing damages to their special ecosystems as well as with adverse effects on local hydrology. As tree growth is sparse and slow, over the last three decades the forest Department raised in large scale monoculture plantations of the fast growing exotic tree *Acacia auriculiformis*, to meet the growing demand for timber, fuel and pulpwood.

Survey of vegetation in the laterite hills and plateaus, was undertaken mainly with the purpose of protecting at least some of these primeval geological formations, with great bearing on continental drift and formation of west coast, along with their for their very special seasonal ecosystems. Out of the many hills and plateaus surveyed during the current rainy season, we recommend specially two of them, one in the taluk of Bhatkal (Bhatkal plateau) and the second in Mugali plateau in Honavar taluk.

Many exclusive species of flowering plants co-evolved with the laterite terrain micro-level heterogeneity. For instance, deeper lateritic bogs support *Eriocaulon cuspidatum*, shallow bogs *Weisneria triandra* while marshy areas have *Utricularias* and other species of *Eriocaulons*. As water is the most critical limiting factor as soon as the rains stop by early October most of these annuals except few such as mat forming hardy perennial herb *Lepidagathis prostrata* and tuber perennating ones like *Euphorbia fusiformis* and *Curculigo orchiodes* die off. Of the two places that we found of the lot as having most specialized lateritic herbs, Bhatkal plateau had richer growth of herbs, since there were more seasonal streams, marshes and meadows. Mugali plateau had its own complement of species and includes as well as the newly developed and spectacular Apsarakonda park, towards its sea facing slope and commanding view of the ocean from the plateau. In comparison was the thinner and sparser vegetation lower diversity of species of Gokarna and Belekeri study areas. Honavar and Kumta laterite formations were intermediate in their biodiversity.

Scrub jungle vegetation with *Memecylon edule, Flacourtia Montana, Canthium parviflora, Sapium insigne* and plantations of cashew-*Anacardium occidentale* were found Mugali plateau. The rainy season splendor of herbal vegetation, especially of insectivorous plants and several rare endemics and the massive flowering at a time when most people hesitate to step into these rocky expanses, is remarkable. Not only these laterites are picturesque to look but they also support wide range of insects such as bees, carpenter bees, beetles, various butterflies etc. acting as a critical food resource for these species during the rainy period when flowering is scanty elsewhere

The mammalian diversity was richer once because of the continuity of this hilly coast with the Western Ghat forests, before heavy human settlements and construction of the National Highway 17 and the Konkan Railway track. Heavy coastal traffic practically reduced major mammals. The laterite plateaus are however rich in certain special kinds of mammals like the pangolin and porcupines. Jackals are common and the wild boars sometimes foray into the region, especially in Bhatkal plateau, which also get occasional barking deers. Bird diversity is quite rich because of the nearness of sea, backwaters, forests, plantations and fields. Peafowls are very notable among the numerous birds. Detailed studies of mammals, birds and reptiles are yet to be taken up. The monitor lizard is a somewhat commoner species. These and pangolins are sometimes hunted for meat. Some kind of conservation status is likely to benefit both these rare species and many others.

Importance of laterite flora for insect diversity: Flower-visiting insects play an important role in maintaining biodiversity and ecosystem services such as pollination, which corresponds to a great economic value. Wild and domestic bees and other pollinators increase production of fruits and vegetables and many other kinds of crops significantly. The emerging threat of a global ‘pollinator crisis’ was expressed over a decade ago. Since then, declines of pollinator and other flower-visiting insects have been confirmed worldwide. The main driver of decline in flower-visiting insects is generally thought to be the loss of suitable habitat through land-use changes and other human activities. Among the various determinants of habitat quality, the loss of floral nectar resources has been most frequently proposed as a major factor contributing to flower-visiting insect declines. Pollination systems in which the host plant provides breeding sites for pollinators, invariably within flowers, are usually highly specialized mutualisms.

The enormous numbers of herbs that carpet the laterite plateaus during the rainy season flower from July to mid-September and some of them beyond for some more time. This period, especially July to August has very less flowering among the other wild plants, including forest trees and shrubs. The *Utricularias,* balsams, *Eriocaulons,* herbs of Scrophulariaceae and many others, which have their profuse flowering in the plateaus during the peak rainy period, act as keystone resources for pollinator insects, especially bees and butterflies and various dipterans. Therefore the conservation of laterite plateaus near every coastal village is necessary, at least as Biodiversity Heritage sites of respective villages.

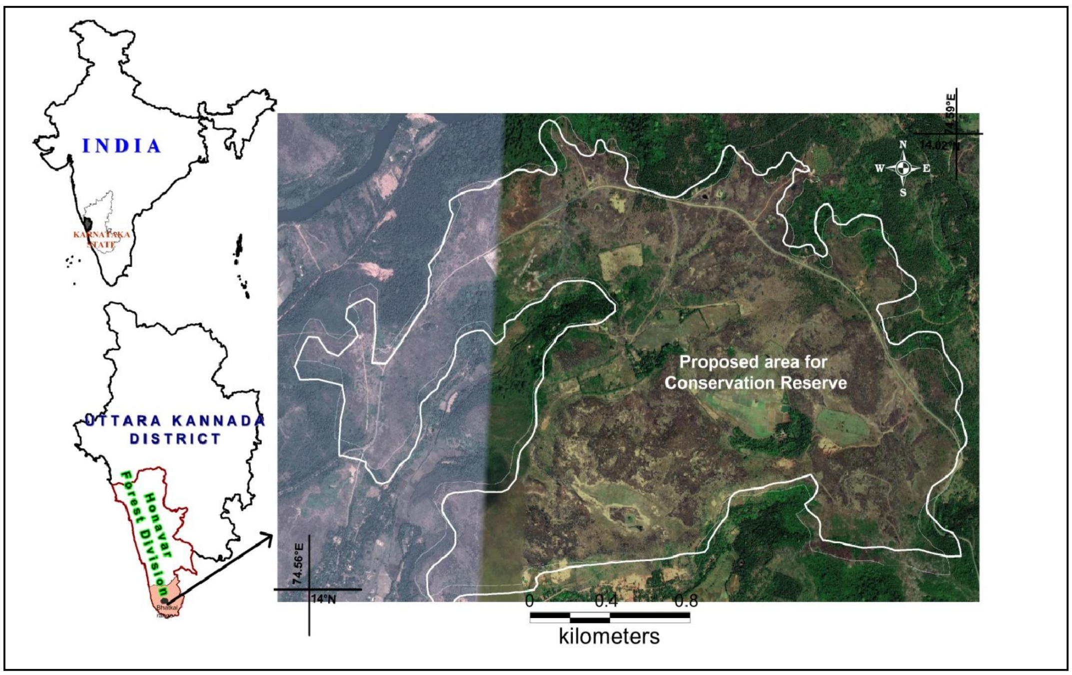
Pollination systems in which the host plant provides breeding sites for pollinators, invariably within flowers, are usually highly specialized mutualisms. The non-butterfly insects identified were *Apis dorsata* var. *dorsata, Apis cerana indica, Apis florea, Trigona* sp., *Xylocop sp.* etc.

COASTAL LATERITE PLATEAUS AS ‘CONSERVATION RESERVES’: Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected. Conservation Reserves can be declared by the State Governments in any area owned by the Government. Particularly stressed are areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with local communities.

Reasons for laterite Conservation Reserves: We are proposing here two lateritic plateaus of coastal Uttara Kannada viz. 1.Bhatkal plateau in Bhatkal taluk and 2. Mugali plateau in Honavar taluk under the conservation category called **Conservation Reserves** under the provisions created by the Ministry of Environment and Forests. Details of the two plateaus are as follows:

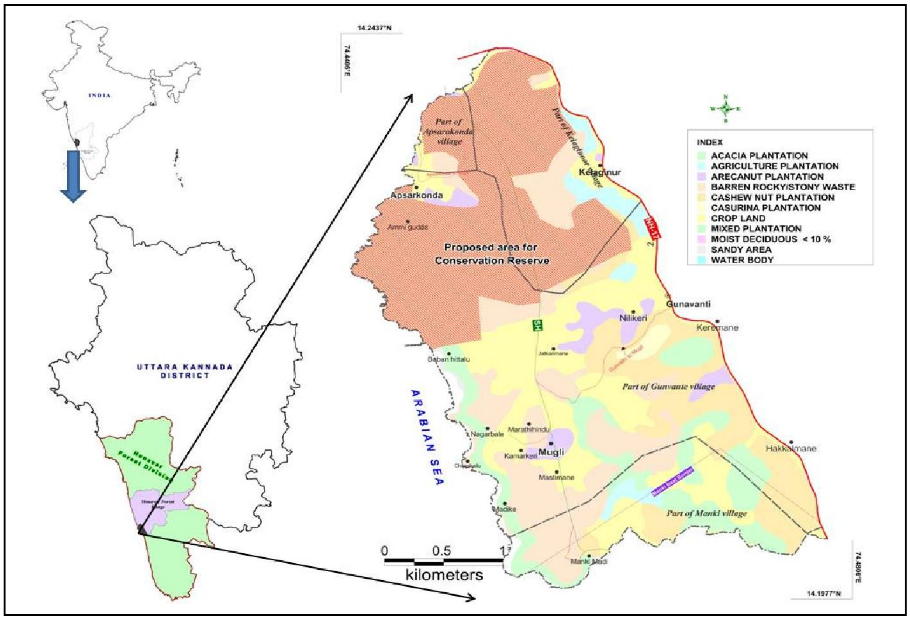
1. **Bhatkal laterite plateau:** The plateau proposed for Conservation Reserve covers part of Bhatkal forest beat and part of Kotkhanda forest beat in the Bhatkal range of Honavar Forest Division. The proposed plateau covers about 425 ha of area within lat.13.99915° -14.02062° N and long. 74.55929°-74.59044°E **(Figure 11.1)**. The detailed study of the flora was carried out and the plateau can be considered one of the richest lateritic floristic provinces of Uttara Kannada, and hence worth of its conservation for the sake of ecology, biodiversity and posterity.

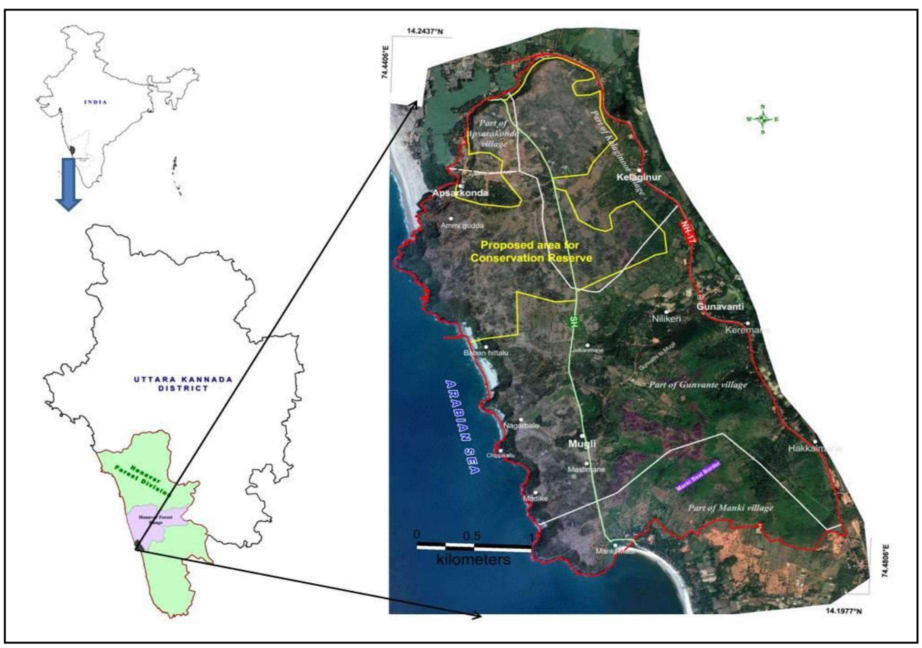
Figure 11.1: Proposed Bhatkal laterite plateau Conservation Reserve



2. **Mugali laterite plateau:** The plateau proposed is also in Honavar Forest Division. It covers area of about 300 ha in the coastal villages of Mugali, Kelaginoor and Apsarakonda villages. The proposed plateau is part of a much larger one and is situated between lat. 14.1977°-14.2437°N and long 74.4406°E-74.4806°E **(Figure 11.2)**.

Figures 11.2: Proposed Mugali laterite Conservation Reserve map (up) and Google imagery





Both the proposed areas are, admittedly, not adjacent to National Parks and Sanctuaries, nor they link one PA with another. Yet they have very important reasons to be considered as such reserves for the following reasons:

- These Conservation Reserves are going to be, perhaps the first in the world, exclusively for lateritic ecosystems

- Laterite is a unique type of tropical sedimentary rock (basalt derived laterite of Maharashtra mountain tops excluded from its purview).
- Western Ghats constitute a global biodiversity hotspot, and several sites have been recently declared by UNESCO as World Heritage Sites. Unfortunately there has been never an effort to recognize the rare herbal vegetation of coastal laterite plateaus and hills, which have a good proportion of rare and endemic herbs.
- Rare animals like Pangolin and Monitor lizard can be conserved ideally in such reserves
- The laterite formations are aesthetically pleasing, and particularly so with the massive flowering of rainy season herbs. The terrain is ideal for tourism and scientific studies
- UNESCO Criterion 9 or declaration of a place as Heritage Site pertains to "**outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features".** The coastal laterite formation is a testimony to India's separation from Madagascar almost 90 million years ago, and the erosion that happened through several million years of the primeval Western Ghats, and deposition of such eroded materials along the coastline, which originally belonged to the Tethys Sea, before the Arabian Sea came into existence.
- The seasonal herbs constitute the main foraging sources for honey bees and various other pollinators during the peak of rainy season, when there is absolute scarcity of any feed for them. Hence such plants may be considered as 'keystone resources'.
- Moreover the declaration of Conservation Reserves is not going to affect the rights of the people living in the area. On the other hand community participation in management can earn revenue for them, especially from tourism
- The State Government can declare the Conservation Reserves.

12.0 ESTUARINE ECOLOGY

Task: Estuarine Ecology (Not assigned as per TOR, but implemented to get holistic picture of the district for assessing carrying capacity)

Reports

1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Marine Fishery in in Uttara Kannada, Sahyadri Conservation Series 39, ENVIS Technical Report 69, CES, Indian Institute of Science, Bangalore 560012, India
2) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Mahima Bhat, Prakash N.Mesta, Sreekanth Naik, 2013. Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64, ENVIS, CES, Indian Institute of Science, Bangalore 560012, India
3) Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
4) Ramachandra T V, Subash Chandran M D, Joshi N V, Rakhi Raj, Prakash N Mesta, sumesh Dudani, 2013. Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka, Sahyadri Conservation Series 27, ENVIS Technical Report 45, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
5) Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
6) Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 20, ENVIS Technical Report: 50, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
7) Ramachandra T V, Subash Chandran M D, Joshi N V and Boominathan M, 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report: 48, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
8) Subash Chandran M. D., Prakash Mesta, Boominathan M., Rao G. R., Vishnu D.M. & Ramachandra T.V., 2011. Aghanashini Estuary in Kumta Taluk, Uttara Kannada - Biological Heritage Site, ENVIS Technical Report: 35, Sahyadri Conservation Series 11, ENVIS-Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
9) Subash Chandran M. D., Rao G. R., Prakash Mesta, Vishnu D.M. and Ramachandra T.V., 2011. Green Walls for Karnataka Sea Coast, ENVIS Technical Report: 34, Sahyadri Conservation Series 10, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

Tropical estuaries are very productive ecosystems. In Uttara Kannada important estuaries are of the rivers Kali, Gangavali, Aghanashini, Sharavathi and Venktapur.. Due to their high productivity estuarine villages and coastal towns closer to them such as Karwar, Ankola, Gokarna, Kumta, Honavar and Bhatkal are densely populated. Because of high diversity and productivity of fishes, prawns, clams and oysters, crabs etc. thousands of fishing families depended on estuaries for their livelihood. Shallow parts of estuarine areas were converted into *gazni* rice fields, coconut groves and human settlements. Estuaries play important roles as egg laying places and nurseries for many marine fishes. They also shelter, altogether over 120 species of birds due to the abundance of food and the shelter which the mangroves gave.

Recommendations

- As estuaries are used by many marine fishes most of which have narrow tolerances for physical and chemical conditions, drastic alterations in such conditions due to human interventions will have adverse consequences on fisheries. As is evident from Sharavathi and Kali estuaries, both of which are adversely affected in biodiversity and productivity due to hydroelectric projects, in future it is very necessary for protecting all the remaining estuaries from major developmental interventions so as to protect biodiversity, ecology and local livelihoods.
- As estuaries make one of the finest nurseries and breeding grounds for a number of commercially as well as ecologically important species of fish, prawn and other organisms, and as the life cycle of many marine fishes contains a stage in which the young ones of the species are concentrated in a specific area or nursery ground in the estuary, such areas, especially mangroves and mudflats need to be safeguarded carefully
- Estuarine ecological changes in coastal Karnataka are so rapid that many estuarine functions such as storing and recycling of nutrients, trapping of sediments are getting affected due to human interventions. Their capacities as detoxifiers of pollutants should not be challenged any further. We recommend that the future plantings should be more mixed using all the locally available species, in the interest of healthier estuarine ecosystems.
- Proposals for ‘Biodiversity Heritage Sites’ in accordance with the provisions of the Biodiversity Act, 2012 for Kali and Aghanashini estuaries are pending with the Biodiversity Board of Karnataka. The constitution of such heritage sites should be expedited through completion of due formalities required.
- Mangroves are known to produce good quality honey with high market demand. Mangrove planting should be also aimed at production of honey to raise supplementary income for the estuarine villagers.

12.1 SAFEGUARDING ESTUARINE ECOLOGY

Tropical estuaries are very productive ecosystems. In Uttara Kannada important estuaries are of the rivers Kali, Gangavali, Aghanashini, Sharavathi and Venktapur.. Due to their high productivity estuarine villages and coastal towns closer to them such as Karwar, Ankola, Gokarna, Kumta, Honavar and Bhatkal are densely populated. Because of high diversity and productivity of fishes, prawns, clams and oysters, crabs etc. thousands of fishing families depended on estuaries for their livelihood. Shallow parts of estuarine areas were converted into *gazni* rice fields, coconut groves and human settlements. Estuaries play important roles as egg laying places and nurseries for many marine fishes. They also shelter, altogether over 120 species of birds due to the abundance of food and the shelter which the mangroves gave.

Estuarine productivity and impact of hydro-electric projects: As per the study requirement rivers with (hydel) projects were given special attention to know their impacts on the ecosystems, including productivity and diversity. Over the last few decades, the establishment of hydro-electric projects in Sharavathi and Kali rivers affected salinity conditions in estuary. Because of constant release of high volume of fresh water into the rivers, even during the summer months, salinity get lowered to nearly fresh water conditions in Sharavathi estuary and considerably reduced in Kali estuary. Fishing collapse is being experienced in Kali and Sharavathi estuaries creating underemployment and seasonal migration in search of jobs to other places. The Table 12.1 gives current comparative account of fishing income and employment related details of Kali, Sharavathi (rivers with hydroelectric projects) and Gangavali and Aghanashini (without hydro-electric projects)

Table 12.1: Impact of Hydroelectric projects on the Estuarine productivity

Details	With hydroelectric projects		Without hydroelectric projects	
	Kali	Sharavathi	Aghanashini	Gangavali
Waterspread area	2813 ha	1336 ha	2842 ha	558 ha
No. of fishing community families	2082	483	2703	1040
Families with active estuarine fishermen	615	103	2011	357
% families with estuarine fishermen	29.5%	21%	74%	34.3%
Total estuarine fishermen	1715	283	6139	996
Active fishermen/ha	1.64	4.72	0.46	0.56
Total fishing days	306420	41420	1497200	246064
Total fishing income Rs	116748000	12852500	435072000	75861500
Per capita/fisherman Rs	68074	45415	70870	76166
Average fishing income/ha/yr	Rs. 41503	Rs. 9620	Rs. 153086	Rs. 135953

Carrying capacity diminished in the Sharavathi estuary: The worst scenario of hydro-electric projects related in fish and bivalve employment is estuarine fisheries is strongly felt in the Sharavathi estuary. This decline could be mainly attributed to extremely low salinity levels in all the six observation stations, including the river mouth. The almost fresh water conditions (Table 12.2, figure 12.1) prevailing everywhere, including towards the river-mouth in interaction with the sea, even during the post-monsoon and summer months, has resulted in the collapse of estuarine ecosystem and crash in fish production. The production of edible bivalves, the collection of which is a major enterprise in the Aghanashini estuary exceeding even the returns from fin fishes, has crashed to practically nil, following the execution of Linganmakki and Gersoppa hydro-electric projects. In 1979-80, Rao and Rao had mentioned 11 ha area in Sharavathi estuary as clam bed area. As no production was reported it has be reasoned that dilution of salinity due to fresh water discharge from Linganmakki dam had already was taking toll on edible clams. At the same time the standing stock of oysters from 11 ha was placed a 515 tons (worth Rs. 51,500,000 at current market price). Today there is no production of oysters also. The total crash in production of clams and oysters would have happened with the commissioning of Gersoppa hydro-electric project in early 2000.

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Mouth	0	0	0	0.3	0.3	0	0	0	0	0.3	0	0.01
Kasarkod	0	0	0	0.4	0.4	0	0	0	0	0.4	0	0
Hosapattana	0.5	0.5	0.1	0.1	0.1	0	0	0	0	0.3	0.07	0
Jalavalli	0	0	0.4	0	0	0	0	0	0	0	0.01	0
Upponi	0	0	0.1	0	0	0	0	0	0	0	0.01	0
Pumphouse	0	0	0.1	0	0	0	0	0	0	0	0.01	0

Table 12.2: Low salinity conditions prevailing throughout the estuary

The sum total of impact of hydro-electric project on fisheries and fishing community employment is quite serious and is a silent suffering for the community. Only 21% of the 615 fishing families, the traditional dwellers of estuarine villages, are employed in fishing in Sharavathi estuary, unlike 74% of the families still engaged in estuarine fishing in the neighboring Aghanashini estuary, unaffected by dams and where salinity conditions are normal (Table 12.3, figure 12.2). The estuary has, like any other typical estuary, high, medium and low salinity zones.

Stations	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Aghanashini	31	31	36	33	34	35	0	0	5.3	30	32	35
Gudkagal	28	29	31	30	31	28	0	0	5.3	28	26	32
Kodkani	20	20	26	28	28	23	0	0	2.4	15	15	18
Tandrakuli	7	9	18	19	19	15	0	0	2	15	7	12
Divagi	4	9	17	17	17	15	0	0	0	1	3	10

Table 12.3: Normal salinity conditions in Aghanashini estuary

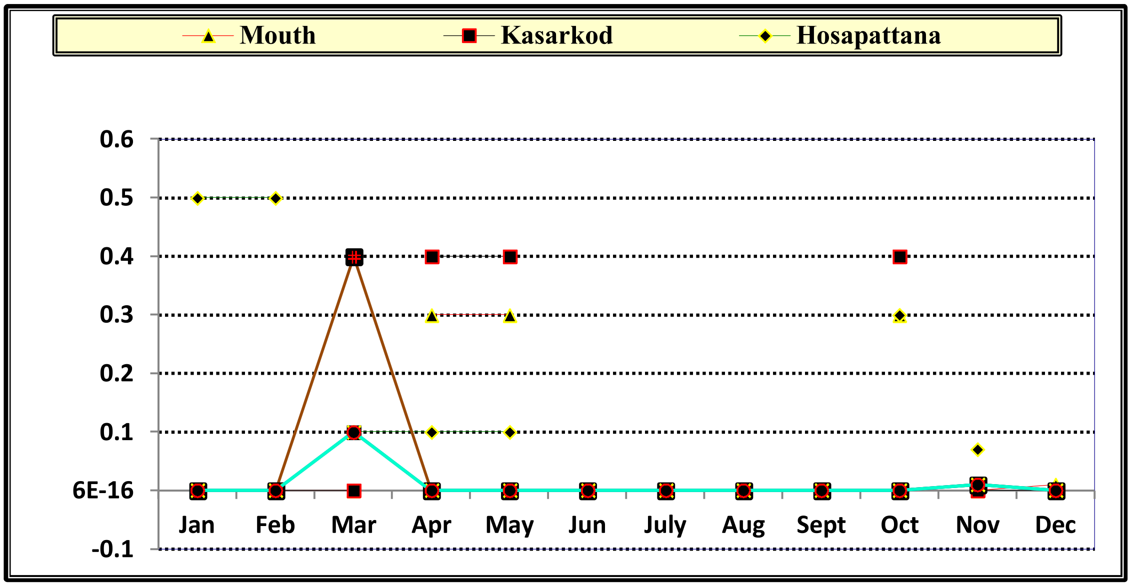


Figure 12.1: Monthwise salinity levels (in ppt) in the 6 stations of Sharavathi estuary- note salinity decline almost everywhere to less than 0.5 ppt

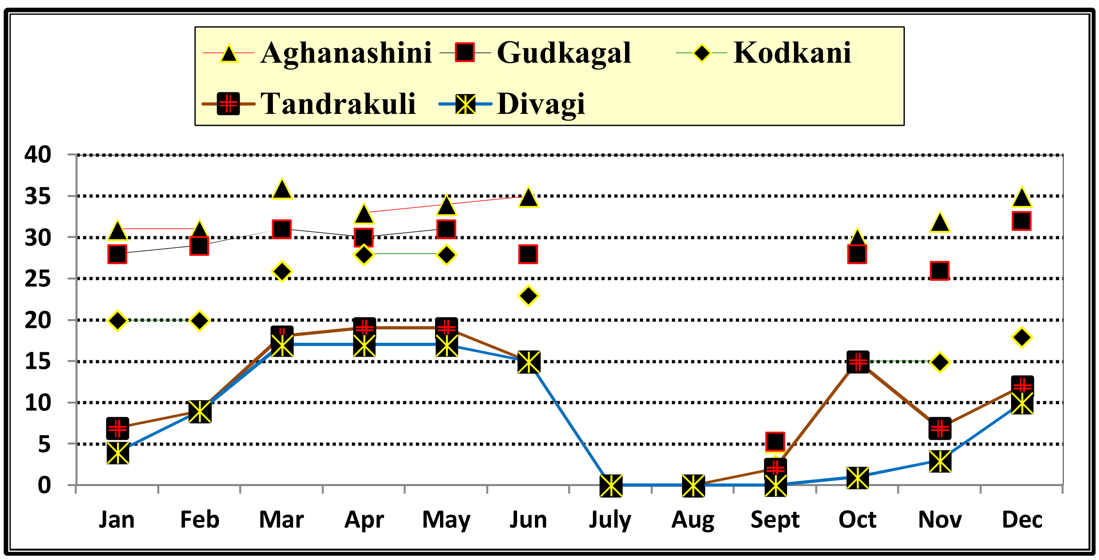


Figure 12.2: Monthwise salinity levels (in ppt) from 5 stations of Aghanashini estuary

Decline in fish productivity in Kali and Sharavathi estuaries: Kali and Sharavathi have fish productivity, in terms of fisheries income/ha/yr, (based on catches of fin fishes only) is reduced to Rs. 41503/- in the former down to Rs. 9620/- in the latter. The average fishing income for one ha of estuary in Aghanashini (Rs.153086) and Gangavali (Rs.135953) are much higher than both the dam affected rivers. The situation in Kali is better on account of better salinity conditions (see Table 12.4 and Figure 12.3) than Sharavathi. However, higher salinity in Kali estuary is only towards river mouth and in some creeks. Medium and low salinity waters cover more of the estuary.

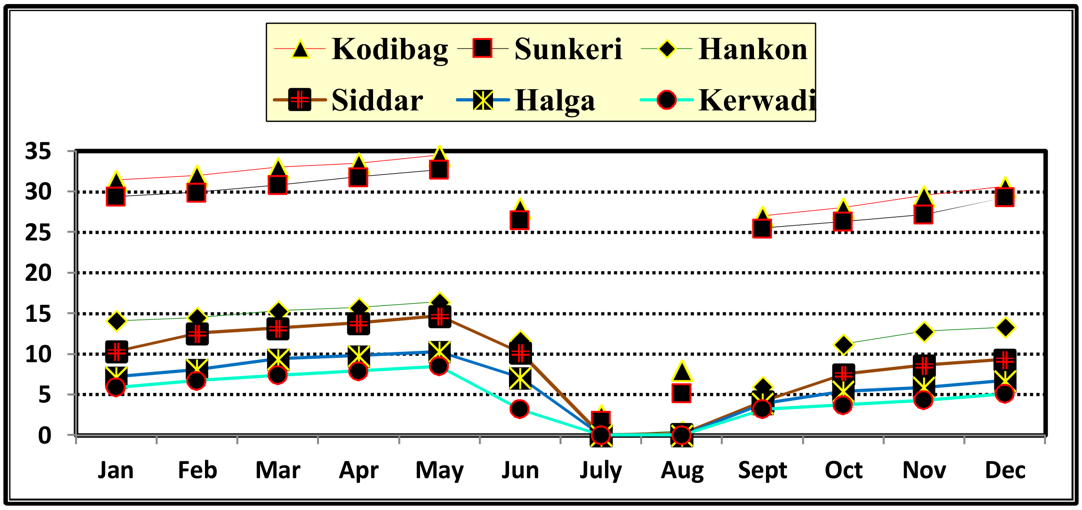


Figure 12.3: Monthwise salinity levels (in ppt) from 6 stations of Kali estuary

Stations	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Kodibag	31.4	32	33	33.5	34.5	28	2.5	8	27	28	29.5	30.6
Sunkeri	29.4	29.9	30.8	31.8	32.7	26.5	1.8	5.2	25.5	26.3	27.2	29.3
Hankon	14.1	14.5	15.3	15.7	16.4	11.7	0	0.5	6	11.2	12.8	13.3
Siddar	10.4	12.6	13.2	13.8	14.7	10.2	0	0.2	4.2	7.5	8.6	9.3
Halga	7.2	8.1	9.4	9.8	10.3	7.1	0	0	3.9	5.4	5.9	6.7
Kerwadi	5.9	6.7	7.4	7.9	8.5	3.2	0	0	3.2	3.7	4.3	5.1

Table 12.4: Salinity conditions in Kali estuary

Edible bivalve production in Kali, Aghanashini and Sharavathi estuaries compared: In Aghanashini, where no hydro-electric projects exist and clam beds are large, a staggering 22,000 tons were harvested during study period of 2008. No standing stock was estimated, and bulk of the landings were transported to distant markets like Goa, and to nearby towns as well due to rising demand. We do not know whether such utilization in large scale will lead to collapse in production. At current market prices the quantity harvested was worth Rs.66 crores. Students and researchers need to estimate bivalve standing stock in Aghanashini and draw lines for sustainable use. Whereas bivalve production is practically nil in Sharavathi, its production quantity is yet to be estimated in Kali and Gamgavali. In Kali, our studies show that, the occupation zone edible bivalves has shrunk and shifted more seaward due to lowered salinity conditions in upstream estuary due to dam discharges.

Decline in fishing days/ha due to hydroelectric projects-related salinity decline: The estuaries without hydro-electric dams generate less number of fishing days/ha/yr than the ones without dams. Thus whereas Sharavathi lowest salinity has only 31 fishing days/ha/yr Kali with most of the water 108.9 fishing days/ha/yr, Aghanashini and Gangavali have 526.8 fishing days/ha/yr and 440.97. The per capita fishing income from Aghanashini estuary presently at Rs.70870/- is a reasonable subsistence income with other fisheries related income shared between mainly fishing communities (for eg. income from clam (bivalve) collection in Aghanashini estuary is around Rs.66 crores). The average annual fishing income for a Sharavathi fisherman is just Rs.45415/-. This low income, combined with the absence of clams and mollusks, has made many fishermen go elsewhere seeking work.

Decline in fish diversity in dammed river estuaries: Kali and Aghanashini are comparable rivers in their estuarine size. But Kali estuary has only 57 fishes reported, whereas our studies reveal Aghnashini having at least 83 species (excluding 7 doubtful types). Gangavali, a smaller estuary, has 46 species compared to Sharavathi with only 26 species.

Recommendations

- As estuaries are used by many marine fishes most of which have narrow tolerances for physical and chemical conditions, drastic alterations in such conditions due to human interventions will have adverse consequences on fisheries. As is evident from Sharavathi and Kali estuaries, both of which are adversely affected in biodiversity and productivity due to hydroelectric projects, in future it is very necessary for protecting all the remaining estuaries from major developmental interventions so as to protect biodiversity, ecology and local livelihoods.
- As estuaries make one of the finest nurseries and breeding grounds for a number of commercially as well as ecologically important species of fish, prawn and other organisms, and as the life cycle of many marine fishes contains a stage in which the young ones of the species are concentrated in a specific area or nursery ground in the estuary, such areas, especially mangroves and mudflats need to be safeguarded carefully
- Estuarine ecological changes in coastal Karnataka are so rapid that many estuarine functions such as storing and recycling of nutrients, trapping of sediments are getting affected due to human interventions. Their capacities as detoxifiers of pollutants should not be challenged any further. We recommend that the future plantings should be more mixed using all the locally available species, in the interest of healthier estuarine ecosystems.
- Proposals for ‘Biodiversity Heritage Sites’ in accordance with the provisions of the Biodiversity Act, 2012 for Kali and Aghanashini estuaries are pending with the Biodiversity Board of Karnataka. The constitution of such heritage sites should be expedited through completion of due formalities required.
- Mangroves are known to produce good quality honey with high market demand. Mangrove planting should be also aimed at production of honey to raise supplementary income for the estuarine villagers.

12.2 **PROPOSAL FOR AN ESTUARINE PARK FOR AGHANASHINI ESTUARY, KUMTA**

The Aghanashini estuary is one of the most pristine estuaries of the west coast, not impacted by any major developmental project and away from urban settlements. It has high diversity of fishes (about 90 species), at least five types of edible bivalves, mud crabs, several species of prawns and about 120 species of birds. It produces annually Rs.43 crores worth fishes (only from water spread area excluding privately owned aquaculture areas), about Rs. 66 crores worth edible bivalves, Rs.70 crore worth cultured prawns, Rs. 8 crores worth molluscan shells, Rs. 8 crores worth salt and agricultural products and sand etc. the values of which are yet to be estimated.

Around three decades ago about 1819 acres of estuarine areas, mainly rice fields were acquired by the KIADB, Government of Karnataka, from the farmers of Aghanshini estuarine belt for allotment to a factory for salt production. The factory, situated at Binaga near Karwar, found the salt production uneconomic returned the land to the KIADB. The Honavar Forest Division raised good lot of mangroves in this area over the last one decade. The mangroves are of the healthiest kind and the shallow waters, away from the main currents of the river offer great safety to the visitors. Village Forest Committees are formed in the adjoining villages for management of mangroves. The concept of eco-tourism through the involvement of local people, specially the VFCS, is being implemented by the Forest Department. The ecology of the region is enriched, the waterscape/landscape is exquisitely beautiful, the fisheries steadily improving and bird fauna (residents, local migrants, and migrants from far off lands) steadily increasing. The availability of different microhabitats like channels, creeks, gullies, mud flats and sand flats and nearness of the Arabian Sea and Western Ghats offer favourable settings for consideration of this area and adjoining places (together approximately about 1000 ha) for an estuarine park.

The importance of the estuarine park

The park will be centre for study, eco-tourism, productivity and conservation as highlighted below:

- It will facilitate visits to fish and shrimp farms for studies/observations, to estuarine fields growing salt tolerant rice etc.
- Visits by tourists to edible bivalve collection centres with amazing productivity
- Visit to bird and bat roosting areas and other estuarine bird diversity
- For observations artisanal fisheries in the estuary
- Mangrove studies and mangrove sight seeing
- Visits to salt making areas
- Biodiversity of mangrove swamps
- Mangrove fish breeding area (about 500 ha)
- Mangrove fishing area, including sport fishing facilities for tourists

It is proposed that the centre should have mangrove diversity conservation area, bird and fish museum helping in identification, coastal arts and culture display centres including an auditorium, a museum of traditional fisheries, traditional rice varieties etc.

The management of the estuarine park could be under the joint supervision of the Forest Department. It will be self sustaining and provide greater livelihood security and generate employment facilities for villagers while enriching environment

12.3 ESTUARINE FISH DIVERSITY AND LIVELIHOOD

Estuaries are zones of transition between river and ocean environments and are subject to both riverine and marine influences, such as tides, waves, and the influx of saline water. The freshwater brought in by the rivers mixes with seawater in the estuary. These transitional zones between river and sea are home to several taxonomic groups of fishes and many are of commercial importance. From the fishery development perspective they have high potential as grounds for feeding, spawning and nursery areas for several kinds of fin fishes and shellfishes. Most of coastal aquaculture activities depend on estuaries as centers of seed collection. The fluctuation of physico-chemical characters in estuarine environment has a profound influence on the seasonal occurrence of the juveniles and fish stocks. Estuaries are ranked among the highest productive ecosystems of the world. Four estuaries of Uttara Kannada, namely Kali, Gangavali, Aghanashini and Sharavathi were studied for fish diversity in relation to water salinity, for capture fishery based livelihoods, for estimating, estuary-wise, numbers of dependent fishermen, their annual income from fisheries, and for problems and prospects for estuarine fishery. Two of the estuaries, Kali and Sharavathi, are impacted by hydroelectric projects in the upstream areas, Gangavali and Aghanashini are unaffected thus far. The water-spread areas of the estuaries, excluding privately owned rice-field cum fish growing areas and prawn farms are excluded.

- ***Fish diversity:*** Kali estuary has 61 fish species from 50 genera and 40 families, Gangavali has 55species from 48 genera and 39 families, Aghanashini has highest diversity of 80 species identified (some by local names yet to be traced out), of 64 genera and 47 families and Sharavathi has lowest number with 31 species identified from 27 genera and 25 families (some by local names yet to be traced out). This high diversity in Aghanashini estuary is obviously due to the relative naturalness of the river, unaffected by dams or other major developmental projects. However, shell and sand mining, intensified in the recent decades, have telling effects on estuarine fishery and livelihoods. Intensive prawn culturing activities that vigorously happened in Kali and Aghanashini estuaries during 1970's and 80's, also causing heavy toll on mangroves and fisheries, is on the decline now. Table 12.5 lists estuary-wise fish diversity.

Table 12.5 Inventory of fishes from four estuaries studied in Uttara Kannada (K= Kali; G=Gangavali); A=Aghanashini and S=Sharavathi)

Family	Scientific name	Common name	Local names (Kannada)	K	G	A	S
Marine							
Clupeidae	*Sardinella fimbriata*	Fringescale Sardinella	Pedi	+	+	+	+

Engraulidae	*Stolephorus indicus*	Indian anchovy	Belanji	+	+	+	+
Carangidae	*Carangoides Praeustus*	Brownback trevally	Haluguruku	+	+	+	-
Scombridae	*Rastrelliger kanagurta*	Mackerel	Bangade	+	+	+	-
Nemipteridae	*Nemipterus japonicus*	Japanees thread fin bream	Rane menu	+	+	+	-
Serranidae	*Cephalopholis boenak*	Blue lined coral cod	Gobrya, Kallumurge	+	+	+	_
Bothidae	*Crossorhombus azureus*	Blue spotted flounder	Masur leppe	+	-	+	-
Paralichthyidae	*Pseudorhombus javanicus*	Javan flounder	Nengu	+	-	+	-
Scombridae	*Scomberomorus commerson*	Narrow-barred Spanish mackerel	Iswana	_	_	+	-
Stromatidae	*Pampus argenteus*	Silver pomfret	Bili manji	-	-	+	-
			Total (10)	8	6	10	2
		Marine - Estuarine					
Scatophagidae	*Scatophagus argus*	Spotted scat	Hulka	+	+	+	+
Carangidae	*Carangoids chrysophrys*	Longnose trevally	Kokkara	+	+	+	+
Ariidae	*Arius arius*	Threadfin sea catfish	Bilisady	+	+	+	+
Siganidae	*Siganus vermiculatus*	Vermiculated spinefoot	Baana, Padiyar	+	+	+	+
Tetraodontidae	*Arothron stellatus*	Starry blow fish	Chonja	+	+	+	+
Engraulidae	*Stolephorus commersonnii*	Commerson's Anchovy	Dodda danashi	+	+	+	+
Platycephalidae	*Grammoplites scaber*	Rough flathead	Vadati	+	+	+	+
Sillaginidae	*Sillago sihama*	Silver sillago	Nogla	+	+	+	+
Sciaenidae	*Otolithes ruber*	Tigertooth croaker	Banagu, Dodi	+	+	+	+
Sphyraenidae	*Sphyraena barracuda*	Great barracuda	Onakaandi	+	+	+	+
Lactariidae	*Lactarius lactarius*	False trevally	Samdale	+	+	+	-
Belonidae	*Strongylura leiura*	Banded needle fish	Burkaandi	+	+	+	_
Carangidae	*Megalaspis cordyla*	Torpedo trevally	Guruku	+	+	+	-
Carcharhinidae	*Scolidon sps*	Shark	Sora	+	+	+	-
Platacidae	*Drepane punctata*	Spotted sickle fish	Chandaka	+	+	+	-
Carangidae	*Caranx ignobilis*	Giant kingfish	Guruku	+	+	+	-
Dasyatidae	*Dasyatis bleekeri*	Bleekers whip ray	Hola	+	+	+	-
Clupeidae	*Opisthopterus tardoore*	Tardoore	Pachage	+	+	+	-

Leiognathidae	*Leiognathus splendens*	Blacktip ponyfih	Guruku	+	+	+	-
Lobotidae	*Lobotes surinamensis*	Tripletail	Pavade	+	+	+	-
Engraulidae	*Thryssa mystax*	Moustached thryssa	Vaintali	+	+	+	-
Rhinobatidae	*Glaucostegus halavi*	Halavi ray	Balagende Torke	+	+	+	-
Leiognathidae	*Secutor insidiator*	Pugnose ponyfish	Guruku	+	+	+	-
Soleidae	*Synaptura commersonnii*	Commerson's sole	Leppe	+	+	+	-
Trichiuridae	*Trichiurus lepturus*	Largehead hairtail	Barik hamle	+	+	+	-
Sciaenidae	*Johnius belangeri*	Belanger's croaker	Banagu	+	+	+	_
Triacanthidae	*Tricanthus biaculeatus*	Short-nosed tripod fish	Kuduremeenu, kadbale	+	+	+	-
Sphyraenidae	*Sphyraena obtusata*	Obtuse bararcuda	Hallin kaandi	+	+	+	-
Cynoglossidae	*Paraplagusia biliniata*	Double lined tongue sole	Leppe	+	-	+	-
Cynoglossidae	*Cynoglossus macrostomus*	Malabar sole	Leppe	+	-	+	-
Platacidae	*Platax orbicularis*	Orbicular bat fish	Manji	+	-	+	-
Siganidae	*Siganus argenteus*	Streamlined spine foot	Baana	+	_	+	-
Engraulidae	*Thryssa malabarica*	Malabar thryssa	Vaintali	+	-	+	-
Gobiidae	*Trypauchen vegina*	Burrowing goby	Bombale	+	-	+	-
Engraulidae	*Thryssa setirostris*	Long jaw thryssa	Vaintali	+	_	+	-
Carangidae	*Atule mate*	Yellowtail scad	Guruku	-	+	+	-
Pempheridae	*Pempheris moluca*	Mollucan sweeper	Ramachi	-	-	+	-
Pomadasyidae	*Pomadasys maculatus*	Saddle grunt	Guruku	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Kari Balagende Torke	-	-	+	-
Ariidae	*Arius Caelatus*	Engraved sea catfish	Gonde Sady	_	-	+	_
Stromatidae	*Parastromateus niger*	Black pomfret	Kari manji	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Hullu Torke	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Hakki torke	-	-	+	-
Rhinobatidae	*Glaucostegus sps*	-----	Het Torke	-	-	+	-
Sciaenidae	*Chrysochir aureus*	Reeve's croaker	Mooru hallin banagu	_	-	+	-
Sphyraenidae	*Sphyraena spp*	-----	Suji kaandi	-	-	+	-
Sphyraenidae	*Sphyraena spp*	-----	Bura kaandi	-	-	+	-

Belonidae	*Tylosurus strongylurus*			-	-	-	+
			Total (48)	35	29	47	11
Estuarine							
Lutjanidae	*Lutjanus johni*	John's snapper	Hottekemsa	+	+	+	+
Lutjanidae	*Lutjanus ruselli*	Russell's snapper	Kemsa	+	+	+	+
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	Eri	+	+	+	+
			Total (3)	3	3	3	3
Estuarine - fresh							
Cichilidae	*Etroplus suretansis*	Pearl spot	Kagalse	+	+	+	+
Gobiidae	*Glossogobius giuris*	Tank goby	Bili Mandli	+	+	+	+
Synbranchidae	*Monopterus albus*	Asian swamp eel	Kolav	-	+	+	-
Gobiidae	*Glossogobius sps*	----	Kari Mandli	-	-	+	-
Cyprinidae	*Dawkinsia filamentosus*	Black spot barb	Pidtol	_	_	_	+
			Total (5)	2	3	4	3
Marine - Estuarine - freshwater							
Gerridae	*Gerries filamentosus*	Threadfin silverbiddy	Girbaingi	+	+	+	+
Gobiidae	*Periophthalmus koelreuteri*	Mudskipper		+	+	+	+
Mugilidae	*Mugil cephalus*	Flathead grey mullet	Madle	+	+	+	+
Mugilidae	*Liza parsia*	Goldspot mullet	Madle	+	+	+	+
Polynemidae	*Eleutheronema tetradactylum*	Four Finger Threadfin	Raws	+	+	+	+
Teraponidae	*Terapon jarbua*	Cresent pearch	Kumbari, Garge	+	+	+	+
Gerridae	*Gerres limbatus*	Saddleback silver biddy	Mundbaingi	+	+	+	+
Leiognathidae	*Secutor ruconius*	Deep pugnose ponyfish	Guruku	+	+	+	+
Latidae	*Lates calcarifer*	Barramundi, Seabass	Kurude	+	+	+	+
Batrachoididae	*Austrobatrachus dussumeri*	Flat toad fish	Gonke, Gorke	+	+	+	+
Ambassidae	*Ambassis ambassis*	Commersons glassy perchlet	Burante	+	+	+	+
Cynoglossidae	*Cynoglossus punticeps*	Spotted tongue sole	Leppe	+	+	+	-
Ophichthyidae	*Pisoodonophis cancrivorus*	Snake eel	Aragotka	+	+	+	-
Apogonidae	*Apogon hyalosoma*	Humpbacked cardinal fish	Burante	-	+	+	-

Ophichthidae	*Caecula polyopthalmus*	Ocellated sand-eel	Hemalga	-	-	+	–
Hemirhamphidae	*Hyporhampus xanthopterus*	Red tipped half beak	Soundkaandi	–	–	–	+
Hemiramphidae	*Hemirhampus lutkeii*	Black barred half beak	Toli	-	-	+	-
			Total (17)	13	14	16	12
Fishes to be traced out							
			Malati pedi	-	-	+	–
			Hembale	–	–	+	–
			Soge	–	–	+	–
			Adaga	–	–	+	–
			Baalya	–	–	+	–
			Murugundu	–	–	+	+
			Avalumeenu	–	–	–	+
			Ante	–	–	–	+
			Bale	–	–	–	+
			Hallmeenu	–	–	–	+
			Kadas	–	–	–	+
			Kelas menu	–	–	–	+
			Kukla	–	–	–	+
			Mogane	–	–	–	+
			Mumb	–	–	–	+
			Susila	–	–	–	+
			Vante	–	–	–	+
			Total (17)	0	0	6	12
	Total species of each estuary			**61**	**55**	**86**	**43**

- ***Restoration of abandoned/unused prawn farms/gajnis***: The Government may consider converting suitable parts of private, unused or abandoned prawn farms/*gajni* fields into mangrove areas through the involvement of the Forest Department/local Self Help Groups/Village Forest Committees so as to increase production of fish, prawns and crabs, in the natural way, and fodder from marsh grasses, apart from facilitating breeding of these organisms. Such steps will also improve nutrient flow in the estuaries and marine areas. Restoration will create healthy, functioning natural coastal ecosystems. The farmers can continue to hold fishing rights through the involvement of local fishermen, if necessary, eliminating contract system.
- ***Safeguarding fishery based employment***: The four estuaries studied, altogether, constitute a very important employment sector, accounting for about 2,092,000 fishing days/year, benefiting

altogether an estimated 3,086 families of estuarine fishermen, earning for them an income of Rs.66.55 crores annually. The four estuaries, together have 7,549 ha area, excluding the private fish/prawn farms and *gajni* rice field cum fishing areas. This works out to the fact that every hectare of estuarine area generates 277 days of fishing work per year and earns an income of Rs.88,157/- ha/year. This is all the more significant that so much of income is without any input from humans except on fishing efforts through human energy alone, as mechanized fishing is not practiced in the estuaries of the district.

- ***Income from edible bivalves (clams and oysters):*** The production of clams and oysters, widely used as food in coastal areas, has been the subject of another report. This is an informal sector of non-specialized fisheries, engaged in also by good number of women and children. When a detailed study was carried out in Aghanashini estuary it came to the light that about 22,000 tons of bivalves were collected in the year 2008-09. About 1738 males and 609 females were engaged in bivalve collection. Many women are involved in sorting of bivalves for sale in outside market. The local sales, including house to house sales are exclusively by women. With the current market value of Rs.30,000/- ton, at Rs.30/- kg. total pricing of the output is estimated at Rs.66 crores annually. Considering the fact so much of produce comes from less than 250 ha of clam beds in Aghanashini, highlights that the annual productivity of one hectare of bivalve bed could be around 88 tons, worth Rs.26.4 lakh at current market prices. As the market value of bivalves, which was known as poor man's food, is steadily rising due to exports to distant markets, the collection is feared to be on a non-sustainable scale. The production of this magnitude is astounding, yet not improbable, as James et al., way back in 1972, had estimated production of 10 kg of clams/sq.m in stretches of estuaries up to one mile from the bar mouth and half that quantity up to 6 miles interior in some of the Dakshina Kannada estuaries. This works out to 100 tons of clams/ha nearer to the estuary mouth in Dakshina Kannada, supporting our estimate of 88 tons/ha especially towards estuary mouth of Aghanashini, and lesser quantities more interior. An estuarine clam collector in the Ashtamudi backwaters of Kerala was estimated to collect approximately 40-50 kg of clams within 3 to 4 hours of collection time per day, way back in 1980's (Appukuttan et al., 1985), which would have been worth at least Rs.1200 to Rs.1500/day if the resource remained to this day!
- ***Bivalve fishery crossing sustainable limits:*** Until some years ago bivalves were very cheap and abundantly available. According to James *et al*., (1972) the price of clams was 20 paise to 50 paise for hundred in Kundapur. As demand was more local the exploitation was limited to 500 to 1200 kg per day. Similar conditions prevailed in Uttara Kannada also. The situation changed drastically today as in Uttara Kannada bulk of the product is being sent to Goa and to other far away markets for higher prices. The clams are sold today in coastal Uttara Kannada markets for Rs.40-60 per hundred and in Goa for Rs.100 for the same number of clams. The exploitation is happening on a big commercial scale without adhering to any norms. This stresses the need for integrated, participatory ecosystem management of estuaries for judicious use of this great food resource.
- ***Reducing pressure on estuarine fishery**:* Fish fauna was abundant some decades ago when fishing efforts were minimal and prices very low. Marine fishing had reached peak in 1980's all over Karnataka coast, when estuarine fish catch was within sustainable limits, as most of the fishing gear was directed towards marine fishing. According to James *et al*., (1972), in the peak estuarine fishing season in the then South Kanara district 400-600 kg of fish was caught from any estuary within two mile distance from the river mouth. The catch was obviously could have been lower to

availability levels, as prices were very low ranging between 50 paise to one rupee per kg. Uttara Kannada situation was not much different then. Today the demand for estuarine fish has escalated as the demand is also from far and wide, and the prices have shot up ranging from minimum of Rs.120/- kg to about Rs.600/- kg. Fishing pressure is very high, so much so, estuarine capture fishery (of fin fishes, prawns and crabs) is passing through a critical phase. All the estuaries surveyed are being overfished, as evident from average fishing days/ha. There is not much scope currently to improve fisheries in the dam affected Sharavathi and Kali estuaries. Percentage of fishermen dependent on estuary partially or fully in Aghanashini and Gangavali, unaffected by dams (marine fishermen of non-estuarine village of Belamber excluded from Gangavali estimate) were 71% and 59% respectively. In dam affected Kali and Sharavathi 57% and 21%, respectively, of fishermen from estuarine families fished in estuaries. The estuarine area available/ head for fishing was 0.56 ha in Gangavali and 0.46 ha in Aghanashini (both without hydel projects), 1.58 ha in Kali and a whopping 4.72 ha in Sharavathi (both impacted by hydel projects).

- ***One hectare water for a fisherman:*** Whereas small-scale cage culturing may be promoted in Kali and Sharavathi backwaters to improve fishing community livelihoods it is desirable to reduce fishing pressure in Aghanashini and Gangavali so as to ensure at least one ha of fishing waters/fisherman that could yield, on a simplistic calculation, approximately Rs.195,000/fisherman/year in Gangavali and Rs.154,000/fisherman/year in Aghanashini, from the current levels of Rs.109,265 from 0.56 ha in Gangavali and Rs.70,870 from 0.46 in Aghanashini.
- ***Enriching estuarine vegetation to aid fish breeding and protection of nursereis:*** Specific areas within the estuaries, especially marshes with vegetation and mangrove areas support much greater densities of organisms, mainly as nurseries, than unvegetated parts (Minello, 1999; Beck *et al*., 2001). Generally an area has been termed as “nursery” if it supports juvenile fish or invertebrates in higher densities, provides greater protection from predators, or grows faster than in other habitats (Beck *et al*., 2001). Identification of fish nurseries within estuaries, where young ones grow faster and in greater numbers than in other areas, is a task to be achieved expeditiously, for future protection through involvement of village communities.
- ***Self-help groups of bivalve collectors:*** Village-wise self-help groups, constituted through local environmental NGO groups, may be organized for evaluation and better sustainability of the resource.
- ***Bivalve collection holidays:*** A concept of two days per week of bivalve collection holidays may be enforced through SHGs’ for voluntary acceptance. NGOs have to play key role in this.
- ***People as integral part of estuarine ecosystems:*** Modern concepts of ecosystem management try to consider people as parts of ecosystems. Estuaries of Uttara Kannada were reasonably well protected through generations by traditional communities, despite interventions for livelihoods, almost until late 1960’s. The estuarine farmers grew salt tolerant rice in reclaimed portions, the *gajnis*, protected by earthen bunds and strengthened by growing mangroves alongside. Fishing was mainly by fisher-folks, even within *gajnis*. The catches were within sustainable limits as there was not much trade in it beyond the district’s limits. Shell collection was mainly for lime making locally. Salt was prepared only in designated areas. Sand mining was in limited quantities to cater mostly for local needs. The situation changed when the Government built permanent embankments for *gajnis* replacing the traditional earthen ones. Mangrove destruction became widespread as they were not needed for strengthening bunds and to meet growing fuel demands. Farmers started

auctioning to contractors fishing rights within *gajnis*, which turned out to be virtual shallow dams for storing estuarine water after harvest of paddy, because of building of permanent bunds. Thus the role of fishermen in catching fish for livelihoods in the *gajnis*, a traditional practice through ages, was replaced with contract system. The fishing pressure thereafter is expected to have intensified in the open water areas of the estuary. The proliferation of ice factories and intensive prawn farming systems destroyed traditional community based management leading to exhaustive catches of fish in markets expanding beyond the district. Considering this background seriously we recommend awareness creation, and people's involvement in fishery management and declaration of parts of estuarine portions rich in mangroves and marsh vegetation as fish nurseries, to be protected through local fishing community involvement.

- **Need for integrative management:** Estuary is a multi-stake-holder based complex ecosystem and a hub of human activities like traditional fishing, edible bivalve harvesting, modern prawns and fish farming systems, cultivation of salt tolerant rice in *gajni* fields, sand mining, shell mining, water transport, salt making, port activities, tourism *etc*. all activities simultaneously going on. The Central Government has made Coastal Regulation Zone Notification applicable to the estuaries. Of the State departments concerned with estuaries in Karnataka are Public Works, Ports and Inland Water Transport, Forests (as regards mangrove afforestation and protection), Agriculture, Fisheries, Brackish Water Fisheries, MPEDA, Mines and Geology etc. Lack of co-ordination among these departments and conflicts with traditional, community based management systems have caused the collapse of the latter, which were more informal. Therefore to safeguard and sustainably use estuarine systems integrated, participatory management is immediate necessity. The Government should evolve an estuarine management policy for safeguarding and restoring integrity of these ecosystems so as to ensure continuity of ecosystem services and the tremendous livelihood support they provide, with practically very little inputs from humans. We need to ensure that estuarine ecosystems are unharmed so that such services are passed on undiminished to future generations as well. Our studies reveal that Sharavathi has nearly lost its estuarine nature and Kali is in the mid-course to its denigration due to upstream hydroelectric projects.
- ***Estuary management to be ecosystem based:*** The present management of estuaries, of which fisheries constitute a vital part, as already explained, is by multiple agencies without any co-ordination, disjointed and disoriented, keeping away the local people, thereby causing enormous harm to the estuarine health and productivity. Therefore, we wish to impress upon the State about evolving ecosystem-based management plans through people's involvement, to be implemented by a single agency. The major issues of such a management plan should be:
    i. Define the physical and functional domain of any estuary through scientific studies.
    ii. Identifying the key components of the given estuary, which need to be considered for upkeep or restoration of estuarine integrity. These components may be physical (salinity, bathymetry, tidal regimes, soils and hydrology) biological, social (stakeholder analysis), natural resource estimate based while taking into account harvesting pressures.
    iii. Analysis of estuarine potential for rendering ecosystem services and livelihood security, threats.
    iv. Preparation of estuary-wise management plans through research, with specifically define management objectives encompassing hydrology, restoration of ecosystem, pollution control, identification and containment of threats, zoning for human uses (fishing, fish

conservation and protection of breeding areas, bivalve collection, sand and shell mining, salt production, aquaculture, mangrove and bird conservation, ecotourism etc.) under principles of sustainability through people's participation.

v. Ongoing monitoring mechanism through research for measuring successes and failures, and estimating progress achieved in fulfilling management objectives.

vi. Monitoring agency should be able to set norms for extraction of estuarine goods fixing the quotas to be harvested/gathered based on sustainable outputs and should come out with periodical progress reports.

vii. Involvement of stakeholders is a necessity in designing management plan.

- ***Biodiversity Heritage Sites in estuaries:*** Using the provision of Biodiversity Act-2002, suitable areas within each estuary need to be declared as Biodiversity Heritage Sites, under local panchayat management, through specially constituted Biodiversity Management Committees as per the Act. We have already submitted a separate report depicting the most important mud flats close to Aghanashini village, known for prolific production of edible bivalves and a small island, surrounded by rich mangroves, in mid estuary as Aghanashini Biodiversity Heritage Site. A similar report was prepared and submitted by Dr.V.N. Nayak for portions of Kali estuary to be declared as Heritage Site. Such Heritage Sites are bound to be buffers against the strong exploitative forces operating today in the estuarine ecosystems. We urge that as the declaration of Heritage sites in estuaries will further the cause of fish breeding and enhancement of harvestable fish, such measures may be taken expeditiously after due consultations with local panchayats.

- ***Protecting estuaries from destructive developmental interventions:*** Estuaries are centres of biodiversity, especially supporting rich fisheries. Even several marine fish species are dependent on them for spawning and nursery purposes. At the same time they are constantly under threat of developmental projects, such as dams in upstream areas and industrial interventions. A good portion of Aghanashini estuarine fields were acquired from local farmers and given to an industry – BILT at Binaga in Karwar, in 1970's, for conversion into salt pans. Subsequently the industry abandoned this plan and returned the areas (1815 acres) to Government after conversion of part of the lands into salt pans, at the cost of ecology and fisheries, and depriving local farmers of their estuarine rice fields, as salt production was found to be uneconomic. Thereafter the same estuarine portion was considered for starting a coal-based ultra-mega thermal plant, a plan that was also abandoned under public pressure and reports of adverse environmental impacts. Any conversion of fishery and mangrove rich estuaries, which are also known for their bird fauna, into industrial hubs will be most unimaginative use of such vital places which provide sustenance to thousands of families. Considering the ecosystem collapse of Sharavathi estuary and impoverishment of Kali estuary, compelling scores of dependent people, particularly fishermen, to look for alternative employment, it is strongly recommended not to utilize estuarine areas, most of which fall within the domain of CRZ-I, for detrimental developmental interventions challenging the functional integrity of these unique ecosystems.

- **Sand mining associated problems:** Sand mining is rampantly happening in all the estuaries of Uttara Kannada. Increased demand for sand from far and wide, coupled with widespread unemployment in fishermen community along the estuarine villages, the resultant of overfishing and fishery collapse due to hydro-electric projects, have attracted many fishermen, having skills in boating and maneuvering in water to work with sand mining contractors and sand traders. This constitutes a well-organized work force in the coastal taluks, who along with main operators try to thwart any attempts to bring controls on sand mining. Whereas periodical sand removal might be necessary to clear the accumulated erosion from land, as a natural process, the present sand policies are being implemented without ascertaining sustainable extraction limits. Environmental problems occur when the rate of extraction of sand exceeds the rate at which natural processes generate these materials. Sand mining licenses are given on administrative terms without any consideration of ecosystem that is affected. Unrestrained sand removal can destroy the estuaries and therefore estuarine fishery and to some extent marine fishery on following counts:

i. Estuarine bottom getting deepened causing subsidence of banks
ii. Habitats of bottom-dwelling fishes, fish nurseries and of other benthic organisms like bivalves and crustaceans are destroyed through siltation. It is reported that intensive sand mining in the Chapora River at Kolvale, Goa, for the last three decades, has eliminated the edible black clam (Times of India, Goa, 17-2-2011).
iii. As total load of suspended particles, which are too small to settle down, increases, light penetration is bound to be affected thereby affecting the photosynthetic phytoplankton and zooplankton which constitute foundation for food chains.
iv. No studies are carried out yet in Uttara Kannada on radiation hazards to biological systems and humans because of sand mining.
v. Adverse effect on ground water systems
vi. Adverse impacts on fishery and fish breeding from oil slicks from boats and noise pollution
vii. Filter feeders like bivalves get clogged with siltation and death takes places in masses.

Recommendations on sand mining

i. Estimate annual sand deposit patterns in the estuarine areas
ii. Limit sand mining operations strictly to areas which have highest deposits and least impacts on physical and biological characters of estuaries
iii. Limit sand mining to sustainable limits (matching deposit and extraction)
iv. Movement of extracted sand for local uses should be limited to within the coastal zone of Uttara Kannada only (from Karwar to Bhatkal).
v. The Biodiversity Management Committees of local panchayats and the Village Forest Committees may be authorized to monitor and report any illegality in adhering to established norms.
vi. The parties transgressing the regulations should pay for mitigation costs and contribute to the welfare of fisher-folks and bivalve collectors of the respective areas damaged
vii. The mussel and clam beds of estuarine areas with peripheral buffer zones of at least one km radius are to be strictly protected under CRZ provisions.

- **Regulations on shell mining:** Rich deposits of bivalve shells, which have happened through millions of years, have already been mined for industrial purposes, on large scale, over the last few decades, from especially Aghanashini and Kali estuaries. Shell mining is in need of moratorium, pending critical ecological evaluation, through a transparent process, as the extraction of shell deposits from the bottom of the estuary creates ecological devastations with consequences on fisheries, edible bivalves and mangroves and plankton which are critical initiators of food chains in the estuary.

- **Alternative employment for fisher-folks:** To reduce pressure on fishing it is suggested to increase and create alternative venues for eco-friendly employment such as mangrove based bee-keeping, mangrove planting and protection (fishing folks to be preferred for employment), eco-tourism, value addition to fishes and edible bivalves and similar kinds of alternative employment.

12.4 SAFEGUARDING COASTAL AREAS FROM SEA-LEVEL RISE

Global warming due to green house gases and deforestation is a major threat to the life on the Earth, including the humans. Threat from sea level rise is looming large globally due to increased green house gases in the atmosphere and consequent global warming. Carbon dioxide has already crossed more than 350 ppm, highest level in more than half million years. The planet is about 0.75 degree warmer than in the year 1875. The sea level is already more than 200 mm than in 1800, and is feared to rise to 500 mm more than present level by the end of 21st century. This is a major threat to all the low lying coastal areas, including of Karnataka. The threat from sea level rise along the west coast is about 1.5 mm/year. Sea erosion problems are on the increase and the under present schemes of defense main thrust is on building of sea walls along the beaches using stones. This is a multicrore rupees work, which is associated with several problems and is not a lasting solution. Small efforts are however under way, under the initiative of the Western Ghats Task Force and the Forest Department to raise more greenery on the sea beaches using appropriate herbs, creepers, shrubs and trees. The vegetation is expected to build up sand dune, which in course of time will established natural defense system against rising sea. Hundreds of crore rupees are being spent on coastal protection through building sea walls. Sea walls can have many adverse consequences as they are built to resist the shock of rising sea waves than absorbing the shock. As the result the walls may be breached, the beach level subsides and sea erosion problems will increase along unprotected beaches. High deposits of sand, the sand dunes, stabilized by natural vegetation of specially adapted creepers, shrubs and trees used to be the main defense against sea erosion from time immemorial. Removal of sand and the conversion of sandy areas too close to the sea into fields and habitations have increased threats from rising sea levels and cyclonic winds. We recommend the following measures as a better, less costly, eco-friendly options:

Recommendations

- Bioshileding of the coast has to be widespread action plan to defend coastal lands and lives from the threats of rising sea level

- Restoration of shore vegetation with the involvement of local communities will create natural, stabilized and ever rising sand dunes, which will act as shock absorbers than resistors.
- The beaches have to be aesthetically planted to increase the tourism potential
- The sea beach management should be brought under the joint management of coastal VFCs and the Forest Department (Apsarakonda and Kasarkod models in Honavar Forest Division)
- Use of NTFP species including of bio-fuel importance like *Calophyllum* (Honne) and *Pongamia* (Honge) will benefit the local communities and biofuel production.
- Planting should be carefully done in beaches used for egg laying by marine turtles so that some good sandy areas are left without planting.
- Periodical monitoring and progress achieved in bio-shielding has to be carried out by independent agencies
- Local sea shore management communities should be formed for creation and protection of the green walls, for protection of turtles that lay eggs in the beaches, for sustainable management of the products from the shore vegetation, to benefit from eco-tourism and to keep the beaches pollution free.
- Coastal Regulation Zone (CRZ) provisions should be strictly implemented for better safety of coastal people and safety of ecosystems including mangroves and estuaries.

12.5 BIO-SHIELDING OF THE COAST

Lowland sea coasts are fluctuating, dynamic boundaries between the sea and the land. From time immemorial humans living in coastal zones had realized the magnitude of problems that may be unleashed by the wrath of the sea by tampering with this dynamic zone beyond its automatic repairing capacity. They lived in most places adhering to certain safety norms and behind the protective shield of large mounds of shore sands stabilized by characteristic vegetation. In the recent times, due to mounting human pressures on the coastal zone in the form of mushrooming of townships and populated villages, expansion of agriculture and habitation to the brim of the sea, construction activities that took away bulk of the sand dunes, hacking of the shore vegetation for meeting fuel-wood and timber needs and a host of other detrimental activities, the proneness of the coasts to catastrophic erosion have mounted substantially. As incidents of sea erosion, storm surges and cyclones increased inflicting losses to lives and property, the remedies worked out expeditiously were in the form of expensive and ecologically ruinous and aesthetically displeasing sea walls and other artificial structures. Ongoing investigations since last few decades undertaken in India and rest of the world, on protecting shores from erosion, using cheaper, eco-friendly, livelihood-supporting alternatives have converged mostly on rediscovering a remedy that revolves ultimately around the ancient wisdom of raising green walls between the land and the sea.

Coastal Regulation Zone Notification, 1991

On 19 February 1991, the Ministry of Environment and Forests issued a Notification called the **Coastal Regulation Zone (CRZ)** which sought to regulate human activities in the area of 500 m from the High Tide Line (HTL) along the coastal stretches of the country. The CRZ Notification was made applicable to the entire coastal belt of India and, in addition, to riverine stretches affected by tidal action. The objective of the CRZ Notification is to protect the coastal areas from becoming degraded due to unplanned and/or excessive development which results in pollution and the eventual destruction of this highly prized, fragile and irreplaceable natural resource. The Notification, for the first time, authorized the State Governments to declare from time to time as CRZ-I areas "areas likely to be inundated due to rise in sea level, consequent upon global warming" and "area between Low Tide Line and High Tide Line". These are among other ecologically sensitive areas of the coast such as mangroves, wild life areas, coral reefs, fish breeding areas etc. which are also to be treated as CRZ-I, requiring high priority coastal protection areas. The CRZ Notification, in modified form is, awaiting Government of India's approval.

The Honavar Forest Division in the Kanara Circle has 97 km long coastline, covering the taluks of Kumta, Honavar and Bhatkal. Compared to Udupi and Dakshina Kannada the coastline is interrupted with hills and therefore rocky shores are many in between sandy beaches. There are several beautiful beaches in this Division. At present the beaches of Gokarna and Murudeshwar have become paradise for an ever growing tourist population. Many other picturesque beaches are slowly waking up to tourism. The notable beaches of the Division are Gangavali, Gokarna, Kudle, Om, Baad, Holangadde, Kumta, Handigon, Dhareshwar and Ramangindi of Kumta taluk, Haldipur, Kasarkod, Apsarakonda, Mugli, Manki and Talamakki of Honavar taluk and Bailur, Murudeshwar, Bengre, Jali, Haldin, Belke and Gorte of Bhatkal taluk.

The beaches which particularly requiring bio-shielding are those which are not bordered by background hills. Mention may be made of Gangavali, Gokarna, Baad, Holangadde, part of Kumta beach, Handigon, Dhareshwar, Haldipur, Kasarkod, part of Apsarakonda, Manki, Bailur, Murudeshwar, Bengre and Jali. These beaches are vulnerable to severe erosion from possible sea level rise, if steps are not taken today to raise high sand dunes on them stabilized by vegetation.

For prevention and mitigation of sea erosion there are both **structural measures** and **non-structural measures**. **Seawall** may be useful in protecting specific area from erosion and storm surges. However, adverse effects can be on the downstream side. **Off-shore breakwater** construction is carried out for shore protection and beach formation. Such breakwaters are constructed in the Arabian Sea in the Project Seabird Naval Base. The barriers like breakwaters are associated with severe downstream shore- erosion. It is also an expensive option and needs regular maintenance to avoid rapid breakdowns.

Vegetation cover is considered a **non-structural soft measure** to protect the shore from erosion. Stabilized sand dunes, natural safety barriers of beaches, are the contribution of **psammophytes**, at no cost to human economy. Plant roots are effective in stabilizing loose sand and protecting it from erosion by waves or wind. This report is devoted to the beach situation in Honavar Forest Division of Kanara Circle and to prescribe raising of appropriate vegetation cover, as a substitute for the artificial structures which are detrimental to the functioning of the beach as an ecosystem. The walls often interfere with natural plant succession along the beaches; they reduce the aesthetics of the coast and hamper the development of coastal tourism. The sea walls are expensive to build unlike the green walls of natural vegetation. The beaches might tend to subside in their levels due to the waves pounding on the rocks and returning vigorously as their turbulent energy is not absorbed by the stone walls**.** Moreover, the local community will be benefited from good vegetation on the sea beach due to various non-timber products and tourism potential. **Bio-shielding,** referring to raising of green walls using appropriate plant species, is a more recent term applied for shore protection with the help of vegetation. Bio-shielding serves the dual purpose of raising the sand dunes as well as increasing the protective cover of the vegetation. Not just the sea beaches but even the backshore has to be managed under integrated coastal management programme.

Dune vegetation traps windblown sand and holds it on to the fore-dunes. The exposed dry sand is easily moved by high velocity winds and large volumes of sand can be rapidly shifted from one place to other. Shifting sands if deposited on herbaceous cover can smother it. But dune vegetation contains characteristic native species and has its own intrinsic biodiversity value. Beaches and dunes are important feeding, breeding and roosting grounds for sea turtles and shore birds.

Steps for protection and development of sand dunes and dune vegetation

- **Dune thatching** is a supporting measure for development of dune vegetation. It refers to covering of developing dunes with brushwood or twigs. It is a simple cost effective process. In our local situation this can be done with active co-operation from the local community, which should be aware of the importance of protecting the developing dunes with twigs or brushwood, so that they are not removed for fuel needs. This organic cover can last for one year and allow dune plants to develop on the sands. We can try experimentally coconut fronds and *Pandanus* leaves for the same purpose.
- **Fencing of sand dunes** is an effective practice to protect the developing vegetation. Fencing is done above the high tide limit. Fencing protects the developing dune vegetation, including beach plantations, from damage from people trampling as well as from trampling and browsing of plants by cattle. Dune fencing is done on the upper beach beyond the reach

of the sea waves and tides. Dune fencing allows also the fore-dunes to develop towards the sea facing side. Fences also reduce wind speed across sand surface while allowing vegetation to develop un-impeded. Local community involvement will greatly help in success of the programme. Barbed wire fencing, though not itself promoting accumulation of sand, unlike the wood or bamboo stakes, is very effective protection measure. It is not advisable to fence beaches which are visited by sea turtles for laying eggs, as they get disturbed or even get entangled if the fencing is specially of barbed wire. In such beaches there is a practice of making parallel strips of wooden fencing vertically aligned to the sea shore, farthest from the water. Thin wooden strips fastened by wires are used for such fencing. The fencing should not exceed five feet in height, and the length of any single stretch of fencing not to exceed 10 feet and leaving about seven feet gap between any two sections of parallel fencing. This type of fencing bordering the backshore of the sea allows sand to collect between strips and behind. Fencing can be parallel to the shore if it will not create regular movement of people into the beach, nor blocking the path of nesting turtles**.**

Species selection: For planting just above the high tide line, for the level portion of the sandy beach, the ideal plants are creeping, salinity and desiccation tolerant perennial species such as *Spinifex littoreus, Ipomoea pes-caprae, Hydrophylax maritima, Launea sarmentosa* and *Cyperus arenarius.* Occasional submergence by storm surges may not completely destroy these species which spring back to full life soon. Their stems creep along the sand surface and root at the nodes stabilizing the loose sands, and building up larger dunes. They are the forerunners of vegetation succession along the foreshore areas where the conditions are not ideal for others. Even if buried under shifting sands these plants will not perish, as they come up again on dune surface and spread by rooting at the nodes of their creeping stems which spread in all directions. They belong to the category of **prime sand-binders.** These species may be propagated during the rainy season by stem cuttings.

The mid-shore, where the perennial species enjoy greater security from flooding, is good for all the above species, where they continue to dominate. Additionally we also find the partial stem parasite, and yet another prime sand binder *Cassytha filiformis*, which forms wiry masses over the sand surface attached to their host stems. *Lippia nodiflora, Canavalia rosea*, a leguminous creeper (common in the beaches of DK – Udupi region) are other prominent sand binders. It is a promising species that needs to be introduced into the Uttara Kannada beaches. The seeds of the legume can be collected and stored until the onset of the rainy season, when the seeds can be dibbled in the sand. Another leguminous species that spread on the mid-shore sand is *Derris trifoliata.* Spreading herbs suitable for the mid-shore are *Glinus oppositifolius* and *Sesuvium portulacastrum.* Shrubs like *Scaveola taccada, Datura metel, Calotropis gigantea, Clerodendrum inerme, Ixora coccinea,* etc. are good for this part of the beach. Among the climbers present are *Premna corymbosa* and *Vitis trifoliata* Numerous seasonal herbs such as *Pedalium murex* (a local medicine for kidney stone), *Alternanthera sessilis, Hedyotis corymbosa, Borreria articularis, Physalis minima, Vernonia cineria, Crotalaria verrucosa, C. retusa, Leucas aspera, Urginea indica, Crinum* *latifolium* are associated with this part. Among the trees that grow here are *Pandanus odoratissimus* which is remarkable for its sand-binding properties, having an entanglement of strong aerial roots that serve the purpose. We also find the palmyra palm *Borassus flabellifer,* the '*Noni*' tree *Morinda citrifolia, Zizyphus mauritiana, Casuarina equisetifolia, Calophyllum inophyllum* etc capable of surviving here.

The far part of the beach, the hind shore, has a variety of trees, shrubs, climbers and herbs. Characteristic of these sea-shore trees are *Pandanus odoratissimus, Calophyllum inophyllum, Borassus flabellifer, Cocos nucifera, Thespesia populnea, Erythrina variegata, Pongamia pinnata, Ficus racemosa, Morinda citrifolia, Zizyphus mauritiana, Casuarina equisetifolia* etc. Various shrubs, climbers and herbs of hinterlands can grow here according to the landscape elements associated with the beach system (such as hill, rice field, household garden etc.).

Use of Vetiver grass (Khas grass, Lavancha) or *Vetiveria zizanoides* is getting popular for dune stabilization. Vetiver grass could withstand very harsh climatic and soil conditions. Planting slips of this deep rooted grass in rows can effectively check erosion. The grass grows very fast, the leaves may dry up in summer but new tillers sprout from the base during rains. Trees take several years to develop extensive and deep root systems necessary to anchor the soil on steep slopes to prevent landslides and reduce erosion, whereas vetiver grass, when properly established, can provide the same effect within 12 months. Vetiver technology is today getting popular in India as a very effective erosion control measure. Vetiver grass has massive, finely structured root system. This massive root system of few meters depth is very effective in preventing erosion by closely planting. The dense stems of the grass can reduce run off water and trap sediment. It has high tolerance to pests, diseases and fire. It tolerates extremes of temperatures from -15^0 to 55^{0}C. Its high tolerance of salinity makes it ideal candidate bio-shielding.

Woody vegetation will serve as speed-breakers in coastal storms, cyclones and tsunami. They will also serve as carbon sinks, helping to enhance carbon sequestration and thereby mitigating global warming. While many species of plants are able to establish on sand or gravel beaches, the extreme conditions of desiccation, salinity and erosion allow few species to reach maturity and set seed. Severity of desiccation increases as particle size increases. On sandy beaches, successful vegetation establishment causes an increase in surface roughness, slowing both the wind and movement of sand, and resulting in the accumulation of sand in the form of coastal dunes. Vegetation cover increases with distance from the water's edge due to decreasing levels of erosive wind and water energy.

Management, planning and execution: Beaches and sand dunes represent flexible barriers which absorb wave energy during storms by moving and adjusting their shapes and position. The management of such ecosystems requires thorough planning and proper execution.

Selection of sites for sand dune rehabilitation depends on available funding and manpower. Initially all beaches are to be surveyed and those beaches alone should be selected which have very specific conditions suitable for formation of sand dunes. Such sites should have existing dunes or having history of dunes during the past 20 years. Dunes have suffered from pressures from humans such as development of agriculture, townships nearby, sand mining etc. Many of the beaches skirted by hills are not much affected except perhaps by tourism. There is no point selecting for dune restoration beaches which are relatively intact.

Rehabilitation methods: Sand trapping fences are useful. Fences are porous barriers that reduce wind velocity so that sand drops of wind stream near the fence. The fence should not block wind but only slow down it. Vertical wooden strips fastened by wire are ideal fences. Fences should have porosity of about 50%. Fences are to be made closer to the shore vegetation, above the dry sand bed, so that it is safe from frequent lashing by waves and tides. The fencing may be parallel to the shore or perpendicular to it in places of turtle nesting or depending on wind direction in the beach. As the cost of wood is high and pilferage from the site might happen, split bamboo may be used. In almost one years' time much of the fence might get buried in dune forming beaches. Another fence might be raised over the dune to trap more sand. The newly built dunes should be stabilized with vegetation. The species for planting should be chosen after due consultation with the experts to increase the degree of success. Organic manures may be judiciously applied as the beach sands are infertile. Surface mulch around the plants will help in retaining moisture and in preventing erosion of loose sand during rains. Branches of trees such as of *Casuarina* placed flat on ground can help accumulation of sand. Planting should be done in the very beginning of wet season.

Co-management and awareness: As beaches are along the densely populated coastline local committees should be constituted for co-management. Periodical meetings with the community are very important. Involving local people in discussions and work will increase their level of awareness. Participation of local schools can increase the degree of success.

Some important species for Bio-Shielding: When we consider the suitability of various species for bio-shielding of the coast, invariably we should consider the following for planting:

- ***Spinifex littoreus:*** Pale green, rigid and rough grass spreading along the sea shore sand and most tolerant of occasional submersion. Forms formidable patches tolerant of human intervention because of its rigidity and sharpness of leaf tips; also immune to grazing and trampling by cattle. Cuttings can be planted during rainy season. It is extensively planted in Tamil Nadu to control movement of sand.
- ***Ipomoea pes-caprae:*** A creeper widely distributed over the tropical and subtropical sandy places, such as sea shores river banks etc. A trailing vine along sand dunes. It roots at nodes, spreads rapidly and far from the base in all directions, very tolerant of salinity. Growing above the HTL the creeper forms large mats, stabilizing dunes. Branches may reach 10 m in length. Tap roots are long and deep sometimes reaching over a meter. Present

throughout tropics and subtropics. Grows vegetatively from stem cuttings and also by seeds. Can resist salt spray and wave splash. It can recover from the high waves from cyclones. Survives heavy rains and drought. The creeper adds to the attractiveness of beach by its large deep rose to purplish flowers. Cuttings can be planted during rainy season. Leaf extract is a traditional remedy for different types of inflammations including dermatitis and skin injuries caused by poisonous jelly fishes. The extract is said to have potency equal to that of aspirin. The extract has antispasmodic activity. It can be propagated by seeds as well as cuttings.

- ***Canavalia* spp:** This perennial legume is an extensive creeper and climber, a very effective sand-binder more found in Udupi-DK beaches. *Canavalia rosea* is common along open mid-shore sands; it is pan-tropical, but exclusive to coastal sands. whereas *C. cathartica* occurs along the tree line behind. *Canavalia* forms dense mats along the sand. It is an under-explored legume as human food; raw seeds of *Canavalia* possess 31-35% proteins and are rich in potassium, phosphorus, sodium and calcium. About 46 species of soil fungi are found associated with the roots of this species in different studies. The tender pods of *C. cathartica* are used as vegetable. Both species can withstand desiccation of the shore and increase soil fertility due to nitrogen fixation by root bacteria. In Padubidri and Sasihitlu the fisherfolks occasionally consume pods and ripe beans. The beans are soaked in water for long time for detoxification. The plants can be propagated by seeds.
- ***Pandanus* spp.** are shrubs to trees, often growing gregariously along the beaches. *P. odoratissimus* is commoner along the shores and borders of backwaters. *P. kaida* occurs along the bunds of coastal rice fields. *Pandanus* can grow on a wide variety of soils including on rocky beaches. It can withstand drought, strong winds and salt spray as well as occasional salt water inundation. The plants can resist moderate to severe cyclonic storms. In habit they are large shrubs to small trees. The species produces strong, aerial roots from the stem. These roots grow downward and anchor the plants firmly to the substratum. Flowers are fragrant and the fruit resembles pine-apple. The units of fruits are dispersed by ocean currents; seeds maintain their viability for months together. Seeds are also dispersed by birds and fruit bats; crabs also feed on the fruits. Pacific islands have several varieties of *Pandanus tectorius* with edible fruits. The natives carefully propagate the species by cuttings. Flavoured varieties of fruits in these islands are used for jams, jellies and juice. The Indian varieties have calcium oxalate crystals that cause irritation. Leaves are used for mats, baskets and hats. Mats are very good as floor mats and last for several years. Fragrant flowers are sold in the market and a perfume is also extracted from the flowers. Along the coast it renders valuable ecosystem services. Apart from its value as a shore protector its fruits are eaten by birds, bats and crabs. The plant has a role in marine ecosystem and food chains. It provides shelter for birds. Honey bees forage on female flowers and fruits. Plant is propagated from seeds as well as branch cuttings.
- ***Calophyllum inophyllum*:** Medium to large evergreen tree prominent along the coast with dark green shady foliage and fragrant flowers. The drupe is light yellow when ripe and

carries single globular, oil rich seed within a hard endocarp. The tree grows in deep soil near sea as well as on pure sand. It is an efficient shore protector. Birds and bats feed on the fruit pulp and disperse the seeds, which are also water dispersed. Germination takes place in 50-55 days. Germination percentage is increased by removal of shell. The seeds yield oil; a tree yields about 22 kg of oil from its seeds. Oil is traditionally used for lighting; it is used for varnishing wood works since it contains 10-30% resin. Used as a lubricant; for tanning of leather; for applying on boats; for making soap, which has anti-fungal properties. Camphor-mixed oil applied for ringworm. Being anti-bacterial, useful for treating burns; also for ulcers and diseases of hooves of cattle. Kernel paste for painful joints; oil applied for rheumatism and gout; for scabies and skin disease. Oil cake is good organic manure; it also controls root nematodes. Timber is very useful. The tree renders considerable ecosystem services; its dense canopy is good habitat for birds and other animals.

The University of Agricultural Sciences of GKVK, Bangalore, in its **Biofuel Park** at Hassan produces high quality **bio-diesel** from the seeds. Farmers' associations have been formed to plant, collect and process seeds of *Calophyllum, Pongamia,* neem, mahua etc. to produce bio-fuels. A fair price of Rs. 13-15/kg is paid to the seed collectors of *Calophyllum* which is becoming very popular with the farmers and poor landless persons who can at least gather seeds and sell and make their livelihood. The Biofuel Park, under the patronage of the **Biofuel Task Force of Karnataka** is organizing massive planting of the species widely in the State. The tree being ideal for the sea-shore should be planted in millions for not only the biofuel but also for its multiple uses and ecosystem services as well as a future source of income for the landless and unemployed.

- ***Borassus flabellifer:*** This tall palm, known as palmyra, is mainly found in DK and Udupi shores. It is very rare in Uttara Kannada; a couple of trees occur in Ramangindi beach and few along the rocky shore of Apsarakonda. Male and female plants are different. Fruits are large drupes, which while tender produces sweet and juicy endocarp, much in demand during the summer months. Ripe drupes are heaped in one place and covered with soil. It takes 10-12 weeks for the seeds to germinate. The palm is very slow growing, but strong and sturdy. Close planting can beautify the sea-shore as well as serve as a defense against erosion. The male inflorescence is tapped for toddy from which palm sugar and sugar candy are produced. The sugar candy is popular for its soothing effects on cough. Leaves are used for weaving mats and various fancy items.
- ***Morinda citrifolia:*** A small tree along the coast, it is sparingly found in Karnataka. Flowers occur in heads and the multiple fruits reach 2.5 cm in diameter. The tree was formerly cultivated as a crop for the roots which yield a dye. The dye yield is maximum in 3-4 years old plants. Morindine is the coloring principle of the roots. Wood yields an yellow dye, which gives mordanted cotton, silk and wool red, purple and chocolate colours. Most parts of the plant are medicinal. It tolerates salinity and drought conditions and grow well on sandy beaches. It can attain a height of up to 20 feet and serve the dual purpose of

preventing soil erosion and acting as a windbreaker. Normally stem cutting is used for propagation. The planting distance is about 15 feet apart. During the last decades Noni products, particularly the juice made from the fruit, has turned into a huge business! By planting Noni along the coastline the country can, apart from preventing soil erosion, capture a major chunk of the fast-growing Noni market. Noni starts yielding in 18 months and has a productive life span of around 40 years.

12.6 MANGROVE DOCUMENTATION AND MAPPING

Mangroves are a group of plants that occur in the coastal intertidal zones of tropics and the sub-tropics. The mangrove community as a whole consists of salt tolerant plants of soft and swampy mud, mostly trees and shrubs, with broad, leathery, evergreen leaves root emerging out of mud for gaseous exchange and in many cases seeds germinating while the fruits are still attached to the parent tree. Mangroves are a group of plants that occur in the coastal intertidal zones of tropics and the sub-tropics. The mangrove community as a whole consists of salt tolerant plants of soft and swampy mud, mostly trees and shrubs, with broad, leathery, evergreen leaves. Mangrove wetlands are a multiple use ecosystems that provide protective, productive and economic benefits to coastal communities. Mangroves contribute to the stabilization of the shoreline and prevention of shore erosion. They serve as a barrier against storms so as to lessen damage to coastal land and residents. The dense network of supporting roots and breathing roots give mechanical support to the tree and trap the sediments. Without mangroves, all silt will be carried into the sea, where turbid water might cause corals to die. Mangrove trees act as sinks, which concentrate pollutants such as sewage, toxic minerals, pesticide, herbicides, etc. The Indian east coast has much larger estuaries with mangroves than the west coast which has smaller estuaries and relatively less mangroves, Gujarat state being an exception. As far as Karnataka is concerned the mangrove are and importance have been under-estimated. The Forest Survey of India estimated mangrove area in the entire State of Karnataka as making just two sq.km, in 2001. Any visual estimate of the estuaries will reveal the mangroves could be something more. Such underreporting the area could have been the cause for long times of neglect. Over the last one decade or so under various schemes mangrove planting got more importance and the area has been on the increase. However, in none of the estuaries was attempted any mapping of the mangroves. As mangroves are very important in coastal ecology, biodiversity and productivity, including of marine fishes, they are expected to have a significant role in ecological carrying capacity of the coast. We therefore attempted an evaluation of the mangroves through locating them, species wise, estimating the number of patches and area under them in four estuaries of Honavar Forest Division of Uttara Kannada. The results have been brought out, estuary-wise, forest range and beat-wise and submitted to the Karnataka Biodiversity Board as a part of the Carrying Capacity project. We used ground verifications, remote sensing imageries, including Google Earth, GPS for estimating mangrove areas in the estuaries of the rivers Gangavali, Aghanashini, Sharavathi and Venktapur as well as in smaller creeks. Maps have been prepared for mangroves at estuary level and forest beat wise so that even grass-root level functionaries of the department can locate not only mangrove patches within the beat but even their species as well as locate potential area for planting. It is for the first time that such mapping has been carried out for any west coast estuaries if not for the whole country. The detailed report carries estuary and creek-wise, and village, range and beat-wise area under mangroves and potential areas available for mangrove planting and suitable species for planting in relation to salinity and soil conditions. The comprehensive mangrove map of Aghanashini estuary and the potential areas demarcated are shown in Figure 12.6 and Table 12.7.

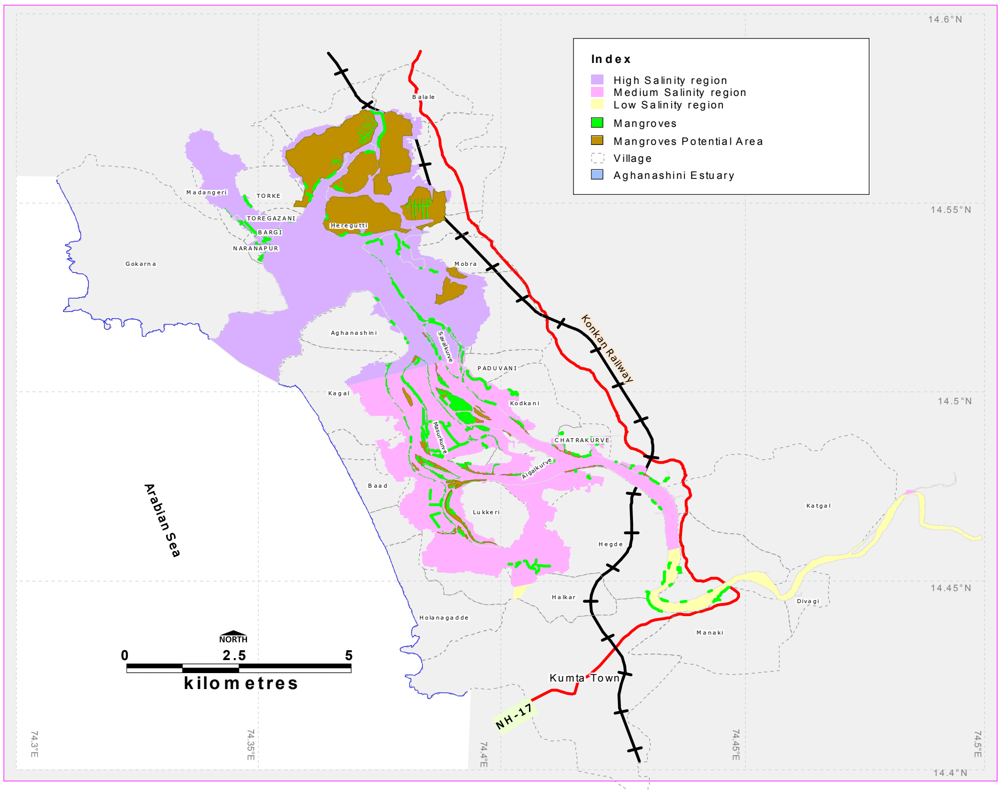


Figure 12.4: Area under mangroves, potential area for planting and salinity regimes in Aghanashini estuary.

Table 12.6: Salinity status-wise mangrove area and potential area for planting in Aghanashini estuary

Salinity level	Mangrove area in ha	Potential area in ha.	Total waterspred area in ha.
High	29.25	675.3	2794
Medium	88.91	57.2	1910
Low	1.2	0	236.7
Total	**119.36**	**732.5**	**4940.7**

Mangroves recommended for planting in relation to salinity are given in Table 12.6

Table 12.7: Mangroves recommended for planting in potential areas

Sn	Mangroves sp.	Salinity zones		
		High	**Medium**	**Low**
1	*Avicennia marina*	√		
2	*A. officinalis*	√	√	
3	*Excoecaria agallocha*	√	√	
4	*Kandelia candel*	√	√	
5	*Porteresia coarctata*	√		
6	*Rhizophora apiculata*	√		
7	*R.. mucronata*		√	
8	*Sonneratia alba*	√	√	
9	*S. caseolaris*			√

Remote sensing imagery of Aghanashini estuary using 2010 IRS p6 L4 MX 5M is shown in Figure 12.5. A Google Earth imagery of Madangeri beat in Hiregutti forest range depicting mangrove area is shown in Figure 12.6 and details of beat area, mangrove area, potential area for planting, species suitable for planting etc. are shown in **Table 12.8.**

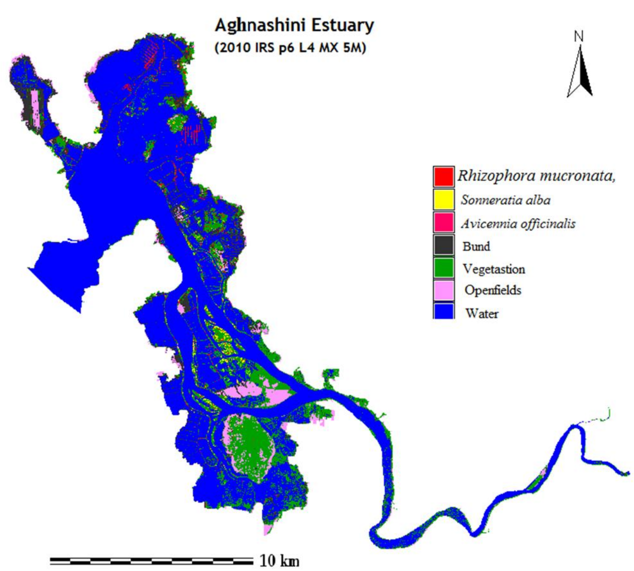


Figure 12.5: 2010 IRS p6 L4 MX 5M imagery ofAghanashini estuary depicting mangroves

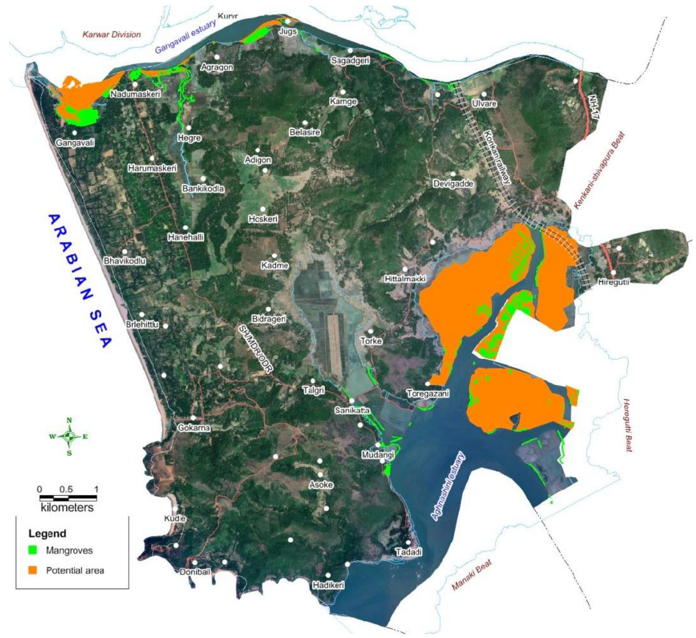


Figure 12.6: Google Earth Imagery of Madangeri forest beat showing mangrove area and potential area for planting

Table 12.8: Details of Madangeri forest beat pertaining mangroves

MADANGERI BEAT

Beat Area (ha)	7233
No. of mangrove patches	190
Mangrove area (ha)	61.93
Perimeter in km	82.84
No. of potential areas for planting	38
Total area for planting (ha)	549.30
Dominant species	*Avicennia officinalis, Rhizophora mucronata, Excoecaria agallocha, Sonneratia alba, Avicennia marina, Acanthus ilicifolius, Rhizophora apiculata, Kandelia candel, Aegiceras corniculatum,*
Recommended Species	*Rhizophora mucronata, Avicennia marina, Excoecaria agallocha, Avicennia officinalis, Sonneratia alba, Kandelia candel, Rhizophora apiculata*
Estuaries	Gangavali, Aghanashini
Taluks	Kumta, Ankola

12.7 **CONSERVATION AND MANAGEMENT OF MANGROVES IN UTTARA KANNADA DISTRICT**

The mangroves constitute a community of usually woody, evergreen, salt tolerant plants of soft and swampy mud of tropical sub-tropical coastal zones preferring river mouths, lagoons and creeks. Mostly found in intertidal zones and stagnant swampy coastal waters they have special adaptations like physiological and structural mechanisms to combat excessive salt in the medium, special aerial root systems for support in unstable slushy substratum and for gaseous exchange as they are anchored in anoxic water-logged conditions. Some, especially members of Rhizophoraceae have their seeds germinating into seedlings while the fruits are still attached to parent plant. These juvenile seedlings fall vertically into the mud, get stuck there and develop into new plants.

Till about 1960s, mangroves were largely viewed as "economically unproductive areas" and were cut down for meeting a variety of human needs and the swamps reclaimed for human habitations. Mangrove areas today rated among the most productive ecosystems on this planet. They generate nutritionally important detritus for fishes, prawns, crabs, oysters etc. and shelter estuarine and marine organisms and provide safe breeding grounds for many, as well as provide home for numerous kinds of birds.

Mangroves play important role in ecosystem functioning and are of great economic importance for fisheries. Detritus is also transported a food by tides to near-shore organisms. Mangroves contribute to the stabilization of the shoreline and prevention of shore erosion. They serve as a barrier against storms so as to lessen damage to coastal land and residents. The dense network of supporting roots and breathing roots give mechanical support to the tree and trap the sediments. Without mangroves, all silt will be carried into the sea, where turbid water might cause corals to die. Mangrove trees act as sinks, which concentrate pollutants such as sewage, toxic minerals, pesticide, herbicides, etc. They sequester much more carbon per unit area than even tropical rain forests. Wherever mangroves are rich livelihood opportunities for humans are great, including promotion of tourism. Among the various direct uses of mangrove products are edible fruits and fronds, honey, medicine, timber, fuel wood, manure, tannin, bio chemicals, paper-pulp, genes for salt tolerance in crop plants, dyes, bio-fuel for blending with petroleum, fibre, perfume, fish feed etc.

Mangrove vegetation was neglected totally in Karnataka State and national level surveys hitherto showed no mangroves or only negligible areas under it (just 1 or 2 sq.km), which is far from the reality. As mangroves are inevitable for integrity of estuarine ecosystems and maintaining their high productivity a detailed micro level survey was found to be necessary in every estuary and creek.

Karnataka estuarine regions are densely populated by humans because of high productivity and transportation facilities that these areas provided in continuity with the Arabian Sea. Bulk of the shallow water coastal swamps areas were presumably cleared for growing salt tolerant rice in reclaimed fields protected from salt water entry by making embankments. Traditionally the farmers planted mangrove trees alongside these bunds. Later when stone bunds were built by the Government, mangroves were cut down in large scale.

The start of Linganmakki dam for power generation in the Sharavathi River would have caused obvious decline in estuarine salinity on account of continuous release of fresh water affecting adversely estuarine ecosystem, particularly mangroves. Such changes went practically unrecorded in science. The arrival of one more dam at Gersoppa in the same river caused still further dilution so much so most of the time estuarine salinity is in near fresh water conditions. The mangrove diversity declined as a consequence leaving behind very few species, especially the tree *Sonneratia caseolaris*, tolerant of nearly fresh water conditions.

Recent decades witnessed spurt of shrimp farming activities in specially prepared shrimp ponds from which every trace of mangroves were removed.

At present there is increased awareness on the importance of mangroves. Under various schemes sponsored by State and Central Governments mangrove plantings have been made in the estuaries of Karnataka. The Honavar Forest Division achieved spectacular progress in mangrove afforestation, especially in Aghanashini estuary and Kumta creek. Increased area under mangroves is bound to have beneficial effects on estuarine productivity and biodiversity as well as causing increased nutrient flow into the Arabian Sea itself.

In spite of such progress, in the absence of overall evaluation and mapping of the mangrove situation it has become difficult to take up the cause for further afforestation of Karnataka's estuaries with mangroves. As evaluation requires mapping of existing mangroves and depiction of suitable areas for further planting a detailed estuary and creek-wise survey is found necessary. Moreover estuaries need to be demarcated into different salinity zones for making appropriate combination of species for planting in high, medium and low salinity zones. The current study was carried out at the behest of Honavar Forest Division of Kanara Forest Circle.

Of the methods used for the survey were all out field studies, physically visiting all the estuaries and creeks and noting down mangrove species present in different patches through sampling, and finding out the geo-locations by using GPS. Google imageries have been very useful in locating mangrove patches and in estimating the potential intertidal areas for future planting. Counts of trees were made in selected locations to find out percentage composition of species. Salinity levels were noted down to classify mangroves into high, medium and low salinity species. Remote sensing imageries had only limited applications for identifying mangrove trees on the substratum, but nevertheless estimates were done of the area under frequently occurring tree mangroves. RS data of 1989, 2000, 2003 and 2010 helped in finding out changes in land use land cover in the estuaries, including one km buffer zone outside.

Honavar Division has four estuaries towards the river mouths of Aghanashini, Sharavathi, Venktapur and part of Gangavali. The Badgani River merges with the Sharavathi estuary towards its mouth. All the estuaries have normal rise and fall of marine tides and normal ranges of salinity expected of local estuaries except the Sharavathi estuary which has minimal salinity (<0.5 ppt) most of the time due to constant release of fresh water from hydro-electric projects from upstream areas. This has caused major decline in mangrove diversity as high salinity mangroves have totally vanished and medium salinity ones turned minimal and low salinity ones, mainly *Sonneratia caseolaris* favoured.

A detailed distribution map of Honavar Forest Division will help in assessing range-wise, section-wise and beat-wise and estuary and creek-wise mapping of mangroves. This is expected to facilitate more efficient management of mangroves. The mapping also covered mangrove associates. The true mangroves (confined to estuaries and creeks) of Honavar Division belong to 6 families, 8 genera and 11 species. If we exclude the exclusive estuarine grass *Porteresia coarctata* the species number will decline to 10. In addition, a fern, *Acrostichum aureum* also occurs in mangrove habitats of less brackish habitats. Rhizophoraceae members *Rhizophora mucronata*, *R. apiculata, Kandelia kandel* and *Bruguiera gymnorrhiza* are typical mangroves with stilt roots and viviparous seeds. *Bruguiera* occurs nowhere except sparingly in Venktapur estuary.

The study covered also about 32 species of notable mangrove associate species which have also distribution beyond the mangrove areas in the lands away from estuaries.

Mangroves of the estuaries and creeks are in high state of fragmentation due to high degree of human impacts through centuries, which include reclamation of estuaries for rice and coconut cultivation, expansion of human settlements, shrimp farming, salt production, shell and sand mining, cutting for fuel and minor timber etc. Altogether 1549 patches were recognized in the Forest Division. These also include linear patches along the borders of estuaries.

We have estimated 391 ha of mangrove areas and 1019 ha suitable for planting. If we consider rangewise mangrove area highest (128 ha) is in Honavar Range, followed by Hiregutti Range (88 ha) and the least occurs in Manki Range (4 ha). Manki also does not have any area for mangrove planting. Hiregutti Range also has largest area (708 ha) suitable for mangrove planting. Honavar Range has 161 ha for mangrove planting while Kumta has 91 ha.

Area under mangroves is highest (169 ha) in Aghanashini estuary, followed by Sharavathi-Badgani (136 ha) and Gangavali (46 ha). Considering estuary-wise suitable area for mangrove planting Aghanashini has highest (711 ha), followed by Sharavathi-Badgani (184 ha), Gangavali (95 ha) and Kumta creek (42 ha). Even the smallest creeks of less than 1 ha are considered in this study.

Whereas *Rhizophora apiculata* and *Avicennia marina* are high salinity mangroves (>15 ppt.), *Aegiceras corniculatum* prefers medium salinity zones (5-15 ppt). *Rhizophora mucronata, Avicennia officinalis, Sonneratia alba, Kandelia kandel* and *Excoecaria agallocha* are seen in high and medium salinity zones. *Acanthus ilicifolius* occurs in all salinity zones, but Sonneratia caseolaris has presence in medium to very low salinity (< 0.5 ppt) conditions.

During mangrove afforestation in the estuaries care should be taken to avoid planting in bivalve and oyster beds which are highly productive of food for humans and animals, including several species of birds.

RECOMMENDATIONS: The exercise carried out in minute details could be of great help to the Forest Department in mangrove management. Mangroves are classified under CRZ-I area and therefore mangrove maps could be used for delineating CRZ I areas.

- It is recommended that similar exercises be carried out in other estuaries of Karnataka as well, considering the tremendous ecological and economic uses of mangroves
- As *Rhizophora mucronata* is the main species used for mangrove afforestation, such monoculturing has to be avoided in future giving way to fair mixing of other species. More importance should be given to *Avicennia* spp. and *Sonneratia* spp.

- The rare population of *Bruguiera gymnorrhiza* in Venktapur estuary should be protected and more number of seedlings should be introduced here from Kali or Kundapur estuaries, as local regeneration is poor.
- Many aquaculture ponds are abandoned due to losses suffered by shrimp farmers. They are also unfit for rice cultivation. Government may formulate a scheme to acquire such areas for planting with mangroves.
- Honey production in mangrove areas is a totally neglected economic activity in Honavar Division as well as in the entire coastal Karnataka. As mangrove honey with rare mix of salts can have greater value bee keeping experiments should be carried out in the estuarine areas.
- Mangrove based tourism for bird watching and for scenic enjoyment should be promoted as a good income generating activity for the local VFCs (Village Forest Committees). Appropriate training for local youth in arranging such mangrove tours will provide newer livelihood opportunities.

12.8 **AGHANASHINI ESTUARY IN KUMTA TALUK, UTTARA KANNADA - BIOLOGICAL HERITAGE SITE** (DECLARATION OF BIOLOGICAL HERITAGE SITE UNDER BIOLOGICAL DIVERSITY ACT 2002)

Note: The proposal made here is for Aghanashini Estuary Biological Heritage Site in Uttara Kannada district of Karnataka. Although the estuary itself is unique in biodiversity and productivity, due to the practical problems that could arise in managing the entire estuary as one unit, two separate core areas are identified within it as Location-1 and Location-2, the former of tremendous importance in Molluscan (bivalves) productivity and the latter of importance for the mangrove ecosystem, which is the core area for biodiversity and productivity. As the estuary is one biologically integrated unit the two locations within it are to be brought under a single Heritage Site Management Committee. The two locations have been described separately for convenience.

1. Identification of Property

a. State : Karnataka

b. Name of the property : **Aghanashini Estuary Biological Heritage Site**
: Location I: Bivalve Mudflats

c. Exact location : Situated in Kumta taluk of Uttara Kannada district. Lat. 14.520833-14.539342 N & 74.353754-74.369593 E

d. Area of Location I : About 229 ha

2. Justification for Declaration

a. What is the significance of proposed site (Location-1)?

i. A highly productive estuary: Aghanashini River in central Uttara Kannada district of Karnataka originates in the Western Ghats and flows westward towards the Arabian Sea, major part of its course through forested gorges and valleys. Having no dams and no notable industrial establishments or major townships along its banks the river may be considered one of the most pristine ones along the west coast. The River meets the sea in the Aghanashini village of Kumta taluk. The tidal portion, or estuary, towards the river mouth is a flat expanse of water dotted with small islands and narrow creeks. This portion, designated as the Aghanashini estuary, is a highly productive and biologically rich waterscape of coastal Karnataka. The high productivity of the estuary is due to the following reasons:

1. The river water carries large quantity of organic materials from the forests in the catchment area of the Western Ghats and deposits the same in the estuary. The debris becomes important base for food chains operating in the estuary
2. The rich mangrove vegetation of the estuary plays significant role in nutrient supply for the diverse faunal community and provide shelter for birds and act as nurseries for many species of fishes and prawns
3. The rich bird community (over 120 species)associated with the estuary contributes to the nutrient cycling through their potash and nitrogen rich castings (Details in Annexure I)
4. The constant churning and circulation of waters due to flow of fresh water from one side and the tidal influx from the Arabian Sea oxygenates the water and circulates the nutrients

ii. **Significance of bivalve (shellfish) production:** Estuaries are ranked among the highest productive ecosystems of the earth. One of the most notable economic and subsistence output of the Aghanashini estuary is the bivalves (Phylum: Mollusca). The meat of these invertebrates is used as a protein rich food by thousands people along the coastal areas of Karnataka and Goa.

Total annual production: Estimated at 22,006 tons, valued at Rs.57.8 million per annum. Most of the of bivalves harvested belong to *Paphia malabarica*, although six other edible species are also gathered in lesser quantities. Bulk of the bivalve harvest is from mudflats bordering the village by name Aghanashini, close to the mouth of the river (bearing the same name). Collectively these bivalve harvesting areas measure about 229 ha. It is significant to note that so much of food production is without any investment or supply of feeds by humans.

The value of an estuary was estimated as Rs.11,41,600/ha/year. This value is the aggregate of all goods and services such as shrimps, fish, crabs, salt, mangroves, in addition to services such as fish spawning grounds, nutrient cycling, hydrology, flood control, soil protection, sink for carbon etc. It is notable that we have provided for the proposed BHS the value of bivalves only and not the other goods and services.

Crucial role in local economy: Bivalve harvesting is the most important aspect of small scale informal fisheries of Kumta coast, an activity traditionally carried out by even persons from non-fishing communities, for family food security and for sale. Bivalve collection provided direct employment for 2,347 people. Of the harvesters 1,738 collectors were men and 609 were women. The collectors belonged to 19 estuarine villages and congregate in mudflats closer to

Aghanashini village during the low tide time for harvesting. The bivalve-linked activities also include minor processing at the site, transportation, collection and sale of empty shells and drying of bivalve meat in small quantities for storage and future use. The calcium rich bivalve shells are used for lime making. The bivalve shell lime is of superior quality for white washing, as fertilizer, prawn feed, poultry feed, production of high grade cement etc.

Food security: Bivalves from the Aghanashini estuary provide excellent protein and mineral rich food for an estimated 198,000 people, especially along the coast. The Indian edible bivalves have protein (5-14%), fats (0.5-3%), calcium (0.04-1.84%), phosphorus (0.1-0.2%) and iron (1-29 mg/100 g of fresh weight).

Ecosystem richness and productivity: The abundant annual production of edible bivalves reflects the rich biodiversity of the estuary in general, which also has around 150 species of fishes, 120 species of birds, 13 species of mangroves, numerous mangrove associates and many more species of lower plants. Organic debris from the bio-diverse community of the estuary itself as well as that brought into the estuary from the Western Ghat forests collectively contributes towards the high production of bivalves.

b. Why the declaration is proposed? Give justification

The proposal is put forward to declare the major bivalve gathering area of 229 ha as part of (Location-1) of Biological Heritage Site due to the following reasons.

i. The bivalve rich area mentioned is the culmination of numerous food chains in the estuary and beyond from the Western Ghats from where nutrients reach the estuary through the river
ii. The local population has strong cultural bonds with the river, which they treat as Goddess. A long history of human association with the river can be traced, as integral part of people's culture and livelihood activities such as fishing, fish and prawn culturing, mangrove planting and utilization, transportation, estuarine rice farming, salt making etc.
iii. The edible bivalve rich mudflats of Aghanashini may be considered as unique, ecologically fragile areas, as their productivity is due to their location towards the river mouth, at appropriate flooding depth during high tides, suitable salinity ranges, and accumulation of a huge quantity organic debris.
iv. Several aquatic and terrestrial bird species, including migrant species use the bivalves and other organisms of nutrient rich bivalve beds as their food.
v. The site recommended for consideration as BHS is not covered under Protected Area network under the Wildlife Protection Act 1972 as amended
vi. No village community has exclusive jurisdiction over the proposed area, although bivalve gatherers assemble here from 19 estuarine villages.
vii. Bivalve gathering, just like fisheries, has been a subsistence and economic activity from pre-historical times. Unlike fisheries the bivalve gathering is not an activity that needs high skills. It belongs to the sector of 'informal fisheries'. The bivalve

production area and activity of gathering and utilization may be considered a common heritage of the people of Aghanashini estuary.

viii. As such the bivalve collection activity is not regulated by any norms made by local communities. It is an unregulated, open to all economic activity engaged in by people, irrespective of caste and community. The activity was carried out traditionally on sustainable basis, more to cater local needs. Over the last few years large scale transportation of bivalves especially to Goa market has resulted in local famine and raises question of sustainability of the resource.

ix. As the bivalve harvesting areas are totally unprotected by any laws from any destructive type development activity or any other kind of disturbances that might happen in the future, in the very site or in any adjoining areas, that could adversely affect the food web of the estuary, it has become necessary to bring such critical areas under Location-1 of 'Aghanashini Biodviersity Heritage Site'.

x. As there is involved here an issue of common resource being used from generations by a set of villages, the proposed property is beyond the jurisdiction of any single Biodiversity Management Committee (BMC) or village panchayat. Section 6a of the Guidelines for selection and management of Biodiversity Heritage Sites (National Biodiversity Authority, 2009) states: "Wherever the BHS extends to more than one local bodies, the management of the BHS shall be the responsibility of the Biodiversity Heritage Site Management Committee ….. approved by the SBB". Here therefore, the State Government's role will come into play in the process of declaration, management and monitoring.

c. Threat if any (give details): For generations together the edible bivalve production areas adjoining Aghanashini village were used sustainably by the village communities as production has been abundant and the demand was mainly local. However in the recent years the demand has shot up from outside markets, especially from Goa, causing unprecedented over-harvesting. As many village communities are traditionally associated with bivalve gathering in the same production areas it is beyond the jurisdiction of any single gram panchayat or the local BMC to regulate harvests within sustainable limits. This situation could spell doom to the sustainability of the resource within few years. Further, the estuary is likely to be affected by various developmental interventions in the absence of any biodiversity centred, state sponsored governance.

3. Description

Present status of conservation: Need for conservation was not felt until recent years, when demand for bivalves as food was more local than from outside. As resource was abundant and extraction pressures limited to sustainable limits there was no need to adopt any special measures of conservation. But such need has arisen now due to over-exploitation for catering to outside markets.

4. Management

a. Ownership: The part of estuary producing huge quantity of edible bivalves is under the jurisdiction of the Government of Karnataka; no private agency or village panchayat has special rights over the 229 hectares of Location-1 of the proposed BHS.
b. Legal status: proposed area comes under the ownership of the Government of Karnataka
c. Agency to manage the site after declaration: The ‘Guidelines for Selection and Management of Biodiversity Heritage Sites’ (http://nbaindia.org/wb_day.htm) states under Section 6 (only relevant clauses presented here):
   a. *Wherever the BHS extends to more than one local bodies, the management of the BHS shall be the responsibility of the Biodiversity Heritage Site Management Committee constituted by the BMC or other local institutions linked to the local bodies in case BMC does not exist, and approved by the SBB.*
   b. *The committee responsible for the management of the BHS shall include representatives of all sections of local communities, and in particular those most dependent on the natural resources as also those who have been traditionally conserving the area.*
   c. *It shall be responsibility of the BMC/BHS Management Committee to prepare and implement a management plan for the BHS which should cover a period of five to ten years*
   d. *SBBs will then recognize and facilitate the implementation of the final management plan. Such facilitation shall include direction to all relevant government departments to assist the communities in implementation, including through appropriate changes in their plans and schemes, to eliminate biodiversity-damaging practices and to fully enable and empower the communities in conserving biodiversity. Where necessary orientation programmes shall be organized for such departments and NGOs.*
   d. *Any project/activity to be implemented by government or any other agency, which is likely to have adverse impact on the BHS may be avoided.*
   e. *Restriction in form of regulating the use of the resources may be warranted in some cases and such restriction shall be totally voluntary on the part of the community.*
   f. Name, designation and address of responsible person/institution for contact: (common for Location -1 & Location – II of proposed BHS)
   g. Sources of expertise : Centre for Ecological Sciences (Indian Institute of Science), Field Station, Viveknagar, Kumta- 581343

5. Factors Affecting the Site
   a. Pressures affecting the site (Encroachment, Agriculture etc.): nil
   b. Environmental pressures: Getting subjected to unregulated exploitation, due to non-sustainable harvests of late
   c. Visitor/tourism pressures: nil

6. Documentation
   a. Existing site management plans if any: ‘Snehakunja’, Kasarkod, an important local NGO had conducted programmes for estuarine communities on CRZ awareness, mangroves, need for sustainable harvests of bivalves etc.

7. Opinion of other concerned stakeholders: Stakeholders (local fishing communities, other bivalve gatherers and traders) would welcome introduction of sustainable management system

8. Details of disputes if any on the site: Nil

9. General remarks if any: Declaration of Location-I as part of BHS and formulation of appropriate management plans for bivalve harvests, in combination with Location- 2, mangrove area will have good positive effects on the mollusk habitat and production and thereby ensure livelihoods and food security of the local communities.

DESCRIPTION OF LOCATION- 2 OF AGHANASHINI ESTUARY BHS

1. Identification of Property

a. State : Karnataka
b. Name of the property : Aghanashini River Mangrove BiodiversityHeritage Site
c. Exact location : Situated in Kumta taluk of Uttara Kannada district. Lat. 14.52083-14.53934 N to 74.35375-74.36959 E
d. Area of site proposed for declaration: About 67 ha

2. Justification for Declaration

a. What is the significance of proposed site?

i. Aghanashini River in central Uttara Kannada district of Karnataka originates in the Western Ghats and flows westward towards the Arabian Sea, major part of its course through forested gorges and valleys. Having no dams and no notable industrial establishments or major townships along its banks the river may be considered one of the most pristine along the west coast. The River joins the sea in the Aghanashini village of Kumta taluk. The tidal portion, or estuary, towards the river mouth is a flat expanse of water dotted with small islands and narrow creeks.

ii. Through millennia the estuary and its environs formed the lifeline of the people and constitute a major cultural and historical heritage of the west coast. It was known as a rice bowl in the historical times and rice surplus was transported through water crafts to other regions. The Mirjan fort on the bank of the estuary built by Bijapur Sultans and the ruins of Aghanashini fort on a hill towards the river mouth giving a commanding view of the sea, the estuary and the Western Ghats are testimonials for the historical and cultural importance of the region. Spices grown in the hinterlands of Western Ghats were traded through the estuary during the European period and earlier to it. Gokarna on its shores has been, from time immemorial, a great place of pilgrimage. Before the road networks came the estuary was a major route for transportation of pilgrims. The beaches dotting the coastline of Gokarna are today well known places of tourism. The picturesque estuary with flourishing mangrove vegetation, its rich birdlife, and traditional way of life of the people need to be protected as a cultural heritage and draw for tourism.

iii. The estuary is a highly productive and biologically rich waterscape of coastal Karnataka. Whereas hundreds of families in the shore villages have direct dependence on it for their livelihoods through activities related to fishing, agriculture, collection of edible bivalves and crabs, shrimp aquaculture, traditional fish farming in the *gazni* rice fields, bivalve shell mining, salt production, sand removal, water transportation etc. scores of consumers in the estuarine villages and in places far away are benefited by the productivity of the estuary, of which the mangroves constitute the heart. The high productivity of the estuary is due to the following reasons:

iv. The river water carries large quantity of organic materials from the forests in the catchment area of the Western Ghats and deposits the same in the estuary. The debris becomes important base for food chains operating in the estuary and beyond in the offshore waters of the sea

v. The rich mangrove vegetation has significant role in food supply for the diverse faunal community. The mangrove swamp acts as food rich and protective nurseries even for many species of marine fishes and prawns, which lay eggs in the swamp.

vi. The rich bird community (over 120 species, about half of them winter visitors)associated with the estuarine ecosystem contributes substantially to the nutrient cycling through their potash and nitrogen rich castings

vii. The constant churning and circulation of waters due to flow of fresh water from one side and the tidal influx from the Arabian Sea oxygenates the water and circulates nutrients.

b. Why the declaration is proposed? Give justification

i. Importance of mangroves: Mangroves are in t**he heart of estuarine ecosystem** and productivity. Their influence is pronounced not only in the estuaries but also extends far into the offshore areas. Tropical estuaries are ranked among the top productive ecosystems of the world, at par with the coral reefs. The major reason for their productivity is attributed to the mangrove vegetation. There are also other reasons for ranking mangroves high in the conservation circles. ii. Mangroves contribute nutrients to the estuarine-marine ecosystem through litter-fall that turn into nutrients eventually. These nutrients contribute significantly towards food web and productivity of the estuary and the coastal sea. The detritus and filter feeding organisms like bivalves contribute substantially to the income and food of the local people. People engaged in bivalve trade and consumers far away are also benefited. The bivalve shell gathering is a major, estuary based enterprise providing direct employment for about 600 persons and many more in associated trade and production of goods using shells such as poultry feed, cement, shell lime, paint, fertilizers etc. The annual output of shells from Aghanashini estuary is estimated to be around

100,000 tons worth Rs.5-6 crores. Fishermen report of good catch of fish closer to mangrove patches than elsewhere. Details are provided in the Annexure II.

ii. Mangroves act as nursery for fishes and prawns. Many sea fish visit nutrient rich mangrove area for laying eggs so that the juveniles grow amidst abundance of food before they leave for the sea. Resident estuarine fishes also take benefit of the mangrove areas for their food and breeding. The mangroves with their entanglement of roots making a dense impenetrable cover provide a safe place for fishes and prawns securing them from predators. The fishermen also do not cast their nets within the mangrove areas due to the physical obstacles created by the root network. Mangroves of Aghanashini provide good roosting place for many species of birds,which find rich food supply in the estuary apart from shelter provided by the mangroves. More than 120 species of birds, half of them migrants, have been recorded (Annexure-1. for recently observed birds) Mangroves protect the islands and mainland from erosion and trap soil and debris that come along with the run-off of the rainy season.

iii. Traditionally the local farmers used to plant mangroves alongside the earthen embankments of their *gazni* rice field cum fish farming areas. These mangroves helped in stabilizing the bunds from erosion due to tides and waves and torrential rains of the region. Ever-since the Government built permanent embankments in the estuaries to protect the rice fields the practice of planting mangroves by the locals almost waned out. Nevertheless the Forest Department, during the last one decade raised mangroves in large areas of the estuary. When fully grown these mangroves will make the estuary a haven for birds, increase productivity of the estuary in terms of fish, prawns, crabs, bivalves, oysters etc.

iv. In the heart of the mangrove enriched estuarine centre is a small uninhabited island which is the abode of 'Babrudevaru', the guardian deity of the estuary. The deity is worshipped by people from all the estuarine villages who have strong cultural bonds with the deity. A stretch of mangrove forest dominated by the several ancient trees of *Avicennia officinalis* is considered so sacred that no one should step inside it wearing footwear. Numerous birds, both migratory (during winter) and resident ones are associated with this sacred *kan* forest.

v. The huge production of edible bivalves in the mudflats adjoining Aghanashini river mouth, although some kilometers away from the proposed mangrove heritage site, owe their productivity to the rich input of detritus from mangroves in addition to the organic matter input brought into the estuary from the Western Ghats.

vi. The site recommended for consideration as Location- II of BHS is not covered under Protected Area network under the Wildlife Protection Act 1972 as amended.

- No village community has exclusive jurisdiction over the proposed area, nor the Forest Department has any legal rights over there, in spite of the Department being responsible for enriching the estuary with mangroves for the last one decade and conserving it. The mangroves do not come under the Reserved Forest and are vulnerable to damages in the future in the absence of any formal protective measures.

Their continued existence has to solely depend on the levels of awareness among the public and the constant vigil that the Department has to keep. Therefore the BHS status can be justified.

- Any decline in mangroves will have severe adverse consequences not only on mangroves but also on the estuarine ecosystem and productivity as a whole; both goods and services from the estuary, will be adversely affected by such contingencies.
- There is involved here an issue of common property resources, beyond the jurisdiction of any single Biodiversity Management Committee (BMC) or village panchayat. Section 6a of the Guidelines for selection and management of Biodiversity Heritage Sites issued by the National Biodiversity (2009) Authority states: “Wherever the BHS extends to more than one local bodies, the management of the BHS shall be the responsibility of the Biodiversity Heritage Site Management Committee ….. approved by the SBB”. Here therefore, the State Government’s role will come into play in the process of declaration, management and monitoring.

c. Threat if any (give details)

The estuarine farmers were aware of the importance of mangroves in protecting the earthen bunds of their estuarine rice fields locally known as *gaznis*. Their practice from time immemorial was to raise mangrove trees alongside the *gazni* bunds. When the Government constructed permanent embankments for the *gaznis* to ensure better protection from salt water inundation on a permanent basis, the awareness pertaining to the importance on the role of mangroves dwindled among the local population. The growth of shrimp farming as an enterprise resulted in the creation of numerous aqua-cultural ponds, very often destroying the mangrove vegetation in the process. Such degradation of the mangroves continued until the end of the last century, until the Forest Department came in a big way to restore mangroves, by planting over a million saplings during the last one decade. As a permanent management mechanism for the mangroves is wanting this precious ecosystem any time in future is likely to be affected, to meet demand for timber and firewood from locals as well as outside. Further, in the absence of any formal protective mechanism the mangrove ecosystem stands to be affected by increasing developmental pressures in the densely populated coastal region.

3. Description

a. Present status of conservation

As the Forest Department is taking constant care of the mangroves and creating awareness among the local communities, the spread and growth of mangrove community, not only in the proposed BHS but also elsewhere in the estuary, presently is remarkable.

4. Management

a. Ownership: The part of estuary proposed under Mangrove Biodiversity Heritage Site is under the jurisdiction of the Government of Karnataka; no private agency or village panchayat has special rights over the mangrove areas proposed for BHS. The prawn farms or privately owned rice fields adjoining the mangrove areas have been excluded from the purview of the BHS. No gram panchayat boundary extends into those parts of the estuary proposed to be under the mangrove BHS.

b. Legal status: proposed area comes under Government of Karnataka

c. Agency to manage the site after declaration: The 'Guidelines for Selection and Management of Biodiversity Heritage Sites' (http://nbaindia.org/wb_day.htm) states under Section 6 (only relevant clauses presented here):

a. Wherever the BHS extends to more than one local bodies, the management of the BHS shall be the responsibility of the Biodiversity Heritage Site Management Committee constituted by the BMC or other local institutions linked to the local bodies in case BMC does not exist, and approved by the State Biodiversity Board.

b. The committee responsible for the management of the BHS shall include representatives of all sections of local communities, and in particular those most dependent on the natural resources as also those who have been traditionally conserving the area.

c. It shall be responsibility of the BMC/BHS Management Committee to prepare and implement a management plan for the BHS which should cover a period of five to ten years

d. SBBs will then recognize and facilitate the implementation of the final management plan. Such facilitation shall include direction to all relevant government departments to assist the communities in implementation, including through appropriate changes in their plans and schemes, to eliminate biodiversity-damaging practices and to fully enable and empower the communities in conserving biodiversity. Where necessary orientation programmes shall be organized for such departments and NGOs.

g. Any project/activity to be implemented by government or any other agency, which is likely to have adverse impact on the BHS may be avoided.

i. Restriction in form of regulating the use of the resources may be warranted in some cases and such restriction shall be totally voluntary on the part of the community.

d. Name, designation and address of responsible person/agency for contact:

1. The Western Ghats Task Force, Government of Karnataka
2. The Honavar Forest Division, Karnataka Forest Department
3. The Centre for Ecological Sciences (Indian Institute of Science), Field Station, Viveknagar, Kumta

5. Factors Affecting the Site

a. Pressures affecting the site (Encroachment, Agriculture etc.): nil

b. Environmental pressure: Presently not significant

c. Visitor/tourism pressures: nil

6. Documentation

a. Photographs : attached

b. Existing site management plans if any: Forest Department, Honavar Division carried out many programmes among local people to develop positive attitude towards mangrove ecosystem. 'Snehakunja', Kasarkod had conducted programmes for estuarine communities on CRZ awareness, mangrove planting, need for sustainable harvests of bivalves etc. The Centre for Ecological Sciences (IISc) is conducting Carrying Capacity Studies in the estuary.

7. Opinion of other concerned stakeholders: Stakeholders (local fishing communities, and farmers) would welcome BHS status and introduction of sustainable management system

8. Details of disputes if any on the site: Nil

9. General remarks if any: Declaration of BHS and formulation of appropriate management plans will strengthen mangrove ecosystem that could benefit the goods and services from the estuary substantially which will promote goodwill of the local communities towards such a precious heritage ranked among the highest productive ecosystems of the earth.

12.9 STATUS OF MARINE FISHERY IN UTTARA KANNADA

India has a coastline length of 8,121 km long coastline is the world's third largest fish producing nation, and an Exclusive Economic Zone of 2.02 million km². Fish and fishery products are a vital and affordable source of high-quality protein, especially in the economically disadvantaged regions. Karnataka State has 300 km of coastline and 27,000 sq km of continental shelf area, rich in pelagic fishery resources. Fisheries sector contributes 0.7% of gross SGDP and 3.18% of Net SGDP to Karnataka State's economy at current prices. Uttara Kannada, the district situated along the north-west of Karnataka, has a coastline of 190 km bordering the Arabian Sea. Coastal fishery is one of the most important subsistence and economic activity in the district, perhaps next only to farming. Mackerel and Oil sardine are the main components of the pelagic fishery wealth of Uttara Kannada coast. Pelagic fish live near the surface or in the water column of coastal, ocean and lake waters, but not on the bottom of the sea or the lake. 331 fish taxa occur in the coastal and marine areas of Uttara Kannada and 89 fish taxa associated with the coral formations of Netrani Island, 12 nautical miles off Bhatkal coast. The district has 11,141 families engaged in fishing activities, bulk of them settled along the coastline fringed with estuaries and salt marshes, sandy and rocky beaches. These families together account for about 61,036 of members, of whom 10,260 men and 2,733 women are engaged in marine capture fishery operations. In coastal fish culturing activities are engaged 784 men and 195 women. In inland capture fisheries are engaged 2731 men and 221 women and in involved inland fish culturing are 308 men and 228 women.

It is necessary to increase the contribution of marine fisheries to the food security, economies and the well-being of coastal communities. It requires effective management plans to rebuild overexploited stocks. Recommendations for the sustainability of marine fishery in a broader context of west coast and national fisheries are:

Strengthened governance and effective fisheries management: Promoting sustainable fishing and fish farming can provide incentives for wider ecosystem stewardship. This requires

1. **Adoption of an ecosystem approach to fisheries and aquaculture**
   - ***Ocean and linked coastal water bodies*** like estuaries, creeks, lagoons, salt marshes, mangrove areas etc. are to be considered as interconnected and valuable ecosystems producing rich food without practically any inputs from humans. These coastal and marine aquatic habitats need to be considered holistically for integrated management.
   - ***Pollution, reclamation, misuse or degradation*** of such ecosystems are to be strictly monitored and prevented.
   - ***Places of fish breeding*** within the marine areas and coastal backwaters are to be identified and demarcated as protected zones, in the interest of sustainability of marine fisheries.
   - ***To promote the breeding stocks of fishes***, it is necessary to know the breeding months of various commercial fish species. Regulations should be imposed on capture especially of breeding stock of fish species by targeted fisheries sector. For instance peak spawning of mackerel was observed during July-August. The percentage of this fish with mature ovaries was 60% of the total in purse-seine operations in late August (Rohit and Gupta, 2004). The ban on mechanized fishing during this period will be helpful in stock recovery of mackerel and many other fishes. Stoppage of intake of such fishes by cold storage units for export purpose may be prevented so that adequate stocks remain. However, there need not be ban on artisanal fishery and capture by small mechanized crafts
   - ***Estuarine integrity*** is very critical for several kinds of marine fishes and prawns which enter the estuaries for breeding or multitudes of their juveniles (fish and prawn seeds/larvae) enter the estuaries to feed and grow in the estuarine habitats like mangroves, sedge areas, mudflats, molluscan beds etc. Integrity of these habitats should be safeguarded through strict implementation of CRZ and considering such areas as ecologically sensitive areas. Involvement of local Village Forest Committees, Biodiversity Management Committees etc. will be of help in keeping vigilance at local level. These committees may be extended financial assistance under the existing forestry schemes or provisions of Biodiversity Act -2002. The Nushikote VFC in the Aghanashini estuary of Kumta, helping the Forest Department in planting and protection of mangroves, is a notable example.
   - ***Multi-species mangrove vegetation*** need to be raised in all areas of estuaries suitable for the respective species combinations.
   - ***Estuarine rice fields*** of Uttara Kannada, especially of Aghanashini estuary, where salt tolerant Kagga rice used to be grown, are locally well known as natural feeding grounds of marine shrimps and various marine/coastal fishes because the farmers used to harvest the tall paddy by cutting only the head portions leaving the rest in the field to degrade and become manure. The paddy stumps in post-harvest fields flooded with salt water are ideal places for juveniles of shrimps as anchoring places. These residues eventually become rich nutrients. However, because of intensification of aquaculture in recent decades many of these estuarine fields or *gaznis* are badly affected, and abandoned for cultivation. The Government should initiate steps to repair the *gazni* bunds and install sluice gates wherever damaged and desilt the *kodi* channels in the interest of not only marine and estuarine fishing but also for boosting the sagging production of rice.
   - ***Destruction/degradation due to damming of rivers*** for power generation has severe adverse consequences on coastal fishery, including bivalve production through reduction in post-rainy season salinity. This has been noticed in Sharavathi and Kali estuaries, most severe collapse of

fishery happening in the former where estuarine water has turned almost into fresh water with salinity less than 0.5 ppt.

- ***Likely diversion of rivers*** will have adverse consequences on estuarine salinity and ecology and on marine and estuarine fisheries.
- ***Need for removal of estuarine mouth siltation*** is necessary for Sharavathi, Aghanashini and Gangavali estuaries where siltation has affected the free movement of tides and therefore of marine fishes entering these estuaries for breeding/feeding.
- ***Regulation of sand and shell mining*** in the estuaries is very important for revival of estuarine and marine fishery. Shell extraction may be limited to the needs of local lime makers and large scale mining may be prohibited in the estuaries for at least the next ten years and the positive influence on coastal fishery studied throughout the period.

2. **Rebuilding collapsed/declining stocks:** The Government of India should adopt a dynamic marine fishing policy through prohibiting periodically export of any fish species the fishery of which is in collapsed/declined state (catches less than 5% of historical maximum), or those species which are seriously depleted or declining to less than 50% of their historical maximum catches, through a comprehensive evaluation system. Such ban may be lifted after the recovery of the stock of such populations to healthy levels. Fishery of all species with collapsed stocks has to be carefully monitored. In the interest of species survival and sustainability
3. **Need for more responsible fishing:** Consensus should prevail that fishing (aquaculture excluded) is not an industrial or business activity but more of an output of ecosystems, which need to be harvested strictly within sustainable limits. Fisher-folks, from time immemorial, depended on fishing for their livelihoods and over-exploitation never happened until commercial, mechanization dominated fishery in the recent times. Wild genetic stock of fish in the marine areas has to be maintained even for the success of aquaculture, where the cultured prawns and fishes are prone to diseases, pollution problems etc. for the surroundings including the marine areas.
4. **Impose uniform monsoon fishing ban in consultation with CMFRI**: The Government of India, through State Governments of respective maritime States, should implements a fishing ban during the monsoon every year, which is a peak season for breeding of many fishes. August is considered peak breeding season for Mackerels for which Karnataka coast is famous. The existing ban on fishing during monsoon by mechanized boats in Uttara Kannada by the State Government for 2013 is from June 15 to July 31, and in Dakshina Kannada from June 15 to August 10. According to CMFRI scientists Rohit and Gupta (2004) 60% of the total Mackerel catch in purse-seine operations during late August were with mature eggs; such catches are likely to have adverse effects on the future stocks. Although there could occur some variability in dates and duration of fishing ban in different states, disparities need to be reduced.

The fishing ban lasts for 45-60 days with each State using a different time period or criteria such as advancement of monsoon as an indicator. Absence of a uniform ban period throughout the coastline has led to fishing trawlers of several States using this legal technicality to fish where fishing ban exists and land in an adjacent State where there is no ban. Fishermen in Goa, Karnataka and Maharashtra along the west coast, complained that the very essence of the fishing ban is flawed as vessels from neighbouring States continue to catch from one State's territorial waters and land in another, leading to low catches during the post ban period. With most of the coastal States having weak enforcement, due to huge gaps in allocated infrastructure, manpower and monetary resources, illegal fishing persists through domestic fishing vessels in inshore waters. Moreover, it also leads to problems in misreported catches where fish caught in one jurisdiction is reported as caught in another location.

To reduce such anomalies it is recommended that the fishing ban from Kerala to Gujarat should be during the same period, with maximum flexibility between any two neighbouring States not exceeding five days.

The artisan fisherman may be permitted to fish in near-shore waters during the fishing ban period, using their traditional fishing gadgets. Fishing concessions to a limited extent may be given to indigenous crafts with outboard engines within a five km distance from the shore.

5. **Strict regulations on mesh sizes of nets:** majority of the depleted and collapsed stocks of South-west India are those species which are mainly caught in trawls. As a first step for rebuilding stocks, trawl effort has to be reduced in both Kerala and Karnataka and strict implementation of the mesh restriction policy on trawl and purse-seine nets is very necessary. Serious thought should be given to revival of Cat fish population which is very badly affected by indiscriminate pure-seining using nets with small meshes where even eggs cannot escape. Karnataka Marine Fisheries Regulation Act requires all mechanized trawlers operating along the coast to use a cod end mesh size of at least 30 mm but, most of the trawlers use 10-15 mm cod end mesh size resulting in indiscriminate capture of juveniles of fish and shrimps. This has also contributed to substantial discards during the monsoon season.
6. **Reducing the carbon footprints of marine fishing boats:** Unrestrained mechanization of the Indian marine fishing sector has not only nearly destroyed traditional artisanal fishery and resulted in imminent collapse of numerous commercially exploited fishes but also caused the release of phenomenal quantities of CO_2 emission. This requires:
   - Improving fuel efficiency of marine fishing boats
   - Reducing the mechanized fleet size to half the present number, limiting to sustainable catches, in a gradual process through not giving new licenses until targets (sustained yields) are achieved
   - Strict enforcement of reserving about 5 km zone from the coastline for non-mechanized fishery and for operation of traditional *rampani* nets etc.
   - A shift from fuel-intensive active fishing methods such as trawling to passive methods such as seining, lining and gillnetting.
7. **Promotion of artisanal fisheries:** estimates indicate that illegal fish catches by trawlers in the inshore traditional zone resulting in annual loss of 1200 - 1950 tons. This loss, needless to say, affects the artisan fishers using canoes and plank built boat, cast nets, shore-seine nets and long lines. The operation of mechanized crafts in the inshore waters (5 km zone) needs to be prohibited to alleviate poverty and underemployment among artisanal fisherfolks.
8. **Reducing fishing by-catches/discards:** Introduction of modern fishing methods and targeted fisheries have resulted in wasteful by-catches of juvenile fishes, non-targeted species like turtles, other fishes, marine invertebrates etc. Such by-catches also have very serious food security implications on one billion people who depend on fish as their principal source of food. Results from this study shows that discards have increased for two main reasons. Firstly, the number of trawlers operating along the Indian coastline has increased over the past four decades. Secondly, the duration of fishing trips by multiday trawlers is in the order of 10-12 days, with trawlers along the Kerala, Karnataka and Maharashtra coastlines increasingly targeting deep sea stocks at 150-350 meters during most of the year.

Increasingly, longer fishing trips in deeper waters means that non-commercial species of fish and shrimps are encountered in larger numbers. The operators of these trawlers cannot store trash fish from all the hauls during each trip, a good part of which are discarded into the sea. Gujarat has a more efficient trash fish collection as they are purchased for higher prices for fish meal factories. More and more landing of trash fish is reported to compensate for decline of commercial fishes. The following are recommendations to reduce by-catches:

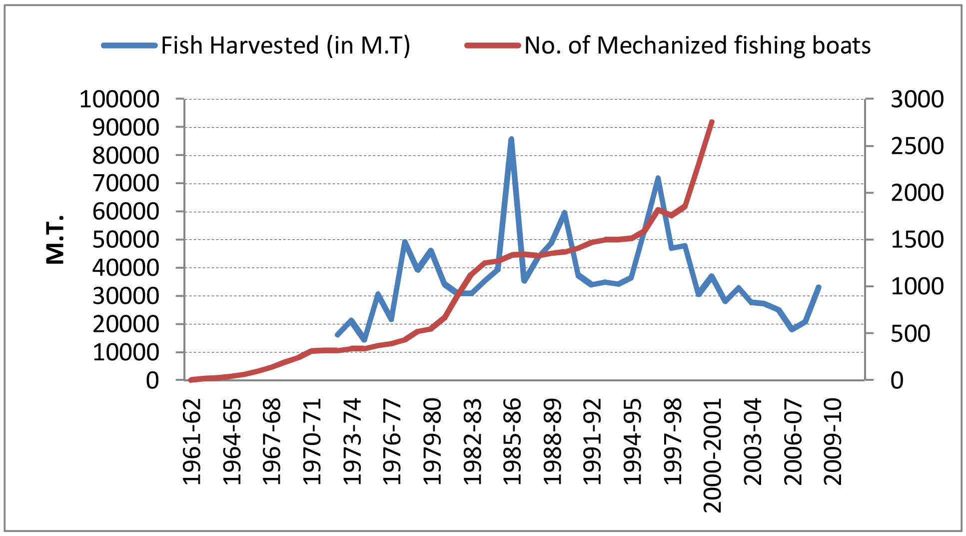
- From a sustainability point of view, limitation of fishery production to safe biological limits is necessary before seeking export markets for the products.
- Given the dynamic complexity of marine ecosystems and the often inter-mingling of various types of species, the practical reality, however, is that selecting and catching only that which is managed will not be solved solely through selective fishing gear. Consequently, the most pressing priority for bycatch reduction and over-fishing, should be reducing the amount of fishing, to meet more the domestic needs than catering to the global demands.
- Trawler fishing should be phased out to reach sustainable numbers by limiting licenses for new ones.

9. **Advisability of aquaculture:** The marine fishery resources are on the brink of collapse with most fishes and seafood in demand having already reached declined, depleted or collapsed states. Aquaculture, one of the fastest growing enterprises in the world, is considered as a strong solution to reducing pressure on marine fishery allowing for recovery of depleted stocks. A variety of chemicals used to inhibit the growth of other organisms may also affect other organisms. The fishing communities of Uttara Kannada coast have complained that the use of bleaching powder and lime in estuarine aquaculture ponds create massive deaths of juveniles of prawns and fishes.
10. ***Eco-friendly aquaculture:*** Government of India enacted the Coastal Aquaculture Authority Act, 2005, enabling the establishment of the Coastal Aquaculture Authority for enforcing proper regulatory measures for carrying out coastal aquaculture in a more sustainable and eco-friendly manner. The awareness levels of coastal shrimp farmers were inadequate and neither the State Government nor the farmers were geared to meet the challenges that were posed by issues such as pollution, viral diseases, etc. The National Fisheries Development Board (NFDB) has allocated funds for training, awareness and enhancing skills for coastal aquaculture, for shrimp and finfish farming. There is a need to set up a dedicated Monitoring and Evaluation Cell in the Department of Fisheries to periodically monitor and evaluate activities implemented under the NFDB.

12.10 GUIDELINES FOR SUSTAINABLE MARINE FISHING

Intensive fishing development due to use of ever increasing number of mechanized boats and no proper regulations on mesh size of nets have resulted in increased efforts and less returns (Figure 12.7).

Figure 12.7: Increase in mechanized boats versus decrease in fish catch in Uttara Kannada



To strengthen status of marine fish are following recommendations:

- Implementation of strict regulations on mesh size, especially for mechanized boats
- Moratorium on sanction of new mechanized boats for at least next five years. We recommend that the number of mechanized boats be limited to within 1500, through a gradual shift in licensing policy. There should be set a limit for one person or a single establishment having fishing monopoly by owning a fleet of boats. The limit to licensing of new mechanized boats (mainly purse seines and trawlers) set rigidly in other coastal districts also for the sake of sustainable marine fishing. Priority and Government subsidies (including for fuel) should be limited to traditional fisherfolks only. Artisanal fishing and use of smaller motorized boats by traditional fishermen should not be curtailed.
- Awareness programmes on responsible fishing
- Strict vigilance on coastal and marine pollution
- Export of marine fishes to other countries should be restricted to save imminent fishing collapse in Karnataka and the west coast as a whole.
- Steps for reducing by-catches of non-target species. Discards at sea is up to 30%. Post harvest losses are up to 15%
- Periodic closing of some identified areas in the sea for fishing purposes making way for restocking of depleted fish resources. Voluntary marine conservation areas to be promoted
- Protection of estuarine ecology and increase in mangrove forests can promote breeding of many marine fish
- Greater protection needed for sea turtle egg-laying areas in beaches through local beach and sea turtle protection committees
- Regulation of plastic waste in the sea is very important

13.0 INVENTORISATION AND MAPPING OF DOMESTICATED BIODIVERSITY (AGRICULTURAL, HORTICULTURAL AND LIVESTOCK).

Task 4: Inventorisation and mapping of domesticated biodiversity
1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash N. Mesta, Sreekantha, Gayatri Naik, 2013. Agro Biodiversity in Uttara Kannada, Sahyadri Conservation Series 38, ENVIS Technical Report 68, CES, Indian Institute of Science, Bangalore 560012, India
2) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Marine Fishery in in Uttara Kannada, Sahyadri Conservation Series 39, ENVIS Technical Report 69, CES, Indian Institute of Science, Bangalore 560012, India
3) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Mahima Bhat, Prakash N.Mesta, Sreekanth Naik, 2013. Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64, ENVIS, CES, Indian Institute of Science, Bangalore 560012, India
4) Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 19, ENVIS Technical Report: 49, ENVIS-Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
5) Ramachandra T V, Subash Chandran M D, Joshi N V and Boominathan M, 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report: 48, ENVIS-Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
6) Ramachandra T V, Subash Chandran M D, Joshi N V, Daval Joshi and Maneesh Kumar, 2012. Soil quality across diverse landscapes in Central Western Ghats, India, Sahyadri Conservation Series 16, ENVIS Technical Report: 42, ENVIS-Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
7) Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

13.1 AGRICULTURE, HORTICULURE AND LIVESTOCK DOMESTICATION

Unlike anywhere else along the flatlands of the maidan areas the traditional Uttara Kannada farming sector is a combination of rice fields, multi-cropping orchards of betelnut, betelvines, pepper, cardamom, nutmegs, bananas etc. and specially maintained leaf manure cum fodder growing forests called bettas. Cattle and buffaloes are essential parts of the system as producers of milk, manure and gobar gas. Farmyard manure of cattle dung and leaves is very critical for soil fertility, gradual release of nutrients and for soil protection from erosion in the heavy rainfall zone.

This ideal traditional system is changing drastically these days due to various reasons. The district used to be a great reservoir of hundreds of traditional rice varieties with wide array of qualities for the rice and the suitably of the varieties for different soils and water conditions. The tall straw provided much required dry season fodder for cattle. The widespread cultivation of dwarfish new varieties of rice in the recent decades has seriously affected cattle straw production. As a result, especially along the coastal taluks, particularly in Honavar, Bhatkal and Kumta taluks, where the cattle number is high (4 to more than 5 per hectare of sown area) fodder scarcity is very serious. The coastal hills and plateaus are of exposed laterite rocks with very little fodder production. Many farmers are compelled to purchase rice straw from other taluks, mostly from other districts, at high cost. This situation is compelling farmers to sell cattle or release cattle for free grazing as they cannot afford purchase of straw and other expensive feeds. The decline in cattle can create serious consequences on the farm sector, which has been by and large organically carried out. The decline of cattle has created scarcity of farmyard manure and most people are compelled to purchase packaged milk from elsewhere. To prevent the farm sector collapse we make the following recommendations:

- We have estimated that nearly 500 traditional rice varieties are likely to surviving in Uttara Kannada. About 100 have been already documented, many are extremely rare and on the verge of extinction. The Government should take steps to promote Uttara Kannada as an organic district, promote through subsidies in situ cultivation of traditional rice for the sake of cattle straw and for safeguarding the gene pool of rice.
- Farmers be given guidance and subsidies to grow suitable fodder grasses for own use and sale in the wastelands, benas and fallow fields.
- Panchayat level fodder farms should be started for helping manure and milk production especially by the landless.
- More than loans or subsidies for purchase of cattle such assistance be extended first for fodder production on priority.
- In the malnadu taluks farmers be encouraged in growing fodder plants in portions of bettas, for own use and sale.
- Dairying be promoted as an employment generating sector which is also crucial for supply of manure and for meeting village level energy needs through gobar gas.

13.2 AGRO BIODIVERSITY IN UTTARA KANNADA

Following the Biodiversity Act, 2002 of India, many State Biodiversity Boards were constituted which in turn is involved in formation of Biodiversity Management Committees (BMC) for "promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity." The **BMCs should prepare People's Biodiversity Register (PBR) containing local knowledge on biological resources and their usages. Nationwide preparation of PBRs,** is expected to be a mammoth exercise for India, a megadiversity country.

A decade is past since the Biodiversity Act, but only tardy progress made in relation to PBRs. Major hurdles hampering the process appeared to be concepts and formats unfriendly for grassroots level people, paucity of taxonomic expertise, low funding and lack of motivation and guidance. Model PBRs prepared were at enormous expenditure, and through the deployment of experts and not easily replicable.

Looking for alternatives to current model of PBR preparation, we attempted the deployment of student community from high schools and colleges to document biodiversity under the banner 'My Village Biodiversity' in the Uttara Kannada district of Karnataka State as part of ongoing "Integrated Ecological Carrying Capacity" assessment of the district. Simplified formats, as understood easily by high school students and village communities, were used for data collection, carried out during 2010-11 and 2011-12. The teachers were given orientation programmes about biodiversity, Biodiversity Act, and on formats to be used. Competitions were conducted for students and nominal rewards announced for the best reports and good presentations. No financing of the educational institutions was done to carry out this model of work. The objectives included:

- **a.** ***Sensitisation of students:*** The very use of data formats were also aimed at sensitizing students to biodiversity related issues. Notable among data to be gathered included forest types, landscape and waterscape elements, plant and animal diversity as the village community understand, crop diversity, preparations and uses of bio-pesticides, organic farming, traditional storage methods, NTFP, management of village environment, community health, wildlife, human-wildlife conflicts, domestic of animal diversity, production of honey and apiculture, energy sources, skilled and knowledgeable people in the villages, sacred groves etc.
- **b.** ***Recording observations:*** Study and understand data formats necessary in the contemporary contexts of conservation and sustainable use.
- **c.** ***Vital information on crop diversity:*** Stress laid on documentation of local varieties of crops.
- **d.** ***Low cost methods to assist PBR preparation:*** No money was paid to partner institutions and students except for meeting the travel expenses for attending workshops.
- **e.** ***Creating ambassadors of goodwill:*** Students, with their unbiased minds were expected to merit greater acceptability in the households, as the villagers otherwise tend to be more reserved with outside agencies like NGOs engaged in such work.
- **f.** ***Expertise in communication:*** Students were expected to gain good communication skills.

About 580 students from 116 high schools and 6 colleges representing the 11 taluks of Uttara Kannada took part in the two year exercise. Biodiversity documentation covered about 190 villages of the total of about 1200 villages in the district. Considering the sluggish scenario of PBR progress, with only 212 panchayats of Karnataka covered by 2008, comments on their merits pending, the cost was high for the Biodiversity Board in its infancy to bear, but at the same time funding considered small by the agencies catalyzing the PBRs at panchayat levels.

The poor quality performance of some schools was mainly on account of teachers missing the orientation programme. If the education departments, make suitable changes in the syllabi to incorporate biodiversity documentation, with due credits to the performers, the outcome would be more fascinating. The students in general found greater acceptability in the villages, got first hand learning opportunities and often turned out to be communicators of good order.

To highlight some results, notably, of 232 villages where rice cultivation was reveiwed, 181 varieties were recorded; out of them 101 were native varieties (Figure 1). Sample survey with regression analysis gives expectation of finding around 492 native varieties in the district. Countrywide adoption of the method will benefit rapid documentation of traditional varieties, feared to have dwindled from around one lakh down to 8-10 thousand, mainly due to unregulated introduction of new varieties. Documentation also covered local varieties of banana, pepper, mango, jack, sugarcane, arecanut, coconut etc.

The villages have rich wealth of traditional knowledgeable knowledge holders like herbal healers specialized in treating ailments like rheumatism, paralysis, migraine, kidney stones, bone fractures, eye and skin problems, jaundice, herpes, paralysis, infertility, epilepsy etc. and cattle diseases. Medicinal plants were exhibited during workshops and their uses documented. Information on persons with knowhow on biopesticides, earthworm manure, water divining, organic farming etc. also is available.

Villagers gave good account of local wildlife, on occasional visiting animals like tiger, leopard, bear etc. Local names of fishes available in the fresh water bodies were recorded. The students provided indications on the presence of hundreds of sacred groves in the villages. They would be interesting places from biodiversity and cultural angles. On the whole pastoralism is on the decline due to fodder scarcity and cattle manure, inevitable for high rainfall agricultural soils, is getting scarce. This can undermine the very farming system of the district.

Our experiment shows the huge potential for harnessing the student power for documentation of the immense biodiversity of the country. Biodiversity awareness creation among the younger generation is a paramount necessity for the successful documentation of the immense biodiversity of India, a megadiversity country with two biodiversity hotspots. The educational system has to be restructured to institutionalize biodiversity documentation, especially using student power from high school and undergraduate levels with due academic credits given to the participants.

In Situ **Conservation of Traditional Rice Varieties of Uttara Kannada:** Before the start of Green Revolution there were over 100,000 native varieties of rice in India. These were the results of selection and propagation by the indigenous farmers through 5000 years of efforts. It is feared that over the last few years, due to the introduction of high yielding new varieties from elsewhere and hybrids bulk of Indian varieties have gone extinct. This is unbelievable loss for the gene pool of rice, prime staple food-grain of the world. There is still hope that through field surveys, especially in places of high landscape heterogeneity, the remaining native rice varieties can be located in farmers' fields and saved from extinction through promotion of *in situ* conservation. As a preliminary exercise we carried out a field survey in about 232 villages of Uttara Kannada to prepare an inventory of rice varieties grown, through interviews with the farmers. Data was gathered also about the notable characteristics and desirable features of these varieties. Out of about 181 rice varieties inventorised about 101 were native varieties (figure 13.1). Most of these are taller to hybrids and other new varieties, over 5-6 in height and yield more fodder for cattle. Though their yields are relatively lower they have more resistance to pests and diseases. Their grains are bolder and longer and the rice comes in white, red and brownish colors. Some like Sannakki and Jeerigesali are fragrant. Doddabatha and Kagga are good for making rice flakes. Chitagya, Doddagya, Halaga, Hasadi etc. are attributed with medicinal properties. Salinity tolerance is found in Bilikagga and Karikagga grown in estuarine fields. Lot of choice exists for selection of rice of different durations, such as Jaddubatha and Kannuru of 90-100 days, Bantwala, Mullarya and Mysore Sanna of 100-120 days, Dibanasale of 120-140 days and Aloorsanna, Honnekattu etc. needing over 140 days. Long duration varieties are good for places with prolonged rainy periods and short duration for lower rainfall areas and irrigated fields. As most of native varieties are grown with organic manure and least or no use of pesticides they are good for human health and their fields ideal for fishes and frogs and other aquatic fauna as well as for birds which feed on them. In this poster GIS maps on the distribution of the native varieties are given along with pictures of many of them.

Figure 13.1: Some traditional rice varieties in Uttara Kannada

IMPORTANCE OF TRADITIONAL VARIETIES

- ✓ High diversity at genetic level.
- ✓ Diverse qualities for rice- height of plant, colour, size, aroma, maturity and habitat.
- ✓ More fodder (5-7 ft height unlike new dwarf varieties).
- ✓ Disease, pest, drought and flood resistance more.

- ✓ High landscape heterogeneity and strong in agriculture traditions make Uttara Kannada a stronghold of genetic diversity of rice and other crops
- ✓ The gene pool of rice was neglected all the while and even the agriculture department does not maintain data on local varieties
- ✓ Widespread introduction of dwarfish new varieties, considered high yielding, is a major threat to rice gene-pool.
- ✓ New varieties are susceptible to high disease and pest attacks and marginally high yield is often eclipsed by these drawbacks
- ✓ Introduction of new varieties has caused fodder crisis in the district which is adversely affecting milk production and availability of cattle dung for manure
- ✓ We have predicted using the sample survey method and regression analysis the talukwise numbers of local varieties available in Uttara Kannada; with nearly 500 expected varieties

13.3 SEVERE FODDER SCARCITY NEEDS TO BE SOLVED FOR SAVING AGRICULTURE AND LIVESTOCK

Uttara Kannada district experiences only five to six rainy months (>100 mm/month), remaining period having with scantier or no rains. During the dry months, mainly from November to May period grasses and herbal fodders dry up making the livestock keepers rely heavily on dry grass (karada) and paddy straw and small quantities of jowar straw in maidan taluks. During the rainy months, particularly June to September period, exceptionally heavy rainfall, from South-west Monsoon is experienced by especially coastal and malnadu taluks, where exposed soils and free grazing pasturelands tend to be eroded of top soils. The grasses start rapidly drying up from November onwards with practically nothing for foraging left for the cattle almost up to the end of May. During this long and difficult period the cattle are fed mainly with paddy straw and green grasses available, if at all, from fallow rice fields, and wetlands. The cattle keepers store straw for the lean period by purchasing or storing the straw from their own fields.

Straw scarcity: Dry straw (hay) used to feed cattle has become scarce due to decline in area under rice cultivation. Until 1960's the rice fields were cultivated mainly with hundreds of native rice varieties, most of which produced tall plants (5-7 ft) with lengthy straw, which was dried and stacked by the farmers. Any straw scarcity was hardly experienced. The widespread introduction of hybrids and improved varieties of rice, most of which are dwarf, not exceeding 3-4 feet, is the major cause for fodder scarcity in the district. Many cattle keepers are forced to purchase straw from places of surplus, including from neighboring districts. The cost of straw and transportation are becoming prohibitive,; so also the prices of cottonseed, oil cakes, and company made concentrates. Average cattle keepers are either compelled to sell their animals or leave them for free grazing in lands often impoverished of grasses.

The worst crisis is felt in the coastal taluks. Honavar with except Karwar. Honavar taluk with 5.4, Bhatkal with 4.5, Kumta with 4.14 cattleheads respectively, per ha of sown area, are the worst taluks facing fodder crisis. Karwar with 3.16 cattleheads per ha of sown area is least affected. In the malnadu taluks Siddapur with 5.24 cattleheads, Supa with 4.5, Yellapur with 4.49 are under high stress. All these taluks come under high rainfall areas, where fodder production needs specially maintained *bena* lands. Mundgod and Haliyal, the rice bowls of Uttara Kannada, are better placed with 2.71 and 2.94 cattleheads respectively **(Figure 13.2)**.

Our sample survey with the cattle keepers in the villages of 10 out of 11taluks (Supa excluded due to inadequate survey) indicates that in Mundgod, the rice bowl area of Uttara Kannada there seems to be no import of straw from other taluks or outside districts. Karwar follows next, in all probability due to decline of about 1918 ha of sown area between 1997-98 and 2010-11 (**Figure 13.3).** Abandonment of rice cultivation would naturally enrich fallow fields with grazing resources for cattle. Honavar, Bhatkal, Yellapur and Siddapur have more proportion of livestock keepers importing fodder from outside their respective taluks.

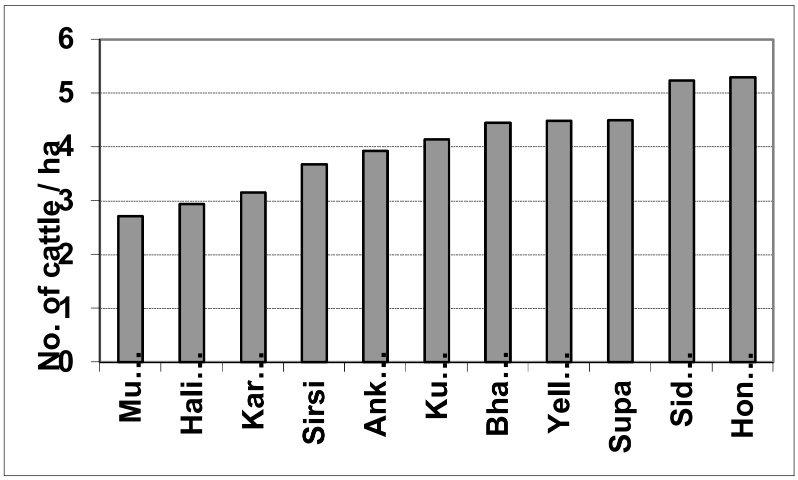


Figure 13.2: Taluk-wise number of cattleheads/hectare of sown area in Uttara Kannada

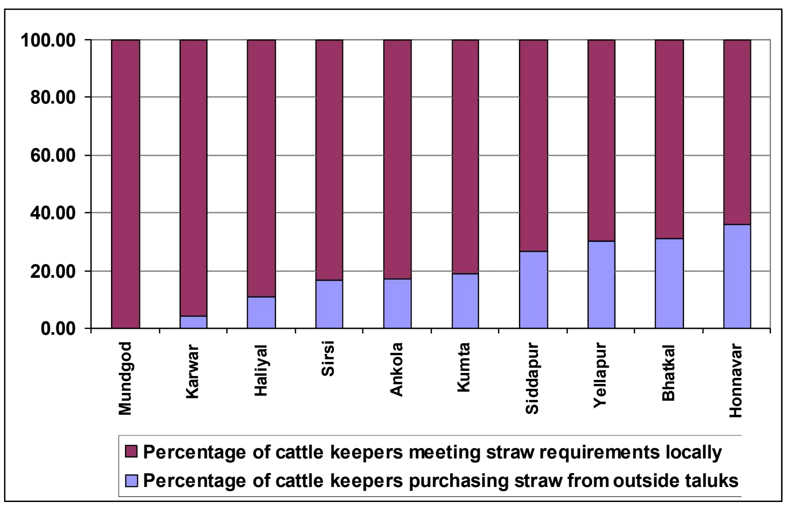


Figure 13.3: Talukwise percentage of cattle keepers purchasing straw from outside

Importance of developing fodder farms: Cattle wealth is critical for agricultural economy for milk, manure, traction and bio-energy. Most of Uttara Kannada's agricultural soils, receiving torrential seasonal rains are prone to severe soil erosion and rapid nutrient losses in the absence of organic manure, bulk of which is traditionally composed of cattle manure. Cattle manure has become dearer these days compelling farmers to even neglecting farming operations. This will have serious implications on farming, and dairying, which together constitute largest sector of employment in the district. It is a dire necessity for dairy farmers to start growing green fodder (grass) if they desire to run their unit profitably. Mere distribution of milch animals by the Government is of no use to farmers. Along with the animals they must be also made aware of the importance of growing their own fodder for the animals. Buying several commercial feeds available in the markets today is not profitable for a small farmer. Green fodder production and sale by farmers has to be developed into a major enterprise. We also recommend that the government start fodder farms, particularly for production of green fodder, mainly grasses and leaves. Priority areas for fodder production, preferably panchayat-wise are Honavar, Bhatkal and Kumta taluks along the coast. Farmers of Siddapur, Sirsi and Yellapur may be assisted in fodder production especially in the bettas, which are under their control. Fodder farms may be started for user groups in these taluks and in Supa taluk, who do not have betta privileges, in common lands. Taluk-wise potential area available for fodder production is given in the **Figure 13.4.** The area is based on total of barren lands, cultivable wastes and permanent pastures. Some of the promising grasses recommended for cultivation are Congo Signal, Guinea grass, Hybrid Napier like CO1, CO2 and CO3. Recently CO4 has become a much sought after, profitable, nutritive and productive grass in southern Kerala.

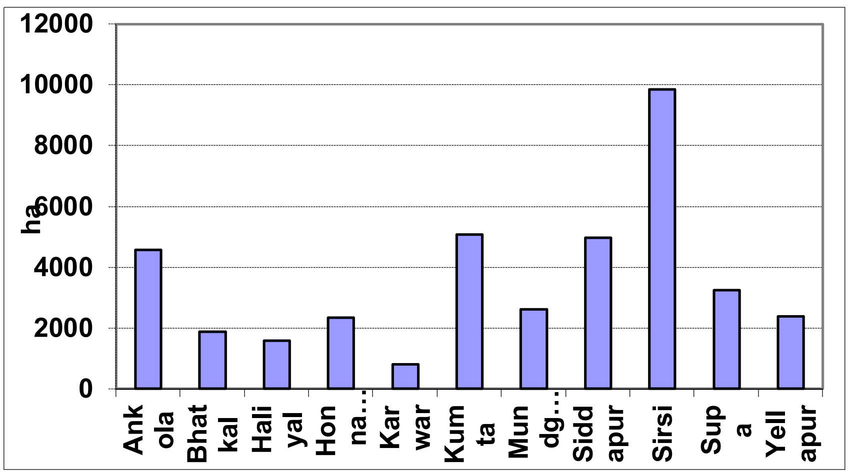


Figure 13. 4: Talukwise potential area for fodder production

13.4 **SOIL QUALITY ACROSS DIVERSE LANDSCAPES**

Soil is one of the most susceptible landscape elements, to land-use change. We collected and analyzed soil samples from different land-use units like agriculture, barren, evergreen, deciduous, and plantations like Arecanut and teak from Uttar Kannada District in Central Western Ghats, India and analyzed them for various physico-chemical parameters. Spatial analysis of key soil parameters was done to understand the variability with reference to the land uses. Soil carbon and nitrogen were severely low in agricultural and barren soils compared to natural landscapes like evergreen and deciduous. All other parameters like bulk density, pH, Ca, available P, available K, Mg were severely affected in agricultural and barren landscapes. Quality of soil in arecanut plantations were comparable to natural ecosystems due to land management practices such as mulching, etc. The severe degradation of agricultural soils places a wider emphasis on adapting holistic management practices towards sustainable use of these lands in future.

Soil carbon sequestration plays an important role in global carbon cycle. Increasing green house gases had lead to emphasis on carbon sequestration into various forms around the globe. The top one meter of soil contains 1500 Gt C and small relative fluxes into and out of this pool can amount to large fluxes on a global scale. Soil carbon is significantly lower in human altered landscapes compared to natural systems like evergreen and deciduous. There is a considerable concern that land use change, in particular may lead to depletion of soil carbon and consequent increase in atmospheric CO_2. This leads to a major concern about soil carbon status in agricultural or human influenced land use systems in the Western Ghats. Soil carbon is an important indicator of soil health.

Soil pH is mostly acidic throughout the district which may be due to the parent material i.e. laterite, granite and gneiss. Slightly neutral soil pH was found in the talukes of Haliyal, Mundgod, Yellapur; which may be due to the Dharwar schist's which is predominant in the region. It was found that soil bulk density was higher in case of agricultural soils than that in other natural land use systems like evergreen, deciduous forest. Bulk density is a function of soil water holding capacity. It has an inverse relationship with porosity. When the forest are cleared for pastures and agricultural purposes, soil aggregates break down due to activities such as tilling leading to compaction of soil, which influences the soil porosity. Such soils have poor soil moisture content which invariably affects the cation exchange capacity in such soils. Significantly lower amount of nitrogen were found in agricultural and barren soils which may be due to leaching out of soil nitrogen sue to physical forces such are runoff and soil erosion. The leaf litter contributes as a major source of soil nitrogen in the natural forests. In agricultural systems soil uptake of nutrients is not compensated by replenishing soil with organic matter from leaf litter. Horticulture gardens with good land management practices have relatively better soil quality. Various practices like drip irrigation, organic mulching and addition of ash are responsible for maintenance of soil properties. Available Phosphorus, calcium, available potassium were found to be higher in this land use type compared to all others. Amongst the exchangeable bases, available K, calcium and magnesium were significantly lower in agricultural soils than that compared to other land use forms. Soil properties in monoculture plantations (acacia, etc.) are comparable to the natural evergreen and deciduous forest.

The soil quality of barren lands was found to be poor as compared to natural forest systems. Soil carbon and nitrogen are degraded, which is a matter of concern. Apart from looking at these lands just as pasture lands it is necessary to address the current grave conditions facing such lands which are in quite a large number in the entire district. The degradation of soil due to various anthropogenic activities has affected the endemic species, and also hydrologic regime in the ecologically sensitive Western Ghats, a global biodiversity hotspot, evident from earlier studies. The study informs a major concern regarding agricultural soil quality which is seen to be degrading rapidly compared to the optimal situations which are assumed to be the natural forest systems. In order to improve the life of the soil and to utilize it for longer time for agricultural purposes there is a need of devising proper management plans which will help sustainable use of these lands in future.

13.4 BEEKEEPING: SUSTAINABLE LIVELIHOOD OPTION IN UTTARA KANNADA

Beekeeping is a forest and agro-based industry, which is beyond the ordinary realms of industry, in the sense that the humans derive benefits from interaction between two living things like plants and bees without affecting adversely both. On the contrary plants, including many crops, prosper with the abundance of bees (as pollinating agents) and the bees, sheltered both by nature and humans provide mainly honey and other by-products like beeswax, bee-pollen, propolis and royal jelly. Bee-keeping, systematically adopted as a supplement to farming, can bring prosperity to the villages of Uttara Kannada, a district endowed with species rich forests and cultivation of a high diversity crops. Unlike intensive farming or fishing that can corrode the natural resource base, abundance of honey bees in a natural environment benefits both crops and wild plants.

Apis of family Apidae is the main genus of honey bee accounting for bulk of honey production, and the genus *Trigona*, also from the same family, is a minor producer of honey. Uttara Kannada has three species of *Apis* viz. *A. dorsata dorsata, A. cerana indica,* and *A. florea* and one species *Trigona* (*T. irridipennis*). In the recent times these bee populations suffered decline in the Western Ghats due to many factors, the major ones being poor management practices, epidemics such as Thai sacbrood, Nosema, and Foulbrood disease and pests like Varroa mites. Predator insects like wasp, wax-moth and some insectivorous birds like bee eaters, drongoes etc are minor causes affecting bee populations.

Beekeepers co-operative societies, formed under the Khadi and Village Industries Commission (KVIC) and the National Horticulture Mission (NHM) played crucial role in strengthening beekeeping activities in the district. Five beekeepers co-operative societies were established at Honavar, Kumta, Ankola, Sirsi-Yellapur and Siddapur of Uttara Kannada. In the current study the performance of beekeepers co-operative societies in the taluks of Ankola, Kumta, Honavar and Siddapur of Uttara Kannada was evaluated with regard to promotion of beekeeping and honey procurement. The constraints for the growth of such societies are discussed. Honavar society had the highest number of members (992) in 2011, and Ankola society had the lowest (204). A glance through the growth in membership over the past 11 years of all these societies reveal only stunted growth. Although the potential of bee-keeping in Uttara Kannada, a well forested and horticulturally important district, is tremendous, the potential is hardly ever realized due to the lack of co-ordinated approach. Sirsi-Yellapur society had gone almost defunct compared to other societies. In a free market economy, with ever increasing demand for honey from local markets and cities, the bee-keeper's societies, instead of going redundant, can play important role in systematically nurturing bee-keeping through awareness creation and training programmes, foster the growth of bee forage plants and pave way for creation of employment for thousands of rural people.

Apart from studies on bee keeping made through the aforesaid society's primary data was collected from randomly selected 83 villages, through interviews with the help of a questionnaire. The information collected include the number of boxes the farmers kept, variability in honey production in relation to regions and climate, processing and marketing of honey and on important bee-forage plants. Problems and prospects of bee-keeping were also assessed. The study revealed that 105 bee-keepers whom we interviewed together owned 1453 bee boxes, at an average of 14 boxes each. The total honey production from the district, based on household surveys, amounted to 10,424 kg, during the year 2011, at a district average of 6.68 kg/per bee box. This figure does not include honey procurement by the societies, which is much lower, as most societies are not good performers and are passing through a waning phase. Average honey production/box ranged from 5.73 kg in Honavar, a coastal taluk, to 9.45 kg in Sirsi taluk of malnadu region. Of the other coastal taluks the average production of Kumta was 5.94 kg/box and that of Ankola was 6.72 kg/box. Siddapur and Yellapur in the malnadu had average production per box of 5.96 kg and 6.29 kg respectively. Even though we documented six apparent types of unifloral honey from Sirsi taluk (viz. from plants *Strobilanthes, Syzygium, Schleischera, Carallia brachiata, Sapindus, Glyricidia)* the consumers in general recognize only two types namely mixed honey and soapnut (*Sapindus*) honey. The demand for soapnut honey is high, despite its high prices ranging from Rs.700-1000/kg, due to its purported medicinal values, as compared to other honey, including mixed honey, where the prices range from Rs.150-300/kg.

The family sizes of bee-keepers in the study area ranged from 2 to 16 members at an average of 5.25 per family. Bee-keeping, evidently, was mostly a male dominated enterprise. Greater participation of female members is necessary to take better care of the economic and nutritional security of rural households. For attracting more people towards bee-keeping, an eco-friendly and high income generating rural enterprise, it is necessary to enrich the surroundings of villages with high nectar producing plants. Vacant lands, public premises, roadsides, estuaries and seashores should be enriched with suitable habitat-specific bee foraging plants. The genera like *Syzygium, Terminalia, Strobilanthes, Holigarna, Sapindus, Vateria, Lagerstroemia, Emblica, Dalbergia, Pongamia, Pterocarpus, Xylia, Strychnos, Careya, Vitex, Avicennia* etc. are some of the important foraging resources for honeybees in Uttara Kannada.

Pollination services: In agriculture, it is widely held that, maximum crop yield can be obtained by a combination of factors, mainly through i) **agronomic inputs** using good quality seeds and planting material, and good practices such as good irrigation, manure and fertilizers and pesticides and ii) use of **biotechnological methods**, such as manipulating rate of photosynthesis and biological nitrogen fixation, etc. Despite using both these crop production at some stage reaches stagnation. The third and relatively less known method of enhancing crop productivity is through **managing pollination** of crops using friendly insects, which in the process of searching for food (mainly nectar and pollen) pollinate flowers and render invaluable service to agriculture.

Unfortunately the enormous benefits that the humans reap from the silent services of honeybees towards crop productivity and to national income get only lesser attention and low priority, in spite of the fact that it needs low capital, it is non-polluting, needs less labour and is complementary to farming and forest ecosystems. The beekeeping industry is rarely put forth as a Key-Factor (Input) in agricultural production. Bees are the most effective pollinators of crops and natural flora and are reported to pollinate over 70 percent of the world's cultivated crops. About 15 percent of the hundred principal crops are reportedly pollinated by domestic bees, including honey bees, and at least 80% are pollinated wild bees.

Crisis in pollination: Pollinator populations and diversity have declined worldwide in the recent years mainly due to the following reasons:

- Decline in the habitat, with the accompanying decrease in their food (nectar and pollen) supplies as a result of decline in pristine areas
- Land use changes due to deforestation, extend agricultural land, urbanization, and industrialization.
- Increase in monoculture-dominated agriculture; earlier, farmers used to grow a variety of crops, which bloomed during different months of the year and provided food and shelter for a number of natural insect pollinators
- Negative impacts of modern agricultural interventions, e.g. use of chemical fertilizers and pesticides. Mono-cropping also requires increased pesticide use which led to the killing of many pollinators due to pesticides.
- Proper disposable of waste, especially paper cups for tea and soft drinks can act as sticky death traps of bees.
- Infestation by diseases and predators.

Need for promoting bee keeping in Uttara Kannada: Bee-keeping can be developed into one of the best developmental options for Uttara Kannada, as a major productive and employment sector next only to farming and fishing, but with favourable impact on environment and productivity, unlike intensive farming or fishing. More of apiculture better it is for environment due to following reasons:

1. Honey production does not require ownership of land and is ideal for employment generation, in rural Uttara Kannada, a wooded district dotted with farmlands producing fruits and spices, betel-nut and coconuts. The bee keepers, if they require, should be permitted to keep their bee boxes in the peripheral areas of forests, in areas designated by the forest department, so that the under tapped honey resources of the vast forest areas could be gathered without any damage to forests. On the other hand presence of more bees will promote pollination and fruit setting in the forest plants.
2. Rural economic activities will get elevated as such places turn into centres of honey production, purification and marketing. Such activities would be a deterrent for current trends in large-scale emigration to the cities.
3. The products like honey, beeswax and propolis are not perishable and can be stored for long periods and even exported.
4. It is ideal for generating employment for women and self-help groups.
5. The technology required bee-keeping is minimal and can be practiced with ease even by educationally backward segments of the society. No foreign technology is involved here and the equipments used are of low cost nature.
6. Transportation of honey is fairly cheap for unit volume unlike most other agricultural products, and being not perishable the transit need not be rapid and of high cost.
7. Bee keeping ideally practiced will dissuade locals from destructive collection of wild honey, so that bulk of the wild bees can be spared for performing the vital ecosystem services.
8. All the necessary inputs are locally available and input required is very low compared to most other enterprises. Production cost of honey is very low compared to other farming activities or cattle keeping. Bulk of the nectar and pollen from a great variety of plants in Uttara Kannada, predominantly a forested cum horticultural district, goes waste, or underutilized as the practice of be keeping is minimal as compared to the vegetational richness.
9. Being a tropical landscape the need for off-season feeding of honey bees can be minimized as a great variety of plants produce flowers during different times.
10. It supports agricultural activities through facilitating critical processes like cross pollination thereby enhancing food production.
11. Bee colonies can be transported from place to place to make best use of flowering by wild plants and crops at different times.
12. Dry areas with large water tanks/ponds covered with lotus can be made centres of producing lotus honey which is highly priced mono-floral honey.
13. Beekeepers do not burden on natural resources; there is no slashing and burning of forests for creation of grasslands or crop fields; digging up of soil or lopping of trees for manure are not needed for bee-keeping; there is no forest burning to create grasslands. Instead bee keeping helps to improve the ecology and food production through cross pollination.
14. Promotion of bee keeping in low rainfall areas like Mundgod in Uttara Kannada, through some special attention paid to the vegetational composition can be a great insurance against the unpredictability in rainfall.

15. Honey itself makes good nourishment, being rich in various nutrients and is used both in traditional medicine and in modern pharmaceuticals. Regular intake of pure honey is believed to increase immunity in humans.
16. It facilitates healthy linkages between biodiversity (insects and plants) towards sustainable livelihoods.
17. Bees are prey for a variety of insects, mammalian and bird predators thereby making themselves important links in the trophic networks operating in ecosystems.

Recommendations regarding beekeeping are:

1. Training programmes

a) ***Honey production*****:** ***theory and awareness:*** There is large number of aspirants for apiculture in Uttara Kannada. If proper awareness and training programmes are conducted bee keeping can be a major income-generating activity especially in rural areas. Many people have interest; yet they are scary of bee stings or about gaining profits due to lack of encouragement and proper knowledge. By appointing adequate number of trainers, directly by the Government, or commissioning experienced bee keepers from the district itself as trainers, on honorary basis, the bee keepers' societies can still play key role in promoting this enterprise and bring it at par with China, the world's highest producer of honey. The trainers need to conduct the programmes at two levels. Using power point presentation, especially at panchayat level they can impress upon the village community on the importance of bee keeping. A selection can be made of prospective persons who can be given the second level of training with more practical components, including a series of visits to successful apicultural farms in the district and outside. Relevant literature on bee keeping theory and techniques should be provided to the trainees free of cost.

b) ***Using wild colonies from the jungles for domestication through traditional expertise:*** Many local villagers, especially belonging to the communities such as Halakkivokkals, Siddis, Kumri Marattis, Kunbis etc. have the knowledge of collecting wild bee colonies and transferring them to the bee-keeper's boxes. This is a much cheaper method, costing about Rs.300- Rs.500, per colony transfer. At the same time purchasing such a colony at market prices will cost anything between Rs.1200-Rs.1700, which many cannot afford. Caution is necessary regarding the timing of bee colony collection from the wild as the period from late March to early June is honey collection period from the forests. It is recommended strongly that for rearing purpose jungle colonies may be transferred to the brood chamber of the bee box during September and October. By February the box will be full of bees, all the seven to eight frames occupied by the bees through multiplication within the box itself. The bee box starts yielding honey from February to end of May. As this is the flowering season for most forest plants and horticultural crops, honey from the boxes can be collected at intervals of seven to 14 days.

c) ***Populating new boxes:*** A well maintained bee box can accommodate seven to eight frames of bees in the brood chamber. Each brood chamber is topped with a super chamber, from which alone honey has to be extracted as the brood chamber honey has to be kept in the reserve for the sake of the growth and functioning of the colony. Once the newly trained bee-keeper, becomes successful in rearing honey bees, he needs training in developing new colonies for introducing in more boxes in his own farm. He can even trade surplus colonies to others. To develop a new colony the bee-keeper may remove four frames with honey bees to a new bee box where already four empty frames are fixed. The new bee box to be populated has to be kept as far away from the original colony so as to prevent the migration of the queen from the old box to the new.

d) ***Regulating the number of queen bees:*** Normally one bee box should have only a single queen bee. If an additional queen tends to develop by chance in a larger cell the worker bees will not provide royal jelly critically necessary for maturity of the queen bee. By mistake if an additional cell with developing larva gets stored with royal jelly one more queen develops in the same box. If more than one queen develops in a bee box it is likely to fly away from the parent box to establish a new colony elsewhere. Her flight is often accompanied by a horde of thousands of worker bees, deserting the parent colony, leading to its collapse, as less number of workers is left here to gather pollen and honey. The bee-keeper should keep an eye on such disorders in the colony and remove the extra queen cell itself or destroy the larva developing in the queen cell.

e) Screening for healthy queen bees: The setting up of a healthy colony depends on the quality of the queen bee. If the queen bee is undersized or unhealthy or infected with parasitic mites it will affect the egg laying capacity, or the eggs hatch into undersized bees etc. The bee keepers are to be guided to select every year a new queen for the colony as it has greater egg laying capacity leading to more number of healthy worker bees resulting in greater honey production.

f) ***Ideal time for setting up new colonies:*** Separation of a queen bee for setting up a new colony has to done before September, in the conditions of Uttara Kannada. After September with the beginning of overall flowering season the bees become active collecting nectar and pollen for brood development and therefore the worker force has to be maintained in the box.

g) ***Shifting bee boxes for greater production:*** An atmosphere of goodwill has to be created among the bee keepers and the general public so as to facilitate the bee keepers shifting the boxes of bee colonies to places with good amount of bee forage plants. Considering also the fact that bees are tremendous forces in pollinating horticultural crops and forest trees, various other medicinal plants etc., the farmers and foresters should welcome bee keepers to set up the bee boxes in their farms and forests respectively. In a small way however, ‘nomadic’ bee-keeping is happening in the district. For instance most of the soapnut trees (*Sapindus laurifolius*), the sources of the highly priced soapnut honey, are concentrated in the coastal taluks. Soapnut trees are the earliest to flower, November-December being their blooming period. Some of the bee keepers from the interior villages set up bee boxes in the coastal taluks on mutual understanding with the locals, so as to harvest soapnut honey, the first honey of the season. Likewise some of the coastal bee keepers also shift their bee boxes into interior hill ranges to derive benefit of the peak flowering season of a variety of wild plants.

h) Training in dis-infestation and disease control: Attack by mites, wax moth etc. and viral, bacterial and fungal diseases can have devastating effect on bee keeping. The bee keepers are scared of such outbreaks of pests and diseases and are often in the dark about how to deal with them. The bee keepers needs training in diagnosing the ailments of the bees and in adopting preventive and quarantine measures before greater expertise to deal with the problem is made available by the Government.

i) ***Protection from predators:*** Ants can be a menace on the bee colonies as honey in the hive is a great attraction for them. The use of water stored in containers around the legs of the box is the safest and most eco-friendly measure for keeping away the ants from access to bee colony. Awareness should be spread against the ill effects of chemical pesticides for that purpose. The attack by carpenter bees which capture and carry away honey bees to feed their young ones is almost an unsolvable problem that needs experts' attention.

j) ***Optional feeding during lean periods:*** The farmers need to be instructed about the importance of conservation of honey in the super chamber of the colony during the lean periods, especially the rainy season, when practically the bees do not get any food. There is the general practice among the bee keepers of providing sugar or jaggery solution as feed for the bees. Although the bees live feeding on such substances, these being mainly of sucrose, provide only calories and not the proteins vital for development of the larvae. Protein rich gram flour (from black gram, soybean, Bengal gram etc.) made into a paste with sugar and honey may be better option to provide vital nutrients to the adults and developing bees.

k) ***Awareness on pollination benefits:*** The great role of bees in pollination of especially horticultural crops need to be highlighted in the training programmes, through excursions to such farms with pronounced yield increase because of bees and through invited talks from such bee-keeper farmers. It is not merely extraction of honey for trade purpose that should motivate the farmers; the role of bees as pollinators to achieve higher yields and quality fruits and seeds is also very important. The bee keeping has to be ingrained as a culture among the farming community and even among the rural landless for the multiplicity of benefits that include income from honey, nutritional security and pollination of both cultivated and wild plants.

l) ***Awareness on organic farming:*** The widespread and indiscriminate use of pesticides in the agricultural sector can be detrimental to bee keeping. The evils of pesticide application can be far reaching on human health as well as of the various beings in the ecosystem. The honey bees are very susceptible to the toxic effects of pesticide use as organophosphates can be deadly neurotoxins on them. The pesticide use is becoming a widespread practice in the coastal areas than in the interior of the district where organic farming is more popular. During our survey, we came across a case of organophosphate application on sweet potato crop in Bijjur village of Gokarna panchayat that caused death of honey bees in five boxes in the vicinity.

2. Forests in support of beekeeping: In Uttara Kannada district most human settlements, barring some major towns, are dispersed among forest lands. These forest lands might be having already good vegetation, or may be poorly vegetated; for instance, the coastal minor forest belt is substantially barren or supports only scrub and Acacia plantations. These are not good places for healthy bee colonies, and naturally, there are less people on the coast having interest in apiculture. In the interior villages the forests may be rich or may be a combination of diverse landscape elements which include monoculture plantations (teak, Acacia etc.), scrub jungle, savanna, betta (leaf manure forests which are often heavily lopped). Our surveys and interviews with the bee keepers reveal that good vegetation with several species of nectar plants are very essential for enhancing honey production. Therefore we recommend the following:

a) ***Enrichment of coastal minor forests with bee forage plants:*** The ground in the coastal minor forests is very eroded, rocky and compact, often lateritic, or strewn with granitic boulders and fragments. The laterite formations of Kumta to Bhatkal have been destitute of good vegetation even before the British arrival in Uttara Kannada. Human impact seems to be the major reason for the general state of vegetational devastation of the coast. Once the original vegetation is destabilized through cutting and burning, for repeated cultivation or cattle grazing, the torrential monsoon rains erode the exposed soils and thereafter the hot sun bake the surface creating hard lateritic surfaces. These coastal hills and plateaus at the most could support scrub or savanna and some kind of stunted semi-evergreen forests where the soil conditions are better. During the last two to three decades a good lot of these areas have been brought under monoculture of *Acacia auriculiformis*. Apiculture in the coastal villages is not all that attractive proposition in the given situation, and the bee keepers are hard to find. Some of them carry their bee boxes into the interior forested villages once the early honey, mainly of soapnut plant origin is harvested. For instance K.B Gunaga from the coastal village of Alageri in Ankola moves into the interior villages of Hillur and Yana to fix his bee boxes, from mid-February of every year, after the soapnut honey season comes to an end as the coast does not have much to offer thereafter. Likewise some of the interior taluk bee-keepers take their bee boxes to the coastal areas to take benefit of the soapnut flowering.

b) ***The importance and profitability of soapnut tree:*** The soapnut tree (*Sapindus laurifolius*) is an excellent producer of high quality honey. It is one of the earliest to flower among the notable nectar plants, coming into bloom during November-December, soon after the rainy season. The honey, esteemed medicinally due to its slightly bitter taste and less sugar and other properties, was sold for about Rs.700/kg till a year ago and fetches these days a price exceeding Rs.1000/kg. Soapnut tree grows commonly along the coastal villages. It can be grown in a variety of soils including in lateritic areas and roadsides. Many bee-keepers demanded that soapnut tree be liberally planted by the forest department in all blank areas. On a modest estimate, if we succeed in raising 100,000 trees, at the average rate of three kg of honey per tree, each kg fetching Rs.1000/- at current market prices the potential income from one lakh soapnut trees could be Rs.30 crores. Apart from income from honey, the soapnut fruit is a non-timber forest produce used in production of soap and cosmetics. The tree will provide also a good cover for the open lands subjected to high degree of soil erosion.

c) ***Need for improving the betta forests:*** The bettas are forests allotted to arecanut gardeners for collection of dry leaves and lopped green leaves from trees as manure for their gardens. Betta allotment is highest in Sirsi, Siddapur and Yellapur taluks where horticulture is most important. Most of the bettas have today heavily lopped trees; they have open canopy and poor vegetation on the ground. Good bee-keepers shy away from keeping their bee boxes inside or closer to these bettas. Therefore, we suggest here that at least one third of the betta lands be enriched with bee forage plants, and the forest and horticulture departments should provide necessary guidance to the farmers and supply saplings of these bee forage plants.

3. Government assistance for bee-keepers: The Government may help bee-keepers with necessary equipments than with cash subsidies. The Government assistance may also include enrichment of bee flora in the village areas and the forests around, by planting such species along roadsides, public premises etc. Free guidance programmes should be taken up to help rural entrepreneurs to take up bee keeping, for purification and packaging honey and in disease prevention and control. Subsidies and loans are to be restricted to the functional boxes only so that Government aid is not misused.

4. Guidance for honey hunters: Honey hunting in the wild often happens to be destructive exercises. The bees are driven away with fire and smoke and the entire hive pulled down and squeezed to extract honey causing destruction of thousands of eggs, larvae and pupae. The honey hunting in the wild should be using sustainable methods. The Village Forest Committees and bonafide forest dwellers like Kunbis, Kumri Marattis, Karivokkaligas, Siddis etc. alone should extract honey on sustainable basis from only areas designated for the purpose by the Forest Department, leaving behind sufficient stock of untapped beehives so as not to decimate the genetic stock of wild bees very necessary for infusing resistance into the domestic bees, as the bee boxes are often colonized by capturing wild bees of the species *Apis cerana.* The Forest Department may periodically take stock of the situation and decide to close certain area of forests to honey collections, which are under threat from overharvests, until such areas recuperate well. The bonafide honey collectors may be provided with protective uniforms and awareness on scientific collection and processing techniques.

5. Bee colony heritage trees: The bees, especially *Apis dorsata,* prefer certain large trees such as *Tetrameles nudiflora* for establishing their colonies. Any such tree with more than ten colonies may be considered for declaration as a 'heritage tree' under the provisions of the Biodiversity Act-2002 of Government of India.

6. Prospects of beekeeping in mangroves: Mangroves play an essential role in maintaining a healthy coastal environment by providing protection for aquatic species, functioning as a habitat for a variety of terrestrial fauna, in improving coastal protection and acting as a source of nutrients that sustains many complex food chains. These swamp forest communities are often employed in promoting shrimp cultures.

The mangroves are good producers of honey. Forest Survey of India (1999) estimated about 487,100 ha area under mangroves in the country. The Sundarbans, which has largest area under mangroves, has been a major production centre for honey. It accounted for 111 tons of honey production, which was 90% of the total honey from mangrove areas of India. *Phoenix– Excoecaria* combination of trees associated with mangrove swamps offer ideal habitats for honey comb formation in the wild in the Sundarbans, accounting for maximum number of combs per unit area. *Rhizophora* and *Avicennia* (*A. alba* and *A.officinalis*) also accounted for good number of combs. *Aegiceras corniculatum* and several mangrove associates are useful for honey production. Area under mangroves is steadily under rise in Uttara Kannada during the recent years due to consistent efforts made by the forest department. If more attention is paid to the planting of nectar producing species more people from the coast will be benefited by bee keeping.

7. Importance of organic honey production: The demand for organic honey is on the rise in developed countries. Honey production from intensive agricultural landscapes, because of usage of chemical pesticides and fertilizers cannot be termed as organic. Bulk of Uttara Kannada's honey production probably would fall in the organic category on account of the cattle and forest dependent farming practices. The district needs to capitalize on this and intensify production of organic honey for export, supply to pharmaceutical companies and for domestic consumption.

The genera like *Syzygium, Terminalia, Strobilanthes*, *Holigarna*, *Sapindus, Vateria, Lagerstroemia, Phyllanthus, Areca*, *Cocos, Caryota, Crotalaria, Dalbergia, Pongamia, Pterocarpus, Xylia, Strychnos, Careya, and Vitex* are some of the very important genera as food sources for honeybees in Uttara Kannada. Honeybee species have their own preferences for plants as habitats. This host specificity is determined by branching pattern, flowering phenology and provision of holes and crevices in tree trunks. *Apis cerana* (cavity nesting bees) require cavities and hollows in big trees for nesting. *Apis cerana* are considered as photophobic bees and prefer shaded parts for colonization. In our study areas we could observe its nesting sites in trees like *Caryota urens, Careya arborea, Terminalia paniculata, Lagerstroemia microcarpa* and *Vitex altissima. Apis dorsata* is a more of a light loving bee and in our study area 21 tree species were associated with its colonies, in addition to the giant rock formations of Yana and some large buildings. *Tetrameles nudiflora*, a very gigantic soft wooded, deciduous tree is a preferred nesting site for this bee and several large sized hives are often seen on the same tree. *Trigona iridepennis,* the stingless small bees, a minor source of honey ('misri' honey of medicinal value) was associated with seven tree species in our study area. In addition it also occurs in the holes and cracks of old buildings.

Recommendations: Honeybees provide a variety of goods (honey, wax, pollen, royal jelly, propolis etc) and services (pollination) to human society and ecosystem. Across the world the bees support millions of livelihoods while also enriching the ecosystem. Beekeeping is an important enterprise to rural communities and related to agricultural and horticultural production. Even though, Uttara Kannada district has over 60% of its lands under forest cover, and about 15% under farming, the honey production is far below its expected potential. The case study conducted highlights that beekeeping could be elevated into much more profitable venture requiring small investment of capital and skilled labor for realizing high yield in comparison to other rural employment and poverty reduction programmes. We have taken into account the static performance of the bee-keeping societies, which had in their earlier days played vital role in spreading awareness on scientific bee-keeping and its profitability and assisted people in setting up bee-keeping units in their homes and helped in marketing the products. Presently there are several individual entrepreneurs in the district who have realized the importance of bee-keeping, in a consumerist society where there is steady and rising market demand for honey as a health food, as medicine, for use in confectionaries, in pharmaceutical industry and so on. We make here certain recommendations for promotion of bee-keeping:

I. Training programmes

a) To spread awareness on the importance of honeybees and bee-keeping
b) On using wild colonies from the jungles for domestication through traditional expertise.
c) On populating new boxes in potential beekeeping regions.
d) To regulate the number of queen bees per box and screening for healthy queen bees
e) For awareness on ideal time for setting up new colonies
f) On the importance of shifting bee boxes from one place to other, say for instance from the coast to the interior and *vice versa* so as to maximize production taking benefit of the different times of flowering.
g) Training in dis-infestation and disease control

h) Training in protection of bee-hives from predators
i) On the importance of providing supplementary food to bees during lean periods and on the composition of such supplementary food
j) Creating awareness on pollination benefits
k) To bring home the benefits of organic farming for healthy bee keeping, for health of humans and ecosystems and for enhancing market value of farm products.

II. The role of the Forest Department

The Forest Department, controlling over 60% of the land area of the district (>6000 sq.km) has to play major role if bee-keeping is to be nurtured as an important enterprise. The departmental involvement can be envisaged as:

a) Designing the vegetational composition of the forests in the immediate vicinity of villages so as to give premium to specially bee-forage plants
b) The department to take lead in raising bee forage plant species, particularly nectar trees (an indicated in the list included in this report) in its nurseries.
c) The coastal minor forest belt on lateritic terrain also to be enriched with bee forage plants
d) Soapnut trees (*Sapindus laurifolius*), indigenous to the region, needs to be raised in lakhs for planting in a variety of habitats, including household gardens, considering the high value of soapnut honey (Rs.700-1000/kg). The trees can come up even in degraded and rocky habitats and can also provide other benefits, such as shade, water and soil conservation, leaf litter for organic manure etc. in addition to the soapnut which has market value as NTFP.
e) Many species recommended for bee-keeping has also NTFP value - for eg: *Adhatoda vasica, Alangium salvifolium, Strychnos nux-vomica* (medicinal), *Mangifera indica, Spondias mangifera, Tamarindus indica* (food value), *Emblica officinalis* (food and medicine) *Canarium strictum, Vateria indica, Anogeissus latifolius, Acacia catechu* and *A. nilotica* (resins and gums), *Pongamia pinnata* (biofuel and pesticide) and so on.
f) Forest Department to permit bee keepers to keep their bee-boxes in the peripheral forests of villages and also allow them to shift their bee boxes to other similar forest areas without affecting National Parks, Sanctuaries and other such specially protected areas.
g) The department to take lead in improving betta forests for furtherance of bee-keeping.
h) Certain special types of large trees such as *Tetrameles nudiflora*, on which numerous large bee-hives of *Apis dorsata* may be found to be declared as ‘Heritage Trees’ under the provisions of the Biodiversity Act 2002, or under any other suitable category to ensure their continued protection.
i) On realizing the potential of mangroves in production of rare kinds of honey it is recommended that the department increase the population of nectar producing mangroves like *Avicennia* spp. *Excoecaria agallocha* etc.

III. Government assistance for bee-keepers

a) People aspiring to take up bee-keeping may be given training and equipments at subsidized rates. On proper utilization of infrastructure granted the entrepreneurs of especially poorer class may be given more assistance.

b) Government to help the entrepreneurs with testing and certification of the genuineness of honey produced so as to fetch good market price for them.
c) Guidance for forest honey collectors on sustainable and safe harvesting methods.
d) Importance of organic honey production.
e) Government assistance for honey quality improvement through making available moisture reduction technique.
f) To make available ready expertise to deal with bee diseases.

IV. General recommendations

a. Honey being a nutritious food the local populace in the honey producing belt should get benefit of honey production. It is recommended that at least once a week, some sweetmeats prepared using honey, may be included in the mid-day meal programmes of the schools.
b. Contract system for collection of wild honey may be dispensed with as the contractors have only short term interest and look for maximization of profit using non-sustainable methods. The VFCs and forest dwelling traditional communities be empowered to do honey collection. The honey should be marketed as 'forest honey' after due purification and dehydration by the Government agencies such as the local beekeepers society. Reasonable price should be paid to the honey collectors by the societies.
c. Honey packaging to be done scientifically and in attractive cartons/bottles so as to fetch good returns for the producers/collectors. Honey from forested villages should be marketed as 'forest honey' so as to fetch better prices
d. Bee-keepers be trained in hygienic collection of royal jelly, bee-pollen, propolis etc. which have much higher value and demand in foreign countries, for pharmaceuticals and as health products.
e. Efforts should be made to preserve nesting sites of honey bees in the wild, as the wild bees constitute important germplasm for the domesticated ones. Branches of certain large trees in the forests and domestic gardens, tree holes, termite mounds etc. are used by bees for build their hives.

14.0 UNDERSTANDING ECOLOGY, BIODIVERSITY AND HYDROLOGY RELATIONSHIPS

Task 4: Understanding ecology, biodiversity and hydrology relationships

Reports submitted

1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Sreekantha, Saira V.K and Vishnu D.M., 2013. Influence of Landscape Dynamics on Hydrological Regime in Central Western Ghats Sahyadri Conservation Series 35, ENVIS Technical Report 65, CES, Indian Institute of Science, Bangalore 560012, India
2) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Mahima Bhat, Prakash N.Mesta, Sreekanth Naik, 2013. Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64, ENVIS, CES, Indian Institute of Science, Bangalore 560012, India
3) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India
4) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V., Sreekantha, Raushan Kumar, Rajinikanth R., Desai S.R. and Subhash Babu, 2012. Ecological Profile of Sharavathi River Basin., Sahyadri Conservation Series 22, ENVIS Technical Report : 52, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
5) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V., Sreekantha, Raushan Kumar, Rajinikanth R., Desai S.R. and Subhash Babu, 2012. Ecological Profile of Sharavathi River Basin., Sahyadri Conservation Series 22, ENVIS Technical Report : 52, November 2012, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
6) Ramachandra T V, Subash Chandran M D, Joshi N V, Daval Joshi and Maneesh Kumar, 2012. Soil quality across diverse landscapes in Central Western Ghats, India, Sahyadri Conservation Series 16, ENVIS Technical Report: 42, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
7) Ramachandra T V, Subash Chandran M D, Joshi N V, Karthick B, Sameer Ali and Vishnu Mukri, 2012. Ecohydrology of Lotic Ecosystems of Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 14, ENVIS Technical Report: 40, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
8) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, Rajinikanth R and Raushan Kumar, 2012. Water, soil and sediment characterization: Sharavathi river basin, Western Ghats., Sahyadri Conservation Series: 4, ENVIS Technical Report: 21, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

14.1 INFLUENCE OF LANDSCAPE DYNAMICS IN A RIVER BASIN ON HYDROLOGICAL REGIME

Pristine forests rich in flora and fauna are being cleared especially in the tropical areas to meet the growing demand of burgeoning populations. This has given rise to concerns about land use/land cover changes with the realization that land processes influence climate. Studies have further indicated its impact on the hydrological cycle and thus the water budget of a region. The present study is an attempt to quantify the hydrological components using Sharavathi river basin as a case study and to determine its changes over time using remote sensing and GIS. Western Ghats region is species rich with a fair degree of endemism in both flora and fauna. A dam was put across the Sharavathi River in 1964 for harnessing electricity. Over the years there have been changes in the land use/land cover owing partly due to unplanned anthropogenic activities subsequent to setting up of the dam. This study explores and quantifies the hydrological parameters that have altered due to large scale land use and land cover changes. In this regard, satellite data has offered excellent inputs to monitor dynamic changes through repetitive, synoptic and accurate information of the changes in a river basin. It also provided a means of observing hydrological state variables over large areas, which was useful in parameter estimation of hydrologic models. GIS offered means for merging various spatial themes (data layers) that was useful in interpretation, analysis and change detection of spatial structures and objects. Studies reveal the linkages among variables such as land use, hydrology and ecology. Regions with significant forest cover and low anthropogenic activities resulted in lesser runoff, higher recharge and thus higher yield to stream resulting in perennial streams whereas regions with poor forest cover and higher anthropogenic activities showed higher runoff, significant reduction of recharge and thus lower yield to streams resulting in ephemeral streams.

***Significance of the Study*:** The Western Ghats comprise the mountain range that runs along the western coast of India, from the Vindhya-Satpura ranges in the north to the southern tip. This range intercepts the moisture laden winds of the southwest monsoon thereby determining the climate and vegetation of the southern peninsula. The steep gradients of altitude, aspect and rainfall make the region ecologically rich in flora and fauna.

There is a great variety of vegetation all along the Ghats: scrub jungles, grassland along the lower altitudes, dry and moist deciduous forests, and semi-evergreen and evergreen forests. Out of the 13,500 species of flowering plants in India, 4500 are found in the Western Ghats and of these 742 are found in Sharavathi river basin. Climax vegetation of the wet tract consists of *Cullenia, Persea, Diptercarpus, Diospyros* and *Memecylon*. The deciduous forest tract is dominated by *Terminalia, Lagerstroemia, Xylia, Tectona* and *Anogeissus*. The region also contains potentially valuable spices and fruits such as wild pepper varieties, cardamom, mango, jackfruit and other widely cultivated plants. There is an equal diversity of animal and bird life. Noticeable reptile fauna in the evergreen forests include burrowing snakes (uropeltids) and the king cobra and among amphibians, the limbless frog (caecilians). The Nilgiri langur, lion-tailed macaque, Nilgiri tahr and Malabar large spotted civet are some examples of endangered endemic mammals belonging to this area.

Sharavathi river valley lies in the Central Western Ghats and represents an area of 2985 km^2. Sharavathi is a west flowing river originating at Ambuthirtha in Shimoga district and during its course, falls from a height of around 253 m at the famed Jog Falls. It flows through Honnavar and eventually into the Arabian Sea. Karnataka Power Cooperation (KPCL) set up a dam across Sharavathi in 1964 known as Linganamakki Dam to harness electricity, which has divided the river basin into upstream and downstream. The construction of this dam has made considerable hydrological and ecological alterations in the river basin. The dam resulted in the submergence of wetlands and forest areas of unmeasured biodiversity. The effects are particularly seen in the upstream of the river basin where the dam submerged many villages and forests to give rise to small isolated islands. These island and surrounding areas have created niches for 150 species of birds, 145 species of butterflies and 180 species of beetles along with mammals such as spotted deer, barking deer, civet, leopard and the Indian gaur.

The reservoir has provided further impetus to farmers and plantation agriculturists. Large tracts of forestlands have been cleared for paddy cultivation and plantation trees such as areca and acacia. Apart from these, vast tracts of natural vegetation has been cleared and replaced with monoculture plantations of *Acacia auriculiformis*, Eucalyptus sp. and *Tectona grandis*. As a result of these activities, there is evidence of changes in runoff and stream flow regimes. There are instances where wells have 'run dry' in the wet spots of the basin, mainly because percolation of rainwater into the ground has decreased due to deforestation. Studies are thus required to quantify the hydrological responses in order to gain an understanding of the effect of anthropogenic activities on the hydrological components and thus the vegetation of study area.

This study explored and quantified the altered hydrological parameters due to large scale land use and land cover changes. In this regard, satellite data has offered excellent inputs to monitor dynamic changes through repetitive, synoptic and accurate information of the changes in a river basin. It also provided a means of observing hydrological state variables over large areas, which was useful in parameter estimation of hydrologic models. GIS offered means for merging various spatial themes (data layers) that was useful in interpretation, analysis and change detection of spatial structures and objects. Studies reveal the linkages among variables such as land use, hydrology and ecology. Following are the conclusions drawn from the hydrological studies of upstream, river basin.

Rainfall analysis based on one hundred years data for Sagara and Hosanagara show reduction of –3.55% and 5% respectively in the Sharavathi upstream river basin Regression analysis was carried out for each rain gauge station considering rainfall as dependent variable and latitude, longitude, altitude and land cover as independent variables. Regression analysis showed rainfall having significant relationship (5% level of significance) between land cover, latitude, longitude, and altitude.

Interception was comparatively high in evergreen/semievergreen forests due to thicker and multilayered canopies. It was followed by moist deciduous forests, plantations, scrub savanna and paddy. Interception was the highest during peak rainfall months and showed least values for shorter crops.

Transpiration also decreased from evergreen/semi-evergreen forests to paddy due to lower albedo in the former. Lower albedo corresponds to higher latent energy, which converts liquid water to water vapour. Transpiration peaks during summer and is the lowest during the monsoon season. Low transpiration during wet months is because most of the energy available for evaporation is consumed by the interception process, which precedes transpiration and because solar radiation is inhibited by clouds in the wet months (Shuttleworth, 1993).

Catchments with good forest (evergreen/semi-evergreen and moist deciduous forests) cover showed reduced runoff as compared to catchments with poor forest covers. The results are similar to conclusions drawn by Bosch and Hewlett, 1982 from various catchment experiments that forested areas have reduced runoff as compared with those under shorter vegetation. Runoff and thus erosion from plantation forests was higher from that of natural forests. Erosion rates in undisturbed natural forest could be considered to represent a natural baseline or background erosion rates against which the erosion rates from all other land uses.

Sub-surface flow caused by pipes in the Western Ghats appears at valley bottoms of forested slopes. The macropore flow collects in the pipes and flows through them into the stream. Recharge in the sub basins varied with respect to vegetal cover and soil texture. Higher recharge was observed in sub basins with good forest cover.

Sub basins with good forest cover showed good amount of dry season flow for all 12 months with the flow decreasing as we move towards east. Decrease of low flows in eastern sub basins can be partly attributed to eucalyptus plantations. Eucalyptus trees have deep roots that tap water deep in the soil mantle creating severe soil moisture deficits. It may take many years of rainfall before field capacity conditions can be established and recharge of the groundwater aquifer and perennial flows can take place. Another reason is the low specific yield of the underlying rock. This highlights the impacts of tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). In short, sub basins with good vegetation cover i.e. natural forests and low anthropogenic activities especially in the western sub basins had high interception, transpiration, recharge and discharge and low surface runoff. On the other hand, eastern sub basins with less natural forest cover had low interception, transpiration, recharge and discharge and high surface runoff.

The anthropogenic influences on the land cover are related to the land use for agriculture, plantation forestry and urbanisation. It was obvious from the present study that land use has an implication on the hydrological components operating in the river basin. However, further research may be necessary to understand the scale of study, low flow mechanism in rivers, sub surface flow distribution under forests in Western Ghats etc.

Some studies that need to be considered in the future analysis are discussed below.

a) The scale of study is important as macro level understanding of the hydrology of a river basin may not be enough to capture the dynamics as some changes are relevant only at micro scale. For example, clearing a few hectares of forest may not influence the regional or global hydrological cycle but it can have implications on the local water cycle. Impact on the local water cycle can affect the micro ecosystem, which may harbour flora and fauna that are adapted to that type of an environment. A water balance study should thus link the ecology and hydrology of a river basin so as to understand the complexities of a region. Ecohydrology describes species diversity, growth forms of vegetation, biomass estimates etc and fuses it with hydrology. Another important area of study is the geology, which is helpful in understanding the occurrence and distribution of ground water and thus the low flow regime of a river. It is important to have a holistic approach when dealing with river basins rather than a pure engineering or ecological approach.
b) Interception analysis in the present study takes into account only the storage capacity and its associated evaporative fraction, intensity of rainfall and seasonality of vegetation. Interception is also dependent on leaf thickness, leaf and stem roughness and leaf orientation, which varies with species. Components such as stemflow and throughfall have not been considered and have to be included in future analysis.
c) Field studies of soil are required to determine the soil infiltration rates. In the present study, infiltration is the difference of net rainfall and surface runoff and the actual values may differ. Studies have proved that infiltration under forested areas in Western Ghats is high.
d) Sub surface flow distribution through pipes in Western Ghats has only been studied in the past few years. Pipeflow have been observed to contribute to flow in streams and in Western Ghats, many dug wells are known to derive their water from large diameter pipes. In regions where Hortonian flow cannot occur, it is observed that pipe overland flow which is new mechanism of runoff generation occurs. This has not been quantified in the studies and needs to be included in future analysis. Studies are also needed to understand the extent and distribution of pipes under forested slopes.
e) Low flow contribution to stream flow in the study area takes into consideration only the natural factors and not artificial factors such as pumping. The effects of groundwater pumping near the head of a perennial river may result in groundwater table depletion through tapping of recharge water. This can result in substantial environmental degradation of the river habitats, loss of naturally sustained fisheries, reduction in the general amenity value of the river. Monitoring of wells in the western sub basins are needed to obtain a more realistic picture in the analysis.
f) The use of remote sensing data should be maximized in watershed studies. It is particularly useful to study the spatial and temporal dynamics in tropical forested watershed as field studies may prove to be difficult depending on the region. However, training site strategies and choice of classification methods have to be considered in order to classify the vegetation in these regions accurately due to its diversity.

14.2 HYDROLOGIC REGIME IN AGHNASHINI RIVER BASIN

Landscape composition has a central role in water cycling and managing the quality and availability of water in the region. However, in recent decades, human activities have significantly altered the landscape composition; major reason being the disturbance and fragmentation of landscape which are the outcomes of unplanned development and the growing demand of the burgeoning population. This has resulted in decline in both quality as well as quantity of the pristine forest which has led to the changes in regional hydrology, raising the concern to understand the impact of landscape degradation on the hydrological regime. Thus the need to understand the coupled interaction between land use and water resources, which is essential to enhance the sustainability of water resources in a region, is of paramount importance. In this context, present study has been carried out to explore and quantify the hydrological components of the Aghanashini River Basin of Karnataka, India and determine the consequences of the land use changes, at the sub-basin level, on the water availability of the region. Global availability of temporal remote sensing data has helped in analyzing the land use condition of the region at different epochs. The result of the investigation suggests groundwater recharge to be a function of the structure of landscape in the region. It also underscores that the sub surface flow which is responsible for the low flows in the river, is a function of vegetation cover in the region. Aghanashini River originates in Sirsi taluk of Uttara Kannada district at an elevation of about 1800ft above the sea level and it encompasses a catchment area of 1370sq.km. with a length of 121km (Figure 14.1). During its course, it forms beautiful falls like Lushington (or Unchalli) falls and Burude falls and flows thorough three major taluks of the district namely Kumta, Sirsi and Siddapur. After making a 13km long estuarine expanse in the coastal zone of Kumta taluk, it finally discharges into the Arabian Sea. Since the River has a large catchment area, hence for the analysis purpose it was divided into seven sub catchments, where each sub catchment was considered as a hydrological response unit (HRU), assumed to be homogenous in hydrologic response to land cover change.

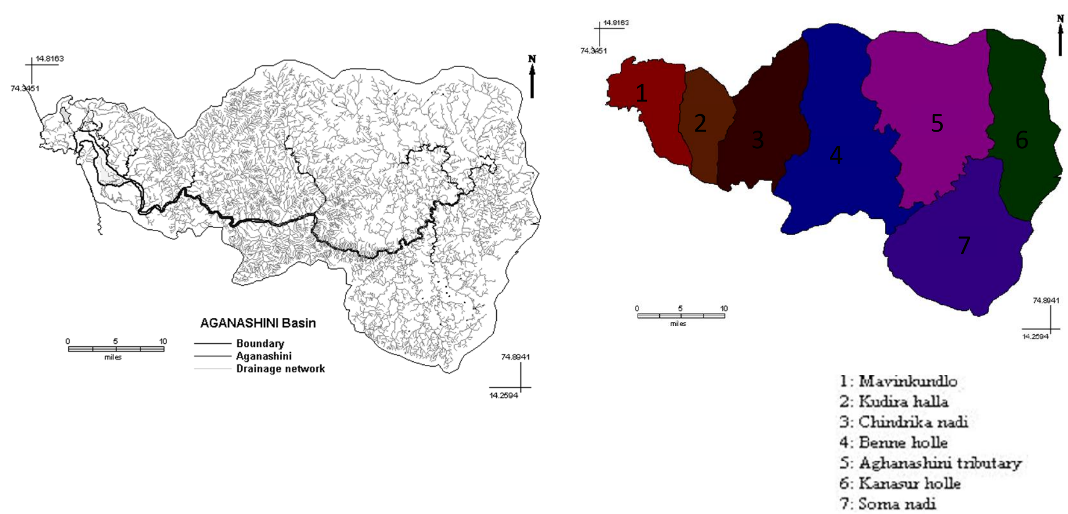


Figure 14.1: Drainage network (a) and sub-basins (b) of the Aghanashini River basin

Land Use Analyses: LU details of each sub-basin of the region since 1971 are shown in Figure 14.2. The change in area of each class for the entire watershed shows that evergreen forest decreased drastically (29.82%) in all the sub-basins during the period of 1972-1989, but remained almost stagnant after that. While deciduous forest initially increased by 21% but thereafter no significant change was observed. Areca plantations have increased manifold by 2010 due to their great economic value.

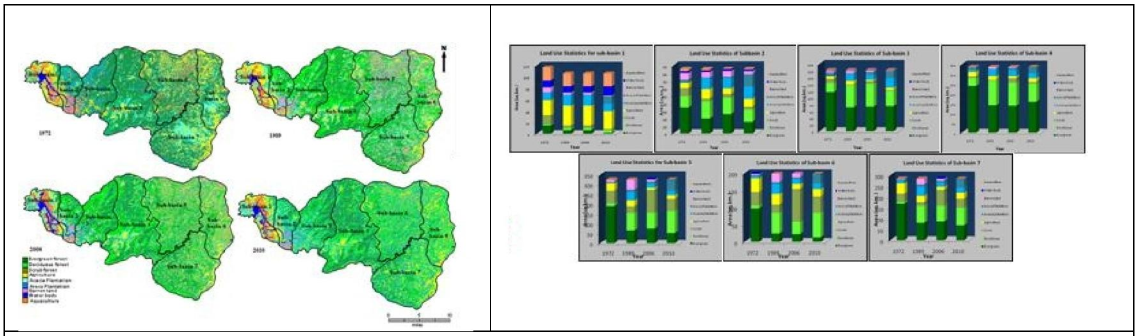


Figure 14.2: Land Use Analysis of the Aghanashini river basin

Water Balance Analysis: Water balance is analysis done with respect to the demand and supply of water to understand the deficit and surplus water. The main stakeholders considered for this analysis are population of the region, livestock, agriculture area to be irrigated and areca plantations (Figure 14.3 and Figure 14.4).

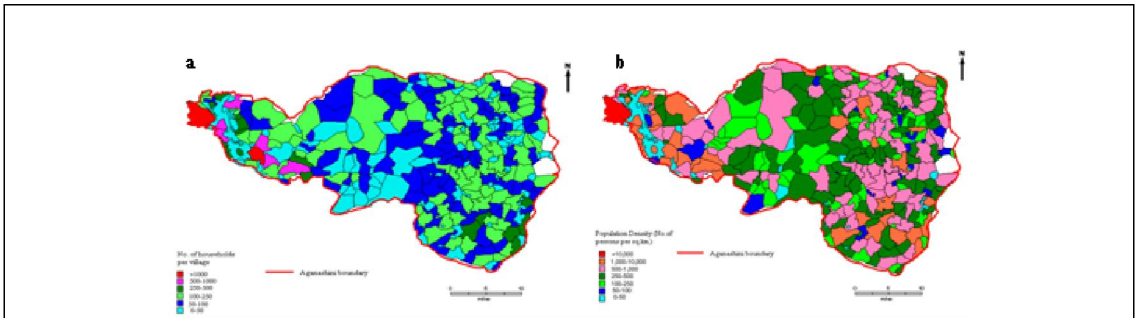


Figure 14.3 Number of household in a village, (b) Population density of each village

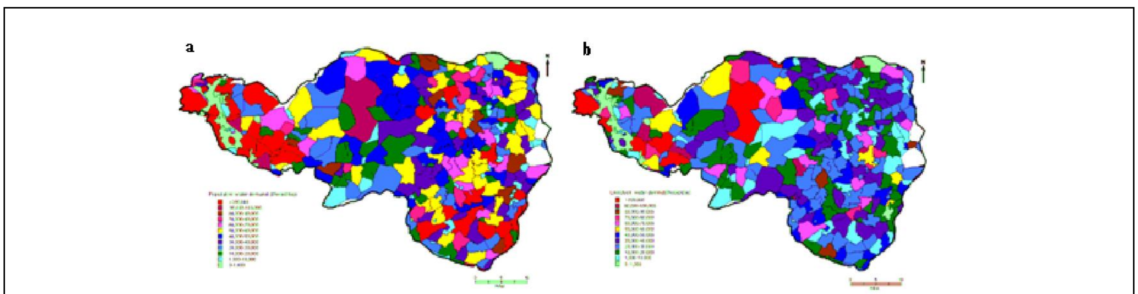


Figure 14.4 Water requirement of (a) human population, (b) livestock

14.3 ECOLOGICAL PROFILE OF SHARAVATHI RIVER BASIN

Freshwater river systems are among the most diverse and productive ecosystems in the world. Much of the biodiversity associated with the riverine landscapes is attributable to heterogeneity at the habitat scale. From a holistic landscape perspective, riverine habitats comprise running and standing waters, permanent and temporary waters, wetlands and groundwater.

Riverine ecosystems are critical components of the global environment. In addition to being essential contributors to biodiversity and ecological productivity, they also provide a variety of services for human beings, including water for drinking and irrigation, recreational opportunities, and habitat for economically important fishes. However, aquatic systems have been increasingly threatened, directly and/or indirectly, by human induced activities. Aquatic ecosystems, in addition to the challenges posed by land-use change, environmental pollution, and water diversion, are expected to experience the added stress of global climate change.

Available information suggests that over the past 30 years, freshwater biodiversity has declined much faster than either terrestrial or marine biodiversity. The ever-increasing demands placed on freshwater resources in most parts of the world has led to the uneven and continued loss of biodiversity. Pollution, siltation, canalization, water abstraction, dam construction, over-fishing, and introduced species will all play a part, although their individual impacts will vary regionally.

Sharavathi Valley forms the northern limit of many endangered ecosystems, flora and fauna such as *Myristica* Swamps, *Gymnacranthera canarica* and Lion-tailed Macaque (*Macaca silenus*). These features illustrate the ecological significance, and the conservation importance of the region. The river basin has a vegetation cover that ranges from evergreen to semi-evergreen forest along with moist deciduous type of forests. Along with this, scrub savanna, grasslands, marshy areas and plantations are the major land covers of the region. Rare evergreen and endemic species belonging to the genera *Dipterocarpus*, *Calophyllum, Lophopetalum, Myristica, Gymnacranthera, Syzygium, Diospyros, Aglaia, Poeciloneuron*, *Palaquium*, etc. and *Semicarpus kathalekanensis*, a rare and endemic tree species that is restricted to Kathalekan of this river basin make Sharavathi river basin an ecologically sensitive region. Presence of around 140 islands in the reservoirs of Sharavathi wherein almost all islands covered with semievergreen to moist deciduous forests represents the fragile ecosystem. Mammals like Gaur, Sambhar, Spotted deer, Boars, Pangolins and Porcupines are also present. The upper catchment of the study area is a habitat for endangered Grey headed Bulbul, Great Indian Hornbill, and endemic species as Black necked stork, White Ibis, Blue bearded Bee-eater, Great Black Woodpecker and Slatyheaded Scimitar babbler (http://wgbis.ces.iisc.ernet.in/energy/sharavathi/svati.htm). Sharavathi River is the dwelling place for a rare freshwater fish, *Batasio sharavatiensis*, a species reported from this river and yet the distribution is limited to this river.

Based on physico-chemical and biological analyses of the water in the river, Sharavathi River basin is categorized into most disturbed (Sharmanavathi, Haridravathi, Keshavapura, Gazni, Sampakai, Gudankatteholé), moderately disturbed (Muppanae, Talakalale Dam, Reservoir, Dabbe falls, Hosagadde) and least disturbed (Yenneholé, Hurliholé, Nittur, Valagere, Dobbod) zones. The disturbance is due to anthropogenic activities in the catchment, mainly agriculture. Presence of coliform bacteria at Sharmanavathi, Haridravathi, Keshavapura and Nandiholé indicates faecal contamination. Before construction of a dam at Gerusoppa, reports indicated that salinity concentration fell rapidly reaching a zero value at Hosad (about 5-6 km from the sea). Field measurements revealed salinity ingress up to Mutta, Balkur (about 15 km from sea). The concentration is highest during the high tide occurring in the morning. It would be desirable to maintain a discharge (*i.e.* release from the power stations) to limit the salinity ingress. Soil samples were collected from 78 locations distributed all over the upper catchment and subjected to physico-chemical analyses. Soils are rich in organic matter and low in phosphate, nitrate and sulphate concentration, while pH ranged between 5.5-6.8. The sediments have low sulphate (0.19-0.68 mg/gm), nitrate (0.0-0.0007 mg/gm) and phosphate (0.00024-0.001 mg/gm) indicating close correlation between sediment and catchment soil. The sediment samples are rich in organic carbon and the elements like Na, K, Ca, Mg are found well within the prescribed standards. Bulk density of sediments in streams of the western region indicates porous condition (0.783-0.983 gm/cm^3) while in the eastern side they are less porous (1.23-1.475 gm/cm^3).

The biological examination of the stream and reservoir ecosystems of Sharavathi River basin showed a rich and diverse phytoplankton population. Desmids predominated in reservoir waters while diatoms in streams. Species diversity is not uniform either in streams or reservoir waters. The study was carried out in 32 localities (16 in the upper catchment and 16 in the lower catchment) of the Sharavathi River Basin to assess the phytoplankton composition. In the upper catchment, 216 species belonging to 59 genera (belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cyanophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae) were recorded. During the sampling, 100, 117 and 110 species of phytoplankton were recorded in collection I, II and III respectively. Species composition was almost uniform in all the three collections, whereas species diversity and species richness varied across stations and collections. Species compositions as well as population of diatoms were more in streams, while that of desmids was more in reservoir water. Various pollution indices applied showed oligotrophic nature of the reservoir waters with slight organic pollution in stream waters. In the lower catchment, 86 species belonging to 38 genera (belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cyanophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae) were recorded . In I-collection 44, II-collection 47 and in III-collection 45 phytoplankton species were recorded. Diatom species as well as population predominated in almost all the streams. Pollution indices showed oligotrophic nature of down stream region.

The freshwater zooplankton fauna of Sharavathi River is rich and highly diversified. Zooplankton diversity assement in 13 localities of Sharvathi river basin reflect a typical tropical assemblage with 37 species belonging to Rotifera, Copepoda and Cladocera groups. Large zooplankton species were absent in this river system, probably due to high predatory pressure. The aquatic communities and more specifically fish communities are very good indicators of disturbances, and since these communities play prominent role in the aquatic food chain, their study can effectively depict the comphrehensive account of aquatic ecosystemstructure and function. The present study of fish diversity in the Linganamakki Reservoir of the upper catchment has recorded 64 species from 32 genera and 16 families. From the lower catchment, 51 freshwater fish species have been recorded. The Sharavathi estuary has a total of 44 species of fishes. The annual fish yield of both the native and introduced fishes of the Sharavathi reservoir is estimated to be 200 ton. The decline in native fish stock necessitates the stocking of indigenous and endemic fishes of Western Ghats. Prevention of over-fishing, migrant fishermen and breeding season fishing can contribute to sustainable fishery in the reservoir. Strict practice of restricted mesh size utility can minimize the death of non-target fishes. Educating local fishermen and activating the inactive cooperative society can lead to sustainable fishery in Sharavathi River basin.

Large number of Western Ghat endemics (18 species) in the region highlights the uniqueness of the region. About 55 % (28 species) of the fishes are found only in peninsular India. Similar comparisons were made with respect to the status of each species. The only critically endangered species, *Tor mussullah* is found in the western parts of the reservoir. Ten species are endangered and require immediate conservation measures, while 12 are vulnerable, 19 are with lower risk and remaining 10 are data deficient. This clearly emphasises the richness and ecological value of the region.

Comparison between the reservoir and streams shows that the species composition of the reservoir is dominated with non-endemic and introduced species. The reason for the flourishing of non-endemics/introduced species is due to development of commercial fishery in the Linganamakki reservoir, since 1969. On the other hand the streams have more number of endemics having narrow range of distribution, emphasizing the importance of streams as natural habitats for endemics. This in turn, accounts for high conservation value of the region.

The data on seeding reveals of lack of scientific approaches. Without determining the carrying capacity and productivity of the reservoir enormous amounts of seeds were introduced during early 90s. The present condition reveals that the approach adopted in seeding has negatively affected the total fish fauna.

Introduction of Tilapia (*Oreochromis mosambica)*: Tilapia is a hardy, territorial and a powerful competitor in nature, and is has started dominating in Linganamakki reservoir. As per the local fishermen, the fish catch of *Tilapia* is increasing over years. The catch starts at the post monsoon period and during November, it dominates in the entire catch. Due to the least demand for this fish in local markets, fishermen treat this fish as unwanted catch. Ecologically these fishes have adverse effects on the native fish diversity. As per the fishermen, the maximum weight that this fish can attain is 0.5 kg in this reservoir.

Endangered Mahseers: *Tor khudree* and *Tor mussullah* are the two endangered species present in the reservoir. These fishes breed during post monsoon period and their habitat is rocky pools. Their commercial value and habitat destruction might be the factors contributing to their decline. In Linganamakki Reservoir, mahseers were recorded in Hallibylu of Sharavathi Wildlife Sanctuary area. In other areas also these fishes are found rarely. At present, the silt deposition at the bottom is slowly disturbing their habitat along with fishing pressure.

***Cyprinus carpio* (Common Carp) Fishery**: During monsoon period, Common carp is the major fish catch in deeper areas like Holébagilu, Madenur and Hasaramakki areas. During other seasons, this fish catch is almost nil. Since Common carp is a bottom dweller, high transparency of the reservoir makes it to move to the bottom surface. During monsoon season, transparency reduces and Common carp comes to the surface. *Cyprinus carpio* is regarded as one of the major competitors to the native species of fishes for food and habitat. In the present case, the fish may affect benthic fishes like *Wallago attu, Ompok bimaculatus* and *Channa striatus* indirectly. Since *Cyprinus carpio* is an herbivorous fish, and its growth is quite fast, it consumes lower level organisms like phytoplankton, zooplankton and other aquatic insects andmay in turn affect the food requirement of carnivorous fishes and result in decreasing their population.

Role of Predatory Fish in Total Fish Catch: Depending upon the fish catch composition it can be concluded that, predatory fishes like *Wallago attu* and *Channa striatus* are least in number. Only *Ompok bimaculatus* catch is quite encouraging. This could be due to excessive introduction of Gangetic carps like *Cyprinus carpio* during the last decade, which has led to competition among the bottom dwellers. Yennehoĺé tributary is the only place with considerable catch of predatory fishes with no introduced species. In this locality, 13 hooks were placed and out of six, 4 *Wallago attu* and 2 *Channa striatus* were caught. This indicates the presence of predatory fishes in this area.

Diseases - Epizootic Ulcerative Syndrome (EUS): The fishermen recall the widespread outbreak of a disease about 5 years back, featured by the severe ulcerative skin lesions over the body, which ultimately caused the death of the fish. Reports on the outbreak of EUS in Shimoga District show that during Dec 1993 – Jan 1994 the disease had caused mortality in the major and minor irrigation tanks. Even though initially the disease affected the bottom dwellers like *Channa* species slowly it spread to catfish and minor carps. Interestingly it has not affected the Indian major carps like Catla, Rohu, Mrigal and common carp in Karnataka (Mohan and Shankar, 1994). This disease might be one of the main reasons for extinction of many species. According to the local fishermen, fish species like *Wallago attu*, *Heteropneustes fossilis* and *Channa striatus* were severely affected by this disease and there was a remarkable decline in their population. Presently there are no such episodes of disease in the reservoir. Still one of the sampling at Lingadakai found a *Garra gotyla stenorhynchus* with lesions on the body.

Parasitic infection to *Mastacembelus armatus*: Recently parasitic infection to the species *Mastacembelus armatus* was observed in areas like Hasaramakki. The infection showed numerous lesions within the abdomen with approximately 1 – 2 cm diameter. After the death of the fish during fishing, nearly 2" long thread like worms (helminthes) were coming out of the abdomen. The infection was at its peak during summer season and affected almost all the fishes of the species. During this period, the commercial use of this fish had almost stopped in this area. However, the question of the suitability of the fish as food and the reason for the first time occurrence of this disease during June 2002 remains unanswered.

Destruction at the breeding ground: Species of *Garra, Puntius, Labeo, Cirhinus, Mystus, and Pseudeutropius* etc. are regarded as resident species. These fishes breed within the reservoir or migrate to smaller distances in search of shallow weedy areas for breeding. Most of the people residing along the bank go for fishing and capture them during monsoon season. Residents here adopt traditional techniques to capture these fishes. These are the localities where large congregations of the spawning fishes are caught and destroyed. Some fishermen even move to shallow upstream areas during monsoon to exploit the breeding grounds. Probably this is a prime factor that retards the population of these migratory fishes. Most of the streams along the western side are observed to be excellent breeding grounds for the native fishes.

Over exploitation and improper fishing system: The over exploitation of the reservoir plays a major role in extinction of the species. The department issues licenses to any number of fishermen. Many fishermen from Tungabhadra dam migrate to this area during rainy season and catch huge quantity of fish. This has adversely affected the livelihood of permanent local fishermen. Over exploitation of the reservoir for fishing has resulted in excessive mortality and reduction in effective population size of the fish. Monsoon is the breeding season for most of the fishes and the fishing activity is at its peak during this season.

The commercial fish catch of the reservoir is dominated by species belonging to Cyprinidae family (54%). The other major families are Bagridae (23%) and the Siluridae (15%). When biomass is considered, the fast growing Indo-gangetic carps, popularly known as Indian major carps, occupy a prominent place. Mainly *Catla catla* (21%), *Labeo rohita* (8.4%) and *Cirhina mrigala* (6.32%). These fishes are introduced to fulfill the commercial fish requirement along with the exotic species (*Cyprinus carpio* 21%). The native fishes with significant biomass are *Gonoproktopterus kolus* (11.5%)*, Ompok bimaculatus* (10%) and *Wallago attu* (9%).

Variable fishing pressure: Monsoon is the peak fishing period and there will be 3.4 times increase in fish catch per person per day during this period compared to non-monsoon period. Even though the monsoon period being shorter than non-monsoon period, about 86.7 % of the total fish-catch takes place during monsoon. Nearly 63.5 % of the original fishermen population arrives here during the initial monsoon season from various parts of peninsular India. As the density of fishermen increases 2.75 times, the fishing pressure also increases. During the initial monsoon season, the reservoir attains the minimum water spread area. It is observed that most of the fishermen get concentrated in the central regions like Holebagilu in order to harvest huge catch. Obviously this results in overexploitation of resource. This is evident from the low fish catches of summer season from this region.

Loss at the breeding grounds: Monsoon is the breeding season for most of the fishes and the fishing activity is at its peak during this season. Muppane, Konjavalli, Melmanji and Kogar represent the peripheral localities of the western region. The biomass composition of this region shows that in these localities, the catch is formed by the native species. These are the flood plains where majority of the fish species breed during monsoon season. Huge quantities of fish catch in these localities during monsoon season poses huge threat to their population. It is evident that the catch per unit effort increases at the periphery than the other localities. Almost all the fishermen move to the extreme ends of the tributaries thereby destructing the breeding fish population.

Fish translocation from other basins: Details on the pattern of introduction clearly reveal that no scientific approach has been adopted before determining the quantity of introduction. Seeds have been introduced depending on the availability. This unscientific approach has resulted in an artificial system of fishing wherein the indigenous fishing population has to rely on an external source to increase the fishing stock. Declined native fish population is inefficient to cope up their livelihood. The low catches during non-monsoon season totally affects the permanent fishermen of the region who are totally relying on this resource for their livelihood. The biomass composition of this region also reveals that other than catfishes, no other native species has succeeded to form a stable population. Thus the fishermen are dependent on an artificial system in the form of introduction and harvest. It is implicative that the original fauna has been changed and hardy fish species has taken advantage of the vacant niches. Thus transplantation of fishes from other basins has led to radical changes in the species set up.

Management Approaches

Conserving the breeding areas: As discussed earlier, shallow and stream joining areas are the breeding grounds of most of the fish species. In this connection, fishing activities should be totally restricted in shallow areas during June to September. The breeding area should be demarcated and these areas should be kept under continuous monitoring. Monsoon fishing should be allowed only at the central part and limited to harvest transplanted species by operating large mesh sized gill nets.

Permanently stopping the fishermen migration: The Fisheries Department should reconsider its revenue-oriented approach in issuing the licenses to the fishermen. Licenses should be issued to the permanent fishermen residing near the reservoir, who are solely dependent on this reservoir for their livelihood. In order to reduce the fishing pressure, it is advisable to avoid migratory fishermen from fishing. Since their fishing period is monsoon, large quantities of breeding fishes are destroyed by over fishing. These fishermen are highly mobile in nature, which complicates the authorities in monitoring. This provides sufficiently large fishing ground to the permanent fishermen thereby considerably retarding the stress on the aquatic system.

Strengthening the indigenous fish population*:* Culture techniques for endangered species should be developed to protect and rehabilitate the endangered species taking into account the critical need to conserve genetic diversity. The native commercial fishes like *Tor khudree, Tor mussullah, Labeo kontius,* etc., have tremendous potential in commercial fishery and their population need to be strengthened by external input. Specifically in the central part of the reservoir most of the cyprinids have poor population indicating the immediate requirement of their culture.

Proper introduction: Presently it is necessary to translocate the gangetic carps to share the fishing stress on the native fishes. However there is a great ecological concern over the introduction of exotic species. In this regard, carrying capacity of aquatic environments should be well studied and the quantification of introduction should be made in order to eliminate the adverse effect on native fish fauna.

Strict supervision: Presently the department is lacking trained staff to strictly and properly supervise the fishing activity. They should be strengthened through increasing their number and proper training. This can enlighten the scientific approach in them towards fisheries management**.**

Activating the Cooperative society: It is another major necessity to activate the Cooperative Society, which is presently passive. All fishing activities should be carried out through the society. Frequent meetings among the fishermen, merchants and the departmental staff can strengthen the society. Here once again banning the temporary fishermen can simplify the task of activating the Cooperative society.

Properly managed data: There is no scientific information available about fisheries in of Sharavathi Wildlife Sanctuary. This severely affects the decision-making. Without any statistical data, it is impossible to maintain the fishery activity in healthy condition. Thus it is the prime importance to maintain at least the data pertaining to total yield statistics, species-wise yield, physicochemical analysis of reservoir water representing the entire water body, disease episodes which is very useful during any planning stage.

Educating the local fishermen: Fishermen should be properly educated about the importance of fish diversity and the associated interconnections between different species. This can considerably decrease improper fishing practices by understanding their negative impacts on fish resources.

14.4 ECOHYDROLOGY OF LOTIC ECOSYSTEMS OF UTTARA KANNADA

Western Ghats is the primary catchment for most of the rivers in peninsular India. Pristine forests in this region are rich in biodiversity and are being cleared due to unsound developmental activities. This has given rise to concerns about land use/land cover changes with the realization that land processes influence climate. Rapid land-use changes have undermined the hydrological conditions, there by affecting all the components in the hydrological regime. The development programmes based on ad-hoc decisions, is posing serious challenges in conserving fragile ecosystems. Considerable changes in the structure and composition of the land use and land cover in the region have been very obvious during the last four decades. Pressure on land for agriculture, vulnerability of degraded ecosystems to the vagaries of high intensity of rainfall and high occurrence of steep erosion and landslide-prone areas, lack of integrated and coordinated land use planning are some of the reasons for rapid depletion of the natural resource base. These changes have adversely affected the hydrological regime of river basins resulting in diminished river / stream flows. This necessitates conservation of ecosystems in order to sustain the biodiversity, hydrology and ecology. In this situation, in order to resolve present problems and to avoid a future crisis, a comprehensive assessment of land use changes, its spatial distribution and its impact on hydrological regime was carried out and accordingly, appropriate remedial methods are being explored for the sustainable utilization of the land and water resources of the catchment. The current research focusing on five rivers (figure 14.5) in central Western Ghats monitors water quality along with diatoms, land use in the catchment and threats faced by these ecosystems.

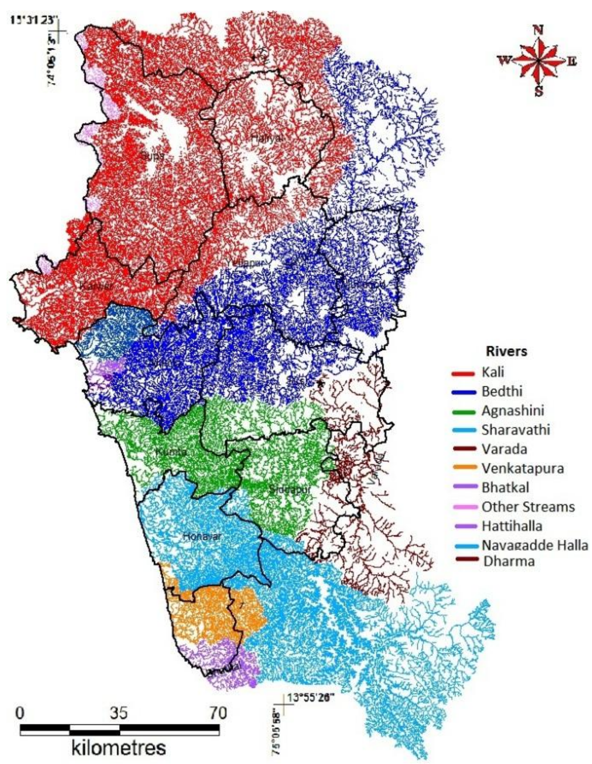


Figure 14.5: Stream network of lotic ecosystems in Uttara Kannada

Kali River: Kali River, which extends to a length of 184 km, earlier originated near the village Diggi in Supataluk, as Karihole. After the construction of the dam near Supa, the entire region is now submerged in the reservoir. Pandri and Ujli are the two main feeders to this river in the North and the stream Tattihalla also joins near Haliyal. The Kaneri and the Vaki are its two main tributaries joins later at Dandeli and Anshi Tiger Reserve. Later near Kadra, Thananala joins the main river. In all, the catchment area of the river is about 5,179 sq. km and the annual river discharge is 6,537 million cu. m. There are four major dam projects on this river - the Supa reservoir near the headwaters, the Bommanhalli reservoir near the Dandeli Wildlife Sanctuary, the Kodasalli dam near Ganeshgudi and finally, one at Kadra (which is the part of the Kaiga project).

Bedthi River: River Bedthi is a result of the confluence of two major streams, and the Bedthi stream, which originates near Hubli taluk. They join near Kalghatgi and the river flows for about 25 km westwards and enters the district of Uttara Kannada. After a southwesterly course of about 32 km, it falls into the sea. The united river extends about 8km south east to the border of Uttara Kannada and flows in the district for a length of 96km. The river, which extends to 152 km with a. catchment area of 3902 sq. km and discharges 4,925 million cu. m of water annually.

Aghanashini River: Aghanashini River arises at Manjguni near Sirsi. After a winding westerly course of about 70 km, it falls off into the sea about 10km south of Bedthi. The river has two sources - a tributary called Bakurhole, rising at Manjguni, about 25km west of Sirsi and Donihalla, which is close to Sirsi. The two streams meet at Mutthalli about 16 km south of Sirsi. Under the name Donihalla, it flows about 25 km south of Sirsi westwards to Sahyadri's west face and at Heggarne in Siddapur, it falls off a height of about 116 m as the Lushington (or the Unchalli) falls. Further down 6 km from Bilgi near Hemanbail, it flows down again as the Burdejog. It finally meets the tide at Uppinpatna. The Aghanashini covers a catchment area of 2,146 sq. km, with an annual discharge of 966 million cu. m.

Sharavathi River: Sharavathi River originates at Ambutirtha in Tirthahallitaluk of Shimoga district. After a northerly course of about 64 km from Sagar, it forms the southeastern border of the Uttara Kannada district for about 13km and flows a further 32 km west in all, it flows 128 km to join the sea at Honnavar. Soon after touching the Uttara Kannada border the river falls off the western face of the Ghats in Jog falls at a height of 252 m into a pool 117 m deep. About 30km west, it reaches Gersoppa. The Sharavathi extends to a length of 122 km, with a catchment area of 2,209 sq. km and an annual discharge of 4,545 million cu.m.

Venkatapura River: Venkatapura River is located between 13.98° - 14.15° N and 74.48°- 74.73° E in the southern part of Uttara Kannada district of Karnataka, India (Figure 1). It originates in Western Ghats and confluence into Arabian Sea after a course of 45 km near Venkatapura with a catchment of 335 km^2. Forest and agriculture are the major land use in the catchment. The river basin is divided in to six sub basins namely Venkatapura tributary, Chitihalla, KatagarNala, BastiHalla, Kitrehole and Venkatapura River based on major tributaries.

A total of 140 diatom taxa were identified across sites, 61 of them reaching a relative abundance of over 5% in at least one site. The species compositions were dominated by *Gomphonema gandhii* Karthick and Kociolek, *Achnanthidium minutissimum* Kützing, *Achnanthidium* sp., *Gomphonema* sp., *Gomphonema parvulum* Kützing, *Nitzschia palea* (Kützing) W.Smith, *Nitzschia frustulum* (Kützing) Grunow var. *frustulum*, *Navicula* sp., *Navicula cryptocephala* Kützing, *Cyclostephanos* sp., *Cymbella* sp., *Eolimna subminuscula* (Manguin) Moser Lange-Bertalot and Metzeltin, *Sellaphora pupula* (Kützing) Mereschkowksy, *Eunotia minor* (Kützing) Grunow in Van Heurck, *Nitzschia amphibian* Grunow f. *amphibia*, *Cyclotella meneghiniana* Kützing, *Gomphonema difformum* Karthick and Kociolek, *Navicula rostellata*Kützing, *Cocconeis placentula* Ehrenberg var. *euglypta* (Ehr.) Grunow, *Brachysira* sp., *Stauroneis* sp., *Encyonema minutum* (Hilse in Rabh.) D.G. Mann, *Cyclotella* sp. and *Nitzschia* sp. The species composition contains cosmopolitan to possible Western Ghats endemic species and in general species from oligotrophy to highly eutrophic condition were also observed. The current study also documents some of the species for the first time in Western Ghats and many new species descriptions are underway. Waters were circumneutral throughout the whole study area, with certain tendency towards alkalinity in the streams drained from agriculture and urban catchment. The highest ionic and nutrient values correspond to the agriculture catchment dominated streams, particularly in the leeward side of the mountains. Oxygenation was generally close to saturation; the lowest values are due to wastewater water inflows in few localities. The most oligotrophic sites were located in mountain watercourses, while downstream sites were generally more polluted, becoming eutrophic in condition.

These results offer insight into our three objectives for this study: (1) all the three water quality regimes shows changes in water quality across seasons, (2) diatom species assemblages changes strongly in all the water quality regimes, due to seasonal water quality conditions, where physical forces are more significant over longer scales of study while eutrophication and regional landuse is moreover evident within climatic seasons, and (3) the species distribution across the sites followed the satellite-mode due to the specific ecological niches of the diatoms. This study also concludes that Western Ghats streams can be monitored during the post monsoon months for biomonitoring ventures and compared to other water monitoring programs. This study also hints that the diatom community in this region is rich with possible endemic taxa; hence considerable amount of importance has to be given for the taxonomy of the lesser-known species before starting the biomonitoring programs.

The analyses and results described here provide insights to the linkages between land use practices and water quality in the streams and the relative sensitivity of water quality variables to alterations in land use. Agricultural activities in stream catchments are closely linked to increasing nutrient and ionic concentrations. Water quality in the eastern leeward regions was most strongly influenced by agriculture land uses, whereas the western windward catchments were dominated by natural forests. The diatom indices and water chemistry variables relation clearly shows the impact of land use on stream ecosystem. In conclusion, this study highlights the role of landscape and proximate factors in the regulation of diatom species assemblages. Understanding the relative importance of natural and anthropogenic variations on diatom species composition is essential for conservation of lesser known organisms like diatoms.

It has been evident from our findings that the causes and sources of water pollution in the 5 River Basins are due to agricultural land use, anthropogenic activities and industrialization. The major occupation in the study area is agriculture, which is main source of increase in nitrates and ionic components in streams. Domestic and industrial sewage discharges in to rivers are responsible for the observed high concentration of electrical conductivity, total dissolved solids, total hardness and other ionic components. Proper treatment of effluent from the industrial processes to the acceptable levels and discouraging stagnation of water through small dams are the two major recommendations to minimize the river ecosystem damage in the central Western Ghats. Figure 14.6 illustrates the water quality in 5 Rivers and the contaminations are due to effluents from industries, untreated sewage and agricultural runoff. The major occupation in the study area is agriculture, which is main source of increase in nitrates and ionic components in streams. Domestic and industrial sewage discharges in to rivers are responsible for the observed high concentration of electrical conductivity, total dissolved solids, total hardness and other ionic components. Proper treatment of effluent from the industrial processes to the acceptable levels and discouraging stagnation of water through small dams are the two major recommendations to minimize the river ecosystem damage in the central Western Ghats.

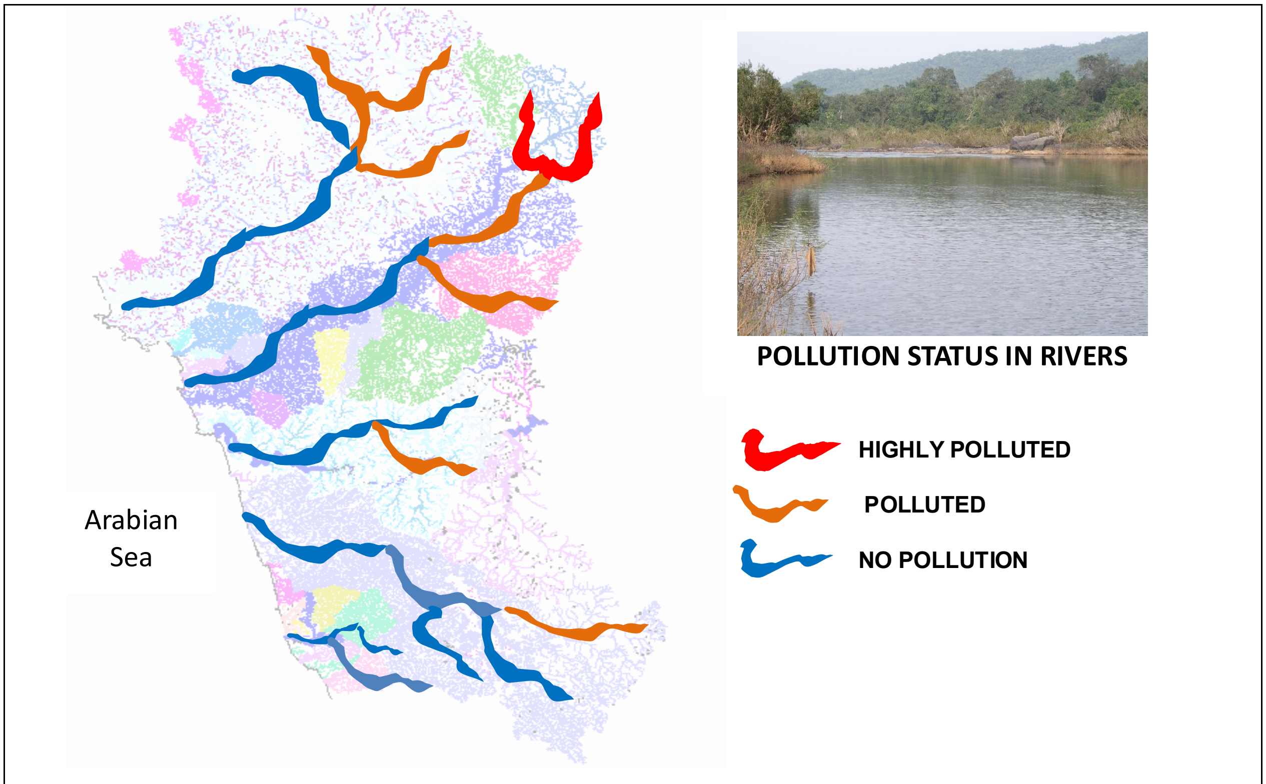


Figure 14.6: Water quality of Lotic ecosystems

River ecosystems of Uttara Kannada: Threats

Dams: Large to small sized dams used for hydroelectricity production and small sized local check dams for intense agriculture purposes. Both large and small check dam affects the riverine biodiversity and water quality.

Loss of riparian vegetation: Removal of riparian vegetation is observed in all river basins. In particular streams flows next to the agriculture lands shows significant removal of riparian vegetations.

Water pollution due to domestic sewage: Bedthi River Basin, in particular upper reaches of Bedthi shows high level of water quality degradation due to the domestic sewage disposal in the main streams. Certain portion of the domestic sewage of Hubli town is disposed into upper Bedthi River. Sewage contaminants flows in to Bedthi River and later gets diluted by the water from tributary like Hasehall, which drains more water even during the summer months. Some of the sites, which are severely affected by the water pollution in Bedthi River basin are Sangadevarakoppa, Kalghatghi and Manchikeri (Yellapura).

Industrial Pollution: Kali River Basin is under the influence of industrialization in Uttara Kannada, in particular Dandeli region with polluting industries. The West Coast Paper Mills Ltd situated in the bank of River Kali pollutes the water and surrounding riparian environment by letting partially treated or untreated effluents into the river. Kervada village, next to Dandeli witness severe water and air pollution due to the effluent of paper mill. Paper mill waste increases total dissolved and suspended solids, turbidity and ionic content. In addition to the effluents the river also receives sewage. Organic waste let in to the river decreases the dissolved oxygen, which eventually causes threat to aquatic biodiversity. Site where confluence of sewage is also witnessed soaring population of Mugger crocodiles resulting in the higher instances of human wildlife conflicts.

Sand Mining: Sand mining is one of the common problems observed in lower reaches of all the river basins. Sand mining is predominant in brackish water region of Kali and Sharavathi River Basins, where mechanized sand mining is in practice for a while. Sand mining cause severe threat to the benthic organisms. Most of the marine and esturine benthic organisms breed in brackish regions faces severe threat due to the mechanized sand mining. Mangrove regions in Kali estuary is also threatened by sand mining due to loss or alteration of habitat.

Mechanized sand mining in Kali River Basin

Table 14.1 lists the river basin wise threats with the appropriate mitigation measures to enhance the functional aspects of aquatic ecosystems.

Table 14.2: Threats and Mitigation Measures

River Basin	Region	Problem	Remedial Measures
Kali	Dandeli	Paper mill effluent	Enforce effluent treatment by the industry (implementation of the control of water pollution, Polluter pays principle)
Kali	Ramnagar	Non-point source pollution in streams and rivers from Agriculture fields	Avoiding intense use of chemical fertilizers and pesticides
Kali	Honkon (Brackish)	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities
Bedthi	Sangdevarkoppa	Non-point source pollution	Avoiding intense use of chemical fertilizers and pesticides

Bedthi	Kalghatghi	Urban domestic sewage, non-point source pollution	Implementation of sewage treatment plant in Hubli town. Sewage should be treated before letting in to the river.
Bedthi	Kalghatghi	Solid Waste Disposal in River	Setting up Solid waste disposal facility in outskirts of Hubli town.
	Manchikeri	Urban domestic sewage, non-point source pollution	Implementation of sewage treatment plant in Hubli town. Sewage should be treated before letting in to the river.
Sharavathi	Gerusoppa and downstream	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities

14.5 WATER, SOIL, AND SEDIMENT CHARACTERISATION

Aquatic ecosystems perform valuable environmental functions like nutrient recycle, ground water recharge, stream flow maintenance, habitat for flora and fauna and provide recreation for people. Structural changes in these complex and dynamic ecosystems will have significant effect on its functioning. These structural changes take place due to unplanned developmental activities without holistic approach on watershed basis. These effects could be cumulative and its assessment is required for remedial measures. To assess these impacts due to river valley projects, the present study was undertaken in Sharavathi river basin. This is done through water, soil and sediment quality analyses by analytical methods. The water quality is impaired due to non-point source of pollution. This includes soil erosion and biological coliform at few sites. Soils under study are deficient in nutrients like nitrates, phosphate and sulphates but rich in organic matter. Since the character of sediment is highly dependent on the basin character, the soils of catchment having less amount of above-mentioned nutrients is consequently reflected in sediment also. The management options suggested are effective in soil erosion control based on soil type and appropriate catchment treatment.

Soils representative of different habitats of entire catchment area like evergreen forests, disturbed evergreen forests, semi evergreen forests, swamps, *Areca* plantations, *Acacia* plantations, paddy fields, teak plantation, *Pinus* plantations, barren lands and riparian habitats were analysed for physical and chemical characteristics.

The soils of the upper catchment ranged from moderately acidic (pH 5.3 in sub-basin Linganamakki) in a semi-evergreen forest to neutral (7.8 in sub-basin Yenneholé) in the soils obtained from a degraded area (*i.e.,* area with less vegetation cover). The slightly acidic soils found in moist deciduous, deciduous, semi-evergreen patches in sub-basins Nandiholé (US1), Haridravathi (US2), Mavinaholé (US3), Yenneholé (US5), Linganamakki (US9) would be due to the high organic content in the soils. The soils generally found in these areas are optimal for plant growth and microbial activity.

The bulk densities of *Acacia* plantations, barren lands, teak plantations, moist deciduous forests in all the sub-basins (0.69 – 1.175 g/cm^3) were slightly higher than the evergreen and semi-evergreen patches (0.70 – 0.97 g/cm^3) in the same basins. These results are supported by high moisture content (19.82 – 27.84 %) in the semi-evergreen patches found in sub-basins Yenneholé (US5) and Linganamakki (US9). The increased moisture content in sub-basin 9 would be due to the fact that this is the main reservoir bed. The deciduous, moist deciduous and *Acacia* plantations (6.96 – 22.55%) in sub-basins Nandiholé (US1), Haridravathi (US2), Sharavathi (US4), Linganamakki (US9), Mavinaholé (US3), Nagodiholé (US7) have high moisture content than the barren lands found in Haridravathi (US2), Sharavathi (US4), Yenneholé (US5) and Hurliholé (US6).

The soils in the upper-catchment are generally rich in organic carbon. The relative richness of organic carbon concentrations for various habitats (Tables 51 and 52) are semi-evergreen > deciduous, moist deciduous and *Acacia* plantations > teak plantations. The high organic carbon content in semi-evergreen, deciduous and *Acacia* habitats was due to heavy leaf litter. The organic carbon varied among the similar habitats in different sub-basins: semi evergreen forests [Linganamakki (US9) > Yenneholé (US5)], Moist deciduous forests [Nandiholé (US1) > Mavinaholé (US3) > Haridravathi (US2)], *Pinus* plantation [Linganamakki (US9) > Sharavathi (US4)], Deciduous forests [Mavinaholé (US3) > Haridravathi (US2)], Teak plantation [Nandiholé (US1) > Haridravathi (US2), Mavinaholé (US3), Linganamakki (US9)], *Acacia* plantation [Nandiholé (US1) > Sharavathi (US4) > Linganamakki (US9) > Haridravathi (US2)] and barren land [Hurliholé (US6) > Sharavathi (US4) > Haridravathi (US2)].

The relative concentrations of various elements are as follows Sulphates > Chlorides > Calcium > Magnesium and Nitrates > Phosphates. From the results it can be concluded that soils of the sub-basins Linganamakki (US9), Yenneholé (US5), Nagodiholé (US7), Nandiholé (US1), Haridravathi (US2), Mavinaholé (US3) of the upstream catchment (reflected by high organic content and low bulk density values) were fertile compared to the sub-basins Sharavathi (US4) and Hurliholé (US6).

The soil analysis for the Sharavathi downstream catchment reveals that the soils from all the habitats analysed are moderate to slightly acidic in nature (4.9 to 6.07), which is shown in the Table 53. Most of the plants grow optimally in this pH range, as the nutrients are available for their growth and the microbial activity is also optimum at this range. Conductivity values for all habitats were within permissible limits for good quality soil. Bulk density (2.02 – 2.25 g/cm^3) was high in the areca plantations in the sub-basins Dabbe falls (DS4), Magod (DS3) and Haddinabal (DS2), which could be attributed to the compactness and nonporous nature of the soil. The mulching of soil would be the reason for higher moisture content in these plantations (20.44 –23.68%). Riparian habitat at Dabbe showed a high value of bulk density 2.05 g/cm^3, due to clayey skeletal nature of the soil, which is generally compact. These results are supported by low water holding capacity (9.76 – 39.24%) and moderate concentrations of organic carbon (0.44 to 0.84%).

The evergreen patches in Dabbe falls (DS4), Haddinabal (DS2) and Kathalekan (DS6) have lower bulk densities (1.29 – 1.94 g/cm^3) than Areca and other plantations. Consequently, these patches have high water holding capacity (13.48 -55.31%) and organic carbon (0.66 – 2.59%). At Idagunji (Magod DS3), Acacia plantations showed organic carbon concentrations of 1.55 % and at Mahasati (Haddinabal DS2) it was 0.20 %. Due to older plantations, in Idagunji leaf litter was high. Areca plantations near Hossagadde and Mavinaholé in Magod (DS3) and Haddinabal (DS2) respectively are deficient in phosphorous levels with 7.88 and 9.46 kg/ha whereas Chandubanu (Haddinabal DS2) is rich in available phosphorous [165.55 kg/ha], which is due to fertiliser applications. Ploughed paddy field at Hebbenkere (Dabbe fall DS4) is deficient in phosphorous with 7.88 kg/ha compared to moderate concentrations of

25.23 kg/ha in unploughed paddy field (DS4) This is probably due to the disturbances to the topsoil (which is rich in phosphorous) while ploughing.

Compared to paddy fields, the riparian vegetation soils in sub-basin 4 have moderate phosphorous levels (28.38 kg/ha). The teak plantations (Haddinabal DS2) grown on slopes is deficient in phosphorous (12.61 kg/ha) when compared to plantations (34.69 kg/ha) in flat terrain. The low phosphorous levels would be due to soil erosion on the slopes. The evergreen patches in certain areas like Kathalekan (sub-basin 6), Chikoli (sub-basin 2), and Chandubanu (sub-basin 2) are deficient in phosphorous levels - 14.19, 1.58 and 15.77 kg/ha respectively. This can be attributed to the disturbance of the soil surface. The Areca plantations in Dabbe falls (DS4), Magod (DS3) and Haddinabal (DS2) have low available potassium (69.5 – 142.9 kg/ha) whereas in other habitats like evergreen and semi-evergreen patches in the same sub-basins, it was higher. Thus, from the results, it can be concluded that the soils in the Areca, Acacia and teak plantations in Dabbe falls (DS4), Magod (DS3) and Haddinabal (DS2) have a low nutrient status (as shown by low water holding capacity, low organic content and high bulk density values) than the soils in the evergreen and semi-evergreen patches in the same sub-basins.

The evergreen patches of sub-basin Haddinabal (DS2) and Kathalekan (DS6) have high available potassium and phosphorous values compared to other habitats and sub-basins. The soils of Haddinabal (DS2) and Kathalekan (DS6) of the downstream catchment of the Sharavathi river basin are relatively fertile compared to Dabbe falls (DS4) and Magod (DS3). Most of the areas in the DS4 and DS3 come under different plantations and have the maximum anthropogenic activity compared to the other two sub-basins.

The water, soil and sediments of Sharavathi downstream and upstream catchments were analysed for their physico-chemical and biological parameters. The upstream and downstream catchments were divided into various sub-basins and their quality in terms of water, soil and sediment was evaluated.

- Field and laboratory investigations of the water quality of the Sharavathi upstream catchment reveal that the tributaries flowing through the sub–basins of Nandiholé (US1), Haridravathi (US2), Sharavathi (US4), Mavinaholé (US3) and Hilkunji (US8) (Group A) are relatively more polluted as evident from transparency, turbidity, suspended solids, phosphates and coliform than the tributaries in the sub-basins of Yenneholé (US5), Linganamakki (US9), and Hurliholé (US6) (Group B and C). The reasons for pollutions in these sub-basins are due to the agricultural and other anthropogenic activities in the catchment area.
- The Sharavathi downstream catchment shows that the streams flowing through the sub-basins of Magod (DS3), Dabbefall (DS4), Mavinagundi (DS5), Kathalekan (DS6) and Gudankateholé (DS7) are fresh and unpolluted. But streams like Dabbod in sub-basin 3 (Magod) showed variations in the physico-chemical characteristics like turbidity because of the increased run-off from the nearby agricultural fields. In certain months, the water is dammed for agricultural purposes and during the months of February, March and April, the water is highly turbid. The tributaries flowing through Chandavar (DS1) and Haddinabal (DS2) of the downstream catchment are prone to salinity (high values of sodium, chlorides, sulphates, hardness, conductivity, TDS, alkalinity, etc.,) as there is seawater intrusion.
- The analysis of the soil samples collected from representative sites in the Sharavathi upstream catchment revealed that the soils of the sub-basins of Linganamakki (US9), Yenneholé (US5), Nagodiholé (7), Nandiholé (1), Haridravathi (US2), Mavinaholé (3) were fertile compared to the sub-basins Sharavathi (4) and Hurliholé (6) (indicated by high organic content and low bulk density values).

- The analysis of downstream catchment soil samples showed that the soils of Haddinabal (DS2) and Kathalekan (DS6) sub-basins are relatively fertile compared to the sub-basins Dabbe falls (DS4) and Magod (DS3). Most of the areas in the sub-basins DS4 and DS3 come under different plantations and have maximum anthropogenic activities in the catchment area compared to the other two sub-basins.
- The sediment samples collected from the Sharavathi upstream area revealed that the sediments were rich in organic carbon but were poor in other nutrients.

ACTION PLANS

- Introduction of any local grass species like *Dichanthium annulatum*, *Panicum antidotale*, *Sehima nervosum*, *Cenchrus ciliaris*, *Csetigerous* and *Chrysopogon fulvus* along the edges in agricultural fields or along the streams as conservation measure will prevent runoff and preserve soil and vegetation, improve soil moisture, prevent direct contamination of the streams and provide fodder for livestock. Preferably this conservation strategy should be strongly adopted at all agricultural fields near riparian habitats. This can be implemented by bringing awareness among the farmers and adopting the above method to conserve the natural resources like soil and water in the river catchment.
- Afforestation or plantation of hardy evergreen tree species like *Olea dioica*, *Aporosa lindleyana* along with grass species that slow down and retain water, which prevent excess nutrient wash and direct fall of water from the evergreen forests. This conservation measure preserves the fertility of evergreen forest existing there, prevents soil erosion, reduces excess nutrient flow to the stream and reservoir preventing sedimentation of the reservoir.
- Construction of bunds to prevent seawater intrusion into the stream at Haddinabal as practiced between Badagani and Gudankateholé or permanent embankment as suggested in the subsequent recommendation.
- Back intrusion of seawater into the stream at Gudankateholé can be overcome by constructing a permanent embankment or dam wall near Badagani with provision for regulating the flow of water from the upstream to downstream from period to period.
- Afforestation programme to be undertaken extensively in the catchments of major tributaries like Nandiholé, Haridravathi, Mavinaholé, Sharavathi and central part of the Sharavathi upper catchment.
- Stream bank afforestation to be undertaken near major tributaries like Nandiholé, Haridravathi, Mavinaholé, Sharavathi, Hilkunji and other lower order streams in eastern part of the Sharavathi upper catchment.
- Utilisation of excessive inorganic fertilisers for cultivation of crops has affected the water quality and soil in the eastern parts like Haridravathi, Nandiholé, areas surrounding Hosanagara in the Sharavathi upper catchment and streams near Gudankateholé, Haddinabal, Dabbod, Magod in the downstream. Therefore, it is recommended to practice organic farming and utilise bio-pesticides. Utilisation of excessive inorganic fertilisers for cultivation of crops has affected the water quality and soil in the eastern parts like Haridravathi, Nandiholé, areas surrounding Hosanagara in the Sharavathi upper catchment and streams near Gudankateholé, Haddinabal, Dabbod, and Magod in the downstream. Therefore, It is recommended to promote organic agriculture, vermiculture etc. in these regions. Local farmers should be educated about the significance of aquatic habitats and possible impacts of unplanned agricultural activity, use of excessive fertilisers/pesticides and discharge of excessive agricultural contaminants directly into the aquatic bodies and its consequences, etc.

15.0 UNDERSTANDING CULTURAL DIVERSITY IN RELATION TO CONSERVATION SUCH AS OF SACRED GROVES AND SACRED TREES, SACRED ANIMALS, TOTEMIC SPECIES, ETC., TRADITIONAL RESOURCE UTILIZATION AND MANAGEMENT, TRADITIONAL SKILLS AND ARTS, TRADITIONAL ECONOMIC ACTIVITIES SUCH AS PRODUCTION OF ARTIFACTS SKILLED FARM LABOUR, ETC. IDENTIFICATION OF HERITAGE AND CULTURAL SITES.

Task 5: Cultural diversity in relation to conservation such as of sacred groves
1. Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India 2. Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012. 3. Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 20, ENVIS Technical Report: 50, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 4. Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 19, ENVIS Technical Report: 49, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 5. Ramachandra T V, Subash Chandran M D, Joshi N V, Sooraj N P, Rao G R and Vishnu Mukri, 2012. Ecology of Sacred *Kan* Forests in Central Western Ghats, ENVIS Technical Report: 41, Sahyadri Conservation Series 15, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 6. Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

15.1 ECOLOGY OF SACRED KAN FORESTS IN CENTRAL WESTERN GHATS

The Western Ghats is one among the 34 global hotspots of biodiversity and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. The flora of Western Ghats comprises about 12,000 species from unicellular cyanobacteria to the flowering plants. In this spectrum of the flowering plants of Western Ghats comprises about 27 % of the Indian flora. Of the 4,000 species of flowering plants about 1,500 species are endemic species. Of the 4,000 species of flowering plants about 3,100 species occur in the wet evergreen forests. The growth forms are result of plant segregation due to light requirements, and availability of space. Main objective of this study is to understand the ecology and conservation aspects of sacred kan forests in central Western Ghats. This study was carried out in Kathalekan a *kan* protected by the peasant community in the past and a good part of the sample area to this day retains features of a primeval forest. It is a home land for various Western Ghats endemic species. One of the main and easily identifiable components of biodiversity is endemism. The study shows that *kans* act as micro-watershed in local areas and are always associated with a fresh water ecosystem used to trap and collect the rain water for the local water supply. Major threats to such fragile ecosystems include cultivation within *kans*, encroachment, grazing, lopping apart from unplanned developmental activities. Kathalekan as a relic forest with high degree of plant endemism and myristica swamp liberally sprinkled with southern climax species such as *Dipterocarpus indicus, Palaquium ellipticum, Mesua ferrea, Syzygium spp*, etc with rich under growth of especially the slender palm Pinanga dicksonii and clumps of Ochlandra is a visual demonstration of congenial microclimatic condition and rich soil with high water conservation values. The swamps being the peak expression of the high water content, the Myristica swamps are also sources of perennial streams and have some of the most ancient land biodiversity of the earth dating back to the Gondwanaland. This short term study therefore has become helpful for formulating a conservation and management plan for Kathalekan, which include declaring as biodiversity heritage site, management of water courses, maintenance of savanna, regulation of cattle grazing and stricter vigil to prevent encroachment.

Rain forests worldwide have been suffering from various anthropogenic pressures for several decades. Demand for land and resources became augmented as result of booming population. Escalating human wants found most of the rain forests becoming victims of ruthless exploitation. In the Western Ghats, forest destruction started with the introduction of agriculture, both shifting and permanent in the valleys. Yet, as the population during the pre-British period was small, and the forests vast, by and large there was a good equilibrium between human activities and forests and wildlife. The Western Ghats is known for excellent timbers, particularly teak. Various evergreen forest trees, most of them endemics, along with associated biota were specially protected in *kans* and other kinds of sacred groves like *devarakadus* and *kavus* by local communities. Wildlife was abundant in this region during the pre and early British period.

***Kans*: past perturbations:** The British domination of the Western Ghats from early 19th century marked a watershed in the forest history of the region. Unplanned forest exploitation for ship-building timbers was started by the British East India Company. Exploitation in early British period was opportunistic and confined to easily accessible places. Although the first Indian Forest Act was enacted in 1878, it was almost the end of the 19th century when the first forest working plans were formulated for systematic exploitation of forests. Selection felling and clear-felling were the norms of routine forestry both during British period and in post independence period. Clear felling in the low altitudes of Western Ghats was mainly for raising teak monocultures. After independence forests were cleared at a greater pace for raising teak monocultures. Especially in southern Western Ghats medium and high altitude forests, rich in endemic species, were cleared for raising commercial crops like tea and coffee. In southern Kerala most of the foothills were cleared off the vegetation to raise rubber plantations.

Most *kans* of central Western Ghats escaped serious interference during the 19th century, despite state monopoly over them, because of their evergreen nature, having mostly perishable softwoods. However, contract system was introduced for gathering non-timber products like pepper and cinnamon. Although these were exhaustively harvested no logging was attempted by the British until the Second World War when there was escalating demand for softwoods for the plywood industry and timbers like *Dipterocarpus* for railway sleepers.

The integrity of the *kans* were, however, slowly getting eroded as the British had not made adequate provision for meeting the biomass needs of the local communities ever since reservation of forests for the state. As the communities were alienated from the *kans,* their worship places and sources of NTFPs, and their entry prohibited as well in the timber rich secondary forests, apparently, the people resorted to extracting biomass from the *kans* themselves. Many *kans* of Sirsi-Siddapur were already infested with weeds like *Lantana* by 1920's. Dry wood collection was permitted in the *kans* by the British in eastern Sirsi and Siddapur. To meet the leaf manure demands of arecanut farmers even *kans* were allotted to them as *betta* or leaf manure forests. The *kans* away from human habitation, towards the crests of the Western Ghats, got merged with forest re-growth on shifting cultivation fallows and other secondary forests, losing their identity. Some of the notable *kans* like Kathalekan in Siddapur, Karikan in Honavar and Alsollikan in Ankola, which are treasure troves of rare and endemic biodiversity belong to this class of *kans.*

Soon after Indian independence, the *kans* like rest of the evergreen forests were caught in the grip a strong industrialization drive. Their massive timbers, hitherto untapped or underutilized, were allotted to plywood, match and packing case industries at extremely low rates. The process of extraction of industrial timbers by selection felling, carried out through a period four decades up to 1987, was too denigrating for the *kan* ecosystems. However, the prohibition on live tree felling since then has brought back new life into *kans* and their endemic biota are slowly springing back to normalcy. At the same time the *kans* are nevertheless immune from onslaughts from local communities, who resort to them for biomass extraction as well as divert the streams associated with them into their arecanut gardens and other crop lands impoverishing the regeneration of sensitive endemic species. The major threats operating in the Kathalekan reserve today are documented here.

Kathalekan: threats – past and present: As described earlier, the development of railways and the soaring demand for softwoods for industries had not spared Kathalekan as well. Many huge trees like *Dipterocarpus indicus, Calophyllum tomentosum, Artocarpus hirsutus* etc. were intensively extracted from here from 1940's to 1980's. Such extraction created enormous incidental damages in addition to exposing the forest floor with its shade and humidity loving species to the scorching tropical sun during the post-monsoon period. The outcome was largescale invasion of the gaps by weeds and other heliophilous pioneers. Even after the ban on selection felling operations were carried out for collection of dead and fallen trees from the forest for some more years. Needless to say all these are expected to be detrimental on the forest ecosystem as a whole, compacting soil, exposing it to erosion, increasing evaporation and also affecting the nutrient inputs into the soil.

Cultivation within kan: Agriculture is the main livelihood of the people in Siddapur as is with most in the interior of Uttara Kannada. The main crops grown are areca, banana and paddy. In fact these crops require large quantity of water so the cultivators target valleys with rich supply of water from streams for starting new gardens or rice fields.

Encroachment: Small scale encroachments that have taken place periodically within the forest, especially in the swamp areas, apparently were not prevented on time. Each such encroachment has left indelible imprint on the extent of the swamp, even though some such encroachments have been cleared by the Forest Department. Taking this as an advantage this type of encroachment is very common.

Cattle grazing: Cattle grazing within the forest was observed during the survey. People from nearby places allow cattle to graze in the forest. Cattle were found to wander even in the interior part of the forests. Trampling by the cattle expectedly would be a hazard for sensitive species. If cattle grazing goes on uncontrolled there could be a selection pressure favouring only browsing tolerant species in the future. The former logging roads help villagers to move within the forest along with their cattle.

Lopping: Lopping the ground plants, mainly tree saplings and shrubs for the green manure purpose has been indulged in, causing serious depletion of ground flora. Many sensitive tree species are thereby affected adversely. Shrubs and small trees are cutting for fencing stakes and poles as well, with adverse effects on the growing stock.

Road: Honnavar-Bangalore National High way is passing through the heart of Kathlekan. Road construction through the forest is one of the major threats in many parts of the Western Ghats. The infrastructural developments became an inevitable need of the time. However optional routes could have been found out instead of sacrificing precious swamps and Dipterocarpus forests for road making. Road breaks the continuity of forest and create edges along it. The road also becomes a certain barrier for animal movements. In the rainy season many endemic amphibians particularly get crushed under the wheels of vehicles.

Conservation and Management plan for Kathalekan: The case of Kathalekan as a relic forest is much stronger perhaps than any such *kans* of central Western Ghats. Here we find high degree of plant endemism, resembling forests of more southern Western Ghats. The *Myristica* swamp resembling those of south Travancore, and the rest of evergreen forest liberally sprinkled with southern climax species such as *Dipterocarpus indicus, Palaquium ellipticum, Mesua ferrea, Syzygium spp*, etc with rich under growth of especially the slender palm *Pinanga dicksonii* and clumps of *Ochlandra* are a visual demonstration of congenial microclimatic condition and rich soil with high water conservation values. The swamps being the peak expression of the high water content, the *Myristica* swamps are also sources of perennial streams and have some of the most ancient land biodiversity of the earth dating back to the Gondwanaland.

That such a forest also having some savanna regions and gorge of the River Sharavathi having tremendous micro and macro heterogeneity should fall prey to cater to escalating human wants for industrial timbers, speaks about the slighting attitude that we have developed towards pieces of primeval nature. This short term study therefore has become helpful for formulating a conservation and management plan for Kathlekan.

i) ***Declaring as biodiversity heritage site***: According to the Biodiversity act, 2002, there is a provision to declare locally unique areas as heritage sites. This study, though primarily focus on plant ecology, nevertheless is sufficient proof of the biological richness of the forest, the rarity of its element and the high potential of water shed conservation. The fauna particularly Lion tailed Macaque, endemic amphibians, rare hornbills and Imperial Pigeon, etc. strengthen the cause of endowing such special status.

ii) ***Management of water courses***: Perennial water sources flanked by swamps in many places are unique to this forest. But as such there is no appreciation of these vital arteries of the forest that has resulted in drastic reduction in summer time water flow. The swamp biota including the newly discovered critically endangered tree species *Semecarpus kathlekanensis* is facing extinction. This situation has arisen because few families living in Kathalekan area have steadily expanded their holdings to the species rich forest for growing primarily arecanut and banana. Streams that should be running through the swamps have been diverted in to these farmland with scanty concern shown for the regeneration and survival of sensitive species. The indiscriminate use of stream water, particularly in summer months also could have caused less water input into Sharavathi River which has a power generating station down stream at Gersoppa. The farm products from just few acres of arecanut and banana are trifles compared to the invaluable plant and animal species of great antiquity and rarity. Therefore it is recommended that the quantum of water used by the few farmers be regulated, especially during summer months. Irrigation if at all required during March to May period should be from wells than from forest streams. Stream bunding and diversion during summer months need to be prohibited.

iii) ***Maintenance of Savanna***: Savannas on hill tops in and around Kathlekan enhance landscape heterogeneity and promote wild life. They need to be maintained as such without bringing under afforestation schemes.

iv) ***Regulation of cattle grazing***: Cattle including buffaloes were found roaming unattended to through forest paths. Especially the entry into the swamp and streams results in trampling of the fragile saplings, destruction through browsing and water pollution from the dung. There should be awareness creation among the locals about especially sparing the swamps from the depredations of cattle.

v) ***Prevention of encroachment***: periodically attempts have been made in the past to clear the patches of forest especially near swamps and streams, for apparently for raising arecanut gardens. These encroachments have created indelible marks especially in *Myristica* swamps and *Semecarpus* patch. If vigilance was strong such damages could have been prevented. Therefore, it is suggested that monitoring by the forest department staff should be carried out on regular basis.

We recommend that the Government of Karnataka take immediate action to arrest the degradation of *kan* forests on priority basis by:

- Proper survey and mapping of boundaries of all *kans*;
- Assign the *kan* forests to the Forest Department for conservation and sustainable management;
- Constituting Village Forest Committees for facilitating joint forest management of the *kan* forests;
- Taking speedy action on eviction of encroachers from the *kans*;
- Giving proper importance to the watershed value and biodiversity of the *kans*;
- Taking special care of threatened species and threatened micro-habitats within the *kans*;
- **Heritage sites status to '*kans*' under section 37(1) of Biological Diversity Act 2002, Government of India** as the study affirms that *kans* are the repository of biological wealth of rare kind, and the need for adoption of holistic eco-system management for conservation of particularly the rare and endemic flora of the Western Ghats. The premium should be on conservation of the remaining evergreen and semi-evergreen forests, which are vital for the water security (perenniality of streams) and food security (sustenance of biodiversity). There still exists a chance to restore the lost natural evergreen to semi-evergreen forests through appropriate conservation and management practices.

16.0 ASSESSMENT OF CARBON DYNAMICS (SEQUESTRATION POTENTIAL, EMISSION).

Task 7: Carbon Dynamics (Sequestration and emission)
1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, 2013. Carbon sequestration in Uttara Kannada, Sahyadri Conservation Series 33, ENVIS Technical Report 63, CES, Indian Institute of Science, Bangalore 560012, India 2) Ramachandra T V, Subash Chandran M D, Joshi N V, Daval Joshi and Maneesh Kumar, 2012. Soil quality across diverse landscapes in Central Western Ghats, India, Sahyadri Conservation Series 16, ENVIS Technical Report: 42, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

16.1 CARBON SEQUESTRATION IN UTTARAKANNADA

Carbon dioxide, nitrous oxide, methane, chlorofluorocarbon and water vapors are major greenhouse gases (GHG). Carbon dioxide (CO_2) is one of the more abundant greenhouse gases and a primary agent of global warming. It constitutes 72% of the total anthropogenic greenhouse gases. IPCC (2007) reported that the amount of carbon dioxide in the atmosphere has increased from 280 ppm (1750) to 394 ppm in 2012. Similarly, methane (CH_4) and nitrous oxide (NOx) concentrations have risen substantially from pre-industrial levels (from 715 ppb to 1730 ppb, and 270 ppb to 319 ppb respectively). For these gases, most of the concentration increases have occurred during the last 100 years. Higher concentrations of GHG in the atmosphere have contributed to global warming and changes in the climate. *Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).*

Carbon footprint refers to the total set of greenhouse gas (GHG) emissions in a region due to anthropogenic activities. Major sources of GHG are forests (deforestation), power generation (burning of fossil fuels), agriculture (livestock, farming, rice cultivation and burning of crop residues), water bodies (wetlands), industry and urban activities (building, construction, transport, solid and liquid waste). Forests mitigate global warming through sequestration of carbon in the environment due to anthropogenic activities. Atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. The sink of carbon sequestration in forests and wood products helps to offset anthropogenic sources of carbon dioxide to the atmosphere. Emission and sequestration of carbon needs to be in balance in the Earth system to maintain the environmental conditions. This necessitates quantification of emissions and carbon sequestration potential to ensure the sustainability of resources. Budgeting carbon involves region wise quantification of the sources and sinks of carbon. Sustainable management practices will enhances the ability of forests to sequester atmospheric carbon apart from other ecosystem services, such as improved soil and water quality.

Forests are vital ecosystems, playing a key role in the food chain, hydrology, and other ecosystem functions. Need to manage these fragile ecosystems has been realized in recent times considering their significant role in sustaining the ecosystem services such as bio-geo chemical cycling, nutrient and hydrologic cycling. Sustainable management of forest ecosystems helps in the conservation as well as the sustenance of ecological services.

Carbon sequestration is a phenomenon for the storage of CO_2 or other forms of carbon to mitigate global warming through biological, chemical or physical processes. Kyoto protocol emphasizes the need to reduce carbon emissions and role of (http://unfccc.int/kyoto_protocol/ items/2830.php). In this regard, many clean development mechanism (CDM) projects were initiated to enhance the assimilation and sequestration of carbon.

The current study assesses the carbon sequestration potential of forest ecosystems in Uttara Kannada district, central Western Ghats. Uttara Kannada district in Karnataka, has a unique distinction of having highest forest cover (~80%). Forests in the southern part (Bhatkal, Honavar, Siddapur and Kumta) have more evergreen-ness than central (Sirsi, Ankola and Yellapur) and northern (Karwar, Supa taluks) regions. Mundgod and Haliyal in the north-east are dominated by deciduous forests and teak plantations. Eastern parts of Sirsi and Yellapur tend to be of deciduous nature. Endemic species of trees occur in evergreen forests of the Ghat areas of Honavar, Siddapur, Bhatkal, and Kumta.

Carbon gets sequestered in the system through vegetation (forest, plantation, horticulture, etc.), aquatic ecosystems (phytoplankton) and soil. Stored carbon and annual sequestration were quantified based on the data from field investigations and compiled from government agencies and literatures. Total carbon stored in forest vegetation and soils are 56911.79 Gg and 59693.44 Gg and annual carbon increment is about 975.81 Gg (1951.61 Gg biomass). Carbon uptake from natural forest is 2416.69 Gg/yr and from forest plantations is 963.28 Gg/yr amounting to the total of 3379.97 Gg/yr.

The study quantifies taluk wise sources and sinks of carbon. Aggregation of carbon emissions from different sources (livestock, paddy cultivation, fuel wood consumption and vehicular transport) are 87.70 Gg/yr, 101.57Gg/yr, 77.20 Gg/yr, 437.87 Gg/yr respectively. The ratio of carbon sink to the source indicates the carbon status of a region. The analysis highlights that forest ecosystems in Uttara Kannada are playing significant role in the regional as well as global carbon budget. Hence the district is a true candidate to enjoy the benefits under Clean Development Mechanism (CDM), as per Article 12 of the Kyoto Protocol. This would help in the improved livelihood of ecosystem people while practicing the conservation and sustainable management of forests The objective of the current research is to carry out taluk wise carbon budget for Uttara Kannada district, Central Western Ghats. This involves:

I. Source wise carbon sequestration assessment with the combination of field and remote sensing data;
II. Sector wise Carbon emission assessment; and
III. Computation of carbon metric (ratio of carbon sink to source).

The population of Uttara Kannada district was 1,353,644 (according to 2001 census data) which account to a population density of 132.42 persons per sq. km implying a growth of 10.9 % in population data of 1991. As per 2011 census population density is 140 persons per sq. km. Bhatkal taluk has maximum, while Supa taluk has minimum population density. Nearly 75 % of the population of the district lives in rural area and remaining 25 % in small towns. Figure 16.1 outlines the method adopted for budgeting carbon in the district.

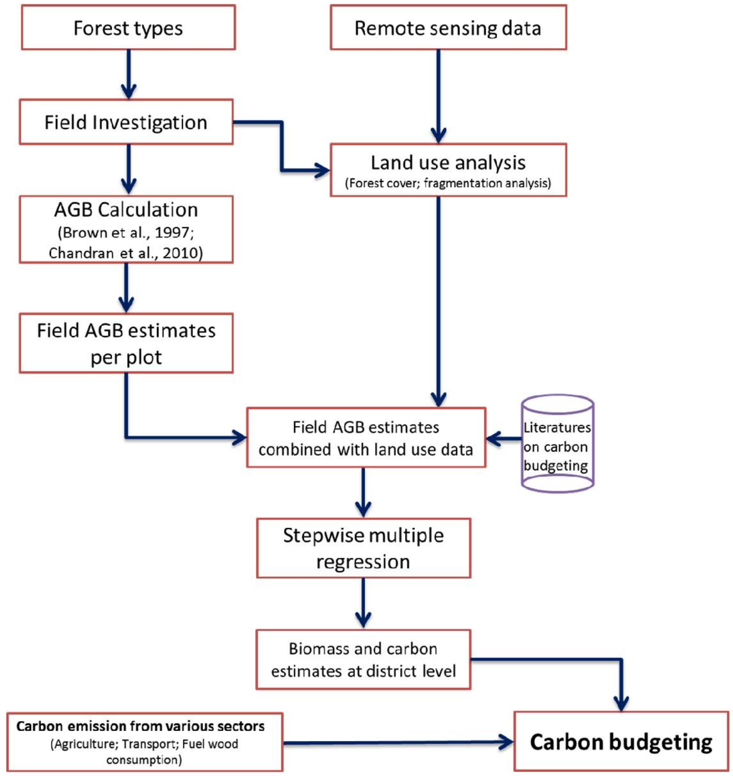


Figure 16.1: Method adopted for carbon budgeting

The carbon sequestration and emission from various sectors is computed for budgeting carbon in the district. The land use is analysed and emission factors from various sources are collected for computation. Carbon sequestered by forests in each grid (of the district) is shown in figure 16.2, which accounts to 59313.8 Gg. Forests in Supa, Yellapura, Sirsi regions have stored higher carbon (600-800 & >800 Gg) compared to the plains and part of coastal regions. Sahyadri region with protected areas and 'sacred kan' forests have sequestered higher carbon, **emphasize the need for protecting forests to mitigate impending changes in the climate due to global warming**. These forests have been protected for long because of the cultural and religious significance attached to them and hence, were relatively less disturbed than others. This has allowed the trees to grow to their fullest and accumulate significantly more biomass than in most other areas, which are prone to ongoing human pressures or due to the disturbances in the past (as in a savannized land).

The supply (availability) to demand ratio is computed to assess the bioenergy status in each grid, considering the annual biomass productivity and fuel wood demand in each grid. Figure 16.3 illustrates the bioenergy status in the district considering the ratio of availability to demand. The ratio less than one indicates of fuel wood scarcity while the ratio greater than one indicates of adequate availability of fuel wood. The supply to demand ratio shows Supa taluk is having higher ratio revealing surplus biomass availability due to higher forest cover and lower demand. The central parts of grids (Karwar, Ankola, Sirsi) also show higher availability due to higher forest in those regions where as towards west in Karwar, Ankola and east part of Sirsi region shows lower ratio due to higher demand (presence of a larger population). Bhatkal, Haliyal, Mundgod and eastern part of Yellapura and Siddapur have the scarcity of resources evident from the supply to demand ratio less than one. Fuel wood scarcity is evident in thickly populated plains and coastal taluks, necessitating the policy interventions to augment bio-resources apart from viable energy alternatives.

Soil carbon constitutes the biggest terrestrial carbon pool. Carbon stored in soil pools is less vulnerable to release through disturbances like fire or harvest removals and emission to the atmosphere than the carbon that is stored in the above ground biomass. The net storage of forest soil carbon in Uttara Kannada district is 59693.44Gg and figure 16.4 gives grid-wise carbon sequestered in forest soil.

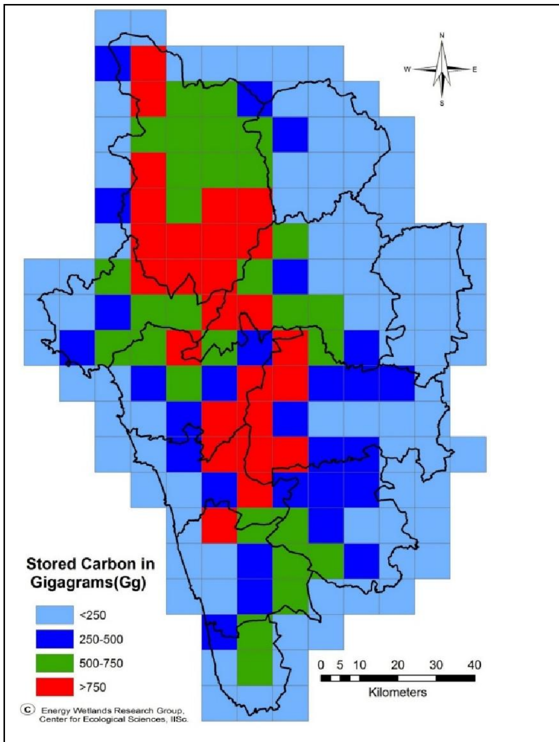


Figure 16.2: Sequestered Carbon estimated in Gg

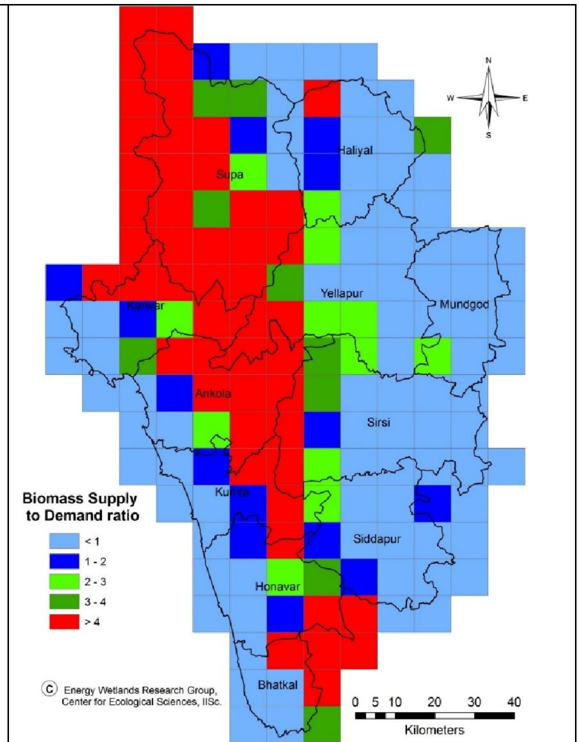


Figure 16.3: Biomass supply to demand ratio

CARBON STATUS IN UTTARA KANNADA: Carbon budgeting would provide information of Greenhouse Gas (GHG) emissions (especially carbon dioxide (CO_2) in the atmosphere, and on the carbon cycle in general), which helps in implementing strategies to mitigate carbon emissions and manage dynamics of the carbon-climate-human system. Budgeting of carbon was done by quantifying carbon sources as well as sinks. The ratio of carbon sinks to sources would provide the carbon status in the region. Sources include livestock, agriculture, fuel wood consumption, transport, etc. Sinks include forest vegetation and soil. The taluk wise total carbon emission and sequestration is shown in figure 16.5. The total carbon emission of didtrict is 704.35 Gg and sink is 3379.97 Gg. The major emission can be seen in Sirsi (135.63 Gg), Karwar (97.57 Gg), Haliyal (86.21 Gg) due to various anthropogenic factors. These regions have higher vehicle density, livestock density, higher emission from paddy fields, fuel wood consumption. The Supa (682.25 Gg), Yellapura (509.11 Gg) and Ankola (396.94 Gg) taluks are acting as a major sink of the district. Carbon status computation shows Supa (27.33), Yellapura (14.41), Ankola (6.90) are having higher values revealing the taluks are aiding in higher carbon sequestration as area under forest cover (Figure 16.6). The net carbon balance calculated as the net source or sink of the forest sector to provide a base for UNFCC. United Nations Framework Convention on Climate Change (UNFCCC) emphasis on the signatory nations to provide a periodic update of carbon budget in the atmosphere. This endevour provides a frame work for carbon budgeting in the region.

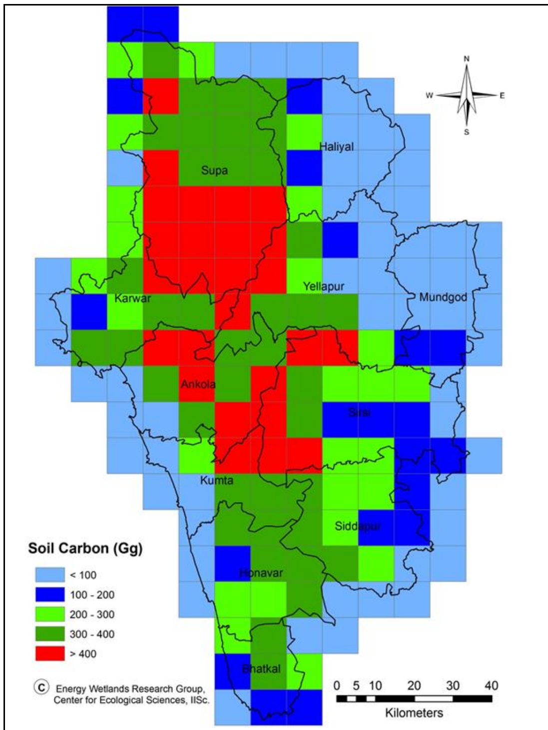


Figure 16.4: Soil carbon sequestration

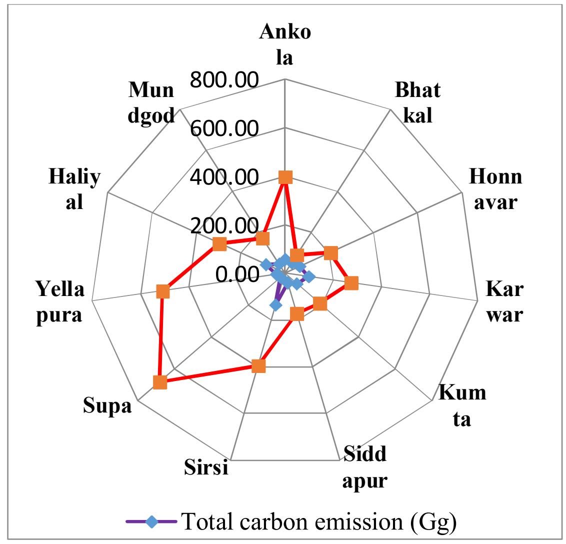


Figure 16.5: Taluk wise estimates of carbon sink and sources

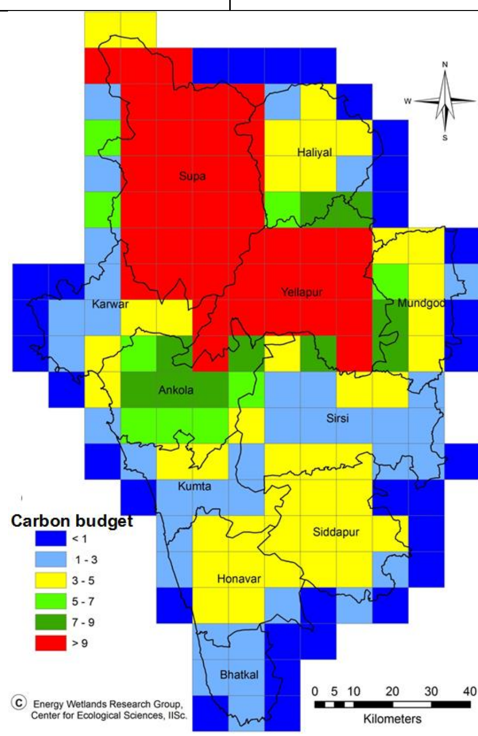


Figure 16.6: Carbon status in Uttara Kannada district

Suggestions: Following are the recommendations provided to enrich the carbon sequestration potential of region and reducing emission.

i. The region has higher rainfall (upwards of 3000 mm/per annum) in most places, a dense forest cover is required to check soil erosion and increase infiltration. Enriching degraded forest patched with the location specific native species (except grasslands or grassy blanks, critical resources for grazing ecosystems) to enhance the carbon sequestration potential of the region.
ii. The forest department, for its administrative/practical convenience would prefer afforestation of large blocks of land than carrying out the process in a diffused fashion in the small blanks and degraded forest patches, which are dispersed widely almost everywhere, except in the steep areas of the ghats. This is understandable because saplings raised in centralized nurseries have to be transported, through the roads in bulk to the planting areas. The labour management will be easier and less expensive than if small planting areas are dispersed here and there, even in the interiors without proper road facility. The model that we suggest here is one of **decentralized local farmer-centric nurseries**, raised in small scale closer to the areas to be planted. This gives scope for sector-wise selection of plant species that are suitable for the local conditions of the respective areas.
iii. We recommend **peoples' nurseries** to get ready saplings instead of centralized nurseries of forest department. This will generate more of rural employment potential, all along the proposed alignment areas, for the same people who might as well be important stakeholders in the future on the very vegetation wealth they create. It is notable that several habitually forest dwelling communities here, such as Gowlis, Siddis, Kunbis, Karivokkaligas, Halakkivokkals etc. who live in these parts can be associated as partners in conservation efforts and benefit sharing in accordance with the various forest regulations and provisions and Forest Dwellers' Act, 2006. Year-wise progress achieved in these afforestation activities has to be recorded. In addition we also recommend **fencing of blocks of forest lands** with basal areas of less than 15 sq. m each, for minimum periods of 8-10 years, will prevent the entry of domestic cattle and humans into these protected blocks and pave the way for natural regeneration of especially native species of plants.
iv. Biomass enrichment is an urgent necessity and poor grade tree plantations of Haliyal, Mundgod, Kirvathi division of Yellapura regions need to be restored with natural forest species through planting of saplings and seeds to enhance eroded soils.
v. The betta and hakkal lands should be fenced and natural regeneration, enriching grassy blocks can be promoted. The degraded regions such as betta and hakkal lands should be reforested by public private partnership.
vi. Create incentives for adopting energy-efficiency measures in industry that accommodate changing market conditions and pressures, energy prices and business concerns that affect the ability and willingness of industry to pursue energy efficiency opportunities.
vii. Promote increased levels of recycling and remanufacturing to recover the energy invested through virgin material processing.
viii. Various plant species of the district are sources of bio pesticides. Preparation of bio-pesticides, harmless to humans and domestic animals, may be promoted as a cottage industry using local plant resources, especially from village peripheral forests/VFC managed areas.
ix. This approach can further improve organic farming in the district while also earning extra income to the locals from production of marketable, homemade bio pesticide formulations, under an assisted programme from the Government.
x. Forest range wise river-stream-swamp protection action plans should be framed which incorporating adequate amount of inviolate vegetation growth for protection of ecology. River and stream bank forests, including inland swamp area forests are to be considered as endangered ecosystems for their high accumulation of biomass, presence of endemic species and higher levels of carbon sequestration.

xi. Investments in research to develop cost effective renewable and efficient energy technologies, improve the performance of carbon energy systems is recommended for clean energy systems.
xii. Increased emphasis and investment in education and training of the employees, NGOs in alternate renewable and energy efficient technologies and their deployment is required for reducing emission by public private participation.

17.0 ASSESSMENT OF ECOSYSTEM SERVICES AND GOODS

Task 8: Assessment of ecosystem services and goods

1) Ramachandra T V, Subash Chandran M D, Joshi N V, Rakhi Raj, Prakash N Mesta, sumesh Dudani, 2013. Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka, Sahyadri Conservation Series 27, ENVIS Technical Report 45, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
2) Ramachandra T V, Subash chandran M d, Joshi N V, Divya Soman, Ashwath D Naik, Prakash N Mesta, 2013. Valuation of goods and services from forest ecosystem of Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 25, ENVIS Technical Report: 44, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
3) Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 19, ENVIS Technical Report: 49, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
4) Ramachandra T V, Subash Chandran M D, Joshi N V and Boominathan M, 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report: 48, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

17.1 VALUATION OF GOODS AND SERVICES FROM FOREST ECOSYSTEM

Forest ecosystems are critical habitats for diverse biological diversity and perform array of ecological services that provide food, water, shelter, aesthetic beauty, etc. Forests provide various services classified as supporting services, provisioning services, regulating services and cultural services Most of these services are underestimated or not estimated and are thus undervalued in policy decisions. This paper is based on the quantification of various provisioning services from forests such as timber, fuel wood, fodder, green leaf manure, medicinal plants and NTFP. The area under different types of forest is derived from remote sensing data. Quantification of forest goods has been done based on the data compiled from the division offices of the Forest Department and micro level studies (productivity, etc.). Market prices were used for valuing the goods. The valuation of forest goods and services at micro level is expected to explore the possibilities for more effective micro level planning. This helps in integrating the environmental services with the economic goals of the region while ensuring the sustenance of natural resources and maintaining intergeneration equity.

Valuation of the services and goods provided by the forest ecosystem would aid in the micro level policy design for the conservation and sustainable management of ecosystems. Main objective of the study is to value the forest ecosystems in Uttara Kannada forest. This involved computation of total economic value (TEV) of forest ecosystem considering provisioning, regulating, supporting and information services provided by the ecosystem

The flow of goods or services which occur naturally by ecological interactions between biotic and abiotic components in an ecosystem is often referred as ecosystem goods and services. These goods and services not only provide tangible and intangible benefits to human community, but also are critical to the functioning of ecosystem. Valuation of ecosystem goods and services is essential to frame, prioritise and justify sustainable development policies oriented towards the protection or restoration of ecosystem.

The ecosystem goods and services with the ecological perspective of valuation can be grouped into four different categories, which are:

i. Provisioning services – it includes products i.e., food (including roots, seeds, nuts, fruits, spices, fodder), fibre (including wood, textiles) and medicinal and cosmetic products.
ii. Regulating services – which are of immense importance to the human society such as (a) carbon sequestration, (b) climate and water regulation, (c) protection from natural hazards such as floods, avalanches or rock-fall, (d) water and air purification and (e) disease and pest regulation.
iii. Supporting services – such as primary and secondary production and biodiversity; a resource that is increasingly recognized to sustain many of the goods and services that humans enjoy from the ecosystem.
iv. Cultural services – which satisfy human spiritual and aesthetic appreciation of ecosystems and their components.

Forests are multifunctional ecosystems that provide both ecological and economic security with provision of goods and services. The functioning and sustainability of global ecosystem depends much on the status of forest ecosystem. Forests are the basis of livelihoods for people who depend on forest goods and services. The degradation of forest is a critical problem, as it negatively affects the livelihood of the forest dwelling communities. However, the value of forest has often been overlooked in the process of decision making. In this context, valuation is necessary for effective conservation and management of forest resources. The present study estimates the value of forest ecosystem of Uttara Kannada district. The total economic value of forest ecosystem is comprised of value of provisioning, regulating, cultural and supporting services. The value of provisioning goods and services are computed by market price method. Surrogate prices are used for those provisioning goods and services which do not pass through market transaction. The value of regulating, cultural and supporting services is based on the values derived from literature. The total value of provisioning goods and services from the forests of Uttara Kannada district was estimated at Rs. 15,171 crores per year, which amounts to about Rs. 2 lakh per hectare per year. The total economic value was estimated to be Rs. 84,321 crores per year. The study clearly shows the undervaluation of forest goods and services that is evident when the estimated total economic value of forest and the value of forest resources calculated in national income accounting framework are compared. The quantification of all benefits associated with the forest ecosystem goods and services would help in arriving at an appropriate policy and managerial decisions. In absence of the ecosystem valuation, policy decisions are lopsided in favor of environmentally degrading practices by neglecting the diffuse social interests that benefit from the use and non-use characteristics of ecosystems.

The framework for incorporating the true value of forest in the GDP requires thorough valuation of the benefits derived from forest ecosystems. Taluk wise forest valuation has been done through the quantification of goods, estimation of values based on the market price, and compilation of values of ecosystem services form literatures. Total economic value of the forest ecosystems in Uttara Kannada has been done considering i) provisioning services, ii) regulating services, iii) supporting services and iv) information services (MEA 2003). The research includes compilation of data from primary (field investigations) and secondary sources (government agencies, published scientific literatures in peer reviewed journals). Data on quantity of timber and non – timber forest products harvested were collected from Divisional Office (Sirsi) of Karnataka Forest Department, Government of Karnataka. Data on the prices of various marketed forest products were collected through market survey. Data on various other provisioning goods and services were compiled from literature pertaining to ecological and socio-economic studies in the district and also through interview with the subject experts. Valuation of forest ecosystems involved:

1. Assessment of different land uses in the district: This was done considering remote sensing data of space borne sensors (IRS P6) with spatial resolution of 5.8m. The remote sensing data were geo-referenced, rectified and cropped pertaining to the study area. Geo-registration of remote sensing data has been done using ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also from known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India (1:50000, 1:250000).
2. Quantification of goods and services: compilation of data from primary (field investigations) and secondary sources (government agencies, published scientific literatures in peer reviewed journals). Data on quantity of timber and non – timber forest products harvested were collected from Divisional Office (Sirsi) of Karnataka Forest Department, Government of Karnataka.
3. Valuation of goods and services: Various functions of forests are the results of interaction between structure and processes, which may be physical (e.g. infiltration of water, sediment movement), chemical (e.g. reduction, oxidation) or biological (e.g. photosynthesis and denitrification). Further, various goods and services obtained from the functioning of forest ecosystem were classified as provisioning goods and services, regulating services, cultural services and supporting services. The study uses two approaches of valuation for the computation of TEV of forest ecosystem, namely: 'market price' method and 'benefit transfer' method of valuation.

Goods and services quantified from forests of Uttara Kannada at taluk level include timber, NTFP, bamboo, canes, food, medicinal plants, honey from bee keeping, fodder, fuelwood for domestic and commercial usage, litter, mulching leaves, inland fishing, domestic water use, industrial water use, water for power generation, irrigation services, ecological water, oxygen provision and wild fruits. Data were compiled from Divisional Office of Karnataka Forest Department, literatures pertaining to ecological and socio-economic studies in the district and also through interview with the subject experts. Spatial extent of different types of forests was analysed using remote sensing data. Minimal forest gate price of the goods are used for valuation of goods and proxy prices are used for goods which do not pass through market transactions. Valuation: The quantified goods and services are valued by market value approach given by the equation 1.

$$V = \sum_{i=1}^{11}\sum_{j=1}^{n} Q_{i,j} \times P_{i,j} \quad \ldots\ldots \; 1$$

Q: quantity of goods, P: price of goods, i: number of taluks, j: goods type

Example:

$$V_{Timber} = \sum_{i=1}^{11}\sum_{j=1}^{7} Q_{i,j} \times P_{i,j}$$

where, V_{Timber} = value of timber in the district; Q = quantity of timber; P = price of timber; i = no. of taluks, j = timber types (teak, rosewood, jungle wood, etc.).

The provisioning services were valued as per the equations in Table 17.1 based on market price method.

Table 17.1:Valuation method for components of provisioning services of forest

Sl. No.	Provisioning services	Equation	Details
1	Timber	$V_{Timber} = \sum_{i=1}^{11}\sum_{j=1}^{6} Q_{i,j} \times P_{i,j}$	Q=Quantity of timber; P = Price of timber; i = no. of taluks; j = variety of timber
2	NTFP	$V_{NTFP} = \sum_{i=1}^{11}\sum_{j=1}^{30} Q_{i,j} \times P_{i,j}$	Q=Quantity of NTFP; P = Price of NTFP; i = no. of taluks; j = variety of NTFP
3	Litter	$V_{Litter} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of litter; P = Price of litter; i = no. of taluks
4	Mulching Leaves	$V_{Mulch} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of mulching leaves; P = Price of mulching leaves; i = no. of taluks
5	Fodder	$V_{Fodder} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fodder; P = Price of fodder; i = no. of taluks
6	Fuel wood	$V_{Fuelwood} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fuel wood; P = Price of fuel wood; i = no. of taluks
7	Food	$V_{Timber} = \sum_{i=1}^{11}\sum_{j=1}^{22} Q_{i,j} \times P_{i,j}$	Q=Quantity of food; P = Price of food; i = no. of taluks; j = variety of food product
8	Inland fish catch	$V_{Fish} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fish catch; P = Price of fish; i = no. of taluks
9	Hydrological services	$V_{water} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of water utilization for different purpose; P = Price of water used for different purpose; i = no. of taluks
10	Wild fruits	$V_{Mulch} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of wild fruits; P = Price of wild fruits; i = no. of taluks
11	Oxygen	Value of oxygen provision from forests was quantified based on the values of oxygen production per hectare of subtropical forest (Maudgal and Kakkar, 1992).	

Provisioning goods and services: Based on the consideration and inclusion of various components in ecological perspectives, total value of provisioning goods and services are presented in scenarios as follows:

- Scenario-I: provisional services include timber, NTFP, litter and mulching leaves, fodder, medicinal plants, fuelwood, food, inland fishing and hydrological services;
- Scenario-II: components in Scenario-I and wild fruits;
- Scenario-III: components in Scenario-II and oxygen services;

The estimated total value of provisioning goods and services for Uttara Kannada district per year for three different scenarios are presented in Table 17.2.

Table 17.2: Provisioning Goods and Services (different scenarios) for Uttara Kannada

Scenario	Value of Provisioning goods and services (in Rs. crores)	Values of Provisioning goods and services (Billion Rs)
Scenario I	9707	97.07
Scenario II	11842	118.42
Scenario III	15171	151.71

i). *Timber*: Timber accounts to Rs. 1,457 crores per year with the share of 10 per cent in scenario – III of the total value of provisioning goods and services obtained from the forest.

ii). *NTFP*: NTFP being the largest contributor among all the components of provisioning goods and services is estimated at Rs. 3,601 crores per year for the district.

iii). *Litter and mulching leaves*: Litter and mulching leaves which is a vital component of sustainable agricultural system of the district is valued at Rs. 689 crores per year.

iv). *Fodder*: The value of total fodder productivity in the forests of the district is valued at Rs. 205 crores per year.

v). *Medicinal plants*: The value of medicinal plants that has been estimated from the benefit transfer method and extrapolated to the different types of forest is found to be worth of Rs. 25 crores per year.

vi). *Fuelwood*: Forest being the important source of energy for domestic and various commercial purposes in the district supplies fuelwood of Rs. 366 crores per year.

vii). Food: The value of various food products extracted from forest is of worth Rs. 59 per year. Further the inland fishing in the district is valued at Rs. 22 crores per year.

viii). *Hydrological services*: The total value of water usage for domestic purpose, industrial purpose, irrigation, water requirement for livestock, power generation and ecological water was termed as hydrological services from the forests. It was found that the forests in the district provide hydrological services of worth Rs. 2,313 crores per year.

ix). *Wild fruits*: Wild fruits being the important component in ecological sustenance of forest ecosystem are being valued at Rs. 1,922 crores per year that is obtained from the forests of entire district.

x). *Oxygen*: The value of oxygen which is computed by benefit transfer method. The result of the study shows that the total forests in the district supplies the oxygen to the atmosphere of worth Rs. 3,000 crores per year. Further 10 percent of the total value of provisioning services supplied from forest being considered as miscellaneous benefits that are derived from forest ecosystem is of value Rs. 1517 crores per year (for scenario – III).

Figure 17.1 portrays the share of different components of total provisioning goods and services in three scenarios. In all the three scenarios, NTFP is the major contributor to the total value. The share of the value of food, inland fishing, medicinal plants, fuel wood, fodder, litter and mulching leaves varies from 14% in Scenario-I to 8% in Scenario-III. These goods have an important bearing on the livelihood of people and especially the livelihood of local people. The value of wild fruits and oxygen provision comprises to about thirty five per cent share in the total value in Scenario – III. These components are often neglected in valuation of forest and policy making but they play an important role in ecosystem sustenance, protection of biodiversity and thus in human wellbeing in the long run. Figure 17.2 presents the talukwise breakup in the total provisioning goods and services of the district. This illustrates that Supa taluk contributes the highest amount of provisioning goods and services with Rs. 3,219 crores per year (21% of the district), while Bhatkal taluk contributes the least of Rs. 541 crores per year (3.6% of the district).

Figure 17.1: Share of Total Value of Provisioning Goods and Services from Forest Ecosystem

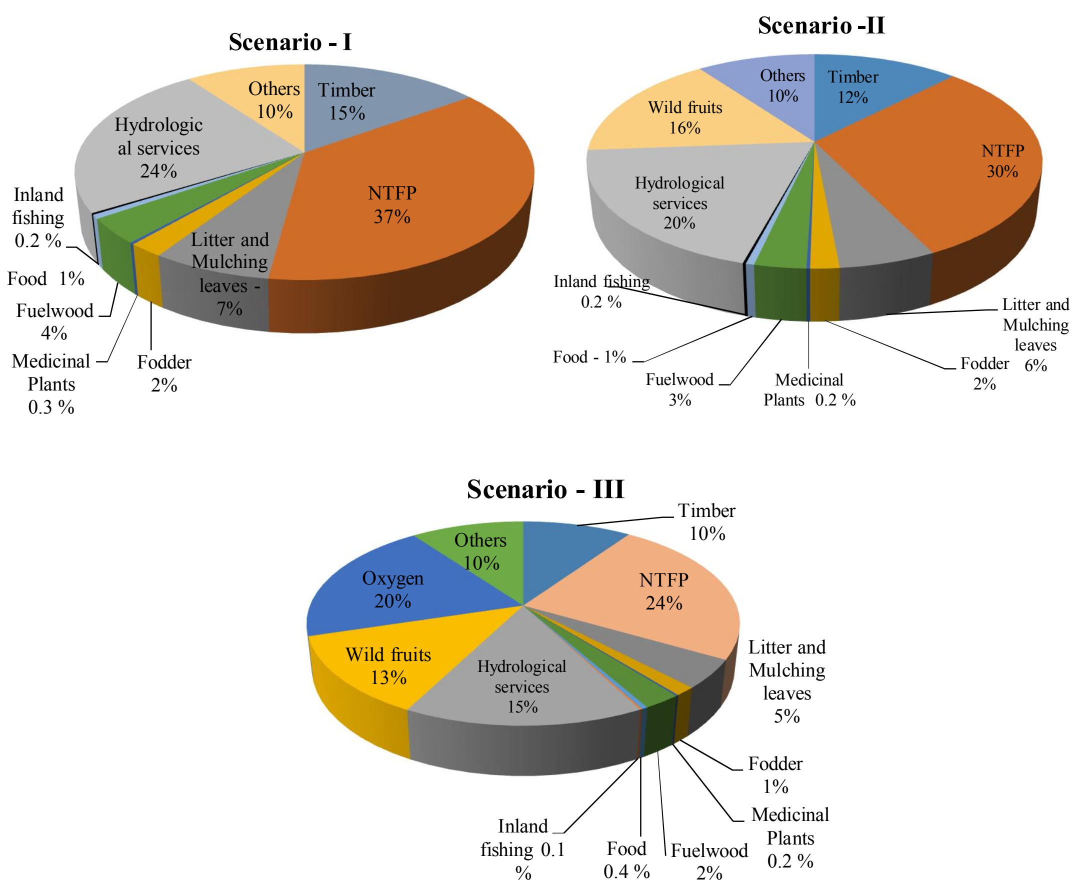
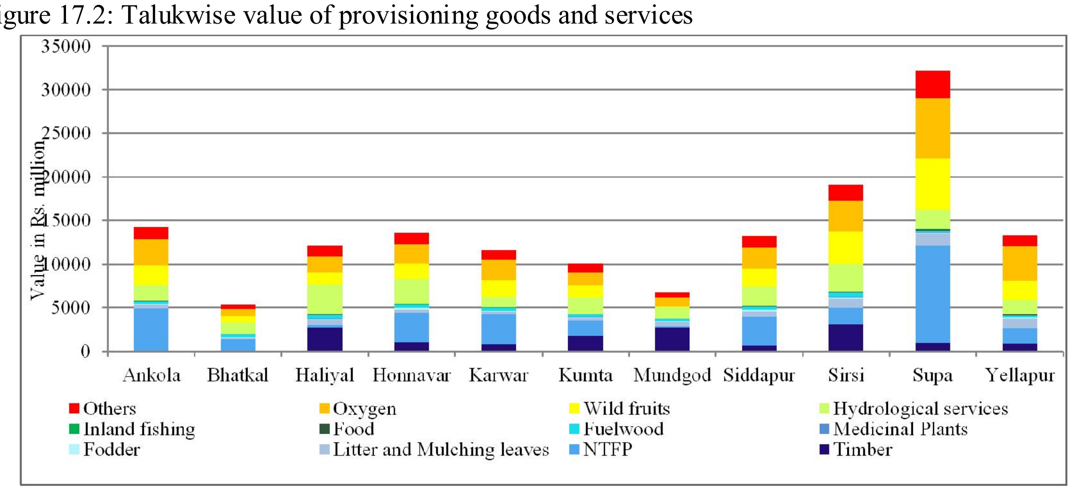


Figure 17.2: Talukwise value of provisioning goods and services



Total Economic Value of Forest Ecosystem in Uttara Kannada district: Total economic value (TEV) is calculated by aggregating provisioning services, regulating services, cultural services and supporting services. Total economic value (TEV) for all three scenarios and are presented in Table 17.3. The TEV of forest ecosystem in Uttara Kannada district is Rs. 78,857 crores, Rs. 80,993 crores and Rs. 84,321 crores for Scenario-I, II and III respectively.

Table 17. 3: Total economic value goods and services from forest ecosystem in Uttara Kannada district (in Rs. crores)

Scenario	Provisioning Services	Regulating Services	Cultural Services	Supporting Services	Total Economic Value
Scenario - I	9,707	45,647	14,388	9,115	78,857
Scenario - II	11,842				80,993
Scenario - III	15,171				84,321

Table 17.4 presents the share of different categories of services from forest ecosystem for scenario – III. Regulating services underpin the delivery of other service categories, contributes to half of the share (54%) of the total economic value of forest ecosystem in the district. Provisioning services (18 per cent), cultural services (17 per cent) and supporting service (11 per cent) contributes to the other half of total economic value. Value of provisioning services provided by the forest ecosystem is about Rs. 2,03,818 per hectare per year and the total value is about Rs. 11,32,832 per hectare per year which is implicit in the subsistence, income and local employment.

Table 17.4: Total value of goods and services from forest ecosystem in Uttara Kannada

Services from forest Ecosystem	District Value per year (in Rs. crores)	Value of services per hectare per year (in Rs.)	Per cent share
Provisioning services	15,171	2,03,818	18
Regulating services	45,647	6,13,254	54
Cultural services	14,388	1,93,296	17
Supporting services	9,115	1,22,464	11
Total Value	84,321	11,32,832	100

Total economic value of forest ecosystem and GDDP: Sector-wise district's Gross District Domestic Product (GDDP) given in Table 17.5. GDDP of Uttara Kannada is about Rs. 5,978 crores and the contribution of forests' goods is about Rs. 180 crores (3% of GDDP), in contrast to the estimated valuation of provisioning services (ranges from 9707 to 15171 crores per year).

Table 17.5: GDDP of Uttara Kannada with Sectors: 2009-10

Sector	**Sectoral contribution (in Rs. crores)**	**Sectoral Share (in per cent)**
Primary Sector (Agriculture, Forestry, Fishing, Mining)	1060	18
Forestry and Logging Sector	180	3
GDDP of Uttara Kannada	5978	100

Source: Directorate of Economics and Statistics, Government of Karnataka.

The forest products included in the national income account framework includes: (a) Industrial wood (timber, match and pulpwood) and fuelwood and (b) minor forest products. It includes only the recorded values by forest department and thus all other benefits from forests are unaccounted in the national income. This necessitates relook at the current approach of computations of Gross domestic district product (GDDP), State Domestic Product (SDP) and Gross Domestic Product (GDP). **Gross underestimation and non-accounting of natural resources and forest resources in particular is responsible for unsustainable utilization of natural resources. Under valuation of ecosystem goods and services is evident from GDDP of Rs. 5,978 crores in 2009-10 (at current prices), which accounts as the sectoral share of forests of Rs. 180 crores contrary to the estimated valuation of provisioning services (ranges from 9707 to 15171 crores per year). This highlights the undervaluation of forest resources in the regional accounting system.**

Forest resources in the Uttara Kannada district has undergone tremendous change and degradation because the value of it is being poorly understood and not considered in the policy making process. However, valuation of regulating services, cultural services and supporting services are more difficult to estimate and thus pose serious challenges to planners and practitioners. As a consequence the values of these services are often overlooked. Hence, valuation of these services in income accounting of a region/ nation is essential to make the plans and policies more sustainable.

The comprehensive valuation has the potential to provide effective options for management of ecosystem. If the total economic value of forests ecosystem in particular and ecosystem in general are not considered in decision and policy making, the policies thus adopted would lead to detrimental effect on human and societal welfare in the long run. Policies therefore have an important role in ensuring that benefits from forest ecosystem are accounted in decision making to avoid underestimation of the values of forest, value of conservation and sustainable use of forest resources.

17.2 VALUATION OF ESTUARINE ECOSYSTEMS, UTTARA KANNADA

Economic valuation is a tool to aid and improve wise use and management of natural resources by providing a means for measuring and comparing the various benefits of those resources. The present study aimed at economic analysis of possible goods and services from the five estuaries - Kali, Gangavali, Aghanashini, Sharavathi and Venkatapura of Uttara Kannada, Karnataka. The provisioning services provided by these estuaries ranges from 55707 (Venkatapura) to 2,19,545 Rs (Gangavali) for smaller estuaries, 2,40,395 Rs/hectare/year (Kali), to 286964 Rs (Sharavathi) for estuaries of rivers with dams and 11,35,847 Rs/hectare/year (Aghanashini) for an estuary without any human interventions (Table 17.6). The overall objective of the present study is to estimating the total economic value of estuarine ecosystem of Uttara Kannada - Kali, Ganagavali, Aghanashini, Sharavathi and Venkatapura in Uttara Kannada.

Table 17.6: Value (Rs/Ha/Yr) of the Goods and Services from estuaries in Uttara Kannada

ESTUARY	Provisioning Services	Regulating Services	Supporting Services	Information Services
Kali	2,40,395	1,839,037	369,435	122,531
Gangavali	2,19,545	2,055,250	348,256	53,210
Aghanashini	11,35,847	1,835,288	1,946,030	87,871
Sharavathi	2,86,964	1,828,300	267,706	70,541
Venkatpura	55,707	1,028,162	211,976	37,247

Kali estuary - Kali estuary situated at 14.816^0 to 14.917^0 N and 74.125^0 to 74.267^0 E in the Karwar taluk of Uttara Kannada district of central west coast in the Karnataka State (figure 17.4). Kali river originate near the Diggi village in the Supa taluk with a total length of 184 Km meets the Arabian sea, 3 Km north of Karwar and forming an estuarine expanse of 3240 ha in area. The Kali estuary is surrounded by a variety of ecosystems such as mangrove swamps, mudflats, creeks and backwaters. The estuary is surrounded by 23 villages and one municipality.

Gangavali Estuary - Gangavali or Bedthi River is formed by the confluence of two streams at Khalghati in Dharward district and flows 25 Km westwards and reaches the Uttara Kannada district (figure 17.5). After a fairly straight south western flow it joins Arabian Sea at Manjuguni village of Ankola taluk and forming an estuarine habitat of about 700 ha area (at 14.586^0 to 14.618^0 N and 74.278^0 to 74.385^0 E). The estuarine habitat support 43.20 ha mangrove vegetation and it is surrounded by 15 villages.

Aghanashini Estuary - Aghanashini River has its source in the forest clad village Manjguni situated at an altitude of about 600 m in the central Western Ghats. Running its course of about 121 km, winding through gorges flanked with evergreen forests and valleys lush with spice gardens and rice fields, the river widens into an estuary covering about 4801 ha before its confluence with the Arabian Sea in the west coast between the villages Aghanashini in the south and Tadadi in the north, lies between 14.391° to 14.585° N and 74.304° to 74.516° E of Kumta taluk in the Uttara Kannada district of central west coast in the Karnataka State of India (Figure 17.6). All along its estuarine banks and few of the tiny islands are villages whose inhabitants mainly are traditionally dependent on agriculture and fisheries. There are about 21 villages of Kumta taluk situated on the estuarine banks.

Sharavathi estuary - Sharavathi estuary is located between 14.241^O to 14.385^O N, 74.418^O to 74.507 ^{O} E of Honavar taluk of Uttara Kannada district having an area of 1600 ha (Figure 17.7). The river has its origin at Tirthahalli taluk of Shimoga district and it joins the Arabian Sea at Honavar. The estuary is brackish in dry weather but during the rains it sweet even close to the mouth. About 8 Km from the mouth, the river widens to lagoon, about 3 Km broad containing a few islands. Towards the estuaries, swamps induce saline sand cultivation. In spite of the silted-up harbour and treacherous sand bar at the mouth, there is a good deal of sailing traffic.

Venkatapura estuary - The Venkatapura river (total length 20 Km) rising in the Sahyadri , near the village of Kranti north east of Bhatkal Taluk falls into the Arabian Sea near Venkatapur and forming a small estuarine expanse located between 14.008^O to 14.085^O N and 74.502^O to 74.569 ^{O} E (Figure 17.8).

Both the direct and indirect values obtained from the estuaries were calculated. The Market Valuation Technique was employed for valuing the goods and services having direct market prices such as fishing, Gazani paddy cultivation, timber and fodder obtained from the mangrove vegetation, aquaculture, sand and lime shell mining, navigation, ferry services and port activities. The market price values were assigned to these goods based on the interaction with the locals residing in that region. The gross revenues obtained from these resources were obtained in the following manner:

Net benefit from the fisheries = Total fish production in the estuary (tons) x Price per ton

Net income from mining/agriculture products = Σ (P Q)

Where, P = price of the product; Q = quantity of the product

The direct, indirect and recreational benefits obtained from the estuaries were summed up together to obtain the Total Economic Values (TEV) of the ecosystem. This value is divided by the total geographical area of the estuary to arrive at the per hectare value of the estuary as a natural resource. These economic values can be considered as underestimates as the natural ecosystems are much more worth in terms of the benefits they provide. The valuation of natural resources is useful for policy formulations and decision making.

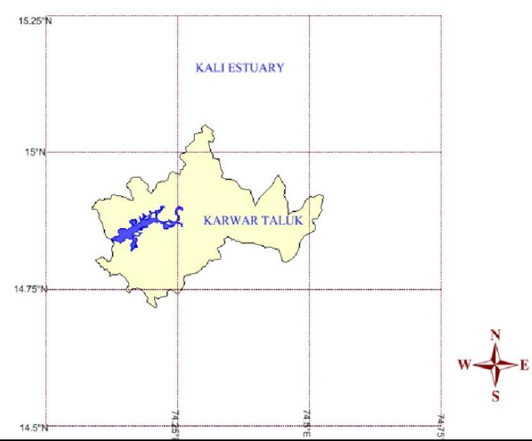


Figure 17.3: Kali estuary in Karwar taluk

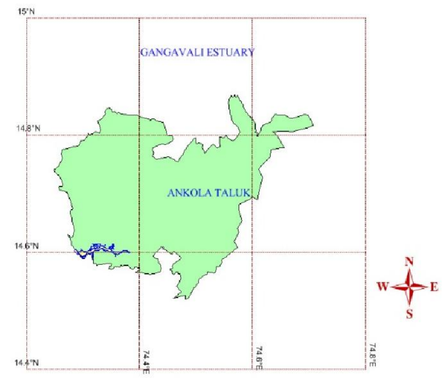


Figure 17.4: Gangavali estuary in Ankola

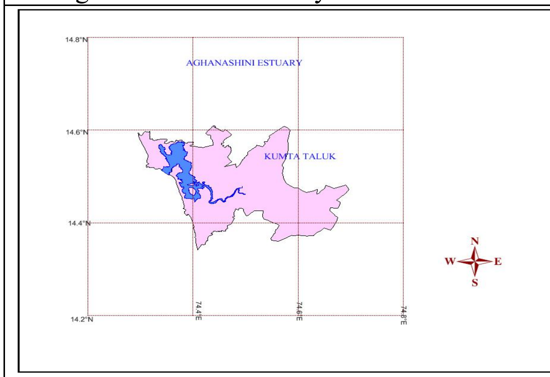


Figure 17.5: Aghanashini estuary in Kumta

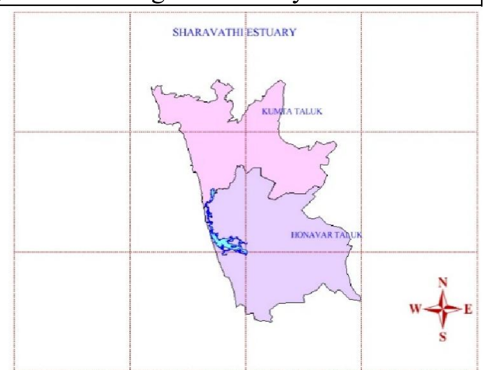


Figure 17.6: Sharavathi estuary in Honnavar

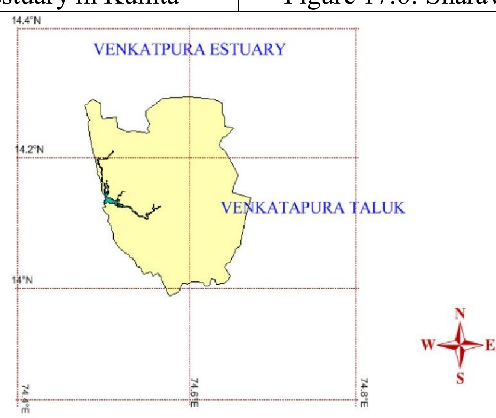


Figure 17.7: Venkatpura estuary

Total Economic Value = Direct use value +Indirect use Value

The present study focused on accounting the economic value of five estuaries namely, Kali, Gangavali, Aghanashini, Sharavathi and Venkatpura located in the Uttara Kannada district of Karnataka State. These are providing variety of living and non-living resources to local communities which offer employment, income, amenities and pleasure to local people. Apart from the direct benefits these ecosystem provides many indirect benefits to surrounding communities. But the policy and management circle has not considered the significance of this precious ecosystem. This study is an attempt to highlight the economic importance of the estuarine ecosystem in Uttara Kannada.

Demarcation of Study Area: Kali estuary spreads across 3240 ha and 100 ha of mangrove patches. The Kali estuarine villages have a population of 41897. Gangavali has 700 ha total area and 43.2 ha of mangrove forest. The total population in this region is 15569 as per 2001 census. Aghanashini is the biggest estuary in Uttara Kannada having 4801 ha of total expanse and it includes the 101.6 ha of mangrove area. Aghanashini supports 64709 peoples. Total area of Sharavathi estuary is 1600 ha with a total population of 47352 and it possess less area of mangrove (5 ha).The smallest and southern most estuary Venkatpura is only 250 ha and there is 8.64 ha of mangrove cover. The population in the Venkatpura estuarine villages is 57685.

Major goods and services from the estuaries were compiled through literature survey and discussion with local persons. These goods and services are then classified as per Millennium Ecosystem Assessment (2003) categorization as Provisioning Services, Regulating Services, Supporting Services and Information Services.

***PROVISIONING SERVICES*:** Provisioning services are estuarine fishery including the fish, finfish, shellfish and aquaculture, mining products, mangrove resources, salt production, agriculture including the saline paddy and coconut and water transport activities like ferry services, navigation and the port activities. In order to calculate the total value, the market price approach was used.

- ***ESTUARINE FISHERY:*** The fishery sector contributes the major livelihood options of the estuarine dependent communities in the coastal villages. It includes the common estuarine fishes, clam, oyster, mussels, bivalves, prawns and aquaculture.

The net income generated from utilization of estuarine fish resources from Kali estuary is 23.05 Crores per year. It is the 5.19% of total Uttara Kannada estuarine fishery resources. The total value includes the contribution of fishes, bivalves, clam, oyster, crab, prawns and aquaculture; from which aquaculture contributes the major portion of income about 17.82 crores and it is the 77.32% of the total revenue obtained. Following the aquaculture estuarine capture fisheries and crab collection contribute 7 % and 5.64% with an income of 16.23 million and 13 million Rs annually. The contribution from prawn fishery is only 2.38 % (5.47 million) and the remaining part filled by the shell fish captures. Out of the shell fish revenue, clam fishery gives the highest value of 8.17 million Rs. (3.55 % of total fishery value).

From the Gangavali estuary the total income for the entire year is 4.2 crores. Here also the aquaculture sector contributes the major percentage (63.07%) of total revenue with annual earning of 2.67 crores. Crab and prawn fishery sector contributes 4.60% and 1.94 % respectively. There is a significant income from bivalve production in Gangavali estuary. The bivalve contributes 20.18% of total production Followed by estuarine fishes and clam production. Mussels are absent in the Gangavali estuary. The estuary contributes only 0.95 % fishery value of Uttara Kannada district.

Aghanashini estuary provides the 92.93% of the income from estuarine fisheries in Uttara Kannada. The annual revenue is 4.12 billion Rs. The 94.64 percentage (3.9 billion) comes from aquaculture activities in the estuarine belt. Aghanashini estuary fishes contribute 12.07 crores with 2.93%. Aghanashini estuarine villages have been benefited by the bivalve collection with a total annual income of 5.7 crores. The total revenue from shell fish collection in this estuary is 7.35 crores comprising of bivalves, clams, oyster, mussels and other molluscans.

Compared to the above mentioned estuaries Sharavathi contributes only 0.73 % (3.24 crores) of total fish production from the estuaries in Uttara Kannada. The table reveals that only estuarine fishes and crab collection contributes the major part of the economy of Sharavathi estuary. Bivalves, mussels and oysters are absent here due to the continuous freshwater discharge from hydro electric station. The aquaculture production is also very less in this region, about 0.52 % (1.6 lakh) only contributes by this sector. The total revenue from crab, prawns and fishes are 6.5 million, 1.53 million and 2.29 crores respectively. Sharavathi estuary support small percentage of clams, i.e. 1.5 million Rs annually.

Venkatpura is the smallest and southern most estuary of Uttara Kannada. It supports 0.20% of the total fishery value of estuarine fishery sector of the district. The total income from fishery sector of the estuary is 8.71 crores annually. Out of these 61% is coming from aquaculture activities. The net income from fishes in estuary is 7.3 lakhs and it is the 8.3% of the total fishery value of the estuary. Venkatpura supports bivalve harvesting in a significant level that gives net income of 1.71 crores and it is the 19.62% of total fishery of Venkatpura. Mussels are absent in the estuary but the presence of clam, oyster and other mollusks make the estuary rich.

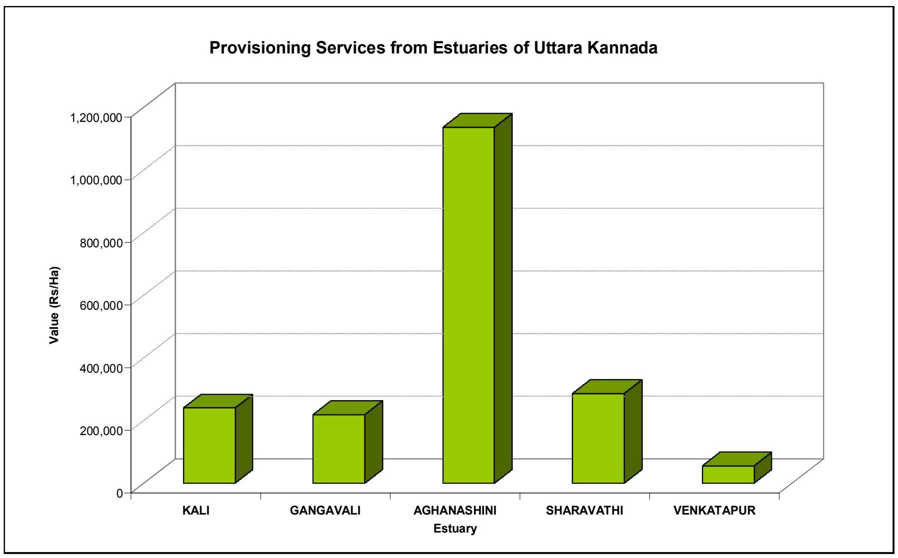
- ***AGRICULTURE PRODUCTS:*** The estuarine belt of Uttara Kannada support saline tolerant paddy (Gazani) and coconut cultivation. The Kali estuarine belt gives an annual income of 3.9 crores from paddy and coconut plantations .It is the 23.53% of the total production from Uttara Kannada estuarine villages. The returns from gazani paddy are highest in the Aghanashini estuarine region with a value of 4.39 crores. The total agricultural production from the estuary is 4.95 crores; it contributes the 29.64% of district total. The table shows that the highest percentage of agriculture production to the total estuarine ecosystem of the district is from Sharavathi (37.43%) and the net return is 6.2 crores. Gangavali and Venkatpura contribute 7.8% (1.3 crores) and 1.5% (2.6 million) respectively to the Uttara Kannada estuarine belt.
- ***MINING PRODUCTS*:** Mining and dredging activities are happening in the estuary of Uttara Kannada in significant level. The net returns from the region are 120.88 crores annually; out of these 99.26% comes from lime shell collection only. Kali estuary contributes 22.87% (48.36 crores) of net income generated from total estuarine area of the district. Here also the lime shell mining provides the higher contribution of about 36.7 crores. Sand mining is highest in Kali estuary with an income of 11.28 crores/year. Gangavali estuary provides revenue of 6.2 crores and here silt dredging is absent. Sharavathi and Venkatpura region also free from silt mining. The annual return from those two estuaries are 35.7 crores and 1.5 million Rs respectively. In Sharavathi 97.29% of the income is from lime shell mining, though the region having huge lime shell deposit. Only sand mining is occurs in the Venkatpura estuary.
- ***MANGROVE PRODUCTS*:** Mangrove forest is being used by the local inhabitants as fodder for live stocks and timber for fire wood needs and construction activities. The revenue obtained from mangrove product extraction is highest in the Kali ecosystem and the net return 5.7 million annually. The Aghanashini contributes 31% of total mangrove product harvest of Uttara Kannada; the income is 5.4 million Rs/ year. In Gangavali region the utilization of mangrove product harvest is only limited to timber. The value generated is 5442 Rs/year. From the Sharavathi and Venkatapure the value generated from mangrove product is 5.2 million and 1 million respectively.
- ***SALT FROM ESTUARIES*:** Net returns from the estuaries are 2 million, 3.5 million, 5 million respectively. According to Mahima *et al.,*, (2010),salt making is a traditional enterprise associated

with some of the villages close to Gokarna, Aghanashini where salt pans annually produce Rs.30-40 million worth of salt.

- **TRANSPORT:** The net income from water transport activities is highest in Aghanashini (52%) followed by Sharavathi (29%).There is no port activities observed in the estuarine coast of Kali and Venkatpura. The value from ferry services in Venkatpura is 30000 Rs/year. Rs.9.38 lakh is obtained from Sharavathi and 1.4 lakh, 4.6 lakh and 1.6 million from Kali, Gangavali and Aghanashini respectively.

- **TOTAL PROVISIONING SERVICES*:*** The provisioning services value of entire estuarine waters of Uttara Kannada is 6.85 billion Rs /year. Aghanashini make up the 79.5% (5.45 billion annually), followed by Kali 11.36 % (77.88 crores/year), Sharavathi 6.7% (45.91 Crores/year), Gangavali 2.24% (15.36 crores) and Venkatpura 0.2% (1.39 crores) respectively. The total value per hectare of estuary are 240395 Rs (Kali), 219,545 Rs (Gangavali), 1135,847 Rs. (Aghanashini), 286,964 Rs (Sharavathi) and 55,707 (Venkatapura) respectively (Figure 17.8).

Figure 17.8: Provisioning services from Uttara Kannada Estuaries



INDIRECT USES*:* The indirect uses of estuarine ecosystem consist of the Regulating services, Supporting services and Information services. All these services are valued by taking the unit value of these benefits (Rs/ha/year) from other studies and adjusted according to the spatial and environmental conditions of our study region.

- **REGULATING SERVICES*:*** The regulating services value from total estuarine area in Uttara Kannada is 19.39 billion Rs/ Year. 45% of it is contributed by Aghanashini estuary and 30% by Kali estuary with a benefit of 8.8 billion and 5.9 billion respectively. This is mainly due to the higher mangrove cover and total area of these two estuaries. A value of 1.4 billion, 2.9 billion and 25.7 million Rs/ year is given by Gangavali, Sharavathi and Venkatpura respectively. The per hectare regulating service value of Kali estuary is Rs.1,839,037 and Aghanashini is Rs.2,055,250, Gangavali is Rs. 1,835,288 and for Sharavathi it is 1,828,300 Rs and Venkatapura has 1,028,162 Rs.

- **SUPPORTING SERVICES*:*** The supporting service value of entire Uttara Kannada estuarine region is 11.26 billion Rs/ year. Aghanashini region makes the 82.935% of the total value and the value is 9.34 billion/year. The value per hectare from Aghanashini is 1,946,030 Rs. Kali provides 1.19 billion Rs/ year and it contributes 10.6% of the district total. The total value from per hectare of Kali estuary is Rs.369, 435 .The total value per year is arrived at Rs.23.4 million from Gangavali (348,256 Rs/ha/year), 42.8 million Rs. From Sharavathi (Rs.267, 706/ha/year) and 5.2 million Rs. (211,976 Rs/ha/year) from Venkatpura.
- **INFORMATION SERVICES**: The total value (Rs/year) from information service in Kali estuary is Rs. 397,000,602 and the per hectare value of this services per annum in Kali is Rs.1,12,253. It is the 41% of information services from total of the entire estuary. Many research and educational activities are being conducted by local universities and CMFRI regional centers. Aghanashini contributes the highest percentage of information services (43%). These salt pans in this region are the visiting place of migratory birds during seasons. It adds to the aesthetic and recreational potential of Aghanashini. The total value of Aghanashini is 421,867,231Rs/Year with a per hectare value of 87,871,Rs.The per hectare value of Gangavali is 53,210 Rs and Sharavathi has 70,541 Rs/ha. Total value of information services from Venkatpura is 37247 Rs/ha/year.

TOTAL ECONOMIC VALUE: In the case of Kali, the total economic value for the entire year is 8.33 billion Rs. And it gives the productivity of the Kali estuary as 2,571,398 Rs/ha/year. 72% of the total economic value is contributed by regulating services and only 9% is the contribution of provisioning services.15% share is given by supporting services and rest are information services. Kali shares the 21% of the total value from estuarine area of Uttara Kannada. The total economic value of Gangavali is 1.87 billion Rs/year with a productivity of 2,67,6261 Rs/ha/Year. Provisioning services contributes 8% of the total value. Here also regulating service is the major contributor. Information services are only 2% and 13% is from supporting services. Gangavali have only 4% share in the total economic value of the total estuarine productivity. Aghanashini estuary is the highly productive and comparatively intact ecosystem; therefore the total economic value is 62% of total district value. The value in Rs/year is 24.03 billion and the productivity per hectare is 5,005,035 Rs/year. Provisioning service makes up the 23% of the total value. Information service share only 2% and regulating and supporting services are 37% and 39% respectively. Sharavathi estuary provides a total value of 3.9 billion Rs annually and the value obtained from per hectare of estuary is 2,453,510 Rs. The total value is shared with 12% by provisioning services and 75% by regulating services and 11% by supporting services and 3% by information services. The total economic value from Venkatapura estuary is 33.32 million Rs/year and it has a production potential of 1,333,092 Rs/ha/year.

The total economic value generated from per hectare of the estuary is highest in Aghanashini estuary 5,005,035 Rs/ha/year followed by Gangavali with value of 2,676,261 Rs/ha/year. Though Kali is second biggest estuary but the value is less than Gangavali due to estuarine health degradation via effluents from Paper and Sugar industries and Kaiga thermal power plant apart series of dams. It makes the estuary lesser productive. Sharavathi has higher spatial extent than Gangavali but the river is dammed and the discharging of the freshwater from hydroelectric station makes the estuary less saline and there is depletion of saline dependent fishery resources. The higher productivity is observed in the estuaries with no dams and comparatively pristine conditions.

17.3 EDIBLE BIVALVES OF CENTRAL WEST COAST

Bivalves (Clams and oysters) contribute to the livelihoods of many people in India. Shell and sand mining in the molluscan beds, over-exploitation of bivalves, and sustained freshwater flows from the hydel projects are expected to have adverse consequences on estuarine bivalve resources. The present study was conducted in the four major estuaries of Uttara Kannada District (Kali, Gangavali, Aghanashini, and Sharavathi), to see the diversity of edible bivalves and their distribution. The study was conducted in 2011-2012 period in these estuaries. The status of edible bivalves of the estuaries was collected through primary observations and interviews with local fisher folks. Past studies were also referred to gather such information. *Anadara granosa, Meretrix casta, M. meretrix, Paphia malabarica, Polymesoda erosa, Villorita cyprinoides* and oysters were present in the Uttara Kannada estuaries. In Sharavathi estuary only *Polymesoda erosa* and oysters were found. The distribution zones of edible bivalves, and thereby their abundance, in the Kali estuary were less than the Aghanashini and Gangavali estuaries. The reasons for such disparity between the neighboring estuaries could be attributed to major human intervention in the form of construction of hydel projects upstream that caused low salinity conditions in the downstream causing depletion of most estuarine bivalves, as is glaringly evident in the Sharavathi estuary.

There are six edible clams, viz. *Anadara granosa, Meretrix casta, Meretrix meretrix, Paphia malabarica, Polymesoda erosa, Villorita cyprinoides* and some oysters present in all the estuaries of Uttara Kannada district, except in Sharavathi estuary where only one clam *Polymesoda erosa* occurs today and the oysters can be seen on rocks close to the river mouth with higher salinity. Among these edible bivalves the genus *Meretrix*, *Paphia*, and *Villorita,* and oysters contributes to the livelihoods of many peoples.

Anadara granosa is present in all the estuaries except, Sharavathi. In Kali, Gangavali, and Aghanashini the distribution of *A. granosa* is restricted to one kilometer range from river-mouth. It prefers soft intertidal muds bordering mangrove swamp forest and salinity range of 13.69 – 34.40 ppt hence, *A. granosa* present only close to the river-mouth where the salinity is usually high. This species was previously reported from Kali, Aghanashini, and Venkatapur estuaries of Uttara Kannada District.

Meretrix casta is distributed in Aghanashini and Gangavali (without any dams) estuaries from the river-mouth to six km interior. Compared to this, *M. casta* is distributed in Kali (with dam) only for three km range from the river-mouth, its occupational area reduced on account of the influx of fresh water releases from the hydel projects upstream. *M. casta* is a euryhaline species (adapted to a wide range of salinity) and it has a greater degree of physiological adaptation in the salinity range of 25.00 to 56.00 ppt. Since, the salinity of Kali estuary is very low *M. casta* is distributed only upto three kilometer distance from river-mouth. Whereas in Sharavathi estuary *M. casta* is absent, probably because of extremly low salinity due to dam water releases.

Whereas the distribution of *Meretrix meretrix* in the undammed Aghanashini and Gangavali estuaries range from river-mouth to three kms inside, in Kali (with dams) *M. meretrix* has only a one km range from river-mouth. *M. meretrix* prefers high salinity hence, its presence closer to the river mouth can be justified. In the Sharavathi estuary *M. meretrix* was present earlier, but seems have vanished today, obviously because of decline in salinity caused by release of fresh water from hydel projects. *M. meretrix* is present to this day in all the other estuaries.

- *Paphia malabarica* occurs closer to the river mouths with salinities of 20 to 30 ppt. It occurs to this day in the high salinity regions of Kali, Gangavali, and Aghanashini estuaries. However, in Sharavathi estuary *P. malabarica* was not reported earlier nor it occurs currently. The species occurs in all the other estuaries viz. Kali Gangavali, Aghanashini, and Venkatapur.
- *Polymesoda erosa* prefers salinity of 7 to 22 ppt. It is present in all the four estuaries. Even though, it is present in Kali, Gangavali, Aghanashini, and Sharavathi estuaries, the population is high in Sharavathi estuary than the other estuaries and also it is the only species of edible clam present to this day.
- *Villorita cyprinoides* associated with medium salinity conditions is known to withstand freshwater conditions. It was reported from Kali, Aghanashini, and Venkatapur estuaries. In Kali estuary, which has more salt water ingress, despite the dams, it is found in 6-12 km range. It occurs in 5-16 km zone in Gangavali, and 9-23 km zone in Aghanashini respectively.

Estuaries although are ranked among the highest productive ecosystems of the earth, and are of immense economic importance to the humans, they have not merited enough attention yet to safeguard their integrity from various kinds of anthropogenic interventions. The fact notwithstanding that estuarine productivity is sustained naturally without any inputs from humans, unlike in agricultural ecosystems or fish farming systems, the ecological conditions of the estuaries, particularly of the Indian west coast are under alterations by humans. We have seen here that in the Uttara Kannada district, which has some of the best preserved forest wealth and water bodies with minimal pollution levels, how alteration of an even single factor like salinity due to continuous water release from hydel projects, can upset their ecology as evident from the decline in abundance and changes in distributional ranges within these estuaries of the edible bivalves. Not only that where especially dams are constructed upstream for power generation, as in Kali and Sharavathi, even fisheries and mangroves are affected. The impact is of the highest order in Sharavathi where only a single species of moderate salinity tolerant clam *Polymesoda erosa* and some oysters are all that are left of the edible bivalves unlike in other estuaries where six species of clams and some oysters are still present. In Sharavathi most of the high and medium salinity tolerant mangroves have given way to low salinity preferring tree *Sonneratia caseolaris*. Fresh water fishes from the upstream areas and low salinity tolerant fishes have occupied the zones where earlier marine fishes used to visit. The very case of the near local extinctions of most of the edible bivalve species from Sharavathi estuary and decrease in distribution range of edible bivalves in Kali estuary, as a consequence of dilution of salinity, is a classical instance highlighting the need for exercising greater caution before executing large-scale development projects like dams for power generation, upsetting ecology of tropical estuaries, rated among the highest productive ecosystems of the world.

SIGNIFICANT OUTCOMES

1. Six species of edible clam bivalves viz. *Anadara granosa, Meretrix casta, M. meretrix, Paphia malabarica, Polymesoda erosa, Villorita cyprinoides*, and oysters are present in the Uttara Kannada estuaries.
2. According to historical data, five species of edible clam bivalves viz. *Meretrix meretrix, M. casta, Anadara granosa, Polymesoda erosa*, *Villorita cyprinoides* and oysters were present in the Sharavathi estuary. Out of them only *P. erosa* and oysters remain in the estuary; the rest are not traceable today.
3. In Kali estuary, the edible bivalves were distributed for about 27 km from river-mouth in 1978

whereas now it is distributed only for about 12 km from river-mouth, and the population of *Paphia malabarica* declined drastically.

4. The major reason for the low bivalve diversity in Sharavathi estuary and reduced distribution zones in Kali estuary could be attributed to the construction of hydel projects causing continuous release of fresh water into the estuary, after power generation, even during the summer months, resulting in very low salinity that is unable to sustain most bivalves.
5. The collection of edible bivalves is a major activity of fisher-folks and even others which contributes to the livelihood of many estuarine villages, but faded away in Sharavathi due to the disappearance of bivalves.
6. The hydel projects have adverse impact on estuarine biodiversity, not only on bivalves but most of high salinity tolerant mangroves of Sharavathi also are not to be found, except in fringes very close to the river mouth.

RECOMMENDATIONS

1. Regulating the shell and sand mining in the estuarine region will have positive impact on the diversity and distribution of edible bivalves.
2. The lessons from serious human impacts caused to Sharavathi estuary ecosystem, in the form of massive disappearance of edible molluscs, decline of high salinity tolerant mangrove species and dislocations in associated biodiversity etc., the implications of which are yet uncounted, should teach us to be more cautious in future in dealing with developmental projects especially affecting riverine systems. The role of estuary as breeding places and nurseries for several marine fishes of economic value has been totally ignored while executing such large river valley projects.
3. Maintenance of physico-chemical properties of estuaries need to be considered while executing any major river valley projects so that they can continue to be centres of diversity and productivity meeting the food and livelihood needs of thousands of families while also performing the vital ecological functions traditionally associated with estuaries.

17.4 ECONOMIC VALUATION OF BIVALVES IN THE AGHANASHINI ESTUARY

Estuaries provide valuable resources like fishes, bivalves, crabs, shrimps, etc. Thus, it plays a pivotal role in rural livelihood and constitute as an important socio-economic entity. Mangrove vegetation, ranking high in productivity, is often associated with tropical and sub-tropical estuaries. Biological productivity in estuaries depend on fresh water ecosystem and hence its terrestrial ecosystems. Estuaries being inter-tidal zones form a vital interface between marine and terrestrial environments. These semi-enclosed bodies of coastal water have a free connection with the open sea and within which seawater is measurably diluted with fresh water of terrestrial origin, forms a highly productive, dynamic and unique ecosystem providing food, transport, recreation, etc.

A study was undertaken focusing on bivalves of the Aghanashini river estuary of South Indian west coast, in an effort to document the edible bivalve diversity and the often neglected socio-economic life based on it. Estimates have been made of people involved in bivalve collection and trade, quantity and species collected and the overall role of bivalves in sustaining a rural economy. Bivalves harvested are *Paphia malabarica*, *Katelysia opima* and *Meretrix meretrix, M. casta* and *Crassostrea* sp. The estuary provides diverse kinds of habitats (in terms of water depth, salinity, soil nature and rockiness) for different bivalve species. Harvests are higher during post-monsoon (November-May) compared to monsoon (June-October). The bivalve-based economy has an estimated turnover of Rs. 57.8 million per year. It generates direct employment for about 2,347 people, and nutritional security of millions more along the Karnataka coast and also in neighbouring states. This study was undertaken at a time when an ultra-thermal plant was to be set up in this estuarine base inconsiderate of its ecology and economics.

Economic valuation is an effective method to understand the significance of ecosystem goods or services provide by nature. The strength of the economic valuation methods is that their concept of value incorporates the relationship between humankind and ecosystem products. Objectives of this endeavour were: i) to document the diversity of bivalves and ii) to describe the benefits derived from them by harvesters and others who are associated with processing and trade. This involved:

- Inventorisation and mapping of the edible bivalve species of Aghanashini estuary
- Estimation of the number of people associated with bivalve collection and trade
- Methods and techniques of bivalve harvesting and
- Quanitification of benefits derived from bivalves: economic valuation of bivalves

Figure 17.9 gives the spatial distribution of clams, mussel and oysters in the Aghanashini estuary. Clam *P. malabarica* inhabits deeper water whereas species like *K. opima, M. meretrix* and *M. casta* are associated with the mud flats of the estuary. The estuarine as well as fresh water bivalve species *V. cyprinoides* inhabits farthest part of estuary with lower salinity in the moderately deep water region. One specimen of blood clam *Arca granosa* was encountered near Aghanashini village. Mussel **(***P. viridis)* occupies deep water rocky surface of the river mouth region, while two species of oysters **(***Crassostrea* sp.) occupied littoral zone of the estuary region which is often referred as oyster bed.

Figure 17.9: Distribution of Calm, Mussel and Oysters in the Aghanashini Estuary.

Bivalve harvesting and trade: Both men and women are engaged in harvesting of bivalves, except P. viridis which only men harvest. Women normally avoid dangerously deep waters and rocky substratum towards the interface of the sea, which is the preferred habitat of P. viridis. Harvesting is done by hand, feet or with the aid of a small hand-held digging stick. The collectors work for three to four hours per day during the low tides. Bivalves are collected in cone shaped nets, baskets, plastic boxes, cement bags, etc. Small non-mechanised crafts are normally used for collection from deeper waters and for transport of bivalves from the collection site to the villages. The boats may be steered by men or women. Harvesting methods, for various bivalves are briefly discussed below.

- *Clams*: *P. malabarica* is most common in Aghanashini estuary followed by *K. opima, M. meretrix, M. casta* and *V. cyprinoides*. Searching for *P. malabarica* is done in shallow water by using hands or feet. *K. opima, M. meretrix, M. casta,* associated with mud-flats are picked by hand or dug out using sticks, mostly by women. *V. cyprinoides* is collected from shallow water, through direct searching using hands or feet mostly by women.
- *Mussels*: *P. viridis*, the only edible mussel of Aghanashini is usually found attached to the steep sub-tidal rocky parts of the river mouth. The species adheres to the substratum by thread like structures called byssus and is manually picked by men.
- *Oysters*: *Crassostrea* sp. form beds on the mud-flats and also attach to the inter-tidal rocks. Usually women extract the meat by opening the oyster shell using a knife.

An estimated 2,347 individuals from 1,202 households are associated with bivalve harvesting; of these 1,738 are men and 609 are women, who belong to 19 estuarine villages, 1,202 families. The majority who harvest bivalves for trade belong to local fishing communities such as Harikanthras and Ambigas. Halakkivokkals, Namdharis, and Gramvokkals, who are traditionally agriculturists, also gather bivalves mostly for domestic consumption and sometimes for trade. Bulk of the harvesters are from Aghanashini village (35.15%) followed by Divgi (18.75%), Gokarn (9.67%), Torke (7.84%) and Mirjan (7.63%). Aghanashini closer to the river mouth has a substantial production of bivalves and also accounts for the largest number of harvesters (825).

Total number of bivalve collecting days in a year is 140 for male and 147 for females. Hence, bivalve harvest in the estuary alone generates 332,843 days of human employment per year. Bulk of the employment for men is through the collection of *P. malabarica*, which is found in deeper parts of the estuary (water depth >1m at lowtide). However, collecting *P. viridis* from steep and rocky parts of the river mouth being a riskier task only a small number of men (2.11% of men collectors) venture to do it. *V. cyprinoides* is collected from shallow waters by both men and women. Collection of the *K. opima, M. meretrix, M. casta* and *Crassostrea* sp. from the mudflats is mostly woman's domain.

Spot purchases of bivalves harvested are made by traders who transport them to nearby towns and even to neighbouring states, especially to Goa. The local marketing is usually carried out by the women of fishing communities, who make household sales in Kumta town and nearby villages. Some female also carry the bivalves to the local fish markets. The harvesters also use small part of the collection for domestic use. Bivalve harvested in this estuary is estimated at 22,006 t/yr, which generates a total primary annual net income of about Rs. 57.8 million (Rs. 57,018,710 from bivalve collection and Rs. 816,267 from supplementary products like empty shells and dried meat). Aghanashini village, which accounts for the highest production of bivalves alone earns about Rs. 33 million (58% of total income). The average income for the male was Rs. 29,129 from 140 collection days for the study year 2006-07, whereas it was Rs. 10,497 for the female from 147 collection days. Some quantity of bivalves collected is used for the production of dried meat, which earns marginally more profit than sale of fresh bivalves. The estimated annual income from the sale of empty shells is Rs. 483,850 and from dried bivalve meat is Rs. 334,983.

Parts of the estuary are leased out for the mining of empty shells, which are used by various industries for the production of poultry-feed, lime, fertilisers, etc. The annual production of shells is around 80, 000 to 100,000 t and the market price ranges from Rs. 750 to 950/t. About 600 persons (only men, especially those operating native boats) are engaged in shell mining in addition to transporters - about 200 persons. As shell mining depends largely on the deposits of dead shells, in the long run it is not going to be sustainable. Sustainable harvest has to be limited to procurement of shells of live bivalves and annual deposits of dead shells of unexploited bivalves which needs further investigation. The gross annual value of the shells is about Rs. 76.5 million.

Valuation of estuary based only on bivalve production: The annual harvest of bivalves in Aghanashini estuary is estimated to be 22,006 t (edible portion about 9% of fresh weight). On an average an individual consumes 50 g of meat for about 200 days a year. Therefore the bivalves of this estuary alone contribute substantially towards protein and mineral rich nutrition of about 198,000 people of the west coast. About 186 ha of the estuary, estimated to be used for bivalve harvesting. Therefore the average annual income per year for every hectare of bivalve harvesting area can be put at Rs. 306,552. It is an amazing yield/ha compared to any other natural ecosystem or agricultural systems, and that too this yield is without input of any kind into the system by humans. Majority of the 105 harvesters whom we interviewed opined that over the years, despite the harvests, there has been hardly any change in the availability of bivalves. However, a small number of harvesters expressed that there has been a declining trend in recent years. It is learnt that during 2007 – 08 period overharvesting due to rising demand from Goa has created local scarcity and spiraling of bivalve prices. Shell mining is done in an area of 100 ha per year out of a total lease area of 809.37 ha (20 years lease period). The shells mined at prevailing market prices are worth Rs. 765,000/ha/yr. Hence, the total value of the estuary based on live bivalve and shell production is worth Rs. 1,071,552/ha/yr. This demonstrates the high productive potential of the estuary compared to any other economic sectors. This valuation does not include other goods that the estuary provides such as production of shrimps, fish, crabs, salt, mangroves, etc. in addition to services such as fish spawning grounds, nutrient cycling, hydrology, flood control, soil protection, sink for carbon, etc. Estuaries are ranked among the highest productive natural ecosystems of the world. The west coast of India is dotted with the estuaries of numerous rivers which originate in the Western Ghats, one of the global biodiversity hotspots. Yet there has been an almost callous neglect and misuse of these high ranking productive ecosystems causing inestimable losses.

Unplanned developmental activities based on ad-hoc approaches in planning in recent decades have telling effects on the Aghanashini estuary. In the early 1970's about 728.44 ha of productive estuarine ecosystem areas were leased for industrial salt production and subsequently abandoned due to failure of the project. Thereafter in a frenzied drive to promote shrimp production for export substantial portion of the estuary was put to intensive shrimp farming, destroying much of the mangroves as well as the traditional salt tolerant *Kagga* rice fields. There has also been a sharp decline in the rich bird and fish fauna following these perturbations. The most recent threat to the estuary has been from the proposed Ultra Mega Power Plant. However, this project has been shelved due to protests from the ecosystem people whose livelihoods were to be imperiled by such an establishment and also from environmentalists. The study underscores the need for greater sensitivity and vision on the part of planners and decision makers towards conservation and sustainable management of pristine and productive ecosystems, particularly of Western Ghats west coast region. This study is an initial attempt to evaluate some important aspects of estuarine goods, which has a major role in livelihood aspects of ecosystem people. However, valuation of the estuary services and goods of an estuary requires further investigations for a comprehensive understanding of various components.

18.0 SOCIO ECONOMIC WORTHINESS OF PEOPLE'S INSTITUTIONS AND ORGANISATIONS

Task 9: Socio economic worthiness of people's institutions and organisations.
1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Socio-economic worthiness of people's institutions and organizations, Sahyadri Conservation Series 40, ENVIS Technical Report 70, CES, Indian Institute of Science, Bangalore 560012, India

The quantitative performance of the co-operative movement of Karnataka is considered impressive compared to other states in the country. From the point of view of the number of societies, Karnataka occupies the 9th place among the states of India. In respect of working capital, it occupies the 6th place. In essence, both from the point of view of credit and non-credit co-operatives, the state of Karnataka is in a comfortable position compared with other co-operatively developed states of India.

Uttara Kannada is a district endowed with tremendous natural resources, most overwhelming of which are forests and water resources, the latter in the form of Arabian Sea, estuaries and creeks, and rivers (mainly Kali, Gangavali, Aghanashini, Sharavathi and Venktapur). The interior of the district is rich in streams and springs. The maidan taluks of the district like Haliyal and Mundgod and relatively less hilly eastern portions of the taluks Yellapur, Sirsi and Siddapur are having numerous ponds and tanks. Despite the richness of natural resources the district's ecology is fragile and lands used for cultivation of seasonal crops (cereals, millets, legumes, sugarcane, vegetables, cotton etc.) and garden crops (arecanut, coconut, spices like pepper, nutmeg, cocoa, vanilla etc. and fruit crops like banana, mango, jackfruit, chikoo, papaya, pineapple etc.) constitute about 15% of the total geographical area of about 10,250 sq.km. Compared to the maidan districts of Karnataka, land under cultivation is very less and land holdings are too small. This situation has fostered through ages high degree of interdependence among the community paving the way for co-operative movement of later times. Traditional natural resource uses of people in the district were largely governed by various local community organization based regulations. People were bound by these regulations which were aimed at prudent utilization of natural resources.

Village communities in forest areas conserved large areas of forests, often in few hundred acres each, as *kan* forests. These *kans* were held as sacred and trees were not cut normally. The village community harvested non-timber produce from these preserved forests from areas designated for each family. This was applicable to forest products like pepper, toddy from *Caryota urens*, cinnamon bark and many other NTFP. These *kans* were important local sources of perennial water.

Many village communities (like at Halkar, Chitrigi, Valgalli, Holagadde etc. in Kumta) had protected village forests even before the formation of the Forest Department by the British. Some of them had even guards called *Rakh-havaldars* to safeguard these forests. Some of the norms followed by the VFP for gathering of forest produce from the village forest under its legal jurisdiction are the following:

- Each family in the village on payment of annual nominal fee is allowed to gather one head-load of biomass, in the form of fallen leaves for manure and dry wood broken by hand towards fuel. Fresh twigs from bushes for manure are permitted only during the rainy season, also restricted to one head-load per household. The same are to be broken by hand and not to be cut by iron implements.
- Cattle are allowed to graze free.

- Collection rights for NTFP like cashewnut, *surugi* flower (*Mammea suriga*), kokum fruit etc. are annually auctioned among the villagers only.
- A fallen tree is auctioned for purchase within village only for domestic use and not for sale outside. A second tree fallen or dead will be auctioned among the rest who were not successful in bidding for the first and so on.
- Acacia poles are sold for household use use for nominal charges.
- No one is allowed to use implements like knife, sickle or axe within forest.

The Halkar village community annually once every year participates in boundary marking of the forest and takes part in operations like trenching and fencing, and tree planting during the rainy season.

Ancient gazni co-operative farming system: *Gaznis* are large estuarine rice fields. They are indeed swamp and marsh areas bordering the estuaries, mainly in the Aghanashini River estuary of Kumta. These rice fields were traditionally protected from inundation of salt water tides by earthen embankments fitted with sluice gates. Each *gazni* field used to be of dozens of acres to few hundred acres, and was traditionally farmed by (rice cultivation) by several farmers. Each family would own certain portion of the *gazni* (in terms of acres-gunta but not physically demarcated within the slushy field). The family members have to take part in the combined operations related to rice cultivation within *gazni* involving field preparation, sowing, harvesting, thrashing the grains from the stalks, measuring etc. The product is shared among the cultivators according to land holdings. For protection of *gazni* bunds annual repairs were conducted and mangrove trees raised alongside to fortify the bunds from collapsing in the rains and by tidal action.

Credit co-operative societies were started in 1905 at Sirsi with the aim of rescuing agriculturists from the clutches of local money lenders. Co-operative Societies Act 1912 was passed for setting up non-credit co-operatives in the field of marketing and supplying domestic items and agricultural materials. Despite small area in the district under agriculture and horticulture the district was well known for arecanut and spices, bananas and rice and several other products. Uttar Kannada district has basically an agrarian economy and the industrial growth is comparatively lesser. The arrival of Primary Agricultural Credit Societies played active role in the prosperity of farm sector

Honey production in Uttara Kannada was almost entirely based on collection of wild honey almost throughout the pre-independence period. The Khadi and Village Industries Commission and the National Horticultural Mission initiated beekeeping as a systematic activity in the district. The Honavar Bee-keeper's Society, the first in the district, was started in 1941. These societies were later established in Sirsi-Yellapur, Siddapur, Ankola and Kumta also. At one time these societies played an important role in popularizing and assisting aspiring people in beekeeping. However, as honey started fetching higher prices in the open market including spot payments to the producers the latter often approached the market directly. The Societies which, probably due to insufficient support from the State, became rather decadent establishments, except Honavar society which continued to maintain its status.

RECOMMENDATIONS

- Community based forest management (**Village Forest Panchayat**) of Halkar in Kumta is found to be one of the most successful management system in the State. The Forest Department and Revenue Department should extend all possible co-operation to this VFP and project it as a model in the world.
- The formation of **Biodiversity Management Committees** is a sluggish process in the district. Wherever such BMCs are formed most do not know what the purpose is and therefore the

tenure of the BMC gets past without even achieving the primary objective of preparing **People's Biodiversity Registers.** The State Biodiversity Board should prioritise villages for BMC formation and get the PBRs prepared through expert assistance, using simplified and theme-wise formats.

- Clusters of panchayats rich in indigenous varieties of cultivated crops may be brought under special attention for declaration of such areas are ***in situ* conservation areas** through proper subsidies to farmers organizations
- Milk producers, especially along the coast are facing challenges in getting cattle fodder which has to be brought from other areas at high cost. This situation is not conducive for making Uttara Kannada self-sufficient in milk production and in organic farming as getting farm manure for the purpose is becoming increasingly difficult. It is recommended to have village-wise fodder farms run by co-operatives of milk producers/farmers. As getting such lands are difficult wastelands, minor forests with poor vegetation etc. may be brought under **fodder production co-operatives** within the fold of **Joint Forest Management.** Unproductive/underproductive public lands are to be treated as wastelands and to be brought under community based fodder farming. More than providing loans for purchase of cows or buffaloes stress, in the present context, should be on fodder development.
- Gowli community is specialized cattle keepers, and major producers of milk and dairy products. Yet most of them are landless. The **Gowli co-operatives may be allowed open forest areas for fodder production** under joint forest management provisions.
- As honey production through beekeeping is lagging behind despite blooming prospects clusters of panchayats may be identified for integrated agriculture and apiculture development through local **co-operatives of beekeepers**. These clusters may be aided with soft loans and subsidies for developing bee-flora, especially of trees and shrubs and seasonal herbs to promote honey production. Bottling and marketing assistance may be extended through existing co-operatives (like Kadamba for instance).
- VFC's should be assisted to promote more of NTFP species specially to provide **NTFP for processing and marketing by Women's SHGs.**
- **Kokam co-operative** may be established in the coast especially to promote kokam tree cultivation, scientific extraction of kokum fat from the seeds, purification and marketing of the same to meet the rising global demand.
- Considering the enormous potential of ecotourism development in the district **community, SHG and youth club based tourism management training** may be given for betterment of local livelihoods while also following better standards of natural resources management.
- As cooperatives, and other collective forms of economic and social enterprise, have shown themselves as distinctly beneficial to improving women's social and economic capacities. Therefore promoting cooperative organization among women is a worthy strategy for self-empowerment.
- **Revival of handloom co-operatives** is a necessity in Uttara Kannada to enhance employment opportunities especially for women. Training in handloom cloth production, garment stitching and marketing should be imparted to the local women especially in villages.
- **Promote self reliance** among co-operatives as a major step towards achieving autonomy.
- **Co-operative fish farming** in the tanks and reservoirs of specially malnadu and maidan taluks may be given serious consideration. Care should be taken not to introduce exotic fishes.
- **The clam beds of Aghanashini estuary** facing threats from over-exploitation may be brought under co-operative management of stakeholders.

- As fuel extraction from forests is a major activity in Uttara Kannada that is causing forest degradation, **clean energy initiatives through women's SHGs should be a priority activity**. This will save forests as well as ease the drudgery of especially women fuelwood collectors who are in thousands.
- Co-operatives of trained persons, especially women, for value added plant products such as **biopesticides and plant dyes**, need to be established. This is with an eye on blooming global market for organic products.
- Establishment of **solar based decentralized electricity generation with smart grids in villages under community management** will be a major step towards rural electrification

19.0 NATURAL DISASTERS: LANDSLIDE PRONE REGIONS

Task 10: Identification and mapping of natural disaster prone regions, monitoring and mitigation measures through eco-restoration (eg. creation of green barriers to prevent sea erosion).
1) Ramachandra T.V., Subash Chandran M.D, Joshi N.V., Pallav Julka, Uttam Kumar, Bharath H. Aithal, Prakash Mesta, Rao G R, Vishnu Mukri, 2012. Landslide Susceptible Zone Mapping in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 7, ENVIS Technical Report: 28, Environmental Information System [ENVIS], Centre for Ecological Sciences, IISc, Bangalore 2) Subash Chandran M. D., Rao G. R., Prakash Mesta, Vishnu D.M. and Ramachandra T.V., 2011. Green Walls for Karnataka Sea Coast, ENVIS Technical Report: 34, Sahyadri Conservation Series 10, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 3) Ramachandra T V, Subashchandran M D and Anant Hegde Ashisar, 2009. Landslides at Karwar, October 2009: Causes and Remedial Measures, ENVIS Technical Report: 33, Environmental Information System, Centre for Ecological Sciences, Bangalore

19.1 LANDSLIDE SUSCEPTIBLE ZONE MAPPING IN UTTARA KANNADA, CENTRAL WESTERN GHATS

Large scale landslides involving human casualties and notable losses to property were practically unknown in Uttara Kannada district situated towards the central Western Ghat-west coast region of Indian peninsula. A rethinking has set in, however, following a major disaster in early October, 2009, when following rainfalls of unprecedented intensity for the period, over 20 landslides happened during a single day in Karwar taluk, in which 19 people were buried alive in a single locality itself, and in other places the residents had providential escape due to marginal shifts in the actual locations of slope failures from human habitations. That the threat for future is at large can be deduced from the recurrence of a rockslide hitting a running train during the rains of 2010, killing one person and injuring others. Yet another hillside collapse happened in the outskirts of Kumta taluk, and the ground below being sparsely populated no casualties happened.

In view of the ever increasing developmental pressures in coastal Uttara Kannada, from the establishment of INS Kadamba, India's largest naval base, yet in the process of growth, Kaiga nuclear power plant, Karwar port and Bellikeri port handling specifically iron ore and granites beyond their carrying capacity limits, development of tourism etc. all leading towards increased deforestation of coastal hills and pediment cutting the risk proneness from slope failures appears to be looming large in the future years. The risk enhancement factor needs to be analyzed in view of the erratic rainfalls, and increased intensities in October, when otherwise the season of rains should have been tapering off. The specter of climatic change necessitates greater focus on slope failures, identification of hillsides prone to slope failures, study of causative and triggering factors , depiction of vulnerable areas on GIS based and locality specific maps and on evolving innovative technologies for future management.

Prediction of Landslide using Remote Sensing and GIS: In order to minimise the damage due to landslides, it is required to identify the regions, which are susceptible to landslides. This requires spatial and temporal data related to the region. Geospatial technologies such as Geographic Information System (GIS) and Remote Sensing (RS) help in the analysis of spatial and temporal data. Remote sensing provides the spatial data at regular intervals, while GIS helps in the analysis. GIS is the ideal tool for the analysis of parameters with a high degree of spatial variability.

Landslide susceptibility is defined as the proneness of a terrain to produce slope failures and susceptibility is usually expressed in a cartographic way. A landslide susceptibility map depicts areas likely to have landslides in the future by correlating some of the principal factors that contribute to landslides with the past distribution of slope failures.

Landslide hazard zonation map can be derived through interpretation of satellite imagery and by using the factors leading to the occurrence of the potentially damaging phenomenon. With the increasing availability of high-resolution spatial datasets along with GIS, it is possible to partially automate the landslide hazard mapping process that eliminates the need of longer time expenditure in fieldwork and extensive expert input. GIS is used combined with remote sensing to determine the relationship between various influencing parameters and predict areas that may be highly susceptible to landslides. Validation of this exercise is done by considering the historical data of past slope failures, and causal factors that resulted in unstable conditions. The essential steps followed in landslide susceptibility zoning are:

- A landslide distribution mapping, differentiated according to type, activity, dimensions, etc., and based on information covering, when possible, a time span as large as possible.
- Spatial mapping of the relevant terrain parameters related to the occurrence of landslides.
- The analysis of the terrain conditions, which are responsible for the occurrence of the different types of landslides.
- The assignment of weights to the causal factors, depending on their role in landslides.
- Formulation of decision rules and designation of susceptibility classes.

In order to predict the landslide prone regions, the data required are gathered in the field using GPS and for the high-resolution spatial data analysis the remote sensing data is used. The landslide map is prepared using remote sensing as well as ground-based maps and statistical data. Base map layers required for terrain analyses were derived from the toposheets. Collateral data (soil, lithology, rainfall, etc.) with the interpreted remote sensing data in GIS helped in mapping. After collecting the information needed it was organised into a database that could be presented graphically and in the GIS form. GIS is suitable to meet the requirements of synthesising the available information. The strength of GIS lies in its capability of storing interpreted and available information as maps and linked attributes. Mapped areas and attributes are retrieved, and cross-calculated. Landslide monitoring involves field data collection for meteorological, hydrological, topographical and geophysical data. The influencing factors that determine the occurrence of landslide hazards are topography (slope angle and aspect), soil, geology, underground water, rainfall intensity, land-use, the distribution of road and various geological features like lineaments, faults, etc. The recent development of automatic sampling, recording, and transmitting devices has helped immensely in landscape monitoring for predicting landslides.

Sharavathi River Basin: In order to do landslide prone zone mapping, suitable map layers along with attribute tables were considered necessary for inclusion in the GIS. Giving relative weightages of susceptibility to the classified objects of these maps, weights' map is prepared that also incorporated image processing techniques. Weight value for landslide susceptibility is calculated from the landslide density of each class of each control factor category. This helped in the division of the entire study area in various zones of hazard classes as per the weight assigned for various classes. The various layers, which were finally used for assigning weights for ranking, are slope, aspect, landuse/ landcover, NDVI image i.e. vegetation, geology i.e. lithological distribution, soil characteristics, drainage density, lineament density, road density and rainfall intensity. The parameters are prioritised based on the hazard potential i.e. higher the ranking higher is the area prone to landslide. The study area is divided into zones of landslide vulnerability viz., very high, high, very moderate, moderate, poor and very poor. The landslide magnitude definition says that the rankings, which are given to various factors, are.

- Rank 1 (Very Poor): No damage to infrastructure because of low-lying areas.
- Rank 2 (Poor): Injury, burial or death of people is likely.
- Rank 3 (Very Moderate): Destruction of smaller trees, powerlines, damage to houses possible, and removal of roadways are likely.
- Rank 4 (Moderate): Destruction of large trees, and burial of small houses possible.
- Rank 5 (High): Destruction of large infrastructure, and derailment of trains likely.
- Rank 6 (Very High): Destruction and burial to multiple infrastructures, parts of towns and villages.

In order to map landslide susceptibility zones in the river basin, considering various causal factors discussed so far, a composite map is generated in GIS by overlaying all causal factor-ranking layers. Higher weights indicate the sub-basin's susceptibility for landslides. Percentage share of each sub basin's weights is computed and are given in the Table 19.1. Values greater than 65.353 % or cumulative weights of 32.6765 were considered to confer the sub-basins' susceptibility to landslides.

Table 19.1: Final ranking values of factors in all Sub-basins

Sub-basin	Aspect	NDVI	Drainage	Landuse	Lineament	Road	Lithology	Slope	Soil	Rain	Sum	% Share
DS7	2	5	2	3.76	2	4	3.12	1.12	2.95	2	**27.95**	55.9
US1	1	5	1	4.15	5	3	4	1.05	4.5	1	**29.70**	59.4
US9	2	5	2	3.7	2	3	3.75	1.15	4.7	4	**31.30**	62.6
US3	1	4	2	4.62	5	4	4	1.1	4	2	**31.72**	63.44
US5	3	2	4	3.94	3	3	3.25	1.47	5.6	2	**31.26**	63.44
DS1	2	4	3	3.79	2	5	2.69	1.32	4.5	3	**31.30**	62.6
DS6	3	1	5	3.44	1	2	3.52	1.99	5.4	4	**30.35**	60.7
US2	1	5	1	4.93	5	5	4	1.05	5.3	1	**33.28**	66.56
US4	1	4	2	4.39	6	4	3.66	1.2	5	3	**34.25**	68.5
DS3	4	3	5	3.57	3	3	2.05	1.77	5.1	3	**33.49**	66.98
US6	3	2	4	4.12	3	2	3.32	1.37	6	5	**33.81**	67.62
DS2	5	3	5	4.15	2	2	3.16	1.97	4.2	4	**34.48**	68.96
US7	4	2	4	3.68	5	2	3.18	1.9	5.8	5	**36.56**	73.12
US8	4	3	3	3.98	6	3	4	2	5	1	**34.98**	69.96
DS4	5	1	6	3.97	3	2	2.94	1.97	4.2	3	**33.08**	66.16
DS5	4	1	5	3.57	1	6	3.98	2.1	5.2	3	**34.85**	69.7
Ranks	**5**	**5**	**6**	**5**	**6**	**6**	**4**	**2**	**6**	**5**	**50.00**	
										Maximum		**73.12**
										Minimum		**55.9**
										Average		**65.353**

The sub basins were grouped into landslide susceptibility zones on the basis of their weights of all causal factors. The zones prone for landslide are classified into 6 zones from very high to very poor based on the relative share of causal factors. Within susceptible sub-basins, considering slope and aspect, data regions were identified that are prone to landslides. This was also compared with the field data of existing landslides.

Regression analysis of each causal factors (as independent variable) and landslide proneness as dependent variable did not reveal any significant relationship (at $p < 0.05$). In order to understand cumulative effects, stepwise regression was carried out and the probable relationship is given by:

$$LS= -1.05801- (0.345238797) S + (0.204210801) L + (0.646266454) RD + (0.615561311) L D – (0.089156743) DD + (0.07793196) R +(1.888490458) A - (1.49700461) Sl – (0.00015434) Lu – (0.296976094) N$$

R = correlation coefficient = 0.5948, standard error of y estimate= 1.008

Where dependent causal factors are: LS= Landslide Susceptibility, S= Soil, L=Lithology, RD= Road Density, LD= Lineament Density, DD= Drainage Density, R= Rainfall, A= Aspect, Sl= Slope, Lu= Landuse and N= NDVI.

Remedial Measures: This hazard can be avoided through implementing protective measures considering delicately positioned properties of the study area as follows:

- To minimise any future slope failure the construction of the road should be at a properly planned position and haphazard road constructions must be avoided.
- Planting vegetation or maintaining slope terraces can also reduce slope-runoff so regulating the amount of vegetation clearing reduces the risk of increasing the number of landslide-prone areas.
- In view of recurring danger to life and property, an appropriate management strategy should be adopted to prevent diversion of streams, deforestation, conversion of hilly areas for plantation and agricultural activities. This would minimise landslides and mass failures.
- Construction of establishments without considering past or estimated peak flow stages may cause extensive damage to property that can be avoided by proper planning.
- Any disturbance that would contribute to deforestation must be avoided. This may fail slope in an above normal monsoon year.
- Socio economic survey reveals that the literacy rate is high in the area and the local residents must be made aware of the consequences of landslide hazards and the causal factors that aggravate the situation due to unplanned anthropogenic activities.

19.2 LANDSLIDES IN COASTAL UTTARA KANNADA: MANAGEMENT TOWARDS RISK REDUCTION

The hilly coast of Uttara Kannada, interrupted with backwaters and river mouths, had no notable history of landslides until multiple slides struck Karwar during the rain-soaked early days of October 2009 causing live burial of 19 persons. That the proneness of the region to landslides has increased due to rising human impacts can be assumed considering the collapse of a hillside along Kumta coast during the peak rainy days of 2010 and in yet another incident near Karwar, boulders rolling down a steep hill hit a running train causing one death and injuries to others.

A combination of factors may be blamed for the landslides that happened and likely to repeat, especially during days of excessive rains which are on the rise. Low lateritic coastal hills are formed of eroded and re-deposited materials from the Western Ghats through geological ages. Vegetation flourished on these hills until pressures from rising population and developmental activities erased bulk of it. The exposed soils of denuded hills got laterised through surface erosion, fine clay materials seeping down into the lower horizons leaving honey-combed iron rich, indurated surface laterite, a poor terrain for plant growth. The indurated surface laterite is an effective shield against landslides, except when deep vertical cuts are made exposing the soft clayey soil horizon beneath.

The vulnerability of deposited lateritic hills to landslides increases if such deposits have taken place along the river courses or estuarine regions, causing capillary rise of water from beneath and descend of rain water through fissures and holes formed by rotten tree stumps. Rainy spells can soak up the soft soils in the interior triggering mudslides due to rupture of the hills, as is the case with the killer landslide at Kadwad in Karwar. Quarrying, pediment cutting, soil removal and stripping of vegetation increase risks.

The granitic hills of Karwar coast are also posing potential landslide problems. The rocks here are of fractured type with ample pockets and cracks with trapped soils. Good forest cover could minimize risks. Deforestation in these is at its peak, caused erosion of top soil and water seepage into the interior of hills. Whereas the soils soak up and expand the granite rocks do not, unlike the laterite. Heavy rainfall acts as triggering cause for landslide hazards in such hills. Pediment cutting and quarrying add to the risk factor.

Probable landslide prone areas in Uttara Kannada district were predicted using algorithms – GARP (Genetic Algorithm for Rule-set Prediction) and Support Vector Machine (SVM) in a free and open source software package - openModeller. Several environmental layers such as aspect, digital elevation data, flow accumulation, flow direction, slope, land cover, compound topographic index, and precipitation data were used in modelling. A comparison of the simulated outputs, validated by overlaying the actual landslide occurrence points showed 92% accuracy with GARP and 96% accuracy with SVM in predicting landslide prone areas considering precipitation in the wettest month whereas 91% and 94% accuracy were obtained from GARP and SVM considering precipitation in the wettest quarter of the year.

To prevent landslide hazards, there should be accepted norms for each region, based on composition of soil and rocks, rainfall, quality and biomass of vegetation etc. Reduction of risk factor lies in providing appropriate vegetation cover, and any interference with the hills should be strictly adhering to norms of geology and ecology of the region. The entire coastal hillscape of coastal Karwar is fragile and calls for urgent attention as to the restoration of ideal ecological conditions leading to greater stability in the region.

Alterations in slope angle: According to Mishra (2009) the original slope angle of Jariwada hill of Kadwad was very low at ~20º, prior to human interference. The modification of the slope by cutting 15-20 m vertical slope (as observed in the right and left flanks of the slide zone of 60 m width and 30 m depth) for human settlement and plantation increased instability. In Kadwad-1, which had a 100 m width slide, of 15-20m depth, there was a vertical cut of 10 m height near the toe. The slope was cut for road formation. There was also excavation at the mid-slope to flatten the slope. The toe cutting and removal of material from the site has increased the driving force. As the slope forming material is mostly lateritic soil, clayey soil and overburden, the over-saturation of the slope material decreased the resisting force. Similar toe cutting, mostly for road making, happened almost in all the studied landslide locations. The original slope angles were gentle with a very low relief.

Land use changes: The clearances of natural vegetation for planting cashew apparently became an important cause for landslide in the Kadwad hills, so too expansion of household gardens into the hill by slope cutting. Slope cutting for road formation was common cause wherever landslides happened. There has been heavy colonization of humans in the Baithkol fisheries port area, causing rampant toe cutting of the isolated, steep sided 210 m tall hill protruding into the Arabian Sea from the south of the Karwar Bay.

Improper drainage: Natural drainage of rainwater has been affected in the slide areas due to different reasons. In the Kadwad hills the water table is high due to the nearness of the estuary and the hills being ancient mounds of soil in the way of a palaeo-river course descending from the Western Ghats. Over-saturation of soils during heavy rains is a constant factor here. Blockage of natural drainage, increasing the overburden saturation during heavy rains has been considered a potent reason for the landslides in Arga and Binaga hills. The high rising compound wall of INS Kadamba Naval Base acted like a dam impeding storm water drainage; the wall itself crumbled in few places due to the rush of storm water and slide material of stones and soil.

Stone quarrying and soil removal: In Zariwada there was reported excavation of soil in front of the slope that failed for the construction of the Konkan Railway embankment, increasing vertical slope height, inducing slope instability due to the volume and weight of material above the toe (Mishra, 2009). Granite quarries in the hills adjoining NH-17 would have also destabilized the hill sides as rocks came tumbling down from near a quarry site towards the highway and damaging the wall of the naval base.

19.3 LANDSLIDE SUSCEPTIBLE LOCATIONS PREDICTION THROUGH OPENMODELLER:

This study use pattern recognition techniques such as Genetic Algorithm for Rule-set Prediction and Support Vector Machine based models to predict the probable distribution of landslide occurrence points based on several environmental layers along with the known points of occurrence of landslides. The model utilises precipitation and six site factors including aspect, DEM, flow accumulation, flow direction, slope, land cover, compound topographic index and historical landslide occurrence points. Both precipitation in the wettest month and precipitation in the wettest quarter of the year were considered separately to analyse the effect of rainfall on hill slope failure for generating scenarios to predict landslides. A free and open source software – openModeller was used for predicting the probable landslide areas. openModeller (http://openmodeller.sourceforge.net/) is a flexible, user friendly, cross-platform environment where the entire process of conducting a fundamental niche modeling experiment can be carried out. It includes facilities for reading landslide occurrence and environmental data, selection of environmental layers on which the model should be based, creating a fundamental niche model and projecting the model into an environmental scenario using a number of algorithms as shown in Figure 19.1.

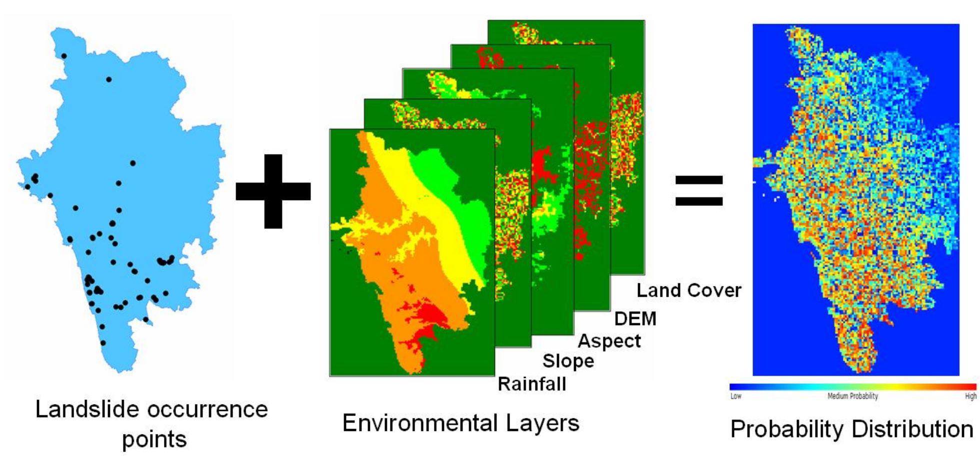


Figure 19.1: Landslide prediction in openModeller.

Two different precipitation layers were used to predict landslides – precipitation of wettest month and precipitation in the wettest quarter of the year along with the seven other layers. Figure 19.2 (a) and (b) are the landslide probability maps using GARP and SVM on precipitation of wettest month. Figure 19.2 (c) and (d) are the landslide probability maps using GARP and SVM on precipitation of wettest quarter with accuracy of 91% and 94% and Kappa values of 0.9014 and 0.9387 respectively. The landslide occurrence points were overlaid on the probability maps to validate the prediction as shown in Figure 19.3. The GARP map had an accuracy of 92% and SVM map was 96% accurate with respect to the ground and Kappa values 0.8733 and 0.9083 respectively. The corresponding ROC curves are shown in Figure 19. 4(a) and (b). Total area under curve (AUC) for Figure 19.5 (a) is 0.87 and for Figure 19.4 (b) is 0.93.

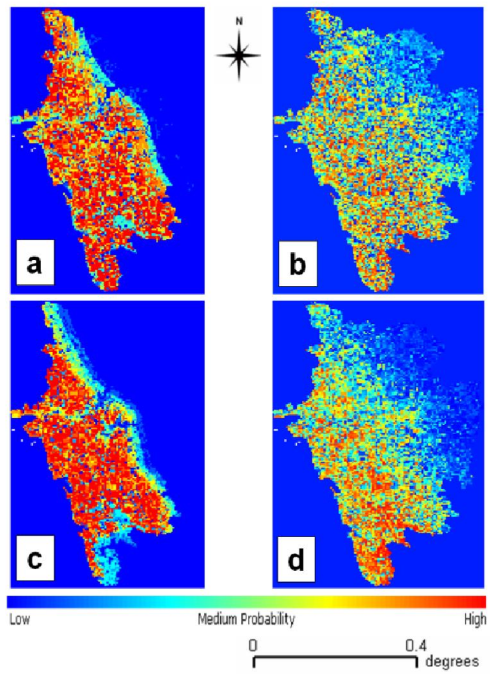


Figure 19.2. Probability distribution of the landslide prone areas.

ROC curves in figure 19.4(c) and (d) show AUC as 0.90 and 0.94. Various measures of accuracy were used to assess the outputs. Table 19.2 presents the confusion matrix structure indicating true positives, false positives, false negatives and true negatives.

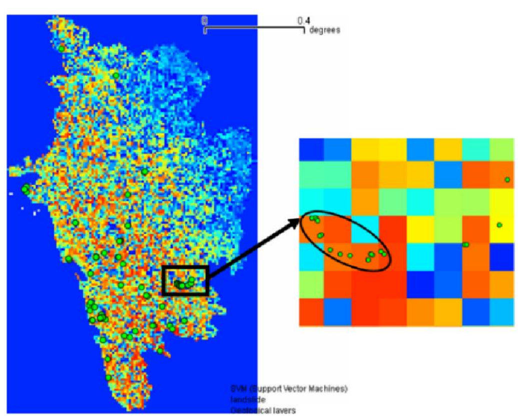


Figure. 19.3. Validation of the probability distribution of the landslide prone areas by overlaying landslide occurrence points.

Confusion matrices were generated for each of the 4 outputs (Table 19.3) and different measures of accuracy such as prevalence, global diagnostic power, correct classification rate, sensitivity, specificity, omission and commission error were computed as listed in Table 19.4. The results indicate that the output obtained from SVM using precipitation of the wettest month was best among the 4 scenarios. It maybe noted that the outputs from GARP for both the wettest precipitation month and quarter are close to the SVM in term of accuracy. One reason is that, most of the areas have been predicted as probable landslide prone zones (indicated in red in Figure 19.2 (a) and (c)) and the terrain is highly undulating with steep slopes that are frequently exposed to landslides induced by rainfall. Obviously, the maximum number of landslide points occurring in the undulating terrain, collected from the ground will fall in those areas indicating that they are more susceptible to landslides compared to north-eastern part of the district which has relatively flat terrain.

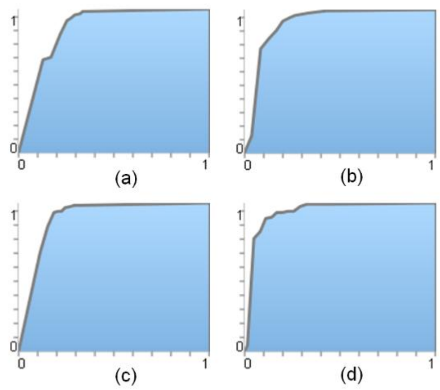


Figure 19.4. ROC curves for landslide prone maps (a) GARP (b) SVM on precipitation of wettest month; (c) GARP and (d) SVM on precipitation of wettest quarter.

TABLE 19.2: CONFUSION MATRIX STRUCTURE

	TRUE PRESENCE	TRUE ABSENCE
PREDICTED PRESENCE	A	B
PREDICTED ABSENCE	C	D

Key: A – True Positive, B – False Positive, C – False Negative, D – True Negative.

TABLE 19.3: CONFUSION MATRIX FOR GARP AND SVM OUTPUTS FOR UTTARA KANNADA

UTTARA KANNADA		TRUE PRESENCE	TRUE ABSENCE	NUMBER OF USABLE PRESENCE	NUMBER OF USABLE ABSENCE
GARP WITH PRECIPITATION OF WETTEST MONTH	PREDICTED PRESENCE	120	0	125	0
	PREDICTED ABSENCE	5	0		
SVM WITH PRECIPITATION OF WETTEST MONTH	PREDICTED PRESENCE	118	0	125	0
	PREDICTED PRESENCE	7	0		
GARP WITH PRECIPITATION OF WETTEST QUARTER	PREDICTED PRESENCE	118	0	125	0
	PREDICTED PRESENCE	7	0		
SVM WITH PRECIPITATION OF WETTEST QUARTER	PREDICTED PRESENCE	117	0	125	0
	PREDICTED PRESENCE	8	0		

TABLE 19.4: STATISTICS OF GARP AND SVM OUTPUTS FOR UTTARA KANNADA

UTTARA KANNADA	PREVALENCE (A+C)/N	GLOBAL DIAGNOSTIC POWER (B+D)/N	CORRECT CLASSIFICATION RATE (A+D)/N	SENSITIVITY A/(A+C)	SPECIFICITY D/(B+D)	OMISSION ERROR C/(A+C)	COMMISION ERROR B/(B+D)
GARP WITH PRECIPITATION OF WETTEST MONTH	-	-	0.96	0.96	-	0.04	-
SVM WITH PRECIPITATION OF WETTEST MONTH	-	-	0.94	0.94	-	0.06	-
GARP WITH PRECIPITATION OF WETTEST QUARTER	-	-	0.94	0.94	-	0.06	-
SVM WITH PRECIPITATION OF WETTEST QUARTER	-	-	0.94	0.94	-	0.06	-

* Key: A – True Positive, B – False Positive, C – False Negative, D – True Negative, N – Number of Samples.

Prevention and management

Several ways of prevention and management, many with general applicability and the others of site specific nature, are employed worldwide. Here only ecologically compatible non-engineering measures have been dealt with.

Identification of landslide prone areas: Based on soil and rock structure, rainfall patterns, slope and vegetation characteristics (evergreen, deciduous, scrub, plantations, fields, gardens etc.) and human impacts, preparation of landslide hazard zonation maps at 1:1000 scale are essential. The methodology has been already evolved by the Department of Science and Technology, Government of India, under the Natural Resources Data Management System.

Drainage correction: In the hilly areas natural drainage patterns should be studied and maintained properly without any blockage. Characteristic stream-side species are to be promoted for stream-bank protection and ecology.

Restoration of vegetation cover: A replanting programme should be undertaken giving priority for strong and deep rooted species which check erosion and withstand water-logging. *Pongamia pinnata, Calophyllum inophyllum, Ficus racemes, Thespesia populnea, Barringtonia* spp., *Terminalia arjuna* etc. may be considered for lower slopes bordering the estuarine areas. Middle and upper slopes in landslide prone areas should be planted with tree having lower biomass but stronger and deeper root networks. High biomass trees are likely to cause the weight of the overburden precipitating slope failures in future. Minimum of 350 trees/ha would be ideal number for the hills. Locality-specific members of the natural vegetation of any given area may be given priority. The general practice of monoculturing of trees has to be discontinued in all hazard zones

Enhancing the scope of VFCs: The scope of the already existing village forest committees may be expanded to landslide/natural resource management as well. Necessary awareness and training programmes may be arranged for them in landslide prevention and management.

Regulations on slope cutting and quarrying: Indiscriminate slope cuttings have to be strictly regulated and engineering solutions such as protective walls/embankments to be made where they are essential. Bio-protection is by far most important. Quarrying for stones and soils to be strictly limited to specified localities which pose no threat of landslides.

Development to be limited to carrying capacity: Karwar with several major projects such as India's largest naval base, Kaiga Atomic Plant, commercial port and a fisheries port, offices and several more establishments appears to be transgressing its ecological carrying capacity. The authors are presently engaged in a project estimating the ecological carrying capacity of Uttara Kannada district, and are expected to formulate specific measures for safeguarding ecological stability of the region as well as recommend developmental projects that are compatible with the rich biodiversity and ecological fragility of the region.

Recommendations

1. **Planting of native vegetation on hilltops and slopes.** The roots of the native vegetation, especially of certain specially chosen tree species, can act as good soil binders, thereby providing slope stability. The removal of trees (with deep tap roots) and subsequent taking over of secondary vegetation, planting of cashew trees on the Zariwada hill by removing earlier natural tree cover, most of them with shallow roots has reduced the soil binding properties.
2. **Restoration of natural drainage network.** Alteration in hydrological regime due to changes in drainage network consequent to deforestation - Inappropriate locations of human habitations on the first and second order streams in Kadwad has also hindered the water movement. Heavy pressure of rain water within the hill removed all the blockages on the way – as evident from mudslide and collapse of houses (in Zariwada)
3. **Discouraging monoculture plantations**– the land given to cashew plantations in the Kadwad hills should be taken back and the afforestation has to be carried out with the native species of flora according to suitably designed planting programmes.
4. **Immediate banning of large scale illegal quarrying of granite stones and mineral mining** considering the hazards proneness of the region (Karwar) and presence of sensitive pockets (Naval base, Kaiga nuclear plant, eco sensitive Anshi-Dandeli tiger reserve). Weathered granites on the hills and weakening of soil due to excessive rains have triggered the landslides near Binaga, National Highway.
5. **Banning soil and rock mining on the hills-** Landslide prone areas should not be leased out for soil or stone removal. All illegal mining and quarrying have to be stopped
6. **Improving drainage connectivity.** The collective rainfall of many days has enhanced the pore water pressure. This with lateral pressure due to swelling of oversaturated clay rich horizon has set the driving force resulting in burial of houses and humans displacement and destruction of houses and loss of properties (at Zariwada, Kadwad).
7. **Need to investigate the suitability of human habitations in regions prone to landslides.**
    a. The Konkan Railway track connecting Karwar town with Goa and other places passes through this Zariwada paleo-river valley and also crosses the lineaments. The vibration generated by movement of trains is also suspected to have developed the cracks on hill tops resulting in the loosening of the soil (subsequent to soil mining reported to have taken place). Long spell of high intensity antecedent rainfall has triggered the mud slide.
    b. Geomorphologically, the valley area was a paleo-river channel that formerly drained into the Kali River that flows in the north of Zariwada/Kadwad. The shift of the river course might have led to the formation of hills/mounds. Composition of this mound which is mainly of laterite clay further confirms the existence of paleo stream in this region. The paleo-river channel is still connected to the Kali River and the groundwater

seepage into the channel increases or decreases rhythmically according to high and low tides in the River.

c. Soil formation for centuries on the hillocks and heavy rain might have led to the swelling of clay inside the hillocks resulting in the landslips.

8. **No large scale developmental projects particularly in Karwar taluk and ecologically fragile regions in Central western Ghats.** Considering the implementation of large number of mega projects in Karwar, it appears that the region has exceeded the carrying capacity and further implementation of any mega projects would prove detrimental to the local population. The region has already prone to hazards and could be categorized as hazard hotspot. This also emphasizes the need for carrying capacity study for Uttara Kannada district.
9. **Considering the hazard proneness of the region it is necessary to set up 'Disaster management centre (DMC)'** to assist in regional planning, management of disasters and also to assist the administration in rehabilitation measures in case of eventualities. Also, the region around 25 km radius of Karwar is seismically sensitive and also occurrence of lineaments further emphasizes the need for setting up a **seismic monitoring cell (within DMC)** in the district to assist the district administration in the predication and also mitigation measures. Disaster management centre shall house seismic monitoring cell, and shall have the state of the art gadgets to predict calamities due to natural as well as human induced causes.
10. **Naval authorities should be asked to remodel the protection wall** considering the natural drainages on priority. Construction of the protective wall by the naval authorities without any due consideration to natural drainage systems has resulted in large scale flooding of the region, which also has triggered series of landslides all along the Highway (NH 17). Removal of the protection walls at many locations during the floods, highlights the need for holistic approaches in planning and implementation of large scale projects. Many such projects have seriously impaired the ecology of the region, affected the livelihood of nature people and also have posed serious threats to the existence of local population.
11. **Shifting of all affected families** (located on the hill side) at Madibag/Zariwada to appropriate locations without affecting their current livelihood dependence.
12. **Afforestation with native vegetation** in the region considering the large scale deforestation in recent times. At present many hill tops are barren or with highly inadequate tree cover.
13. **Setting up special Uttara Kannada package to restore ecosystems –** The funding shall be from all developmental projects in the district. **Karwar taluk, in all probability, has transgressed its limits of growth, beyond the carrying capacity** - Series of landslides consequent human tragedies and property loss is the indication of the lack of integrated approaches in planning and the region has crossed the thresholds of carrying capacity. Large scale land cover changes has resulted in alterations in hydrological regimes evident from the conversion of perennial streams to seasonal streams, enhanced siltation in the catchment evident from increased sedimentation in reservoirs in recent years. The region being one among the global biodiversity hotspots call for immediate measures to restore the ecosystems. Large scale projects such as hydro power plants, project sea bird, Kaiga nuclear plants have played significant role in degradation the ecosystems which have also affected the livelihood of local people. **These projects shall also make provision to provide a recurring grant to sustain the proposed Disaster Management Centre at Karwar and also for Ecological Research in Karnataka part of Western Ghats.**
14. Considering the level of devastations in Karwar, **landslide susceptibility mapping should be carried out to delineate potential zones of instability**, particularly in areas where human lives and properties are involved. If any indication of slope instability is noticed in an area which has

major risk elements, the fact should be shared with society in a proper way. This suggestion has two major implications.

a. First, with the increasing large scale environmentally unsound development activities in the region, the risk posed by natural hazard must also be evaluated. This is well-exemplified by a series of natural hazards (landslides) in the region. Considering rainfall-intensity and changes in climate / hydrologic regimes (due to global warming) stochastic relationships have to be developed to assess high-risk areas.
b. Secondly, with the successful establishment of relationship between rainfall and landslide activity, analysis of palaeo landslides would provide insights based on the past variation in rainfall patterns. Equally, such relationships aid in predicting changes in mass movement activities based on modelled regional impacts of global climate change.

15. Apart from reforestation of barren hill slopes and hill tops, sealing of cracks, slope-grading, proper drainage measures, soil reinforcement using geo-grid and biotechnical measures have to be done. However, appropriate selection of these measures along with their design is only possible after an in-depth geological and geotechnical study of the slide area.

20.0 RIVER BASIN-WISE, INTEGRATED HOLISTIC VALUATION (TANGIBLE AND INTANGIBLE) AND ASSESSMENT OF ECOLOGICAL CARRYING CAPACITY.

Task 12 : River basin-wise integrated holistic valuation and assessment of ecological carrying capacity
1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Vinay S., Bharath H A and Bharath Setturu, 2013, Carrying Capacity of River Basins considering Ecological and Social Demands, Sahyadri Conservation Series 36, ENVIS Technical Report 66, CES, Indian Institute of Science, Bangalore 560012, India

20.1 CARRYING CAPACITY OF RIVER BASINS CONSIDERING ECOLOGICAL AND SOCIAL DEMANDS

Carrying capacity refers to the maximum number of activities (biological, developmental, agricultural, and industrial, population) that can be supported over a period of time in the habitat without damaging the existing quality of life, balance of resources, ecology and productivity of the ecosystem. Ecological Carrying Capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. This provides theoretical basis with practical relevance for the sustainable development of a region. Carrying capacity of a river basin refers to the maximum amount of water available naturally as stream flow, soil moisture etc., to meet ecological and social (domestic, irrigation and livestock) demands in a river basin. Monthly monitoring of hydrological parameters reveal that stream in the catchments with good forest (evergreen to semi-evergreen and moist deciduous forests) cover have reduced runoff as compared to catchments with poor forest covers. Runoff and thus erosion from plantation forests was higher from that of natural forests. Forested catchment have higher rates of infiltration as soil are more permeable due to enhanced microbial activities with higher amounts of organic matter in the forest floor. Streams with good native forest cover in the catchment showed good amount of dry season flow for all 12 months. While strems in the catchment dominated by agricultural and monoculture plantations (of Eucalyptus sp. and *Acacia auriculiformis*) are sesonal with water availability ranging between 4-6 months. This highlights the impacts of land use changes in tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). This emphises the need for integrated watershed conservation approaches to ensure the sustained water yield in the streams. Assessment show that most Gram panchayats of Karwar and Bhatkal taluks, the Ghats of Supa, Ankola, Kumta, Honnawara, Siddapura, Sirsi and Yellapura have water for all 12 months (perennial). Gram panchayath in the coasts of Honnavara, Kumta and Ankola along with the Ghats of Siddapura, Sirsi, Yellapura and Supa towards the plains have water for 10 – 11 months, the plain regions of Haliyal and Mundgod taluks with part of Yellapura and Sirsi taluks show water availability for less than 9 months (intermittent and seasonal).

Quantification of silt yield highlights the linkage of silt yield with the land use in the respective sub-basin. Lower silt yield in sub-basins with good vegetation cover of thick forests, forest plantations, etc. The plains due to the higher lands under irrigation and are open lands, the silt yield is comparatively higher than that of other topographic regions. Strategies to regulate sand extraction are

- **Creation of No Development Zones (NDZ)**: Industries needs to be classified based on their type, and polices shall be amended upon which between 500 m to 10 km either sides of the river as listed in Table 4 and CRZ 1 (Coastal Regulation Zone 1).
- **Fixing of time for silt removal**: Removal of sand be permitted between 7 AM and 4 PM
- **Fixing of sand removal location and quantity**: Based on category of river, sand removal shall be allowed only from the river bed, and no sand removal operation be allowed within 10 m of the river bank. No sand removal is allowed within 500 m from any bridge, irrigation project, pumping stations, retaining wall structures, religious places, etc. Quantity of sand extracted at particular location shall not exceed the quantity of silt yield per annum. Weighing bridges are to be fixed at identified locations to regulate the quantity of sand extracted during a year.
- **Fixing vehicle loading points**: Vehicles shall be parked at least 25 to 50 m away from the river banks, no vehicles shall be brought near the river bank. Erecting of pillars to demarcate vehicle restriction regions, beyond which vehicle should not be allowed
- **Restriction on mechanized removal**: No pole scooping or any method shall be carried out in sand removal operation
- **Restriction or ban on sand removal**: Sand shall not be removed from likely places where saline waters mixes with fresh water. Sand removal quantity per year based on scientific assessment and approval of on expert committee of district. Sustainable harvesting of sand considering the yield at point of extraction. Regions such as breeding habitat of fishes and other aquatic organisms, endemic species of riparian vegetation, and basins where ground water extraction is prevalent, are to be identified in the river basins for restricting sand mining. District collector may ban sand removal in any river or river stream during monsoons, based on the Expert Committee. Based on the acts, rules and orders made by the GOI/ state the expert committee shall prepare river development plans for protection of river to keep up the biophysical environment along the river banks
- **Liability of District Collector**: Fifty percent of the amount collected by the local authorities shall be contributed as river management fund and shall be maintained by the district collector.

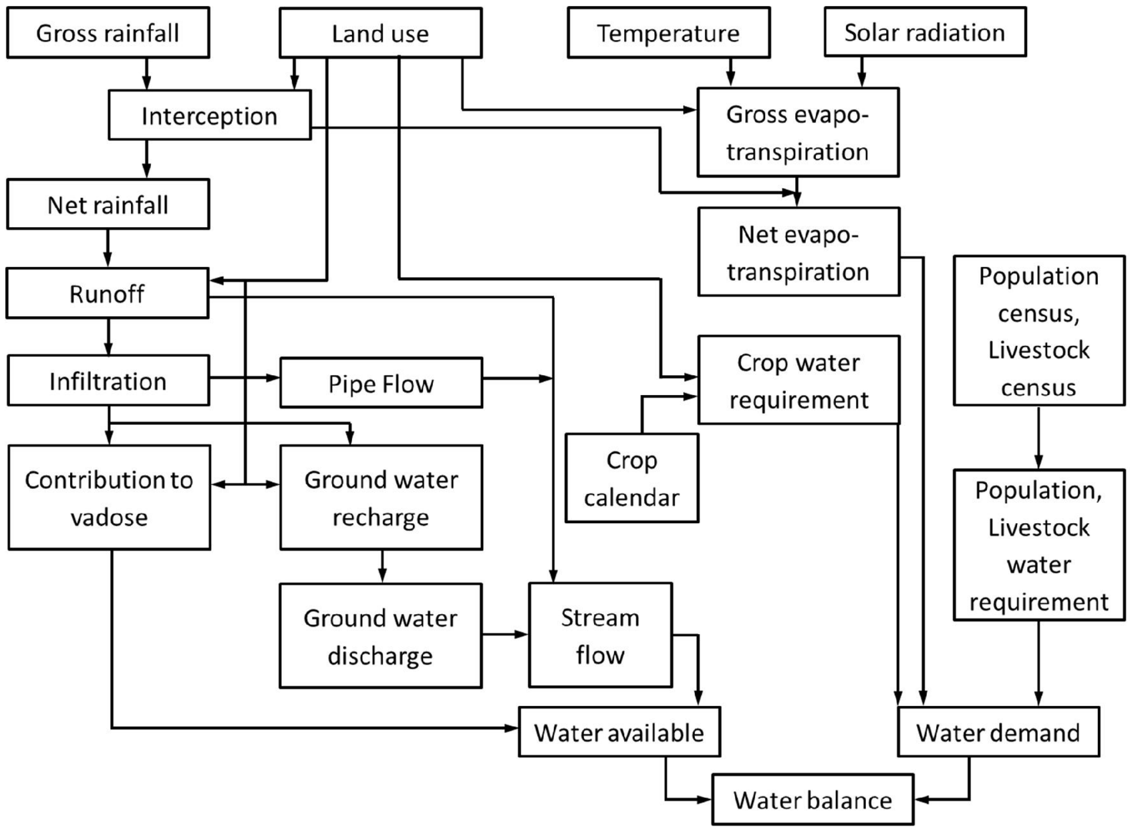
- **No construction between 500 m to 1 km from flood plain**: To protect life and property damages in cases of flash floods
- **Different stretch of rivers different regulations:** Rivers are dynamic, they come across different geomorphic, climatic, sociopolitical settings. Due to this different stretches of rivers faces different issues. Rivers where rivers originate, they are at the highest purity level which needs to be maintained as it is the source contributor for the downstream.
- **Flood Plain protection**: To protect against the damage that affects the floral and faunal diversity, intern maintaining the aesthetical and economic value of the river basins. No chemical based agriculture or fertilizers shall be used in the agricultural fields that affect the river channel polluting and affecting the ecosystem

Uttara Kannada District located (at74^{0}05'13" - 75^{0}05'58" E and 13^{0}55'26" - 15^{0}31'23" N) towards the centre of the Western Ghats, along the coast of Karnataka has geographical area of about 10,280 sq.km (Figure 20.1). It is a region of gentle undulating hills, rising steeply from a narrow coastal strip bordering the Arabian Sea to a plateau at an altitude of 500 m with occasional hills rising above 600–860 m. There are five west flowing rivers namely Kali, Gangavali, Agnashini, Sharavathi and Venkatapura (Figure 20.1) and two east flowing rivers Dharma and Varada. These river basins extend from N 13^{0}43'4" to N 15^{0}33'38" Latitude and E 75^{0}4'54" to E 75^{0}19'52" Longitude, and are spread across neighboring districts such as Belgaum, Hubli, Dharwad, Haveri and Shimoga.

Figure 20.1: Rivers with their catchment (and respective regional administrative boundaries)

Quantification of Hydrological Regime: Sub-basin wise hydrological assessment for major rivers of Uttara Kannada has been done using land use information with meteorological and lithological parameters. Figure 20.2 outlines the method adopted for assessing the hydrological parameters and water budgeting with ecological flows.

Figure 20.2: Method for hydrological assessment



Water Balance: Sub-basin wise water balance (W_B) is a function of water availability (W_A) and water demand (W_D) and is given by equation 1.

$$\mathbf{W_B = \mathit{f}(W_A, W_D)} \qquad \ldots..1$$

Where, W_B = Water balance, W_A = Water available, W_D = Water demand

The water availability in the sub basin depends on hydro-meteorological factors and demographics (land use, slope, soil…etc.) of the region, where as the water demand depends on the irrigation, domestic and livestock water requirements along with evapotranspiration. In any river basin if W_A is less than W_D, then this condition in the river basin during the month can be referred to as water deficit period.
Hydrological water balance equation is used to quantify the amount of water that goes through various phases of the Hydrological Cycle. The water balance equation is based on the law of conservation of matter and is given by equation 2.

$$\mathbf{Inflow = Outflow} + \Delta_{\mathbf{Storage}}. \qquad \ldots\ldots\ldots 2$$

Inflow into a river sub basin includes precipitation and groundwater discharge, whereas out flow from sub basin involves interception, surface runoff, pipe flow (lateral flow), transpiration, evaporation, groundwater recharge.

Rainfall: Rainfall analysis was carried out using daily rainfall data for the period 1901 and 2010 of 144 Rain gauge stations in and around the study area (covering all sub basins of major rivers in Uttara Kannada). Mean annual rainfall ranges from 550 mm (in the plains towards Hubli-Dharwad District) to over 6500 mm (in the Ghats of Sagara and Hosanagara taluks of Shimoga district). Within the region, rainfall varies between 750 mm to over 5500 mm. Figure 20.3a indicates the annual rainfall distribution across the region. Ghats section with thick forest cover receives annual rainfall of over 4000 mm, whereas the coast receives annual rainfall between 3000mm to 4000 mm and the plains with moderate forests receive annual rainfall between 1000 to 3000 mm (Figure 20.3b). Plains with no/very little forest cover or scrubs receive very low annual rainfall of less than 1000 mm. Figure 20.4 shows annual rainfall received in the whole catchment by interpolating the rainfall (rain gauge station) and isohyets.

Forest vegetation depend on the quantity of rainfall and number of rainy days/wet days. Number of rainy days computed, rain gauge station wise considering rainfall (i) more than 50 mm/month and (ii) more than 100 mm/month. Figure 20.5a and figure 20.5b shows the spatial distribution of rainy days and rainy months on an average in a year for both cases. For both the cases coasts and the Ghats receive rainfall for over 90 days in a year, indicating higher annual rainfall, good vegetation (forest) cover and high variations in terrain at these rain gauge stations, rainy months at these rain gauge stations are over 6 months in both cases, and extend over 8 months when rainfall is over 50 mm per month. With terrain getting flatter and less undulating towards the plains, the rainfall intensity decreases with less dense or degraded vegetation (forest) cover, the number of rainy days dropdown to less than 90, and 6 or less rainy months in an year in both cases, and drops to 2 months in case of rainfall less than 100 mm/month in parts of Hubli and Dharwad. The plains in the north east receives rainfall in 2 rainy seasons, one during the south west monsoon, the other during north east which results in higher rainy months/days. Sub basins surrounding the dam sites and large lakes receive local rains during summer, observed near Linganamakki reservoir of the sharavathi river basin, at Supa, Bommanhalli, Tattihalla, Kadra, Kaneri and Kodsalli dam sites of Kali basin, and Gangavali basin respectively.

Figure 20.3a: Annual Rainfall in mm (Rain gauge station wise) with Rainfall Contours

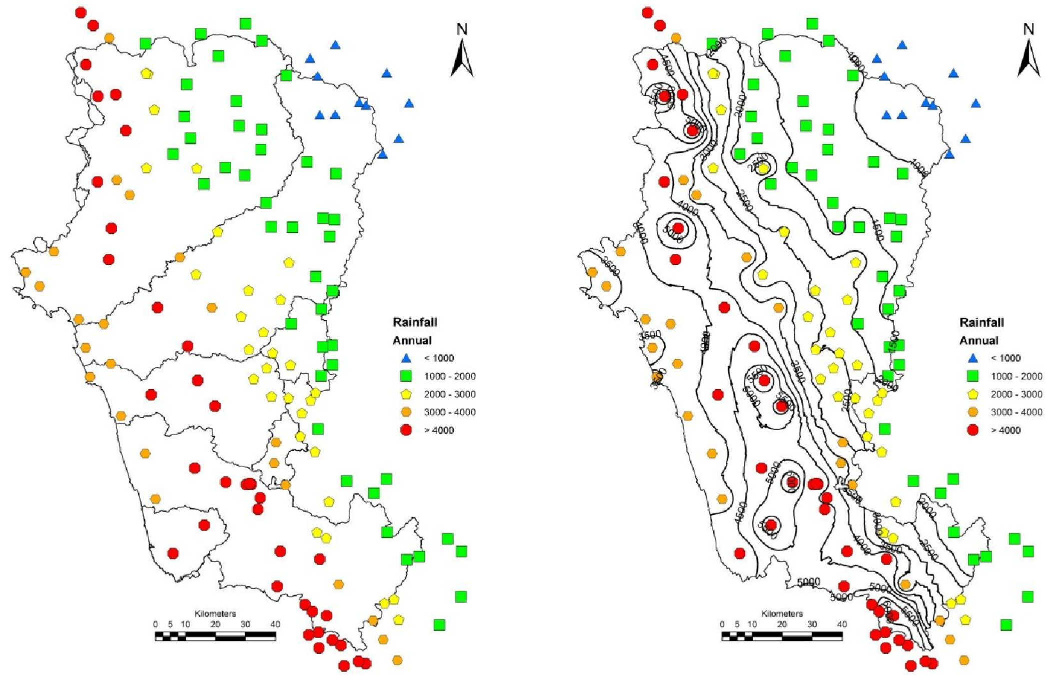


Figure 20.3b: Annual Rainfall in mm overlaid on DEM

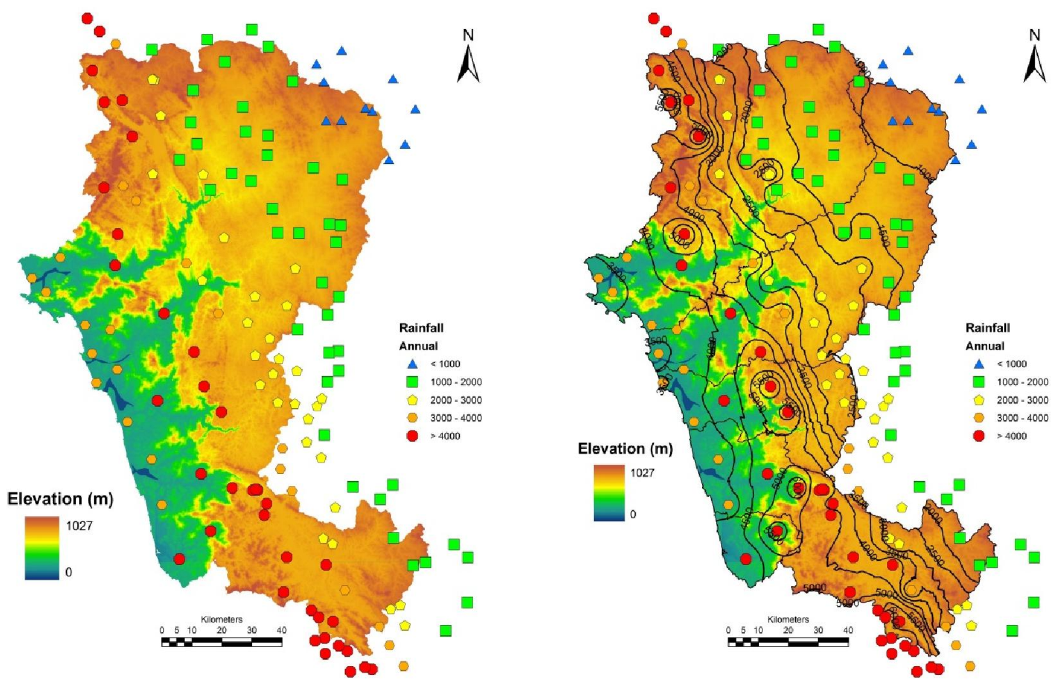
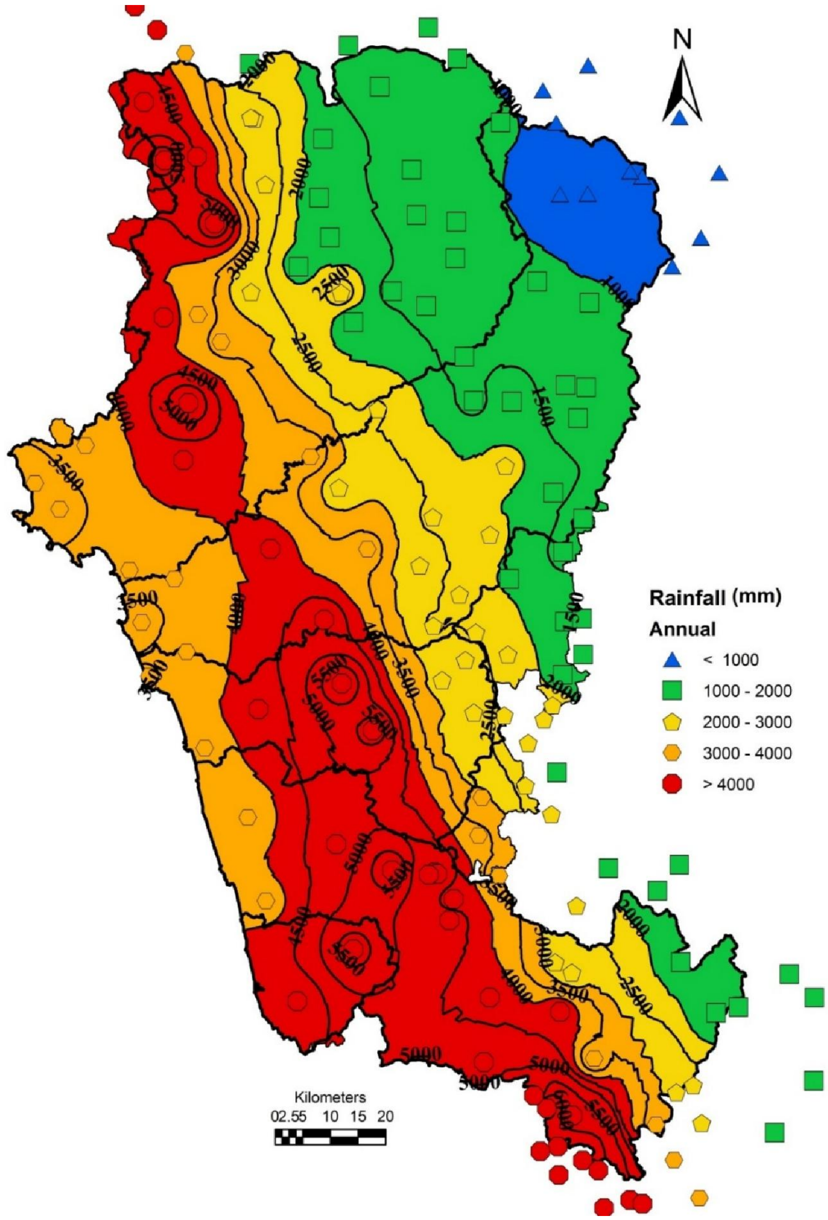
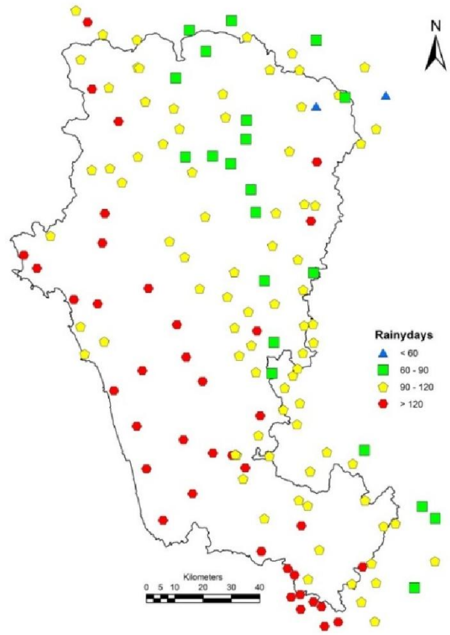


Figure 20.4: Annual Rainfall (in mm) with contours and rain gauge stations

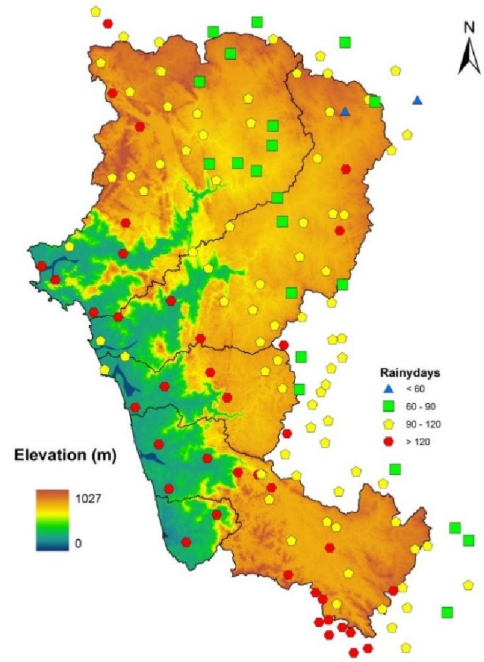


Water Budget and Stream flow assessment: Figure 20.6 indicates the hydrological status highlighting the basins with the water availability as either surplus or deficit (scarce). If the ratio of availability to demand falls below 1, sub-basin indicates the scarcity of water. Streams were graded as A, B, C and D depending on the perennial, intermittent or seasonal water availability (which are comparable to field measurements). Figure 20.7 also highlights the water availability as number of months in a year. The Ghats and some part of coast (with good forest cover) show water availability during all 12 months, whereas some sub-basins towards the plains and the rest of the coast the surplus is available between 6 to 11 months and the plains has the water available for less than 6 months

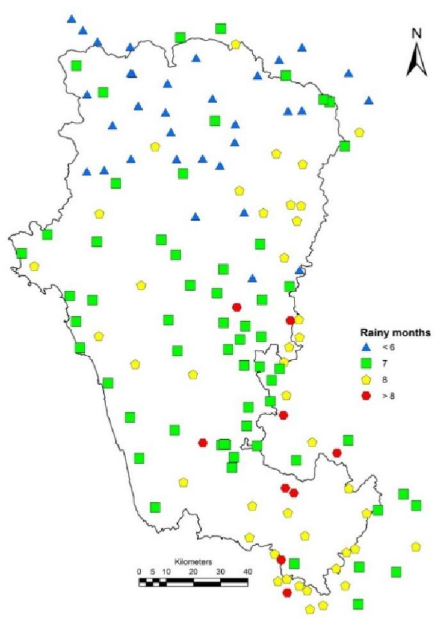
Figure 20.5a: Rain gauge stations with monthly rainfall more than 50 mm



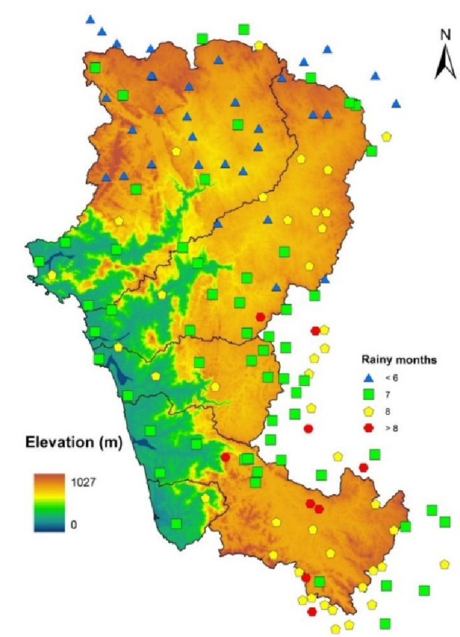
Rainy days



Overlaid on DEM

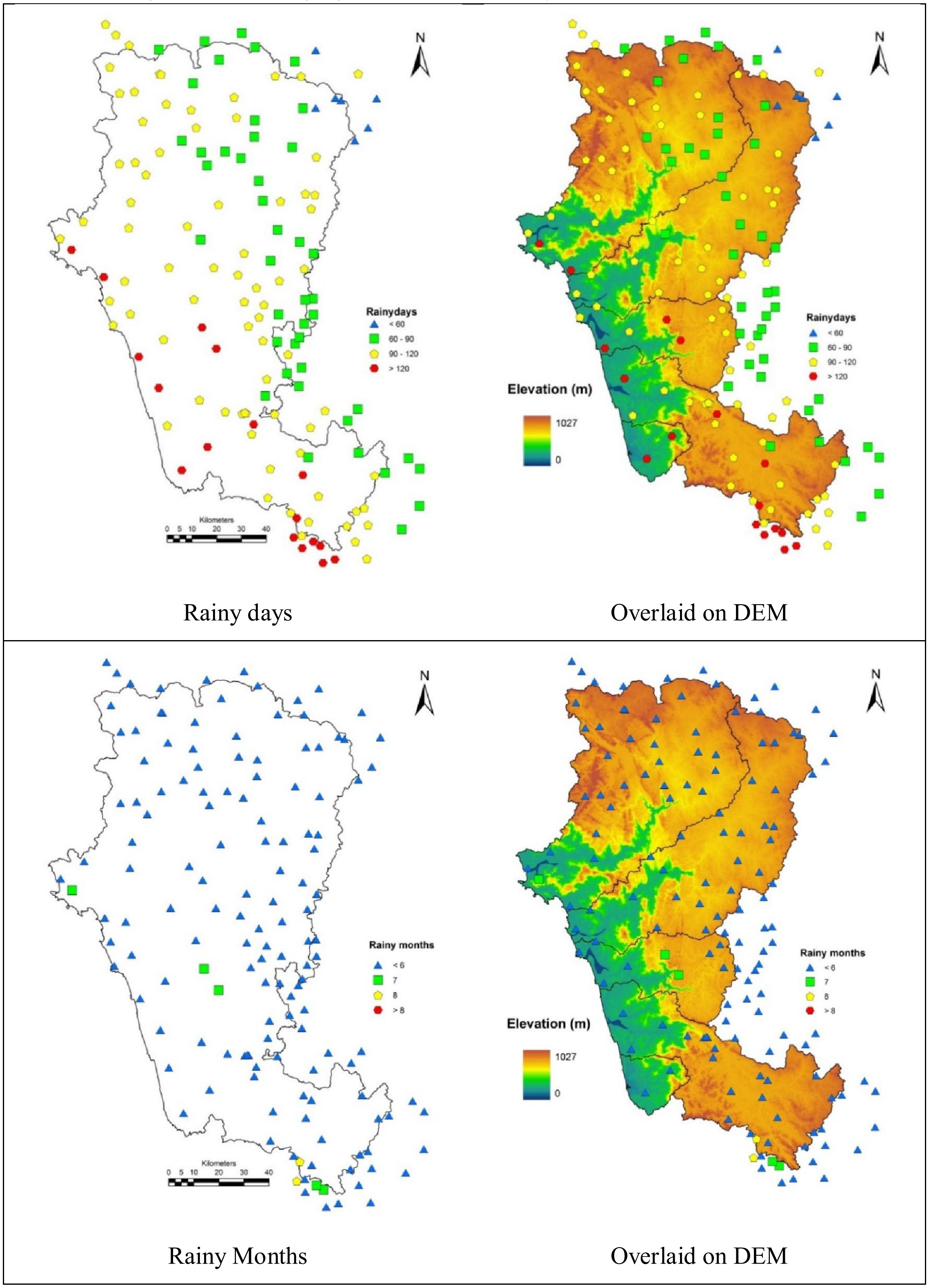


Rainy Months



Overlaid on DEM

Figure 20.5b: Rain gauge stations with monthly rainfall more than 100 mm



Rainy days — Overlaid on DEM

Rainy Months — Overlaid on DEM

Figure 20. 6: Hydrological Status (ratio of supply to demand)

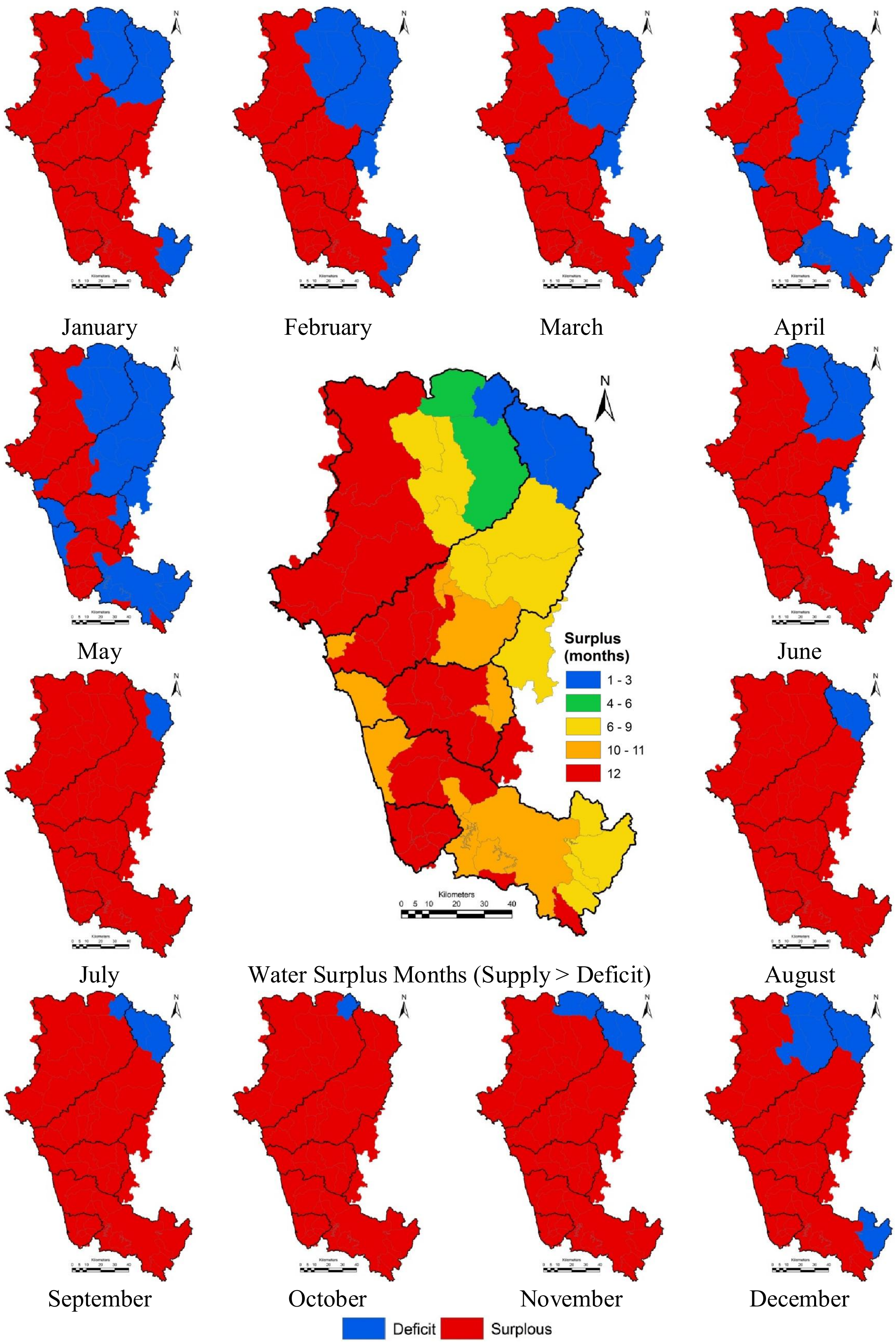
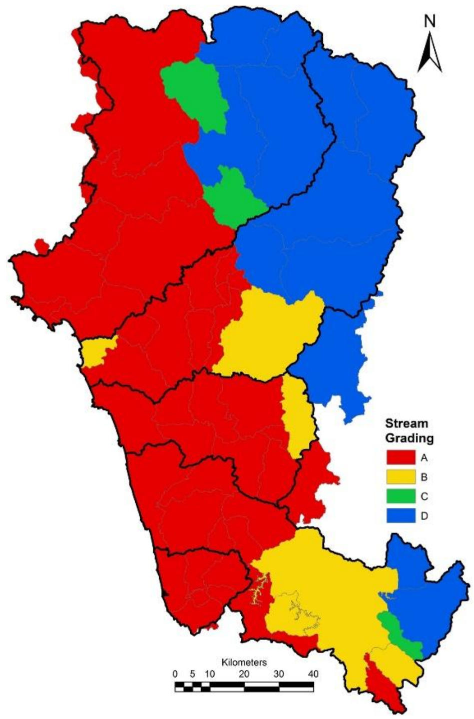


Figure 20.7: Stream Grading based on field measurements



Stream Grading	A	B	C	D
Flow Months	12	9	6	3

The significance value for all the above relationships were less than 0.05, indicating good confidence level of 95 % of the relationships. The relation between runoff, ground water discharge, interior forest and perforated forest provides significant results with coefficient of determination as **0.802**. i.e.,

$$Fl = 0.0034 * R + 0.0086 * Gwd + 7.571 * If + 20.092 * Pef + 1.740 \quad \text{.....42}$$

The equation indicates that the presence of interior forest has higher importance over the flow regime, as forests hold higher water in vadose and ground water zones and releases water during lean season to streams as pipe flow or base flow.

Silt Yield in Uttara Kannada District: Soil erosion is the result of complex processes involving alteration of landscape structure due to denudation and transportation of surface soils, the process of frosting and thawing action of rocks, which is controlled by climatic, topographic, geologic, geomorphic, and land use characteristics. Anthropogenic activities leading to deforestation and agricultural intensification influence the rate of erosion and sedimentation. This section quantifies the silt yield based on land use of sub –basin and suggest measures to regulate unsustainable extraction of sand in this region. Silt yield per hectare computed as discussed in Methods section (table 20.1, based on 4 scenarios) is depicted in figure 20.8. Quantification of silt yield based on equation 6 (Garde and Kothyari) indicated lower silt yield in the Sahyadri with good vegetation cover of thick forests, forest plantations, etc. The plains due to the higher lands under irrigation and are open lands, the silt yield is comparatively higher than that of other topographic regions. Figure 20.9 gives the total silt yield in each sub-basin of the district.

Table 20.1: Silt yield using empherical equations

Silt Yeild in kilo cum/ annum	Chandewadi	Magod
Khoslas	249.2	1293.6
Dhruva Narayan and Babu	226.5	1014.5
Garde and Kotyari	209.7	2300.2
Average	228.4	1536.1

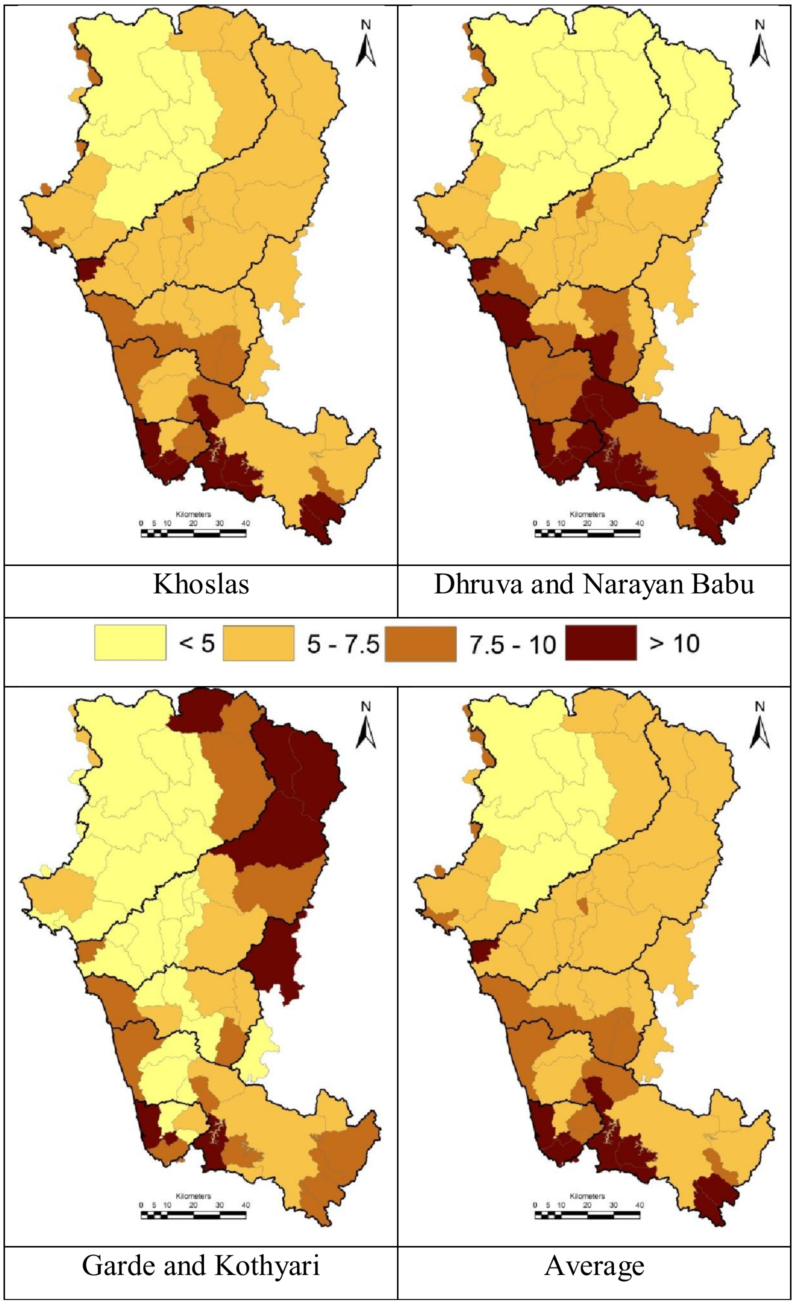


Figure 20.8: Silt Yeild in cubic metre per hectare per annum

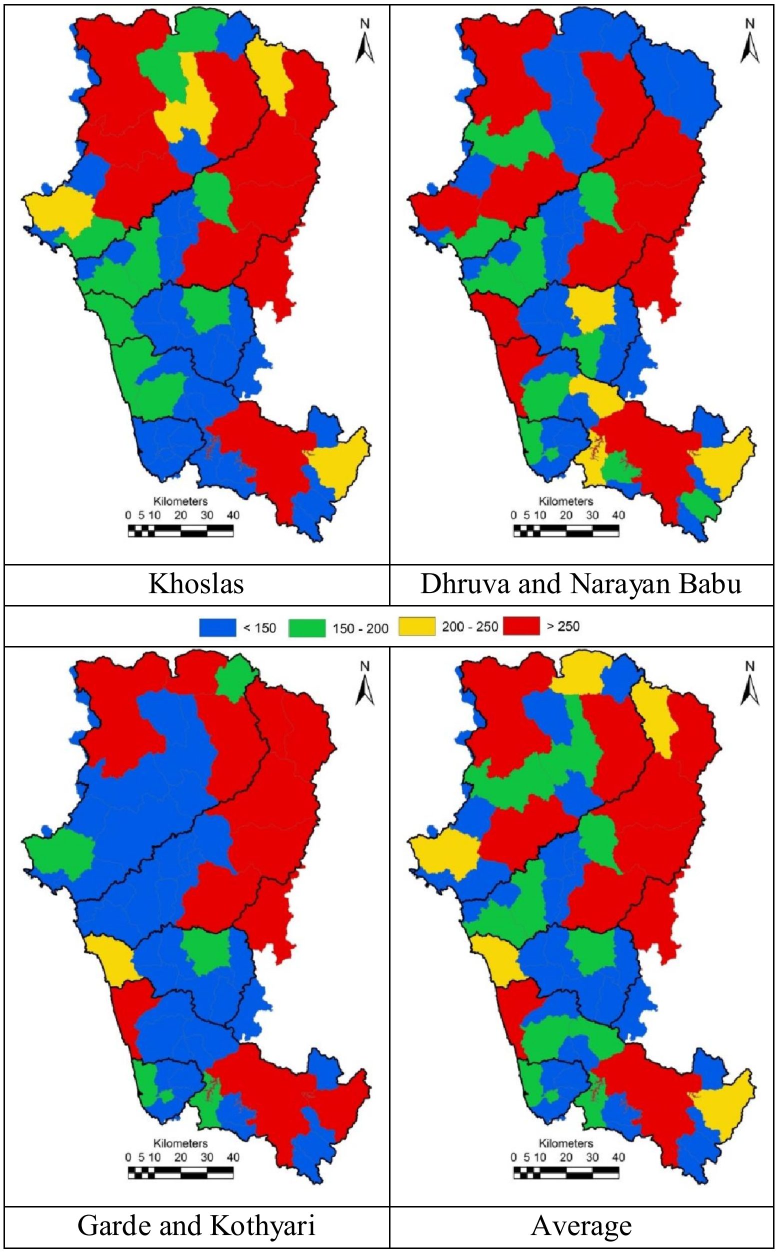


Figure 20.9: Sedimentation in kilo cubic meter per annum

Table 20.2 lists the strategies to overcome the excessive silt extraction or sand mining.

Table 20.2: Strategies to regulate excess sand extraction

Slno	Strategy	Discretion
1	Creation of No Development Zones (NDZ)	Industries needs to be classified based on their type, and polices shall be amended upon which between 500 m to 10 km either sides of the river as listed in Table 4 and CRZ 1 (Coastal Regulation Zone 1)
2	Fixing of time for silt removal	Removal of sand be permitted between 7 AM and 4 PM
3	Fixing of sand removal location and quantity	Based on category of river, sand removal shall be allowed only from the river bed, and no sand removal operation be allowed within 10 m of the river bank. No sand removal is allowed within 500 m from any bridge, irrigation project, pumping stations, retaining wall structures, religious places, etc. Quantity of sand extracted at particular location shall not exceed the quantity of silt yield per annum. Weighing bridges are to be fixed at identified locations to regulate the quantity of sand extracted during a year.
4	Fixing vehicle loading points	Vehicles shall be parked at least 25 to 50 m away from the river banks, no vehicles shall be brought near the river bank. Erecting of pillars to demarcate vehicle restriction regions, beyond which vehicle should not be allowed
5	Restriction on mechanized removal	No pole scooping or any method shall be carried out in sand removal operation
6	Restriction or ban on sand removal	Sand shall not be removed from likely places where saline waters mixes with fresh water Sand removal quantity per year based on scientific assessment and approval of on expert committee of district Sustainable harvesting of sand considering the yield at point of extraction Regions such as breeding habitat of fishes and other aquatic organisms, endemic species of riparian vegetation, and basins where ground water extraction is prevalent, are to be identified in the river basins for restricting sand mining District collector may ban sand removal in any river or river stream during monsoons, based on Expert Committee. Based on the acts, rules and orders made by the GOI/ state the expert committee shall prepare river development plans for protection of river to keep up the biophysical environment along the river banks
7	Liability of District Collector	Fifty percent of the amount collected by the local authorities shall be contributed as river management fund and shall be maintained by the district collector.

8	No construction between 500 m to 1 km from flood plain	To protect life and property damages in cases of flash floods
9	Different stretch of rivers different regulations	Rivers are dynamic, they come across different geomorphic, climatic, sociopolitical settings. Due to this different stretches of rivers faces different issues. Rivers where rivers originate, they are at the highest purity level which needs to be maintained as it is the source contributor for the downstream.
10	Flood Plain protection	To protect against the damage that affects the floral and faunal diversity, intern maintaining the aesthetical and economic value of the river basins No chemical based agriculture or fertilizers shall be used in the agricultural fields that affect the river channel polluting and affecting the ecosystem
11	Creating awareness among the stake holders	Very essential in order to protect the riparian vegetation, stake holders includes fishermen, dhobi's, cattle heard's, manufacturer's, entrepreneurs, environmentalists etc… all of those shall be made aware of impact of their activities on the environment/ rivers
12	Afforestation	To prevent the erosion of soil To prevent landslides along the banks of rivers

21.0 FORMULATION OF ECOLOGICALLY SOUND DEVELOPMENTAL PLAN FOR SUSTAINABLE PRODUCTIVITY OF THE DISTRICT.

Task 14: Formulation of ecologically sound developmental plan for sustainable productivity of the district.
Reports Submitted   1) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, Rao G R., Prakash Mesta, 2013. Ecologically sensitive regions in Uttara Kannada, Sahyadri Conservation Series 37, ENVIS Technical Report 67, ENVIS, Centre for Ecological Sciences, Indian Institute of science, Bangalore 560012   2) Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

21.1 ECOLOGICALLY SENSITIVE REGIONS IN UTTARA KANNADA

Ecologically Sensitive Regions (ESRs') are the 'ecological units' that may be easily affected or harmed. It is a bio-climatic unit (as demarcated by entire landscapes) wherein human impacts have locally caused irreversible changes in the structure of biological communities (as evident in number/ composition of species and their relative abundances) and their natural habitats' (Section 3 of the Environment (Protection) Act 1986 (EPA)). This approach of conservation or ecological planning considers spatially both ecological and social dimensions of environmental variables. Ecological sensitive regions with exceptional biotic and abiotic elements are being degraded or lost as a result of unplanned developmental activities. Landscapes sustainability as a basic goal for development requires comprehensive picture of the biophysical and socio-cultural information of a region and this approach provides an opportunities and constraints for decision-making and sustainable management of natural resources. Conservation by prioritisation of sensitive regions has been widely used to improve ecosystem by conservations practices. This study prioritises the regions at Panchayat levels in Uttara Kannada district, Central Western Ghats, considering attributes (biological, Geo climatic, Social, etc.) as ESR1(Regions of highest sensitivity or Ecologically Sensitive Region 1), ESR2 (Regions of higher sensitivity), ESR3 (Regions of high sensitivity) and ESR4 (Regions of moderate sensitivity).

The current research envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka –Uttara Kannada district. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. This process in due course will create an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government. Integrated

Ecological carrying capacity study provides the regional planner in evolving appropriate conservation strategies for sustainable management particularly on a defined geographical area. Decision making on developmental activities, entail planning that depends upon the availability of reliable and accurate data. Data required for natural resource planning include spatial data such as, information of physiography of the area, land use, assets, etc. Geographic information system (GIS) with a capability of handling spatial data helps in the analysis and visualisation of results effectively, and aids decision making process.

Uttara Kannada district located in the central western Ghats lies between 13^0 55' to 15^0 32'N and 74^0 05' to 75^0 05'E covering approximately an area of 10, 291 km^2. It forms arts of narrow Malabar where its location is almost central. The district extends N-S to maximum of 180 km and W-E to maximum width of 110 km. The Arabian sea border it on west creating a long continuous through narrow, coast line of 120km running N-S. Goa, Belgaum, Dharwad and Shimoga- Dakshina Kannada form Northern-Eastern and Southern boundaries respectively.

Western Ghats with a repository of endemic flora and fauna is one of the 34 hotspots of the world. The range of ancient hills that runs parallel to western coast of India form several ecological regions depending upon the altitude, latitude, rainfall and soil characteristics. The vegetation varies between the western escarpment, the crest with its lateritic plateaus and the drier eastern slopes. In few areas that are relatively undisturbed, the crest-line has isolated patches of unique tropical evergreen forest with open short grasslands. These forests are severely fragmented in the northern part of range, while in the south they still cover several larger stretches. The western slopes have a more moist vegetation patterns, whereas on eastern sides, drier vegetation merges into the scrubland of the Deccan-off shoots, such as Nilgiris, Annamalai in South India, form corridors between Western and Eastern Ghats. The southern ranges have higher rainfall, leading to some of the most lush evergreen forest tracks in the country. The forest of Western Ghats consists of evergreen forests, semi-evergreen forests and deciduous forests.

As a result of high variation in latitude, altitude and climate, the Western Ghats supports a wide variety of habitats and, thus, high overall biodiversity. Long periods of isolation from similar habitats elsewhere in the Indian sub-continent have led to the development of high levels of endemism, particularly within the region's moist deciduous and evergreen forests. Among vertebrate groups, amphibians exhibit the highest level of endemism (78 percent of species found in the region are endemic), followed by reptiles (62 percent), fish (53 percent), mammals (12 percent) and birds (4 percent). Of the 4,000 species of flowering plant found in the Western Ghats, 1,500 (38 percent) are endemic. The Western Ghats also contains numerous medicinal plants and important genetic resources, such as the wild relatives of various cereals (rice, barley, etc.), fruits (mango, banana, jackfruit, etc.), and spices (black pepper, cinnamon, cardamom and nutmeg). In addition to rich biodiversity, the Western Ghats is a home to diverse social, religious, and linguistic groups. The high cultural diversity of rituals, customs, and lifestyles has led to the establishment of several religious institutions that strongly influence public opinion and the political decision-making process. The presence of hundreds of sacred groves and sacred landscapes in the region bears testimony to society's commitment to conservation. The irreplaceable biodiversity and ecosystem service values of the Western Ghats are threatened by a variety of human pressures.

Biodiversity conservation, socio-economic development and sustainable management of natural resources requires information such as landscape dynamics, which helps in assessing threats as well as opportunities. Natural forest cover in the district is about 542,475 hectares, of which 25.62% are contiguous interior forests and standing biomass is about **113823** Gg. The region harbors variant rich flora, fauna and conservation habitats.

Uttara Kannada district was divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2. Grids are ranked based on an aggregate weightage metric score considering the information related to spatial extent of forest cover, extent of interior forests, occurrence of endemic flora and fauna, presence of conservation reserves, standing biomass, annual increment of biomass, geo-climatic parameters (slope, altitude, rainfall), estuarine diversity and productivity and presence of forest dwelling communities. Grids were ranked as ESR 1 to ESR 4 depending on the score. Ecological sensitive regions (ESR) at panchayat level / disaggregated levels suitable for local level planning (implementation of Biodiversity act, 2002) were delineated by overlaying spatial layer of panachayat. Uttara Kannada has 209 panchayats with the enactment of the 73rd Constitutional Amendment Act to strengthen the grassroots democratic processes. Among these, 102 panchayats are in ESR 1, while ESR 2 has 37 panchayat, ESR 3 has 33 and ESR 4 has 37 panchayats. ESR 1 and ESR 2 are most ecologically sensitive regions of the district. The degradation of these areas will have irreversible impact on the ecology, biodiversity and sustence of natural resources. Regions under ESR 1 and 2 are "***no go area"*** for any developmental activities involving large scale land cover changes. ESR 2 have ecosensitiveness similar to ESR 1, and has scope to attain the status of ESR 1 with eco-restoration measures (as some pockets are degraded). ESR 4 are regions of moderate sensitivity, wherein sectors such as agro processing, information technology (IT), and such environment friendly sectors be permitted. Suggestions regarding ESR are:

1. Restrictions on large scale land cover changes;
2. Encouragement to organic farming;
3. No monoculture plantation of exotics like Eucalyptus, Acacia, etc.;
4. Extraction of medicinal plants only with strict regulations;
5. Ban on hazardous or toxic waste processing units;
6. Protection of high altitude valley swamps and water bodies;
7. Restoration of land cover through appropriate catchment area treatment plans of hydroelectric and major irrigation projects to improve their life span by reducing silt yield in the catchment;
8. Setting up fodder farms to support local livestock population;
9. Ban large scale mining;
10. Controlled quarrying and sustainable sand mining;
11. Involving education institutions to document biodiversity in the neighbourhood (village level);
12. Eco clubs at all schools and students to take part in environment monitoring (part of curriculum);
13. Environment profile indicators be worked out by Research institutions, NGOs along with local communities;
14. Setting up agro processing industries, cottage industries to support local livelihood;
15. Collection of NTFP through local people (complete removal of contract system);
16. Development of forest nurseries of local species through the active participation of local villagers;
17. Incentives to VFC's for conservation and protection of forests.
18. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada (Source: Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012)

19. Integrated clustering of villages for inclusive growth promoting eco-friendly, local resources, local skill and man-power based thematic developmental programmes through laying a stronger foundation for sustainable growth.
20. Micro-finance and revival of village centred enterprises and clustering of villages for thematic development programmes can greatly improve financial and livelihood security of rural homes, and could provide largest venues for women empowerment.

Cluster-based economic development approach is considered an important aspect of a broader re-orientation of research and economic policy towards laying the foundations of a microeconomic approach for prosperity and growth. The past decades were under the spell of macroeconomics and the creation of market institutions in developing economies. While there is now fairly broad consensus on the type of macroeconomic and legal conditions necessary to achieve economic progress, it is also becoming clearer that these conditions are not sufficient. As a new approach to help economies reap the full potential of an improved macroeconomic and legal context cluster-based efforts have received a lot of attention. Clusters are groups of companies and institutions co-located in a specific geographic region and linked by interdependencies in providing a related group of products and/or services. Because of the proximity among them – both in terms of geography and of activities – cluster constituents enjoy the economic benefits of several types of positive location-specific externalities.

Cluster facilitators and need for institutional structure for implementation: Village panchayats form ideal units for implementation of cluster approach for integrated eco-friendly development. The success of cluster based development programmes will depend on the active participation of facilitators. The various Government departments, financial institutions and NGOs will have active roles to play for the success of the integrated cluster-base approach. In addition there is also need for district and taluk level facilitator committees for scrutinsation of developmental plans and review of progress achieved. The role of some facilitators, are indicated below:

Forests and wildlife departments: As forests constitute a major asset of the district the Forest Department need to be strengthened with adequate manpower at ground level.

- Development of nurseries involving local people. People be encouraged and guided to make nurseries of forest trees and medicinal plants (*Coscinium fenestratum, Nothapodytes nimmoniana, Asparagus racemosus, Emblica officinalis, Saraca indica, Terminalia bellirica, Adhatoda vasica, Rauwolfia serpentina, Tinospora cordifolia* etc)
- It is suggested to look into the feasibility of purchase of medicinal plants or their products by the Forest Department itself, or by the local VFCs from the producers at fair prices, and the sale/supply of these goods to pharmaceuticals to be undertaken by the Forest Department itself. This recommendation is being made so as to stop rampant illegal collection and trade of medicinal plants from the wild.
- The local ayurvedic pharmaceuticals (within the district), and local people to be engaged in cultivation and value addition to medicinal plants be supplied with medicinal plants/products on priority basis to enrich the local economy and employment potential
- NTFP collection (removal of contract system of middle men) and value addition,
- Developing bee-keeping involving forests and mangroves. As bee-keeping is recommended as an important activity for almost all clusters, roadsides, common lands, under-stocked or degraded forest patches around villages be planted with appropriate nectar plant species.

- Contract system for collection of NTFP from forests found to be highly detrimental to forests and biodiversity and economic well being of local people be stopped forthwith and co-management system involving local people be adopted.
- Production of bamboo based products by local craftsman and effective utilization of bamboo for local development is important
- Use of alternative energy sources replacing firewood
- Development of bettas for tree farming, medicinal plants and fodder,
- Promoting backwater, mangrove, and beach tourism, development of rural tourism and home stays in the vicinity of forests and wildlife areas
- Regular conduct of training in bird-watching, wildlife studies, trekking trails, hygiene and solid waste management involving VFCs, local youth in forest and wildlife related tourism areas be arranged with view of generating eco-friendly employment potential.
- Utilization of weeds and harvestable trees/tree parts, bamboos, canes etc. from plantations or other designated areas for vegetable dyes, medicines, weaving, furniture, handmade paper, sports goods production
- Awareness creation and conservation of sacred groves, sacred kans, which are biodiversity and hydrology significant areas and still playing unique cultural roles in rural society.
- All hydrologically significant forest patches, as indicated, for instance, by high Western Ghats endemism among trees, be preserved both for the sake of perenniality of water courses and for the biodiversity content.
- The Department to consider pooling back good part of income from VFC managed areas into sustainable income generating activities in the cluster level

District Industries Centre (DIC): Main focus agency for promotion of small scale and cottage industries.

- Easy registration of small scale and cottage industries
- Infrastructure assistance, Investment subsidies
- Linking with Employment Generation programmes
- Entrepreneurship development programmes, Technical training
- Assisting in sale of products, buyer-seller meets
- No new red and orange category industries in malnadu and coastal taluks. Orange category may be considered under strict norms and social audit, away from biodiversity centres

Tourism Department: Integrated community based eco-tourism development is being conceptualised to benefit some clusters of adjoining local self government units as a strategy to address high incidence of poverty among the communities while such areas are teeming with tourism potential

- Developing integrated community based eco-tourism
- Assistance in building aesthetic cottages/rooms as part of home stays of bonafide locals or local VFCs. Local grass root level tourism related enterprises to be preferred against construction and commercial lobby.
- Developing tourism awareness in the appropriate panchayat clusters. Conducting programmes on safeguarding local cultures, performing arts and biodiversity.
- Training youth in tourism/homestay management.

- Fostering tourism related entrepreneurship among the local people so as to increase self employment opportunities in rural areas and small towns.
- Getting necessary registration/licenses for village home stays managed by individuals/VFCs/communities, and exhibiting details on location-wise home-stays through web pages

Horticulture Department

- Facilitate farming of desired crops only under insurance coverage
- Training in preservation of fruits and vegetables to women
- Promoting organic cultivation for exports and Indian markets

Financial institutions: Government financing and micro-financing institutions to step in to promote cluster level development programmes through local panchayats, VFCs, BMCs, NGOs, departments, societies etc. Financing from charitable and voluntary organizations and NGOs and not-for profit financiers to be considered and may be recommended by related departments. Crop insurance, preferably, in identified human-wildlife conflict zone is highly necessary for future of biodiversity conservation. Financial literacy is very critical for participatory development progrmmes envisaged.

Mining and Geology

- Mining in Western Ghats to be phased out. Mining for building stones/jelly be limited to meet local demands, and in any case not to be transported out of the district.
- Sand mining in west coast rivers and estuaries to be limited strictly for use within the district only.
- Considering coastal laterite as Gondwanaland soil/rock deposit, and its limited nature, its special ecosystem value sustaining rare and unique biodiversity, laterite quarrying from coastal hills be strictly limited to meeting local demands. Laterite transport to outside the needs to be banned
- Mining of stones/sand/shell etc. from VFC/BMC jurisdiction areas be limited to bonafide local use and in any case not to be transported outside local area/district as is deemed fit by the joint decision of VFC-BMC and Forest and Mining-Geology departments.

Education Department (Primary and Secondary): Our initiatives with high school students and teachers show, they are effective in documenting many aspects of biodiversity and related knowledge existing at village level. With a reasonable time, say one or two days spent on motivating them and familiarizing them with the concepts of biodiversity documentation and data collection formats, they could contribute substantially towards building up a dynamic database at village level ready for integration into the People's Biodiversity Registers. They are more effective in meeting and interviewing organic farmers, in noting down details on traditional cultivars, collecting details on sacred groves, major wildlife related details etc.

District administration/Zilla panchayat

- Thin plastic carry bags production and sale to be banned, so as to promote locally produced cloth and paper bags.
- Hoteliers and bulk purchasers of milk to purchase milk in larger containers, which the milk producers are to use mandatorily and need based
- Use of plastic disposable cups and plates to be banned so as to reduce environmental hazards and to provide market for locally produced biodegradable eco-friendly materials made up of say areca-spathe or washable utensils. Government institutions, offices, public sector undertakings,

educational institutions, temples, hoteliers and roadside eateries, and bulk caterers to comply with such norms.
- Imposition of fines/cleaning charges be levied on polluters at all levels
- Toilet facility within reach of every household

The objective of the current endevour is to identify and prioritise ecologically sensitive regions based on ecological, biological, social and geo-climatic attributes. This involved

1. Creating an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government.
2. Compilation of primary data related to biodiversity, ecology, energy, hydrology and social aspects..
3. Demarcation of local hotspots of biodiversity for conservation based on biotic, abiotic and social criteria.
4. Designation of a comprehensive management frame work that counter measures to mitigate forest loss to attain sustainable growth of region and also support to preserve biodiversity.

The smallest geo-climatic unit wherein the response of ecosystems to environmental disturbances can be observed, evaluated and mitigated is the landscape (Forman and Godron, 1986). Ecological sensitivity concerns ecosystems and their ability to cope with various kinds of environmental disturbances that have the potential of adversely changing the structure of the natural landscapes. Ecologically sensitive regions in the district are prioritized considering biological (terrestrial and aquatic flora and fauna, estuarine biodiversity), ecological (diversity, endemism, conservation reserve), geo-climatic (altitude, slope, rainfall), renewable energy prospects (bio, solar, wind), social (population, forest dwelling communities) as outlined in Figure 21.1.

Table 21.1 lists weights assigned for each metric of various themes considering minimal impact on landscape and also to prioritise conservation regions for future planning. Assigning weightages based on the relative significance of themes for prioritizing eco-sensitive regions provides a transparent mechanism for combining multiple data sets together to infer the significance. The weightage is given by Equation 1.

$$Weighatge = \sum_{i=1}^{n} W_i V_i \qquad \ldots\ldots\ldots 1$$

Where n is the number of data sets (variables), V_i is the value associated with criterion i, and W_i is the weight associated to that criterion. Table 1 expresses the theme wise decision variable considered with their level of significance, ranked between 1 and 10. Value 10 corresponds to highest priority for conservation whereas 7, 5 and 3 corresponds to high, moderate and low levels of prioritisation. Assigning weightages based on individual proxy based extensively on GIS techniques, has proved to be the most effective for prioritizing ESR. Visualisation of levels of ESR help the decision makers in opting eco-friendly development measures. Table 2 lists the existing conservation reserves in the district.

The study area is divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2 (Figure 2) for prioritizing ESR. A detailed database has been created for various themes covering all aspects from land to estuarine ecosystem. The theme wise description is given below highlights the consideration of variables for study and their significance in conservation priority.

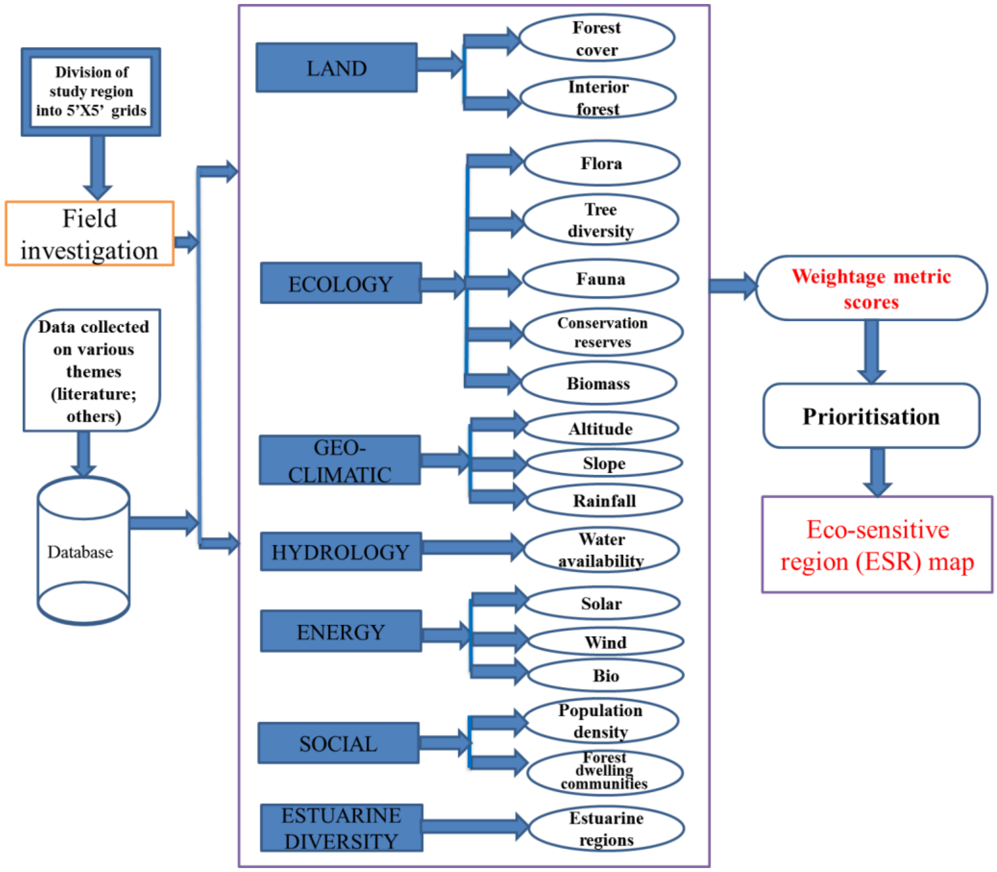


Figure 21.1: Criteria for prioritizing ESR

Table 21.1: the various themes considered and their weightages

S.NO.	Themes	Weightages / ranking				
		1	3	5	7	10
1.	LAND					
	Land use	FC<20%	20<FC<40%	40<FC<60%	60<FC <80%	FC > 80%
	Interior forest	IF<20%	20<IF<40%	40<IF<60%	60<IF<80%	IF> 80%
2.	ECOLOGY					
	Flora	NEND	END<30%	30<END<50%	50<END<70%	END>70%
	Tree diversity	SHD<2	2<SHD<2.5	2.5 <SHD<2.7	2.7<SHD<3	SHD>3
	Fauna	-	NEND	-	-	END
	Conservation reserves (CR)	-	-	-	-	National parks, Wild life reserves, Myristica swamps, Sanctuaries
	Biomass (Gg)	BM<250	250<BM<500	500<BM<750	750<BM<1000	BM>1000
3	GEO-CLIMATIC					
	Altitude					
	Slope	-	-	-	Slope > 20%	Slope > 30%

	Precipitation	-	1000>RF> 2000 mm	2000>RF> 3000 mm	3000>RF> 2000 mm	RF> 4000 mm
4.	**HYDROLOGY**					
	Stream flow	WA<4	4<WA<6	6<WA<9	9<WA<12	WA=12
5.	**ENERGY**					
	Solar	-	-	<5 KWh/m^2/day	5-6 KWh/m^2/day	6-6.5 KWh/m^2/day
	Wind	-	-	2.4 to 2.55 m/s	2.5 to 2.6 m/s	2.6 to 2.7 m/s
	Bio	SD<1	SD>1	1>SD<2	2<SD<3	SD>3
6.	**SOCIAL**					
	Population density (PD)	PD>200	100<PD<200	100<PD<150	50<PD<100	PD<50
	Forest dwelling communities (Tribes)	-		Tribes are present then assigned 10; if no tribal population exists, then assigned as 0		
7.	**ESTUARINE DIVERSITY**					
	Estuarine regions	-	low	moderate	high	very high

FC-forest cover; IF-interior forest cover; END-endemic; NEND-non-endemic; BM-biomass; SD-supply to demand ratio; WA-Water availability

Floristic diversity: Field investigation were carried out in 116 sample transects (marked in Figure 21.2) for data on the plant species diversity, basal area, biomass, estimates of carbon sequestration, percentage of evergreenness and Western Ghats endemism and about the distribution of threatened species etc.

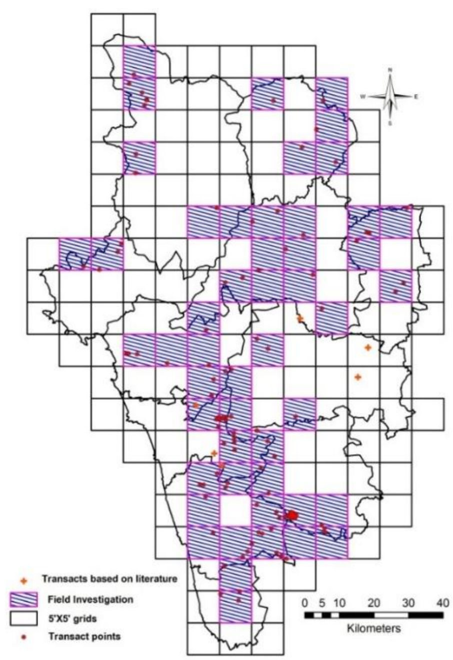


Figure 21.2: Grids with the distribution of transacts

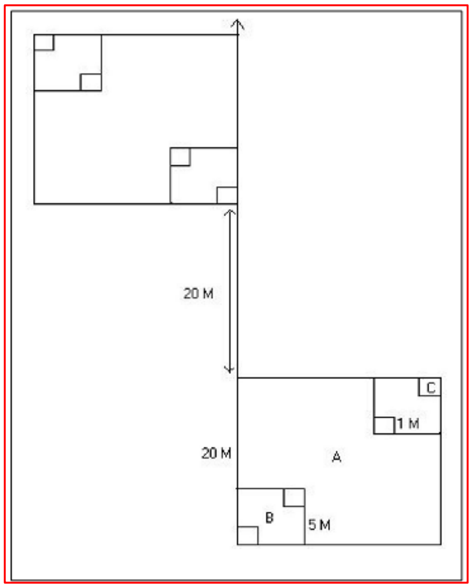


Figure 21.3: transect cum quadrats (2 of 5 quadrats of 20 x 20 m only shown)

Along a transect length ranging upto 180 m, quadrats each of 20 x 20 m were laid alternatively on the right and left, for tree study (minimum girth of 30 cm at GBH or 130 cm height from the ground), keeping intervals of 20 m length between successive quadrats. Number of quadrats per transect depended on species-area curve and most transects had maximum of 5 quadrats. Within each tree quadrat, at two diagonal corners, two sub-quadrats of 5m **x** 5m were laid for shrubs and tree saplings (< 30 cm girth). Within each of these 2 herb layer quadrats, 1 sq.m area each, were also laid down for herbs and tree seedlings (figure 21.3). Supplementary data were compiled through the review of published literatures, unpublished data sets and ground based surveys other than transacts.

Appraches adopted in documenting flora and fauna are available in
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India
Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

- **Land:** Landscape dynamics is essential to investigate forest landscape pattern and process to understand how forest ecosystems change under anthropogenic disturbances. At any instant of time land cover (LC) Land use (LU) modifications refers to the way humans and their land resources, usually with assent on the functional role of land for economic activities. This change is prominent and measured at temporal scale with remote sensing data (Ramachandra et al., 2013). The study highlights temporal dynamics of forest landscapes emphasises the interaction between human activities and ecological process. The present status of land use of forest (year 2013) is considered and prioritised as per the area covered. Interior forest cover is another prime variable considered, which explains the health of forest and status of fragmentation at landscape level. Forest fragmentation statistics and the total extent of forest and its occurrence as adjacent pixels is computed through fixed area windows surrounding each forest pixel, which is used to classify the window by the type of fragmentation (Ramachandra et al., 2013). The interior forest cover of year 2013 is considered as one of proxies under land theme. Fragmentation analysis will provide description of different components that will help us to analyse the status of forest in a region. **Interior** forest cover is the forest pixels that are reasonably far away from the forest-non forest boundary. Interior forested areas are surrounded by more thick forested areas. **Patch** forest type is referred as forest pixels that comprise a small forested area surrounded by non-forested land cover. **Edge** forest type comprises forest pixels that define the boundary between interior forest and large non-forested land cover features. **Perforated** forest cover is defined as forest pixels that are the boundary between interior forest and relatively small clearings (perforations) within the forested landscape. **Transitional** types are clearly depending on non-forest and edge pattern. These are in between edge type and non-forest types. If higher pixels are non-forest then they will be tending to non-forest cover with higher degree of edge. The water bodies or river coarse are considered as non-fragmenting features, because they act as natural corridors in forested landscape. Non-forested areas including buildings, roads, agricultural field, and barren land, along with developed land, are considered fragmenting features.

LULC dynamics with agents of changes are documented in
Ramachandra T V, Subash Chandran M D, Joshi N V, Bharath Setturu, 2013. Land Use Land Cover (LULC) dynamics in Uttara Kannada Central Western Ghats, Sahyadri Conservation Series 28, ENVIS Technical Report 56, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
Ramachandra T.V., Subash Chandran M.D., Joshi N.V. and Bharath Setturu, 2013. Fargmentation of Uttara Kannada Forests, Sahyadri Conservation Series 29, ENVIS Technical Report 57, ENVIS, Centre for Ecological Sciences, Indian Institute of science, Bangalore 560012
Ramachandra T.V., Subash Chandran M.D., Joshi N.V. and Bharath Setturu, 2013. Land use changes with the implementation of Developmental projects in Uttara Kannada district, Sahyadri Conservation Series 31, ENVIS Technical Report 61, ENVIS, Centre for Ecological Sciences, Indian Institute of science, Bangalore 560012

- **Ecology:** The health of ecosystem and its significance is derived based on the key variables – endemism, floral diversity, evergreenness, etc. for evolving composite conservation index. Data compilation included combination of field and earlier literatures. Tree species diversity is another measure was calculated using a Shannon's diversity index (H') as defined in equation 2

$$(H)' = -\sum_{i=1}^{n} (p_i) \ln p_i \qquad \ldots.\ 2$$

where, i is the proportion of the species relative to the total number of species (p_i) multiplied by the natural logarithm of this proportion (ln p_i) and the final product multiplied by -1. The Shannon's index ranges typically from 1.5 to 3.5 and rarely reaches 4.5. So, higher diversity range will be assigned as higher weightage for conservation.

Faunal diversity is another variable which enhances eco-sensitivity of a region. The Central Western Ghats is store house of endemic fauna, in which endemicity appears to increase in the undulating terrains of upper ghats. The current study investigates floristic diversity associated with different forests and computes basal area, biomass and carbon sequestration in forests. Apart from the inventorying, mapping of endemic tree, documentation of faunal species has been done to find out areas of high endemism and congregations of threatened species. A set of criteria for prioritising the regions has been prepared based on field investigation, interaction with stakeholders (researchers working in this region, forest officials, local people, subject experts).

Mammals are well represented in this chain of mountains and many endemic birds are found in all other places of the district. The endemic and non-endemic status of all faunal diversity is categorised based on literature and also field sampling. Many hill birds are common to the Sahyadris (mountainous part of district) and also move locally up and down the Ghats from the plains to the coast line forests seasonally. Disturbances in the migration movements, increasing forest fragmentation with isolation of the forest patches could be responsible for major losses of avifauna in the near future.

Conservation Reserves (CR) are being established under the framework of Protected Areas (PA) under the Wildlife (Protection) Amendment Act of 2002. CRs are typically buffer zones or connectors and migration corridors between National Parks, Wildlife Sanctuaries and reserved protected forests in the district (table 21.2). These reserves protect habitats that are under private ownership also, through active stakeholder participation. The biological diversity in these zones like National parks, Sanctuaries, Botanical gardens, Zoological gardens hosts threatened (rare, vulnerable, endangered) flora / fauna. Higher weightage is assigned for CR's.

Table 21.2: Details of Conservation Reserves in Uttara Kannada

Name	Area (sq.km)	Conservation priority species	Priority locations
Anshi Dandeli Tiger reserve (ADTR)	1365	conservation Tigers & Hornbills	Joida, Haliyal and Karwar taluks
Aghanashini LTM Conservation Reserve	299.52	Lion tailed macaque (LTM), Myristica swamps	Unchalli Falls, Kathalekan, Muktihole
Bedthi Conservation Reserve	57.07	Hornbills & *Coscinium fenestratum* (medicinal plant)	Magod Falls, Jenukallu gudda, Bilihalla valley, Konkikote
Shalmala Riparian Eco-system Conservation Reserve	4.89	Diverse flora, fauna and as an important corridor in Western Ghats of Karnataka	Ramanguli
Hornbill Conservation Reserve	52.50	Hornbills	Kali River
Attivery Bird Sanctuary	2.23	Endemic birds	Mundgod taluk

Biomass is another important indicator of forest health and reveals its role in global carbon sink. Trees play an important role as carbon sink, during the process of photosynthesis, the atmospheric CO_2 is utilized by the leaves for the manufacture of food in the form of glucose, later on its gets converted to other forms of food materials i.e. starch, lignin, hemicelluloses, amino acids, proteins etc. and is diverted to other tree components for storage, which is referred as biomass, measured in Giga grams. Most of Uttara Kannada falling in the high rainfall zone, except Mundgod and eastern parts of Haliyal and Yellapura support trees with higher biomass. Undisturbed forests tend to have more biomass than disturbed and secondary forests or savannas.

Details of biomass quantification, flora and fauna diversity are available in
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, 2013. Carbon sequestration in Uttara Kannada, Sahyadri Conservation Series 33, ENVIS Technical Report 63, CES, Indian Institute of Science, Bangalore 560012, India
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India
Ramachandra T V, Subash Chandran M D, Joshi N V, Karthick B, Sameer Ali and Vishnu Mukri, 2012. Ecohydrology of Lotic Ecosystems of Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 40, Sahyadri Conservation Series 14, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, and Shalini Kumar, 2012. Conservation of Endangered Fauna in Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 6, ENVIS Technical Report : 22, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, Ajay Narendra and Ali T.M., 2012. Ant Species Composition and Diversity in the Sharavathi River Basin, Central Western Ghats., Sahyadri Conservation Series: 3, ENVIS Technical Report : 20, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
Ramachandra T V, Subash Chandran M D, Joshi N V, Sooraj N P, Rao G R and Vishnu Mukri, 2012. Ecology of Sacred *Kan* Forests in Central Western Ghats, ENVIS Technical Report: 41, Sahyadri Conservation Series 15, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra T V, Subash Chandran M D, Joshi N V, Divya Soman, Aswath D Naik, Prakash N Mesta, 2013. Valuation of goods and services from forests ecosystem of Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 25, ENVIS Technical Report 44, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
Ramachandra T V, Subash Chandran M D, Joshi N V, Gururaja K V, Sameer Ali and Vishnu Mukri, 2012. Amphibian Diversity and Distribution in Uttara Kannada District, Karnataka, ENVIS Technical Report: 47, Sahyadri Conservation Series 18, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., ENVIS Technical Report: 51, Sahyadri Conservation Series 21, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

- **Geo-climatic:** Geo-climate plays a major role in determining the speed of recovery (lag-time) of a landscape (and the ecosystem that governs it). The elevation map is generated using Cartosat DEM of 1 arc second resolution. Areas with steep slopes and high altitudes are likely to be eroded more easily, and hence vulnerable to natural erosion or landslides. Obviously such areas need to be considered as least resilient and hence environmentally sensitive zones areas. The analysis has considered that the slopes and altitudes can be normalized within each grid from 0 (least average slope or lowest average altitude) to 10 (high slope and high altitude) and assigned to the grids. The slope map is generated from DEM data set. The rate of change (delta) of the surface in the horizontal (dz/dx) and vertical (dz/dy) directions from the center cell determines the slope. Slope values are (measured in degrees) extracted using slope the algorithm as,

$$\text{Slope degrees} = \text{ATAN}\left(\left(\left[{dz}/{dx}\right]^2\right) + \left(\left[{dz}/{dy}\right]^2\right)\right) \times 57.296 \quad \text{…. (2)}$$

Where, dz/dx is the rate of change in the x direction; dz/dy is the rate of change in the y direction.
Point based daily rainfall data from various rain gauge stations in and around the study area between 1901 and 2010 were considered for analysis of rainfall (Ramachandra et al., 2013). The rainfall data used for the study were obtained from Department of statistics, Government of Karnataka; Indian metrological data (IMD), Government of India. Rainfall trend analysis was done for selected rain gauge stations to assess the variability of rainfall at different locations in the study area. The points based long term daily rainfall data were used to calculate the monthly and annual rainfall in each rain gauge station based on mean and standard deviation of rainfall at selected rain gauge stations. The average monthly and annual rainfall data were used to derive rainfall throughout the study area through the process of interpolation (isohyets).

Details are available in
Ramachandra T V, Subash Chandran M D, Joshi N V, Daval Joshi and Maneesh Kumar, 2012. Soil quality across diverse landscapes in Central Western Ghats, India, ENVIS Technical Report: 42, Sahyadri Conservation Series 16, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra. T.V, Subash Chandran M.D, Joshi N.V, Rajinikanth R and Raushan Kumar, 2012. Water, soil and sediment characterization: Sharavathi river basin, Western Ghats., Sahyadri Conservation Series: 4, ENVIS Technical Report: 21, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
Ramachandra T.V., Subash Chandran M.D, Joshi N.V., Pallav Julka, Uttam Kumar, Bharath H. Aithal, Prakash Mesta, Rao G R, Vishnu Mukri, 2012. Landslide Susceptible Zone Mapping in Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 7, ENVIS Technical Report: 28, Environmental Information System [ENVIS], Centre for Ecological Sciences, IISc, Bangalore

- **Energy:** Dependence on the conventional energy resources for electricity generation is eroding the natural resources at faster rate. The process of electricity generation causes significant adverse effect on ecology by producing enormous quantity of byproducts including nuclear waste and carbon dioxide. Improving energy efficiency, switch over to renewable sources of energy and de-linking economic development from energy consumption (particularly of fossil fuels) is essential for sustainable development of a region (Ramachandra et al., 2013). Potential of renewable energy sources are assessed (Solar, Wind, Bioenergy) month wise and captured the variations (Ramachandra et al., 1997; Ramachandra et al., 2013). The Solar energy datasets are derived based on NASA's Surface Meteorology and Solar Energy (SSE) methodology The solar energy is available greater than 10 months with higher potential. Availability of wind energy and its characteristics of Uttara Kannada District have been analysed based on primary data collected from India Meteorological Department (IMD) observatories. Wind energy conversion systems would be most effective during the period May to August. Energy Pattern Factor (EPF) and Power Densities are computed shows that the coastal taluks such as Karwar, Ankola and Kumta have good wind potential. This potential, if exploited would help local industries, irrigating orchards (coconut and areca plantations) and makes the wind energy a desirable alternative. The domestic fuel wood consumption survey of this region reveals that 82 to 90% of the households still depend on fuel wood and agro residues. Analyses of sector-wise contribution in the energy surplus zones shows that horticulture residues contribute in the central dry zone, southern transition zone and the coastal zone, while in the hilly zone, forests contribute more towards the available bioenergy. Adaptation of green technologies can contribute significantly to cutting down harmful greenhouse gases and hence reduction in carbon footprint. Weightages are assigned based on the leval and quantum of availability of renewable resource.

Details are available in
Ramachandra T V, Subash Chandran M D, Joshi N V, Ganesh Hegde, Gautham Krishnadas, 2013, Sustainable energy alternatives for Uttara Kannada, Sahyadri Conservation Series 26, ENVIS Technical Report 58, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

- **Hydrology:** Hydrology helps in the understanding of material flows, environmental quality and stream ecosystem in a basin. Conservation of high biodiversity forest landscapes is justified on the basis of hydrological benefits – in particular, reduction of flooding hazards for downstream floodplain populations. Forest conservation leads to preservation of hydrological flows, mitigation of extreme hydrologic events, retention of soils and sediments, conservation of productivity and biodiversity, as well as maintenance and purification of water supply.

  Monthly monitoring of hydrological parameters reveal that streams in the catchments with good forest (evergreen to semi-evergreen and moist deciduous forests) cover have reduced runoff as compared to catchments with poor forest covers. Runoff and thus erosion from plantation forests was higher from that of natural forests. Forested catchment have higher rates of infiltration as soil are more permeable due to enhanced microbial activities with higher amounts of organic matter in the forest floor. Streams with good native forest cover in the catchment showed good amount of dry season flow for all 12 months. While strems in the catchment dominated by agricultural and monoculture plantations (of Eucalyptus sp. and *Acacia auriculiformis*) are sesonal with water availability ranging between 4-6 months. This highlights the impacts of land use changes in tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). This emphises the need for integrated watershed conservation approaches to ensure the sustained water yield in the streams. The grids where water availability across all the year (perennial flow) is assigned higher values.

Details are available in
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Vinay S., Bharath H A and Bharath Setturu, 2013, Carrying Capacity of River Basins considering Ecological and Social Demands, Sahyadri Conservation Series 36, ENVIS Technical Report 66, CES, Indian Institute of Science, Bangalore 560012, India
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Sreekantha, Saira V.K and Vishnu D.M., 2013. Influence of Landscape Dynamics on Hydrological Regime in Central Western Ghats Sahyadri Conservation Series 35, ENVIS Technical Report 65, CES, Indian Institute of Science, Bangalore 560012

- **Social aspects:** In the regional planning, demographic aspect is one of the most significant aspects because planning is basically for and by the citizen. Land degradation results mainly due to population pressure which leads to intense land use without proper management practices. Understanding the key interactions between vegetation cover and dynamic disturbance agents is critical in identifying desired vegetation cover conditions and regional management priorities. Population density per sq. km is considered as one of the influencing social factor for prioritisation and the grids with lower population density are assigned higher weightage. The need for combining nature conservation with social aspect is to emphasise receiving a livelihood from natural resources and participation in enriching biodiversity. The Biological Diversity Act (BDA) of 2002 stipulates the conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental threat. Forest Rights Act, 2006., Government of Inida seeks to recognize and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in forests for generations but whose rights could not be recorded. A large chunk of population is directly dependent on these resources even today; trading them in conservation will be unfruitful approach. Forest dwelling communities (tribes) of district is mapped at village level and the grids with tribal population is assigned higher weightage.

Details are available in
Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 49, Sahyadri Conservation Series 19, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Mahima Bhat, Prakash N.Mesta, Sreekanth Naik, 2013. Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64, ENVIS, CES, Indian Institute of Science, Bangalore 560012, India
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash N. Mesta, Sreekantha, Gayatri Naik, 2013. Agro Biodiversity in Uttara Kannada, Sahyadri Conservation Series 38, ENVIS Technical Report 68, CES, Indian Institute of Science, Bangalore 560012, India

- **Estuarine diversity:** Estuarine ecosystems are biologically most productive, socio-economically important, and aesthetically attractive while providing food and shelter for many vital biotic species. The estuarine productivity is sustained naturally without any inputs from humans, unlike in agricultural ecosystems or fish farming systems. The ecological conditions of the estuaries, particularly of the Indian west coast estuarine banks are densely populated with fishing hamlets and are under alterations by humans. The role of estuary as breeding places and nurseries for several marine fishes of economic value has been totally ignored while executing large river valley projects. This emphasises the need for integrating these ecosystems for sustainable resource management with conservation planning. West coast estuaries of district were assessed based on productivity, biodiversity and human pressure. The analysis has identified the mangroves at species level using remote sensing data with field based measurements. Estuarine productivity based on goods and services of the district bring out the disparity in productivity and diversity between the neighboring estuaries due to major human intervention in the form of construction of hydroelectric projects in upstream. This has caused low salinity conditions in the downstream causing depletion of most estuarine productivity evident in the Kali and Sharavathi estuaries. Estuaries were given weightages based on the productivity and diversity.

Details are available in
Ramachandra T V, Subash Chandran M D, Joshi N V, Rakhi Raj, Prakash N Mesta, sumesh Dudani, 2013. Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka, Sahyadri Conservation Series 27, ENVIS Technical Report 45, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
Ramachandra T V, Subash Chandran M D, Joshi N V and Boominathan M, 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., ENVIS Technical Report: 48, Sahyadri Conservation Series 17, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 50, Sahyadri Conservation Series 20, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Marine Fishery in in Uttara Kannada, Sahyadri Conservation Series 39, ENVIS Technical Report 69, CES, Indian Institute of Science, Bangalore 560012, India

Ecologically sensitive regions in the district are prioritized considering biological (terrestrial and aquatic flora and fauna, estuarine biodiversity), ecological (diversity, endemism, conservation reserve), geo-climatic (altitude, slope, rainfall), renewable energy prospects (bio, solar, wind), social (population, forest dwelling communities) as outlined in Figure 21.1. The district is divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2 (Figure 21.2) for prioritizing ESR. Weightages are assigned to the grids for prioritizing eco-sensitiveness based on the relative significance of themes – biological, ecological, geo-climatic, energy and social. Multiple data sets based on their wightages in each grid helped in prioritizing the grids based on aggregate metric score as ESR 1, ESR 2, ESR 3 and ESR 4 respectively.

Land use dynamics: Land use analysis reveal a distressing trend of deforestation in the district (Table 3), evident from the reduction of evergreen-semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analysis reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (20.63 to 1.52). Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone.

Figure 21.4.1 highlights gridwise extent of forest cover. Good forest cover (> 80%) is confined to the grids in Sahyadri region (Supa, Yellapura, Ankola, Sirsi taluks). The coastal taluks are having forest cover in the range 60 - 80% towards eastern part whereas western side totally degraded due to higher pressure. The plains shows least over (< 20%) revealing the degradation level. The natural forest cover left today is 542,475 Ha only. The land clearing and subsequent agricultural expansion, exotic plantations resulted in damage of large patches of forests. The major developmental projects further disturbed the landscape and reduced the distribution of forest cover. Weightages were assigned to the grids based on the extent of forest cover (as discussed in Table 1). Figure 21.4.2 illustrates grids with ranks / weightages based on the extent of forest cover. Grids in Sahyadri region has highest ranking (of 10) compared to some grids in plains (with rank 1).

Forest fragmentation: Table 21.3 lists land use and fragmentation status (category wise) of forests in the district. Fragmentation analysis considering the spatial extent of forests, reveal that contiguous forests (interior forests) has declined from 87.51 (1973) to 48.60% (2013). Forest fragmentation at landscape level show a decline of interior forest 72.95% (1973) to 25.62% (2013). Land use under non-forest categories (crop land, plantations, built-up, etc.) covers 47.29% of the landscape, while areas under natural forests constitute about 542,475 Ha. Mitigation of biodiversity loss in the district requires regeneration of forests through appropriate protection measures and also reforestation with native species of vegetation.Figure 21.5.1 depicts the extent of interior forest in each grid, while Figure 21.5.2 gives the relative wightages based on the extent of interior forests across grids in coast, Sahyadri and plains.

Table 21.3: Land use and fragmentation of forests in Uttara Kannada

<table>
<tr><th rowspan="2">Category</th><th colspan="2">Land use analysis (2013)</th><th rowspan="2">Fragment type</th><th colspan="2">Spatial extent (2013)</th></tr>
<tr><th>Ha</th><th>%</th><th>Ha</th><th>%</th></tr>
<tr><td>Built-up</td><td>31589</td><td>3.07</td><td>Transitional</td><td>59435</td><td>5.78</td></tr>
<tr><td>Water</td><td>28113</td><td>2.73</td><td rowspan="2">Perforated</td><td rowspan="2">8909</td><td rowspan="2">0.87</td></tr>
<tr><td>Crop land</td><td>145395</td><td>14.13</td></tr>
<tr><td>Open fields</td><td>37660</td><td>3.66</td><td rowspan="2">Patch</td><td rowspan="2">30618</td><td rowspan="2">2.98</td></tr>
<tr><td>Moist deciduous forest</td><td>161,996</td><td>15.74</td></tr>
<tr><td>Evergreen to semi evergreen forest</td><td>330,204</td><td>32.08</td><td rowspan="2">Edge</td><td rowspan="2">179870</td><td rowspan="2">17.48</td></tr>
<tr><td>Scrub/grass</td><td>40402</td><td>3.93</td></tr>
<tr><td>Acacia/ Eucalyptus/ hardwood plantations</td><td>122927</td><td>11.94</td><td rowspan="2">Interior</td><td rowspan="2">263643</td><td rowspan="2">25.62</td></tr>
<tr><td>Teak/ Bamboo/ softwood plantations</td><td>67111</td><td>6.52</td></tr>
<tr><td>Coconut/ Arecanut / Cashew nut plantations</td><td>53,993</td><td>5.25</td><td rowspan="2">Non-forest area</td><td rowspan="2">486611</td><td rowspan="2">47.3</td></tr>
<tr><td>Dry deciduous forest</td><td>9873</td><td>0.96</td></tr>
<tr><td>Total</td><td colspan="5">1029086</td></tr>
</table>

Mismanagement of Kans (sacred forests) and land use changes in reserve forests have contributed to the decline in interior forest. Increased edges and perforated patches highlight the loss of connectivity and contiguous forest patches. Stream diversion and impoverishing forests of water other reasons for the decline moisture loving species. Commissioning of series of dams, has impelled large sacle land conversions to agriculture (with the availability of water). Grids in Supa taluk has higher proportaion of interior forests. Forest encroachments, land conversion due to development al projects are the drivers of forest loss.

Ecology: Flora and fauna of terrestrial and aquatic ecosystems have been studied to understand the ecological processes. This involved assessment of vegetation diversity, endemic flora, fauna, biomass of forests, status of conservation reserves through field investigation and compilation of information from published literatures. Forests of all major kinds were studied using transect cum quadrat methods (altogether 116 transects, each transect with five quadrats of 400 sq.m each for tree vegetation, 10 subquadrats each of 25 sq.m for shrubs and tree saplings and 20 subquadrats of one sq.m for herb layer diversity. Out of 116 transects 8 were studied using point-centre quarter method). Altogether for tree vegetation 540 quadrats, each of 400 sq.m were studied. Necessary permission was, however, not granted for forest studies within the Dandeli-Anshi Tiger Reserve area, so no transact is covered; only limited literature available is considered for analysis of this region. The details of endemism, endemic, non-endemic species of flora is demarcated and analysed. Data analysis is done by using latitude, longitude of various places, where species found and plotted on map of Uttara Kannada district to understand their distribution pattern, habitat. The species were plotted in two ways, according to taxonomic classification of each species with IUCN (International Union for Conservation of Nature) status of each species; according to endemic and non-endemic with IUCN status of each species.

Flora: Data interpretation was done by analysing diversity and distribution of flora and fauna in various taluks and villages. Regions rich in biodiversity with high distribution of most of the taxa's of flora and fauna need to be prioritised for their ecological sensitive ness and conserved. Field investigation and compilation of information from literatures has helped in documenting 1068 species of flowering plants, representing 138 families. Among these 278 were trees species (from 59 families), 285 shrubs species (73 families) and 505 herb species (55 families). Moraceae, the family of figs (Ficus spp.), keystone resources for animals, had maximum tree sp (18), followed by Euphorbiaceae (16 sp.), Leguminosae (15 sp.), Lauraceae (14 sp.), Anacardiaceae (13 sp.) and Rubiaceae (13 sp.). Shrub species richness was pronounced in Leguminosae (32 sp.), Rubiaceae (24 sp.) and Euphorbiaceae (24 sp.). Among herbs grasses (Poaceae) were most specious (77 sp.); followed by sedges (Cyperaceae) with 67 sp. Orchids (Orchidaceae) were in good number. The high endemic species like *Gymnacranthera canarica, Myristica fatua, Dipterocarpus indicus, Hopea Ponga, Vateria indica, Syzygium travancoricum, Semecarpus kathalekanensis* etc. are well distributed in the district. Numerous relic trees, especially of genus *Ficus*, or several others like *Mimusops elengi, Mesua ferrea, Mangifera indica, Mammea suriga, Aegle marmelos* etc. are present dotting the landscapes of villages and towns signifying sacred locations of cultural value. Fgure 21.6.1 depicts the distribution of flora and endemism. Honnavar, Kumta, Sirsi and Siddapur taluks have higher endemism (> 80%) and least can be seen in Mundgod due to least natural forest cover. Figure 21.6.2 depicts prioritoised grids (weights based on the occurrence of endemic flora species), illustrating Honnavar (Eastern grids), Kumta (eastern grids, towards Sirsi), Bhatkal (Hudil region), Siddapur are representing greater weights and Mundgod and Haliyal (eastern grids) shows least endemism.

Fauna: Figure 21.7.1 maps fauna in Uttara Kannada district with their ecological status. Main predators are tiger (*Panthera tigris*), leopard, wild dog (dhole) and sloth bear. Leopards are in good number and wild dogs are in very less number, usually sighted in Kulgi and Phansoli ranges of Dandeli. Sloth bears are frequently sighted in Ambikanagar, Virnoli, Bhagavati, Yellapura areas. Prey animals are barking deer, spotted deer (*Axis axis*), wild boar, sambar (*Cervus unicolor*), gaur (*Bos gaurus*). The district has an important elephant corridor between Karnataka and Maharashtra for about 47 elephants which are frequently sighted near Sambrani, Bommanahalli dam backwaters. One can also find Malabar Giant Squirrel, Slender Loris etc. The district is a paradise for birds, 272 birds are listed in the Dandeli, out of which 19 are considered to be endemic. Mundgod Attivery bird sanctuary is hosting endemic birds as well as important visitors from other countries as a roosting place. Some of the important birds are Malabar Trogon, Malabar Pied Hornbill, Malabar Grey Hornbill, Indian Grey Hornbill, Great Indian Hornbill, Emerald Dove, Ceylon Frog mouth, Pompador Pigeon etc. Kali river accommodates about 200+ marsh crocodiles and good number of these can be sighted near Dandelappa temple in Dandeli town. Another rare reptile found is Draco (Flying Lizard) which are often sighted near Mandurli IB, Anshi Nature Camp, Sathkhand falls. There are wide variety of snakes i.e., King Cobra, Cobra, Malabar Pit Viper, Hump nosed pit Viper, Bamboo Pit Viper, Kraft, Ornate flying snake, wolf snake etc. There is also wide variety of butterflies - Crimson Rose, Common Rose, Leaf, Clipper, Tigers, Southern Bird wing, Cruiser etc. The Uttara Kannada district has a rich endemic fish distribution such as *Batasio sharavatiensis, Ehirava fluviatilis, Gonoproktopterus kolus, Tetradon travancoricus, Puntius sahyadriensis, Puntius filamentosus, Salmostoma novacula* etc. The distribution of fresh water fishes is highly correlated to terrestrial landscape elements, of which quantity and quality of evergreen forests are more important. While the focus is conserving each of these iconic species, the end result of protecting the entire ecosystem will lead to conservation of a number of other endemic and endangered species including the river ecosystem. Higher weightages (10) are assigned (figure 21.7.2) to grids with endemic species and least (3) were assigned for grids with non-endemic fauna.

Biomass is considered as another variable used for prioritising grids. Recent biomass estimates (Ramachandra et al., 2013) is considered as base to map regions of higher standing biomass. The standing biomass helps to estimate the productivity of an area and also gives information on the carrying capacity of forest land. The analysis has calculated total standing biomass of forest's vegetation based on field data and remote sensing data. Transacts wise basal area per hectare were estimated using allometric equations. The basal area is also computed using regression equations and compared with field transact wise estimations. This approach has revealed the strong relationship between predicted basal area and estimated values using regression. Grid wise biomass is estimated based on the spatial extent of forest and per hectare basal area and is depicted in figure 21.8.1. The total biomass of the district is **113823.58** Gg. The Supa, Sirsi, Yellapura regions are having greater biomass (>1200 Gg) in Sahyadri region. Similarly, Karwar, Ankola, Kumta, Honnavar taluks are having greater biomass in coast. The plains and part of coastal regions have least biomass (< 200 Gg) in the district. The plains taluks constitute more agriculture lands, built-up environments and having least deciduous forest cover. Lowest biomass values were seen in savanna and disturbed moist deciduous forests (ex. hill top savannas of Ankola, Siddapur & stretches of forests in Supa which were under extensive shifting cultivation until end of the 19^{th} century). Hill slopes and sacred groves had higher basal area and biomass with diverse species. Lowest biomass was also seen in deciduous to dry deciduous forests of Haliyal, Mundgod taluks.

Net Carbon uptake by the forests of Uttara Kannada was estimated and given talukwise in Table 21.4. The net carbon value is estimated as half of the biomass. Grids with higher standing biomass regions were assigned higher weightages (Figure 21.8.2), as these regions help in maintaining global carbon through sequestration.

Table 21.4: Taluk wise biomass and carbon stored in forest vegetation

Taluks	Forest coverage type	Total standing biomass (Gg)	Total carbon stored (Gg)
Ankola	Semi evergreen to moist deciduous; evergreen forest (at central)	12856.41	6428.20
Bhatkal	evergreen to semi-ever green forest; moist deciduous towards coastline	2859.65	1429.82
Honnavar	Dominated by evergreen to semi-evergreen cover; moist deciduous found toward coastal line and disturbed regions	7592.32	3796.16
Karwar	Laterite thorn to moist deciduous and laterite evergreen to semi-evergreen	9135.00	4567.50
Kumta	Dominated by moist deciduous, semi-evergreen and evergreen towards west to east	6449.66	3224.84
Siddapur	Evergreen to semi evergreen and moist deciduous type towards east	7413.87	3706.93
Sirsi	Evergreen to semi evergreen and moist deciduous type towards east	15466.63	7733.32
Supa	Evergreen to semi evergreen, moist deciduous and disturbed moist deciduous (towards north and east)	35421.49	17710.72
Yellapura	Dominated by moist deciduous at central; evergreen cover to semi-evergreen towards Arabail Ghat	13158.49	6579.25
Haliyal	Dominated by dry deciduous; moist deciduous; evergreen cover found in Kali river valley	2701.31	1350.66
Mundgod	Dry deciduous and scrub type	768.76	384.38
Total		**113823.58**	**56911.79**

Tree diversity: Tree diversity is computed through Shannon diversity index. Figure 21.9.1 shows that most evergreen to semi evergreen forests with diversity values ranging between 3 and 4. The evergreen tracts of Supa, Sirsi, Kumta and Siddapur are with diversity greater than 3. The moist deciduous forests in the rugged terrain of Ankola-Yellapur areas had relatively higher diversity, compared to such forests in plainer areas. This is due to greater heterogeneity of the hilly landscapes. Lower Shanon diversity was in dry deciduous and highly disturbed forests of Mundgod, Haliyal, Yellapura (eastern grids) such as Gunjavathi (1.51), Sambrani (1.61), Katur (1.70), etc. These forests were not only disturbed but were extensively used for teak mono culture plantations. These forests had also prolific growth of weeds such as Eupatorium sp. and several thorny shrubs. Figure 21.9.2 gives the prioritised grids with higher diversity in Sirsi, Siddapur, Honnavar taluks based on tree diversity.

National Parks, Sanctuaries, and Conservation Reserves: Karnataka has five National Parks and 21 Wildlife Sanctuaries. Uttara Kannada district has two important protected areas namely **Anshi National Park** and **Dandeli Wildlife Sanctuary** (figure 21.10 .1). These two PAs are brought under **Dandeli-Anshi Tiger Reserve** for tiger conservation. The DATR presently covers an area of 1365 sq.km in the taluks of Joida, Haliyal and Karwar. Four species of hornbills - Common Grey Hornbill (*Tockus birostris*), Malabar

Grey Hornbill (*Tockus griseus*), Malabar Pied Hornbill (*Anthracocereros coronatus*) and Great Pied Hornbill (*Buceros bicornis*) are sighted in the District. Among the four species in the State, the Great Pied Hornbill and the Malabar Pied Hornbill are protected under the Wildlife Act. The Malabar Pied, endemic to the Western Ghats, has also been declared near-threatened by the Birdlife International - a body that lists the endangered and red-listed birds across the world. Declared as a reserve on May 31, 2011 under Section 36(A) of the Wildlife Protection Act 1972, the boundary of the reserve spreads across the two taluks of Joida and Haliyal of the district. Recently (in 2011), **Attivery Bird Sanctuary** was declared in Mundgod taluk covering 2.23 sq.km area, mainly composed of a reservoir and its peripheral areas. Figure 10.1 shows conservation reserves and protected areas of district. **Aghnashini Lion Tailed Macaque (LTM) conservation reserve** is between Sharavati and Aghnashini rivers harbouring high endemic fauna, flora. Bedthi conservation reserve is rich in biodiversity and has rare endemic palm species (*Corypha umbraculifera*). Aghnashini and Bedthi have been identified as reserves for the presence of the Lion Tail Macaque and Myristica swamps. The water accumulated in the valleys here provides a unique breeding site for butterflies and amphibians. Higher weightage are assigned to locations of these protected area (figure 21.10.2) as they are key eco-sensitive regions with diverse biodiversity.

Geo-climatic information of region is analysed to identify sensitive zones by considering altitude, slope and rainfall. Geo-climate determins the speed of recovery (lag-time) of a landscape (and the ecosystem that governs it). The longer the lag-time, landscape would be more ecologically sensitive. Higher altitude, easterly aspect, steepness and longer dry seasons make a landscape more sensitive.The altitude map is generated using GRASS (***Geographical Resources Analysis Support System***- http://wgbis.ces.iisc.ernet.in/grass/index.html) - free and open source tool to identify the variation of elevations in the region. Figure 21.11 .1 depicts the altitude profile of the district, highest elevation is 758 mt in Supa taluk. Grids are assigned weights (figure 21.11 .2) as > 600 mt as higher priority for conservation and > 400 mt is moderate and rest is least concern.

Slope: Figure 21.12.1 depicts the slope in the region while Figure 21.12.2 depicts the grids with weights assigned based on the sensitiveness of the slope.

Rainfall: rainfall pattern of the district depicted in figure 21.13 .1, show most part falls in the high rainfall zone, except Mundgod and eastern parts of Haliyal, Sirsi, Yellapura. The tallest emergent endemic species are well distributed in higher rainfall region. The diversity, endemism and rainfall are interrelated each other. Grids are assigned weights based on the quantum and duration of rainfall, given in figure 21.13.2. Western part of Sahyadri region, eastern part of coastal taluks receives annual rainfall greater than 4000 mm.

High rainfall areas have high biodiversity values and higher conservation values. High rainfall areas of Sahyadri and coastal taluks are major seats of endemic biodiversity of both plants and animals.

Hydrology of the region is analysed by the data as stated in method section. Monthly monitoring of hydrological parameters reveal that stream in the catchments with good forest (evergreen to semi-evergreen and moist deciduous forests) cover have reduced runoff as compared to catchments with poor forest covers. Runoff and thus erosion from plantation forests was higher from that of natural forests. Forested catchment have higher rates of infiltration as soil are more permeable due to enhanced microbial activities with higher amounts of organic matter in the forest floor. Streams with good native forest cover in the catchment showed good amount of dry season flow for all 12 months. While strems in the catchment dominated by agricultural and monoculture plantations (of Eucalyptus sp. and *Acacia auriculiformis*) are sesonal with water availability ranging between 4-6 months. This highlights the impacts of land use changes in tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). The sub basin wise analysis was carried out to account perennial, seasonal flows of region. Perennial flows of a region depict health of the ecosystem. Figure 21.14.1 depicts the duration of stream flow in each grid of the district. Grids in Sahyadri regions shows 12 months water availability in the streams and were assigned higher weightages (figure 21.14.2). Haliyal, Mundgod, eastern part of Yellapura showing stream flow as only 4 months due to scarce rain fall and less vegetation.

Prospects of Renewble Energy: Environmentally sound alternative sources of energy explored considered for prioritisation are Solar, Wind, Bio energy. Figure 21.15.1, 21.16.1 and 21.17.1 depicts the potential of solar, wind and bioenergy. Uttara Kannada is located in the west coast of Karnataka, India, receives an average solar insolation of 5.42 kWh/m^2/day annually and has more than 300 clear sunny days. This solar potential can be utilized to meet the domestic and irrigation electricity demand. Domestic demand of the household in rural region is about 50 to 100 kWh per month and that in urban region is less than 150 kWh/month in Uttara Kannada. The solar potential assessment reveals that, domestic demand can be supplied by installing rooftop SPV modules, and less the 5% of the rooftop is required in majority of the houses. Irrigation demand can be met by installing PV modules in wasteland where less than 3% of available wasteland area is sufficient. Bio resource availability is computed based on the compilation of data on the area and productivity of agriculture and horticulture crops, forests and plantations. Sector-wise energy demand is computed based on primary household survey of 2500 households, the National Sample Survey Organisation (NSSO study) data, and the information compiled from literatures. Bio resource status is computed for all the agro climatic zones using the data of bio resource availability and demand. The ratio of bio resource availability to demand gives the bio resource status. The ratio greater than one indicates bio resource surplus zones, while a ratio less than one indicates scarcity. The supply/demand ratio in the district ranges from less than 0.5 to more the 2. If the ratio is less than 1 (demand >supply) then that place is fuel wood deficit place and where the ratio is more than 1 (supply >demand) then that place is referred as fuel wood surplus region. In Uttara Kannada, most of the Taluks with ever green forest cover (Sirsi, Siddapur, Yellapur, Supa and eastern hilly areas of Kumta, Honnavar and Ankola) are fuel wood surplus regions where the supply/demand ratio is currently > 2 (compared to 8-9 in early 1990's). Wind resource assessment shows Wind speed varies from 1.9 m/s (6.84 km/hr.) to 3.93 m/s (14.15 km/hr.) throughout the year with minimum in October and maximum in June and July. District experiences annual average wind of 2.5 m/s to 3.0 m/s in all taluks indicating the prospects for WECS installation. Hybridizing wind energy systems with other locally available resources (solar, bioenergy) would assure the reliable energy supply to meet the energy demand at decentralized levels. Grids were assigned weights based on the availability of solar, wind, bio-energy and are given in figures 21.15.2, 21.16.2 and 21.17.2 respectively. This highlights the scope for ecologically sound energy technologies in the district.

Social aspects: Forest rights act, 2006. Government of Inida recognises and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations. Considering this, forest dwelling communities were spatially mapped (Figure 21.18.1) and grids with forest dwelling tribal communities were assigned highest weights

(Figure 21.18.2). These people are directly and indirectly dependent on forest resources and have been protecting forests. The imbalance in forest sector will affect these people's livelihood, so they have considered as prime indicators of social aspects of forestry. The forest dwelling communities of Uttara Kannada are *Kunbis, Siddis, Goulis, Gondas*. Kunabis are said to be the most backward tribals of Uttara Kannada District. They have migrated from Goa and entered Karnataka State through the Coastal region. They are settled down and thickly populated in and around Joida and Yellapur taluks. They live in the bamboo huts built in a row sharing common walls in remote parts of forest. Siddis are ethnic group decedents of African Negros, who were brought to India mainly by Arabs, the Portuguese and the Dutch. They are predominantly found in the forest areas of Ankola, Mundgod, Haliyal and Yallapur taluks. The Siddi community in district represents 31,000 people of which Haliyal taluk hosts 7,000 and rest of them present Yellapura, Supa, Sirsi. They live in small clusters constituting settlement of a villages or an independent settlement. Their occupation is agriculture, they are also engaged in harvesting honey and some of them are forest laborers. They are socially and politically backward and most of them depend on casual labor, trading forest products for their livelihood. Goulis are nomadic tribes migrated from Maharashtra. They are mainly cow and goat harvesters. They stay on the fringes of forest. Some have taken up agriculture. Gonds are mainly confined to the forests of Bhatkal taluk. They depend on forest products and have rich folk culture of tribal dance. The majority of the groups were farmers, laborers and petty workers. The Gonda tribes are closely connected to nature and live a sustainable life that includes agriculture, fishing, weaving (baskets and mats) and boating. But many are migrating towards town of Bhatkal for more economic opportunities. Grids with the presence of tribes were assigned higher weightages (figure 21.18 .2).

Population density is considered as another proxy of ESR mapping. Villagewise population density is computed considering 2011 population census data (http://censusindia.gov.in). Grid wise population is computed by aggregating villages in the respective grid. Population density is computed for each grid and is given in figure 21.19.1. Grids were assigned weightages based on population density (figure 21.19.2) – lowest population density (< 50 persons) is assigned highest weight.

Estuarine diversity: The Uttara Kannada District has four major estuaries viz. Kali, Gangavali, Aghanashini, and Sharavathi (Figure 21.20 .1). The major mangrove species present are *Rhizophora mucronata, Sonneratia alba, Avicennia marina, Avicennia officinalis, Kandelia candel, Rhizophora apiculata, Sonneratia caseolaris, Bruguiera gymnorrhiza.* The Kali estuary is located in the northern most part of the district, the Bedthi or Gangavali about 32 km south from Kali river-mouth, the Aghanashini or Tadri estuary, about 10 km south of Gangavali, and the Sharavathi estuary is about 24 km south of the Aghanashini estuarine mouth. The mangrove vegetation in Uttara Kannada district is found associated with the estuaries and creeks. Before the agricultural interventions by the humans these areas were pristine, intact patches of mangroves. However, after introduction of agriculture, good portions of shallow estuarine areas were reclaimed by preparing earthen embankments for rising of salt tolerant rice varieties like 'Kagga'. Devoid of mangroves, such estuarine areas (also known as 'gaznis') are cultivated with Kagga rice varieties, especially during the rainy season when the fields get flooded and salinity levels decline substantially. The farmers also plant rows of mangrove trees just outside these bunds to fortify them from collapse. This traditional system of estuarine cultivation with mangrove planting was a sustainable system.

Kali Estuary has four major dams with hydro power stations viz. Supa, Nagjhari power house, Kodashalli, and Kadra. **Gangavali Estuary** has no dam or hydel power station. It joins the Arabian Sea at Gangavali near Ankola. The estuarine part starts near the village Gundbala (about 15 km interior) and the area of the estuary is 640 ha. **Aghanashini** or Tadri river meets the tide at Uppinapattana and it winds south-west and then north-west together about 13 km to Mirjan. From Mirjan it runs parallel to the coast for about 13 km and meets the Arabian Sea at Aghanashini. This river has no dam or hydroelectric power station in it. **Sharavathi** join the Arabian Sea near Honavar. Traditionally the estuarine portion extended from the river mouth to the village of Gersoppa, about 27 km interior, towards the base of the Western Ghats. The total area of the estuarine portion was stated to be 1600 ha. This river has two major dams with hydro power stations, first one built at Linganamakki in Shimoga district and the second dam at Gersoppa. These dams have caused substantial changes in the estuarine characteristics, primarily by reducing its salinity. Venkatapura is another small estuary present in the district with moderate diversity. The diversity wise analysis shows Agnashini, Ganagavali has higher fish diversity and mangrove species as compared to other due to absence of major anthropogenic activities (dam or hydro projects). The Sharavathi, Kali are severely disturbed due to continuous flow of fresh water, which led to reduction of salinity. This has affected mangroves, fish yield and other substances. The provisioning services provided by these estuaries ranges from 55707 (Venkatapura) to 2,19,545 Rs (Gangavali) for smaller estuaries, 2,40,395 Rs/hectare/year (Kali), to 286964 Rs (Sharavathi) for estuaries of rivers with dams and 11,35,847 Rs/hectare/year (Aghanashini) for an estuary without any human interventions. Coastal grids were assigned weightages based on the estuarine diversity and productivity (Figure 21.20.2).

Ecologically Sensitive Regions: Figures 21.4.2 to 21.20.2 gives the relative weight of metric corresponding to biological, ecological, geo-climatic, renewable energy and social variables. Aggregation of these spatial layers, based on the composite metric score, grids were delineated as ecologically sensitive regions (ESR) and graded as ESR 1, ESR 2, ESR 3 and ESR 4 respectively. Figure 21.21 illustrates the distribution of grids among ESR 1 to ESR 4.

88 grids represent high ecological sensitiveness with ESR 1 status This is followed by ESR 2 with 24 grids, ESR 3 with 22 grids and the ESR 4 with 34 grids. Spatially 52.38% of the district represents ESR 1, 14.29% of area respresnts ESR 2, 13.1 % of area represents ESR 3 and about 20.23 % of the district is in ESR 4. Figure 21.22 depicts ESR with taluk boundaries. It shows Supa, Yellapura, Ankola, Sirsi, Siddapura, Honnavar, Kumta taluks in ESR 1. Figure 21.23 depicts gram panchayat (gram sabhas) wise ecologically sensitive regions (ESR). Uttara Kannada district has 209 panchayats and among these, 102 panchayats are in ESR 1, 37 panchayats in ESR 2, 33 panchayats in ESR 3 and 37 panchayats in ESR 4. Table 21.5 lists ESR wise villages and the same is depicted in figure 21.24. Sahyadri and eastern part of coastal regions represents highest ecological sensitivitiveness. Figure 21.25 (i to xi) represent taluk wise villages with ESR status.

Table 21.6 lists permitted, regulated and prohibited activities across ecologically sensitive regions. ESR 1 represents ecologically highly sensitive requiring strict conservation measures with sustainable management involving VFCs (Village forest committees). ESR 2 is as good as ESR 1, except degradation of forest patches in some localities. ESR 3 represents moderate conservation region and only regulated development is allowed in these areas. ESR 4 represents less sensitiveness.

Table 21.5: Panchayat and villages wise eco-sensitive regions in Uttara Kannada district, Karnataka

Panchayat and village wise eco-sensitive region (ESR) details					
ECOLOGICALLY SENSITIVE REGION - 1					
SNO	**TALUK**	**SNO (PANCHAYATS)**	**PANCHAYAT**	**NO OF VILLAGES**	**VILLAGE NAMES**
1	**ANKOLA**	1	ACHAVE	4	Bogribail, Kuntgani, Manigadde, Achave
		2	AGSUR	9	Navagadde, Adlur, Kanchimale, Marugadde, Heggar Makkigadde, Agsur, Kodsani, Vasar Kudrige, Shirgunji
		3	DONGRI	6	Dongri, Shevakar, Heggar (Ankola), Kalleshwar, Halvalli, Kammani
		4	HATTIKERI	11	Sakalbena, Hattikeri, Berde, Nellurkanchinbail, Heggarnikotebavi, Gule, Lakkeguli, Kendige, Shikliturli, Mallani, Sheveguli
		5	HILLUR	2	Gundabala, Hillur
		6	MOGTA	8	Mogta, Andle, Karebail, Takatgeri, Kenkanishivapur, Moralli, Kabgal, Brahmur
		7	SUNKSAL	5	Kavalalli, Kattinhakkal, Sunksal, Hebbul, Kodlagadde
2	**BHATKAL**	8	BAILUR	1	Bailur
		9	BENGRE	1	Bengre
		10	HADVALLI	20	Hudil, Badabag, Agga, Henjale, Hasarvalli, Hallyani, Bastigalmigte (Koppa), Murkodi, Bilurmane, Kuntavan, Hadavalli, Voni Bagil, Devastan Megthe, Kurandur, Kulawadi, Aravakki, Kerehittal, Hallari, Hejjil, Kekkod
		11	HEBLE	1	Heble
		12	KAIKINI	1	Kaikini
		13	KOPPA	1	Koppa (Bhatkal)
		14	JOLI	1	Venkatapura
		15	KONAR	6	Joli, Hadeel, Hadlur, Konar, Bese, Mugali
		16	MARUKERI	4	Kitre, Antravalli (Bhatkal), Marukeri, Kotkhanda,
		17	MAVALLI	1	Mavalli
		18	MUTTALLI	5	Behalli, Mudbhatkal, Muttalli, Talan, Belalkhanda
		19	SHIRALI	1	Shirali
3	**HONNAVAR**	20	KHARWA	5	Mandalakurve, Kharwa Koodla, Kudrige, Shirkur
		21	BALKUR	6	Balkur, Heggar (Honavara), Kelgin-Mannige, Talgod, Gudemakki, Melin-Mannige
		22	CHANDAVAR	4	Mallapur (Honavara), Chandavar, Kadnir, Hodke Shiroor
		23	CHIKKANKOD	6	Gundabala (Honavara), Hirebail, Hosgod, Janna Kadkal, Chikkankod, Heravali
		24	HADINBAL	5	Berolli, Nagre, Nirwattikodla, Hadinbal, Mutta

		25	HERANGADI	5	Tumbolli, Melinamudkani, Kelgina-Mudkani, Adkar, Herangadi
		26	HOSAKULI	1	Hosakuli
		27	JALAWALLI	5	Kulakod, Padukuli, Jalwal Karki, Kervalli, Jalwalli
		28	KADLE	3	Kadle, Vandoor, Nilkod (Honavara)
		29	KADTOKA	2	Kekkar, Kadtoka
		30	KELGINOOR	3	Apsarkonda, Kelginoor, Gunavante
		31	KODANI	7	Hinnur, Anilgod, Beranki, Kodani, Birangod, Magod (Honavara), Balemet
		32	MANKI	12	Manki, Dabbod, Adukal, Hadikal, Sampolli, Kota, Tumbebeela, Sulebil, Herali, Kuchodi, Adekekuli, Ashikeri
		33	MAVINKURVA	2	Mavinkurva, Hosad (Honavara)
		34	MELIN-IDGUNJI	4	Malkod, Kelgin-Idgunji, Melin-Idgunji, Molkod
		35	MUGWA	2	Mugwa, Arolli-Mundagod
		36	NAGARBASTIKERI	7	Hanehalli, kabbinahakkal, Hulegar, Khandodi, Nagarabastikeri, Begodi, Hadgeri,
		37	SALKOD	1	Salkod
		38	UPPONI	3	Upponi, Mahime, Saralagi
4	**KARWAR**	39	DEVALMAKKI	7	Naitisavar, Bargal, Belur, Devalmakki, Shirve, Nivli, Nagekove
		40	GHADASAI	5	Reservoir, Halgejoog, Bolshitta, Ghadasai, Ulga
		41	GOTEGALI	6	Bhaire, Goyar, Kamargaon, Lande, Gotegali, Wailwada
		42	HANKON	5	Hotegali, Maigini, Hankon, Gopashitta, Hankonjoog
		43	KADRA	2	Kadra, Balemane
		44	KERWADI	3	Kadiye, Katar, Kerwadi
		45	MALLAPUR	9	Angadi, Mudgeri, Hosali, Mallapur, Virje, Kuchegar, Hartuga, Devakar, Kaiga
		46	WAILWADA	1	Siddar
5	**KUMTA**	47	ALKOD	15	Toppalgutta, Alkod, Yedatare, Bellangi, Sandolli-Muttolli, Yana, Kodambale, Harita, Anegundi, Santur, Bhandival, Uppinpattana, Shirgunji (Kumta), Hebbail, Malwalli
		48	BARGI	6	Kelaginstala, Betkuli, Kurigadde, Bargi, Bargigazani, Paduvani
		49	GOKARN	2	Gokarn, Naranapur
		50	KAGAL	5	Aghanashini, Kagal, Hubbangeri, Baad, Gudeangadi
		51	KODKANI	8	Savalkurve, Keppekurve, Masurkurve, Pattubele, Tannirhonda, Aigalkurve, Chatrakurve, Kodkani (Kumta)
		52	MIRJAN	8	Mugvekanvadi, Nagur, Kadkod, Yelavalli, Yeshwantimule, Yattinabail, Mirjan, Nilkod
		53	MUROOR	7	Alvalli, Madki Bail, Mur00R, Karkimakki, Kallabbe, Hosad, Kandavalli

		54	NADUMASKERI	3	Nadumaskeri, Harumaskeri, Bhavikodla
		55	SANTEGULI	23	Kavalodi, Kanakale, Holavalli, Kalve (Kumta), Chimmolli, Bangane, Mudgi, Basolli, Santeguli, Hegde-Hosalli, Bastikeri, Divalli, Santagal, Haravalli, Abbolli, Hindbail, Honagere, Ullurmath, Algar, Mudnalli, Soppinahosalli, Morse, Medini
		56	HIREGUTTI	16	Bankikodla, Hanehalli, Hoskeri, Kadime, Gonehalli, Bidrageri, Nagarbail, Toregazani, Torke, Hittalmakki, Yennemadi, Hiregutti, Midlagazani, Morba, Kolimanjaguni
		57	MADANGERI	1	Madangeri
6	SIDDAPUR	58	ANALEBAIL	13	Sarkuli, Kelgin Sarkuli, Umbalmane, Bidarmane, Murur, Balekoppa (Kibballi), Ainbail, Hegnur, Kibballi, Analebail, Keregadde, Halegouri, Attimurd
		59	BILGI	6	Kattekai, Golikai, Bilgi, Hosamanju, Kuravante, Kuppagar
		60	DODMANE	14	Gijagini, Bilegod, Nirgod, Kodigadde, Kaunsale, Dodmane, Uppingadde, Kallole, Kadavadi, Naigar (Siddapur), Kalkai (Siddapur), Kibale, Halegubbi, Kudegod
		61	HALGERI	17	Malemane, Hejani, Chandraghatgi, Hemagar, Kodkani, Kulibid, Mensi (Siddapur), Halgeri, Nagarbhavi, Padavanbail, Mattigar (Siddapur), Husur, Kilar, Uppadaki, Hematemane, Heggadde, Algod
		62	HASARGOD	10	Hasargod, Balesar, Shamemane, Karjagi, Bannige, Yelugar, Kodsar-Halkani, Halkani, Malubalgar, Hirekai (Kodsar Halkani)
		63	HEGGARANI	8	Hullunde, Taresar, Heggarani, Hegge, Unchalli (Siddapur), Hostot, Harigar, Haldot
		64	ITAGI	4	Sashiguli, Taragod, Itagi, Gunjagod
		65	KYADGI	8	Begar, Gubbagod, Illimane, Mavinkod, Kyadgi, Lakkabbekeri, Balgod, Suttalmane
		66	NILKUND	13	Hallibail, Kanchikai, Mulgunda, Nilkund, Hukli (Nilkund), Shivalmane, Hutgar (Nilkund), Tandagundi, Handiyane Math, Nandyane, Nirgan, Manigar, Halehalla
		67	SOVINKOPPA	8	Honnekomb, Havinbil, Sovinkoppa, Ojagar, Hadrimane, Chapparmane, Nirgar, Tarakhanda
		68	WAJGOD	10	Talekeri, Danmav, Wajgod, Huvinmane, Keremane, Hukali (Wajgod), Kudagund, Alavalli, Kelginmane, Sangolimane
		69	MALAVAJADDI	9	Malvajaddi, Koralkai, Musavalli, Malavalli, Heggekoppa, Kallur, Hasavante, Malalavalli
		70	MANMANE	1	Manmane
7	SIRSI	71	BANDAL	9	Manjaguni (Sirsi), Teppar, Hebre, Devimane, Bugadi, Hosur, Bandal, Khurse, Badagi
		72	DEVNALLI	8	Mundganmane, Kelginkeri, Sarguppa, Devanmane, Benagaon, Kallalli, Devanalli, Kalugar

		73	JANMANE	7	Hostota, Hanagar, Kukri, Adalli, Kondalgi, Nerlavalli, Janmane
		74	SHIVALLI	23	Koligar, Muregar, Kudragod, Neelkani, Naigar, Jaddigadde (Sirsi), Manadur, Singanalli, Kelgin Onikeri, Melin Onikeri, Modur, Kadbal, Shigehalli, Onigadde, Kambigar, Hakkigadde, Mudgar, Kotgehalli, Shivalli, Shivagaon, Kanalli, Heggar
		75	VANALLI	9	Dhoranagiri, Muski, Kakkalli, Kanamuski, Shirgani, Gonsar, Vanalli, Guruvalli, Tattisar
		76	SALKANI	1	Salkani
8	YELLAPURA	77	HITLALLI	6	Harigadde, Tolagod, Hiresar, Bidralli, Hittlalli, Ilehalli
		78	ANGOD	11	Bisgod, Nagarakhan, Hukkali, Angod, Savagadde, Baragadde, Geral, Shistamudi, Tatagar, Shigepal, Hutakmane
		79	KAMPLI	4	Somanalli (Yellapur), Chikkotti, Kampli, Kerehosalli
		80	KANNIGERI	6	Gotguli, Lalguli, Kannigeri, Kannadagal, Belegeri, Kolikeri
		81	MAVINMANE	5	Kanur, Bare, Marahalli, Benadaguli, Mavinamane
		82	NANDOLLI	15	Hastakaragadde, Balekani, Nandolli, Kavadikere, Belakanda, Analgar, Hulagan, Sulagar, Heggumbale, Holemadu, Devaragadde, Magod, Chandguli, Malalgaon, Hutkhanda
		83	VAJRALLI	12	Baraballi, Kodsalli, Kalache, Honagadde, Targar, Beegar, Baginkatta, Chimanalli, Telangar, Vajralli, Jogalepal, Ambagaon
		84	IDAGUNDI	14	Lingadabailu, Hamsana, Gadde, Donagar, Gharwas, Gopadmane, Jogadamane, K0Madi, Idagundi, Kodlagadde (Yellapur), Chikkumane, Gullapur, Arbail, Dabaguli, Kelashi
		85	DEHALLI	4	Kattige, Dehalli, Hiriyal, Balagar
9	HALIYAL	86	AMBIKANAGAR	4	Kulgi, Jamaga, Amga, Ambikanagara (CT)
		87	DANDELI	1	Dandeli
10	SUPA	88	AKHETHI	11	Viranjol, Palada, Rangarook, Varlewadi, Akheti, Vatala, Karambal, Anamod, Atle, Devulli (Tinai), Payaswadi
		89	ANASHI	4	Nujji, Badpoli, Anashi, Nigundi
		90	ASU	13	Chandawadi, Konshet, Iliye Dabe, Durg, Chapali, Asu, Bori, Shindholi, Varande, Wada, Kasarle, Boregali, Kamra
		91	AVEDA	7	Kurandi, Aveda, Konda (Haliyal), Kondapa, Mavalinge, Badgund, Ambeli
		92	BAZAR KUNANG	12	Reservoir (Supa), Ivoli, Aveda Poppal Wadi, Ghvane, Bandoda, Pisose, Viral, Bazar Kunang, Kuveshi, Diggi, Asulli
		93	JAGALBET	7	Velif Kumbeli, Timbholi, Kumbral, Vaini, Bamanawadi, Durgi, Jagalbet,

		94	JOIDA	8	Chapoli (Kalsai), Devulli (Joida), Tinai Khand, Joida, Nagari, Hudasa, Kumbeli, Gangoda
		95	KALAMBULI	2	Kalambuli, Kunagini
		96	KATELI	8	Kundal, Zalawali, Terali, Deriye, Katel, Kateli (Kumbar Wada), Kalasai, Godashet
		97	SAMJOIDA	10	Panjeli, Karanjoida, Nagoda, Samjoida, Chapoli (A), Chapakhand, Amarde, Bapeli, Khodli, Sangave
		98	NANDIGADDE	7	Avurli, Gund, Nandigadde, Chinchkhand, Kariyadi, Bedasgadde, Shevali
		99	YERAMUKH	1	Yeramukh
		100	PRADHANI	10	Birampali, Pradhani, Gavegali, Phansoli, Virnoli, Kalamkhand, Shiroli, Amagaon, Sannamaga, Kavale
		101	SHINGARGAON	10	Miras, Kumbeli, Amshet, Malamba, Vaijagaon, Kasarwadi, Shingargaon, Kudalgaon, Donshet, Usoda, Pusheli
		102	ULVI	11	Ambolli, Chafer, Bidoli, Tulasgeri, Vadkal, Shivapur, Hebbal, Ulavi, Kodthalli, Neturge, Birkhol
ECOLOGICALLY SENSITIVE REGION - 2					
	TALUK	**SNO (PANCHAYATS)**	**PANCHAYAT**	**NO OF VILLAGES**	**VILLAGE NAMES**
1	ANKOLA	1	ALGERI	2	Algeri, Baleguli
		2	AVERSA	1	Aversa
		3	BELEKERI	1	Belekeri
		4	BELSE	3	Talgadde,Belse, Shirur
		5	ANKOLA	2	Nadibag, Ankola (TP+OG)
		6	HARWARDA	1	Harwada
2	BHATKAL	7	BELKE	4	Gorte, Belke, Kaggundi, Nuz
		8	MUNDALLI	1	Mundalli
		9	BHATKAL (OG)	3	Taggorgod, Jali, Bhatkal (TMC+OG)
		10	YALAVADIKAVOOR	8	Bastigalamigte (Hadin), Hadin, Chavathani, Purvarga, Golibilur, Yelavadikavoor, Herur, Benandoor,
3	HONNAVAR	11	KASARKOD	3	Kasarkod, Kankichitta, Hosapatna,
4	KARWAR	12	AMADALLI	2	Todur, Amadalli,
5	KUMTA	13	KUJALLI	3	Konalli, Kujalli, Hegle,
6	SIDDAPUR	14	HARSHIKATTA	10	Karkisaval, Honnehadda, Harshimane, Harshikatta, Manikmane, Hutagar (Muthalli), Muthalli, Kodsar (Muthalli), Bhandarkeri, Sampagod
		15	KAVANCHUR	6	Akkunji, Haralikoppa, Arendur, Kavanchur, Dugadikoppa, Nejjur
		16	SHIRALGI	5	Kolgi, Shiralgi, Balekoppa (Shiralgi), Bikkalse, Mugdur
		17	TYAGALI	10	Matti Halli,Hangarkhanda, Shigehalli (Siddapur), Kodgadde, Kalgadde, Shelur, Tyagali, Hirekai (Tyagali), Kalen Halli, Surgikoppa, Mudhalli,

7	SIRSI	18	BANAKKAL	8	Mattihalli, Ummadi, Bilur, Gongatta, Gonur, Kandraji, Bankanal, Malanji,
		19	BHAIRUMBE	10	Hulgo, Malenalli, Arasapur, Belale, Golikoppa, Bhairumbe, Bommanalli, Agasal, Dasangadde, Sadashivalli
		20	BISALKOPPA	14	Shivalli, Angodkoppa, Mudebail, Wadgeri, Hudelkoppa, Bislakoppa, Ullal, Adnalli, Yekkambi, Malalgaon (Sirsi), Benagi, Hallikoppa, Kotekoppa, Kuppalli
		21	DODNALLI	6	Achanalli, Narebail, Dodnalli, Byagadde, Husri, Bachagaon
		22	GUNDAPUR	8	Hadalagi, Madralli, Gudnapur, Navanageri, Golikatta, Mundgehalli, Kantraji, Ajjarni
		23	HULEKAL	9	Audala, Mogadde, Mathadeval, Kodigar, Bakkal, Nakshe, Hancharata, Sonda, Harehulekal
		24	ISLOOR	8	Boppanalli, Isloor, Sannakeri, Huldevansar, Goudalli, Somanalli, Chipgi, Hebballi
		25	NEGGU	15	Hostota_s, Navilgar, Sampakhanda, Kugtemane, Balavalli, Janmane, Kodgibail, Hallusargi, Bommanalli_s, Mattigar, Neggu, Uratota, Bappanalli, Tataguni, Tuduguni
		26	SUGAVI	10	Margundi, Halgadde, Sugavi, Madankeri, Halsinkoppa, Bidralli (Sirsi), Vaddinakoppa, Kalgundikoppa, Gadgeri, Bengle,
		27	UNCHALLI	12	Nurkalkoppa, Kankoppa, Kabbe, Kerekoppa, Unchalli, Umblekoppa, Somanalli, Uplekoppa, Koppa, Kalli, Kogod, Sahasralli
		28	KUNDARGI	25	Halasinkoppa, Kanenalli, Shigemaneummachagi, Chavatti, Kanagod-Balehadda, Sankadagundi, Kotemane, Totadakallalli, Hunasemane, Hullaramane, Jakkolli, Jaddigadde, Savane, Uchageri, Bharatanahalli, Bharanii, Kannur - eggaranii, Tarehalli, Hemmadi, Vanakemane, Kundargi, Hasalmane, Bellambi, Sampekoppa, Beejanakoppa
8	YELLAPURA	29	YELLAPURA	1	Yellapura (TP)
9	HALIYAL	30	ALUR	16	Haregali, Gobral, Vitnal, Kumbarkop, Ambewadi, Bedarshirgur, Alur, Kalginatti (kalginkopp), Dandeli(Rural), Kerwad (Dandeli), Kariyampali, Badakanshirda, Harnoda, Mainal, Hosakumbarkop, Tatgera,
		31	ARLWAD	4	Mundki, Arlwad, Hunswad, Satnalli,
		32	BHAGWATI	19	Rayapattan, Chimnalli, Malawad, Kalbhavi, Gutti, Donshirgur, Badashirgur, Narnalli, Bommanalli (Haliyal), Kegdal, Vincholli, Addigera, Bhagawati, Malawadi, Thakkar Basapur, Bhimanalli, Machapur, Balshettikop, Chotakanshirda,
		33	JANAGA	6	Dodkop, Janaga, Chinaginkop, Jatga, Basawalli, Nandigadda
		34	MANGALWAD	5	Malwad, Ambodaga, Pala (Haliyal), Kalasapur, Mangalawad

		35	KAWALWAD	12	Karlkatta, Sambrani, Bukkankoppa, Nilwani, Hosur (Haliyal), Adikehosur, Jatgahosur, Mavinkop, Tattigeri, Bogur, Kawalwad, Hampehalli
		36	YEGODA	14	Kesrodaga, Singatgeri, Ajgarni, Handli, Ramapur (Haliyal), Modalgera, Bidrolli, Yedoga, Channapur, Bablikop, Baloga, Harwalli, Satmani, Jawalli
		37	SALAGAON	1	Salagaon
ECOLOGICALLY SENSITIVE REGION - 3					
SNO	**TALUK**	**SNO (PANCHAYATS)**	**PANCHAYAT**	**NO OF VILLAGES**	**VILLAGE NAMES**
1	BHATKAL	1	MAVINKURVE	4	Karikal, Talgod (Bhatkal), Mavinkurve, Belni,
2	HONNAVAR	2	HALDIPUR	1	Haldipur,
		3	KARKI	3	Pavinakurve, Karki, Duggur,
		4	NAVILGONE	4	Madageri, Kakurve, Navilgone, Aunsalli
		5	HONNAVAR (TP)	1	Honavar (TP)
3	KARWAR	6	ARGA	1	Arga
		7	CHANDIYE	1	Chendiye
		8	SHIRWAD	1	Shirwad
4	KUMTA	9	DEVGIRI	6	Devagiri, Math, Kadekodi, Talgod (Kumta), Holegadde, Horbhag,
		10	HEGDE	2	Lukkeri, Hegde,
		11	KALBAHG	1	Handigona
		12	KUMTA (CMC+OG)	1	KUMTA (CMC+OG)
5	SIDDAPUR	13	BHANKULI	4	Bhankuli, Muttige (Gunjagod), Bedkani, Tyarshi,
		14	BIDARKAN	10	Godlabil, Hingar, Muttige (Kaval Koppa), Naligar, Kavalkoppa, Kodgibail (Siddapur), Bidarkan, Golgod, Bandisara, Maghegar
		15	KANGOD	4	Nidgod, Aigod, Ballatte, Kangod (Siddapur),
		16	KOLSIRSI	11	Heggodmane, Tumbargod, Mandlikoppa, Kunaji, Kolsirsi, Balguli, Avarguppa, Halagadikoppa, Wadageri, Kastur, Mutmurd,
		17	TAREHALLI	14	Tagginbalgar, Adkalli, Malenhalli, Gavingudde, Balekai, Tarehalli-Kansur, Kangod-Kansur, Ghattikai, Madankal, Devisar, Girgadde, Arehalla, Kalkatte Hunasekoppa, Hosakoppa
		18	SIDDAPUR (TP)	1	Siddapur (TP)
6	SIRSI	19	HUNSEKOPPA	6	Yachadi, Kalve, Sannalli, Janmane (H), Hunsekoppa, Hanumanthi
		20	SIRSI (CMC+OG)	2	Sirsi (CMC+OG), Hutgar
		21	ITAGULI	8	Balegadde, Karjigimane, Itaguli, Koppa, Andolli, Devarkoppa, Harepal, Kalgar
		22	KANGOD	9	Amblihonda, Mashigadde, Kangod, Hannondugudde, Ajjibal, Karoor, Balgar, Jaganalli, Bislakoppa_s

		23	KODNAGADDE	5	Kalgadde Kanchigadde, Sonaginmane, Kodnagadde, Mensi, Balekaimane
		24	KULVE	6	Terkanalli, Kageri, Padageri, Baroor, Kulve, Gadihalli,
		25	YEDALLI	10	Bilgalmane, Hedigemane, Sankadmane, Heepnalli, Sirsimakki, Mundagesar, Yadalli (Sirsi), Karsulli, Kalkai, Betkoppa
7	HALIYAL	26	KESROLLI	11	Niralagi, Domagera, Kyatangera, Gardolli, Gadagera, Agasalkatta, Ajga0N, Kesrolli, Halsi, Kurigadde (Haliyal), Siddapur (Haliyal),
8	MUNDGOD	27	GUNJAVATHI	6	Gunjavati, Mainalli, Balehalli, Kusur, Tattilli (Mundgod), Basavanakoppa
		28	HUNGUNDA	2	Agadi, Hungunda
		29	INDOOR	4	Indoor, Kopp (Ind), Pur
		30	KATUR	18	Chipageri, Ganadahalli, Tattalli (Katur), Kallalli (Mundgod), Nagnoor, Chikka Haravalli, Chitgeri, Chalgeri, Ammatgar, Attangi, Doddaharvalli, Katur, Mudasali, Alalli, Mavakoppa, Maragadi, Shinganahalli, Hulihonda,
		31	NANDIKATTA	4	Yerebail, Hulihonda, Nandikatta, Ugginkeri
		32	SALGAON	5	Sanavalli, Bappalgundi, Bappalkatti, Ajjihalli
9	SUPA	33	RAMNAGAR	1	Ramnagar

ECOLOGICALLY SENSITIVE REGION - 4

SNO	TALUK	SNO (PANCHAYATS)	PANCHAYAT	NO OF VILLAGES	VILLAGE NAMES
1	ANKOLA	1	BHAVIKERI	1	Bhavikeri,
		2	AGRAGON	9	Agragon, Hegre, Adigon, Joog, Kamge, Devigadde, Sagadgeri, Ulware, Balale,
		3	SHETGERI	15	Poojgeri, Shetgeri, Bhasgod, Kogre, Belambar, Wadibogri, Honnebail, Shinganmakki, Surve, Kanagil, Hichkad, Hadav, Bilehoingi, Manjaguni
		4	VANDIGE	2	Hosgadde, Bole
2	KARWAR	5	MADHEWADA	5	Kanasgiri, Kolage, Arav, Sawantwada, Madhewada
		6	CHITAKULA	1	Chitakula
		7	KADWAD	3	Kadwad, Makheri, Sunkeri,
		8	KINNAR	1	Kinnar
		9	MAJALLI	1	Majalli
		10	KARWAR (CMC+OG)	1	Karwar (CMC+OG)
3	KUMTA	11	HOLANGADDE	4	Holanagadde, Manikatta, Halkar, Chitragi
4	SIRSI	12	ANDGI	7	Fharsi, Kirwatti, Hebbatti, Andgi, Kyadgikoppa, Mugilkoppa, Kalkardi
		13	BADANGOD	7	Danaganahalli, Badanagod, Kalangi, Bellankeri, Kuppagadde, Waddal, Santolli
		14	BANAVASI	4	Kadgod, Banavasi, Mugvalli

		15	BHASI	5	Tigani, Bhasi, Chikkadugli, Kalkoppa, Naroor
5	YELLAPURA	16	HASANGI	13	Bendigeri, Gadijogadmane, Bhomnalli, Kundoor, Kusguli, Hasanagi, Aalwad, Bilki, Puratbomnalli, Hotageri, Mudanagi, Shiranala, Hitlasara
		17	KIRAVATTI	3	Kanchanahalli, Kiravatti, Hosalli
		18	MADNUR	9	Kalasuru, Heggapur, Madnur, Bankasalli, Yadalli, Devarakallalli, Malakoppa, Halagod, Baichgod
6	HALIYAL	19	BELWATGI	2	Guledkop, Belwatgi
		20	BHANASAGERI	2	Buzurkanchanalli, Bhanasageri
		21	GUNDOLLI	7	Kumbarkop, Tippingeri, Pura (Haliyal), Arshingeri, Kalginkop, Gundolli, Ajminal
		22	HAVAGI	4	Timmapur, Havagi, Kerwad (Haliyal), Magwad
		23	MADNALLI	5	Homnalli, Madnalli, Dusagi, Muttalmuri, Antrolli
		24	MURKWAD	3	Murkwad, Mugadkop, Khurd Kanchanalli
		25	NAGSHETIKOPPA	5	Nagshetikop, Mundwad, Shivapur (Haliyal), Dongrikop, Golehalli
		26	TATWANGI	4	Tatwanagi, Ammankop, Jogankop, Ghadiyal
		27	TERAGON	1	Tergaon
		28	HALIYAL (TP)	7	Tegnalli, Alolli, Khamdolli, Chibbalgeri, Guttibail, Malwadi, Haliyal (TP)
		29	RAMPUR	2	Handli, Ramapur (Haliyal)
7	MUNDGOD	30	BACHANKI	3	Wadagatta, Bachanaki, Nyasargi, Kundargi (Mundgod)
		31	BALEKOPPA	2	Halaharavi, Balekoppa
		32	CHOWDALLI	10	Kargolli, Tamyankoppa, Chowdalli, Teginkoppa, Lakkolli, Malavalli (Mundgod), Byanalli, Kalkeri, Rayanalli, Andalgi,
		33	CHIGALLI	3	Kavalakoppa, Hirehalli, Chigalli
		34	KODAMBI	13	Ramapur, Veerapur, Kodambi, Bhadrapura, Bommarshikoppa, Kurli, Togralli, Atabail, Kanchikoppa, Shanvalli, Ummachagi, Hostot (Mundgod), Bedasgaon
		35	MALGI	14	Bekkod, Naginkeri, Siddapur, Malgi, Kop (Gotgudi), Gotagudi, Kolgi (Mundgod), Haraganalli, Veerapur, Jangeri, Hoskoppa, Borangudda, Kyadgikop, Yemagalli
		36	PALA	6	Oralgi, Borangudde, Hudelkoppa (Mundgod), Pala, Ingalki, Kalkoppa (Mundgod)
		37	MUNDGOD (TP)	2	Kyasankeri, Mundgod (TP)

Table 21.6: Activities that can be allowed in ESR -1, 2 3 & 4.

SNO	ACTIVITIES	ECOLOGICALLY SENSITIVE REGIONS			
		ESR-1	ESR-2	ESR-3	ESR-4
1	**ENERGY**				
	(A) Solar (Roof top)	✓	✓	✓	✓
	(B) Wind power	✗	✗	✓	✓
	(C) Bio energy	✓	✓	✓	✓
	(D) Coal based (Thermal power)	✗	✗	✗	✗
	(E) Gas or liquid fuel based	✗	✗	✗	✓
	(F) Hydro power (Major)	✗	✗	✗	✗
	(G) Hydro power (Micro)	✗	✗	✗	✓
	(H) Nuclear power	✗	✗	✗	✗
2	**FORESTS**				
	(A) Land use change (Forest to non-forest usages)	✗	✗	✗	✗
	(B) Monoculture plantations	✗	✗	✗	✗
	(C) Extraction of medicinal plants (with strict regulations)	✗	✓	✓	✓
	(D) Forest improvement through VFCs	✓	✓	✓	✓
	(E) NTFP collection	✓ (Strict regulation by department)	✓ (Strict regulation by department)	✓ (Strict regulation by department)	✓
	(F) Encroachment of forests and Myristica swamps	✗	✗	✗	✗
3	**AGRICULTURE**				
	(A) Agro forestry	✓	✓	✓	✓
	(B) Organic farming	✓	✓	✓	✓
	(C) Land use change / Encroachments	✗	✗	✗	✗
	(D) Genetically modified crops	✗	✗	✗	✗
	(E) Animal Husbandry	✓	✓	✓	✓
4	**HORTICULTURE**				
	(A) Organic farming	✓	✓	✓	✓
	(B) Nitrogen and Phosphorus (N&P) fertilizers	✗	✗	✗	✓ Dosage as prescribed by Agriculture department
	(C) Endosulfan	✗	✗	✗	✗
	(D) Pesticide, weedicide	✗	✗	✗	✓

	(E) Watermelon & Muskmelon farming	✓	✓	✓	✓
5	**INDUSTRIES (Larger scale)** (A) Agro processing industries	✓	✓	✓	✓
	(B) Information Technology industries (IT)	✗	✗	✓	✓
	(C) Red category (Polluting) industries	✗	✗	✗	✗
	(D) Garment industries	✗	✗	✓	✓
	(E) New establishment of Industries	✗	✗	✗	✓ (Allowed only after critical review by local stake holders and experts)
	(F) Nonpolluting (Green) Industries	✗	✗	✓	✓
6	**INDUSTRIES (Small scale)** (A) Garment industries	✗	✗	✓	✓
	(B) Domestic (Home based) industries a. Papad	✓	✓	✓	✓
	b. Mango processing	✓	✓	✓	✓
	c. Areca nut processing & Coir industries	✗	✓	✓	✓
	d. Milk products and processing	✓	✓	✓	✓
	e. Dry fruits & Spices	✓	✓	✓	✓
	f. Fruit processing (Ex: Kokum Juice *(Garcinia indica)*)	✓	✓	✓	✓
	g. Fish and sea products processing	✓	✓	✓	✓
	h. Bee keeping and bee nurseries	✓	✓	✓	✓
	i. Pongamia plantations for biofuel (in private lands)	✗	✗	✓	✓
	j. Bio pesticides manufacturing	✗	✗	✓	✓
	k. Poultry farms and powdered eggs	✗	✓	✓	✓
	l. Vegetable dyes; fruits and vegetables preservation	✓	✓	✓	✓
	m. Medicinal plants cultivation and processing	✓	✓	✓	✓
	n. Aromatic plants and essential oil distillation; orchids and cut flowers harvesting industries	✗	✓	✓	✓

7	**TOURISM**				
	(A) Ecotourism	✓	✓	✓	✓
	(B) Organic village and home stay	✓	✓	✓	✓
	(C) VFC managed tourism	✓	✓	✓	✓
	(D) VFC managed home stay tourism in higher forest cover regions and protected areas	✓	✓	✓	✓
	(E) Arts and handicrafts museum and trade center	✓	✓	✓	✓
8	**MINING AND MINERAL EXTRACTION**				
	(A) Iron ore	✗	✗	✗	✗
	(B) Manganese	✗	✗	✗	✗
	(C) Bauxite	✗	✗	✗	✗
	(D) Limestone	✗	✗	✓	✓
	(E) Quartz	✗	✗	✓	✓
	(F) Sand extraction (on sustainable basis by Ban on exporting)	✗	✗	✓	✓
9	**WASTE DISPOSAL**				
	(A) Hazardous waste processing units	✗	✗	✗	✗
	(B) Solid waste disposal	✗	✗	✗	✓ (For composting and manure preparation)
	(C) Liquid waste discharge	✗	✗	✗	✓ (Treatment plants (STP) for processing)
	(D) Recycling and waste processing and units	✗	✗	✗	✓ (compliant with PCB)
10	**TRANSPORTATION**				
	(A) Widening of highways (B) Roads and express ways	✗	✗	✗	✓ (Allowed only after strict EIA)
	(C) Rail and freight corridors	**Hubli- Ankola rail connectivbity**: Implementation with EMP, mechanism for post project monitoring, Strict regulation and social audit **Talaguppa – Honnvar**: This line passes through LTM habitat and ecologically sensitive – not to be permitted			
	(D) Up gradation of existing infrastructure	✗	✗	✓ (Subject to EIAs, strict regulation and social audit)	✓

Remarks
• ESR_1 represents zone of highest ecological sensitivess, no further degradation be allowed. ESR-2 has potentiality to become ESR-1 provided strict implementation norms and regulations for improvement of degraded patches of forests. Further erosion of ESR-2 will have more adverse effects in ESR-1. • Forest Rights Act to be implemented in its true spirit. • Monoculture plantations are not allowed, existing exotics should be replaced by planting location specific native species. • Promote use of renewable energy sources such as (solar, wind power) through incentive based decentralized electricity generation. • Mining is to be banned in ESR 1, ESR 2 and ESR 3 • No new licenses to be given for quarry and sand mining in ESR 1 and 2**.** • Local agro based industry to be promoted with strict regulations and social audit. • Adapt development projects (discussed in the next section) which will have least environmental impact by involving local community members in decision making and environmental monitoring. • No new major roads, widening of highways • Proposed Talaguppa – honnavar rail link to be shelved (affects LTM habitat, and ESR1) • Eco tourism (comparable to Goa and Kerala model and based on MOEF regulations)after taking into account social and environmental costs. • The laterite formations are aesthetically pleasing, and particularly with the massive flowering of rainy season herbs. The terrain is ideal for tourism and scientific studies.

LAND

Figure 21.4.1: Forest cover

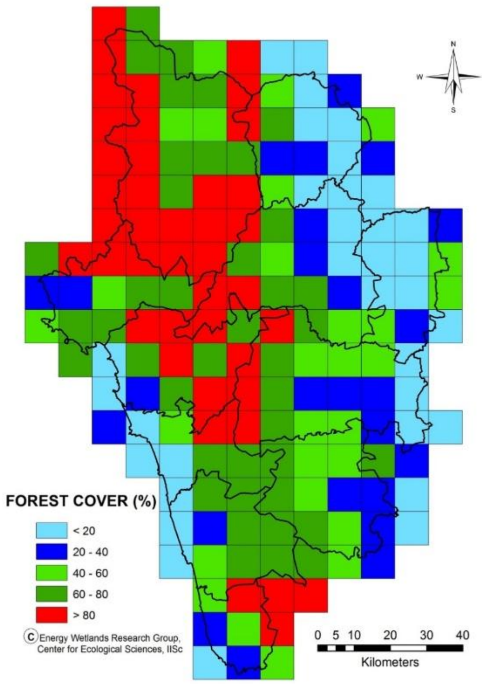


Figure 21.4.2: Forest cover weight / rank

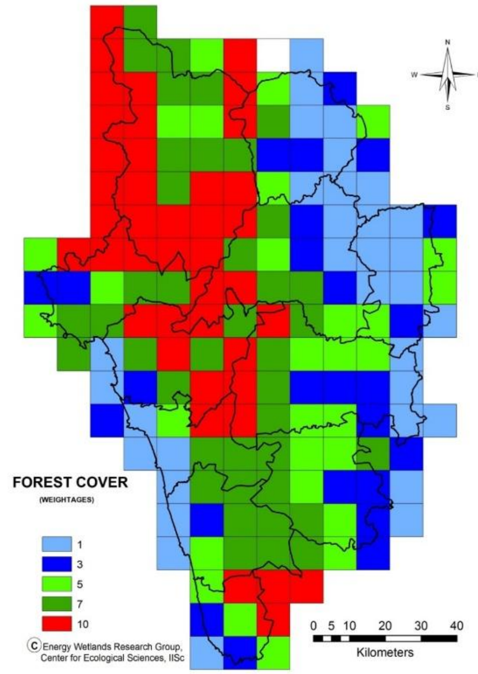


Figure 21.5.1: Interior forest

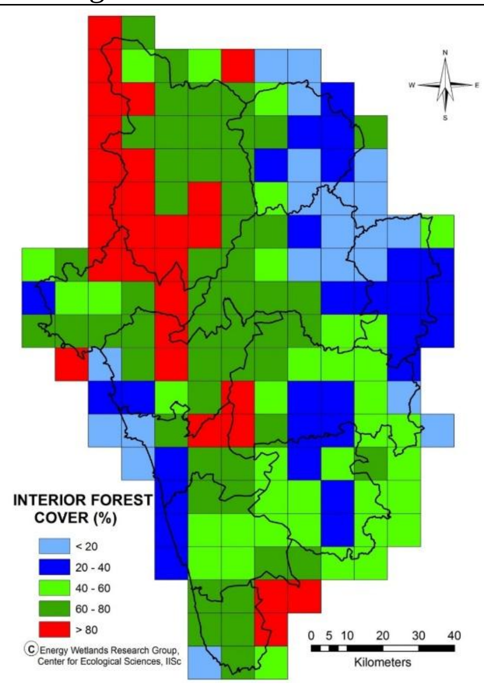
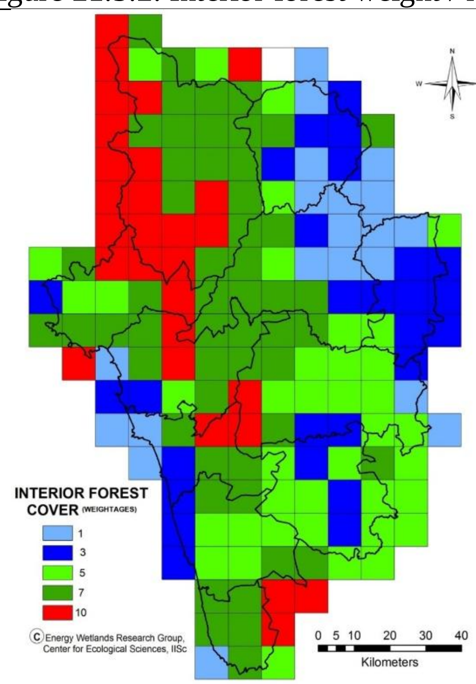


Figure 21.5.2: Interior forest weight / rank



Ecology

Figure 21.6.1: Floral diversity

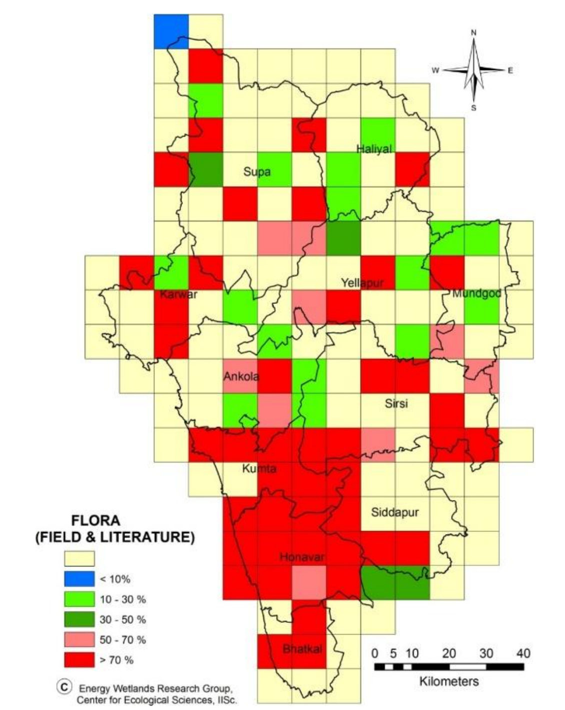


Figure 21.6.2: flora weight / rank

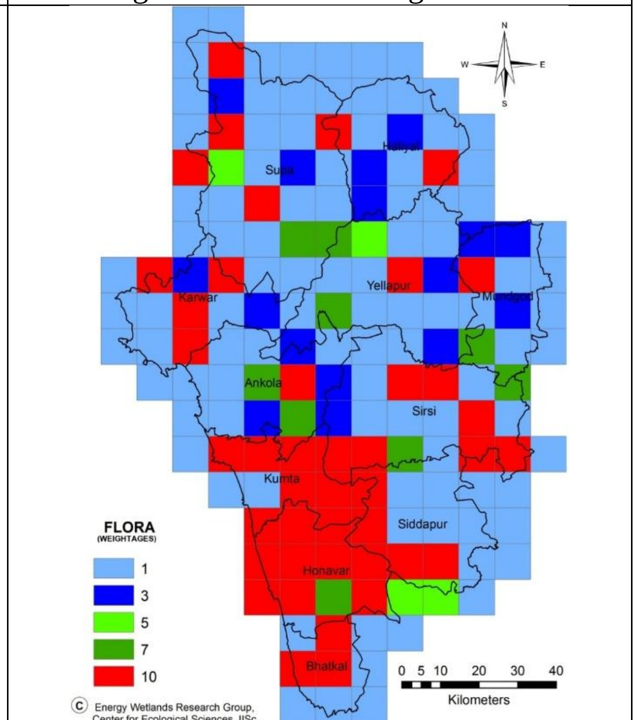


Figure 21.7.1: Faunal diversity

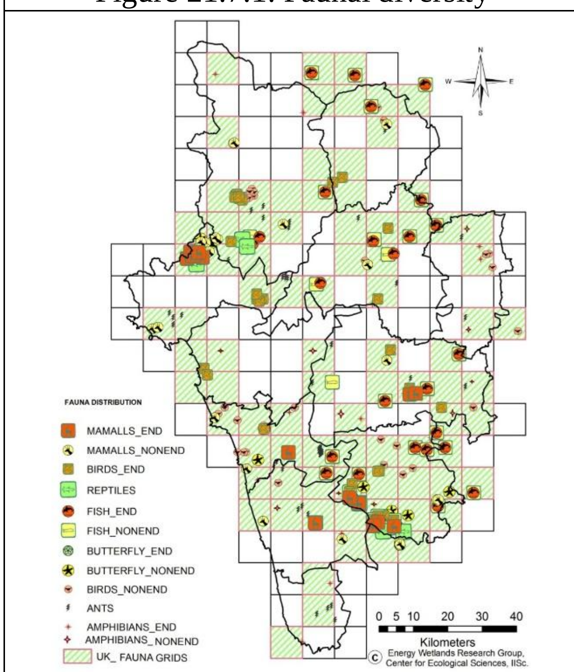


Figure 21.7.2: fauna weight / rank

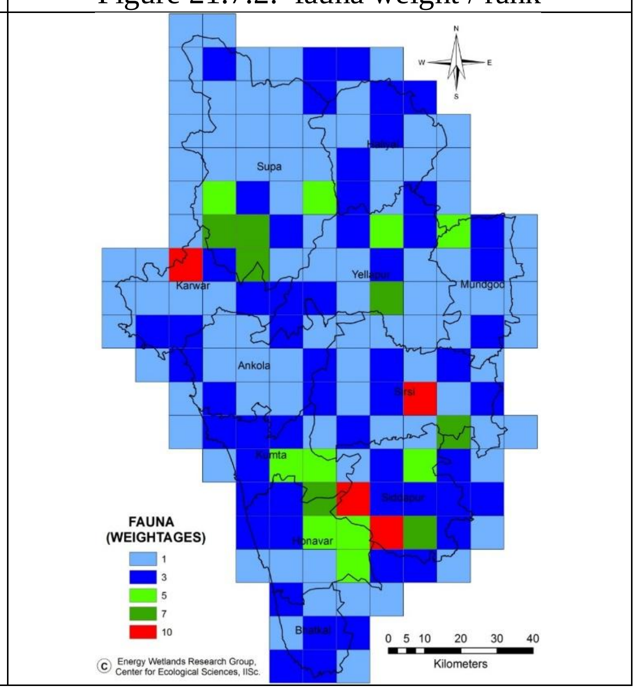


Figure 21.8.1: Biomass of forests

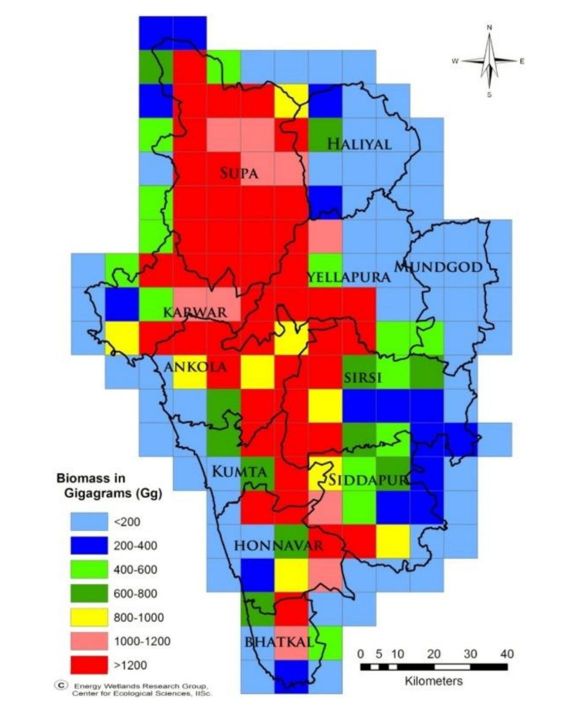


Figure 21.8.2: Biomass weight / rank

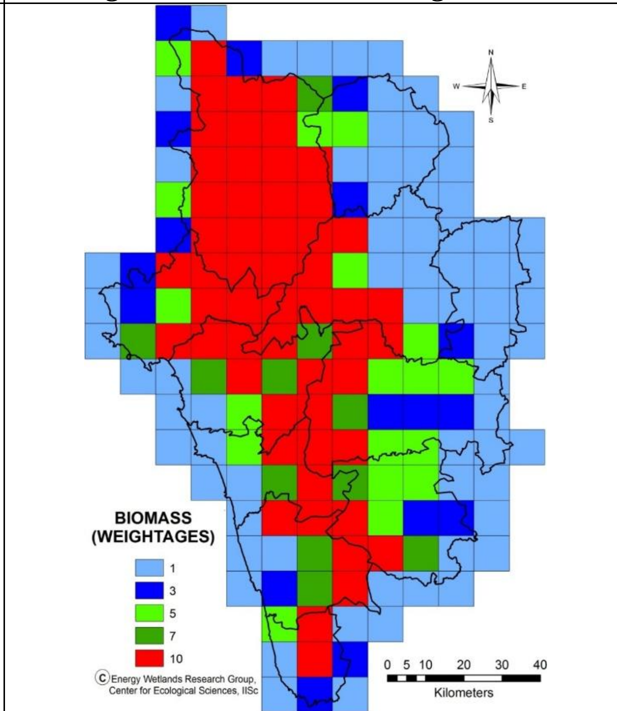


Figure 21.9.1: Shannon diversity – tree diversity

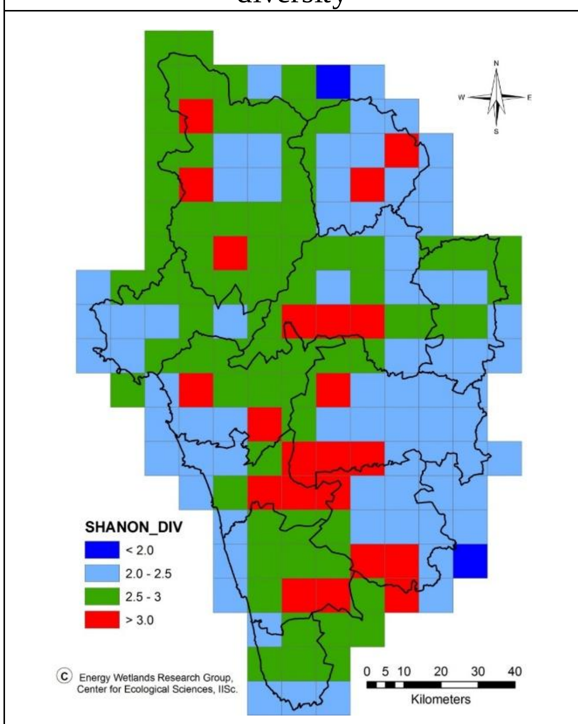


Figure 21.9.2: tree diversity weight / rank

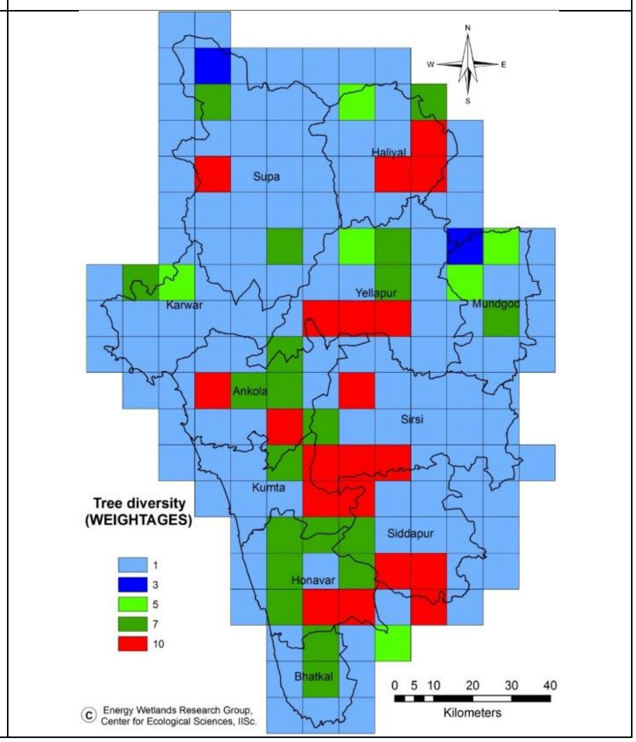


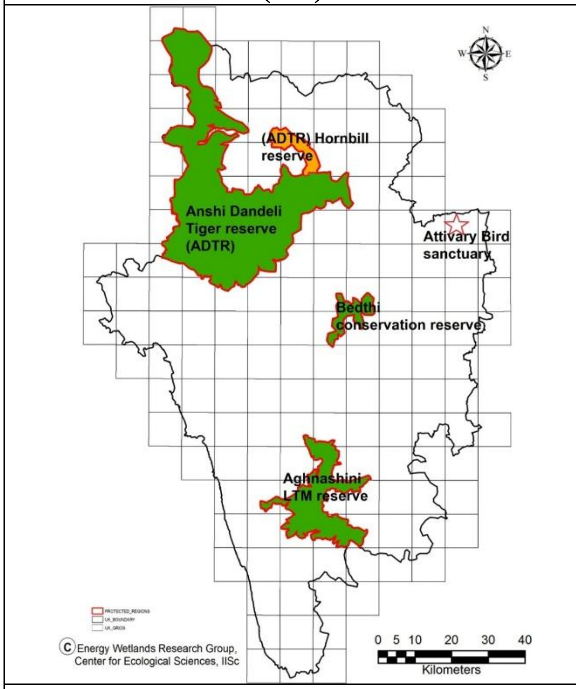
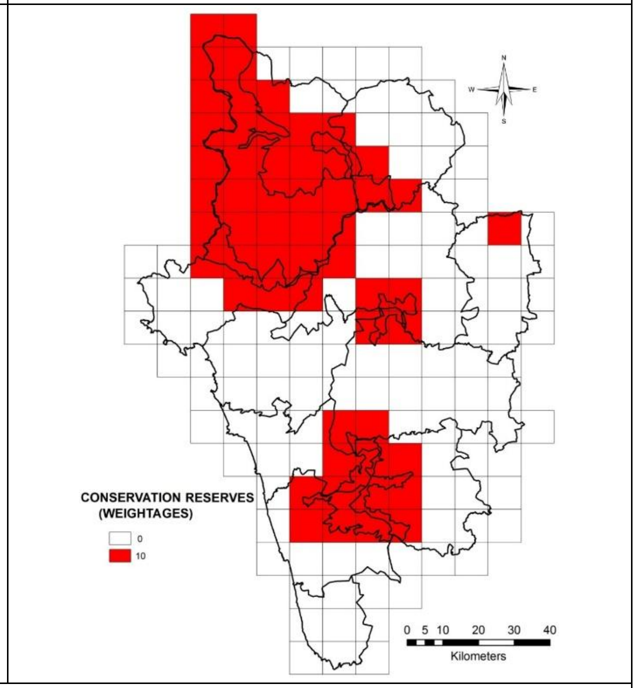
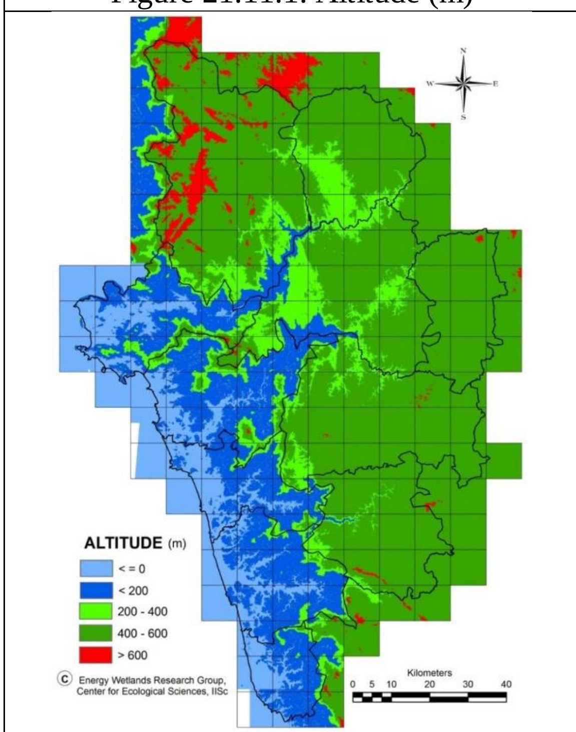
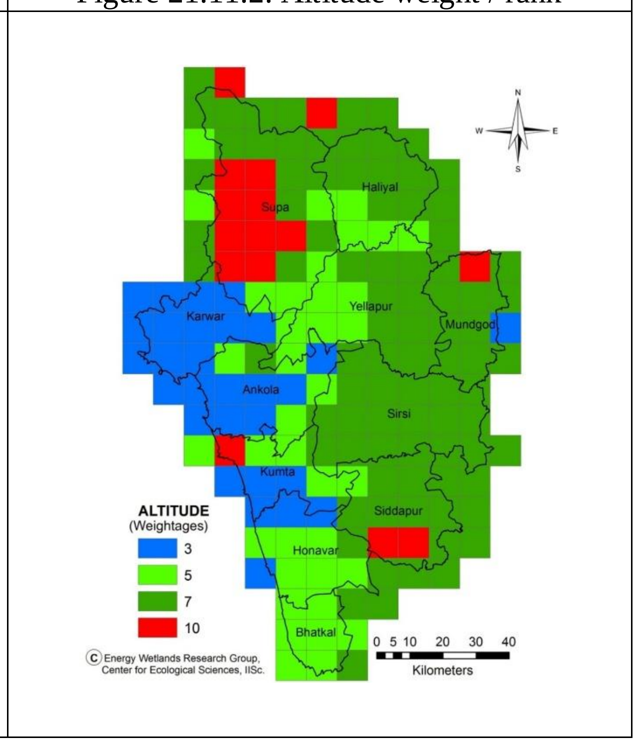
Figure 21.10.1: Conservation reserves (CR)	Figure 21.10.2: CR weight / rank
	
Geo-Climatic	
Figure 21.11.1: Altitude (m)	Figure 21.11.2: Altitude weight / rank
	

Figure 21.12.1: Slope (%)

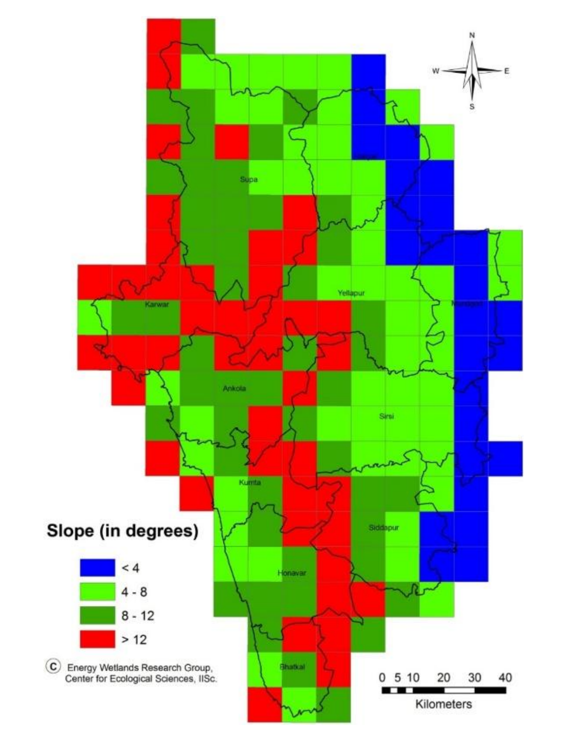


Figure 21.12.2: Slope weight / rank

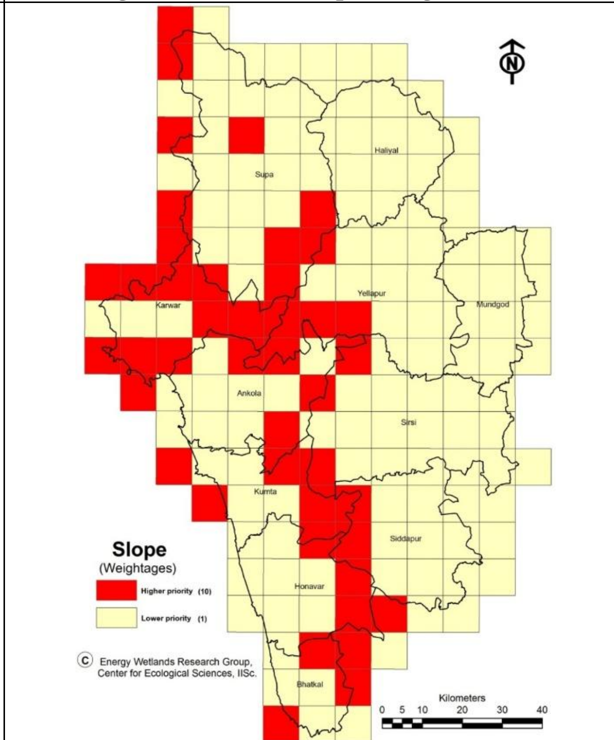


Figure 21.13.1: Annual rainfall

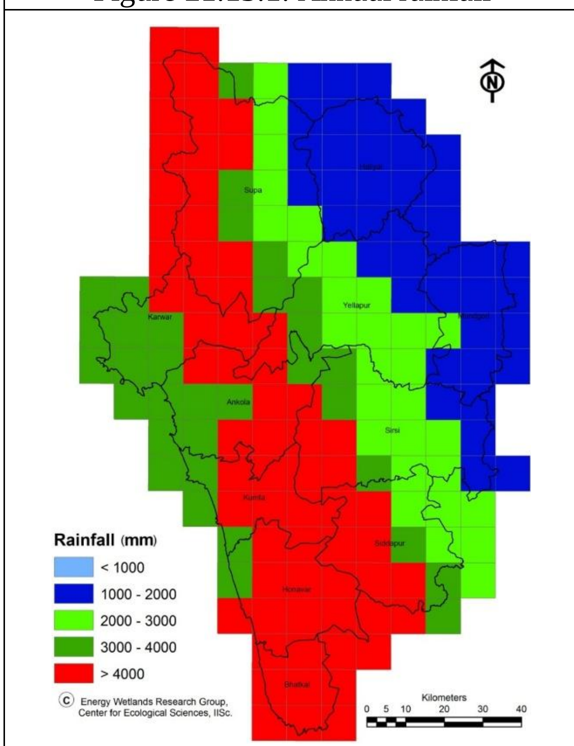
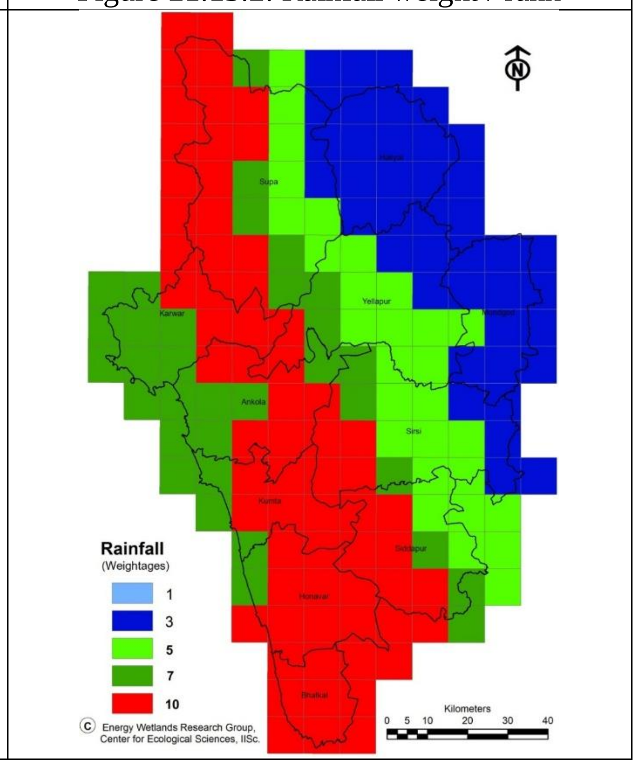


Figure 21.13.2: Rainfall weight / rank



Hydrology

Figure 21.14.1: Stream flow status

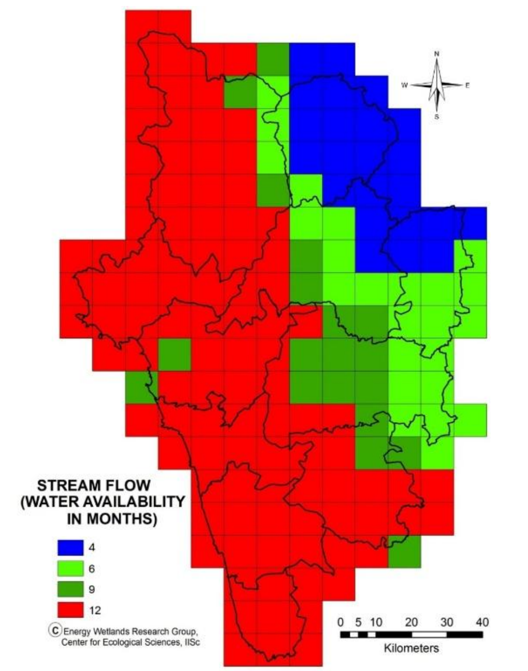
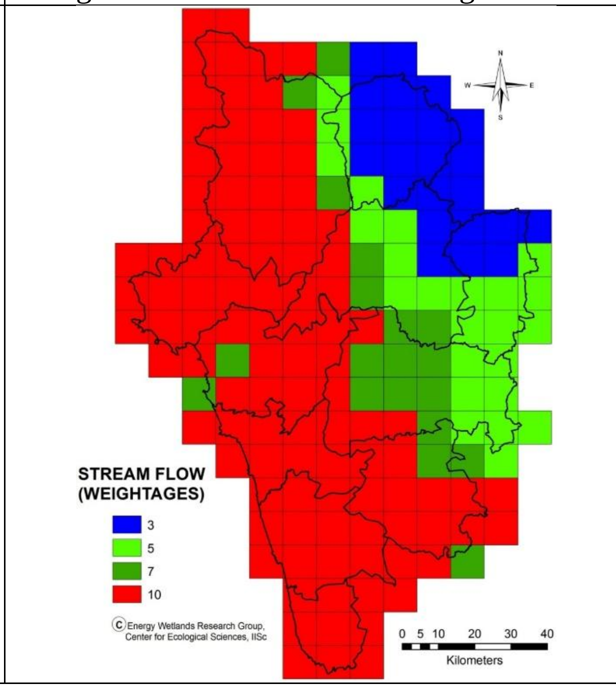


Figure 21.14.2: stream flow weight / rank



Energy

Figure 21.15.1: Solar energy

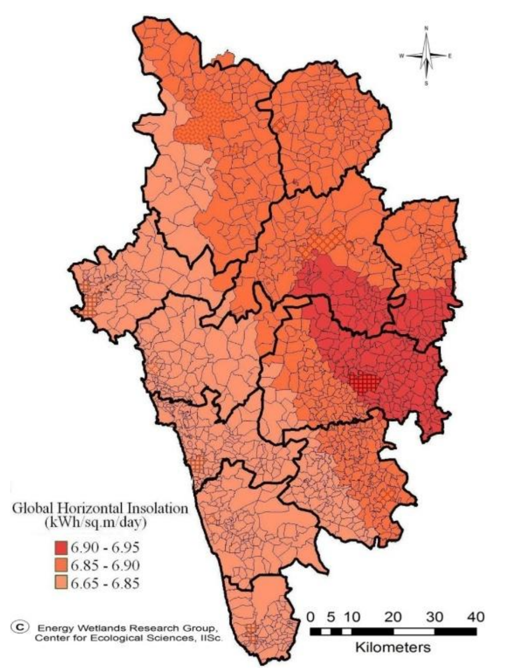


Figure 21.15.2: Solar energy - weight / rank

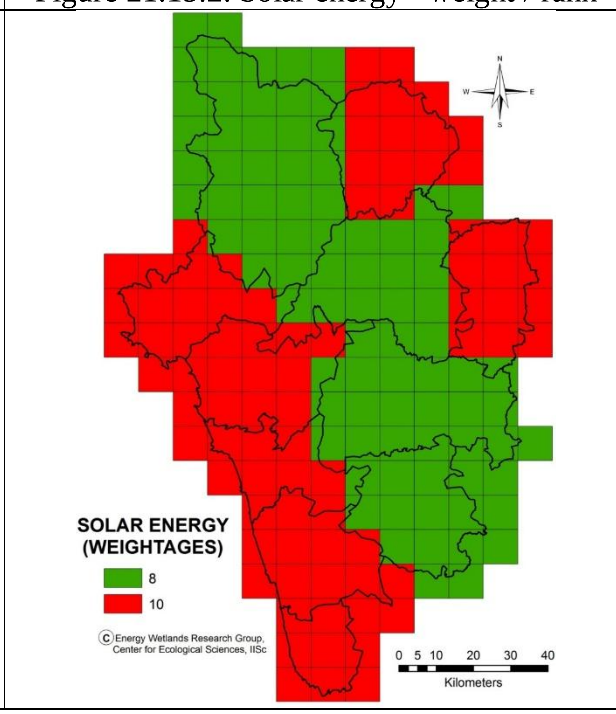


Figure 21.16.1: Wind energy

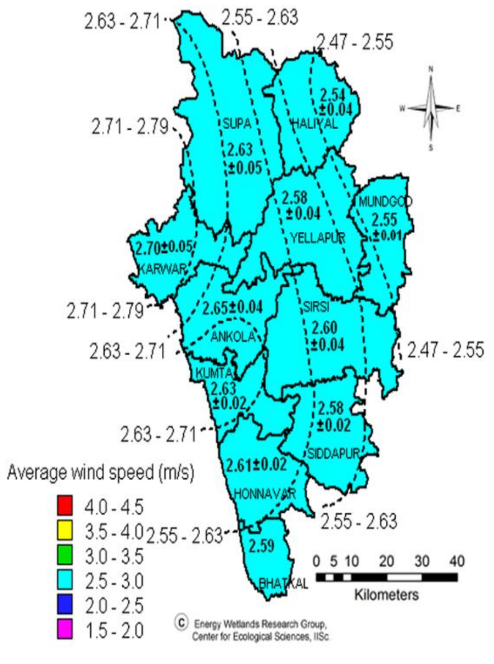


Figure 21.16.2: wind energy - weight / rank

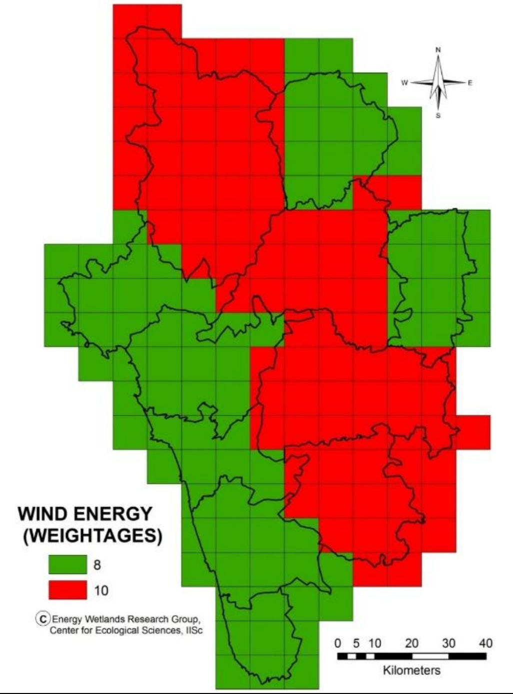


Figure 21.17.1: Bio energy

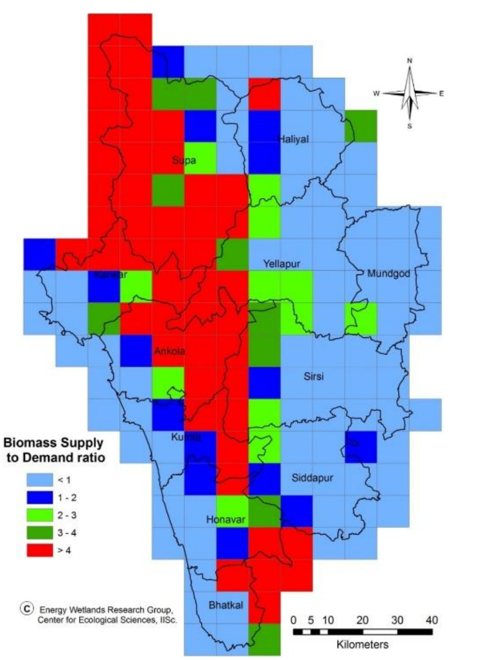
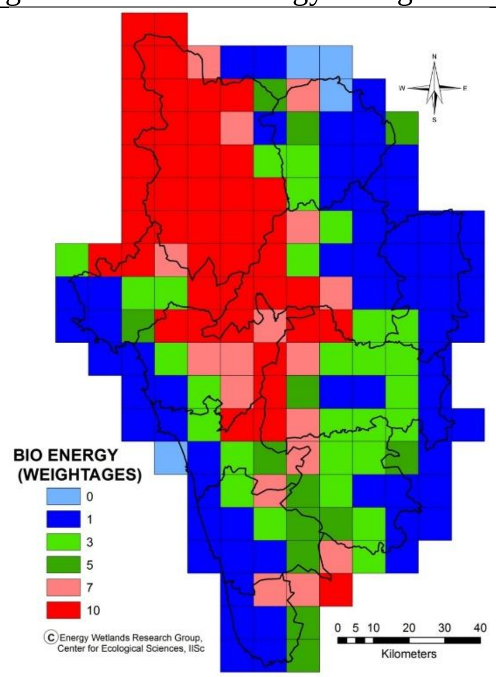


Figure 21.17.2: Bio energy - weight / rank



Social aspects	
Figure 21.18.1: Forest dwelling communities	Figure 21.18.2: Ranking based on forest dwelling communities

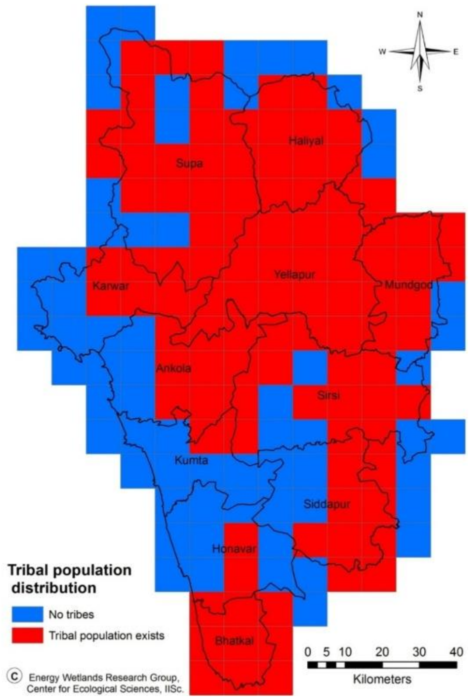
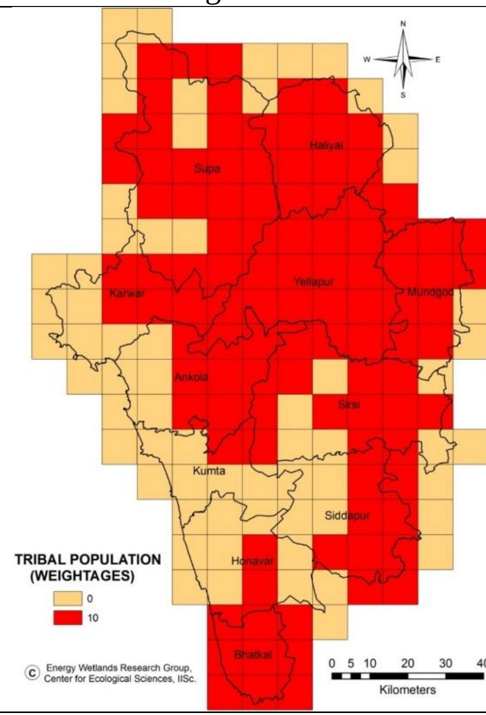
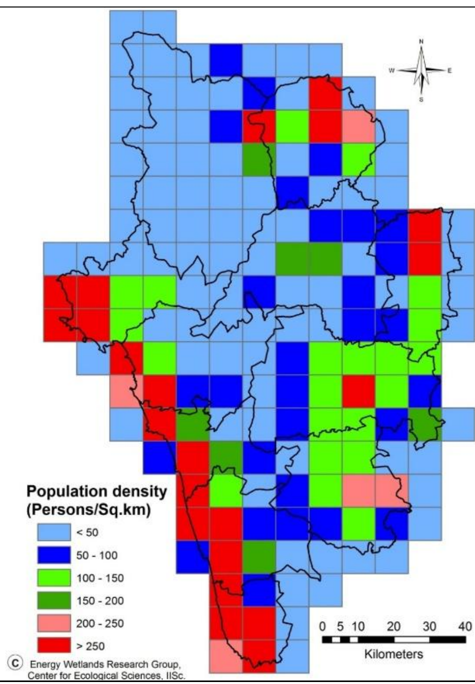
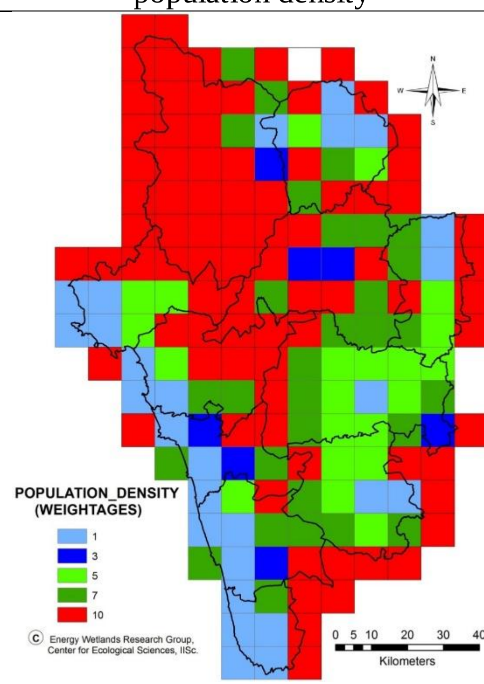

	

Figure 21.19.1: Population density map	Figure 21.19.2: Ranking based on population density
	

Estuarine diversity

Figure 21.20.1: Estuaries of Uttara Kannada

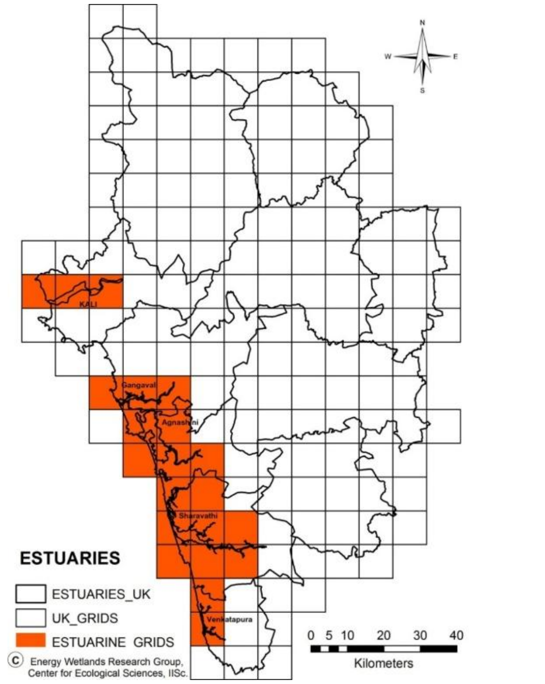


Figure 20.20.2: Estuarine diversity weight / rank

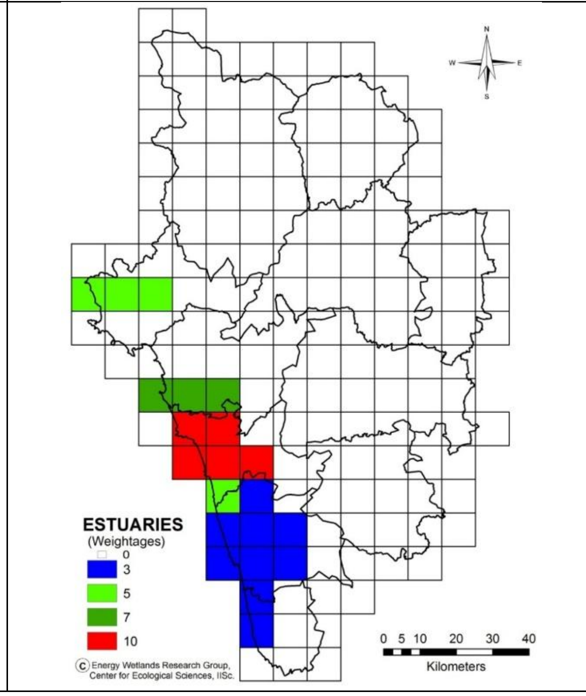


Figure 21.21: Ecosensitive zones in Uttara Kannada district

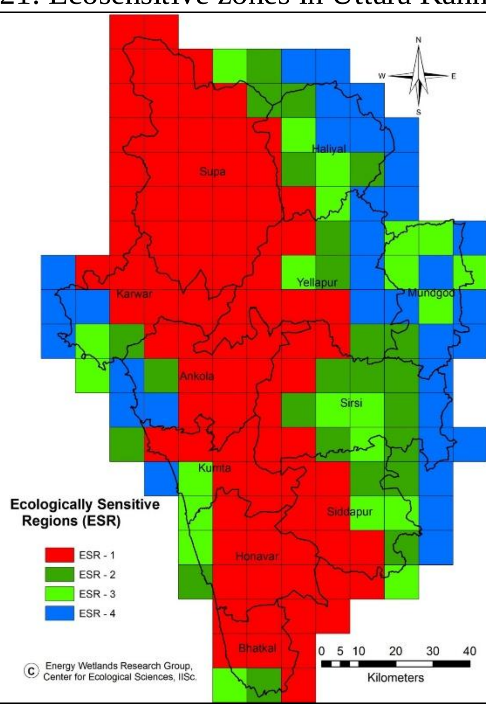


Figure 21.22: Ecosensitive regions of Uttara Kannada at taluk level

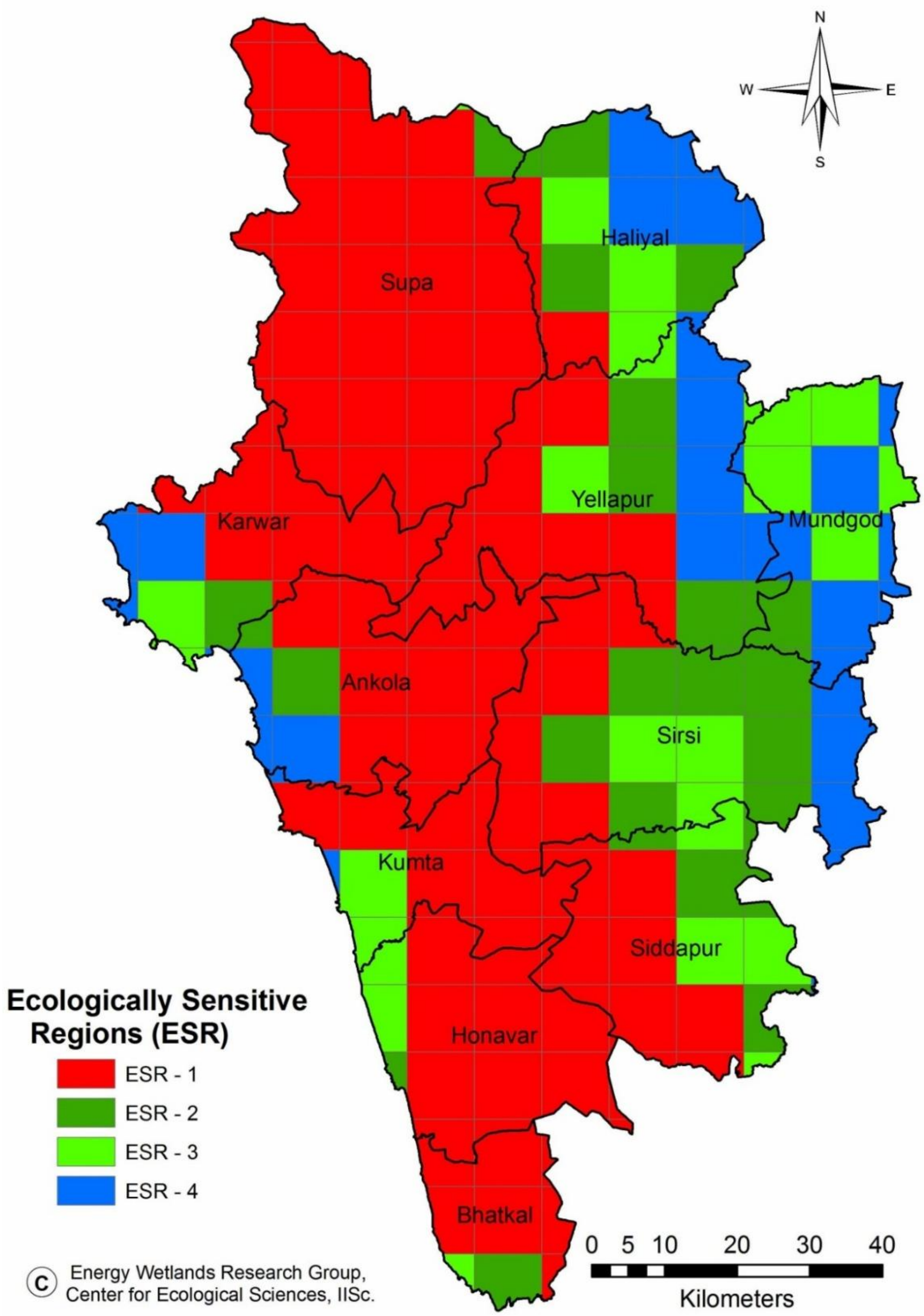


Figure 21.23: Panchayat wise ecosensitive regions

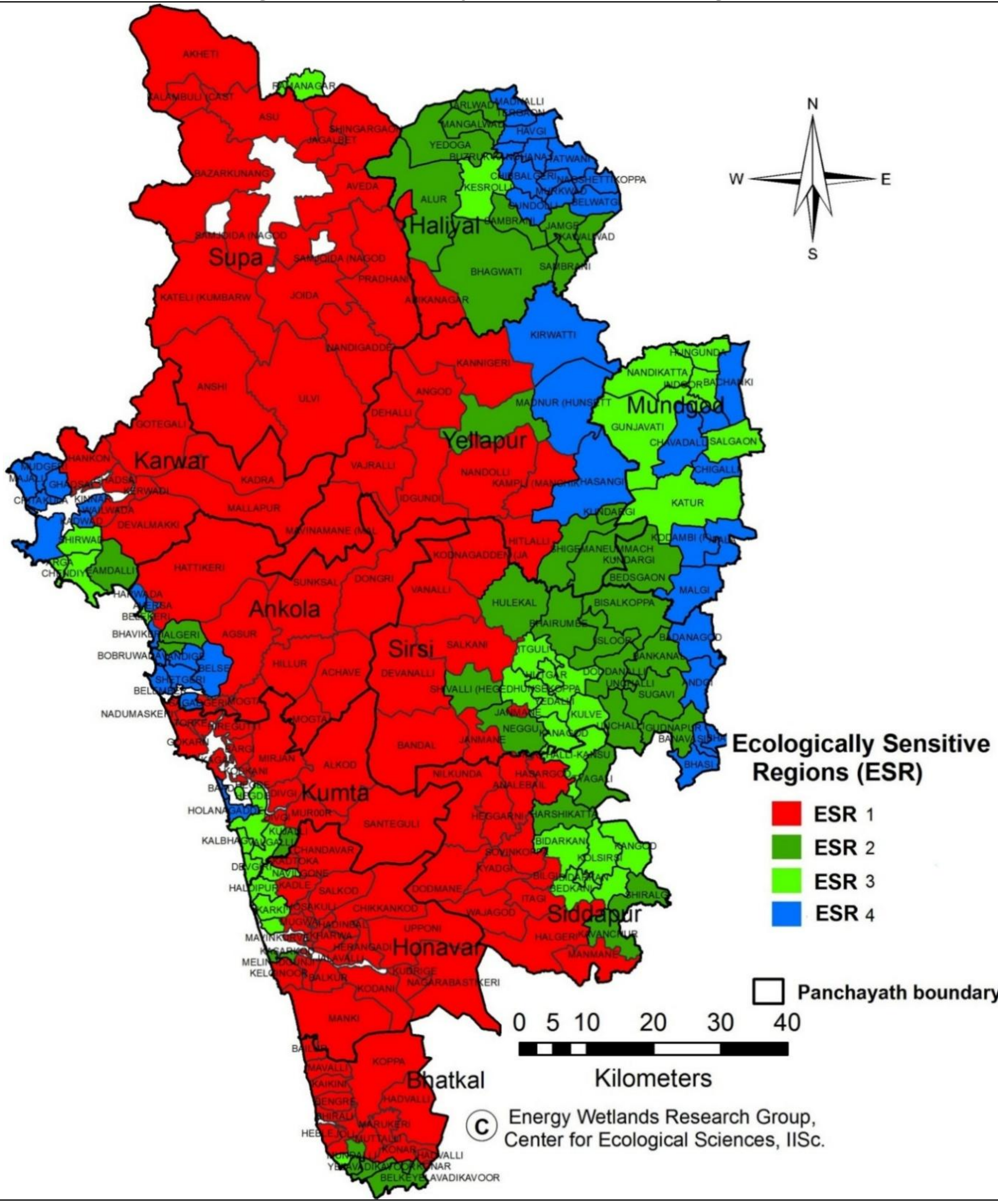


Figure 21.24: Village level ecosensitive regions

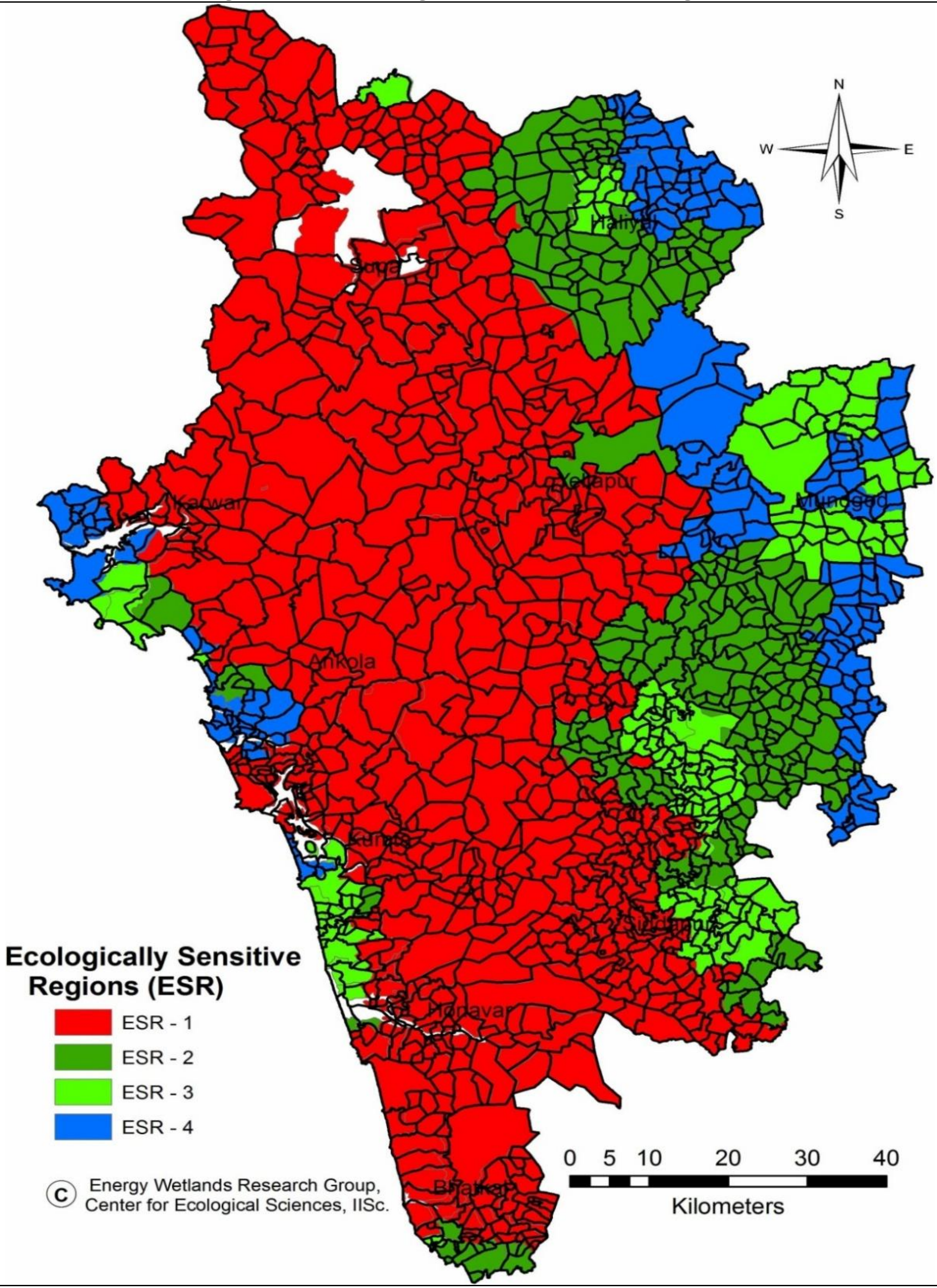
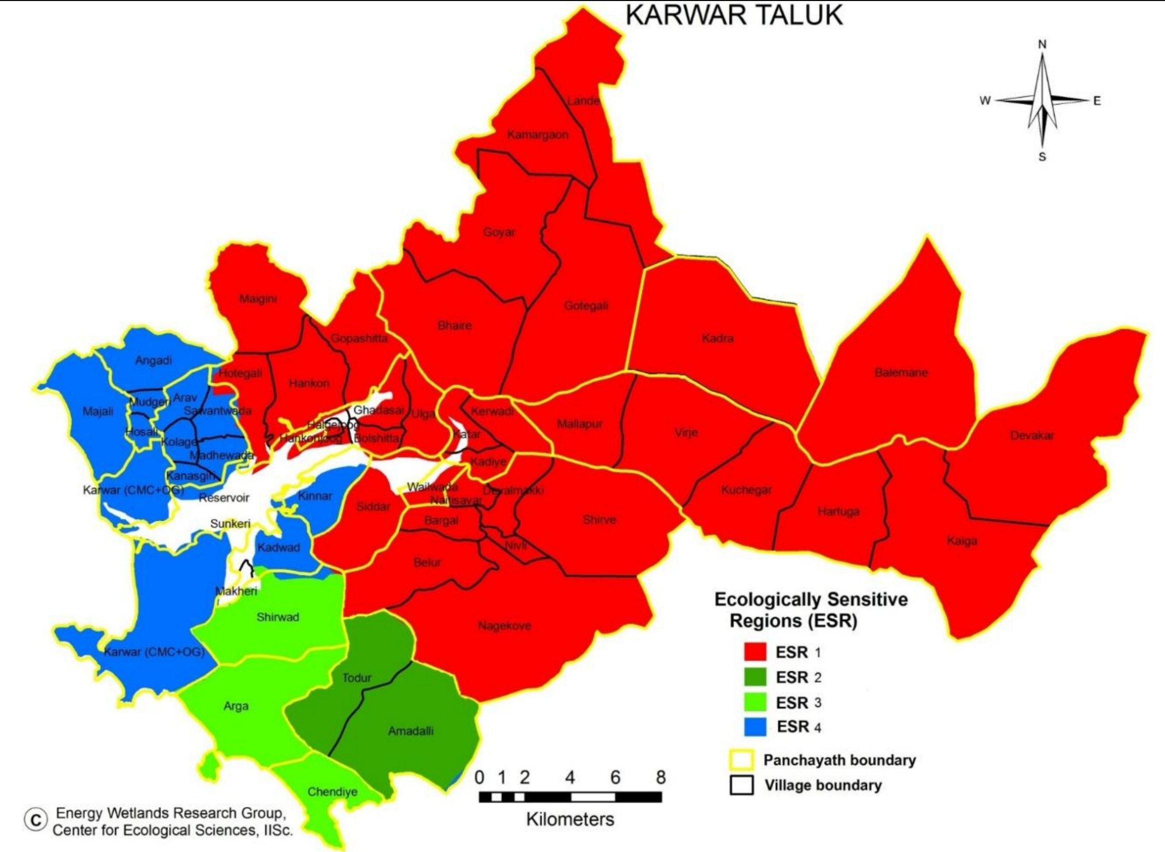
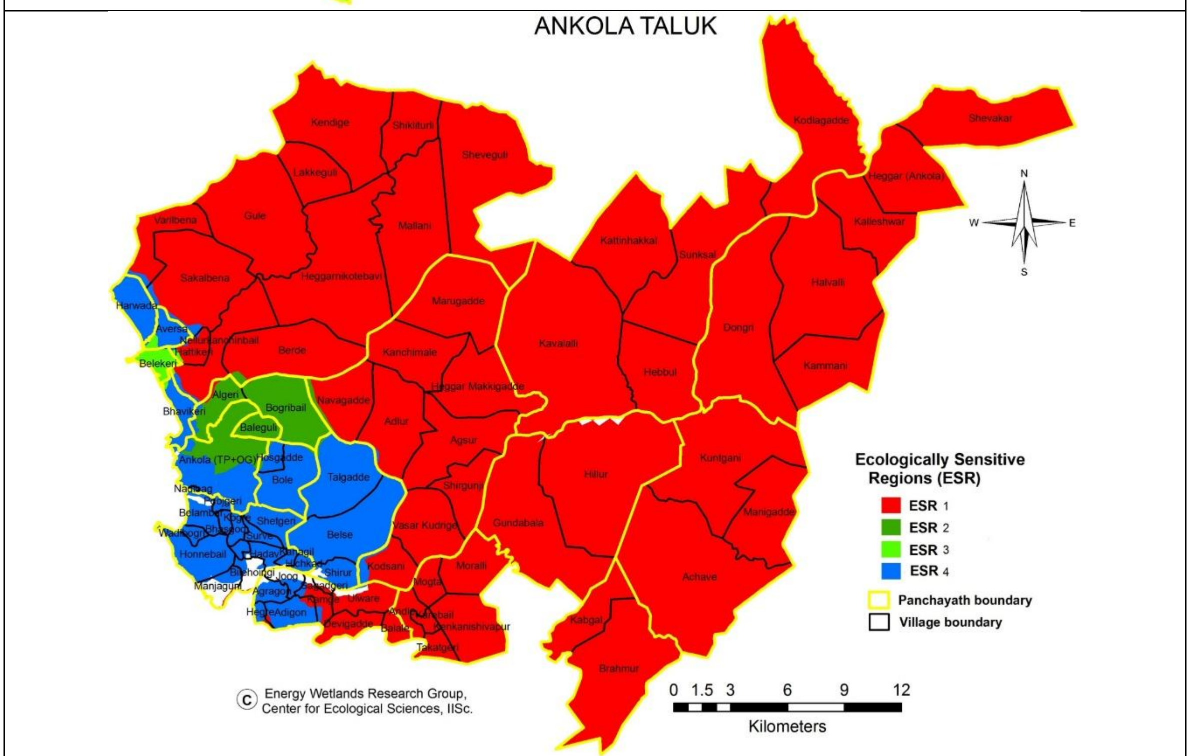
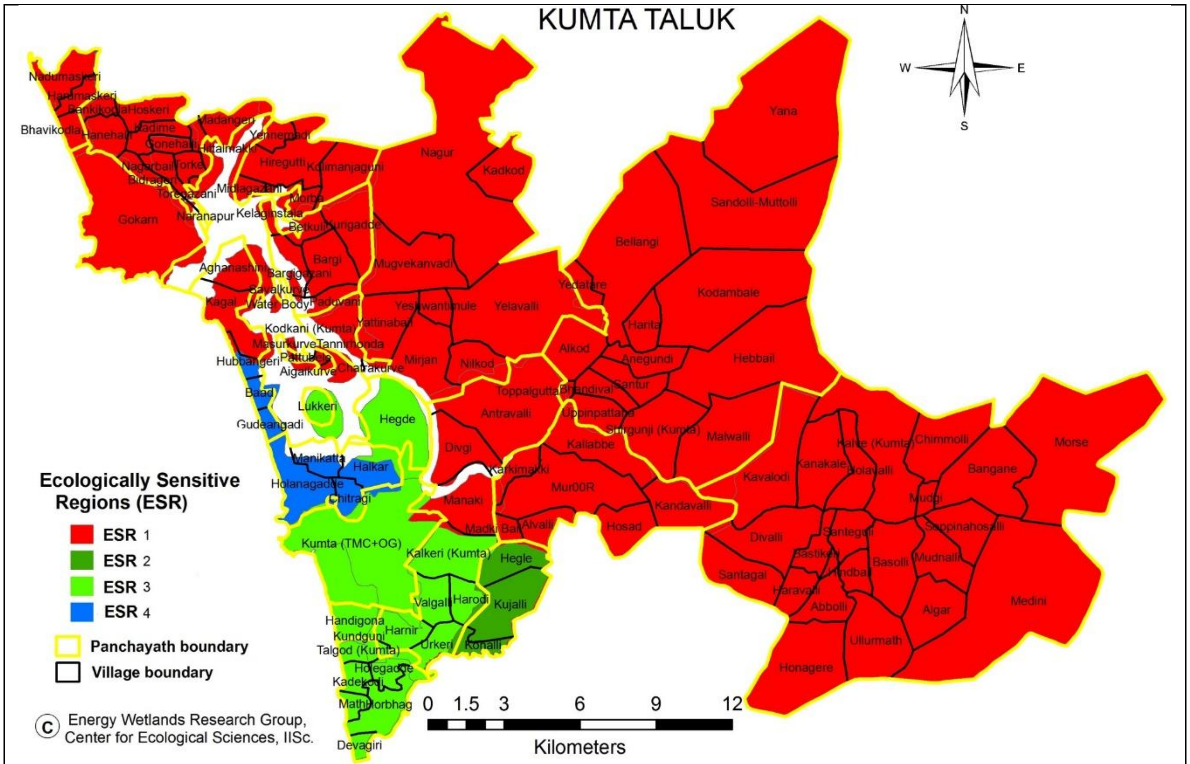
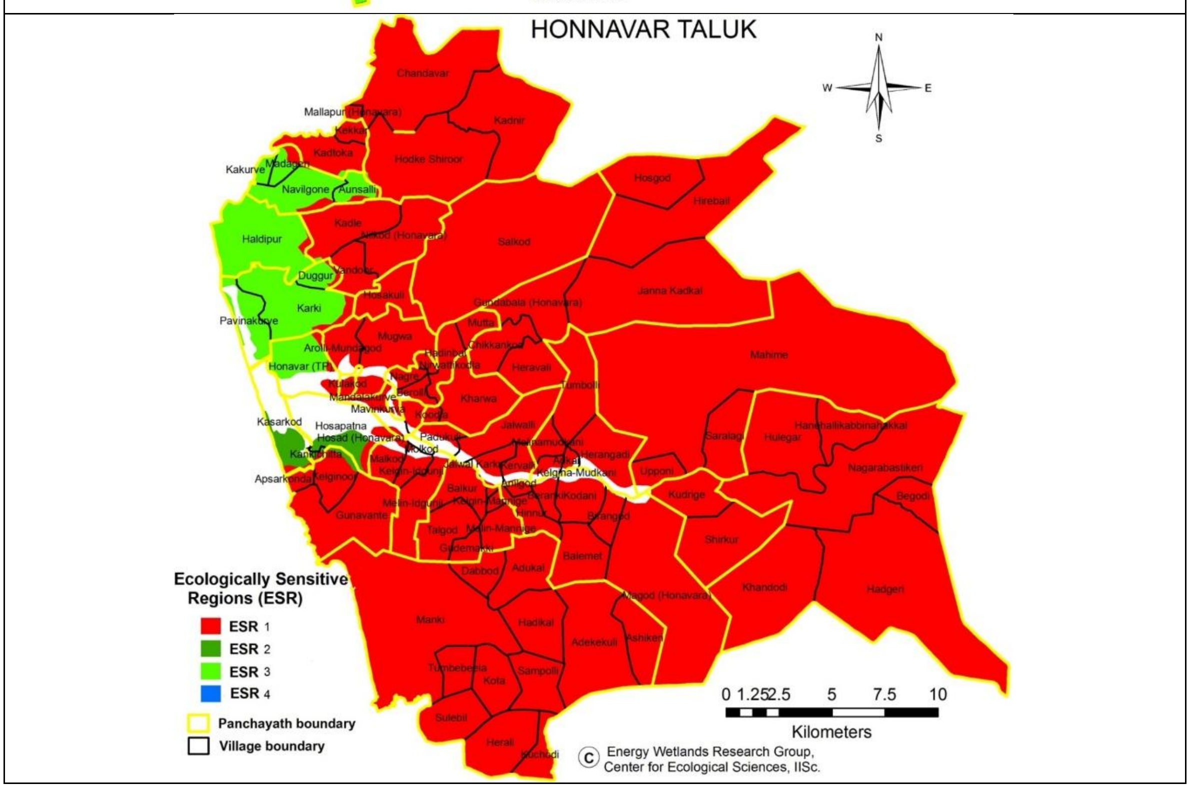


Figure 21.25 (i to xi) Taluk wise ESR with villages






KUMTA TALUK
N
S
W
E
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.
0 1.5 3 6 9 12
Kilometers


HONNAVAR TALUK
N
S
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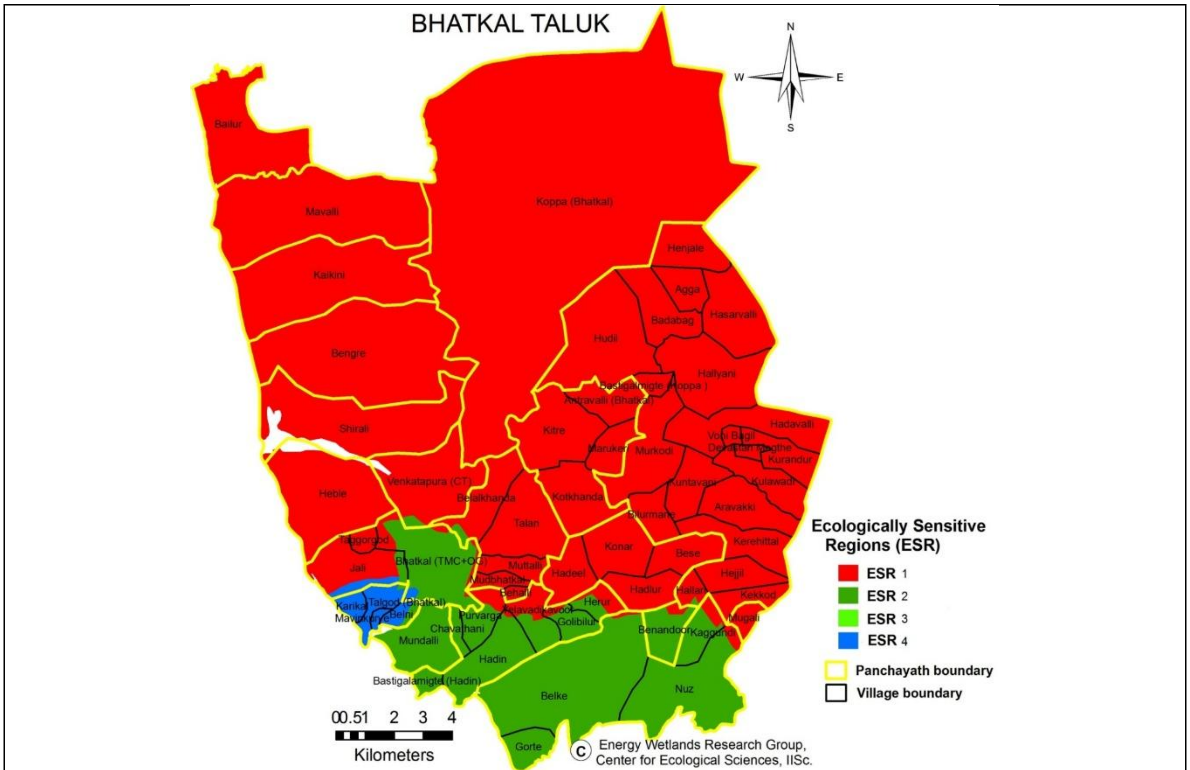
E
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 1.25 2.5 5 7.5 10
Kilometers
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.


BHATKAL TALUK
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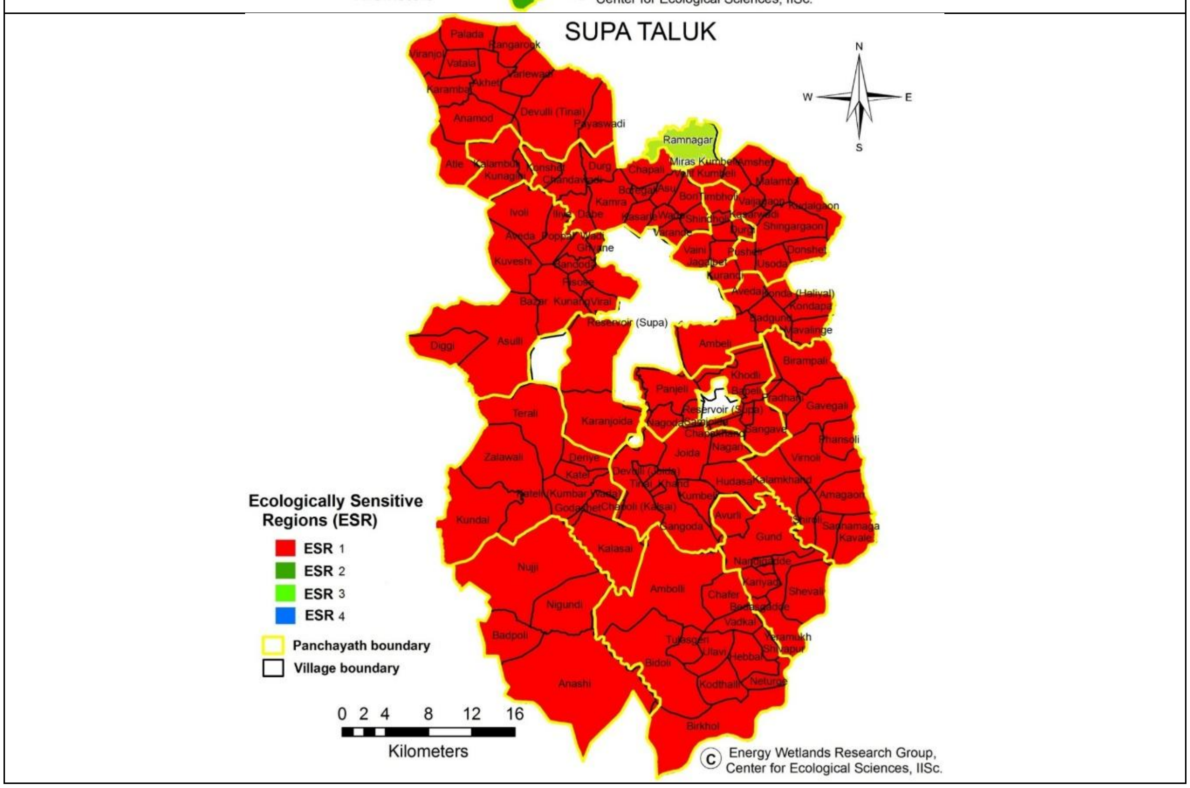
W
E
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 0.5 1 2 3 4
Kilometers
© Energy Wetlands Research Group, Center for Ecological Sciences, IISc.


SUPA TALUK
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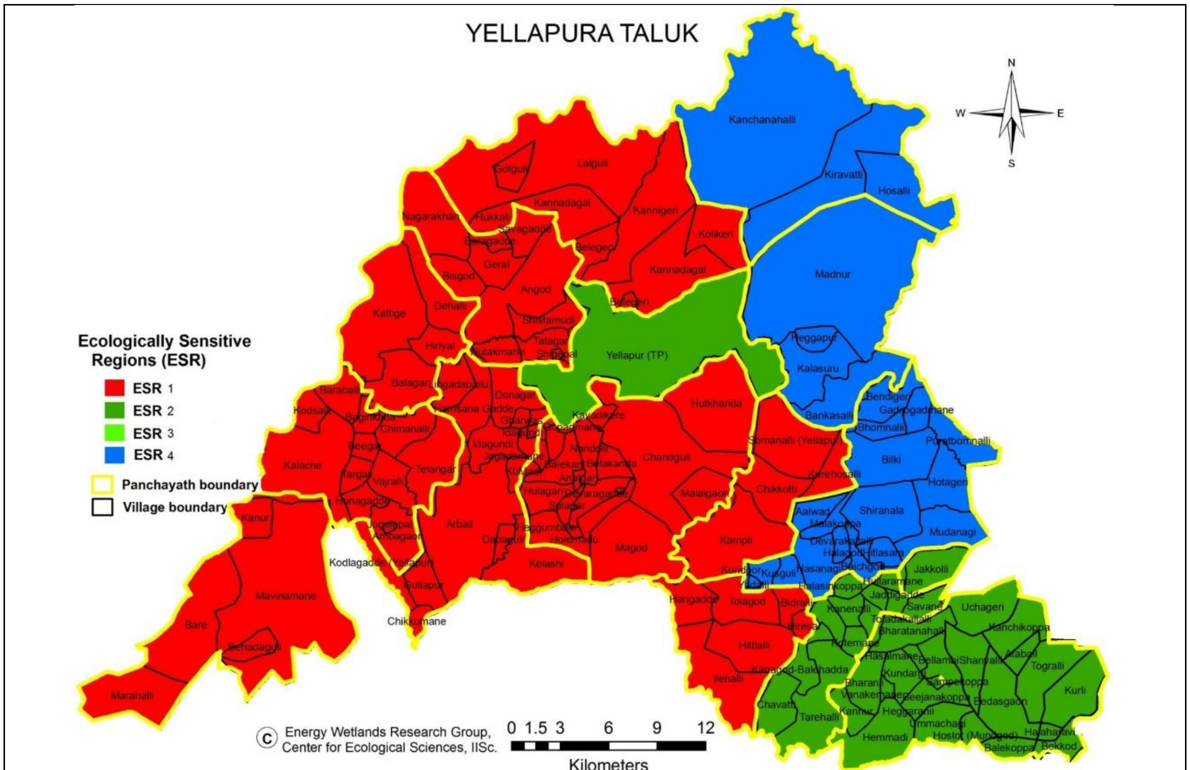
W
E
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 2 4 8 12 16
Kilometers
© Energy Wetlands Research Group, Center for Ecological Sciences, IISc.


YELLAPURA TALUK
N
W
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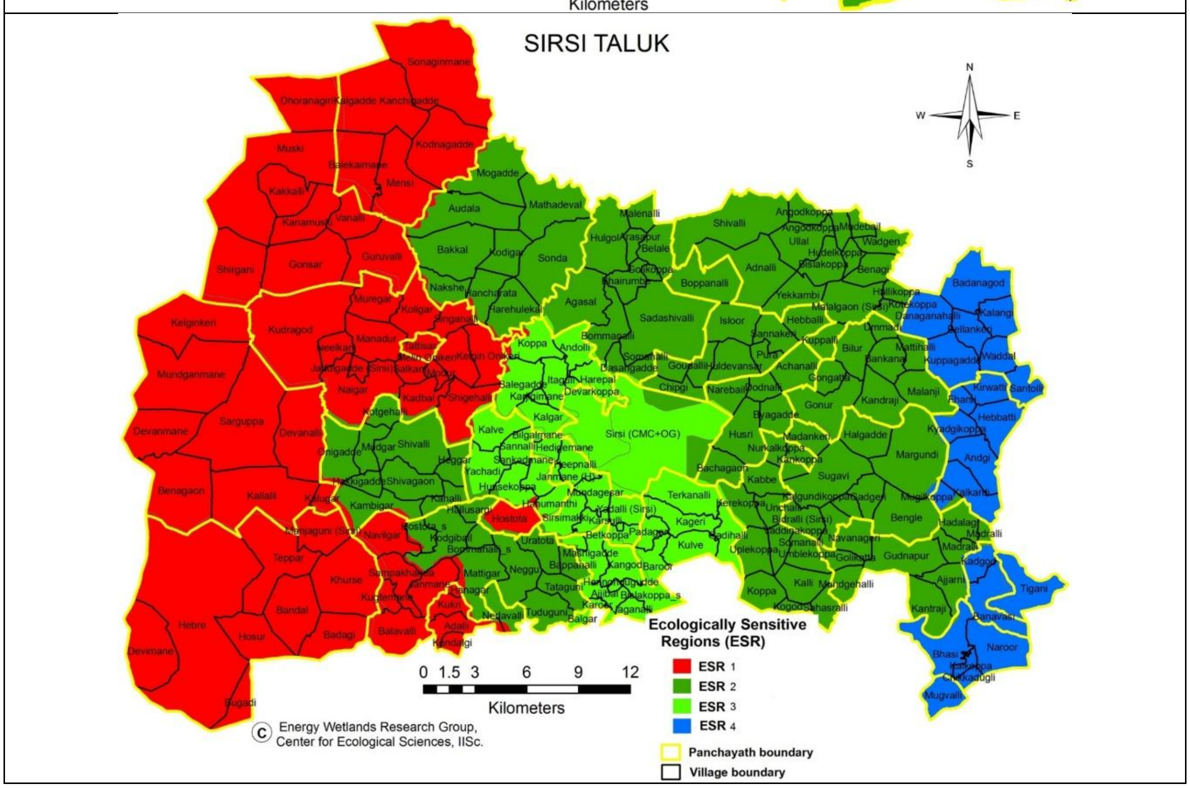
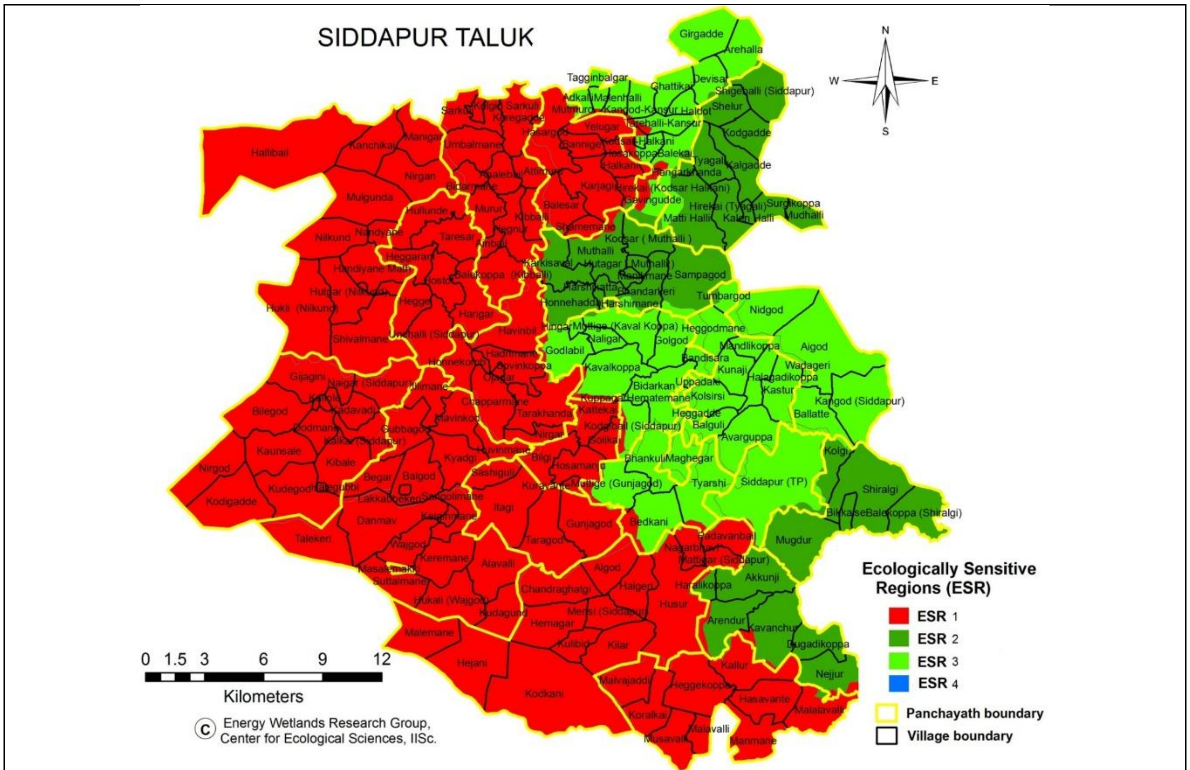
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.
0 1.5 3 6 9 12
Kilometers


SIRSI TALUK
N
W
E
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 1.5 3 6 9 12
Kilometers
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.


SIDDAPUR TALUK
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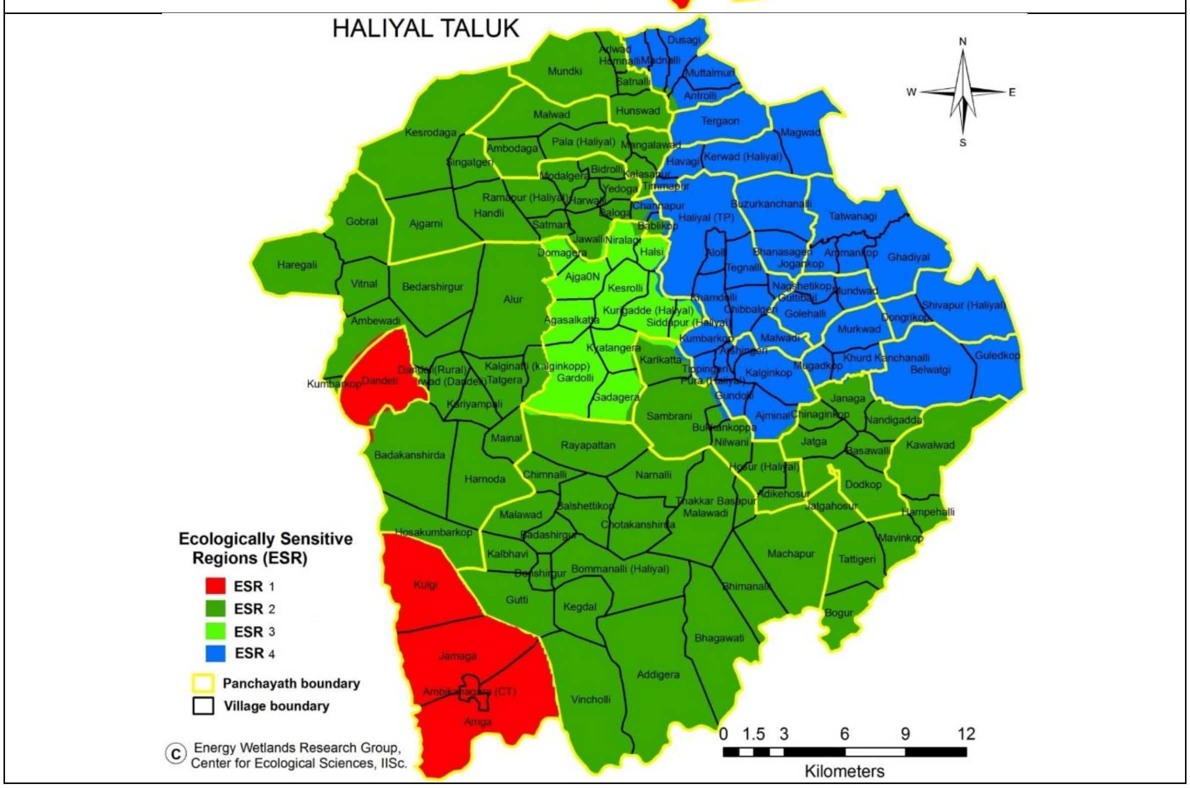
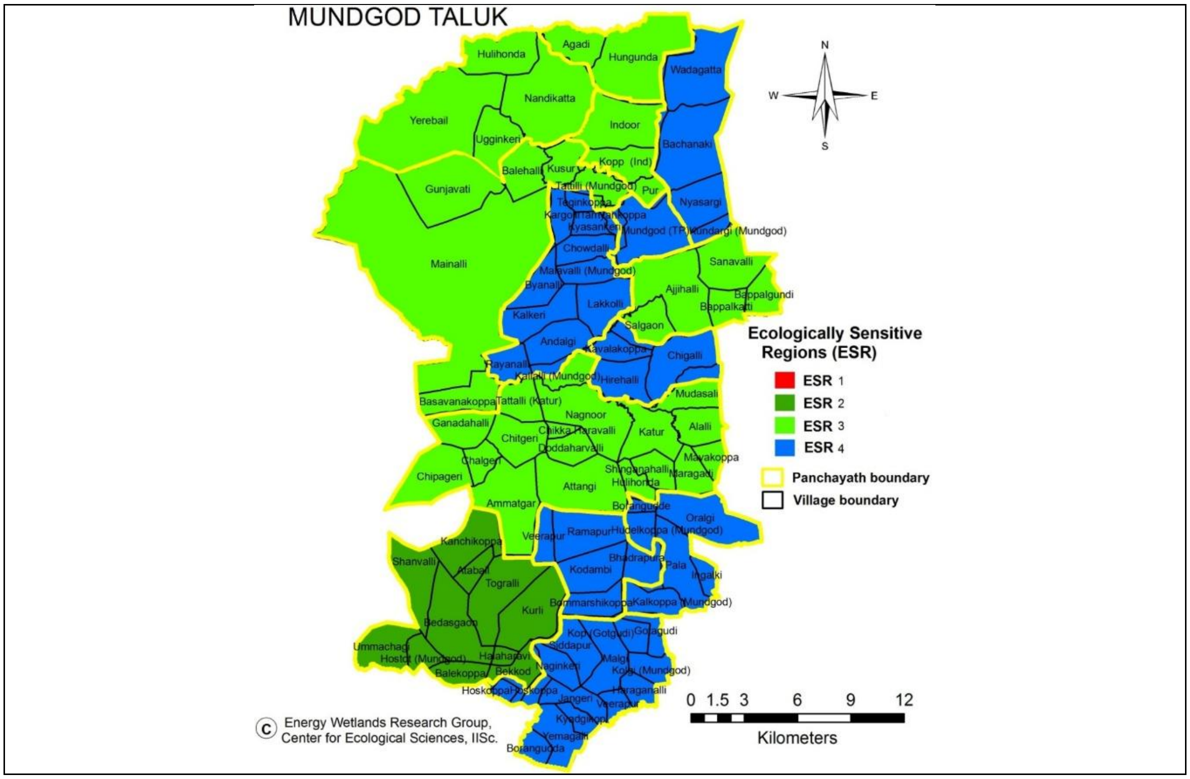
W
E
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 1.5 3 6 9 12
Kilometers
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.


HALIYAL TALUK
N
W
E
S
Ecologically Sensitive Regions (ESR)
ESR 1
ESR 2
ESR 3
ESR 4
Panchayath boundary
Village boundary
0 1.5 3 6 9 12
Kilometers
Energy Wetlands Research Group, Center for Ecological Sciences, IISc.



21.2 ECOLOGY INTEGRATED CLUSTERING FOR DEVELOPMENT OF LOCAL BODIES

The geographical clustering approach for integrated, ecologically sound development seems to the only solution for sustainability in rural India, a country which is still a fair mix of advanced state of biotechnology, IT industry and global leaders in textile production, iron steel and transportation co-existing with slash and burn cultivation in the North-East, handmade clothes, village blacksmiths, bullock carts and stone age canoes. The integrated eco-cluster approach, recommended here for Uttara Kannada district, is meant to protect ecology, biodiversity, water resources, culture and traditions while paving way for locality-specific economic development, primarily aimed at elevating levels of livelihood security. Such development is meant to counter the adverse impacts of globalization on environment and human life in this fragile, humid tropical zone rich in biodiversity, both cultivated and wild, and to arrest the recent trends in mass migration of youth, deserting their villages, seeking better livelihoods in big cities. The clustering of gram panchayats, including small towns, for carrying out a proposed set of economic activities per cluster, envisaged here, is the best alternative to mega-projects and macro-economic development for a fragile tropical zone, a part of the Western Ghats, one of the Global Biodiversity Hotspots of the world. As the cities like Bangalore are becoming unlivable due to burgeoning population and chaotic development with water and power crisis looming large, rising pollution and scanty living spaces, the strains are felt in the Western Ghats for siphoning of water, producing hydro-power and even thermal and nuclear power, and extracting diverse kinds of natural raw materials, endangering ecology and impoverishing rural life, making the youth migrate in large numbers deserting their rural homes and leaving behind their traditional livelihoods.

Cluster Development Approach for Uttara Kannada: Sector-wise cluster development approach is already inherent and is gaining increasing importance in Karnataka. For, instance in the field of crop production Bangalore urban and Rural, Kolar and Tumkur constitute a mango cluster targeting production of export quality mangoes. Dakshina Kannada, Udupi, Uttara Kannada and Kolar make a cashew cluster. Most of the malnadu districts of the State belong to a cocoa cluster and so on. All sector integrated, ecology based cluster approach is lacking so far.

A taluk-wise clustering of Uttara Kannada has been proposed [Figure 21.26 (i to xi)] for future ecology-integrated sustainable development. In each taluk the taluk headquarters along with adjoining gram panchayats will constitute one cluster. The coastal gram panchyats are grouped into coastal clusters in view of their proximity to sea, marine fishing as a form major livelihood, their threats from sea level rise and sea erosion in future, nearness or inclusion of estuaries and creeks, which themselves are highly productive ecosystems, low, hilly lateritic terrain, the possible compacted deposits of ancient Gondawanaland erosion, with specialized ecosystems and so on. The inner coastal panchayats bordering on Western Ghats are grouped into separate clusters. If major west flowing rivers intervene in the landscape the gram panchayats on either sides are grouped into separate clusters. In the Malnadu taluks the eastern relatively drier gram panchayats and western ones along the crest of the Western Ghats, clad in mainly evergreen forests, make separate clusters. The Anshi-Dandeli Tiger Reserve, inclusive of Anshi National Park and Dandeli Wildlife Sanctuary along with associated villages constitute one cluster. In this cluster developmental activities are primarily related to eco-tourism and associated ones, considering the sensitivity of the conservation area. In Mundgod and Haliyal, the taluks merging with the Deccan zone, the GPs of relatively flatter eastern portions having numerous ponds and lakes are brought in clusters separate from those bordering Malnadu forests. Development activities are proposed considering the terrain, landscape elements, ecology, farming systems, associated human life etc. The resulting clusters form self- reinforcing networks of local industries, research institutions, universities, financial bodies and public sector organisations characterised by high level of competition and collaboration. Decentralised energy options for sustainable devlopment of Uttara Kannada is given in Figure 21.27.

Cluster facilitators and need for institutional structure for implementation: Village panchayats form ideal units for implementation of cluster approach for integrated eco-friendly development. The success of cluster based development programmes will depend on the active participation of facilitators. The various Government departments, financial institutions and NGOs will have active roles to play for the success of the integrated cluster-base approach. In addition there is also need for district and taluk level facilitator committees for scrutinsation of developmental plans and review of progress achieved. The role of some facilitators, for instance, are indicated below

Forests and wildlife departments

- As forests constitute a major asset of the district the Forest Department need to be strengthened with more manpower.
- Development of nurseries involving local people. People be encouraged and guided to make nurseries of forest trees and medicinal plants (*Coscinium fenestratum, Nothapodytes nimmoniana*,

Asparagus racemosus, *Emblica officinalis*, *Saraca indica*, *Terminalia bellirica*, *Adhatoda vasica*, *Rauwolfia serpentina*, *Tinospora cordifolia* etc)

- It is suggested to look into the feasibility of purchase of medicinal plants or their products by the Forest Department itself, or by the local VFCs from the producers at fair prices, and the sale/supply of these goods to pharmaceuticals to be undertaken by the Forest Department itself. This recommendation is being made so as to stop rampant illegal collection and trade of medicinal plants from the wild.
- The local ayurvedic pharmaceuticals (within the district), and local people to be engaged in cultivation and value addition to medicinal plants be supplied with medicinal plants/products on priority basis to enrich the local economy and employment potential
- NTFP collection and value addition,
- Developing bee-keeping involving forests and mangroves. As bee-keeping is recommended as an important activity for almost all clusters, roadsides, common lands, under-stocked or degraded forest patches around villages be planted with appropriate nectar plant species.
- Contract system for collection of NTFP from forests found to be highly detrimental to forests and biodiversity and economic well being of local people be stopped forthwith and co-management system involving local people be adopted.
- Production of bamboo based products by local craftsman and effective utilization of bamboo for local development is important
- Use of alternative energy sources replacing firewood
- Development of bettas for tree farming, medicinal plants and fodder,
- Promoting backwater, mangrove, and beach tourism, development of rural tourism and home stays in the vicinity of forests and wildlife areas
- Regular conduct of training in bird-watching, wildlife studies, trekking trails, hygiene and solid waste management involving VFCs, local youth in forest and wildlife related tourism areas be arranged with view of generating eco-friendly employment potential.
- Utilization of weeds and harvestable trees/tree parts, bamboos, canes etc. from plantations or other designated areas for vegetable dyes, medicines, weaving, furniture, handmade paper, sports goods production
- Awareness creation and conservation of sacred groves, sacred kans, which are biodiversity and hydrology significant areas and still playing unique cultural roles in rural society.
- All hydrologically significant forest patches, as indicated, for instance, by high Western Ghats endemism among trees, be preserved both for the sake of perenniality of water courses and for the biodiversity content.
- The Department to consider pooling back good part of income from VFC managed areas into sustainable income generating activities in the cluster level

District Industries Centre (DIC)

Main focus agency for promotion of small scale and cottage industries.

- Easy registration of small scale and cottage industries
- Infrastructure assistance
- Investment subsidies

- Linking with Employment Generation programmes
- Entrepreneurship development programmes
- Technical training
- Assisting in sale of products, buyer-seller meets
- No new red and orange category industries in malnadu and coastal taluks. Orange category may be considered under strict norms and social audit, away from biodiversity centres

Tourism Department

Integrated community based eco-tourism development is being conceptualised to benefit some clusters of adjoining local self government units as a strategy to address high incidence of poverty among the communities while such areas are teeming with tourism potential

- Developing integrated community based eco-tourism
- Assistance in building aesthetic cottages/rooms as part of home stays of bonafide locals or local VFCs. Local grass root level tourism related enterprises to be preferred against construction and commercial lobby.
- Developing tourism awareness in the appropriate panchayat clusters. Conducting programmes on safeguarding local cultures, performing arts and biodiversity
- Getting necessary registration/licenses for village home stays managed by individuals/VFCs/communities, and exhibiting details on location-wise home-stays through web pages
- Training youth in tourism/homestay management
- Fostering tourism related entrepreneurship among the local people so as to increase self employment opportunities in rural areas and small towns.

Horticulture Department

- Facilitate farming of desired crops only under insurance coverage
- Training in preservation of fruits and vegetables to women
- Promoting organic cultivation for exports and Indian markets

Financial institutions

Government financing and micro-financing institutions to step in to promote cluster level development programmes through local panchayats, VFCs, BMCs, NGOs, departments, societies etc. Financing from charitable and voluntary organizations and NGOs and not-for profit financiers to be considered and may be recommended by related departments. Crop insurance, preferably, in identified human-wildlife conflict zone is highly necessary for future of biodiversity conservation. Financial literacy is very critical for participatory development progrmmes envisaged.

Mining and Geology

- Mining in Western Ghats to be phased out. Mining for building stones/jelly be limited to meet local demands, and in any case not to be transported out of the district.
- Sand mining in west coast rivers and estuaries to be limited strictly for use within the district only.

- Considering coastal laterite as Gondwanaland soil/rock deposit, and its limited nature, its special ecosystem value sustaining rare and unique biodiversity, laterite quarrying from coastal hills be strictly limited to meeting local demands. Laterite transport to outside the needs to be banned
- Mining of stones/sand/shell etc. from VFC/BMC jurisdiction areas be limited to bonafide local use and in any case not to be transported outside local area/district as is deemed fit by the joint decision of VFC-BMC and Forest and Mining-Geology departments.

Education Department (Primary and Secondary)

Our initiatives with high school students and teachers show they are effective in documenting many aspects of biodiversity and related knowledge existing at village level. With a reasonable time, say one or two days spent on motivating them and familiarizing them with the concepts of biodiversity documentation and data collection formats, they could contribute substantially towards building up a dynamic database at village level ready for integration into the People's Biodiversity Registers. They are more effective in meeting and interviewing organic farmers, in noting down details on traditional cultivars, collecting details on sacred groves, major wildlife related details etc.

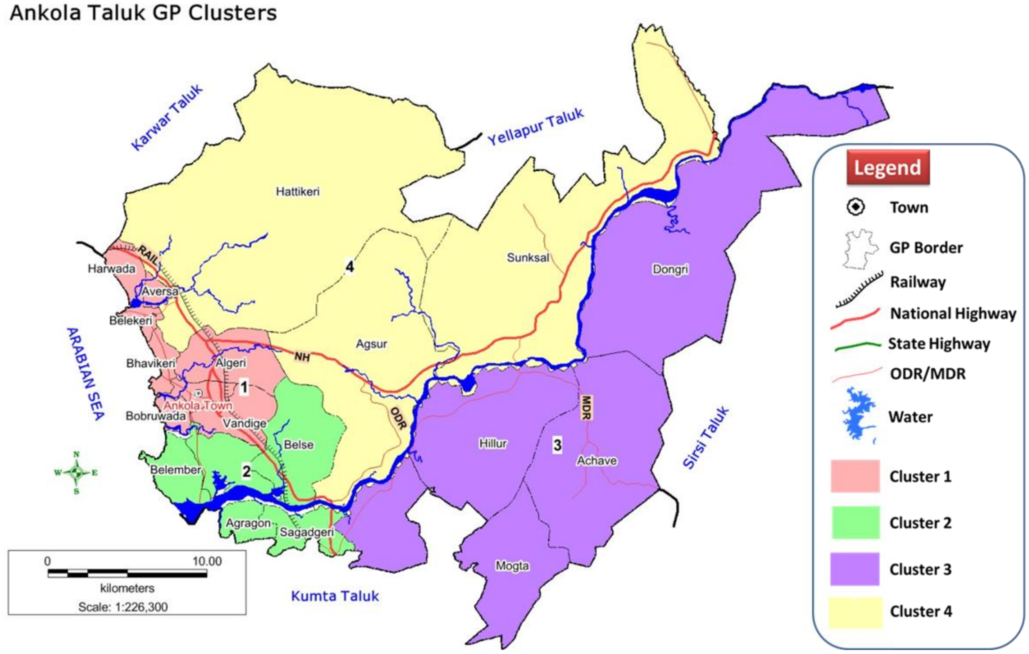
District administration/Zilla panchayat

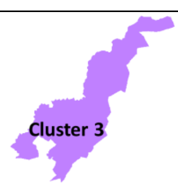
- Thin plastic carry bags production and sale to be banned, so as to promote locally produced cloth and paper bags.
- Hoteliers and bulk purchasers of milk to purchase milk in larger containers, which the milk producers are to use mandatorily and need based
- Use of plastic disposable cups and plates to be banned so as to reduce environmental hazards and to provide market for locally produced biodegradable eco-friendly materials made up of say areca-spathe or washable utensils. Government institutions, offices, public sector undertakings, educational institutions, temples, hoteliers and roadside eateries, and bulk caterers to comply with such norms.
- Imposition of fines/cleaning charges be levied on polluters at all levels
- Toilet facility within reach of every household

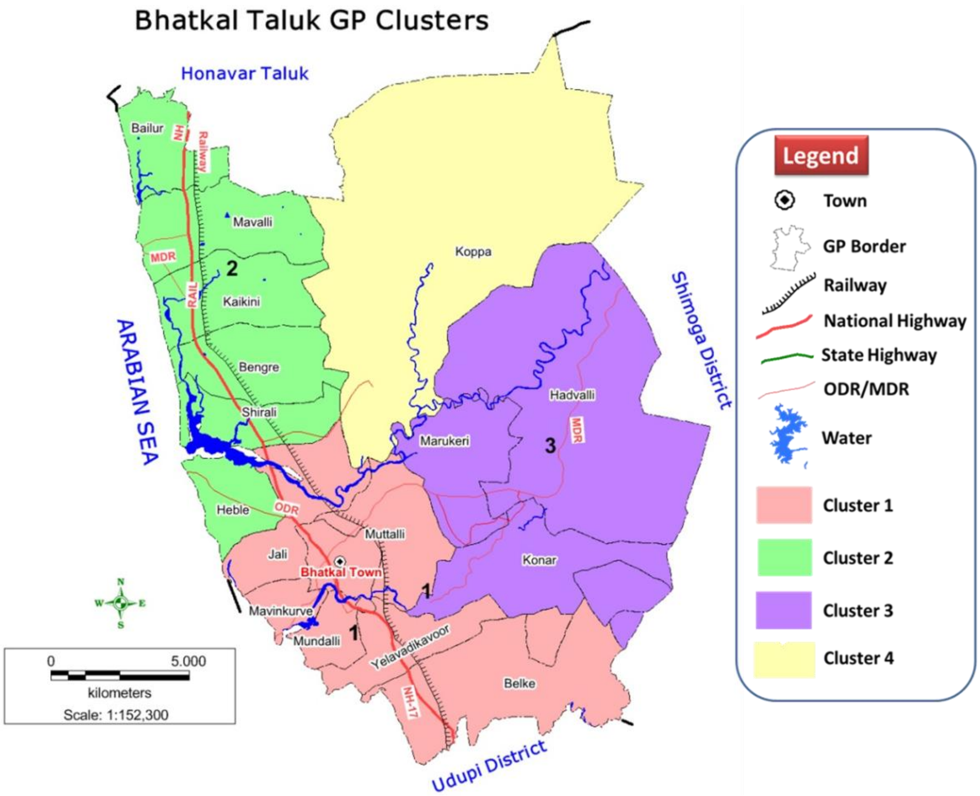

Ramnagar
Mangalwad
Haliyal
Dandeli
Sambrani
Joida
Abikanagar
Anshi
Kirwatti
Nandikatta
Gunjavati
Mundgod
Yellapur
Kadra
Hankon
Majali
Vajralli
Mallapur
Wailwada
Katur
Hasangi
Karwar
Malgi
Sunksal
Vanalli
Bisalkoppa
Ankola
Hegdekatta
Hillur
Belse
Sirsi
Banavasi
Bandal
Janmane
Gokarna
Mirjan
Katgal
Kagal
Heggarni
Bedkani
Santeguli
Kumta
Chandavar
Siddapur
Salkod
Dodmane
Honavar
Upponi
Hadinbal
Kavanchur
Kasarkod
Gersoppa
Manki
Murudeshwar
Hadvalli
Bhatkal
0 15 30
kilometres
Legend
Aghanashini Biodiversity Heritage Site management
Apiculture and avenue trees
Bio-shielding and turtle conservation
Bivalve shell mining to be reviewed
Fish breeding area cum mangrove conservation (VFC managed)
Integrated participatory management of Kali estuary
Integrated participatory planning and management of Aghanashini estuary
Mango nursery
Mangrove diversity area (various mangrove species and associates to be grow
Nursery for forestry
Nursery for forestry and avenue trees
Rain water harvesting
Sand mining to sustainable limits
VFC/panchayat FHM plantations

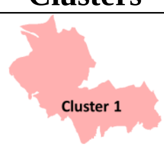
Figure 21.26 (i to xi) Taluk-wise Clusters

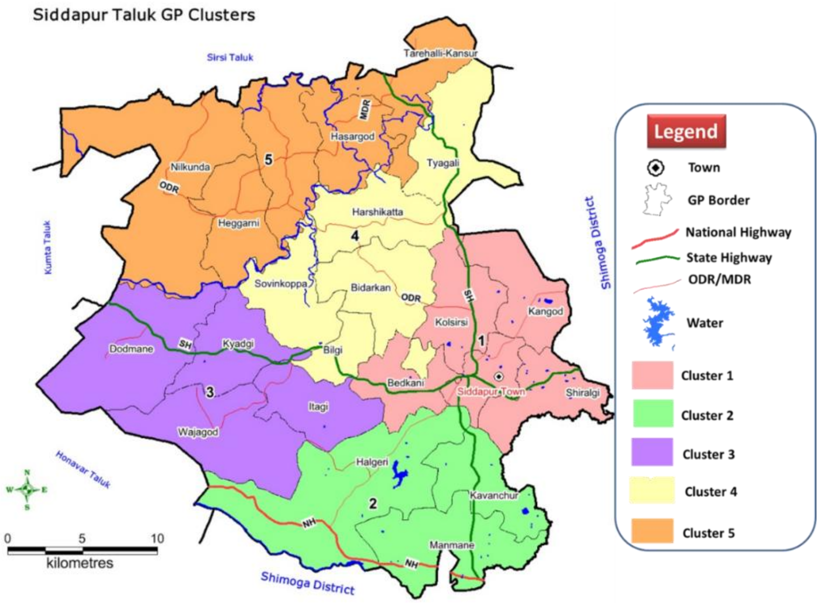
Ankola Taluk GP Clusters



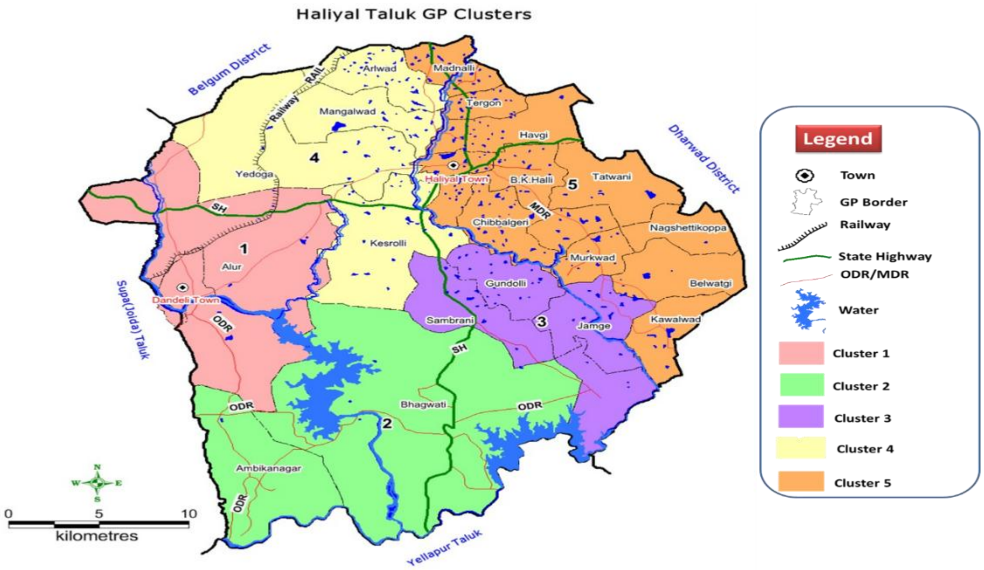
Clusters		Activities
		Biopesticides, food products, gem and jewellery, readymade garments; training center for fashion technology; watermelon cultivation; fish products; home stays; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping and bee nurseries; VFC/panchayat FHM plantations, home for elderly; medicinal plants cultivation & processing; Water melon cultivation; mango pulp; mango nursery; incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; VFC managed health tourism; Motigudda home stays and tree houses; mango pulp; hospital services, incentives for rare traditional cultivars, rewards to certified organic farmers, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; sericulture
		Bee keeping, livestock and dairying, gobar gas, VFC/panchayat FHM plantations; vegetable dyes; nursery for forestry, apiculture and avenue trees; herbal toilet soaps; hospital services, incentives for rare traditional cultivars, rewards to certified organic farmers, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; sericulture

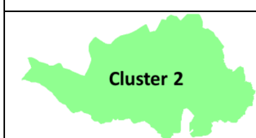
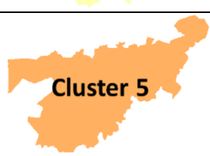


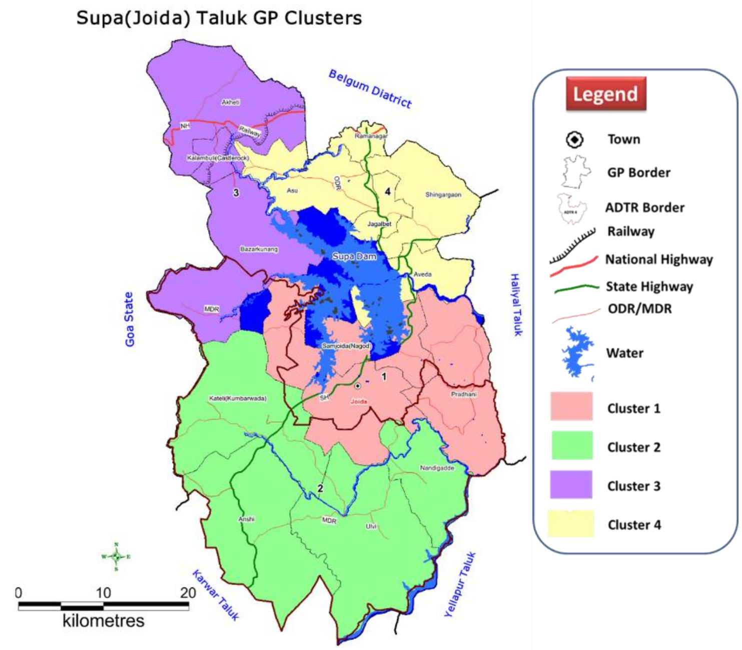
Clusters		Activities
		Bee keeping, VFC/panchayat FHM plantations, home for elderly; vegetable dyes, readymade garments; jasmine cultivation, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		VFC/panchayat FHM plantations; biopesticides and bio-fertilizers; VFC/individuals managed home stay tourism, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; medicinal plants cultivation and processing; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping and bee nurseries; livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; herbal toilet soaps, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; VFC managed home stay tourism



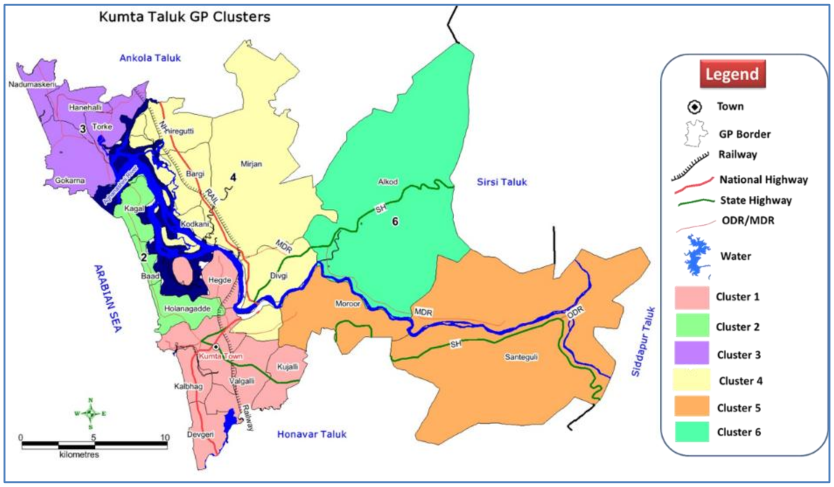
Clusters		Activities
		Bee keeping, livestock and dairying, gobargas, sericulture, home for elderly; vegetable dyes; medicinal plants cultivation and processing; bamboo products; Tulsi cultivation and extract; hybrid seeds, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, sericulture; vegetable dyes; handmade paper products; home stay tourism; bamboo products; Pongamia plantations, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; VFC/individual managed home-stay tourism; training in making bamboo cottages
		Bee keeping, Fish farming, livestock and dairying, gobargas, sericulture; Pongamia and neem plantations; biodiesel and bio-pesticides; tamarind plantations and products; poultry; hospital services, incentives for rare traditional cultivars , incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, sericulture; mulberry nursery; Pongamia and neem plantations; bio-pesticides and biodiesel; purified neem oil; hybrid seeds; poultry, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, sericulture; poultry feed; Pongamia and neem plantations; biodiesel and bio-pesticides; bio-fertilizers; purified neem oil; hybrid seeds; poultry and powdered eggs; tamarind products, tamarind nursery, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators



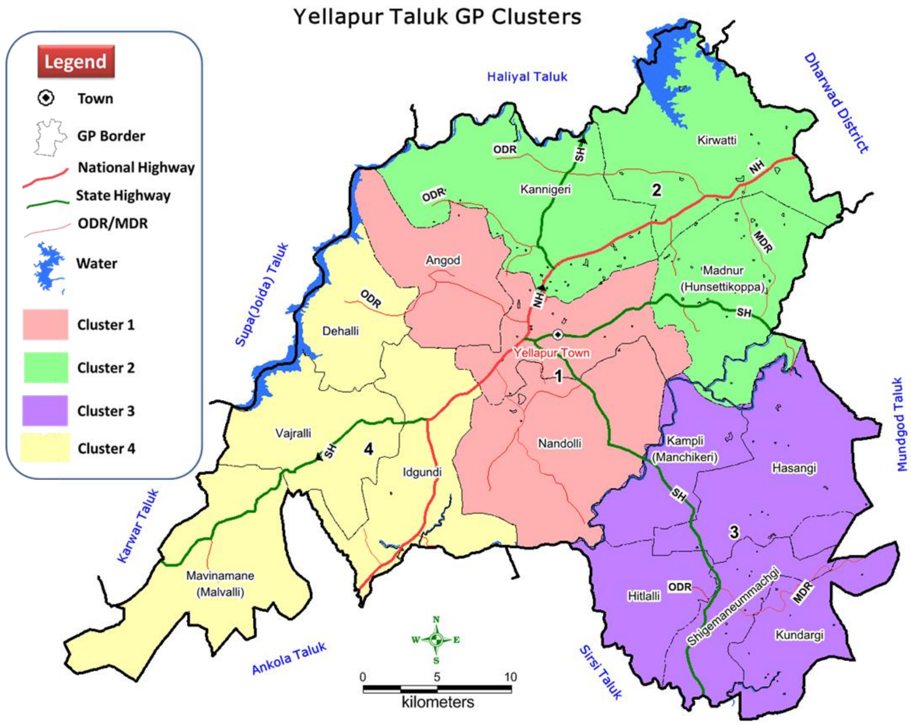
Clusters		Activities
		VFC/panchayat FHM plantations, sericulture, home for elderly; organic products certification; microwave assisted hot air and vacuum drying of food & spices, ayurvedic medicines; sun dried fruits and vegetables; training centre for bee keeping and honey testing lab, incentives for rare traditional cultivars , incentives to certified organic farmers ; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping and bee nurseries; livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; palm sugar; aromatic plants and essential oil distillation; orchids and cut flowers, indoor plants, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; cloth and paper bags
		Bee keeping, VFC/panchayat FHM plantations; medicinal plants cultivation & processing; handmade paper products; palm sugar; aromatic plants and essential oil distillation; wild mango pickles; orchids and cut flowers, indoor plants; home-made organic chocolates; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; VFC/individual managed home stay tourism
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; fruits and vegetables preservation; wild mango pickles; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, VFC/panchayat FHM plantations; indoor plants and orchids; medicinal plants cultivation and processing; organic village home stay tourism; handmade paper products; palm sugar; wild mango pickles; home- made organic chocolates; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition

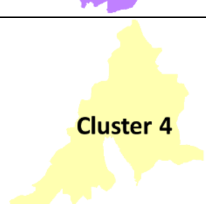


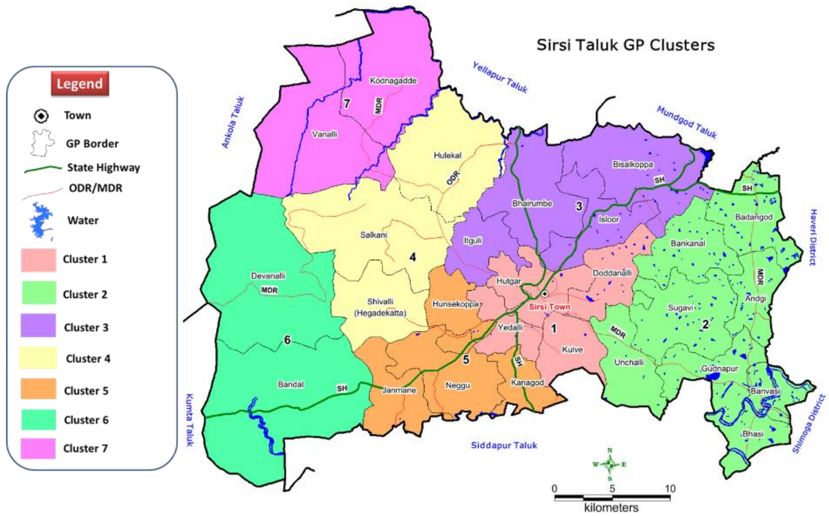
Clusters		Activities
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; handmade paper; cloth and paper bags; sports goods making; leather products; computer training centre; weaving with palm leaves, cane and bamboo works; training in making bamboo poducts; Pandanus leaf products; trekking and bird watching to Sintheri Rocks and Kavala caves, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping, organic and forest honey sales, medicinal plants cultivation and processing; VFC managed home stay tourism; wildlife tourism Anshi National park; Ulavi pilgrimage; tourist cottages in Ulavi; training in tourism management; VFC managed holiday home bamboo cottages; pickles from wild berries; Tulsi cultivation and extract; bamboo mat painting; incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; water-sports training; VFC managed home stay tourism in forest villages; holiday home bamboo cottages; monsoon trail to Dudhsagar Falls; aromatic plants and essential oil distillation; orchids and cut flowers; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; nursery for forestry and avenue trees; bamboo products; orchids and cut flowers; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; VFC/individual managed holiday homes

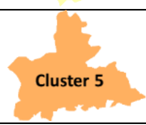


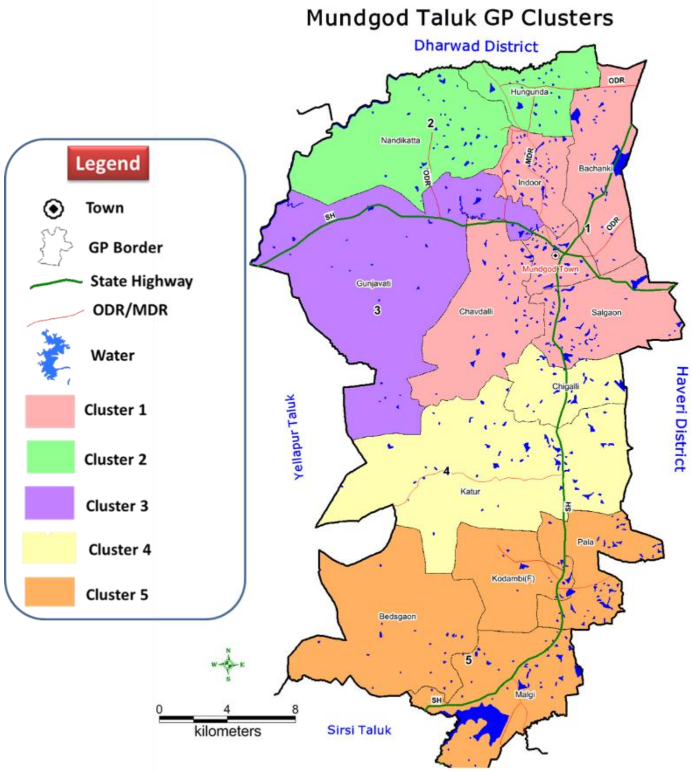
Clusters		Activities
		Vegetable dyes; Coconut products (virgin coconut oil; purified oil; spray-dried coconut milk powder, desiccated coconut, coconut vinegar), hand-made paper; cloth and paper bags; wood carving; metal inlaid wood carving; training centre for handicrafts; jewellery development and training centre; organic lime industry; Alvekodi onion expansion and storage, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		Dry fish, marine algae products; coastal home stay tourism; training in tourism management; training in making palm-bamboo cottages; training in stone carving; Pandanus leaf products; Integrated, participatory planning and management of Aghanashini estuary. Bio-shielding and turtle conservation programmes. Bivalve processing and canning. Aghanashini Biodiversity Heritage Site management; bivalve shell mining to be reviewed; sand mining to sustainable limits, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Vegetable dyes; home stay tourism; iodized salt, confectionery, bakery; bakery training centre for women; bee-keeping; training centre for bee-keeping; arts and handicrafts museum and trade centre; sales of organic products; certified organic eateries, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping, VFC/panchayat FHM plantations, home for elderly; cloth and paper carry bags; mangrove study tourism, bird watching and sport fishing; estuary interpretation centre, VFC run estuarine holiday home. Fish breeding area cum mangrove conservation (VFC managed); mangrove diversity area (various mangrove species and associates to be grown); estuarine crab fattening area. Integrated, participatory planning and management of Aghanashini estuary; sand mining to sustainable limits, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; sericulture
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; poultry, poultry feed, powdered eggs, vegetable dyes, kokam products, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition;sericulture
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations, vegetable dyes, medicinal plants cultivation and processing; pickles from wild berries etc; cane and palm leaf products; VFC managed holiday home palm houses; Yana trekking and bird watching; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition



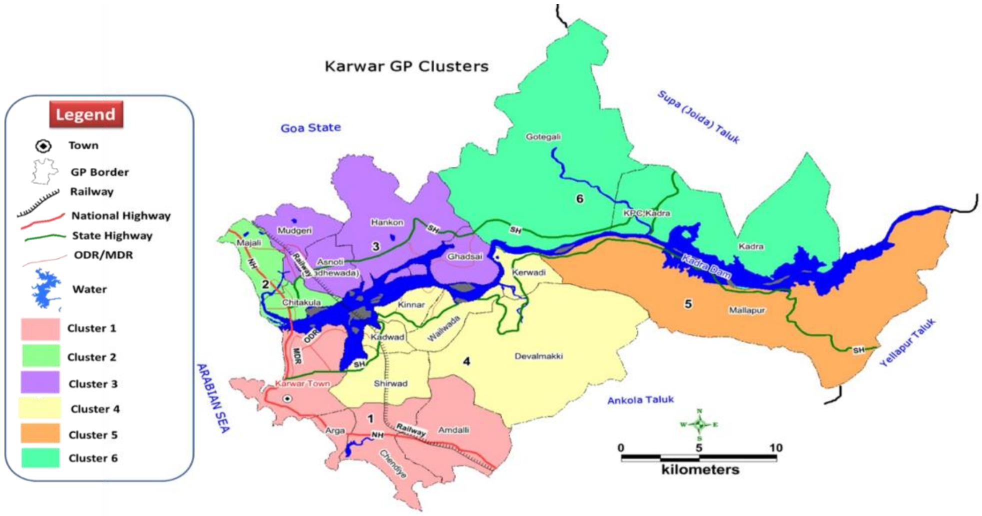
Clusters		Activities
		Bee keeping, training centre for bee-keeping; forest honey; honey testing lab; livestock and dairying, gobargas, VFC/panchayat FHM plantations, home for elderly; handloom units; VFC/individual run home stay tourism; holiday home bamboo-palm cottages; training in making bamboo-palm cottages; Pongamia plantations and biodiesel unit, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping, Fish farming, VFC/panchayat FHM plantations, sericulture; vegetable dyes; bamboo products; Pongamia plantations; aromatic plants and essential oil distillation, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; cloth and paper bags
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; Pongamia plantations; desiccated banana, jackfruit, papaya etc. , incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping and honey certification; livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; medicinal plants cultivation & processing; home stay tourism; orchids and cut flowers; home-made organic chocolates; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition

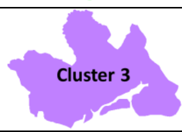
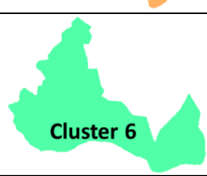


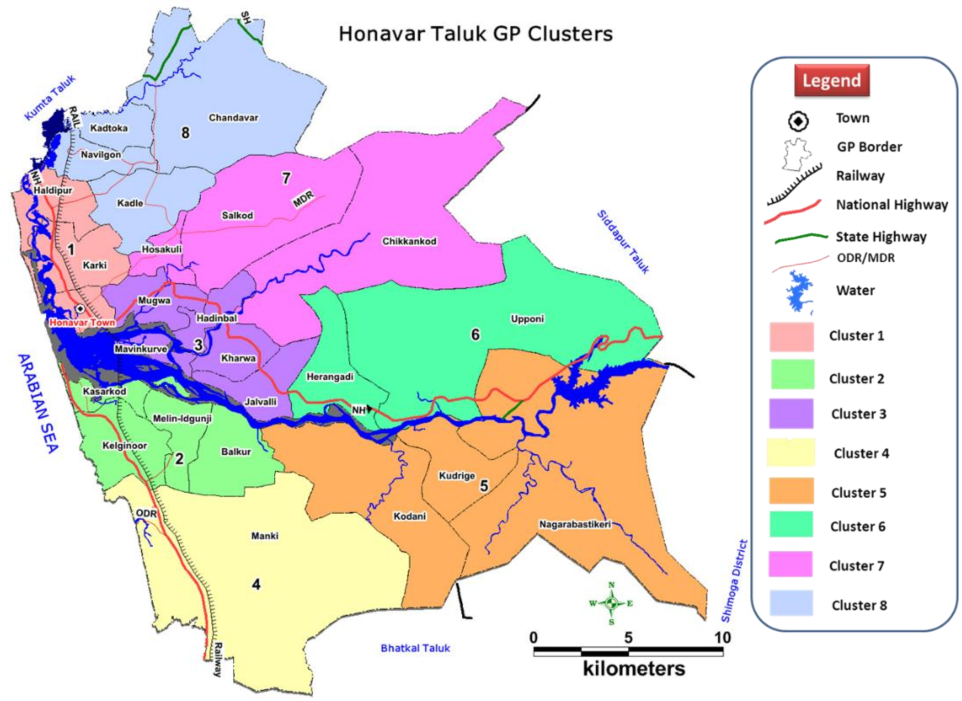
Clusters		Activities
		IT related activities, Livestock and dairying, gobargas, fish farming, home for elderly; vegetable dyes, food products; entrepreneur development institute; incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; tour operators
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; mulberry nursery; sericulture training institute; home stay tourism; hybrid seeds, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; hybrid seeds, incentives for rare traditional cultivars; incentives for community/private sacred groves in good condition
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; aromatic plants and essential oil distillation; medicinal plants and processing units; home-made organic chocolates, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, VFC/panchayat FHM plantations, incentives for rare traditional cultivars, incentives to certified organic farmers, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; cloth and paper bags
		Bee keeping, VFC/panchayat FHM plantations; vegetable dyes; medicinal plant cultivation and processing; holiday home woodland cottages; orchids and cut flowers; hospital services, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, VFC/panchayat FHM plantations; vegetable dyes; orchids and cut flowers; hospital services , incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; areca spathe products

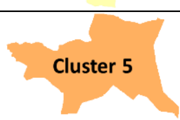
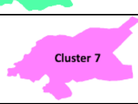
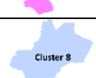


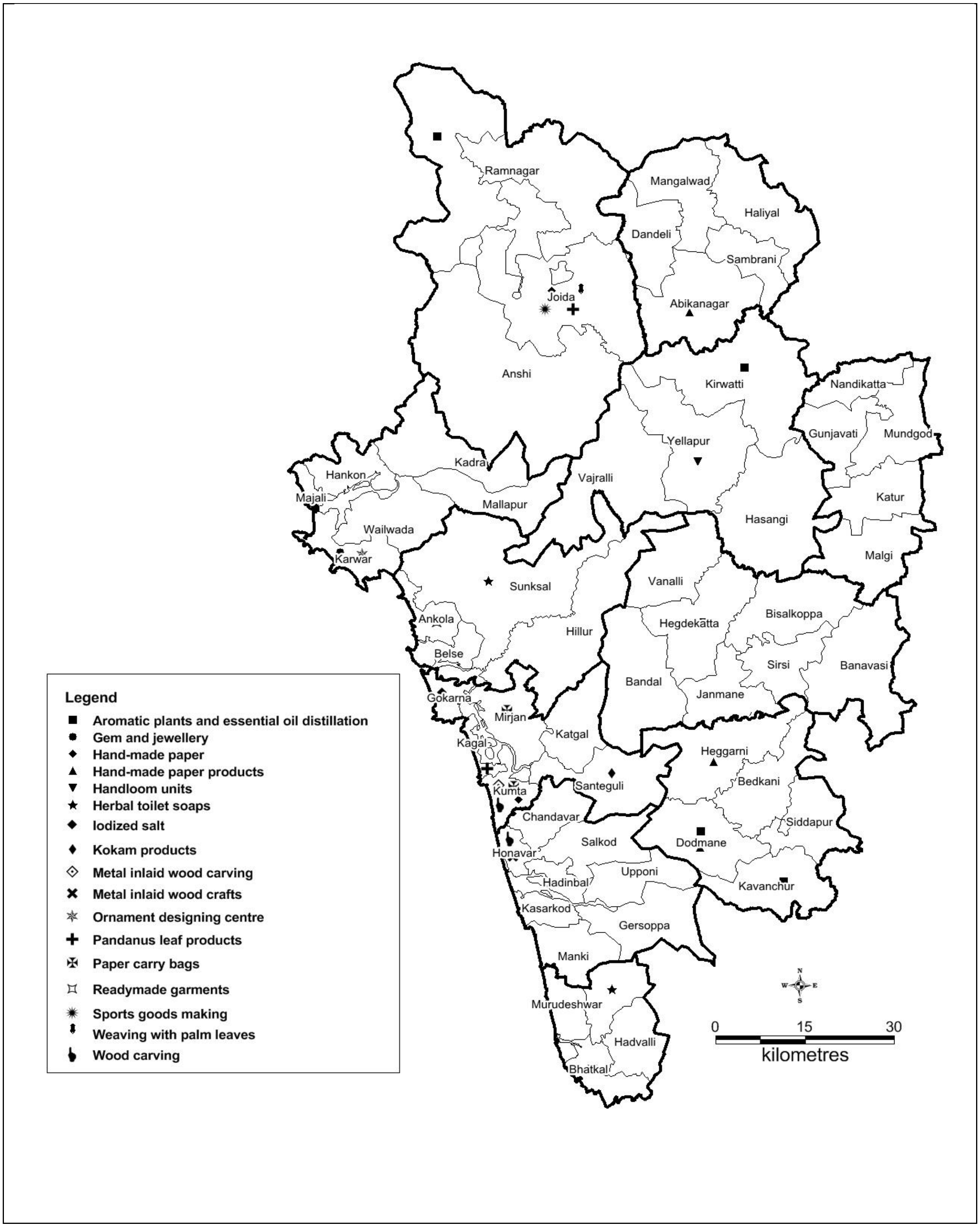
Clusters		Activities
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; CFTRI based ragi products; organic tomato sauce, poultry, powdered eggs; training institute for handloom and wool weaving; mango pulp; home stay (linked to mainly Tibetan colony visits) , incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture, poultry, tamarind farms and tamarind products (concentrates etc.); mango pulp, incentives to certified organic farmers; incentives for community/private sacred groves in good condition; training in making bamboo cottages
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; tamarind farms and tamarind products (concentrates etc.) , incentives for rare traditional cultivars, incentives to certified organic farmers incentives to certified organic farmers; incentives for community/private sacred groves in good condition; cloth and paper bags
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; vegetable dyes; mint cultivation & encapsulation; hybrid seeds, incentives for rare traditional cultivars, incentives to certified organic farmers; incentives for community/private sacred groves in good condition
		Bee keeping, Fish farming, livestock and dairying, gobargas, VFC/panchayat FHM plantations, sericulture; medicinal plants cultivation & processing; hybrid seeds; hospital services, incentives for rare traditional cultivars, incentives for certified organic farmers



Clusters		Activities
		IT related development; Vegetable dyes; medicinal plants cultivation & processing; gems and jewelry, ornament designing centre, Tulsi cultivation and extract; integrated participatory management of Kali estuary; tour operators
		Dry fish; coastal home stay tourism; training in making palm cottages; medicinal plants cultivation; Noni cultivation; Tulsi cultivation and extracts; integrated participatory management of Kali estuary; cloth and paper bags; turtle conservation
		Bee keeping, VFC/panchayat FHM plantations, home for elderly; coir products; backwater tours in native crafts; river front home stays; integrated participatory management of Kali estuary, incentives for rare traditional cultivars, incentives for certified organic farmers
		Bee keeping, VFC/panchayat FHM plantations; medicinal plants cultivation & processing; coir products; hospital services; integrated participatory management of Kali estuary, incentives for rare traditional cultivars, incentives for certified organic farmers
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes, incentives for rare traditional cultivars, incentives for certified organic farmers; sericulture
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes, incentives for rare traditional cultivars, incentives for certified organic farmers; areca-spathe products; sericulture



Clusters		Activities
		VFC/panchayat FHM plantations; organic products certification; honey testing lab; medicinal plants cultivation & processing; organic coconut hair oil; coconut oil natural soap; Calophyllum inophyllum cultivation and bidiesel; wood carving; metal inlaid wood crafts, incentives to certified organic farmers; tour operators
		Bee keeping, VFC/panchayat FHM plantations, dry fish, home stay tourism; academy for Yakshagana and performing arts; Calophyllum inophyllum cultivation, incentives for rare traditional cultivars, incentives to certified organic farmers; cloth and paper bags
		Bee keeping, VFC/panchayat FHM plantations; cattle feed; coir products; training centre for coir products; backwater tours in native crafts; river front home stays, incentives for rare traditional cultivars; incentives for certified organic farmers
		Coastal home stay tourism; training in making palm-bamboo cottages; Bee keeping, VFC/panchayat FHM plantations; Calophyllum inophyllum cultivation, incentives for rare traditional cultivars, incentives for certified organic farmers;
		Bee keeping, VFC/panchayat FHM plantations; woodland holiday homes of bamboo and palms; trekking trail to Govardhanagiri (Kanur fort) and bird watching; hospital services, incentives for rare traditional cultivars, incentives for certified organic farmers; areca-spathe products
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; hospital services, incentives for rare traditional cultivars , incentives to certified organic farmers
		Bee keeping, livestock and dairying, gobargas, VFC/panchayat FHM plantations; vegetable dyes; cane and palm leaf products; hospital services, incentives for rare traditional cultivars, incentives for certified organic farmers
		Bee keeping, VFC/panchayat FHM plantations; vegetable dyes; medicinal plants cultivation & processing, incentives for rare traditional cultivars, incentives for certified organic farmers



Ramnagar
Mangalwad
Haliyal
Dandeli
Sambrani
Joida
Abikanagar
Anshi
Kirwatti
Nandikatta
Gunjavati
Mundgod
Yellapur
Kadra
Hankon
Majali
Vajralli
Mallapur
Katur
Hasangi
Wailwada
Karwar
Malgi
Sunksal
Vanalli
Bisalkoppa
Ankola
Hegdekatta
Hillur
Belse
Sirsi
Banavasi
Bandal
Janmane
Gokarna
Mirjan
Katgal
Kagal
Heggarni
Santeguli
Bedkani
Kumta
Chandavar
Siddapur
Salkod
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0
15
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N
S
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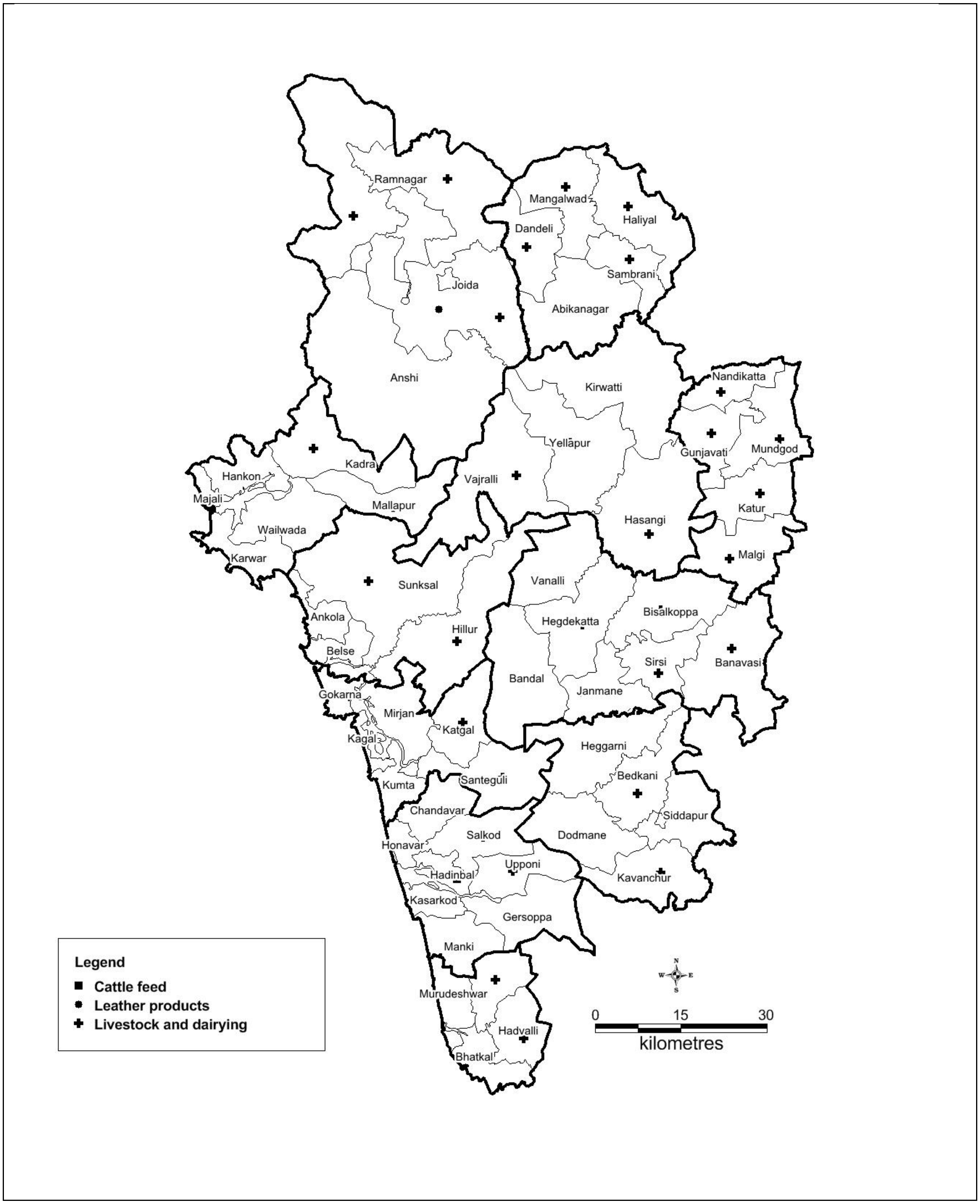
Legend
Aromatic plants and essential oil distillation
Gem and jewellery
Hand-made paper
Hand-made paper products
Handloom units
Herbal toilet soaps
Iodized salt
Kokam products
Metal inlaid wood carving
Metal inlaid wood crafts
Ornament designing centre
Pandanus leaf products
Paper carry bags
Readymade garments
Sports goods making
Weaving with palm leaves
Wood carving


Ramnagar
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Santeguli
Chandavar
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Dodmane
Honavar
Upponi
Hadinbal
Kavanchur
Kasarkod
Gersoppa
Manki
Murudeshwar
Hadvalli
Bhatkal
Legend
Cattle feed
Leather products
Livestock and dairying
0
15
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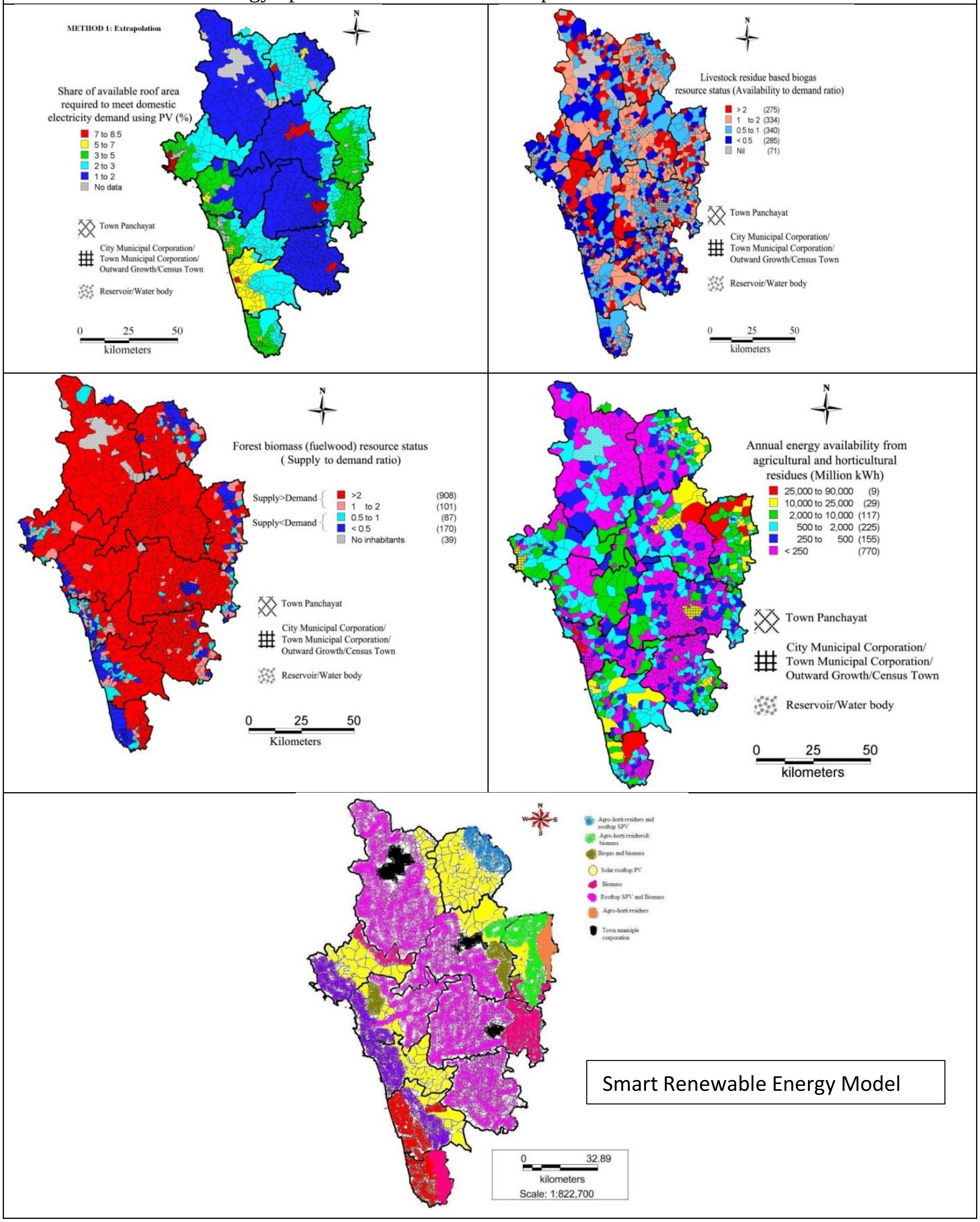
kilometres

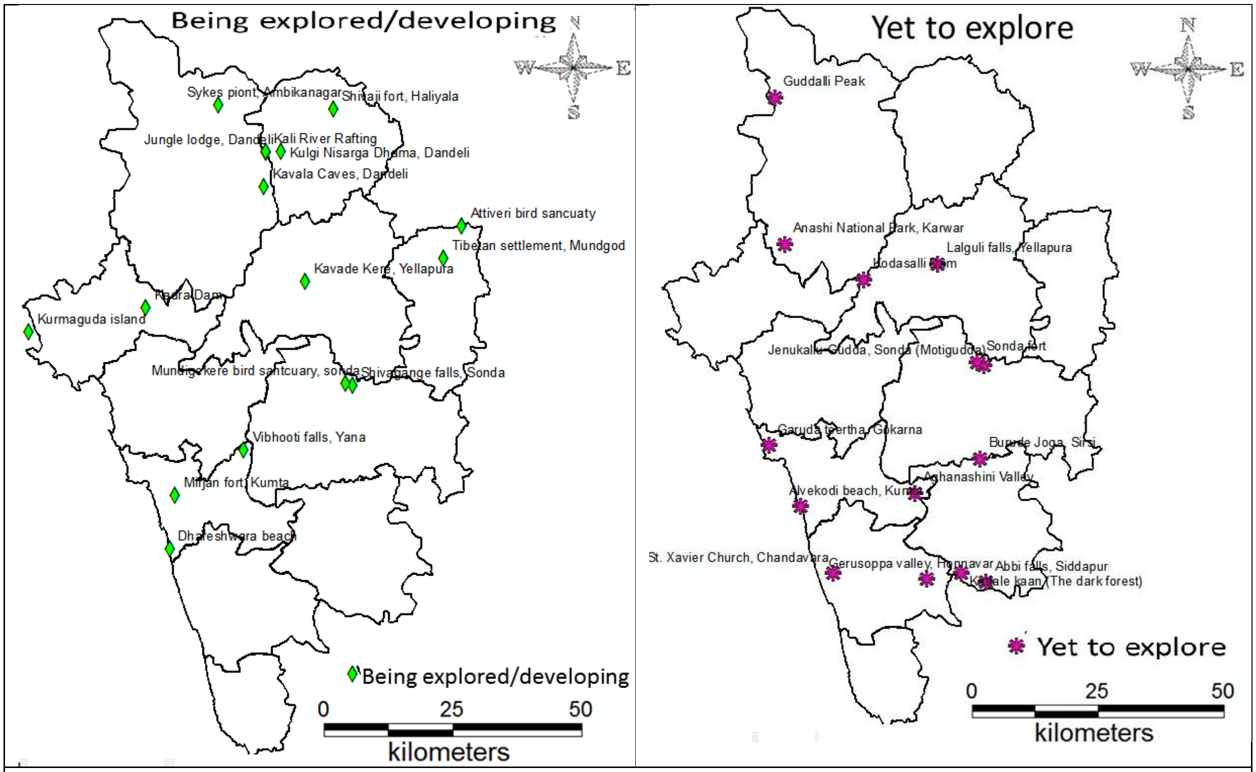
21.27: Decentralised energy options for sustainable devlopment of Uttara Kannada



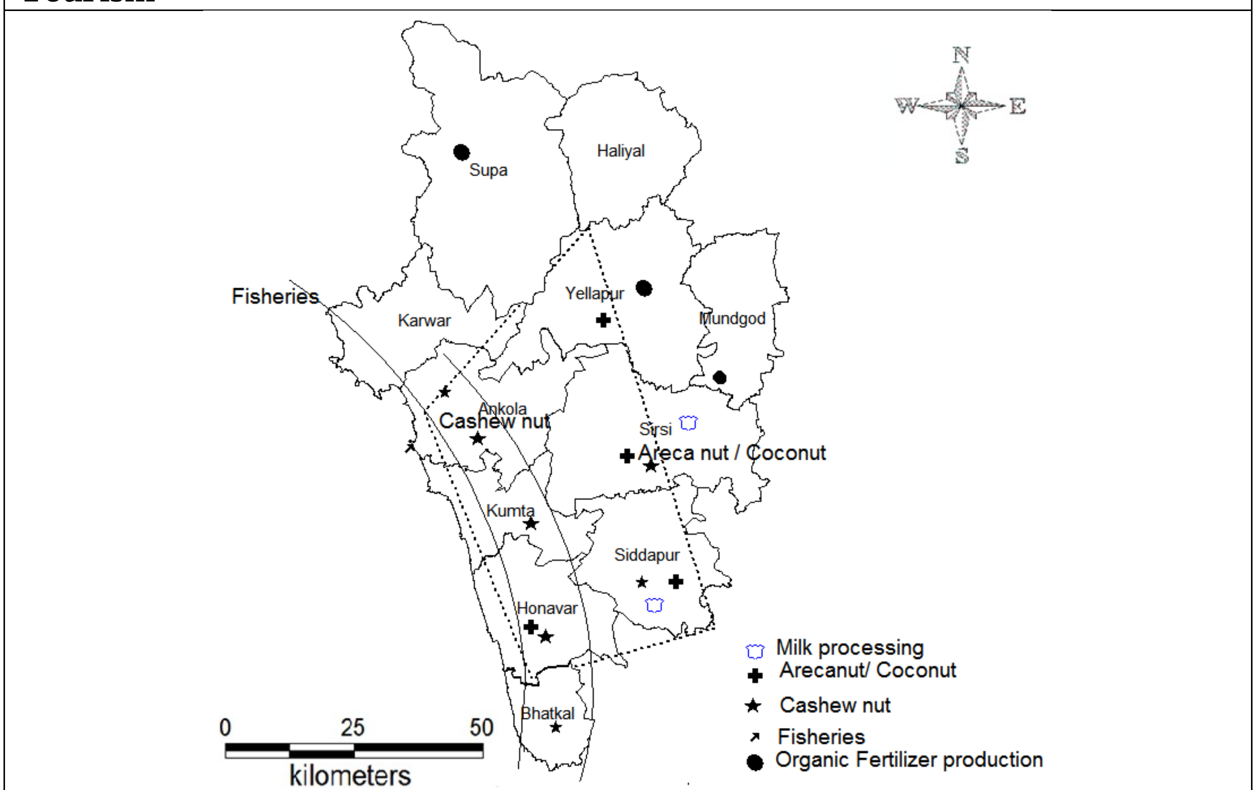
22.0 TOURISM PROMOTION FOR DISTRICT'S PROSPERITY

Uttara Kannada has enormous undertapped potential for tourism development. Tourism income can be raised manifold times through proper planning, without compromising the district's ecology, culture, history and lifestyles. The tourism policy should aim at essentially:

- ***Development of international tourism*** by opening opportunities for appreciation of Uttara Kannada's history, culture and environment in the background of Karnataka's, especially Western Ghat's history and culture.
- ***Developing understanding of other people's customs and cultures*** among the locals is very essential for success of international tourism
- ***Employment, income and foreign exchange generation*** are integral to tourism growth
- ***Helping diversification of economy*** can be achieved through tourism promotion while preserving near pristine conditions for varied ecosystems. Tourist attractions like forests, natural sceneries, waterfalls, sea beaches, mangroves, sanctuaries and national parks, ethnic cultures, arts and crafts, places of pilgrimage, indigenous health care and medicines etc., if judiciously utilized for tourism, both domestic and international, can benefit varied sections of the society.
- ***Redistribution of income*** especially from urban rich to the rural poor will be facilitated through promotion of nature studies, providing opportunities for understanding local cultures, history, arts and crafts, for treatments under local systems of medicine etc.
- ***Sensitizing local youth on the importance of conservation and appreciation*** of Uttara Kannada's scenic beaches, estuaries and mangroves, splendid waterfalls, sacred forests, sanctuaries and national parks, pristine rivers and springs, Myristica swamps, endangered plants and animals etc. can lead to tremendous opportunities for better livelihoods through tourism growth.
- ***Efforts required for betterment of roads, infrastructure:*** The poor state of major roads has adverse impact on tourism development.
- ***Need for short term research for preparing masterplan for developing thematic tourism*** is a critical necessity. Practically no studies are made about the interests of tourists visiting the district, whether they arrive to study about culture, archaeology and history, or appreciate nature, wildlife and birds, learn yoga, fine arts or music, or for pilgrimage or health promotion etc. No training programmes are arranged in details regarding food and accommodation of foreign visitors for especially small scale entrepreneurs; nor do we have any well trained tourist guides. Theme based tourism development can raise income for the district manifold while preserving its cultural and ecological integrity. We propose twelve months as the time required for preparing such a master plan for the district.



Tourism



Employment prospects in Uttara Kannada

RECOMMENDATIONS/GUIDELINES FOR MANAGEMENT OR IMPROVING ECOLOGICALLY SENSITIVE REGIONS: Delineating ESR at panchayat levels helps the local administration (and Biodiversity Management Committees (BMC's) as per Biodiversity act 2002) in implementing Biodiversity act 2002 and taking up appropriate conservation and development activities to improve and maintain sustainability of natural resources. The rules promulgated under Biodiversity Act, 2002 include the provision to constitute the BMCs in each panchayat. The mandate of the BMCs is conservation, sustainable use, documentation of biodiversity and chronicling of knowledge relating to biodiversity. Environment clearance of projects requires BMC's concurrence. BMC aid the local administration to approve applications either for access to biological resources or any activities that are likely to affect the sustainability of natural resouces.

Land use:

- Land use alteration should not permitted from forest to non-forest uses or agricultural to non-agricultural in ESR 1 and 2.
- Large scale sand mining in Uttara Kannada rivers, estuaries at larger scale has affected biodiversity and nearby ground water resources. CRZ regulations do not cover activities in the river bed. The sand removal from river beds is reported to choke the respiratory passages of the bottom dwelling clams (shell-fish). Suatainable sand mining (considering the silt yield per year) and tender allotment to be through panchayat, by imposing a proper time schedule (introduce sand mining holidays) for mining and strict implementation of ban on exporting sand outside of the district.
- The mining or mineral extraction activities in the district are leading to irreversible changes. The Bisgod mines of Yellapur has already caused irrepairable damage to the watershed. A large pond *Anekere* - 'elephant's pond'- (where historically elephants used to drink water) has been totally filled up with mining refuse. Moreover the tail-endings eroded the forested hill-slopes into a tributary of Kali river. Surface mining has impacted ground water resources in some places and partially buried plantations when amount of mine dump was washed down by torrential rains. Complete ban on mining in ESR 1 and 2 within 2 years and controlled mining be allowed in ESR 3 and 4 to meet only the district's requirement with appropriate regulatory mechanism.
- Commercial establishments and Special Economic Zones (SEZ) not allowed in ESR 1, 2 and 3 due to long lasting impacts of these sectors.
- From ancient times the coastal hills and plateaus of Uttara Kannada, from Ankola to Bhatkal, presented a picture of a barren and desolate terrain with sparse growth of woody vegetation. In the recent decades, these regions are used for raising monocultures of *Acacia auriculiformis* and open quarrying for brick making. During the rainy season, open lateritic (tropical sedimentary rock) areas get carpeted with tiny herbs, where billions of flowers bloom providing crucial off-season nectar resources for honey bees thus, immediate protection of these unique lateritic hills of coastal taluks as they are habitat for nectar plants during monsoon.

Forests:

- There are considerable areas of degraded forests in ESR-3, ESR-4 of Uttara Kannada, the biomass of which has to be increased substantially through protection, enrichment and co-management. This approach will increase carbon sequestration in the forest areas and mitigate climate change at locally as well as global. The forest management should aim at improving degraded patches of the deciduous forest zone in Mundgod, Haliyal and in the drier eastern parts Yellapura, Siddapur and Sirsi. These forests have ability to attain basal areas exceeding 35 sq.m/ha.

- The secondary moist deciduous forests along the coastal taluks have been in impoverished state due to high density human impacts. Bulk of such forests constituted the 'minor forests' meant for meeting the biomass needs of coastal people, including cattle grazing. Through special protection of promising forest patches using barbed wire fencing, and closing any kind of exploitation in such protected areas, natural regeneration can be promoted, for at least five year period. Thereafter these forests can be open for free movement of wildlife and more such selected blocks can be protected, using the mode of forest working plans.
- The exotic plantations in ESR-1, ESR-2 should completely phase-out within five years by planting location specific native species. Monoculture plantations lying adjacent to the water sources have to be taken on priority for enrichment through native vegetation. This programme should be integrated within the forest working plan of the respective division. Financial and technical supports need to be provided to the department and participatory agencies during the conversion period.
- The kan forests and 'sacred grooves (devarabanas)' were unique cultural identities of historic period. 'kans' are important sources of springs and streams, a fact even acknowledged by the Government of Bombay (1923) and many are located in ESR 1 & 2. The decline of the kans are due to tree felling (eastern Sirsi and Siddapur for fuelwood), in eastern Sirsi 769 ha of kans were converted into soppinbettas or leaf manure forests, overexploitation of the products of the kans by contractors, changes in the religious beliefs related to sacred forests (Chandran and Gadgil, 1993). Community based conservation is anticipated to be most effective solution for this problem. Efforts should be made to trace them out, map and protect them. The protection of these regions should be considered as a prime requirement by involving village forest committees (VFCs) for enrichment.
- The joint forest protection and management (JFPM) has been mostly assigned highly degraded parts of the forests for management. The range of issues dealt with by the JFPM in their micro plans include fodder development, raising of NTFP (Non-timber forest products) and fuel wood yielding plantations, use of energy saving devices, encroachment problems, and various other location specific issues. This practice is providing good results in the district especially Sirsi region. So this model is needed to be replicated in all taluks with active forest department involvement.
- Non-timber forest products (NTFP) collection should be done only by VFC's, local communities rather than contractors in ESR 2, 3 & 4. The contractor is always associated with destructive extraction of forest produce, evident from the decline of forest produce such as peppar, cinnamon, mango, etc. The exploitation by the contractor is more opportunistic and without any thought on the regenerative capacity of the exploited resources. The contract system is associated with lopping the branches of wild nutmegs –"Rampatri" (*Myristica malabarica*), "Uppage" (*Garcinia cambogea*), nellikai (*Emblica officinalis*), stripping the cinnamon trees of bark, pulling down of pepper vines, cutting the branches of trees with bee-hives and so on.
- The opening of forest canopy following excessive industrial exploitation had created ideal conditions for Eupatorium to establish itself and it rapidly took over the forest floor from past four decades. The larger, shade tolerant, evergreen tree species were replaced by smaller, sun loving deciduous species and weedy plants like Eupatorium. The large biomass of the annual Eupatorium fuelled intense forest fires in the dry season, suppressing regeneration of trees. All these changes meant a drastic reduction in the availability of grazing for livestock. As the economic conditions of the herders deteriorated, they shifted

from selling of butter, to selling of milk, and then to firewood extracted from forests. In parallel, there was substantial extraction of raw material for poly fiber and plywood industries as well, at highly subsidised rates, and at levels that were unsustainable. All of this meant far-reaching changes in the forest cover with a drastic reduction in the standing biomass of trees. So fodder depots should be maintained by forest department in connection with gram panchayat and more grass lands should be created in degraded forest patched available in ESR 3&4.

- Realizing the fact that depletion of forests of food resources and human induced vegetation changes in forests has adverse consequences on wildlife while increasing crop raids by animals enrichment of secondary forests and poor grade tree plantations with food resources for forest herbivores is highly desirable.

Agriculture:

- Farmers are to be encouraged by the Government, forest department in growing and marketing of medicinal plants and their primary products. Medicinal plants grown in forests by VFC, in home gardens or in fields, which also grow in wild, should be procured by the Forest Department. This would bring down the illegal practices associated with harvesting of medicinal plants from the forests, unauthorized exploitation by outside agencies and more importantly would better the local livelihood.
- The complete ban of pesticides, chemicals in agriculture/horticulture and monitoring is to be done by gram panchayats. The excessive use of chemicals in agriculture in the region has shown various adverse effects such as health problems to humans and domestic animals; adverse effects on soil quality (structure, porosity, soil organisms); pollution of water bodies; adverse effects on biodiversity- honey bees, butterflies, fishes, amphibians, birds, wild mammals etc.
- Excessive use of chemical fertilizers have contaminated soil and water. Need to regulate the use of chemical fertilisers and replacing with organic manure.
- Subsidies need to be provided for practicing organic farming, development of organic manure, crop rotation and raising green manure crops.
- Introduce incentive payments as conservation service charges to selected farmers for maintaining of traditional local varieties. More the local varieties of a crop, greater are the stability of agricultural sector. No genetically modified crops (GMOs) are encouraged in all ESR regions. Encourage participatory breeding programmes to improve productivity of traditional cultivators; encourage precision agricultural practices.
- Monoculture crops like rubber and banana plantations in steep slopes and heavy plowing has led to increased surface runoff along with loss of treasurable top soil. The deforestation for areca nut, coffee and cardamom plantations located at higher altitudes (Siddapur, Sirsi taluks) has contributed to drying up of hill streams and swampy areas.
- The agriculture system should be ***mixed cropping*** systems rather than monoculture to poly culture. The food crops and edible fruiting trees should replace existing large extent of monoculture plantations such as rubber, coffee and cardamom to integrate more indigenous crops, which are suited to the locality. This approach will fetch greater amount of benefits to farmers as well as ecosystem by reducing soil erosion, enhance productivity and improve economic returns.
- Various plant species of the district viz. Neem, Pongamia, Vitex negundo etc. are sources of bio pesticides. Promotion of such plants in private lands, VFC managed forests and betta lands can further

the cause of organic farming in the district while also earning extra income to the locals from production of marketable, homemade bio pesticide formulations, under an assisted programme from the Government. Forest department nurseries should provide saplings to interested groups by engaging nearby village unemployed women.

Fisheries:

- Absence of participatory management in fisheries sector is observed in the district. The present management of coastal and marine fisheries almost totally ignores the vast store of traditional knowledge among the fishing communities. The encouragement should be prompted to traditional fisherman and discourage mechanical boat usage by regulating licensing of fishing. The restrictions on fishing in specified areas such as breeding sites, and ban on monsoon fishing, should be implemented by more community participation.
- Establishment of fish sanctuaries in all the rivers and estuarine regions of district should be taken with local fisherman involvement and strengthen awareness programmes to ensure the sustainability and survival of fish resources.
- Information and maps regarding migration, breeding and spawning grounds of threatened fishes should be generated through extensive surveys and analysis. Such database is essential for both ex situ and in situ conservation of the endemic fish species of the district.
- Regulating the shell and sand mining in the river/estuarine regions will have positive impact on the diversity and distribution of fishes, edible bivalves.
- Maintenance of physico-chemical properties of rivers need to be considered with the help of school/college students so that they can continue to be centers of diversity and productivity meeting the food and livelihood needs of thousands of families while also performing the vital ecological functions.

Hydrology:

- River and stream bank forests, including inland swamp area forests are to be considered as endangered ecosystems for various reasons, including for their high accumulation of biomass and higher levels of carbon sequestration. Forest range wise river-stream-swamp protection action plans, incorporating adequate amount of inviolate vegetation growth for protection of ecology of these vital water courses along with their rare and endemic species is critical. The maps and action plans prepared for special protection of the riparian vegetation should be made available to all beats of forest divisions.
- The widespread vegetational changes, forest fragmentation is observed. Blocking of the rivers by building dams has enormously affected the input of organic litter from the forests into the coastal estuaries and the sea. They can heavily modify the magnitude (amount) of water flowing downstream, change the timing, frequency and duration of high and low flows. This has created loss in terms of production of fish and other economically important marine and estuarine organisms, loss of revenue to the State, financial losses to banks from poor recovery of fishing loans, and adverse effects on the fishing communities of coastal Uttara Kannada. So, further construction of dams and hydroelectric projects (Macro/mini/micro) should not be allowed in ESR-1 and 2. In ESR-3 the allotment should be considered only by more public requirements.

- Drinking water scarcity is on the rise in river bank panchayats of district in spite of being close to the river courses. The major amount is spent for providing drinking water in panchayats on river banks. The watershed based management plans afforestation, eco-restoration of catchments, rainwater recharging and harvesting, storm water drainage; water auditing, recycling and reuse etc. should be built into the plans by local self- government level management plans. These water management plans should integrate into basin level management plans.
- Panchayats should get river management funds that can be utilised for activities related to improve river health by riparian vegetation, watershed management programmes and not for construction or other developmental activities in the basin.
- The release of effluents in the Kali river rendering its water unfit for use by villagers and their cattle, and also resulted in fish kills. The release of untreated sewage from Dharwad district showing major impact on Bedthi river. Stringent waste management (solid & liquid) policies as per the water pollution act and also municiapl solid waste management rule 2000 are to be implemented to reduce the effect on riverine ecosystem.

Public participation:

- Greater interaction with local community, forest dwellers and involving them at all stages of planning and implementation of forestry programmes run by the Department, and supporting their own planning and implementation of community-based forestry programmes will ensure their resourceful economic and social development. This approach will lead to sustainable environment, protracted natural resource availability and holistic development of region.
- Environmental education can play a vital role in this effort by preparing well sensitised responsible citizenry, with a good understanding of various forces operating in the environment and their consequences. Local educational and research institutions should be encouraged to take up documentation of traditional practices, study of local and global demands of forest products, research projects to help forest department for enrich local ecology and farmers to shift from non-organic methods to organic farming.
- Energy efficient stoves, biogas, solar devices, use of agricultural wastes etc. are to be promoted as fuel in rural areas by creating awareness through schools and panchayats. Energy plantations raised on degraded lands providing right to public will help in improving the ecological status of the region, provide biomass feedstock for rural bioenergy programmes and also help in meeting fuel wood demand.

Landscape changes are driven by the interaction of ecological, geographical, economic, and social factors. Changes in the structure of the landscape has altered its functional abilities such as nutrient cycling, water availability, etc. Ecologically Sensitive Regions (ESRs') are the 'ecological units' that may be easily affected or harmed. It is a bio-climatic unit (as demarcated by entire landscapes) wherein human impacts have locally caused irreversible changes in the structure of biological communities (as evident in number/ composition of species and their relative abundances) and their natural habitats' (Section 3 of the Environment (Protection) Act 1986 (EPA)). This approach of conservation or ecological planning considers spatially both ecological and social dimensions of environmental variables. Ecological sensitive regions with exceptional biotic and abiotic elements are being degraded or lost as a result of unplanned developmental activities. Landscapes sustainability as a basic goal for development requires comprehensive picture of the biophysical and socio-cultural information of a region and this approach provides an opportunities and constraints for decision-making and sustainable management of natural resources. Conservation by prioritisation of sensitive regions has been widely used to improve ecosystem by conservations practices. Uttara Kannada district was divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2. Grids are ranked based on an aggregate weightage metric score considering the information related to spatial extent of forest cover, extent of interior forests, occurrence of endemic flora and fauna, presence of conservation reserves, standing biomass, annual increment of biomass, geo-climatic parameters (slope, altitude, rainfall), estuarine diversity and productivity and presence of forest dwelling communities. Grids were ranked depending on the aggregate score of attributes (biological, Geo climatic, Social, etc.) as ESR1 (Regions of highest sensitivity or Ecologically Sensitive Region 1), ESR2 (Regions of higher sensitivity), ESR3 (Regions of high sensitivity) and ESR4 (Regions of moderate sensitivity).

Ecological sensitive regions (ESR) at panchayat level / disaggregated level suitable for local level planning (implementation of Biodiversity act, 2002) were delineated by overlaying spatial layer of panachayath. Uttara Kannada has 209 panchayats with the enactment of the 73rd Constitutional Amendment Act to strengthen the grassroots democratic processes. Among these, 102 panchayats are in ESR 1, while ESR 2 has 37 panchayat, ESR 3 has 33 and ESR 4 has 37 panchayats. ESR 1 and ESR 2 are most ecologically sensitive regions of the district. The degradation of these areas will have irreversible impact on the ecology, biodiversity and sustence of natural resources. Regions under ESR 1 and 2 are "***no go area***" for any developmental activities involving large scale land cover changes. ESR 2 have ecosensitiveness similar to ESR 1, and has scope to attain the status of ESR 1 with eco-restoration measures (as some pockets are degraded). ESR 4 are regions of moderate sensitivity, wherein sectors such as agro processing, information technology (IT), and such environment friendly sectors be permitted.

23.0 RECOMMENDATIONS FOR INVOLVEMENT OF STUDENT COMMUNITY IN BIODIVERSITY DOCUMENTATION

Following the Biodiversity Act, 2002 of India, many State Biodiversity Boards were constituted which in turn are involved in formation of Biodiversity Management Committees (BMC) for "promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity." The **BMCs should prepare People's Biodiversity Register (PBR) containing local knowledge on biological resources and their usages. Nationwide preparation of PBRs,** is expected to be a mammoth exercise for India, a megadiversity country.

A decade is past since the Biodiversity Act, but only tardy progress made in relation to PBRs. Major hurdles hampering the process appeared to be concepts and formats unfriendly for grassroots level people, paucity of taxonomic expertise, low funding and lack of motivation and guidance. Model PBRs prepared were at enormous expenditure, and through the deployment of experts and not easily replicable. Looking for alternatives to current model of PBR preparation, we attempted under the aegis of the Integrated Ecological Carrying Capacity Project for Uttara Kannada the deployment of student community from high schools and colleges to document biodiversity under the banner **'My Village Biodiversity'**. Simplified formats, as understood easily by high school students and village communities, were used for data collection, carried out during 2010-11 and 2011-12. The teachers were given orientation programmes about biodiversity, Biodiversity Act, and on formats to be used. Competitions were conducted for students and nominal rewards announced for the best reports and good presentations. No financing of the educational institutions was done to carry out this model of work. The objectives included:

- **a.** ***Sensitisation of students:*** The very use of data formats were also aimed at sensitizing students to biodiversity related issues. Notable among data to be gathered included forest types, landscape and waterscape elements, plant and animal diversity as the village community understand, crop diversity, preparations and uses of bio-pesticides, organic farming, traditional storage methods, NTFP, management of village environment, community health, wildlife, human-wildlife conflicts, domestic animal diversity, production of honey and apiculture, energy sources, skilled and knowledgeable people in the villages, sacred groves etc.
- **b.** ***Recording observations:*** The students were advised to read and understand data formats under the guidance of teachers
- **c.** ***Vital information on crop diversity:*** Stress laid on documentation of local varieties of crops.
- **d.** ***Low cost methods to assist PBR preparation:*** No money was paid to partner institutions and students except for meeting the travel expenses for attending workshops.

- **e.** ***Creating ambassadors of goodwill:*** Students, with their unbiased minds were expected to merit greater acceptability in the households, as the villagers otherwise tend to be more reserved with outside agencies like NGOs engaged in such work.
- **f.** ***Expertise in communication:*** Students were expected to gain good communication skills.

About 580 students from 116 high schools and 6 colleges representing the 11 taluks of Uttara Kannada took part in the two year exercise, in the course of the Carrying Capacity project work. Biodiversity documentation covered about 190 villages of the total of about 1200 villages in the district. Considering the sluggish scenario of PBR progress, with only 212 panchayats of Karnataka covered by 2008, comments on their merits pending, the cost was high for the Biodiversity Board in its infancy to bear, but at the same time funding considered small by the agencies catalyzing the PBRs at panchayat levels.

Some schools fared poorly in their outputs on village biodiversity recordings, mainly on account of guiding teachers missing the orientation programmes. If the education departments, make suitable changes in the syllabi to incorporate biodiversity documentation, with due credits to the performers, the outcome would be more fascinating. The students in general found greater acceptability in the villages, got first hand learning opportunities and often turned out to be communicators of good order.

To highlight some results, notably, of 190 villages where rice cultivation was reviewed, 181 varieties were recorded; out of them 101 were native varieties. Sample survey with regression analysis gives expectation of finding around 492 native varieties in the district. Countrywide adoption of the method will benefit rapid documentation of traditional varieties, feared to have dwindled from around one lakh down to 8-10 thousand, mainly due to unregulated introduction of new varieties. Documentation also covered local varieties of banana, pepper, mango, jack, sugarcane, arecanut, coconut etc.

The villages have rich wealth of traditional knowledge holders like herbal healers specialized in treating ailments like rheumatism, paralysis, migraine, kidney stones, bone fractures, eye and skin problems, jaundice, herpes, paralysis, infertility, epilepsy etc. and cattle diseases. Medicinal plants were exhibited during workshops and their uses documented. Information on persons with knowhow on biopesticides, earthworm manure, water divining, organic farming etc. also is available.

Villagers gave good account of local wildlife, on occasional visiting animals like tiger, leopard, bear etc. Local names of fishes available in the fresh water bodies were recorded. The students provided indications on the presence of hundreds of sacred groves in the villages. They would be interesting places from biodiversity and cultural angles. On the whole pastoralism is on the decline due to fodder scarcity, and cattle manure, inevitable for high rainfall agricultural soils, is getting scarce. This can undermine the very farming system of the district.

Our experiment shows the huge potential for harnessing the student power for documentation of the immense biodiversity of the country. Biodiversity awareness creation among the younger generation is a paramount necessity for the successful documentation. **The educational system has to be restructured to institutionalize biodiversity documentation, especially using student power from high school and undergraduate levels with due academic credits given to the participants.**

24.0 **REPORTS SUBMITTED TO KARNATAKA BIODIVERSITY BOARD**

1) Ramachandra T.V., Subash Chandran M.D. and Joshi N.V., 2014. Integrated Ecological Carrying Capacity Of Uttara Kannada district, Karnataka, Sahyadri Conservation Series 41, ENVIS Technical Report 71, CES, Indian Institute of Science, Bangalore 560012, India
2) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Socio-economic worthiness of people's institutions and organizations, Sahyadri Conservation Series 40, ENVIS Technical Report 70, CES, Indian Institute of Science, Bangalore 560012, India
3) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash Mesta, 2013. Marine Fishery in in Uttara Kannada, Sahyadri Conservation Series 39, ENVIS Technical Report 69, CES, Indian Institute of Science, Bangalore 560012, India
4) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Prakash N. Mesta, Sreekantha, Gayatri Naik, 2013. Agro Biodiversity in Uttara Kannada, Sahyadri Conservation Series 38, ENVIS Technical Report 68, CES, Indian Institute of Science, Bangalore 560012, India
5) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, Rao G R., Prakash Mesta, 2013. Ecologically sensitive regions in Uttara Kannada, Sahyadri Conservation Series 37, ENVIS Technical Report 67, ENVIS, Centre for Ecological Sciences, Indian Institute of science, Bangalore 560012
6) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Vinay S., Bharath H A and Bharath Setturu, 2013, Carrying Capacity of River Basins considering Ecological and Social Demands, Sahyadri Conservation Series 36, ENVIS Technical Report 66, CES, Indian Institute of Science, Bangalore 560012, India
7) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Sreekantha, Saira V.K and Vishnu D.M., 2013. Influence of Landscape Dynamics on Hydrological Regime in Central Western Ghats Sahyadri Conservation Series 35, ENVIS Technical Report 65, CES, Indian Institute of Science, Bangalore 560012, India
8) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Mahima Bhat, Prakash N.Mesta, Sreekanth Naik, 2013. Estuarine Fish Diversity and Livelihoods in Uttara Kannada district, Karnataka State, Sahyadri Conservation Series 34, ENVIS Technical Report 64, ENVIS, CES, Indian Institute of Science, Bangalore 560012, India
9) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Bharath Setturu, 2013. Carbon sequestration in Uttara Kannada, Sahyadri Conservation Series 33, ENVIS Technical Report 63, CES, Indian Institute of Science, Bangalore 560012, India

10) Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Rao G.R., Vishnu Mukri, Sumesh N. Dudani, Balachandran C., Prakash N.Mesta, Sreekanth Naik, 2013. Floristic diversity in Uttara Kannada district, Karnataka State, Central Western Ghats, Sahyadri Conservation series 32, ENVIS Technical Report 62, CES, Indian Institute of Science, Bangalore 560012, India
11) Ramachandra T.V., Subash Chandran M.D., Joshi N.V. and Bharath Setturu, 2013. Land use changes with the implementation of Developmental projects in Uttara Kannada district, Sahyadri Conservation Series 31, ENVIS Technical Report 61, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
12) Ramachandra T V, Subash Chandran M D, Joshi N V, Prakash Mesta, 2013. Adopting Clustering Approaches - Ecology Integrated Sustainable Development of Uttara Kannada, Sahyadri Conservation Series 30, ENVIS Technical Report 60, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
13) Ramachandra T V, Subash Chandran M D, Joshi N V, Bharath Setturu, 2013. Fragmentation of Uttara Kannada forests, Sahyadri Conservation Series 29, ENVIS Technical Report 57, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
14) Ramachandra T V, Subash Chandran M D, Joshi N V, Bharath Setturu, 2013. Land Use Land Cover (LULC) dynamics in Uttara Kannada Central Western Ghats, Sahyadri Conservation Series 28, ENVIS Technical Report 56, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
15) Ramachandra T V, Subash Chandran M D, Joshi N V, Rakhi Raj, Prakash N Mesta, sumesh Dudani, 2013. Valuation of Estuarine Ecosystem, Uttara Kannada District, Karnataka, Sahyadri Conservation Series 27, ENVIS Technical Report 45, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
16) Ramachandra T V, Subash Chandran M D, Joshi N V, Ganesh Hegde, Gautham Krishnadas, 2013, Sustainable energy alternatives for Uttara Kannada, Sahyadri Conservation Series 26, ENVIS Technical Report 58, ENVIS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012
17) Ramachandra T V, Subash chandran M d, Joshi N V, Divya Soman, Ashwath D Naik, Prakash N Mesta, 2013. Valuation of goods and services from forest ecosystem of Uttara Kannada, Central Western Ghats, Sahyadri Conservation Series 25, ENVIS Technical Report: 44, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
18) Ramachandra T V, Subash Chandran M D, Surya Prakash Shenoy, Rao G R, Vinay S, Vishnu Mukri and Shrikanth Naik, 2013, Kumaradhara River basin, Karnataka Western Ghats: Need for Conservation and Sustainable Use, Sahyadri Conservation Series 24, ENVIS Technical Report: 54, , ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
19) Ramachandra T V, Subash Chandran M D, Sudarshan P Bhat, Bharath H. Aithal, Rao G R and Vishnu Mukri, 2013. Status of Forest in Shimoga district, Karnataka, Sahyadri Conservation Series 23, ENVIS Technical Report: 53, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

20) Sumesh Dudani, Mahesh M K, Vishnu Mukri, Subash Chandran M D and Ramachandra T V, 2013. An appraisal and conservation strategies for the Pteridophytes of Uttara Kannada, CES Technical Report 129, Centre for Ecological Sciences, IISc, Bangalore
21) Ramachandra. T.V, Subash Chandran M.D, Joshi N.V., Sreekantha, Raushan Kumar, Rajinikanth R., Desai S.R. and Subhash Babu, 2012. Ecological Profile of Sharavathi River Basin., Sahyadri Conservation Series 22, ENVIS Technical Report : 52, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
22) Subash Chandran M.D, Ramachandra. T.V, Joshi N.V., Rao G.R, Prakash N. Mesta, Balachandran C. and Sumesh N. Dudani, 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
23) Ramachandra T V, Subash Chandran M D, Ananth Ashisar, Rao G R, Bharath Settur, Bharath H Aithal, Sreekanth Naik, Prakash Mesta, 2012, Tragedy of the *Kan* Sacred Forests of Shimoga District: Need for Urgent Policy Interventions for Conservation, CES Technical Report 127, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
24) Subash Chandran M D, Ramachandra T V, Joshi N V, Prakash Mesta, Bharath Settur and Vishnu Mukri, 2012, Conservation and Management of Mangroves in Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 50, Sahyadri Conservation Series 20, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
25) Ramachandra T V, Subash Chandran M D, Joshi N V and Balachandran C, 2012, Beekeeping: Sustainable Livelihood Option in Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 49, Sahyadri Conservation Series 19, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
26) Ramachandra T V, Subash Chandran M D, Joshi N V, Gururaja K V, Sameer Ali and Vishnu Mukri, 2012. Amphibian Diversity and Distribution in Uttara Kannada District, Karnataka, ENVIS Technical Report: 47, Sahyadri Conservation Series 18, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
28) Ramachandra T V, Subash Chandran M D, Joshi N V and Boominathan M, 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., ENVIS Technical Report: 48, Sahyadri Conservation Series 17, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
29) Ramachandra T V, Subash Chandran M D, Rao G R, Amit Yadav, Gururaja K V, Karthick B, Uttam Kumar, Durga Madhab Mahapatra and Vishnu Mukri, 2011, ecological status of Dandeli-Anshi Tiger Reserve, ENVIS Technical Report: 43, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
30) Ramachandra T V, Subash Chandran M D, Joshi N V, Daval Joshi and Maneesh Kumar, 2012. Soil quality across diverse landscapes in Central Western Ghats, India, ENVIS Technical Report: 42, Sahyadri Conservation Series 16, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

31) Ramachandra T V, Subash Chandran M D, Joshi N V, Sooraj N P, Rao G R and Vishnu Mukri, 2012. Ecology of Sacred *Kan* Forests in Central Western Ghats, ENVIS Technical Report: 41, Sahyadri Conservation Series 15, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
32) Ramachandra T V, Subash Chandran M D, Joshi N V, Karthick B, Sameer Ali and Vishnu Mukri, 2012. Ecohydrology of Lotic Ecosystems of Uttara Kannada, Central Western Ghats, ENVIS Technical Report: 40, Sahyadri Conservation Series 14, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
33) Ramachandra T V, Subash Chandran M D, Joshi N V, Sumesh Dudani, 2012. Exploring Biodiversity and Ecology of Central Western Ghats, ENVIS Technical Report: 39, Sahyadri Conservation Series 13, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
34) Rajasri Ray, Ramachandra T V and Subash Chandran M D, 2011. Sacred groves in Siddapur Taluk, Uttara Kannada, Karnataka: Threats and Management Aspects**,** ENVIS Technical Report: 38, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
35) Gururaja K V and Ramachandra T V, 2011. Anuran diversity and distribution in Dandeli Anshi Tiger Reserve, ENVIS Technical Report: 37, Sahyadri Conservation Series 8, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
36) Subash Chandran M. D., Rao G. R., Vishnu Mukri, Prakash Mesta and Ramachandra T V, 2011. Grasslands of Anshi-Dandeli Tiger Reserve, ENVIS Technical Report: 36, Sahyadri Conservation Series 12, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
37) Subash Chandran M. D., Prakash Mesta, Boominathan M., Rao G. R., Vishnu D.M. & Ramachandra T.V., 2011. Aghanashini Estuary in Kumta Taluk, Uttara Kannada - Biological Heritage Site, ENVIS Technical Report: 35, Sahyadri Conservation Series 11, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
38) Subash Chandran M. D., Rao G. R., Prakash Mesta, Vishnu D.M. and Ramachandra T.V., 2011. Green Walls for Karnataka Sea Coast, ENVIS Technical Report: 34, Sahyadri Conservation Series 10, ENVIS- Environmental Information System, Centre for Ecological Sciences, Indian Institute of Science, Bangalore

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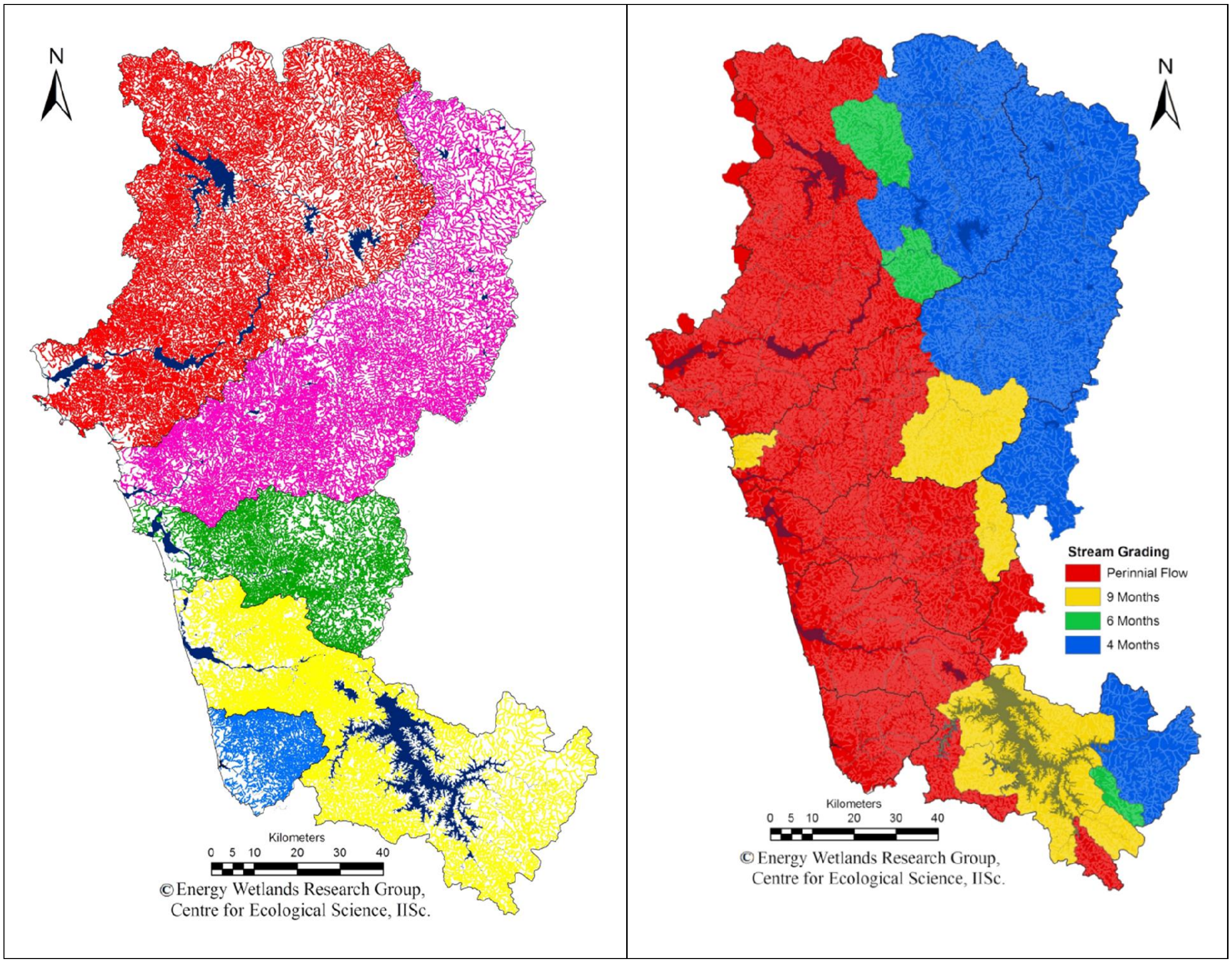

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Ramachandra T.V., Subash Chandran M.D. and Joshi N.V., 2014, Integrated Ecological Carrying Capacity of Uttara Kannada district, Karnataka, Sahyadri Conservation Series 41, ENVIS Technical Report 71, CES, Indian Institute of Science, Bangalore 560012, India, http://ces.iisc.ernet.in/energy