Karnataka Biodiversity Board

Forest, Ecology and Environment Department
Government of Karnataka

" ECONOMIC VALUATION OF POTENTIAL BIORESOURCES FOR ACCESS AND BENEFIT SHARING "

UNEP–GEF–MoEF–ABS PROJECT

"Strengthening the implementation of the Biological Diversity Act and Rules with focus on its Access and Benefit Sharing (ABS) Provisions"

Department of Forest, Ecology and Environment Vanavikas, Ground Floor, 18th Cross Malleshwaram,
BANGALORE- 560 003. Email: kbb-ka@nic.in | Website: http://www.karnataka.gov.in/kbb Ph: 080-23448783, Fax: 080-23440535

Edited and Compiled by:

Dr. Vidya Pradeep Kumar,

State Coordinator, UNEP-GEF-MoEF-ABS Project, Karnataka Biodiversity Board

Disclaimer:

The contents published in this book are based on the inputs provided by researchess and experts, from their respective know-how. Any error or lapse is purely unintended and inconsequential and shall not make either the Board or the Project liable for the same.

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808, 14th Main, 50th Cross, 3rd Block, Rajajinagar, Bengaluru - 560 010

Ph : +91-80-2330 9803, Email: print@paramountcolor.com

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GOVERNMENT OF KARNATAKA
Karnataka Biodiversity Board
(Forest, Ecology and Environment Department)

S.P. SHESHADRI
Chairman

"Vanavikas", Ground Floor, 18th Cross,
Malleshwaram, Bangalore – 560003
Ph : (Off) 080-23448784 / 23448783
Fax:23440535
M: 9880787566 E-mail : kbb-ka@nic.in
Website : www.kbb.kar.nic.in

Foreword

The Convention on Biological Diversity, a legally binding multilateral environmental agreement was inspired by the world community's growing commitment to sustainable development. It represents a remarkable step forward in the conservation of biological diversity in general and genetic resources in particular. India is a party to the Convention and the Biological Diversity Act, 2002 is enacted by the Parliament with the objectives to provide for conservation of biological diversity, sustainable use of the components, and fair and equitable sharing of benefits arising out of the commercial use of biological resources and associated knowledge.

The Benefit Sharing, popularly referred to as "ABS", is a relatively new concept as it was hitherto practiced to a limited extent in forestry management in this country. ABS is determined based on the price of biological resources or on the ex-factory sale of the products manufactured from the biological resources. Now the Biological Diversity Act provides an opportunity to implement the concept across the entire spectrum of bio resources, whether cultivated or wild. Though the basic framework has already been provided by National Biodiversity Authority in guidelines issued on 21st November 2014, the whole dynamics relating to ABS which includes cultivation/harvesting practices, trade links and marketing mechanism has to be fully understood for the implementation of the concept.

The present study of valuation of bioresources from select three ecosystems forest, agriculture and wetlands is an attempt towards the same. It is taken up by the Karnataka Biodiversity Board as a study under the UNEP-GEF-MoEF-ABS Project to assess the economic value of few accessed bioresources and propose value chain analysis that would help in identifying the real value of each bioresource used.

Contd...

I complement Dr. Virender Singh, IFS, Member Secretary, Karnataka Biodiversity Board for this initiative. The document is divided into ten chapters and contains inputs shared by experts on biological resources from three select ecosystems forest, agriculture and wetlands. The book is not exhaustive, but will definitely serve as a handy reference to the farmers, industries, researchers, administrators and students in the days to come. The bench mark information now compiled at one place can be a starting point for studies leading to complete database for realization of ABS obligation from all concerned with ultimate objective of biodiversity conservation.

Chairman
Karnataka Biodiversity Board

Chairman
Karnataka Biodiversity Board
Bengaluru

Chapter 1

Economic Valuation of Potetial Bioresources for Access and Benefit Sharing (ABS)

Introduction:

India is one among the 17 mega bio diverse countries of the world and out of the 34 biodiversity hot spots identified to date, 4 of them are from India. Hence it becomes imperative for all of us to look into the conservation and sustainable aspects of biodiversity. The Convention on Biological Diversity (CBD), a 1992 landmark treaty of Rio De Janeiro, Brazil, had set the framework for which India became a signatory along with many other countries introducing the concept of protecting biodiversity and associated traditional knowledge legally. ***The convention recognizes the sovereign rights of the states over their natural resources in areas under their jurisdiction with three main objectives to conserve and sustainably use the components of biodiversity and also equitably share the benefits arising out of the use of biological resources.***

National Biodiversity Authority, India is currently implementing the first National Project on Access and Benefit Sharing, the UNEP-GEF-MoEF-ABS Project on ***"Strengthening the Implementation of the Biological Diversity Act and Rules with focus on its Access and Benefit Sharing Provisions",*** a program to access genetic resources, assess their economic value and share the benefits arising out of them among the local people. This project is implemented across 10 states in India, with an overall objective to increase the institutional, individual and systemic capacities of the stakeholders to effectively implement the Act and thereby achieve Biodiversity conservation through implementing Access and Benefit Sharing (ABS) agreements in India.

Mainstreaming and Strengthening the ABS process can be done through identification of bioresources or genetic resources, with potential for ABS from select ecosystems, such as forests, wetlands and agriculture and assessing the fiscal value (estimation of the real value) by developing standardized economic valuation methods for pricing bio-resources and using the same in decision making process.

Generally, large quantities of divergent bio-resources are collected or extracted from the ecosystems which can directly or indirectly be used either as food, medicines or biomass. These goods are also involved in research and development (which lead to the innovation of new consumer products) and trade, and act as the basic raw-material or input factor in manufacturing many products.

Forests: A large number of resources (goods) come from the forests as timber and non-timber forest products, apart from the various non-marketed ecosystem services. These goods include timber, fuel wood, fodder, non-timber forest products, food (honey, mushrooms, fruit, and other edible plants), genetic resources and cultural resources. Most of these resources are used as an unavoidable input factor for manufacturing various value added products, having a huge market potential.

Agriculture: Agricultural biodiversity includes, harvested crop varieties, livestock breeds and non-domesticated ('wild') resources in fields, forests, rangelands, and in aquatic ecosystems; non-harvested species within production ecosystems that support food provision, including soil micro-biota, pollinators and so on; and non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystems). The primary goods provided by the agriculture and grassland ecosystems include, food crops, fibre crops, crop genetic resources, other crops (energy, fodder, etc), cultural resources, and livestock (food, hides, fiber). Agricultural products have a huge market and business potential, and play a significant role in manufacturing different food items and achieving food security.

Bio-resources / biological resources means: plant, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value added products) with actual or potential use or value, but not human genetic material (The Biological Diversity Act, 2002).

Wetlands: Inland and coastal wetlands are the most productive ecosystems and their functions include nutrient cycling and hydrological cycling. The system also has attributes of a diversity of species. Coastal ecosystems can provide goods such as, fish and shellfish, fish meal (animal feed), seaweeds (for food and industrial use), salt, genetic resources and cultural resources. The goods provided by the freshwater ecosystem are fish, genetic resources and cultural resources. Wetland species (animals and plants) have huge economic value and ABS potential.

Commercial utilization is defined as end uses of biological resources for commercial utilization such as drugs, industrial enzymes, food flavors, fragrance, cosmetics, emulsifiers, oleoresins, colors, extracts and genes used for improving crops and livestock through genetic intervention, but do not include conventional breeding or traditional practices in use in any agriculture, horticulture, poultry, dairy farming, animal husbandry or bee keeping.

Valuation Methods:

The different methods drafted for bio-resources valuation are (a) Value Chain Analysis, (b) The "Maximum Willingness to Pay" Approach, (c) Application of the Appropriate Economic Instruments: (tax, cess, charges, royalty etc.), (d) Minimum Support Price for Bio-resources and (e) Collectors' Willingness to Accept and Minimum Livelihood. However,

experts propose that **"value chain analysis"** of bio-resources based product is more appropriate in identifying the real value of bio-resources. Further it is significant to develop case specific and / or separate formulas for valuing bio-resources based on its nature, availability, potential uses etc.

Most of the goods from our ecosystems (forests, rivers, estuaries, oceans, etc) being common properties, experience market failure or distortion, and priced insignificantly. The demand, supply and price mechanisms do not function effectively as they do in the case of other commodities and hence the ecosystem goods are 'underpriced'. The providers (local communities) are being exploited because of their limited knowledge on the value of bioresources and hence end up getting only a meager price, by the traders and companies, who make substantial profits from the business.

Hence it becomes imperative to value biodiversity ecosystem goods and determine the real or true value of bioresource for realizing the objective of Nagoya protocol-The Access and Benefit Sharing. The compilation tries to emphasize on the economic valuation methodology used for an assortment of bioresources from three select ecosystems forest, agriculture and wetlands and extrapolate the true value of a bioresource for operationalizing ABS. The study, to a greater extent would help us adapt the proposed valuation methodology to other similar bioresources and determine their true value for a fair and equitable benefit sharing process.

1. Forest Bioresources

2. Agricultural Bioresources

3. Wetland Bioresources

Dr. Vasudeva. R

Professor and Head Department of Forest Biology
and Tree Improvement University of Agricultural Sciences,
Dharwad College of Forestry, SIRSI campus,
Uttara Kannada, Karnataka 581 401
Email: vasudevar@uasd.in Ph.no +91 9448933680

Chapter 2

Developing Framework for Economic Valuation of Forest Genetic Resources and Bio-Resources under the Access and Benefit Sharing Regime

Introduction:

Forests have been an abode of rich biological diversity and central to the human survival. Forests provide bio-resources to fulfill human needs which include food, fibre, medicine, shelter, fuel and raw material for the industries. Even today, the most-prescribed drugs are derived from various elements of biological diversity. For example, about 25% of all pharmaceutical prescriptions in the USA contain active ingredients derived from forest ecosystems. The study by Grifo et al., (1997) has shown that 57% of the top 150 prescription drugs in US were derived directly or indirectly from biodiversity. Some Non Timber Forest Products (NTFP) such as bamboo, rattan, medicinal plants, and others have large formal markets and are traded both nationally and internationally thereby generating income and employment to forest-dwelling people. Further, forest ecosystems contain many potentially useful new resources. Genetic resources derived from forest ecosystems represent a rapidly growing and highly promising source of new drugs, agricultural products, and other fruits of biotechnology. For instance, ants found in forests may provide novel antibiotics that are important for human medicine, silk from spiders may provide the lightest but high tensile fibre which may be stronger weight-for-weight than steel, etc. Services provided at free of cost by forest ecosystems around the globe are benefiting humankind. Examples include oxygen production, climate control by forests, nutrient cycling, water purification, natural pest control, and pollination of crop plants. In 1997, these services were valued at US$33 trillion per year, almost double the US$18 trillion yearly global national product (Torrance Andrew, 2000).

Although the economic value of the products derived from forest biodiversity (e.g., NTFPs, genes for the development of new crops and biomolecules as a source for the development of new drugs) is difficult to assess, their value has been estimated to

touch many billions of dollars annually. The volume of global medicinal plants market has been estimated at US$ 60 billion per year, growing at a rate of 7% annually. Global demand for herbal products, mostly derived from forest ecosystems in recent years has experienced a quantum jump in volume of plant material traded within and outside the countries of origin. Further, globally, NTFPs generate social benefits and play an important role to improve livelihoods of local communities which are involved in their harvesting, processing and trade.

India is one of the richest countries in the world for forest resources including genetic resources of NTFP species. Nearly half of higher plants documented in India are medicinally active species and comprise of about 8,000 species. About 90% of the medicinal plants, used by herbal industry in India, are collected from the wild source and more than half of these collections involve destructive harvesting. As a result of such exploitative practices combined with excessive collections, many important medicinal plants are becoming endangered or threatened. The economic value of natural products, genetic resources, and biomolecules derived from biodiversity could provide a powerful incentive to conservation in developing world which are the hotspots of biological diversity. It has also been suggested that prospecting for high-value biomolecules could afford poorer countries a unique opportunity to develop their economies (Torrance Andrew, 2000).

Here we try to provide broad framework for the rapid valuation process of the genetic resources in general and bio-resources, derived from the forest ecosystems, focusing on NTFPs, from the ABS viewpoint inparticular. The valuation of ecosystem services is not attempted.

Values and Valuation of Forest Resources

The concept of value is central to any economic valuation, although 'value' itself essentially means different things to different people. The valuation of biological resources varies greatly depending on the perspective of value, economic theory adapted to estimate it, as well as on the assumptions made. Till recently, policy-makers often assumed forests have no economic value unless they are logged or goods collected (Dove 1983). Use values include both direct and indirect values. This typology however is context-specific. 'Direct values' are those derived from direct use or interaction with a biological resource system. They have direct role in consumption and production. For instance, value of 'timber or NTFP' derived from a forest ecosystem forms a direct use. The 'indirect use values' are derived from an non-economic interaction with the resource system and are very important for the production of direct use values. For instance, in a forest ecosystem, a microorganism involved in the litter degradation or an insect involved in the pollination that in turn helps the production of the timber or NTFP would form an indirect value system. These are largely termed as "ecosystem services". Of course the scale at which the biological processes are considered determines the range of such services. More and more indirect values are to be discovered and valued within every forest ecosystem.

There are several advantages of valuation of biological resources. Valuation helps in understanding the bias in the system because of an unscrupulous consumption of the resources and forms a basis for its correction. More importantly it forms the basis for sharing of benefits. Poorly and improperly valued usurpation of resources always leads to poor collective well-being. In recent years, due to increasing conflict over rights and responsibilities for these resources appreciation of the monetary and non-monetary value of biological resources has grown enormously (Gokhale, 2011). Hence valuation is the key in such situations. Unfortunately, economic valuation of forest resources is like an optical illusion, viewing it from different angles can lead to different perceptions (Kate and Laird, 1999).

Although robust methods are employed to estimate value of biodiversity, which may include one or a combination of various econometric methods such as: 1. willingness to pay for on-farm diversity; 2. contingent valuation measure; 3. hedonic pricing; 4. other hedonic approaches; 5. option values; and 6. production losses averted, valuation of forest resources is plagued by inadequate measurement of costs, quantities extracted, and prices. Researchers have produced important case studies, the results of different studies cannot be directly compared because different methods have been adopted. Most such valuations seem to have been an after-thought. More specific information on different valuation methods can be found in the CBD Technical Series 28 "An exploration of tools and methodologies for valuation of biodiversity and biodiversity resources and functions" and the TEEB 2010 report "Ecological and Economic Foundations." (Pascual and Muradian, 2010)

CBD, ABS System and the Scope of Economic Valuation

The Convention on Biological Diversity introduced in 1992 at the United Nations Conference on Environment and Development is a landmark to establish an comprehensive international legal framework for the conservation of global biodiversity. CBD recognizes sovereignty of a nation over its biodiversity and promotes the fair and equitable sharing of the benefits that flow from the utilization of bioresources. The CBD is under the premise that benefits will be generated by the use of natural products and genetic resources to be developed into commercial drugs, products and crops. Many countries have implemented the provisions of CBD by establishing legal / policy regimes governing the access to their biodiversity resources. Its objective is to encourage legal access to genetic resources, promote appropriate transfer of relevant technologies, sharing of the benefits arising from utilization of genetic resources in a fair and equitable way, thereby contributing to the conservation of biological diversity and the sustainable use of its components. The Nagoya Protocol, on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization, is an international agreement under CBD, adopted by the Conference of the Parties to CBD at its tenth meeting on 29 October 2010 in Nagoya, Japan. The protocol envisages the setting up of an international regime on access and benefit sharing of genetic resources, which will lay down the basic ground

rules on how nations shall cooperate in obtaining genetic resources and sharing the benefits arising from their utilization.

Since the purpose of this valuation exercise is to provide broad frame work for the valuation of the forest products from the ABS viewpoint, it is essential to estimate the monitory value of various forest products. This would help in determining the structure of economic instruments to be adopted and determine magnitude of benefit/incentive that could be shared with the people. The ecosystem services offered by the forests is not considered here as it requires still higher level of theory and it may almost be impossible to assign a monitory value to them. The exercise encompasses bioresoureces and genetic resources separately and are viewed differently.

Valuation Forest Genetic Resources: Shopping the Wild

Genetic resources are the materials harboring units of heredity for present or future use as a source of genes to improve a species. These genetic resources are the basis for biotechnology, crop improvement, drug development, development of products for healthcare/food additives/ preservation, crop protection, a myriad of other uses in the industry. One of the earliest rough estimates of global value of these myriad uses of genetic resources was at US $ 500 to 800 billion (Kate and Laird, 1999), which was comparable to that of a petroleum industry or that of the computer hardware industry. However if one considers the use of genetic resources at the subsistence levels of a village, value of the genetic resources could be astronomical. The examples on valuation of genetic resources available today have different basis for valuation and many of them do not disclose the rate of royalties. This creates a strange dilemma while fixing value of genetic resources. For example, a single wild relative of the tomato contributed genetic resources that increased the solids content of processing tomatoes by 2.4%. This has been worth US$ 250 million a year in the state of California alone, because it reduces energy needs in processing (Stolton *et al.,* 2006). Three different wild peanuts have been used to breed commercial varieties resistant to root knot nematodes. It is helping to save peanut growers around the world an estimated $100 million a year *(http://www.unep.org/documents. multilingual / default.asp ? Document ID= 399 & A rticleID =4542 & l=en)*.

Similarly, examples of valuing genetic resources are available as a growing number of countries are establishing legal regimes with respect to access and benefit sharing of forest genetic resources. The Philippines has established an elaborate and strict access regime (Kate and Laird, 1999). A technical secretariat to review and evaluate the proposals for biopropecting as well as for prior informed consent from stakeholders has been established. The fees for the access of bioresources for prospecting is set by the national level board. However benefit sharing arising out of the access to forest resources has not yet been reported from this country. In contrast Costa Rica and Mexico have set up a flexible access regime that encourage bioprospecting agreements as potential sources

of revenue. Often quoted successful example for legal biopropsecting is of the National Biodiversity Institute of Costa Rica (INBio). About 10,000 chemical samples from a variety of Costa Rican organisms were supplied under a legal frame work to Merck & Company, Inc. in return for a $1 million payment, $130,000 worth of modern research equipment, as well as future royalties (at an undisclosed rate) on the total profits of any commercial product successfully developed from the INBio samples. It has successfully developed partnerships with commercial bioprospectors and have received both modest remuneration and the promise of future royalties on successful commercial products developed from their biodiversity (Downes, 1993). Another example at regional level is an agreement known as the Andean Pact Common Regime on Access to Genetic Resources (1996) where, Bolivia, Colombia, Ecuador, Peru and Venezuela have successfully agreed to an common legal regime for granting access agreements for bioprospecting. These examples emphasize the need for the establishment of a key technical secretariat that involves practicing bio-prospecting scientists to evaluate the proposals for bioprospeting and develop guidelines for a benefit sharing on a case by case basis. Its function should encompass assessing the potentiality of the applicant to develop new products vis-a-vis the potentiality of the concerned genetic resource at the global level, arrive at appropriate terms of reference, the magnitude of upfront fees and royalty to be paid by the potential bioprospectors. Since this is a highly technically demanding job it is essential that the scientists of high stature and integrity should be included. The committee should also be empowered to review the earlier cases of biopropecting which otherwise have escaped from sharing the benefit. The following example may depict one such episode.

One of the largest partnerships to pursue a natural product drug discovery programme under the banner of the Queensland Pharmaceutical Research Institute (QPRI) was between the State of Queensland's Griffith University with Astra Pharmaecuticals and other partners from four countries including India (Secretariat of the Convention on Biological Diversity 2008). Based in the UK, AstraZeneca is one of the pharmaceutical giants, ranked number six in 2006 with global sales of $26.7 billion US$. Under this programm, over 45000 biota were collected from partners and from which 200,000 optimised natural product extracts were derived. Today, Griffith University retains the ownership over all the samples collected as part of this partnership. A private company based in Bangalore India, Biocon supplied a collection of approximately 1800 strains of soil fungi between 1996–2000 to this programme (Secretariat of the Convention on Biological Diversity 2008). Whether the company has accessed these genetic resources of India and transferred them to a multi-national company with appropriate protocols under the Biological Diversity Act is however, not clear. It is stated that benefits were accrued to all the collaborators in the partnership—AstraZeneca Griffith University, The Queensland Herbarium, The Queensland Museum, and companies and institutions in China, India, Papua New Guinea, and Tasmania. Benefits included monetary benefits like fees for samples (or to cover the costs of an agreed-upon workplan) and royalties as well as non-monetary benefits including the provision of vehicles, equipment, technology,

training, building of a state-of-the-art natural product discovery unit, and increased knowledge of biodiversity. Further, it is also reported that broader benefits were achieved or may still emerge for the state of Queensland, the Australian research community, the Australian public, and the international community. Although this partnership was forged within the CDB regime to which India is a signatory, the benefit accrued to the state (India) because of this access is still not clear.

Estimates for Annual Markets for Products Derived from Biodiversity (adopted from Kate and Laird, 1999)

Sector	US$ billion) LOW	(US$ billion) HIGH
Pharmaceuticals	75	150
Botanical medicines	20	40
Agricultural produce	300+	450+
Ornamental plants	16	19
Crop protection products	0.6	3
Other biotechnology	60	120
Personal care & cosmetics	2.8	2.8
Rounded total	500	800

Valuation of Non-Timber Forest Product (NTFP) Bio-Resources

NTFP comprises of a wide array of products such as fruits, medicinal plants, gums, resins, dyes, mushrooms, honey, bush meat, etc., derived from equally wide array of plant and animal parts such as leaves, flowers, fruits, seeds, roots, tubers, bark, meat, excreta, bones, etc. The term Non-Timber Forest Products (NTFPs) was perhaps first used by Beer and McDermott (1989) to categorize all biological materials other than timber, which are extracted from forests for human use. According to FAO, NTFPs defined as "all goods for commercial, industrial or subsistence use derived from forest and their biomass". The importance of NTFP came into major attention globally because of the idea that NTFP production and trade had the potential to supply local people with sufficient incomes for livelihood as well as to provide them with incentives to conserve these resources (Nepstad and Schwartzman, 1992). For instance, as much as 50 % of the income of the Soliga Tribe in Chamarajnagar district of Karnataka is dependent mainly on the collection of Lichens, Nelikai (amla) and honey. According to FAO, the total value of world trade in NTFPs was approximately at US $ 1100 million during 1997, and during 2000 the volume of global medicinal plants market (part of NTFP) has leaped to US$ 60 billion per year, growing at a rate of 7% annually. In India an estimated 50 million people are dependent on over 3000 NTFPs for their subsistence and cash income (Hegde *et al.,* 1996). It appears that less 150 species have potentially large markets. Hence analysis of value chains could be the key in NTFP valuation.

The value chains of NTFPs and smallholder agricultural products differ significantly (Table 1). Harvesting of NTFPs often happens from locations that are distant from the home of the collector. As NTFPs are often the product of a range of production strategies carried out by different people, they have complex resource tenure and intricate or often opaque value chains that are difficult to penetrate. NTFP are harvested in very unreliable quantities from very different locations of production due to the biology of the species and vagaries of the weather. In the Western Ghats, for example, the quantities of wild amla produced is influenced by the winter temperature; and that of wild aromatic pickle mango is correlated with unseasonal rainfall during December. Quantity of NTFP gathered by the collectors is also influenced by the competing opportunities from other sources and industrial demand. For instance, the quantities of *Garcinia gummi-gutta* collected and processed has shown huge variation in the last ten years essentially due to varying industrial demand. Further, the whole value chain from production to consumption of NTFP is rarely encompassed in a single enterprise. The key prerequisite for the sustained value chain system of NTFPs is that the collection of sufficient volumes of raw or partially processed material to be collected to make any subsequent processing step more economically viable. The key function determining the ultimate value derived from the NTFP is the industrial level processing.

Table 2. Key differences in the value chains of NTFPs and smallholder agricultural products (adopted from Belcher and Schreckenberg, 2007)

Factor	NTFPs	Smallholder agricultural products
Resource biology	Collection areas for wild harvested NTFPs often distant from the home	Fields usually close to or in walking distance of home
Resource biology	Low density production means bulking-up becomes very important	Cultivation leads to higher density; usually many producers in one area
Resource biology	Usually, wild or relatively unimproved leading to problems of inconsistent quality, sometimes highly dependent on vagaries of the weather	Known varieties and availability of inputs allow for more uniform production
Resource tenure	Insecure tenure over collection areas leads to risk of over-exploitation; inability to manage the resource (to improve quality and/or quantity)	Individual tenure therefore ability to exclude others provides incentive to invest in the resource
Resource – knowledge base	Traditional knowledge only, little formal research	Many staple and minor agricultural products subject of agricultural research and extension programmes

Policy issues	Little relevant policy in support of commercialization; usually restricts harvest and/or transport and sale of NTFPs	Supportive policies in place, including credit provision, extension, research
Market structure	"Thin markets" – often few buyers for the total product from a production area	Many buyers at different scales. Producers have more options for trading.
Market information	Very little available; channeled through intermediaries	Often widely available via radio, parastatals

Following points need to be considered while valuation using different methods:

1. Forests and forest products are highly heterogeneous systems in terms of the bio-physical characteristics of their sites, collection methods and drudgery of processing. Hence the cost estimations of forest products should consider these aspects.
2. Robust sampling is essential, considering the attributes of the forest product collectors such as income of the collectors an essential step. A stratified random sampling to include all the categories may be adopted to while sampling.
3. Year-long collection of data on the extraction is a must to arrive at the right estimates.
4. For a most robust valuation estimations of the total stock quantity of a resource (inventory) in a forest ecosystem and the quantity actually collected annually (flow) should be estimated. The most accurate method of valuing the products extracted is to identify, count, weigh, and measure them as they enter the village/local market each day/season.
5. The most difficult part of valuation is assigning the products a monetary value. Perhaps the best method of valuation is to make use of the prices that exist of the commodity concerned, or that prevail in related markets. Another method could be to use the value of a close substitute with a price. This will require establishing a relative price between the priced and un-priced products, which can be done on the basis of product characteristics. If neither of these methods is feasible, contingent valuation approach could be used where users of the product are asked what is their willingness to pay for the product. Contingent valuation methods have been widely tested in developed countries with strong market traditions.
6. To get an accurate measure of the marginal costs of extracting and processing non-timber tropical forest products, it is essential to compute the cost of the materials used, the labor time directly associated with finding, extracting, processing, and transporting the goods from the forest to the village or to the market, and the temporal cost of resources-the benefits forgone by delaying the sale or the use of the good.

Broad Frame work for the Rapid Assessment of Value Chain of NTFP

1. *Identify potential NTFP species of a region and estimate the stock quantities available (density) and spatial distribution in a region such as the Western Ghats.*

   Local, national, and global data sources could be used to arrive at the potential NTFP and stock densities. For instance the database on NTFP bio resources developed under the initiation of National Bioresource Development Board (NBDB), of the Department of Biotechnology, New Delhi could be used (Ganeshiah et al., 2012; www.ibin.com) This national initiative was broadly aimed at: a) quantitatively assessing the geographic distribution and population status of the plant resources of the Western Ghats, b) identifying the threats to these plant resources and c) setting up a Western Ghats eco-region specific database of plant resources. In this multi-institution network project was initiated by the DBT, New Delhi in the year the following institutes of Karnataka participated:. UAS,Bengaluru, UAS Dharwad; Ashoka Trust for Research in Ecology and the Environment (ATREE), Bengaluru; and College of Forestry, Ponnampet were involved in this massive exercise of mapping the Western Ghats. A survey of 3132 grids, each of 6.25 km x 6.25 km geographical area, undertaken in the project perhaps represents one of finest-scale vegetation survey of any hotspot of biological diversity in the world. This is the largest primary data ever assembled on the Western Ghats vegetation in the Indian history. All major forest types available in the Western Ghats have been sampled. Apart from such primary data on resources, several other secondary data sets could also be used for this purpose.

2. *Derive the estimate of extractions of NTFPs using the primary and secondary data.*

   Local, national, and global data sources could be used to arrive the at annual flows. Recently Ved and Goraya (2007) have reported that of the 960 traded medicinal plant species of India, 178 species are extracted in volumes exceeding 100 Metric Tonnnes per year, with their consolidated consumption accounting for about 80% of the total industrial demand of all botanicals in the country. About 93 species are solely sourced from the forests (see Annexure 2). These highly traded species may be focused first.

3. *Categorize the NTFP into those that are declared as endangered due to habitat destruction / high extraction and restrict the extraction from the forest ecosystems.*

   Several agencies have suggested the list of endangered species (please see the annexure). A separate list of "endangered species of NTFP" could be prepared and all activities may be banned including the extraction from natural habitats.

4. *Categorize the NTFP that are not endangered, based on the value of the ultimate product and scale of their use as High Value and Low value*

   For example *Nothapodytes nimmoniana (Mappia foetida), Garcinia gummi-gutta* merit as the high value NTFPs since the products derived have high value as well as larger market. An attempt to prioritize the species of Garcinia is provided in the Box 2.

Hence the board may notify a list of species for which the value chain need to be understood on priority.

5. *Exclude all NTFP that are collected in small quantities, by less number of people and for subsistence level under from ABS mechanism.*

   A separate list of "traditionally used NTFP" may be prepared and temporarily exempted from ABS system.

6. *Conduct a participatory rapid assessment of the value chain to arrive at the links, actors and magnitude of change in the value of the product from raw material to the ultimate product.*

7. *Use appropriate economic instruments such as export tax (for export oriented NTFP), CESS / Access fee (for those with high extraction but locally used NTFPs).*

An example of the categorization has been provided which needs to be debated

Value of the NTFP	Domestic market	International market	Domestic market + International market
High Value	Cess Access fee Direct Market Price : Auctioning	Access fee Export Tax CESS International Market price	Access fee Export Tax Cess Direct Market Price : Auctioning
Low Value	Cess Access fee Direct Market Price : Auctioning	Access fee Export Tax CESS	Access fee Export Tax Cess Direct Market Price : Auctioning

Conclusions and Recommendations

In this exercise rapid valuation process of the genetic resources in general and bio-resources (NTFPs), from the ABS viewpoint is attempted. The valuation of ecosystem services is not considered. The economic value of natural products, genetic resources, and biomolecules derived from biodiversity could provide a powerful incentive to conservation in biodiversity rich India. Unfortunately there is hardly any example in the country wherein the valuation of genetic resources is done as a source of deriving incentives for conservation. There is a need for the establishment of a key technical secretariat that involves practicing scientists to evaluate the proposals for bioprospeting (both for bio molecules and genes) and develop guidelines for a benefit sharing on a case by case basis. Its function should encompass assessing the potentiality of the of the applicant to develop new products vis-a-vis the potentiality of the concerned genetic resource at the global level, arrive at appropriate terms of reference, the magnitude of upfront fees and royalty to be paid by the potential bioprospectors. A generalized broad frame work for the Rapid Assessment of Value Chain of NTFP has been suggested, which needs to be tested in a few high value NTFPs. Estimation of stock quantities

(density) annual flow using databases is suggested. Excluding all the NTFP species that are endangered/used in very low quantities for the from the ABS is suggested. Based on a participatory mode the value of the ultimate product could be categorised as high value and low value. Use appropriate economic instruments such as export tax (for export oriented NTFP), CESS / Access fee (for those with high extraction but locally used NTFPs) is suggested. The key function determining the ultimate value derived from the NTFP is the industrial level processing.

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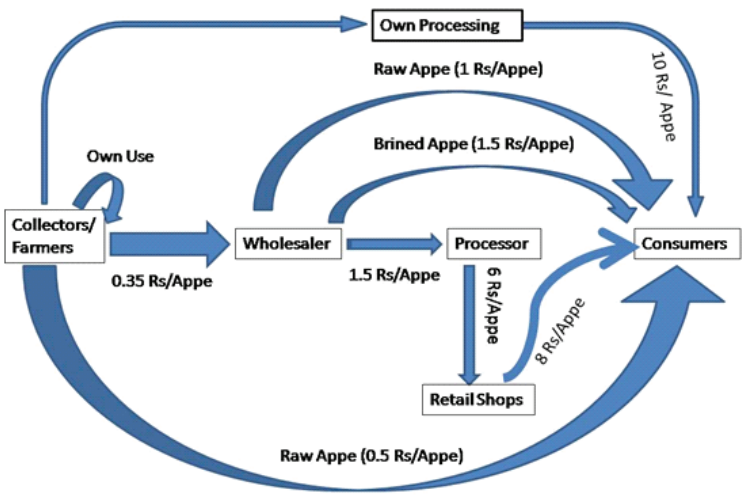
BOX 1

A Glimpse of Value Chain of Aromatic Pickle Mango-Appe Midi (Mangifera Indica)

Wild-Aromatic Pickle Mango (WPM), popularly called the '*appemidi*' in Kannada, is a delicacy in the central Western Ghats region of India because of its unique effervescent aroma. Locals relish the pickles made of these immature fruits as an integral part of every single meal. This distinctive fruit is sour and bitter with aromas so unique and variable that they can range from that of cumin seeds to that of camphor. When collected from the riverine habitats and sold in local market, WPM is a major source of income for the rural landless poor. Fully matured good type WPM (small sized, elongated, highly aromatic fruit which has at least two years of shelf life) tree can potentially provide an income of between Rs. 25,000 to 50,000 (about 550 US$ to 1,100 US$) to a collector in a season.

Value chain is essentially a sequence of value-addition activities brought out by various players right from harvesting of a resource till it reaches the ultimate consumer (Kaplinsky and Morris, 2002). It involves range of activities such as harvesting, processing, storage, transport, marketing and financing. These activities create employment / livelihood opportunities to the rural and peri-urban masses. Typically harvesters, middlemen, traders, processors and distributors, etc. are involved in a chain. In a wild harvested resource such as pickle mango, the chain starts at the harvesting and in a typical chain ends when the pickle is sold to the consumer. The value of the product increases at every link of the chain, though not symmetrically and uniformly. Generally, in case of wild harvested NTFPs, these chains are invisible, partially known or not apparent. Analysizing such chains is essential to identify the key players, understand how value is created and how volume changes occur at every step. Most importantly it helps in understanding the constraints and opportunities for intervention in a chain. Terminology such as 'supply chain analysis' and 'market chain analysis' are used sometimes interchangeably used with value chain analysis. Value chain analysis could be done at very elaborate scale to the local scale depending on the situation.



To study the value chain system of WPM, 5 different villages, a structured questionnaire was adopted. Survey was done in farmers of different income level which ranges from 50,000 – more than 3,00,000 Rs. per annum. It is noticed that 80% of the households were depending on the forest for the extraction of *Appe midi*. It is observed that tender fruit of *MI* were marketed at the

rate of 60-80rs per kg. In recent year there is high demand for some of the special varieties viz., *Tuduguni appe, Jeerige midi, haladota appe, nandagara appe, Maanibhatta, Anantabhatta, Maalanji etc.* These varieties sold at the rate 150-200rs per kilo. Price is also increasing gradually and it is encouraging farmer to grow in their farm/home-garden. On an average, collectors/farmers are found to be collect 300-500kg of tender fruit per year and sell it. Processors are taking the raw materials directly from growers and occasionally from the market. This is marketed for 500rs per kg.

BOX 2

Prioritizing Garcinia Bio-resources for Value Chain Assessment

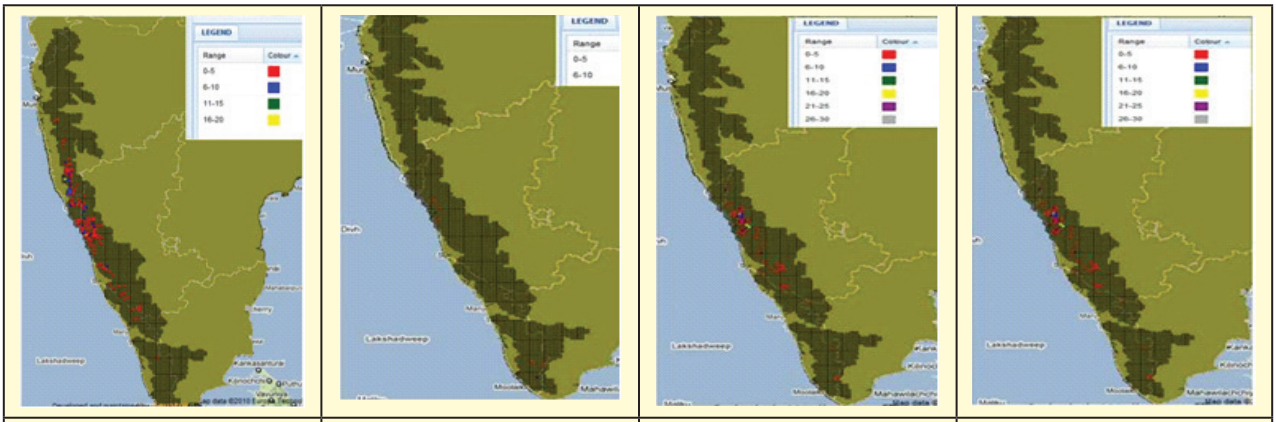
Prioritizing of different species of Garcinia of the Western Ghats for rapid value appraisal considering stock density, level of extraction, plant parts extracted, product value based on the market.

Sl. No.	Species of Garcinia	Stock Density in the Western Ghats* (Stock)	Extraction Level (Flow)	Plant part extracted (Vulnera bility due to extraction)	Product Value (perceived based on product range and usage)	Priority for Value Chain Analysis
1	*Garcinia darwiniana* K.R.K. S.N.Yoga. K.Vasu	Very Low	NIL	-	NIL	NC
2	*Garcinia gummi-gutta (L.)* Robson.	High	High	Fruit+Seeds	Very High	HIGH
3	*Garcinia imbertii* Bourd.	Low	NIL	-	NIL	NC
4	*Garcinia indica* (Thouras) Choisy	High	High	Fruit+Seeds	Very High	HIGH
5	*Garcinia morella* (Gaertn.) Desr.	High	Moderate	Fruit/latex / seed	Medium	MODERATE
6	*Garcinia pictorius* (Roxb.) D'Arcy	Low	NIL	-	NIL	NC
7	*Garcinia rubro-echinata* Kosterm.	Very Low	NIL	-	NIL	NC
8	*Garcinia spicata* (Wight & Arn.) Hook. f.	Very Low	Negligible	Fruit+Seeds	Negligible	NC
9	*Garcinia talboti* Raiz. & Sant.	Moderate	Low	Fruit/Latex	LOW	LOW
10	*Garcinia travencorica* Bedd.	Very Low	Negligible	Fruit	Negligible	LOW
11	*Garcinia wightii* T. Andr.	Low	NIL	-	NIL	LOW
12	*Garcinia xanthochymus* J. Hk. ex T. And.	Moderate	Moderate	Fruit	Medium	MODERATE

* based the Western Ghats bio-resource database (see map below for a few species).

NC = not considered

Thus among the dozen species of the Garcinia found in the Western Ghats of Karnataka, only two species merit the high priority value chain analysis, two species with moderate priority and two with low priority, the other six species are not considered for the value chain analysis. The high priority species could be focused for the value chain analysis.



G. indica	*G.spicata*	*G. talbotii*	*G. morella*

Spatial distribution map of stocks of four species of Garcinia in the Western Ghats. Areas that have large densities may be focused first for the implementation of the ABS

Annexure 1

Red listed Non-Timber species in the Western Ghats (including IUCN and Red Data Book of India and other sources)

Sl. No.	Species	Status	Endemicity
1	*Acorus calamus*	Vulnerable	Non-Endemic
2	*Adenia hondala*	Vulnerable	Non-Endemic
3	*Adhatoda beddomei*	Critically Endangered	Endemic
4	*Aegle marmelos*	Vulnerable	Non-Endemic
5	*Ailanthus malabarica*	Vulnerable	Non-Endemic
6	*Amorphophallus campanulatus*	Vulnerable	Non-Endemic
7	*Ampelocissus araneosa*	Vulnerable	Endemic
8	*Ampelocissus indica*	Endangered	Non-Endemic
9	*Aphanamixis polystachya*	Vulnerable	Non-Endemic
10	*Aristolochia tagala*	Vulnerable	Non-Endemic
11	*Artocarpus hirsutus*	Vulnerable	Non-Endemic
12	*Baliospermum montanum*	Vulnerable	Non-Endemic
13	*Buchanania lanzan*	Lower Risk Least Concern	Non-Endemic

14	*Calophyllum apetalum*	Vulnerable	Endemic
15	*Canarium strictum*	Vulnerable	Non-Endemic
16	*Cayratia pedata*	Critically Endangered	Endemic
17	*Celastrus paniculatus*	Vulnerable	Non-Endemic
18	*Chonemorpha frgrans*	Endangered	Non-Endemic
19	*Cinnamomum macrocarpum*	Vulnerable	Endemic
20	*Cinnamomum riparium*	Vulnerable	Endemic
21	*Cinnamomum sulphuratum*	Vulnerable	Endemic
22	*Cinnamomum wightii*	Endangered	Endemic
23	*Commiphora wightii*	Vulnerable	Non-Endemic
24	*Coscinium fenestratum*	Critically Endangered	Non-Endemic
25	*Curcuma pseudomontana*	Vulnerable	Endemic
26	*Cycas circinalis*	Critically Endangered	Non-Endemic
27	*Decalepis hamiltonii*	Endangered	Endemic
28	*Diospyros candolleana*	Vulnerable	Endemic
29	*Diospyros paniculata*	Vulnerable	Endemic
30	*Dipterocarpus indicus*	Endangered	Endemic
31	*Drosera indica*	Endangered	Non-Endemic
32	*Drosera peltata*	Endangered	Non-Endemic
33	*Dysoxylum malabaricum*	Endangered	Endemic
34	*Elaegnus conferta*	Lower Risk Least Concern	Non-Endemic
35	*Embelia ribes*	Vulnerable	Non-Endemic
37	*Embelia tsjeriam-cottam*	Vulnerable	Non-Endemic
38	*Embelia tsjeriam-cottam*	Vulnerable	Non-Endemic
39	*Eulophia cullenii*	Critically Endangered	Endemic
40	*Garcinia gummi-gutta*	Lower Risk near threatened	Endemic
41	*Garcinia indica*	Vulnerable	Endemic
42	*Garcinia morella*	Vulnerable	Non-Endemic
43	*Garcinia travancorica*	Endangered	Endemic
44	*Gardenia gummifera*	Vulnerable	Non-Endemic
45	*Gloriosa superb*	Vulnerable	Non-Endemic
46	*Glycosmis macrocarpa*	Vulnerable	Endemic
47	*Gymnema khandalensis*	Endangered	Endemic
48	*Gymnema montanum*	Endangered	Endemic
49	*Hedychium coronarium*	Lower Risk near threatened	Non-Endemic
50	*Heliotropium keralense*	Critically Endangered	Endemic
51	*Heracleum candolleanum*	Vulnerable	Endemic
52	*Holostemma ada-kodien*	Vulnerable	Non-Endemic
53	*Humboltia vahliana*	Endangered	Endemic

54	*Hydnocarpus alpina*	Vulnerable	Endemic
55	*Hydnocarpus macrocarpa*	Endangered	Endemic
56	*Hydnocarpus pentandra*	Vulnerable	Endemic
57	*Janakia arayalpathra*	Critically Endangered	Endemic
58	*Kaempferia galanga*	Critically Endangered	Non-Endemic
59	*Kingiodendron pinnatum*	Vulnerable	Endemic
61	*Madhuca longifolia*	Vulnerable	Non-Endemic
62	*Michelia champaca*	Endangered	Non-Endemic
63	*Michelia nilagirica*	Vulnerable	Endemic
64	*Moringa concanensis*	Lower Risk Least Concern	Non-Endemic
65	*Myristica dactyloides*	Lower Risk/conservation dependent	Endemic
66	*Myristica fatua var. magnifica*	Endangered	Endemic
67	*Myristica malabarica*	Vulnerable	Endemic
68	*Nilgirianthus ciliatus*	Endangered	Endemic
69	*Nothapodytes nimmoniana*	Vulnerable	Non-Endemic
70	*Ochreinauclea missionis*	Vulnerable	Endemic
71	*Oroxylum indicum*	Vulnerable	Non-Endemic
72	*Paphiopedilum druryi*	Critically Endangered	Endemic
73	*Plectranthus nilgherricus*	Endangered	Endemic
74	*Piper barberi*	Critically Endangered	Endemic
75	*Piper longam*	Endangered	Non-Endemic
76	*Piper mullesua*	Critically Endangered	Non-Endemic
77	*Piper nigrum*	Lower Risk Least Concern	Endemic
78	*Plectranthus vetiveroides*	Extinct in the wild	Non-Endemic
79	*Pseudathria viscida*	Vulnerable	Non-Endemic
80	*Pterocarpus santalinus*	Endangered	Non-Endemic
81	*Pueraria tuberosa*	Critically Endangered	Non-Endemic
82	*Rauvolfia serpentina*	Endangered	Non-Endemic
83	*Salacia chinensis*	Vulnerable	Non-Endemic
84	*Salacia oblanga*	Endangered	Endemic
85	*Santalum album*	Vulnerable	Non-Endemic
86	*Saraca asoca*	Endangered	Non-Endemic
87	*Schrebera swieteniodes*	Vulnerable	Non-Endemic
88	*Shorea tumbuggaia*	Critically Endangered	Endemic
89	*Sterculia urens*	Vulnerable	Non-Endemic
90	*Swertia corymbosa*	Vulnerable	Endemic
91	*Swertia lawii*	Endangered	Endemic
92	*Symplocos racemosa*	Vulnerable	Non-Endemic

93	*Syzygium travancoricum*	Critically Endangered	Endemic
94	*Tragia bicolor*	Vulnerable	Endemic
95	*Terminalia arjuna*	Lower Risk near Threatened	Non-Endemic
96	*Trichopus zeylanicus*	Endangered	Endemic
97	*Ulteria salicifolia*	Critically Endangered	Endemic
98	*Valeriana leschenaultia*	Critically Endangered	Endemic
99	*Vateria indica*	Vulnerable	Endemic

Annexure 2

High Value Traded Medicinal Plant Species sourced from Tropical Forests (Adopted from Ved and Goraya, 2007)

Acacia catechu (Katha), *Acacia nilotica* (Babool), *Acacia sinuata* (Shikakai), *Aegle marmelos* (Bael), *Albizzia amara* (Cheroola), *Alstonia scholaris* (Saptaparni), *Anogeissus latifolia* (Dhawada), *Asparagus racemosus* (Shatavari), *Baliospermum montanum* (Dantimool), *Bombax ceiba* (Simal), *Boswellia serrata* (Salai guggul), *Buchnania lanzan (Chironji), Butea monosperma* (Tesu phool), *Careya arborea* (Vaai kumbha), *Cassia fistula (Amaltas), Celastrus paniculatus* (Malkangani), *Chlorophytum tuberosum* (Safed musali), *Cinnamomum sulphuratum* (Dalchini), *Clerodendrum phlomides* (Arnimool), *Coscinium fenestratum* (Maramanjal), *Cyclea peltata* (Paadu kizhangu), *Decalepis hamiltonii* (Magali), *Desmodium gangeticum* (Salparni), *Embelia tsjerium-cottam (Vai-vidang), Emblica officinalis* (Amla), *Garcinia indica* (Kokam), *Gardenia resinifera* (Dikamali), *Gmelina arborea* (Gambar Chhal), *Gymnema sylvestre* (Gudmar), *Helicteres isora* (Marod phali), *Holarrhena pubescens (Kutja), Holoptelea integrifolia* (Aavithali), *Holostemma ada-kodien* (Jeevanti), *Ipomoea mauritiana* (Palmudhukkan kizhangu), *Ixora coccinea* (Thechippoovu), *Lannea coromandelica* (Jhinganjingini), *Litsea glutinosa* (Maida chhal), *Lobelia nicotianaefolia* (Lobelia leaves), *Madhuca indica* (Madhuka), *Messua ferrea* (Nagakesar), *Mimusops elengi* (Bakul), *Morinda pubescens* (Manjanathi), *Mucuna puriens* (Kaunch beej), *Nilgirianthus ciliatus* (Kurinji), *Operculina turpethum* (Nishoth), *Oroxylum indicum* (Tetu chhal), *Premna serratifolia (Arnimool), Pterocarpus marsupium (Vijaysaar), Pterocarpus santalinus* (Rakta chandan), *Rauvolfia serpentina* (Sarpagandha), *Rubia cordifolia* (Manjishtha), *Santalum album (Chandan), Sapindus mukorossi* (Reetha), *Saraca asoca* (Ashoka Chhal), *Schrebera swietenioides* (Ghanti phool), *Semecarpus anacardium* (Balave), *Shorea robusta* (Raal), *Smilax glabra* (Chopchini), *Soymida febrifuga* (Rohan), *Sterculia urens* (Karaya), *Stereospermum chelonoides* (Patala), *Strychnos nux-vomica* (Kuchla), *Strychnos potatorum (Nirmali), Symplocos racemosus* (Lodh pathani), *Terminalia arjuna* (Arjan), *Terminalia bellirica (Behra), Terminalia chebula* (Harda), *Vateria indica* (Manda dhoopa), *Wrightia tinctoria (Inderjau), Ziziphus xylocarpus* (Ghonta phala)

Dr. M. D. Subash Chandran

Consulting Scientist, Centre for Ecological Sciences,
(Indian Institute of Science, Bangalore)
CES Field Station, Gandhinagar, Kumta- 581343, Karnataka
Email: subhashc@iisc.ac.in; mdschandra@yahoo.com

Chapter 3

ANANTMOOL - *Hemidesmus indicus* (l.) r. br. - The case study of a promising medicinal herb & need for re-organizing collection and trade under the provisions of the Biological Diversity Act-2002

Introduction

Since time immemorial medicinal plants have been used by the humans world over, exclusively for medicine or, in many cases, as 'nutraceuticals' serving purposes of nutrition and medicine. The global pharmaceutical industry is currently witnessing phenomenal growth, through active production of drugs, the cues for such growth mainly got from the growing literature on indigenous herbal medicine, with hardly any instances of the industry sharing the gains with the practitioners of the latter. The pharmaceutical industry, as in India, had shown utter disregard for conservation and sustainable use of medicinal plants exploited from natural ecosystems, traded in bulk by contractors, middlemen and marketing giants; nor has it *suo motto* shared the gains with the traditional knowledge (TK) holding individuals or societies, posing challenges to the Indian Biodiversity Act-2002, often dragging the State Biodiversity Boards (SBBs) into litigation processes, which the latter are ill-equipped to cope up with currently. The successful implementatation of the BD Act itself has become a complex task in the absence of comprehensive documentation, species-wise, on every aspect of commercially exploited elements of biodiversity, a basic necessity for its troublefree implementation.

This article is an effort to build up a comprehensive foundation for 'Anantmool' *(Hemidesmus indicus),* a celebrated Indian medicinal plant highlighting its distribution, associated TK, as inherent in the forest tribes and rural communities, and as recorded in the Ayurvedic texts. It is an effort to also unravel the probable contributions of ethomedicine using *H. indicus,* towards Ayurveda, by bringing out the similarities in uses, presuming that the indigenous medical systems evolved, along with human civilizations, much before the documentation and codification processes began. The process of benefit sharing with the original TK holders hardly existing, even the codified

Ayurvedic system in India, never parted its gains with the hereditary practitioners of folk medicine. As a consequence, and also due to the non-lenience shown by the Indian Medical Acts towards the folk practitioners, the ethno-medical systems are weakening and fading away, as the younger generation particularly does not wish to continue the legacy from the shadows of legitimacy (Chandran, 2016).

The BD Act, 2002 acclaims India as "rich in biological diversity and associated traditional and contemporary knowledge systems," and in consistence with UN Convention on Biological Diversity, 1992, promulgates "conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the benefits of utilization of genetic resources." The "benefit claimers" are the "conservers of biological resources, their byproducts, creators and holders of knowledge." The benefits arise from "commercial utilization," of a bioresource. In the case of the target species, *H. indicus* commercial utilization would mean mainly, uses as "drugs, food flavours, fragrance, cosmetics and extracts" etc.

Considering India's global status as a Mega-diversity country, most SBBs are facing the challenges of systematic documentation of biodiversity. Fulfilling the major objectives of the Act necessitates tracing of the trade links, a minimum need for the SBBs and the local level Biodiversity Management Committees (BMCs). The deficiency in comprehensive documentation of the target species is yet another hurdle facing the SBBs, towards implementation of the Act, especially on aspects of sustainable utilization and sharing of the benefits. Species-wise database creation is a major task, beyond the practical limitations of BMCs, where, the deployment of experts becomes necessity. Such laxity, while causing our biodiversity rich Nation major economic losses, will also inflict serious damages to the bioresources through unregulated harvests. As every single bioresource of commercial potential is a critical and basic necessity, the Karnataka Biodiversity Board's (KBB) current mission towards creation of focused work on few tradeable bioresources is laudable and hopefully set the model for more such detailed expositions to come.

While scanning through substantial amount of scattered literature on *H. indicus* covering ethno-biology and Ayurvedic literature efforts have been made towards validating the traditional usages through review of recent scientific research on the species. Data on the species from karnataka is scanty in comparision to many other parts of the country. This is despite the fact that its uses are widespread in the State and raw materials are exported as air cargo from the Banaglaore airport, although the bulk movements through road are yet untraced. While not reported as an NTFP of note from the State, the pharmaceutical companies and marketing agencies are making merry out of the business involving raw materials and finished goods, as their catalogues are flush with advertisements and rates for *H. indicus* using products.

HEMIDESMUS INDICUS (L.) R. Br. BOTANY AND ECOLOGY

Hemidesmus indicus (Kan: Sogadeberu; Sugandhiberu; Mal & Tamil: Nannari; Telugu: Sugandhipala; San, Hindi: Sariva, Anantmool) a latex bearing, slender, perennial, undershrub is widespread in the India- Sri Lanka region and Southeast Asia. Belonging to the family Apocynanceae (earlier of Asclepiadaceae), *H. indicus* is widespread in the Indian plains and the coast and in the mountains up to a height of 600 m, further beyond not exceeding 1000 m. Preferring drier tracts, including the ravines of Chambal River in Rajasthan, and in the Aravalli Ranges of north Gujarat-Rajasthan the species avoids growing under the dark canopies of evergreen forests. Sloppy and undulating terrain are preferred habitats and being light loving occurs more in sparsely wooded terrain twining on bushes and trees. It is commoner in the ground flora of deciduous forests, and occurs also in scrub and savanna; in pockets of soil on rocky hills and in abandoned dry fields. In the Western Ghats it occurs along the edges of evergreen-semi-evergreen forests, in the scrub jungles, on hedges and in the ground flora of tree plantations. Sea coast, proper estuarine and water logged habitats do not support the species (Singh, 1988; Shiddamallayya et al., 2010; Modi & Mathad, 2016). Venkatesh (2017) lists it as a "forest weed" in Hassan and Kodagu districts.

The slender but strong roots of *H. indicus* (diameter less < 1cm) are pleasant to smell and sweetish in taste. The stem bark is purplish brown. Simple leaves in opposite pairs are elliptic–oblong to linear–lanceolate, sometimes variegated, and dark green above and duller beneath. Small flowers, purplish to yellow, occur in axillary, compact, nearly stalkless cymes. Fruits are slender, terete, long, pointed follicles in pairs. On dehiscence numerous seeds, small, light and flat, with tufts of silky hairs favouring wind dispersal emerge. Seed maturity is timed with dry weather **(Figs. 1 & 2).**

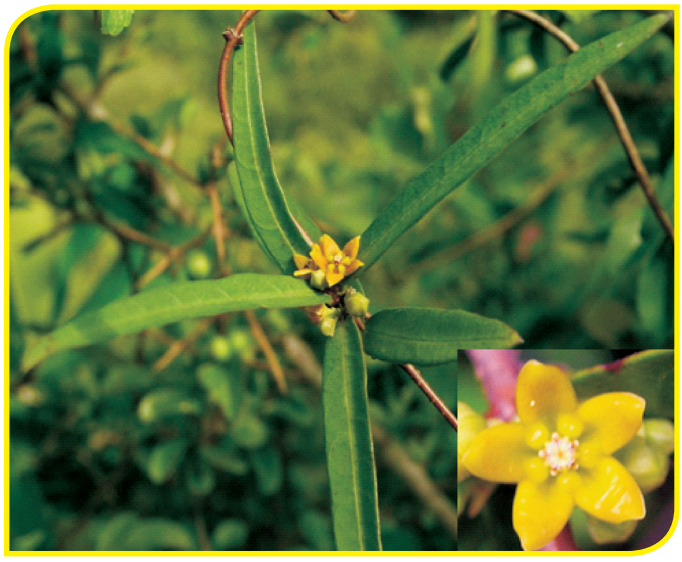


Fig.1 (L): Hemidesmuc indicus creeper in flowers (inset: flower enlarged)

Fig.2 (R): Dried roots, the marketed raw material

The National Medicinal Plants Board (NMPB) includes *H. indicus* among 140 "Prioritized Medicinal Plants for Development and Cultivation" under Centrally Sponsored Scheme of National Mission on Medicinal Plants (Ayush.gov.in/sites/ default/files/ Annexure%20IV_1.pdf). Currently the cultivation of it is more in the Deccan region and reported as increasing. It can be grown with less investment and care, less risks and minimal irrigation and bear less risks from pests and diseases. Being deep rooted its planting could improve degraded forest lands. In Andhra Pradesh, the NMPB provided 30% of expenditure as subsidy to farmers for growing it (Ramadevi et al., 2017).

The National Botanical Research Institute, Lucknow recommends *H. indicus* for humus rich, slightly alkaline (pH of 7.5–8.5), loam to silt-clay loam soils. Stem and rootstock cuttings of over one-year-old plants can be used to raise planting stocks in nursery, the rootstock having better sprouting and survival. While Warrier et al. (2000) found 95% germination of seeds, the performance of stem and root cuttings were not satisfactory. Rao et al. (2000) reported enhanced rooting of *H. indicus* when treated using the 'quick dip' method in different concentrations of rooting hormones (IBA, IAA, NAA). The cuttings are planted in polythene bags or styrofoam trays. Roots sprout in 30–45 days; shade nets may be used in summer months. About 28 000 rooted cuttings are required for planting in 1 hectare of land.

Planting is recommended with the onset of rains, in ploughed, harrowed and leveled plots; rooted plantlets at 3-5 leaved stage are planted in pits of 30 cm × 30 cm × 30 cm at spacing of 60 cm. About 1–2 kg of farmyard manure, mixed with soil and sand in equal quantities, is used to fill the pits. Sand increases soil porocity and aeration while facilitating easier removal of roots. Being a climber intercropping in orchards is also good. Weeding is done at regular intervals. Organically raised plants are preferred for pharmaceutical industries. While minimal irrigation may be required when rains fail, once established, the plants do not need watering. Crop gets mature (with root maturity), after a period of two-and-a-half years. Roots are dug out in December and January; some part of the root left in the soil facilitates regeneration. The harvested roots are washed, shade-dried, stored moisture-free and packed for marketing. Root yield per ha could be approximately 1.2 tonnes. Quoted from http://e-charak.in/echarak/ templates/Hemidesmus)

MEDICINAL USES

H. indicus tops a list 49 medicinal plant species from India being used in the treatment of at least 34 diseases followed by *Aegle marmelos with 31 Phyllanthus emblica, 29, Gloriosa superba, 28, and Solanum nigrum* 27 medical applications (Kala et al., 2006). NMPB considers it as "highly traded one from tropical forests" (Saha et al., 2003). The popularity it enjoys among rural communities and forest tribes may be guessed from its over 200 vernacular names, 109 names in Tamil itslef, followed by Kannada (43) and Sanskrit (41) (envis.frlht.org/ frlhtenvis.nic.in). Tamil Nadu, probably, is the largest

producer, user, trader and exporter of *Nannari*. *Nannari* extract sherbet is most popular indigenous soft drink of South India. Karnataka although likely to be one of the best growth centres for *H. indicus,* it has'nt gained deserving recognition unlike in other southern states. Not much is done to estimate its growth centres, production and trade, all being largely unaccounted would be causing much loss to the State and to TK holder communities

Anantmool in Indian ethnobotany

Weissner (2014) extolled Anantmool's rising popularity in the US consumer market. The plant gained entry into European medicine way back in 1831 (Greenish, 1899). Western pharmacopeia is closely following clinical/biomedical trials proving of the herb's potential for novel treatments, and as preventatives for cancer, diabetes, and cardiovascular diseases. Having gone through over 100 animal and laboratory studies since the 1960's Weissner (2014) defends the traditional medical uses. Notable information gathered on Anantmool's ethno-medical uses are given in the Table 1.

Table 1: Ethnobotanical applications of *H. indicus* for healthcare in India

User group/ community	Locality & State	Disease/ health problem	Part used-mode	Reference
Irula tribe	Kanchipuram, Thiruvellore dist. TN	Anaemia	Root decoction	CPREEC, Chennai
Mullukuruma tribe	Waynad, Kerala	Anaemia	Root paste/ decoction consumed	Silja et al., 2008
Folk medicine	Western Karnataka	Anaemia	Roots	Shiddamallayya et al. (2010)
Rajgond tribe	Bidar dist., Karnataka	Asthma, respiratory problems	Roots	Pooja & Vidyasagar, 2015
Ethno-medicine	Hassan dist., Karnataka	Asthma	Roots	Kumar& Shidda-mallaih, 2016
Tribes	Chittoor Dist., A.P.	Chronic cough in children	Root decoction with milk & sugar	Vedavathi et al., 1997
Kani tribe	South Kerala	Cough	Root juice consumed	Vijayan et al., 2006
Malamasar tribe	Parambikulam, Kerala	Cough – children's	Root paste with sugar	Yesodharan & Sujana, 2007
Irular tribe	Nilgiris, TN	Body pain	Root cream applied	Selvam et al., 2000.

Various tribes	Eastern Ghats, Vizianagram dt., AP	Joint pain	Roots	Parijatham et al., 2016
Ethno-medicine	Tamil Nadu	Rheumatism	Whole plant (?)	Ayyanar, 2013
Ethno-medicine	Belgahna region, Bilaspur dt., Chattisgarh	Rheumatic pains	Leaf & root juice	Singh et al., 2017
Santhals	Sundarbans, W. Bengal	Blood purification	Roots	Majumdar & Sana, 2015
Local tribes	Mayurbhanj dt., Orissa	Blood purification	Powdered roots	Rout et al., 2009
Ethno-botanical	Hassan dt., Karnataka	Blood purification	Roots	Ravikumar & Theerthavathy, 2012
Kani tribe	Thodu hills, Thiruvananthapuram, Kerala	Blood purification	Roots	Xavier et al., 2014
Various tribes	Eastern Ghats, Vizianagaram dt., AP	Blood purification	Roots	Parijatham et al., 2016
Village communities	Meerut, UP	Blood purification	Root decoction	Tomar, 2009
Local tribes	Dhenkanal dt. Orissa	Blood purification	Roots	Mohanty et al., 2015
Irular tribe	Nilgiris	Body coolant	Root powder with sugar	Selvam et al., 2017
Soliga tribe	BR Hills, Chamarajanagar dist. Karnataka	Body coolant for burning sensation	Roots	Gireesha and Raju, 2013
Ethno-medicine	Hassan dt., Karnataka	Body coolant for burning sensation	Roots	Kumar & Shiddamallayya, 2014
Ethno-medicine	TN	Body coolant, Fever	Whole plant	Ayyanar, 2013
Ethno-medicine	Kanchipuram, TN	Body coolant,	Extract of whole plant	Muthu et al. (2006)
Yanadi tribe	Chandragiri forest, Chittoor dt., AP	Body coolant, controls sweating	Root powder in water	Savithramma et al, 2016
Tribes	Jharkhand	Fever	Roots	Singh, 2008
Baigas	Amarakantak Bio-Reserve, M.P	Fever	Roots (?)	Kapale, 2012
Santhals	Sundarbans, W. Bengal	Fever	Roots	Majumdar & Sana, 2015
Tribes	Nanded dt., Maharashtra	Fever	Roots	Holmukhe & Antwal, 2018

Paliya tribe	Idukki dt., Kerala	Fever	Decoction of entire plant	Mathew et al., 2016
Malamasar tribe	Parambikulam, Kerala	Fever	Root paste applied on forehead	Yesodharan & Sujana, 2007
Irula tribe	Walayar valley, Palghat dt (Kerala), Coimbatore dt. (TN)	Fever	Root decoction consumed	Venkatachalapathy, et al., 2016
Irulas & Soliga tribes	Sathyamangalam, Erode dt, TN	Fever	Decoction of whole plant	Poongodi et al., 2011
Ethno-medicine	Goa	Fever, cold	Entire plant	Rodrigues, 2015
Tribes & others	Vishakhapatanam	Fever	Root paste in hot water	Padal et al., 2014
Ethno-botanical	Coastal Karnataka	Herpes	Roots for herbal therapy	Bhandary & Chandrasekhar, 2011
Various tribes	Eastern Ghats, Vizianagaram dt; AP	Herpes	Roots	Parijatham et al., 2016
Forest tribes	Papikondlu WLS, Eastern Ghats, AP	Herpes	Paste of roots with those of few other sp. applied	Rao et al., 2016
Rural women	Chikkanaikanahally tk; Tumkur dt. Karnataka	Jaundice	Leaves crushed with cardamom and jaggery used	Lavanya & Pattar, 2017
Ethno-medicine	Western Karnataka	Jaundice	Roots	Shiddamallayya et al. (2010)
Ethno-botanical	Bangladesh	Jaundice, Hepatitis	-	Rahim et al., 2012
Ethno-botanical	N.R.Pura, Chikmagalur dt., Karnataka	Jaundice	Leaf decoction	Prakasha et al.(2010)
Irular tribe	Nilgiris, TN	Skin ulcers	Root powder with sugar	Selvam et al., 2017
Soligas	B R Hills, Chamarajanagar dt. Karnataka	Skin problems; leucoderma	Roots	Gireesha & Raju, 2013
Ethno-medicine	Ajara tehsil, Kohlapur dist., Maharashtra	Skin problems: leucoderma	Roots, latex	Sadale & Karadge, 2013
Lodha tribe	Paschim Mednipur dt., W.Bengal	Skin problems: leucoderma	Root paste	Sarkhel, 2014

Santhals	Sundarbans, W. Bengal	Skin problems	Roots	Majumdar & Sana, 2015
Ethno-medicine	North-east Karnataka	Skin problems, feet infection	Root powder appli-ed. Oil extracted from roots applied;	Rajasab & Ishq Tapassum & Vidya Sagar, 2017
Ethno-medicine	Western Karnataka	Skin problems	Roots	Shiddamallayya et al. (2010)
Ethno-medicine	Hassan dt., Karnataka	Skin problems	Roots	Kumar & Shidda-mallayya, 2014
Mullu-kuruma tribe	Waynad, Kerala	Skin problem: Eczema	Root paste/ decoc-tion consumed	Silja et al., 2008
Malayali tribe	Kolli Hills, Namakkal dt., TN.	Skin problems: Pimples on face	Root paste applied	Vaidyanathan et al., 2013
Village communities	Meerut, UP	Skin problems	Root decoction	Tomar, 2009
Tribes	Chittoor dt. AP.	Fissures	*H. indicus, Rubia cordifolia* roots powdered, boiled with gingelly oil, with bee wax applied to fissures	Vedavathi et al. 1997
Mullukurumas	Waynad, Kerala	Diabetes	Root paste/ decoc-tion consumed	Silja et al., 2008
Palliar tribe	Sirumalai Hills, Dindigul dt., TN	Diabetes	Root infusion twice a day for 6 weeks	Maruthupandian et al., 2011
Folk healers	Eastern Shimoga, Karnataka	Diabetes	Root paste with ginger & coconut kernel	Rajakumar & Shivanna, 2006
Ethno-medicine	Western Karnataka	Diabetes	Roots	Shiddamallayya et al. (2010)
Gond & Kol tribes	Uttarakhand	Diabetes	-	Prakash, 2011
Ethno-medicine	Ajara, Kohlapur dt., Maharashtra	Urinary problems	Roots & latex	Sadale & Karadge, 2013

Folk medicine	Western Karnataka	Urinary diseases	Roots	Shiddamallayya et al., 2010
Tribes	Sagar dist., M.P.	Urinary disorders	Root juice	Gupta et al., 2006
Ethno-botanical	Sira tk., Tumkur dt., Karnataka	To reduce blood sugar	Roots	Shivakumar and Karigar, 2016
Santhals	Sundarbans, W. Bengal	Dysentery	Roots	Majumdar & Sana, 2015
Tribes	Nandurbar dt., Maharashtra	Dysentery	Root paste used	Dongarwar & Thakur, 2012
Kandha tribe	Kandhmahal dt. Orissa	Diarrhoea, infants	Root pasted with black pepper or Root powder with honey- 3-4 days	Behera et al., 2006
Tribes	Chittoor dt., AP	Diarrhoea in children	Root decoction with milk & sugar	Vedavathi et al., 2007
Malamalasar tribe	Parambikulam, Kerala	Diarrhoea in children	Root paste with sugar	Yesodharan & Sujana, 2007
Kandha tribe	Kandhmahal dt. Orissa	Stomatitis, and diarrhoea, diarrho	Root powder with 2 more ingredients	Behera et al., 2006
Various tribes	Eastern Ghats of Vizhianagaram dt., AP	AIDS	Roots	Parijatham et al., 2016
Kandha tribe	Kandhmahal dt. Orissa	Mouth infection, stomatitis infants	Root powder with honey- 3-4 days	Behera et al., 2006
Paliyar tribe	Sadhugiri hills, Virudhanagar dt., TN	Mouth ulcer	Roots	Aadhan & Anand, 2018
Ethno-medicine	Tamil Nadu	Mouth ulcer	Roots;	Ayyanar, 2013;
Savara tribe	Seethampeta, Srikakulam dt., AP	Sore tongue	Paste of flower, fruits & leaf applied	Rao et al., 2008

Corwa, Oraon, Pando tribes	Ambikapur dt. MP	Stomach ulcer	Fresh roots crushed with black pepper, 2 gm on empty stomach- 7 days	Sharma & Kumar, 2014
Kuruchia tribe	Kannur dt., Kerala	Stomach ulcer	Grounded roots with black pepper	Rajith & Ramachandran, 2010
Kani tribe	South Kerala	Abdominal colic	Root powder with coconut milk	Vijayan et al., 2006
Ethno-medicine	Bhadra WLS, Karnataka	Stomach-ache	Whole plant ground with milk	Parinitha et al., 2004
Ethno-medicine	Western Ghat villages, Shimoga dt. Karnataka	Stomach-ache	Whole plant ground with milk	Parinitha et al., 2005
Ethno-medicine	Hassan dist., Karnataka	Dyspepsia	Roots	Kumar & Shiddamallaih, 2014
Kanis	Kerala	Heartburn (pyrosis)	Roots crushed and extract consumed	Vijayan et al., 2006
Tribes	Mayurbhanj dt., Orissa	Piles	Leaf paste applied	Rout et al., 2009
Tribes	Phulbani, Orissa	Eye ailments	Roots	Sahoo, 1995
Ethno-medicine	Ajara, Kohlapur dt; Maharashtra	Eye ailments	Roots & latex	Sadale & Karadge, 2014
Local tribes	Mayurbhanj dt, Orissa	Rheumatism: for gout & joint pain	Roots crushed & boiled in mustard oil applied	Rout et al., 2009
Baigas	Amarakantak Bio-Reserve, M.P	Kidney stones	Whole plant (?)	Kapale, 2012
Mishing tribes	Golaghat dist. Assam	Anti abortive	Roots	Das & Hazarika, 2015
Tribal healers	Kamarup dt., Assam	Leuorrhoea	Stem & root	Deka & Kalita, 2013
Ethno-medicine	Kerala	Lactation, post-natal	Daily intake root decoction in water & cow's milk	Beegam & Nayar, 2011

Ethno-medicine	Yadigir dt. Karnataka	Lactation, post-natal	Leaves	Modi & Mathad, 2016
Lambani tribe	Chikmagalur, Karnataka	Lactation (colostrum)	Daily cup of root decoction, for one week	Shivanna et al. (2008)
Folk healers	Vedaranyam tq, Nagapattinam dt., TN	Promoting lactation	Roots	Balamurugan et al., 2018
Forest tribes	Bariya Forest Division, Gujarat	Promoting lactation	Leaf	Parmar & Joshi, 2016
Tribes	Sagar dist., M.P.	Promoting lactation	Root with Cynodon dactylon ground, given in goat milk after childbirth	Gupta et al., 2006
Tribes	South Bastar, Chhattisgarh	Promoting lactation	*H. indicus* preparation	Chakraborty et al., 2015
Gonds	Chhattisgarh	Promoting lactation	*H. indicus* preparation	Mishra & Broker, 2009
Ethno-medicine	Bargarh dist., Orissa	Menstrual problems: leucorrhoea	Whole plant (?)	Sen and Behera, 2010
Tribes, rural folks	Bihar	For increased lactation	Roots	Sukla & Verma, 1996
Tribes, rural folks	Chhattisgarh	For increased lactation	Root paste consumed	Shukla et al; 2008
Kunabi tribe	Uttara Kannada dist., Karnataka	For increased lactation	Root crushed with Gulmav bark given with milk	Harsha et al., 2002
Kunabi tribe	Uttara Kannada dt., Karnataka	Menstrual problems: leucorrhoea	Root crushed with Gulmav bark and given with milk	Harsha et al., 2002
Siddi tribe	Uttara Kannada dt., Karnataka	Leucorrhoea	Roots	Bhandary et al., 1995
Ethno-medicine	Sattordem , Goa	Menstrual problems: leucorrhoea	Whole plant (?)	Kamat, 2011
Mullukuruma tribe	Waynad, Kerala	Menstrual problems: leucorrhoea	Root paste/ decoc-tion consumed	Silja et al., 2008

Mising tribes	Dhemaji dt., Assam	Menstrual problems	Whole plant (?)	Sharma & Boissya, 2003
Various tribes	Eastern Ghats, Vizianagaram dt., AP	Menstrual problems	Roots	Parijatham et al., 2016
Irulas, (snake catchers)	TN	Snake bite	Crush & chew roots	Gnanavel & Franklin, 2014
Ethno-medicine	India,widespread traditional use	Snakebite	Aquous extract of roots given daily	Dey & De, 2012
Tribes	Purulia dt., W. Bengal	Snake bite	Root paste applied	Chakraborty & Bhattacharjee, 2006
Korku tribe	Central India	Snake bite	Pounded roots	Kadel & Jain, 2008
Gond, Kol tribes	Uttarakhand	Snake bite	Prepared from plant consumed	Prakash, 2011
Ethno-medicine	Western Karnataka	Spider poisoning	Roots	Shiddamallayya et al., 2010
Ethno-medicine	Western Karnataka	Wound healing	Roots	Shiddamallayya et al., 2010
Ethno-medicine	Western Karnataka	Glandular swellings	Roots	Shiddamallayya et al., 2010
Village communities	Meerut, PP	Swellings	Root paste applied	Tomar, 2009
Different tribes	Vizianagaram dt., AP	AIDS	Roots	Parijatahm et al., 2016

Anantmool in Ayurveda

Ayurvedic pioneers Charaka, Susruta and Vagbhatta used the name 'Sariva' for *H. indicus* -also known as Sweta-sariva. The darker *Ichnocarpus frutescens* and *Cryptolepis buchanani* of Apocynaceae, make *Krishna-sariva*. *Vallaris solanacea* and *Decalepis hamiltonii* are also used as Sariva though not genuine. *Charaka Samhita* considers *Sariva* as *Jwarahara-* for treating fever, *Daha prashamana* – reliever of burning sensations, *Pureesha sangahaniya* - promoter of bowel movements and *Stanya shodhana* – purifyier of breast milk. It promotes good health by balancing the *Tridoshas* namely *Vata, Pitha and Kapha*. Decoction of leaves was prescribed by Charaka in sallow complexion, loss of voice, cough, menstrual disorders and dysentery whereas entire plant is prescribed for treating asthma, cough, abdominal swelling and aching limbs (Khare, 2004).

Ayurvedic texts treat *H. indicus* as *Kushtahara* (useful in skin diseases), *Kanduhara* (for itching), *Mehanashana* (diabetes and urinary tract infections), *Durgandhanashana*

(relieves bad odour), *Shukrala* (promoter of male fertility), *Atisarahara* (cures diarrhea and dysentery), *Vishpaha* (antitoxic), *Shvasa Kasahara* (for respiratory ailments, cough, cold, asthma), *Pradharanut* (gynaecological problems) etc. (source: Dr. J.V. Hebbar, https://easyayurveda.com/). Medicated ghee containing *H. indicus* with few other plants is used in chronic fever, asthma, cough, hiccup, headache, burning of body and vitiation of digestive fire (Gupta, 2006). It is *Raktashodak* (blood purifier) and *Vishaghna* (expeller of toxins) (Meena et al., 2017).The herb's healing powers are evident from its use several Ayurvedic formulations **(Box-1 & Table 2).**

Box-1 Traditional Ayurvedic formulations using *Hemidesmus indicus*.

Aravindaasava, Saarivaadyaasava, Asvagandhaadyarista, Asvagandhaadi lehya, Arkaadi kvaatha choorna, Ashwagandhaadichurnam, Brahanmanjisthaadi kvaatha choorna, Chandanaadi choorna, Draaksaadi kvaatha choorna, Pusyaanuga choorna, Stanyasodhana kasaaya choorna, Amritamalaka taila, Balaasvagandhalaaksaadi taila, Balaadhaatryaadi taila, Brihat gudoochee taila, Chandanaadi taila, Chandanabalaalaaksaadi taila, Dhaanvantra taila, Yeshtimadhu taila, Triphalaadi taila, Jaatyaadi taila, Kacchooraadi choorna, Madhuyastyaadi taila, Mahaa visagarbha taila, Manjisthaadi taila, Pinda taila, Sataavaree guda, Gopanganadi kasahyam Draksadikasayam, Brahat phala ghritha, Daadhika ghritha, Jaatyaadi ghritha, Kalyaanaka ghritha, Mahaa kalyaanaka ghritha, Mahaa panchagavyaa ghritha, Mahaatiktaka ghritha, Pippalyaadi ghritha/gana Triphalaa ghritha, Vastyaamayaantaka ghrita, Marma gutikaa, Maanasamitra vataka, Saarivadi bati, Chandrakalaa rasa, Shatavari rasayana; Mathalarasayanam (Nayar et al, 1978; Iyer, 1983; Sivaranjan and Balachandran, 1994; Kumar & Shiddamallayya 2016);

Table 2: *H. indicus: Notable* applications in Ayurvedic medicine

Health conditions treated	Formulation with *H. indicus* as notable ingredient	References
Gout, rheumatism, joint pains; rheumatoid arthritis	Sarivadyasavam; Asvagandhaadi lehya; Capsule Sariva; Sariva syrup; Mahamanjishta dikashaya	https://ayurmedinfo.com/2012/02/09/sarivadyasava; http://www.planetayurveda.com/library/Saribadyasavam; singleherbs.com; Sri Sri Ayurveda
Diabetes, diabetic carbun-cles, related skin problems; ulcers	Sarivadyasavam; H	https://ayurmedinfo.com/2012/02/09/sarivadyasava http://www.planetayurveda.com/library/saribadyasavam

Blood detoxification/ puri-fication-	Sarivadyasavam; Asvagandhaadi lehya	https://ayurmedinfo.com/2012/02/09/ sarivadyasava/http://www.planetayurveda.com/library/ saribadyasavam
Blood puirifation- therefore effective in skin problems	Sarivadyasavam; Sariva syrup	Saini (2013); Sri Sri Ayurveda
Skin problems: including allergic dermatitis	Formulations like Mahamanjishtadi kashayam	https://ayurmedinfo.com/2012/02/09/ sarivadyasava; Dhanvantari nighantu (Sharma & Sharma, 1998)
Skin: Cracked heels	Sariva based	https://ayurmedinfo.com/2012/02/09/ sarivadyasava
Skin problems: ring worm, acne, pimples, boils	Sarivadyasavam; *H. indicus;* Capsule Sariva	https://ayurmedinfo.com/2012/02/09/ sarivadyasava; Saini, 2012; Meena et al., 2017; singleherbs.com
Skin: Leucoderma	Sarivadyasavam (Sarivasava); use of Sariva alone	Claimed use in Ayurveda
Skin: psoriasis, urticaria	Capsule sariva	singleherbs.org
Burning sensation, skin; excess swetting	Roots	https://ayurmedinfo.com/2012/02/09/ sarivadyasava, http://www.planetayurveda.com/library/ saribadyasavam
Fever (*pitta* type) with burning & excessive thirst	Gopanganadi Kashayam	Kerala Ayurvedic formulation
Kidney problems; cystitis; dysurea, burning urination,	Capsule Sariva	http://www.planetayurveda.com/library/ Saribadyasavam; singleherbs.com
Enlarged prostate	Sarivadyasavam	Saini, 2012
Cough, chronic cough, loss of voice; allergic rhinitis; asthma	Leaf decoction; Asvagandhaadi lehya; hot infusion of root with milk & sugar, Mathalarasayanam	*Charak Smahita* (Pansare et al., 2018); Chatterjee et al., (1995); *Sushrut Sanhita,*
Ear infection, hearing problems, tinnitus	Sarivadi vati	Patanjali & Baidynath Ayruvedic Pharmacies
Cancer syndrome	Polyherbal formulations with *H. indicus*	Feruzzi et al., 2013

Antenatal care, growth of foetus, mother's health, preventing miscarriage	Pipplyadigana	Vidhya & Nishteswar, 2016
Promoting lactation, improves quality of milk	'Maa-Lact' – Ayurvedic commercial product	'Solumiks' Herbaceuticals
Menstrual problems	Gopanganadi Kashayam	Kerala Ayurvedic formulation
Preventing abortion	Capsule Sariva	singleherbs.org
Digestive problems, gastri-tis, colitis	Gopanganadi Kashayam; Capsule Sariva, Sarivadyasavam	Kerala Ayurvedic formulation;singleherbs.org; http://www.planetayurveda.com/library/

REFLECTIONS OF ETHNOMEDICINE IN AYURVEDA

Ethnomedicinal knowledge of indigenous people must have grown independently in human societies. Interactions between such societies in a large region are expected to facilitate sharing of knowledge to different degrees, although taboos and secrecies limited such sharing. Numerous tribes of UP and Bihar (like Tharu, Kol, Gond, Kharwar, Korwa, Santhal, Paharia, Oraon, Munda etc.) would have lived through generations without hearing about or meeting the Baigas of Amarakantak in MP, needless to sayof the Irulas and Soligas of Sathyamanagalm forests in Tamil Nadu, or the Paliyas in the recesses of Idukki rain forests of Kerala. Yet, they all used roots of *H. indicus* as antipyretic. If that be a more generic use it springs greater surprise that in Kerala ethnomedicine, the Lambanis of Chikmagalur, the Kunbis of Uttara Kannada, the folk healers of Vedaranyam in Tamil Nadu, the tribes of Bariya in Gujarat, of Sagar district in MP and Bihar, far separated though, all used Sariva root extracts for neo-natal lactation or increased lactation. Close parallelism (with likely interactions) exists between ethno-medical and Ayurvedic uses of *H. indicus* notably in gout, rheumatism, joint pains, arthritis, diabetes related problems, in blood purification, skin problems including leucoderma, burning sensation, fever, menstrual and digestive disorders, urinary problems, in postnatal care, respiratory problems etc.

Validation of Ayurvedic and ethno-medical applications of *H. indicus*

Modern research on H. indicus, its derivatives, its action alone or in combination with other plants, most of which conducted in animal and *in vitro* studies validate many traditional applications recommended in Ayurveda, indirectly endorsing most of the ethnobotancial uses (Table for details). While diseases like cancers, cardiovascular diseases, hypertension, AIDS etc. had hardly equivalent terms in the ethno-medicine or classical Ayurveda, both used *H. indicus* majorly or synergistically with other species for 'blood purification'. 'Bad blood' could be due to cancers (leukemia itself is blood

cancer), cardio-vascular problems (rising lipid levels in blood, are major causes); kidney problems, dysurea, alterations in urine chemistry etc. could be symptoms of 'bad blood'; pale skin could be due to anemia, a blood disorder. Hepatitis affecting blood cells can cause anemia. Ayurvedic concept of health revolves much around healthy blood. *Sushrut Samhita Sutrasthana* states:

"Blood is the origin of the body. It is blood that maintains vitality. Blood is life. Hence it should be preserved with the greatest care"

Medical science strongly links the state of blood with health, as the doctors insist on the blood test for most patients prior to diagnosis. Whereas high lipid levels are associated with cardiovascular diseases blood sugar exceeding limits leads to diabetes. Complications of diabetes include skin infections, eye problems, nerve damages, kidney diseases, hypertension, digestive problems etc. Ayurveda considers leukemia as vitiation of blood. Blood tests may be used to confirm or rule out latent or active tuberculosis. In holistic systems of traditional Indian medicine, *Sarivadyasavam* or *Sariva* capsules where Sariva is the major component, is used for blood purification as well as for gout, rheumatism, skin and urinary problems, respiratory system ailments, cancer syndrome etc. **Table 3** based on modern researches is a strong endorsement of the multipronged action of the herb in the folk medicine and Ayurveda.

Table 3: Validation of curative properties attributed to *H. indicus* or its products in traditional healing systems of India

Ailment/health issues			
	Folk	**Ayur**	**Validation by modern research**
Cancer syndr-ome: leukaemia & breast, liver, hepatic others	+	+	Cytodifferentiating, cytotoxic & cytostatic activities of *H.indicus* offers scientific basis in polyherbal preparations against **leukaema** (Ferruzzi et al. 2013).). Extract showed in vitro cyto-toxic activity on MCF7 breast cancer cell lines (Mazumder et al., 2010). **Antihepatocarcinogenesis** (Iddamaldeniya et al., 2006 Galhena et al., 2012) Root extract against **Ehrlich Ascites Tumor** in mice (Zarei & Javarappa, 2012)
			Anti-leukemic activity while enhancing also some chemotherapeutic drugs (Fimognari et al., 2011; Lakshmi & Rajendran, 2013).

			Antiproliferative properties of root decoction of H. indicus, used as food supplement in Western medicine, on different cancer cell lines: HepG2 cells **(Hepatocellular carcinoma:** 5th most common cancer worldwide; on HepG2, LoVo **(human colon cancer cell line),** MCF-7 (a **breast cancer cell line),** K562 (a leukaemia cell line) , and Jurkat cell lines **(T cell leukaemia)** (Statti et al., 2015)
			Strong evidence that *H. indicus* root extracts have in vitro cytotoxicity against HeLa cells causing cervical cancer (Jesline et al., 2013)
			Radiation protection **of DNA and membrane in vitro by extract of *H. indicus* Shetty et al. (2005).**
			Protective effects against cancers linked to its chemical components like saponins, tannins, phenols, terpenoids, flavonoids, and coumarins (Ananthi et al., 2010)
			Stem extract showed **antimutagenic activity** in laboratory studies (Aqil et al., 2008)
			Root bark intensively active in **scavenging DPPH and superoxide radicals which may cause cancer** (Ravishankara et al., 2002)
Rheumatoid arthritis	+	+	**Free radicals scavenging** property of root bark (Ravishankara et al., 2002) can justify its traditional used inflammatory autoimmune diseases like rheumatoid arthritis. Antiarthritic property attributed to presence of terpenoid (Mehta et al., 2012)
Diabetes	+	+	Showed **hypoglycemic activity** in diabetic rats (Gayathri, & Kannabiran, K. 2008); extracts increased enzymic antioxi-dants (Gayatri and Kannabiran, 2012); β-amyrin palmitate from roots showed remarkable anti-hyperglycemic activity in rats (Nair et. al., 2014); Root bark has **free radical scavenging** activity (Saravanan & Nalini, 2007). *H. indicus* extract regulated diffusion of glucose across a bio-membrane, thereby showing its potential use for **diabetes treatment** (Archit et al., 2013)

Cardiovascular related		+	Studies in rats using aqueous and methanolic extracts of *H. indicus* showed its **cardio-protective action** as regards congestive heart failure (Chidrawar et al., 2009). Root extract can **protect ischemic myocardium of heart** against contractile dysfunction and reperfusion-induced irregular beats and reduce tissue damage (Khandelwal et al., 2010). Root extract **blood thinning,** therefore antithrombotic as observed in rabbits (Mary et al., 2003). In diabetic rats, root extract **reduced serum cholesterol,** triglyceride, free-fatty acids, and phospholipids (Sowmia and Kokilavani, 2007). **Serum lipids reduced** and brought to within limits in diabetic rats treated with *H. indicus* extract (Gayathri, & Kannabiran, 2009)
Ulcers – gastric-duodenal	+	+	Root extracts having **antiulcer properties** in experi-ments on rats (Anoop & Jegadeesan, 2003; Vishali et al., 2013)
Ulcers – other types	+	+	-do-
Antacid property	+	+	In vitro studies demonstrated **antacid property** (Farooq & Atar, 2016)
Fever, pneumonia, body heat	+	+	Root extract significantly lowered chemically induced high body temperature in rats (Lakshman et al., 2006). Root extract showed **antipyretic and analgesic properties** (Gupta et al., 2010); Root extract inhibited growth of **pneumonia** causing Klebsiella pneumoniae, Pseudomonas aeruginosa & E. coli (Joseph et al., 2011; Kavitha et al., 2010)
Herpes	+		
Various Skin infections	+	+	Root extract effective against Staphylococcus aureus and Candida albicans, which cause various **skin infections** (Ahmad & Baig, 2001)
Diarrhoea, dysentery	+	+	Root extract **antibacterial** (Das et al., 2003); effective against E. coli & Shigella dysenteriae (Ahmad & Baig, 2001). Root powder or its water extract promotes absorption of water and electrolytes in the rat intestine (Evans et al., 2004). Root extract inhibits diarrhea causing E. coli, & Pseudomonas aeruginosa (Kavitha et al., 2010). Extracts acted against multidrug resistant enteric bacteria in lab studies (Ahmad and Aquil, 2007).

Dysurea, urinary tract infections; increased need to urinate; kidney problems	+	+	Root extract effective against E. coli (Ahmad & Baig, 2001); **checks oxidative damage** in rat kidney (Saravanan & Nalini, 2007); acts against E. coli & Klebsiella pneumoniae that can cause **urinary tract infections** (Kavitha et al., 2010; Das et al., 2017); Root extracts tested showed **diuretic** properties (Gadge and Jalalpure, 2011);
Better functioning of kidney	+	+	*H. indicus* helped in the management of renal impairment, induced by gentamicin in rats (Kotnis et al., 2004). *H. indicus* has inhibitory action on urease enzyme; the increased production increases pH of urine creating adverse impact on health (Sikri & Dalal, 2017)
Abortion risks		+	*H. indicus* fights infections (various studies)
Menorrhagia		+	
Snake bite	+		Lupeol acetate from roots **neutralized the venom of Russel's viper and Monocled cobra** *(Naja kaouthia)* (Chatterjee et al., (2006). An organic acid from root showed **viper venom inhibiting activity** (George et al., 2008). Alam et al. (1994) extracted a compound HI-RVIF from *H. indicus* roots which significantly antagonized viper venom-induced lethal, haemorrhagic, coagulant and anticoagulant activity in experimental rodents.
Hepatotoxicity, liver problems	+	+	Protective activity against certain types **of hepato-toxicity/liver problems-** proving in rats (Prabhakaran et al., 2000). Rats recovered from ethanol-induced liver injury by the inhibitory effect of active principle 2-hydroxy 4-methoxy benzoic found in *H. indicus* (Saravanan & Nalini, 2008).
Memory loss, Alzheimer's disease		+	Rasayana, a rejuvenative herbal therapy of Ayurveda, uses *H. indicus* roots as a notable **memory enhancer.** Root has biochemicals having **anti-inflammatory action on brain;** tested rats showed increased 'discrimination index' performed better in 'avoidance tests' and in **retention of memory** (Shete & Bodhankar, 2010). Fragrant phenolic compounds, 2-hydroxy-4-methoxybenzaldehyde (MBALD) from root and pod extracts had inhibitory potential against acetylcholinesterase (AChE) that causes **Alzheimer's and other neurological dysfunctions** (Kundu and Mitra, 2013).

Inflammation due to diverse causes, especially wounds, acne	+	+	*H. indicus* has wound healing properties (Ganesan et al., 2012). Human clinical trials of root extract established wound healing property (Vijayakumari & Nishteswar, 2012), **suppress free radicals generated at the site of injury** (Arturson, 1996). Root extract inhibits the expression of the genetic factor Interleukin-8 and others which cause inflammation and related complications (Guerrini et al., 2014); remedies acne related inflammation (Jain & Bansal, 2003).
HIV-1	+		Investigations on the anti-HIV-1 activity of H. indicus, which contains which contains the active priniciple Lupeol, supported the potential of *H. indicus* as a multi-target active drug source. Due to its many active metabolites, *H. indicus* inhibited the RT-associated RNase H function, and the HIV-1 RT-associated RNA dependent DNA polymerase activity and the cellular α-glucosidase (Esposito et al., 2017).
Herpes	+	+	Tests based on hydroalcoholic extract prepared from roots exhibited a remarkable **anti-herpetic** activity through multiple mechanisms, notably by reducing the infectivity of viral particles released from infected cells (Bonvicini et al., 2018).

Research findings based IPR claims

The European Chemicals Agency (ECHA) certified *H. indicus* root powder as cosmetic ingre-dient for skin conditioning and identified Indo-World Trading (New Delhi) as the herb supplier.

- A US patent granted (to Eladevi Shah) in 1997 for a preparation involving *H. indicus* among others for skin disorders such as psoriasis, eczema and lichen planus and for promotion of good health and alleviation of stress.
- A patent application for a synergistic formulation involving *H. indicus* is pending with World Intellectual Property Organization (WO).
- Patent applications filed with WO (2 nos) for renoprotective and lipid lowering herbal formulations
- Patent application filed with WO for anti-inflammatory action of a polyherbal composition involving also *H. indicus* for treating all kinds of arthritis and musculo-skeletal disorders.

- Indian patent granted to CSIR in 2010 for process to extract antioxidants from roots
- A US patent granted in 2011 (to Zeyad Technologies LLC) in 2011for a polyherbal composition involving *H. indicus* for treating subject having viral infection, particularly with hepatitis-B and hepatitis-C viruses

COLLECTION AND MARKETING

Having wider distribution in the Indian sub-continent, and the supply, mostly from the wild, would have been sufficient to meet the domestic demand for Ayurveda and folk medicine and for preparation of popular beverages like "nannari sherbet" in South India. The spate of recent publications on *H. indicus* and the increasing validation of its traditional uses by scientific research have propelled the domestic and international demand. As the raw material prices increased the profits are largely cornered by the contractors, wholesalers and the marketing companies, with only sketchy accounts of demand and supply to arrive at trade volumes.

Collection, cultivation and market prices of raw material

The folk healers generally collect the medicinal herbs, from their own localities. The forest dwellers collect and sell the roots to traders, contractors or directly to the companies. In more organized areas raw material is sold to tribal co-operatives. The tribes of Attappady collected *H. indicus* and marketed through their societies or through private channels. The Kurumba Society paid a sum of Rs.200/- for kg of roots in 2013-14 (Alex & Vidyasagaran, 2016). Roots were relatively low priced in 1990's. A1993 report of the Kerala Ayurvedic Manfacturing Association stated that Arya Vaidya Sala, Kottakal, purchased roots at Rs.17.30/kg and sold at Rs.45/- kg. The prices in the major markets two decades ago are available from an FRLHT (2002) **(Table 4).** In 1997 the Girijan Co-Op. Society of A.P. procured 309 kg at Rs.15/kg (FRLHT, 2000).

Table 4: Trade status (prices and volumes traded) of Hemidesmus roots in Indian markets (Survey report, FRLHT, 2002)

Market	Price/kg (Rs.)	Qty traded (kg)
Delhi	12 to 40	Not reported
Tuticorin	35	Not reported
Chennai	25	Not reported
Hyderabad	40	Not reported
Mumbai	35 to 60	>60000 kg
Calcutta	37	10000-80000
Bangalore	25 to 45	10000-80000

Report of the Task Force on Conservation & Sustainable Use of Medicinal Plants (Planning Commission, 2000) placed 200 tons/yr of Anantmool as the annual requirement of raw material in India; the bulk came from wild collection in TN and AP States. The NMPB (2008) estimated the market demand at 300 tons/yr, while the Tribal Cooperative Marketing Federation of India Ltd. (TRIFED), of the Ministry of Tribal Affairs, which aims at socio-economic development of tribal people through development of tribal products for marketing estimated Anantmool requirement in India at 200 mt/ year (Sharma et al., 2008). There are apparently conflicts in these reports as TN and AP are the largest producers whereas Chattisgarh alone estimated 100 Mt as the annual available quantity (Source: Export Potentional Survey Report of CSIDC). As early in 2002 the FRLHT (2002) estimated 10,000 to 80,000 kg (10 to 80 tons) of Anantmul roots as being traded in Bangalore market alone at the rate of Rs. 24-45/kg. With rising awareness on the importance of Anantmool the prices started escalating from 2000. In 2006/07 the market price was reported as Rs 65/kg of dry root. Ghate et al. (2014) reported Rs.360-380/kg as the National wholesale market rate for *H. indicus* (red variety) in August 2013 and Rs. 280/- in December 2014. Hafmin Foods, Kolai (TN) charges Rs.400/-kg of roots. Although in Karnataka the plant is distributed widely there is hardly any data on from where arrivals in Bangalore are happening. Moreover, *H. indicus* roots exported through Bangalore Airport alone, during years 2015-16 is a more reliable quantification. Table 5 could just be tip of the iceberg as regards the resource in Karnataka, as the quatities consumed within the State and being sent to other States through road and rail are still eluding statistics.

Table 5: details of *H.indicus* exported through Bangalore airport in 2015 & 2016

Date	Item	Qty (kg)	Unit price	Value Rs.	Destination
22-07-2015	Organic Sarasaparilla roots	6000	446	2676267	Netherlands
21-04-2016	Organic Anantmool, whole	875	602.07	526811.18	Oakland, USA
22-06-2016	Organic Sarasaparilla roots	103	816.77	84127.16	New York
27-08-2016	Organic Sarasaparilla root powder	105	720.94	75698.94	Houston
21-10-2016	-do-	30	384.93	11547.9	New York
19-11-2016	- Sarasaparilla roots cut & sift	404	849.45	343178.25	Chicago

Prolific trade in Anantmool is happening with hardly anything coming under the scanner of SBBs for application of the provisions of ABS Notification of the MoEF. Details of *H. indicus* suppliers, especially of dry roots and powder, and the prevailing rates/unit are given in **Table 6**

Table 6: Rates quoted for *H. indicus* (roots & root powder), by different suppliers (Note: 1. Procurement prices are hardly provided by any dealer; 2. The list is not exhaustive; 3. MP has some of the lowest selling prices)

Marketed raw materials	Suppliers	Prevailing prices
Dried Roots	Bharti & sons, Dehra Dun	Rs.150/kg
Anantmool	Elixir International, T.P. Nagar, UP	Rs.38/- kg
Dried roots	Himalayan Herbaria, Sector 60, UP	Rs.650/- kg
Dried roots	R.R. Sales Corporation, Tilak Bazaar, Delhi	Rs.320/kg
Dried roots	National herbs Co., Khari Baoli, Delhi	325/-kg
Dried roots	Mahadev Enterprises; Old Delhi	350/kg
Dried roots	Abhai Enterprises, Khari Baoli, Delhi	350/kg
Dried roots	Krishna Trading Co. Khari Baoli, Delhi	390/kg
Dried roots	Ram Brothers, Chandni Chowk, Delhi	325/kg
Dried roots	Apex International, Jaipur	Rs.500/kg
Root powder	Apex International, jaipur	Rs. 500/kg
Dried roots	Aditi Trading Co., Dholpur	Rs.1300/kg
Dried roots	Industrial Estate, Neemuch, MP	Rs.25/kg
Dried roots	Verderoots Services, Neemuch, MP	500/kg
Anantmool herbal	Akankshah Herbal, Kolar Road, MP	Rs. 550/kg
Dried roots	Verde Roots Services, MP	Rs.500/- kg
Dried roots	Agarwal Trading Co., Sheopur, Shivpuri, MP	12/kg
Root extract	Ansar Indistries, Surat, Gujarat	Rs. 1800/- kg
Anantmool extract	Green Heaven India, Nagpur	Rs.800/kg
Root extract	Konark Herbals and Healthcare, Dehra Dun; Daman & Diu	Rs. 1400/kg
Dried roots	Arun Agri Traders, Guntur, AP	550/kg
Dried roots	Bariyy Feeds & Bioenegry, Adyar, TN	Rs.300/kg
Dried roots	R.N.Rajan & Co., Kumarappa Maistry Street, Chennai, TN	270/kg
Root powder	MG Naturals, Ambattur, Chennai	Rs.335/ 250 gm
Dried roots	Indian Aromatics & herbs, K.K. Pudur, Chennai; Combatore, TN	Rs. 350/- kg
Root powder	Neoteric, Coimbatore, TN	Rs. 699/300 gm

Marketed raw materials	Suppliers	Prevailing prices
Dried roots	Al Bismi Eterprises, Pallathur, TN	400/kg
Dried roots	Muthu traders, Tuthukudi, TN	150/kg
Dried roots	SMA Traders, Karur, TN	350/kg
Dried roots	Jireh Exports, Tuthukudi	270/kg
Dried roots	Mylal Exports, Sundarapuram, TN	750/kg
Dried roots	Hafmin Foods, Ambur, TN	30 kg & 50 kg units
Dried roots	Karthik Enterprises, Shanmugapuram, TN	245/kg
Dried roots	The Counts, Coimbatore, TN	400/kg
Dried roots	Siva Traders, Kamarajar Salai, TN	420/kg
Dried roots	Dr. Murali Export & Import, Vellore, TN	190/kg
Root powder	EkGaon product, Pollachi TN	Rs. 129/ 100 gm
Dried roots	Malnad Traders, Sosale, Mysore, Karnataka	Rs.500/kg
Dried roots	Sahyadri Traders, Hosanagara, Shimoga, Karnataka	
Dried roots	Hebsur Herbal Store, Hubli, Karnataka	
Root powder	Vaidya Narayan Healthcare, Indlavadi village, Anekal, Karnataka	Rs. 505/- (250 gm)
Root powder	Herbalkart, Online shopping site	Rs. 330/200 gms
Root powder	Truu Herbs	Rs. 477/100 gms
Dried roots	The Spice Market, online	Rs. 788/ kg
Indian Sarasa-parilla roots	Alibaba.com	$5-10/kg
Indian Sarasa-parilla roots	E-Silk Route Ventures (marketed by Alibaba.com)	$ 7.5-11/kg
Indian Sarasa-parilla root powder	Xian SR Bio Engineering (marketed by Alibaba.com)	$ 10-30/kg
H. indicus, roots	Saroj Exporters (through Alibaba.com)	$100-200/tonne (minimu 10 tons)

The market prices seem to be fixed arbitrarily and opportunistically as 100 gms of root powder was sold by 'True Herbs' at Rs. 477/- (Rs. 4770/kg) whereas the same qty by Herbalcart was Rs. 165/- **Table 7** provides the price structure of Anantmool based pharmaceutical products.

Table 7: The type of medical preparations based on *H. indicus* marketed by Pharmaceutial companies

Product	Producer Co.	Recommended uses by companies	Unit	Price (2018)
Anantmool Ghana	Chaitanya Pharmaceuticals	Diuretic, digestive, useful in skin & urinary diseases	60 tablets	$ 8.20
Hemidex capsule (20 components)	Ayusearch Drugs &			
Pharma, Haryana	Blood purifier	1 Box	Rs.480	
Sariva capsules	Dr. Wakde's	Food supplement	60 capsules	$ 21.89
Anantmool capsules	Baidyanath	For various health benefits	60 capsules	$ 8.99
Sri Sri Sariva syrup	Sriveda Sattva Pvt. Ltd., Bangalore	For burning sensation, loss of appetite, indigestion, diarrhea, cough, difficult breathing, skin diseases, fever, blood problems	200 ml	Rs. 110
Sariva Ghana Vati	Pentacare Ayur Pharma, Bangalore	Various benefits of Sariva	30 tablets	Rs. 100
Sarivadi Bhati	Baidyanath	Hearing problems, tinnitus, ear infection	20 tablets	Rs. 75
Sariva Arka	B. V. Pundit's Traditional & Herbal Health Care	Body coolant, dysurea, heartburn, gastric & duodenal ulcers etc.	200 ml	Rs. 100
Sarsaparilla syrup	-do-	Skin problems, burning micturition, redness of eyes, heartburn, gastric-duodenal ulcers, excess heat etc.	500 ml	Rs. 280
Sariva Kalpa	Swadeshi Pharma, Udupi	Arthritis, Oliguria, Pimples, Urticaria, Nephritis, Herpes, skin ailments, urinary infections, pruritis	450 ml	Rs. 180

Product	Producer Co.	Recommended uses by companies	Unit	Price (2018)
Anantmool choorna	Birla Ayurveda, Maharashtra, Bangalore	For balancing *pittakapha,* blood purifier, diuretic, antipyretic, anti-inflammatory, gout, menorrhagia, breast milk purification etc.	60 tablets	Rs. 156
Anantmool powder	Hebsur Herbals, Bangalore	Autoimmune disease, rheumatoid arthritis, skin disorders, leucoderma, gonorrhea, asthma, bronchitis, bleeding piles, jaundice, dysetery	200 gm	Rs. 187
Anantmool powder	Herbo Natural, Delhi	Skin health, overall health	100 gm	$ 12
Anantmool churna	Jagriti Sansthan, Jaipur, Rajasthan	Carbuncle, skin diseases, rheumatism, hemorrhage etc; blood purifier	500 gm	Rs. 150
Roots & Herbs Anantmool Face Wash Lep	NYKAA, Mumbai	Anantmool & other herbs based cream for protection from sun damage, removing impurities from skin pores, replenish skin moisture	100 gm	Rs. 650
Anantmul Ghana	Chaitanya Pharma, Nasik	Alterative tonic, diuretic, digestive, skin diseases, urinary diseases	60 tablets	$ 7.75
Anandmool powder	M G Naturals, Ambattur, Chennai	Facial application kit	50 gm	Rs.100
Nannari syrup	'Urban Platter', Amazon marketed	Cooling, alkalizing	1 lit	Rs.250
Sarasaparilla (Nannari) syrup	VSR brand, Amazon marketed		700 ml	Rs.768
Sarasaparilla extract	Alibaba.com (global traders) with a capacity to supply 2000 liters of extract per month from Kerala alone through Cochin port		1 kg	US $ 55.2

Other uses

As a beverage: *'Nannari sherbet'* is a fragrant South Indian beverage prepared with the root extract of *H. indicus* (*Nannari* in Tamil). Considered a coolant reducing body temperature, it promotes appetite in hot summer. A cottage industry product in Tamil Nadu, the TN Medicinal Plant Farms & Herbal Medicine Corporation Ltd. has streamlined the preparation of the root extract. The cottage industry and the soft drink sales have generated good employment potential. The annual raw material requirement for the soft drinks was placed at 936 kg of roots, and the demand was stated as increasing at 6-7% per annum. The manufacturing procedures involve application of community traditional knowledge. Ethnomedicine properties of the root extract are scientifically documented. Soam and Hussain, (2011) from the National Academy of Agricultural Research Management, Hyderabad, rank the indigenous *Nannari* drink at par with drinks from Kokum fruit and *Rhododendron* flowers. As product acceptability by the retailers and consumers is high, the likelihood of big players entering into manufacturing is high posing questions on the fate of the cottage industry and benefit sharing with the TK holders. The soft drink market in India is growing at 8.9% per annum and likely to touch 64 billion rupees by 2020 (-ibid.) this issue has to be addressed seriously under the Biodiversity Act. Root is used in Gulbarga villages for flavoured tea and soft drinks (Rajasab & Isaq, 2004). (see also Box 1).

Soagdeberu powder is an ingredient of a malnadu beverage called *kasyaya,* considered medicinal and refreshing. Foreseeing the future of *H. indicus* as an economic resource, fit for cultivattion even in drought prone areas, steps should be taken up for developing this resource by the line departments under the guidance of the KBB

ABS provisions to be strictly applied to *H. indicus* collection & trade

Currently medicinal plants marketing sector in India is in bad shape, ridden with ruthless and unaccounted extraction from the wild and lagely controlled by middlemen, contractors and wholesalers. The forest dwellers collecting the plants do not know about the phyto-medicinal market, nor about the prices of the products sold, thanks to the impervious screens put up by the middlemen (Datta, 2003). As such situation amounts to contravention of the Biodiversity Act and also non-adherence to the 2014 Notification of the MoEF & CC on "Guidelines on Access to Biological Resources & Associated Knowledge & Benefit Sharing Regulations" the following measures are recommended to redeem the situation:

- As there is scanty data on the centres of growth in Karnataka of *H. indicus,* despite growing realization on its medicinal and nutraceutical applications, the State Forest Department may initiate a data collection drive by collecting resource status on important medicinal plants in various forest ranges with the help of forest watchers and guards. Forest Division-wise consolidated data may be sent to the department headquarters and to the KBB.

- The collection and trade happening, if any, within forest range level to be brought under the scanner and the quantifications to be ascertained and the parties involved to be reported for further action.
- In centres of collection and trade the VFCs or tribal groups may be empowered for sustainable collection from designated areas only. The quantities collected and the parties involved in trade need to be recorded in the respective People's Biodiversity Registers (PBRs) and the BMCs are to be trained in how to account for such and levy the collection fee at source. Details of the contractors and purchasers involved are to be recorded and reported periodically to the KBB by the respective BMCs for further action
- As *H. indicus* has deep growing roots its collction involves digging into the ground which is not desirable for forest areas. Therefore AYUSH and Forest Department should prepare plans for promoting this relatively risk-free crop in marginal or drought-prone lands of farmers and in secondary or degraded forests with usufruct rights conferred to the VFCs/forest tribes; the cultivation may be carried out in designated areas, in specially prepared beds with softer soils facilitating easy removal.
- The trade in unorganized areas of collection should be involving not more than two or three steps namely: Primary collector to the collector's society or federation for further trade directly with the manufacturers or bulk trading agencies.

Box 1: Beverages & pickles from H. indicus

The root extract of *H. indicus* is used for preparing a herbal beverage called *'nannari sherbet.'* Once a hugely popular South Indian summer beverage, the sherbet got nearly eclipsed when the traditional Indian soft drink market got flooded with the exotic Colas and Pepsis. As the world is awakening to the potential dangers posed to health from these sugar-rich exotics with their closely guarded chemical formulas, the Government of India in 2003 banned use of Pepsis and Colas and all similar nature in the canteens of the Parliament, although the same yardstick is not applied for marketing such products in the rest of the country. In 2017 The Western Central Railways had banned sale of colas at 300 stations under its jurisdiction. Because of the drain of ground water several traders associations in Tamil Nadu and Kerala declared boycott of Cola and Pepsi.

Progress is being made in formulating carbonated soft drinks from *H. indicus* roots with more pleasing natural flavor and taste. Expected to hit the market in the near future this herbal and health promoting drink will have great potential to replace the more chemicalised, obesity and ill-health causing soft drinks which dominate the market today.

Pickle of *H. indicus* roots, under trade name 'Mahani pickle' is a traditionally prepared item, although it is yet to gain deserving popularity as a nutraceutical. 'Nannari milk,' a preparation made by adding H. indicus syrup to milk, sweetened with jaggery or honey could turn out to be a wonder drink of the future, especially for children and adults.

Notable initiatives

- Uttar Pradesh Forest Corporation has taken up the cause of tribes by directly procuring medicinal plants collected by forest tribes (Datta, 2003)
- In West Bengal buyers can directly purchase medicinal plants from the villagers under the supervision of the Forest Protection Committees (Datta, 2003)
- In Karandhaimalai hills of Dindigul in TN the Valaiyar community of NTFP gatherers, is backed by their federation which purchases such NTFP to their best benefits, so that the traders in between are avoided (ATREE, 2009)
- In most of Kerala, the NTFP collection rights are with the tribal groups. About 36 Tribal Service Cooperative Societies (TSCS) are engaged in the NTFP collection, in about 398 settlements. The State SC/ ST Federation is active in marketing products-with only two stages involved, sale of collected products by the tribes to the federation through the societies and marketing of the same by the federation. The societies can also trade with private traders and companies. The collection rate for *H. indicus,* given to the individuals by the Kurumba tribe co-op.society in Attappady during 2013-14 was Rs.200/- kg. The quatity to be collected of any resource in each tribal settlement was fixed in advance depending on the strength of the resource (Alex & Vidyasagaran, 2016).
- In Kerala the earlier system was of the tribal people collecting NTFP opportunistically and selling the same for paltry gains to the middle men. The Kerala Forest Department evolved successful models for sustainable collection through forest protection and eco-development committees. For value addition and marketing of NTFP, a "Vanasree Cell" was set up in the Forest Department. Value added products sustainably harvested, hygienically processed and packaged in eco-friendly materials are marketed as "Vanasree" products (http://www.forest.kerala.gov.in/index.php/vanashree).
- 'Vanasree' model efforts in Karnataka, would pave way for better organized, accounted, and sustainable harvests of forest produce. Such efforts can strengthen the functioning of the village level BMCs which are legally supposed to accout for sustainable harvests and equitable sharing of benefits according to the ABS formulas evolved by the MoEF & CC, vide its Notification in 2014.

CONCLUSIONS AND RECOMMENDATIONS

Global resurgence in the use of plant based drugs is an opportunity for India to attain self-reliance and boost the export of herbal drugs. Good part of the medicinal herbs has been traditionally collected from the wilderness by forest tribals and other village communities living at the grassroots. The demand for medicinal plants is escalating phenomenally, nationally and internationally, with the increased realization of their effectiveness in treating diseases, and many herbs celebrated for their action on seemingly incurable, chronic and modern lifestyle diseases. There is also immense treasure of traditional knowledge on Indian medicinal plants and their applications latent

in the Indian society, especially among the forest tribes and village communities. The recent times have seen proliferation of ethno-botanical literature covering far and wide of the country. The tapping of such priceless heritage, reflecting the medical acumen gained through generations, has become a handy tool for pharmaceutical companies to probe further into the curative powers of the concerned species, and produce newer formulations with associated claims of IPR, cornering global rights for marketing with utter disregard for sharing of benefits with the traditional knowledge holders, causing also loss to the nation in billions of rupees annually.

Around 90% of the medicinal plants used by the Indian Pharmacies today are beleived to be collected from the wild/natural sources. Less than 20 species of plants are under commercial cultivation and many of these have their uses for other purposes like perfumary/condiments/spices. The crude drug trade is based on local names. The bigger supply of the raw material is procured by pharmacies from the drug dealers in the markets of cities like Mumbai, Delhi, Calcutta, Chennai, Hyderabad, Amritsar, Patna and many small cities of the country. These drug dealers of the cities in-turn procure them from the so called unknown sources. The case study on *H. indicus* is quite revealing of the hidden trade happening, and the profits gained from even a single herb by traders and pharmaceuticals are still beyond the reach of the BMCs, from whose jurisdiction is vanishing priceless bioresources.

The situation calls for detailed examination and consolidated documentation on every important species, which are in few thousands, and adopt measures for safeguarding such knowledge, using strictly the provisions of the Biodiversity Act. Such comprehensive documentation, species-wise, is at the moment, beyond the reach of forest tribes and village communities, who are required to record such in the PBRs. This needs the involvement of experts and the findings should lead to action plans for streamlined, sustained harvests, with accountability vested with the concerned BMCs, so that the benefit sharing formulas have to be worked out appropriately, which is hardly happening today, despite the passage of 16 years since the enactment of the Biodiversity Act. The SBBs may have to focus their limited manpower and resources on selected BMCs in resource rich areas, and build prototype mechanisms for implementation of the ABS provisions evolved under the Act.

The case study dealt with in this article is of *Hemidesmus indicus*. The formulations using the herb have emerged even in the Western markets especially in the management of cardio-vascular, degenerative, renal problems and for chronic skin diseases. This predominantly Indian medicinal and nutraceutical herb, with a wealth of traditional knowledge associated with it, and documented formulations already existing in the Indian systems of medicine, shows how vulnerable our natural resources are to unregulated exploitation and profiteering, with the rural folks at the toiling end gaining scanty share as wages, of the huge unaccounted profits which traders and companies are making. The situation calls for inter-departmental co-operation facilitating meticulous accounting of the resource flows from every village with the BMCs trained and strengthened to be playing major roles in the future.

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Dr. A. G. Koppad

Professor and University Head (NRM)
Department of Natural Resource Management College of Forestry,
Sirsi-581401, UAS, Dharwad

Chapter 4

Resource assessment and economic valuation of *Artocarpus lakoocha* in Uttara Kannada district under the Access and Benefit Sharing regime.

A Case study on availability and value chain of ***Artocarpus lakoocha*** in different watersheds of Sirsi taluk.

Introduction:

Artocarpus lakoocha Roxb, belonging to the family Moraceae is a tropical fruit originated from India. Commonly known as Monkey fruit, Monkey Jack and Barhal in Hindi, wotehuli and esuluhuli, in Kannada. It is distributed throughout the Indian subcontinent and peninsular tropical region, Western Ghats, in states of Karnataka, Kerala and Tamil Nadu. It is also available in some Asian countries like Bangladesh, Bhutan, Nepal, Myanmar, Sri Lanka, Thailand, Malaysia, Singapore, Vietnam and Cambodia. In Karnataka, it is found abundant in Sirsi, Yellapur and Joida taluk of Uttara Kannada district.

It is an evergreen tree having large spreading crown and can grow up to 20 m in height and bears edible fruits. Fruits are 5-10 cm in diameter, generally eaten fresh (Hossain *et al* 2016). Each fruit contains 20–30 seeds that are fleshy with thin seed coat. They are grown in wild in moist forests, river banks, and near streams, more popular in villages and tribal areas than in the lively cities. Lakoocha's high perishability inhibits the fruit from making regular and consistent appearances on the shelves anywhere outside the regions in which it grows. Lakoocha goes from green to a dull yellow, and finally settles on a pinkish brownish yellow tinge when fully ripe. It has a pleasant but unusual flavor, sweet with tangy, sour, citrusy overtones that resembles kiwi, but has a distinct taste not found in any other fruit. However, lakoocha also exudes stick latex from its skin when cut. In terms of nutritional value, 73 kcal includes 90 g Moisture, 2 g Protein, 1 g Fat, 1 g Mineral, 3 g Fiber, 67 mg Calcium and 25 mg Phosphorous.

Some traditional practitioners use the fruit and the plant derivatives to treat dysentery, arthritic swelling, prevent skin diseases and clean wounds. The edible fruit pulp is believed to act as a tonic for the liver (Jagtap, and Bapat 2010). Different portions of this fruits and spike of male flower are used to prepare curries, pickles and delicious sauce (Hossain *et al* 2016). The lakoocha tree is also valued for feed (Sunita *et al* 2012) and timber. Hardwood is sold as lakuch, which is durable outdoors as well as in under water construction, in furniture, boat making and cabinet work. Tree bark contains 8.5 % tannin that can be chewed like betel nut and to treat skin ailments. Seeds contain artocarpins (ALA-I and ALA-II), the isolectins which exhibit high haemagglutination activity (Sopit wongkham 1995). The Journal of Natural Products published a study illustrating that compounds from lakoocha's roots have cytotoxic activity against breast cancer cells and nasopharyngeal carcinoma.

The keeping quality of ripe lakoocha is very short and hence has to be stored in the refrigerator to keep the fruit fresh for two to three days. Unripe lakoocha acts as a vegetable substitute in lieu of raw jackfruit. Rural doctors suggest lakoocha as a tamarind substitute to alleviate acid sensitivity. Fruits are highly nutritious and serve as an important food item in the human diet. It contains vitamins and minerals, most of which are excellent sources of antioxidants such as vitamin C, beta-carotene, zinc, copper, manganese and iron (Jahan *et al* 2011). Antioxidant like flavonoids and phenolic acids help in maintaining normal health and protects against coronary heart diseases and cancer. These properties of lakoocha fruit are attracting attention from scientists, food manufacturers and consumers.

World Health Organization estimated that about 80% of the world population depends on traditional herbal medicine for their primary health care. The different components and chemical extract of this plant has been used as possible sources for new drugs (Tijani *et al* 2008). Many scientists reported that consumption of the fruit can reduce the risk of no-communicable diseases like diabetes, cancer, coronary heart disease, neurodegenerative ailment etc.

A. lakoocha has both medicinal and pharmacological uses. It is anti-inflammatory (Supawachara *et al* 2010), antiviral, anticancerous and anti-HIV (Likhitwitayawuid *et al* 2005). Tree bark is used to treat skin lesions (Tomar *et al* ,2015). Powder from bark is applied to cure wounds and to draw out purulent matter from any abscess (Anima Pandey and Bhatnagar, 2009). The seed and bark of the plant are useful for stomach and liver disease. The unripe fruit causes tridosa impotency, loss of appetite and blood complaint. The ripe fruit is sour sweet, tonic to liver (Piyush and Ramesh 2014). The fruit contains β-amyrin acetate and lupeol acetate, a potential antihyperglycemic and hypolipidemic that could be used as a lead compound for production of effective medicines for diabetes and atherosclerosis. The juice and seeds from this plant are used as purgative and the bark is used as an astringent. Root is used as refresher and the leaves are used in treating dropsy (Tengamnuay *et al* 2006)

Extract of *A. lakoocha* contains liposomes with phospholipid bilayer and an aqueous cavity that can entrap, protect and deliver the water soluble substances into deep skin which can effectively enhance the skin permeation. Phyto oxyres veratrol (POV) extracted from *A. lakoocha* have effective anti-aging activity and prevent cellular aging due to its antioxidant and anti-glycation activities. Studies revealed that 25 μg/ml of POV can prevent DNA damage and was non-toxic to the cell. However, more and more studies are required to formulate suitable pharmaceutical formulations (Prasit *et al* 2012). Effectiveness of *A. lakoocha* extract in the treatment of taeniasis has been scientifically proven (Charoenlarp *et al* 1981). Dried aqueous extract of *A. lakoocha* has been used for treatment of tape worm infections (Veerawat *et al* 2014).

The Western Ghats of India forms a rugged range of hills stretching for about 1600 km along the west coast from south of Gujarat to the end of the peninsula (lat. 8^0 and 21^0 N and long. 73° and 78° E). This constitutes one of the 34 global biodiversity hotspots with complex geography, wide variations in annual rainfall ranging from 1000-6000 mm. The Western Ghats harbours 4,000 species of flowering plants of which 38 % are endemic. Uttara Kannada district is the northernmost coastal district of Karnataka state and is located between latitude 13^0 to 15^0 N and longitude between 74^0 to 75^0 E. It has a geographical area of 10,291 km2 of which more than 70% is covered with forests. The District is known for its rich wild economic NTFP and medicinal plants such as *Artocarpus lakoocha, Garcinia gummigatta, Garcinia indica, Cinnamom,* wild nutmugs, mushrooms, bamboo,, variety of palms and wild relatives of pepper and mango.

Sirsi is located in the central part of the Western Ghats, 80 percent of the area is covered with forest. One third of household income is contributed by non timber forest products, of which 60 - 70 % is wild fruits. The major NTFP species occurs in Sirsi area are *Garcinia indica, Garcinia gummigatta, Artocarpus lakoocha, Wild Mango,* etc.

Many studies have been conducted on non-timber forest products (NTFPs) over the years. The techniques of remote sensing and GIS have been successfully employed for monitoring different vegetation types, landscapes and forest fragments including individual species mapping. RS and GIS is useful in mapping natural distribution and abundance of tree species. Limited information is available on *Artocarpus lakkocha* with respect to its availability, mapping and its market chain. Keeping these points in view, a study was carried out in different watersheds of Sirsi taluk to assess the quantity of *A.lakoocha,* and its economic valuation.

1 MATERIALS AND METHODS

a. Study Area

The study was carried out in five watersheds of Sirsi Taluk, Uttara Kannada District. The District lies between 13°55' to 15°31' N latitude and 74°09' to 75°10'E longitude with an altitude of about 700 m. The total forest Cover of the district is 8,271 sq. km (80 % of the geographical area) out of total geographical area of 10,291 sq. km. The district has higher forest cover in Karnataka spread over 6,502 sq. km under dense and 1305 sq. km under open forests. The major forest types in the district are evergreen, semi evergreen, moist deciduous and dry deciduous/scrub forest.

Sirsi Taluk lies between 14°21' to 14°51' N Latitude and 74°34' to 75°4' E Longitude. The five major watersheds in Sirsi Taluk coded as 5B1A2, 5B1A4, 5B1A5, 4D4F4 and 4D4F5. The latitude and longitude Sirsi taluk with grids of 2' X 2' minute showing watersheds are shown in figure 1. There are 100 grids covering the entire taluk, out of which 91 grids were marked and a systematic field survey was conducted with line transect of 100 m X10 m for each grid to assess the *A lakoocha* abundance.

b. Field Survey:

The transect survey was conducted in Sirsi taluk to assess the availability of *A. lakoocha*. Transect of 100 m X10 m each was marked in all 91 grids falls in five watersheds. The transect location latitude, longitude and altitude was recorded with GPS. The same data was used as ground truth to classify the forest in to different classes' using IRS LISS-III data under supervised classification in ERDAS software. Considering the forest cover in Sirsi taluk, 0.01% (sampling intensity) of forest area was surveyed through transect.

The total geographical area of Sirsi taluk is 1,31,831 hectare of which major five watersheds covered an area of 1,20,601 hectare. In Sirsi taluk, dense forest and sparse forest covers 98,699 hectare where as five major watersheds in which survey was conducted have covered 90,450 hectare by dense and sparse forest. Total 91 transect was laid out randomly in both dense and sparse forest which covers 9.1 hectare area indicating sampling intensity of 0.01 percent.

The location of the survey conducted in different watersheds of Sirsi taluk, their latitude and longitude and altitudes are given in table 1.

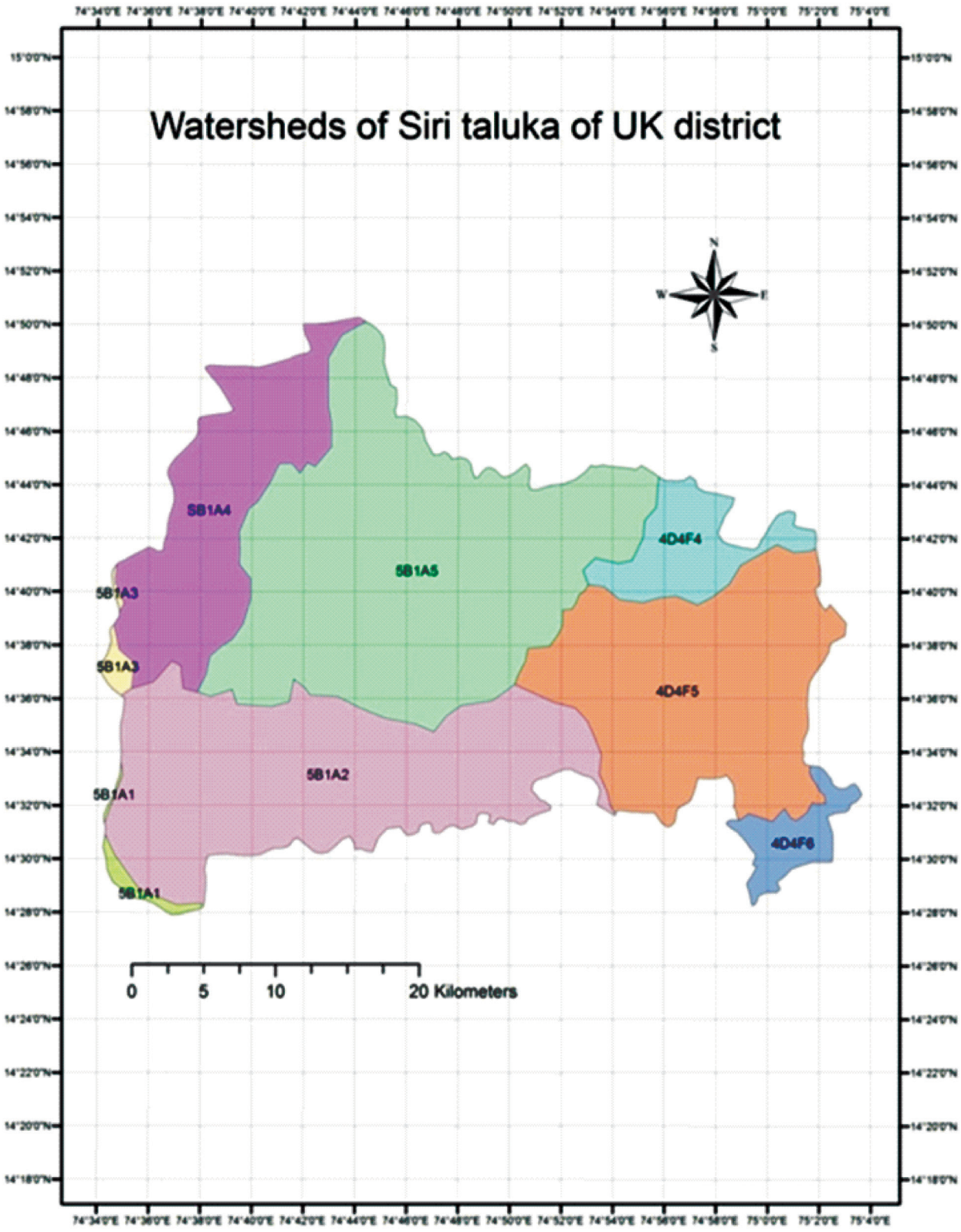

Fig.1. Watershed delineation map of Sirsi taluk with Lat-long

Table 1. Transect location and their lat-long and altitudes in Sirsi taluk

Sl. No	Location	Latitude N	Longitude E	Altitude (m)
1	Near vanalli	14°48'39.0"	74°42'52.3	564
2	Shivganga falls	14°47'51.1"	74°45'01.5	417
3	Muregar	14°41'07.7"	74°42'13.9	525
4	Shivgiri	14°39'45.8"	74°36'56.2	483
5	Near Vaddi	14°37'01.0"	74°37'05.5	574
6	Vaddi	14°37'00.3"	74°36'03.6	546
7	Vaddi	14°36'29.8"	74°34'23.3	548
8	Mattigatta	14°34'25.1"	74°36'42.3	511
9	Ragihosalli	14°31'21.5"	74°35'11.8	438
10	Hebre	14°31'33.7"	74°36'50.3	412
11	Before Hebre	14°31'39"	74°38'55.0	529
12		14°29'36.1"	74°37'20.7	555
13		14°42'27.9"	74°43'3.8	506
14	Near Jaddigadde	14°47'37.9"	74°41'04.7	518
15		14°40'41.0"	74°37'48.8	526
16		14°40'55.6"	74°41'17.3	482
17	Muregar	14°40'16.7"	74°42'43	562
18	Balegadde	14°39'45.2"	74°45'51.5	483
19	Sundalli	14°36'54.8"	74°37'57	577
20		14°36'20.3"	74°40'01.6	590
21	Hosgadde	14°35'25.4"	74°39'55.8	573
22	Kuppalli	14°32'02.8"	74°37'30.9	465
23	Khurse	14°32'05.0"	74°39'54.6	540
24	Janmane next	14°32'33.9"	74°41'39	566
25	Manjguni	14°33'33.6"	74°40'27.0	541
26	Amminalli	14°33'07.1"	74°43'36.0	536
27	Ragihosalli	14°31'25.3"	74°40'16.0	566
28	Revankatta	14°30'35.5"	74°43'37.9	516
29	Gonsar	14°44'17.8"	74°39'30.8	552
30	Dhoolalli	14°45'48.7"	74°43'27.2	553
31		14°45'08.8"	74°44'38.6	529

Sl. No	Location	Latitude N	Longitude E	Altitude (m)
32	Near Bakkal	14°42’46.3”	74°42’41.1	468
33	Hulekal	14°43’22.4”	74°47’02.4	530
34	Hulekal next	14°43’10.8”	74°47’02.4	530
35	Before Ummachgi	14°43’31.7”	74°49’25.6	447
36		14°44’00.7”	74°51’15.8	492
37		14°41’24.5”	74°39’20.0	550
38	Sonagijaddi	14°40’37.2”	74°45’32.8	531
39	Targod	14°40’33.4”	74°49’47.1	545
40	Hasrur	14°41’11.9”	74°53’54.2	657
41		14°38’13.2”	74°42’48.7	594
42		14°39’40.9”	74°45’34.2	530
43	Near balegadde	14°38’14.7”	74°47’14.6”	521
44	Islur	14°39’59.23”	74°52’35.0”	635
45	Devnalli	14°37’03.2”	74°39’11.6”	558
46	After devnalli	14°36’10.0”	74°42’03.1”	613
47		14°36’15.6”	74°44’7.3”	571
5				
48	Heepnalli	14°37’54.1”	74°48’02.4”	558
49	Near neelekani	14°36’01.8”	74°48’39.1”	587
50		14°36’38.2”	74°58’18.04”	590
51	Kallalli	14°35’07.7”	74°39’14.8”	553
52		14°35’01.9”	74°41’55.4”	541
53	Kalmane	14°35’33.9”	74°45’14.6”	548
54		14°35’53.2”	74°51’34.3”	590
55	Unchalli	14°34’17.6”	74°5’38.2”	611
56	Somnalli	14°34’08.3”	74°54’14.5”	594
57	Kolgibees	14°33’27.6”	74°45’02.6”	529
58	Kibballi	14°33’21.6”	74°46’44.7”	565
59	Hosalli	14°33’30.3”	74°46’43.3”	541
60	Ajjibal	14°33’57.5”	74°49’19.2”	560
61		14°33’57.0”	74°54’0.7”	593
62	Navangere	14°33’00.9”	74°55’21.7”	576

Sl. No	Location	Latitude N	Longitude E	Altitude (m)
63	Bennehole falls	14°31'32.1"	74°37'25.2"	445
64	Halligadde	14°42'43.2"	74°39'40.3"	556
65	Gonsar	14°42'56.3"	74°40'01.5"	554
66	Bisilkoppa	14°42'05.8"	74°56'22.7"	657
67	Hulekal	14°41'03.8"	74°45'03.6"	517
68	Ekkambi	14°41'31.3"	74°54'50"	663
69		14°41'0.1"	74°57'2.2"	624
70	Bisilkoppa next	14°41'41.4"	74°59'26.4"	610
71		14°41'03.7"	74°00'516"	593
72	kavalibeelu	14°39'291"	74°55'55"	630
73		14°38'45.1"	74°59'57.5"	585
74	Kuppagaddi	14°38'36.8"	75°00'39.3"	588
75		14°38'26.0"	75°00'36"	557
76	Near sirsi	14°37'51.0"	74°52'18.4"	589
77	Banvasi	14°37'05.8"	75°00'01.8"	593
78		14°34'01.4"	74°56'04.2"	601
79		14°35'26.2"	74°59'33"	563
80		14°34'59.1"	75°00'001"	582
81		14°32'52.3"	74°56'30.6"	601
82	Kalkaradi	14°35'44.1"	75°00'37.9"	575
83		14°46'31.8"	74°44'32.8"	529
84	Vanalli	14°44'18.0"	74°41'53.0"	510
85	Bakkal	14°42'35.1"	74°44'43.1"	518
86		14°39'47.1"	74°41'15.1"	424
87	Salkani	14°39'38.9"	74°42'25.7"	574
88		14°35'51.8"	74°43'05.6"	556
89	Malali	14°35'01.0"	74°46'10.0"	568
90	Chikkadi	14°33'33.6"	74°40'27.0"	541
91	Bandalike	14°32'06.8"	74°48'33.9"	539

In each transect the growth parameters all the species and NTFP species were recorded. All the trees having girth of ≥30 cm GBH (Girth at breast height) occurring within the boundaries of transect were recorded and the species identification was done based on morphological characters using field key (Pascal and Ramesh, 1997). The NTFP tree species in the region were identified based on the available secondary literatures.

The tree GBH was recorded with tape and tree height was recorded using Ravi altimeter. The lat-long, altitude was recorded with GPS. The number of each species and name of the different species was recorded for assessing the biodiversity indices. The basal area was estimated using the formula $\pi d^2/4$ where, d is diameter at breast height.

c. House hold Survey:

House hold survey was conducted in all five watersheds of Sirsi taluk. All the categories of families such as large, medium, small sized families including land less laborer were interviewed and information on collection of *Artocarpus lakoocha* from the forest and marketing of lakoocha fruits was recorded through questionnaire. Nearly 500 households were interviewed. The majority of farmers collected the fruits for their home consumption. Nearly 5 to 10 farmers in each village collected the fruits, dried them and sold it to the local market at Sirsi (Kadamba market, Sirsi; local wholesalers and retailers).

d. Bio-diversity indices

The data collected was subjected to analysis by assessing relative frequency, relative density and relative dominance. Based on these parameters, the Importance Value Index (IVI) at species level was calculated following the method of Curtis and Macintosh (1951). The IVI is the indicator of ecological success of the species which is sum of relative density, relative frequency relative dominance. This was done with respect to *A. lakoocha*. Using following formulae.

IVI = Relative frequency + Relative density + Relative dominance (for growing stock)Where,

$$\text{Relative frequency} = \frac{\text{Frequency value for a species}}{\text{Total frequency value of all the species}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of transect in which a species occurs}}{\text{Total number of transect sampled}} \times 100$$

$$\text{Relative density} = \frac{\text{Number of individuals of a species}}{\text{Total Number of individuals of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal area of species A}}{\text{Total basal area of all species}} \times 100$$

$$\text{Abundance} = \frac{\text{Number of individuals of species A}}{\text{Number of transect in which occurrence of species A}} \times 100$$

Species diversity is composed of two components such as species richness (total number of different species) and species evenness (how equally the individuals are represented from each species.) Shannon's index of diversity is the measures of the average degree of uncertainty of predicting to what species individuals chosen at random from a collection of 'S' species, 'N' individuals would belong. This average uncertainty increases as the distribution of individuals among the species becomes even. Thus, H'= O when all species are represented by the same number of individuals. It is estimated by using the formula:

$H' = \sum_{i=0}^{s} [(\frac{ni}{N}) \ln(ni/N)]$

Where, H' = Shannon's diversity index

Ni = Number of individuals belonging to the 'I'th species

N = Total number of individuals in the sample

S = Number of species

Evenness Index (Pielou, 1996)

The evenness index of dominance was calculated by,

E = H'/In (S)

Where, H' = Shannon's index

S = Species richness

'E' approaches to 'O' as a single species become more and more dominant in a community; the value of 'E' increases with the more evenness of the species.

2. RESULTS AND DISCUSSIONS

a. Land use land cover classes in Sirsi taluk

The land use land cover map for Sirsi taluk was prepared using IRS LISS-III image in with supervised classification in ERDAS software. The land use land cover classes with their area is given in table 2 and figure 2. The classification indicated that 48.37 per cent area is covered by dense forest, 26.5 per cent area is covered by sparse forest and third largest area is covered by agriculture (16.47%). Among the different classes, only dense forest and sparse forest area was surveyed for assessing availability of the *A. lakoocha*. The land use land cover map was prepared in Arc GIS (Fig 2).

Table 2: Land use land cover classes with their area (ha and %)

Sl.No.	LULC CLASSES	Area in Ha	Area%
1	Dense forest	63,763.00	48.37
2	Sparse forest	34,936.60	26.50
3	Horticulture plantation	4,437.54	3.37
4	Agriculture	21,715.30	16.47
5	Open land	1,279.95	0.97
6	water	586.02	0.44
7	Settlement	5,112.39	3.88
	Total	**1,31,831.00**	**100**

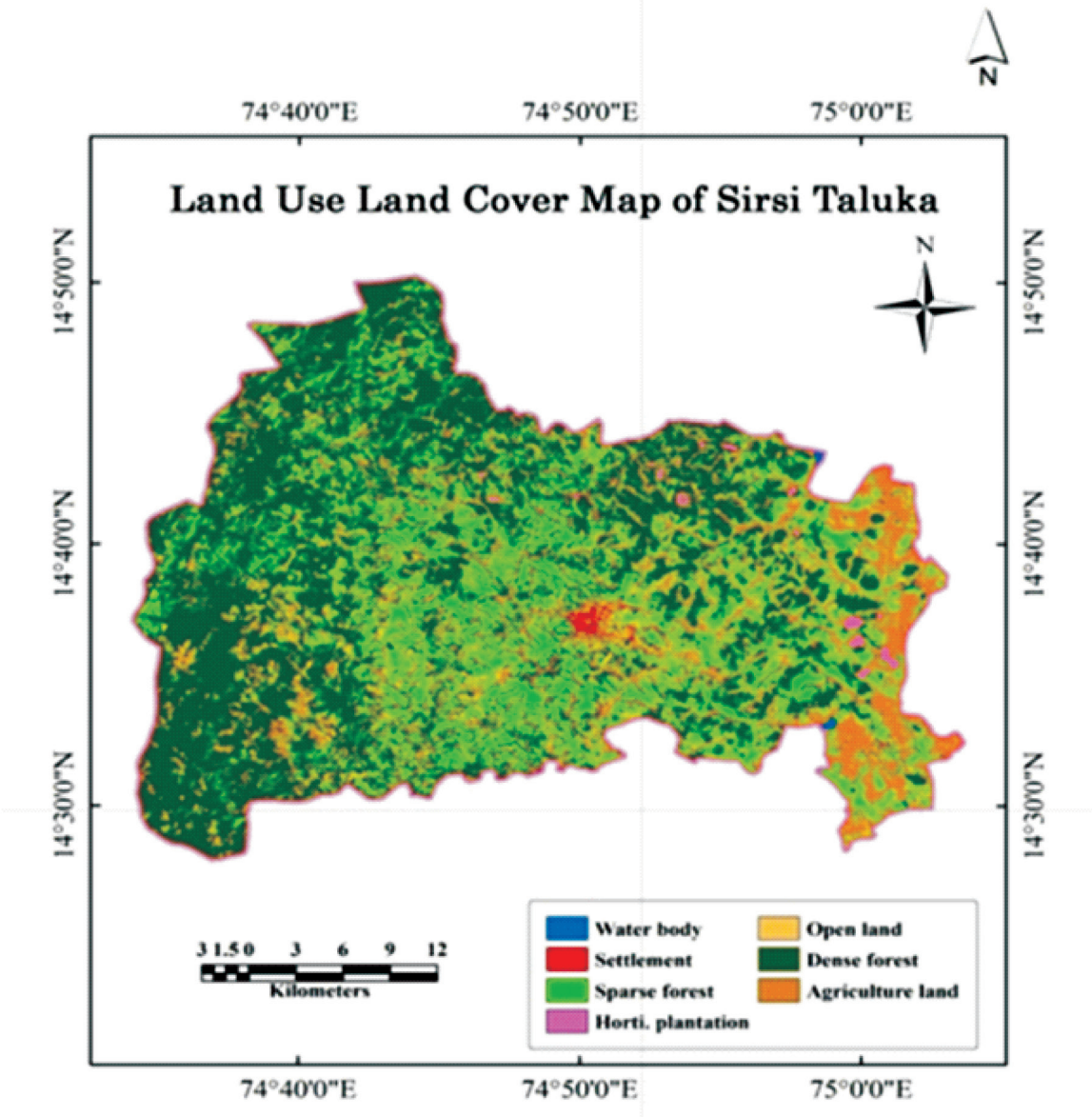

Fig.2 Land use land cover classes of Sirsi Taluk

b. Composition of NTFP species in watersheds of Sirsi Taluk.

The floristic composition pertaining to the NTFP species of the entire study area is represented by 73l, species. Among them *Artocarpus lakoocha* is one of the NTFP species. The *Artocarpus lakoocha* is found in three watersheds i.e 5B1A2, 5B1A4 and 5B1A5 and it was not found in 4D4F4 and 4D4F5 watershed. The species composition varies with watersheds, highest species was recorded from 5B1A5 watershed (54 species) followed by 5B1A2 watershed (53 species) and 5B1A4 watershed (40 species).The least NTFP species composition was registered in 4DF4F4 (18 species) followed by 4D4F5 watershed (37 species).

The analysis of family composition that existed in five watersheds of Sirsi taluk indicated that 5B1A5 watershed was found to be richest in tree family composition (26 families) followed by 5B1A2 watershed (25 families), 5B1A4 watershed (21 families), 4D4F5 watershed (20 families) and least was with 4D4F4 watershed (13 families) as against an overall family composition of 30 tree families in entire Sirsi taluk. The number of tree families and species present in each watershed is shown in figure 3

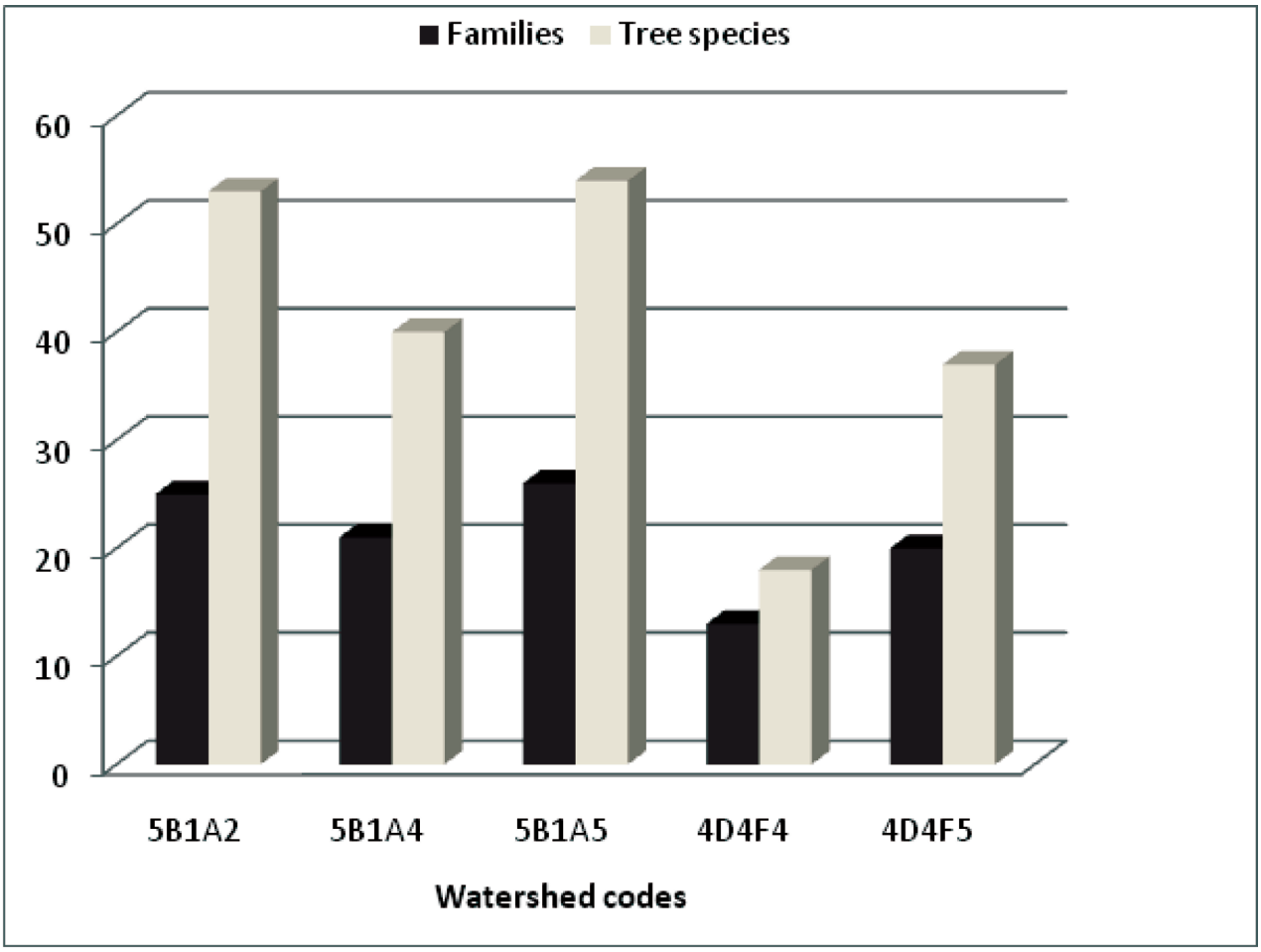

Fig 3 . Number of tree families and species found in watersheds of Sirsi taluk.

c. Tree species diversity

The diversity of tree species as indicated by different indexes is given in table 3. The diversity of tree species as indicated by Shannon's diversity index was highest in 5B1A5 watershed (3.36), followed by 5B1A2 watershed (3.33), 5B1A4 watershed (3.17) and in 4D4F5 watershed (2.97) where as it was least in 4D4F4 watershed (2.44).

Table 3. Biodiversity indices for NTFP species in different watersheds of Sirsi Taluk.

Biodiversity indices	Watershed codes				
	5B1A2	5B1A4	5B1A5	4D4F4	4D4F5
Shannon index (H')	3.3398	3.1723	3.3630	2.4419	2.9789
Simpson's index of dominance(D)	0.0505	0.0608	0.0503	0.1226	0.0840
Evenness index(E)	0.8412	0.8659	0.8431	0.8449	0.8250

Shannon index:

Shannon Index is a commonly used diversity index that takes into accounts both abundance and evenness of species present in the community.

Simpson's index of dominance:

The Simpson's index of dominance values of NTFP tree species across different watershed are presented in the Table 3. The Simpson's index values showed that, index was highest in 4D4F4 watershed (0.122), followed by other watersheds such as 4D4F5 (0.084), 5B1A4 (0.060), 5B1A2 (0.050) and 5B1A5 (0.050).

Evenness index:

The evenness values of tree species across different watersheds in Sirsi is presented in the Table 3. The evenness index values of NTFP species varied from 0.8250 to 0.8659. Among the watersheds, 5B1A4 watershed showed higher value (0.86) followed by 5B1A2, 5B1A5, 4D4F4 watersheds (0.84 each) and 4D4F5 watershed with 0.82 evenness value.

The Shannon diversity index and evenness is shown in fig. 4 and Simpsons dominance index and evenness is shown in fig.5

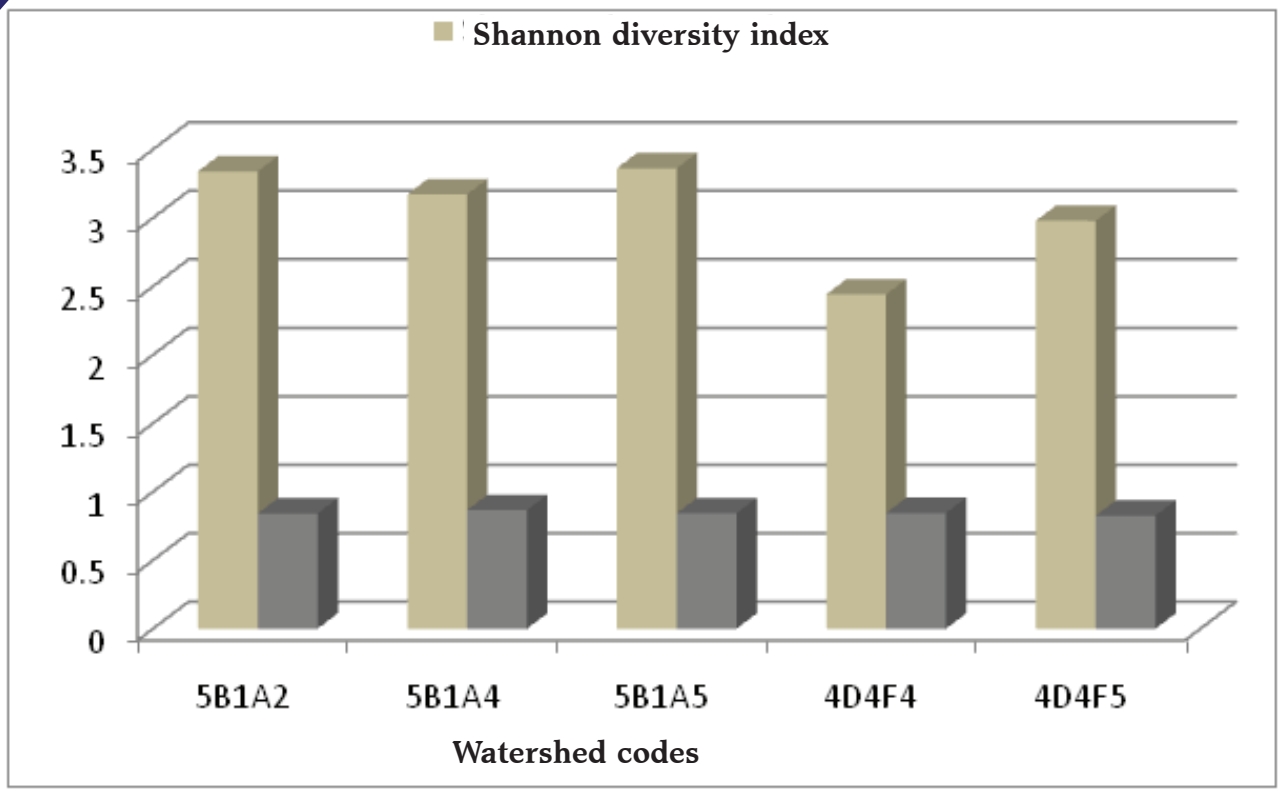

Fig 4. Shannon index and Evenness in different watersheds of Sirsi.

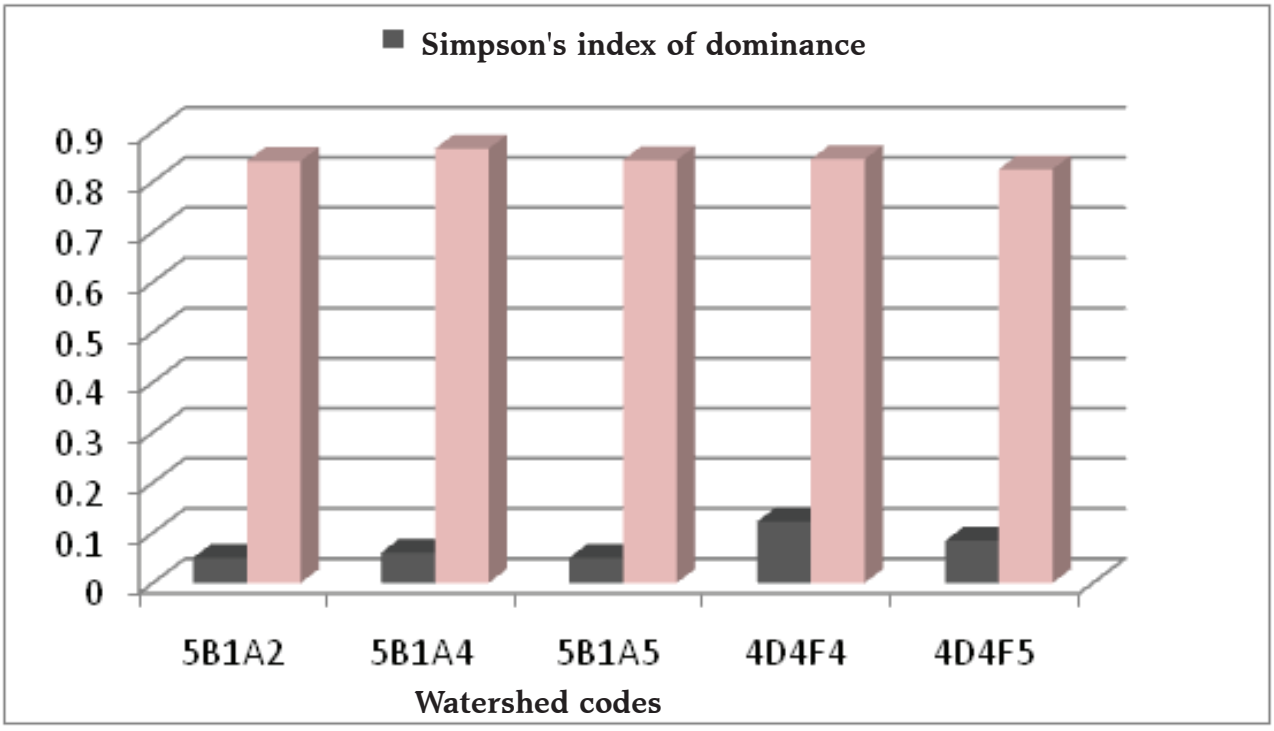

Fig 5. Dominance and evenness indices for NTFPs species in different watersheds of Sirsi taluk

Estimation of abundance:

The abundance estimation study was carried out in all the five watersheds of Sirsi and population attributes like density, basal area per hectare along with floristic attributes like relative density, relative frequency, relative dominance and Importance Value Index are presented below.

The abundance value of NTFP species ranged from 100.00 to 457.14 percent. The highest abundance value of 457.14 % was recorded for *Garcinia morella* Nearly 50 percent of the species were represented for the lowest abundance value of 100.00% among them *Artocarpus lakoocha* is one such species recorded for low abundance value. Among different species, Artocarpus lakoocha recorded basal area of 0.48 m2/ha having abundance value of 100, relative frequency was 1.46 and relative density was 0.77. The relative dominance for this species was 1.22 and IVI for the *A.lakoocha* was 3.45.

Similarly all parameters recorded for *A. lakoocha* from 5B1A4 watershed indicated that the basal area was 1.27 m2/ha and abundance value was 133.33. The relative frequency and relative Dominance was 3 and 3.8 respectively and the IVI for the species was 9.04.

In the watershed 5B1A5 *A lakoocha* recorded 0.73 m2/ha with 100 per cent abundance. The RF and RD are 2.12 and 1.17 respectively. The relative dominance and IVI for the species was 1.24 and 4.54 respectively. The *A. lakoocha* was not found in 4D4F4 and 4D4F5 watersheds.

d. Mapping of *A lakoocha* in watersheds of Sirsi taluk

The Sirsi areas satellite data from cartosat1 DEM was downloaded from Bhuvan web site NRSC, Hyderabad. The elevation of the Sirsi areas and the drainage lines are mapped in Arc GIS. Based on drainage lines the watershed delineation map from the DEM data was prepared from Arc GIS software, both the maps are shown in figure 6 and 7 respectively. The figure 6 indicated that the elevation in the Sirsi taluk varies from -6 m to 654 m. The color shade indicated in the map is for the elevation differences.

The location of the availability of *Artocarpus lakoocha* trees recorded during the transect survey are shown in Sirsi taluk (Figure 7). The location of the *A lakoocha* tree are found mostly in moist deciduous and semi evergreen forest along the drainage lines.

These plants preferred dense forest ecosystem and near water sources, hence the trees are found all along the streams.

The economically important NTFP species occurred in different watersheds of Sirsi taluk was assessed. Among different NTFPs, the three economically important species are *Garcinia gummigatta, Garcinia indica* and *Artocarpus lakoocha*. The occurrence of *A lakoocha* was mapped in comparison with *G.gummigatta and G. indica*. The combined map of the economically important three species distributed in different watershed of Sirsi taluk is shown in figure 8.

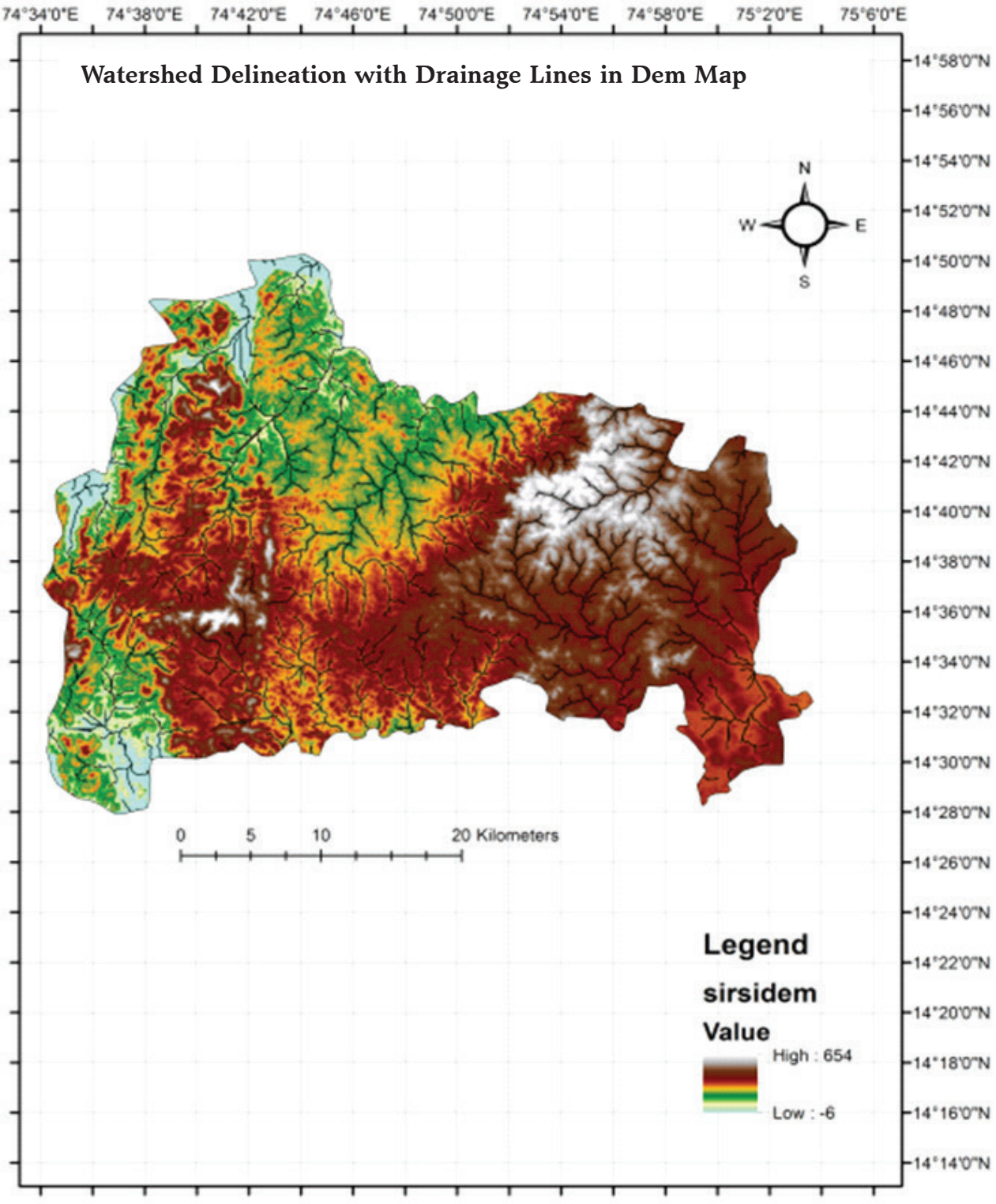

Fig. 6 Elevation and drainage line map of Sirsi taluk

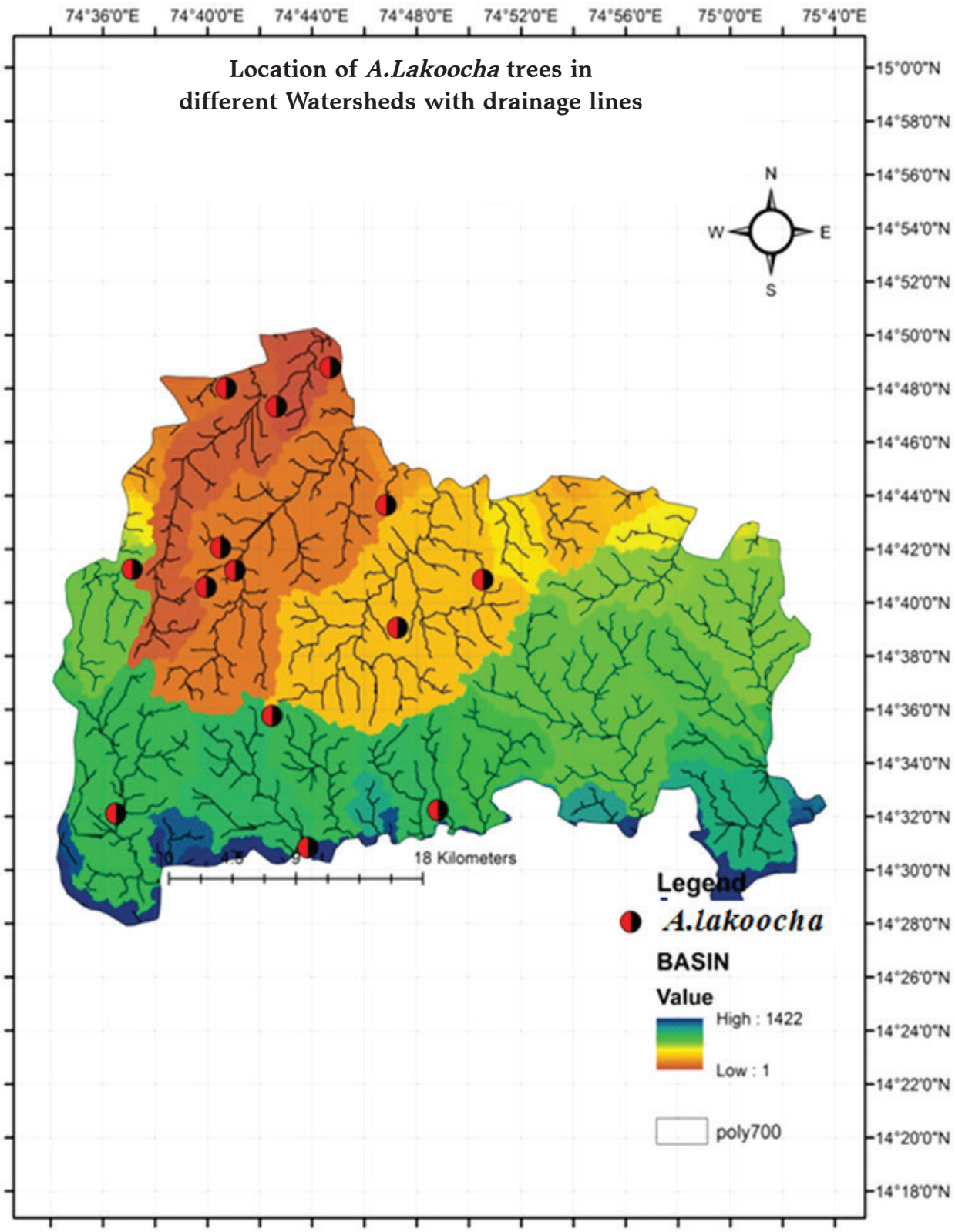

Fig.7. Location of A.lakoocha trees in different Watershed with drainage lines in Sirsi taluk

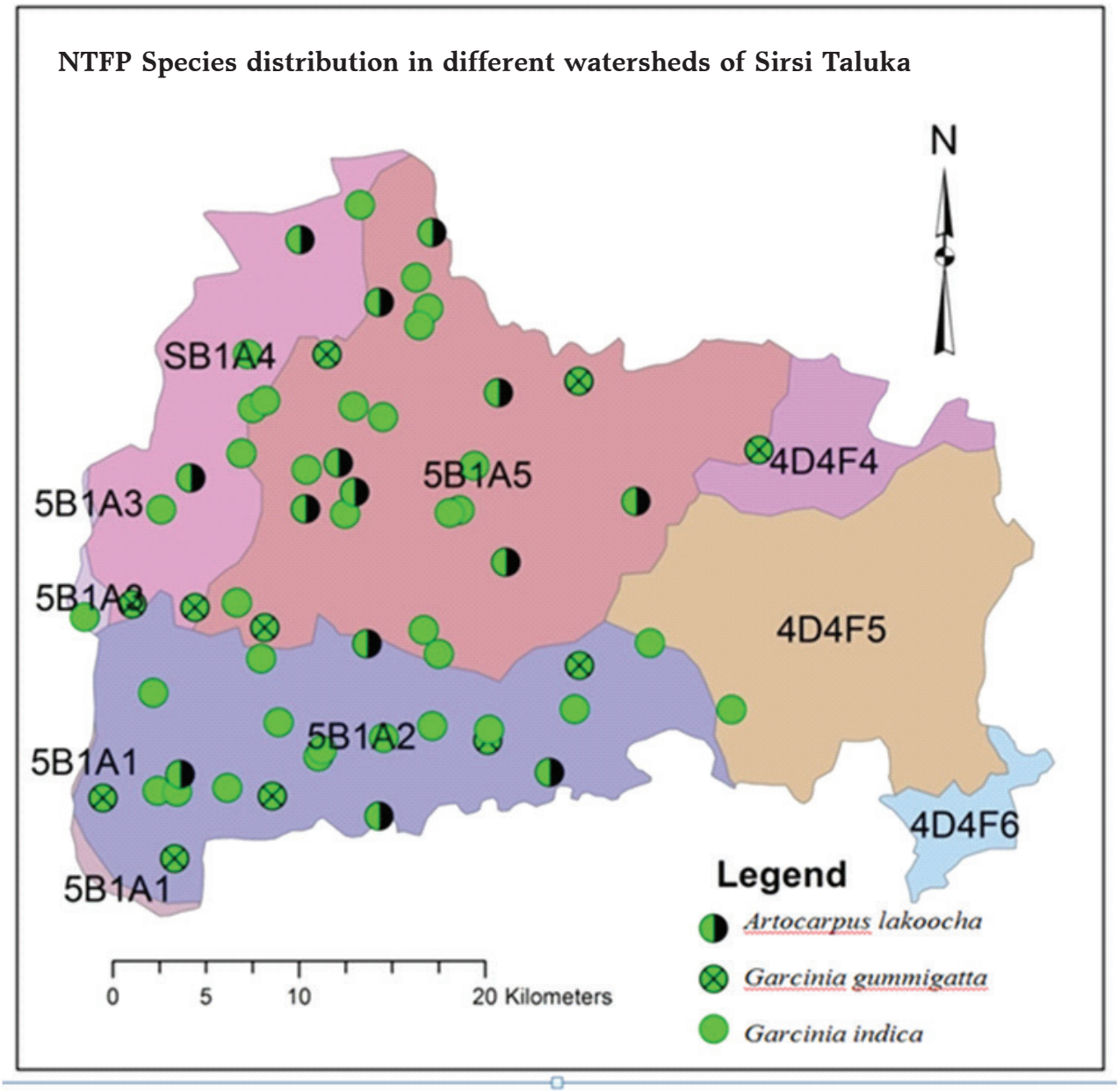

Fig.8. Distribution of *A lakoocha* as compared to *Garcinia* species in Sirsi taluk.

e. Quantification of available trees of *A. lokoocha* in Sirsi Taluk .

As per the transect survey in five watersheds of Sirsi taluk, trees of *A. lakoocha* is found only in three watersheds. There are 14 trees were found in 91 transect laid out in five watershed as shown in table 4. The three watersheds 5B1A2, 5B1A4 and 5B1A5 with their area are 29893, 15000 and 43168 hectare respectively. The number of *A.lakoocha* trees present in three watersheds of Sirsi are 1,20,046. As per the household survey the farmers have given the availability of fruits, its usage and marketing channels. On an average each tree would give 50 to 60 kg of dried fruits, the trees gives the highest yield once in 10 years which is called seed year during which yield of each tree would go up to one quintal. Considering the normal yield of average 50 kg per tree, the

potential yield availability in Sirsi taluk would be about 60,000 quintals. Considering only 80 per cent of the trees are producing the fruits then the expected yield would be 48,000 quintals.

As per the market survey at Sirsi and household survey in these watershed areas, it is estimated that a maximum of 100 quintals of *A lakoocha* dried fruits is coming to market at both Kadamba marketing Society and local wholesaler market. Still more than 40,000 quintal fruits are available from these three watershed areas, which is a huge quantity. However, the household survey indicated that majority of the peoples are using the *A lokoocha* fruits for household uses. In forest area, most of the fruits are being eaten by Monkey. The tree is large in size, well branched and harvesting of fruits from the tree is difficult and only part of the tree is being harvested for household uses. The sustainable harvesting tools and techniques are necessary for harvesting higher quantities from the forest area.

There is a good scope for marketing of *A lakoocha,* as it is put to day to day use in place of tamarind. Because of its medicinal properties, people are using it to treat many ailments. Majority of the fruits collected by the farmers are sold at Sirsi market which is further processed and converted in to powder as value added product and sold in local as well as national markets. The market linkage is depicted in the Flow Chart 1, linking trade at all levels.

Table: 4. Total population of *Artocarpus lakoocha* as per transect survey in watersheds of Sirsi Taluk

Watersheds	Area (Ha)	No. of transect	*A.Lakoocha as per transect survey* (Nos).	Total population
(Nos)				
5B1A2	29893	20	4	11210
5B1A4	15000	10	2	22500
5B1A5	43168	30	8	86336
4D4F4	5883	11	0	0
4D4F5	26657	20	0	0
Total	**1,20,601**	**91**	**14**	**1,20,046**

During the house hold survey the farmers were asked about the usage of the fruit for different purposes, the usage of fruits by the farmers are explained below.

f. Local uses of *Artocarpus lakoocha:*

1. Fruits are being used as vegetables especially the Brahman community used the fruits in large quantities.
2. The fruit (half spoon) is being used for making curry along with bitter guard to reduce the bitterness of curry.

3. Half spoon of the Lakoocha powder is being used for preparing lady finger baajji to reduce the viscous of lady finger.

4. Ripen fruits of the Lakoocha after removing the seeds are dried under the sunlight for 10 to 15 days and stored in the bottle jar and used subsequently for the preparation of curry.

5. 1 to 2 spoons of the powder is being used for preparation of sambar along with other ingredients such as curry leaves, garlic, green chilly, red chilly, mustard and oil.

6. *A. lakoocha* is used for preparing sweet chutney (recipe: ingredients 25 to 30 numbers of black peppers are roasted and make it as powder form and then 1 to 2 table spoon of lakoocha powder is added, little bit of jaggery and 1 spoon of ghee. The mixture can be stored for one month).

7. Cassava leaves are washed and boiled for 5 minute with the salt and 1 spoon of lakoocha powder added, mixed and grounded thoroughly with pungent chilly and used with food.

8. Used in the preparation of dry chutney (ingredients like dry coconut, garlic, chilly, roasted salt and 2 piece of dried lakoocha lobes are mixed the mixed ingredients are grinded and used daily).

9. Lakoocha pickle preparation: Raw lakoocha is washed and dried before chopping, heated till it gives smoke and then allowed it to cool down, to this, red chilly powder, turmeric, salt, fenugreek seeds, fennel seeds, 1 spoon of pepper and 3/4th spoon of mustard oil, was added, mixed and preserved in tight bottles and it can be consumed immediately.

10. Peppers are grinded by adding milk or rice water, lakoocha powder was added and heated with all the ingredients. The heated paste is applied to cure wounds and sprains.

11. The raw fruits of lakoocha are cut into small pieces and mixed with salt and dried in sunlight for 8 to 10 days and dried slices are powdered.

g. Marketing chain of *A.lakoocha*

Local Market

The farmers collect the *A lakoocha* fruits from forest, betta land and farm land during the months of April and May. The location of tree as per transect survey in Sirsi taluk is shown in fig 7. Majority of fruits are being collected for marketing from Vanalli, Kakkalli, Jaddigadde, Hulekal, Devanalli, Mattigatta, Manchikere and Ragihosalli from Sirsi Taluk.

Around 80- 100 farmers collect the fruits from forest, betta lands and farm lands from three watershed areas of Sirsi taluk (fig 7 and 8). The collected fruits are cut and cut fruit is dried under sun for few days and dried fruit is marketed to Kadamba

Marketing Society, APMC, Sirsi for Rs.50 to 60 per kg. Some farmers sell them to local wholesales for Rs 40-50/kg and many farmers directly sell to retailers for Rs 60-65/kg. The Kadamba Marketing society further processes the dried cut fruits rind in to powder which is then made into 250 gram packets before selling it to the retailers for Rs. 50 each packet. 15 % wastage occurs during the processing of dried rind into powder. The society also sells powder to wholesalers and retailers for Rupees 150-160 per kg and unprocessed dried cut fruits of lakoocha for rupees 80 per kg at the local market. The cost of dried fruits for buyers directly from retail shop of Kadamba is between rupees 100 to 120 per kg (further dried, cleaned and packed).

The local wholesalers are selling only dried cut fruits of lakoocha without further processing. The wholesalers are selling the lakoocha at the rate of rupees 60 per kg to the retailers. The wholesaler also sells the lakoocha directly to the end-users for rupees 70 to 90/kg. The local retailers in turn sell only dried cut fruits of *A. lokoocha* for rupees 75 to 80/kg.

Presently the quantity of dried *A lokoocha* cut fruits flow from forest, betta land and farm land through farmers from Sirsi taluk is to the extent of 30 quintal to the Kadamba Marketing Souharda Sahakari Ltd and 20 quintals to local wholesalers and retailers. The quantity of lakoocha coming to Sirsi market varies every year and once in 10 years the yield would go up. During 2012-13, it was about 100 quintals of lakoocha came to Kadamba market (total quantity of dried lakoocha cut fruits that came to Sirsi market was 150 quintals) and the same trend is expected during the year 2022-23. The yield of lakoocha two years preceding to the good seed year was very less (2 to 5 quintals only). After that every year nearly 50 quintal fruits are being marketed in Sirsi.

National Market :

Kadamba Marketing Souharda Sahakari Ltd Sirsi, is playing a major role in marketing the dried cut fruits and powder of *A.lakoocha* directly to Ahmedabad, Gujarat, Goa and Maharashtra market. The powder is being sold (nearly 5 quintals) at the rate of rupees 15,000 per quintal. The quantity of dried cut fruits of *A. lakoocha* being sold every year to Ahmedabad, Goa and Konkan Maharashtra is about 10 to 15 quintals at the rate of rupees 8,000 per quintal. The major quantity of lakoocha (both cut fruits and powder) is being used for preparation of curry. In Goa it is being used for preparation of fish curry. The lakoocha cut fruits as well as powder is being sold to Goa, Maharashtra and Gujarat through online transactions. Further the rate of lakoocha increases in the National Market. In Goa dried cut fruits of *A lakoocha* is being sold at the rate of rupees 150/kg, whereas powder is being sold at rupees 300/kg. The higher prices are being quoted for both cut fruits and powder of *A lakoocha* in all the three (Goa, Maharashtra and Gujarat) states. As per survey it is indicated that major quantity is being used for preparation of sambar, curry and rasam. Majority of the hotels in Goa are invariably using lakoocha in the preparation of food items. In Maharashtra lokoocha is used in place tamarind for culinary purposes.

The forest survey conducted in Sirsi taluk to assess availability of *A lakoocha* through transect survey and lakoocha plants are shown in plate 1. The lakoocha dried cut fruits and powder prepared and packet by Kadamba marketing Sirsi is shown in plate 2. The flow chart of the marketing channels is displayed in figure 9.

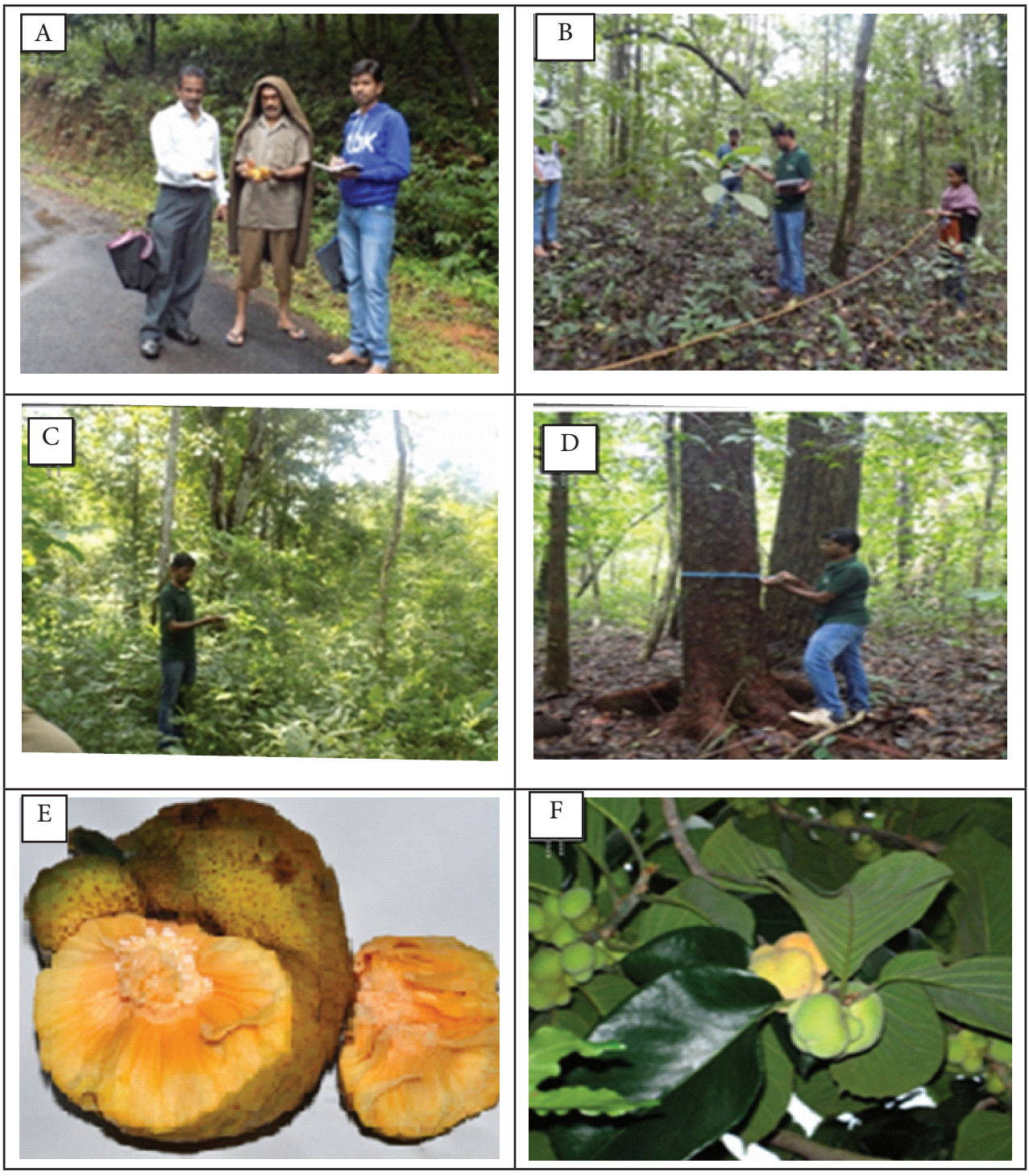

Plate 1. Transect survey for recording NTFP species in Sirsi taluka (A TO D), fruits bearing *Artocarpus lakoocha* (E&F) plants.

Fig 9. Flow chart of *A lakoocha* market chain links

h. Scope for setting small scale industries for *A.lakoocha:*

As per the field transect survey, there is a huge potential on the availability of fruits from three watersheds of Sirsi taluk. It was estimated that nearly 48,000 quintal fruits are being harvested, even 50 percent of the fruits harvested would be more than 20,000 quintal available. The overall market turnover as per the present rate of rupees 50/kg at farmers level would be around 10 crore rupees. If the value added product is prepared and sold in national market the turnover would reach up to 29 crore rupees.

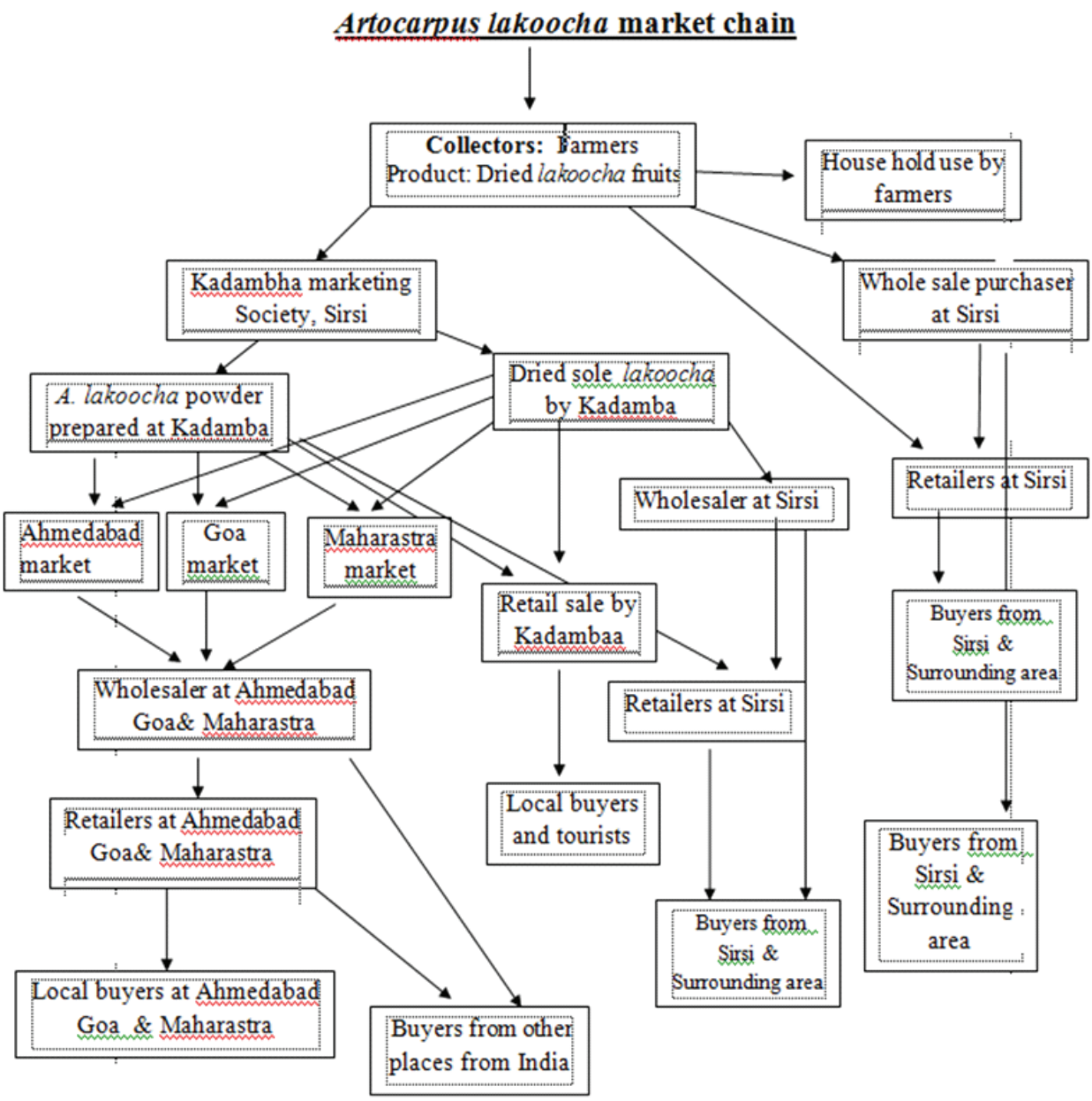

Fig 9. Flow chart of *A lakoocha* market chain links

As per survey, still there is availability of more than 40,000 quintal fruits of *A lakoocha* from three watersheds, hence one can set up small scale industries to process the fruit in to powder and other products for selling in National and International markets. Complete harvesting of fruits from forests is a challenge as mentioned earlier, since the tree is wide branched and it needs tools and techniques for sustainable harvesting. The forest Department has to take lead to procure all the fruits on tender basis which makes sufficient availability of fruits for small scale industries. As per the present market and availability of fruits the turnover expected from *A lakoocha* powder would be to the extent of 29 crore rupees.

3. CONCLUSION:

- The field survey and household survey indicated that there is a huge quantity of *Artocarpus lakoocha* available in three watersheds of Sirsi taluk.
- The market linkage is existed from farmer's level to local market and National level market through Kadambha Marketing Society and local wholesaler and retailers.
- There is a very good scope for value added products from fruits to the powder with 2 to 2.5 times higher prices for powder as compared to dried sole raw fruits.
- There is good scope to extract the huge quantity of fruits from three watersheds of Sirsi Taluk. As per field survey more than 40,000 quintal fruits can be harvested.
- Only less than 1 % of the fruit is being marketed, hence there is very good scope for market and value added products mainly for the powder.
- The present turnover of market for the *A lakoocha* at Sirsi is only 15 lakhs. The potentiality of market is to the tune of 10 crore rupees and with value addition in the form of powder the turnover would reach to 29 crore rupees if all the fruits are used for marketing from three watersheds.
- In this study RS and GIS techniques are found most useful for mapping the biological resources from forest area.

4. RECOMMENDATIONS:

- Since huge quantity of *A. lakoocha* is available in the forest, it is recommended that the sustainable harvesting of fruits from the forest is must by the forest department to maintain the *A. lokoocha* population.
- The small scale industries on *A.lakoocha* fruit processing and packing for national and international marketing with farmers share holding can be established at Sirsi.
- Since *A. lokoocha* has many medicinal uses, hence a local Ayurvedic doctors can take it as a profession in the medical field to treat the illness of human being.
- Opening of many fruit collection centers at appropriate places is necessary for running successful industries on *A lakoocha*.
- Taking large scale planting of *A lakoocha* in the forest area is must to meet the demand of fruits and its product in National and international market in future days.

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Dr. Ravikanth. G and Dr. Siddappa Setty. R

Fellow

Ashoka Trust for Research in the Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Jakkur post, Bangalore 560064, India

**Corresponding authors: siddappa@atree.org, gravikanth@atree.org*

Also contributed by Harisha, R. P, Madegowda C, Venkata Naidu

Chapter 5

Honey and Gooseberry-Non-timber forest products: economic valuation and conservation challenges

Abstract

The Non- Timber Forest Products (NTFPs) provide livelihood to millions of forest dwelling communities. Soligas, the indigenous community in Western Ghats earn 30-40% of their cash income from NTFPs. In recent years, enterprise based conservation has been encouraged among theSoliga community to bring livelihood security under the Forest Right Act. This in turn would increase community stake in the conservation. The additional income generated by the community is expected to be an incentive to conserve and monitor the resources. The institutional arrangements, norms and collective social practices in NTFP collection, value addition and lessons learned from enterprise-based initiatives are discussed in this paper. Three decentralized processing units have been established with community participation, adding value to honey and nelli besides other forest products. Participatory resource monitoring of NTFP species and activities related to assessment of resource production, extraction, regeneration and adaptive management have been carried out.. Establishment of decentralized processing unitshas enabled the communities to value add as well as diversify the NTFP products leading to enhanced income. Enterprise linked conservation involves the community in conservation and monitoring. Enhancing incomes from the sustainable harvest of NTFPs can help sustain local livelihoods and provide economic incentives to conservation.

Key words: Socio-economic, Soligas, Non-timber forest products,Conservation

Introduction:

The non-timber forest products (NTFP's) are an important source of livelihoods to many forest dwelling and forest fringe communities (Siddappa and Ravikanth 2017). It is estimated that the international trade in NTFPs is in billions of US dollars (Olsen and Treue, 2003). In India alone, NTFP trade is over US2.7$ billion per year and

absorbs 55% of the total employment in forestry sector (Shackleton 2015). The NTFP's traded include wide variety of medicinal plants, fruits, tubers, leaves, stems, flowers, lichens and wild animal products such as honey, wax, silk etc (Shaanker et al., 1998). In recent years, increased demand for these NTFP's has led to large-scale commercialization of NTFPs. While commercialization of NTFP's has helped to some extent in providing livelihoods to local harvesters, it has also led to large-scale exploitation of harvesters and local communities and benefitting a number of middlemen and large traders (Lele et al., 1996). Further, it is often seen that, when the demand for NTFPs increases, the local harvesters tend to over-exploit them, either because of economic insecurity or due to lack of management rules.

However, this could have negative ecological impacts (Ravikanth and Siddappa 2017) with either the species' populations becoming endangered (Ramesha et al 2007) or destructive harvesting could lead to reduced regeneration and ecosystem imbalance (Shivaprakash et al 2014). The commercialization of NTFPs should therefore focus not only on market access, value-addition and enhancing livelihoods but also on the negative ecological and population impacts that can result from over-harvesting or destructive harvesting practices.

Most of the commercialized NTFP's once harvested by the local harvesters are sold to processing units or to middlemen who in turn transport the products to processing units or to large traders. The processed products are then branded and marketed by the large-scale traders or by the commercial companies. However, in the local markets, the NTFP's are either sold by the collectors themselves or by the middlemen.

In southern India, the Local Adivasi Multi-purpose Co-operative societyhas been playing a major role in the NTFP trade (Lele et al., 1996). However, many other co-operative institutions also deal with the trade of NTFPs. Since there is no national or international framework to monitor the trade of many NTFP species, it is often believed that they are subject to overexploitation. In the recent, Forest Rights Act, the rightsof the indigenous people to customary lands, territories, resources have been recognized. The FRA alsoprovides legal rights to the communities on individual rights and community rights over resources for NTFP collection, utilization and conservation.NTFP species are vital sources of livelihoods to a number of forest dwelling and forest fringe communities (Murali et al 1996; Shaanker et al 2004; Siddappa et al 2008). The local communities' socio-economic and cultural relationships are deep rooted with forest and its produce (Gadgil 1993; Shackleton et al 2004). However, over the last two decades due to globalization and change in policy regimes, the NTFP collection, which was once at a subsistence level, has acquired commercial value (Murali et al 1996).

Keeping in view the economic potential of the NTFP species and their role in enhancing the livelihood of forest dwelling communities, the present paper focuses on the

conservation challenges with specific examples from gooseberry and honey.We discuss the institutional arrangements, norms and collective social practices in NTFP collection, value addition and lessons learned from enterprise-based initiatives.

Study area

The study was conducted in two protected areas in the Southern India; Biligiri Rangaswamy Temple Tiger Reserve (BRT) and Malai Mahadeshwara Hills Wildlife Sanctuary (MM Hills) (Figure 1). The BRT and MM Hillsare located in the southeast corner of Chamarajanagara district in the state of Karnataka, India.These sanctuariesare a confluence of the Western and Eastern Ghats. About 10,000Soligas, indigenous tribal communities live in forest villages called podus (tribal settlements). Traditionally, the Soligas were hunters and shifting cultivators and collected a wide range of non-timber forest products (NTFP). The Soligas retained the sole right to NTFP extraction under the aegis of tribal cooperatives called Large-Scale Adivasi MultiPurpose Societies (LAMPS). LAMPS are set up by the Indian government for integrated tribal development through the marketing of NTFP in regions with significant tribal populations.

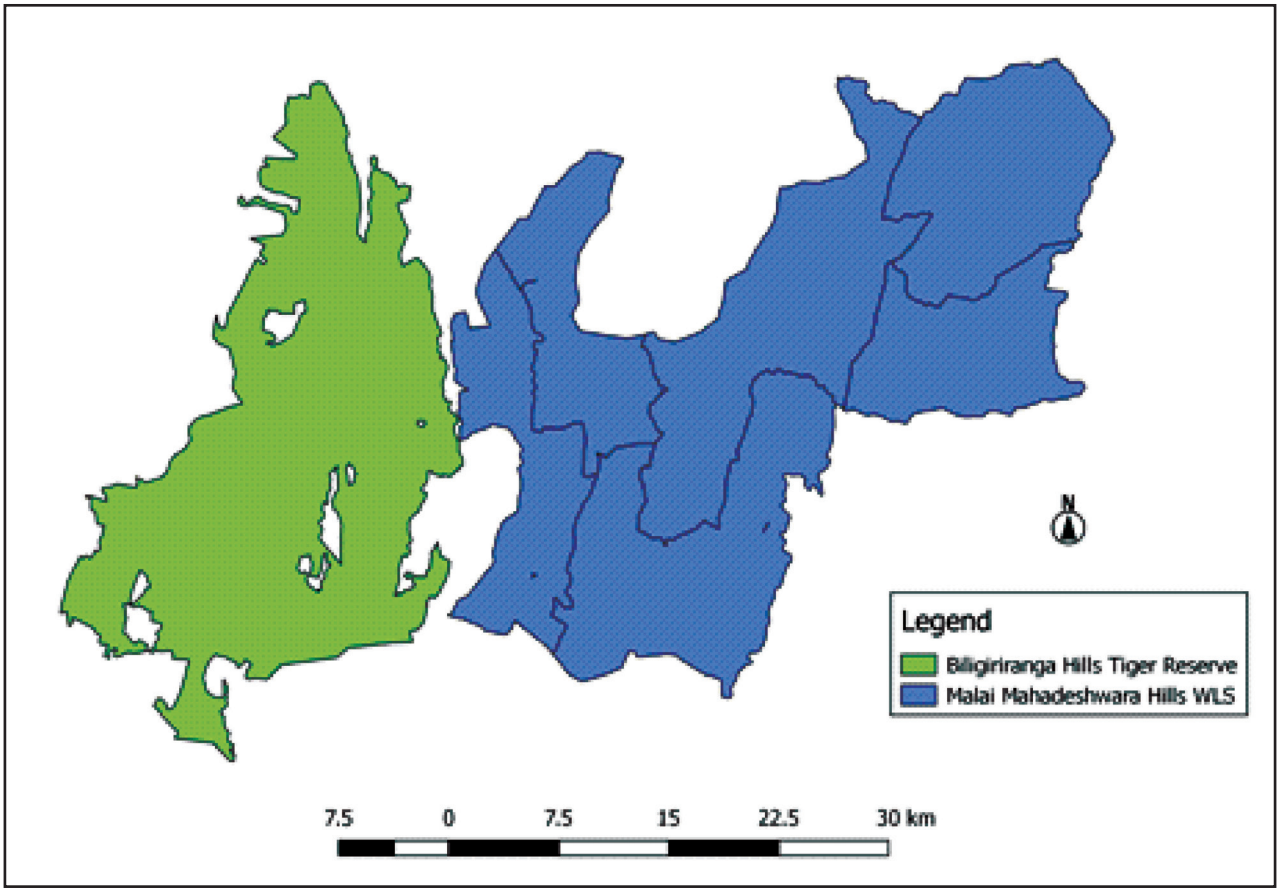


Figure 1. Location of the study sites

Gooseberry

The fruit Gooseberry (Amla) or locally called as Nelli in Kannada, belongs to the family Euphorbiaceae. The fruits of Nelli are collected from two conspecific species *Phyllanthusemblicaand P. indofischeri* in southern India. The species *P. emblica* is widely found in India, Sri Lanka, China, Vietnam and Thailand. It isindigenous to tropical Southeast Asia and occurs mainly in the dry or moist deciduous forests of central and south India (Arora and Nayar 1984; Shaanker and Ganeshaiah 1997). The other species *P. indofischeriis* endemic and restricted to Deccan Plateau including Eastern Ghats of Southern India (Ganesan, 2003).

P. emblica is found in dry deciduous forests as well as woodland savanna found between shola forests (1300 to 2000 m elevation) of the Western Ghats. *P. indofischeri* grows in scrub forests and is mostly restricted to low elevations. In the study site both the species show a clear altitudinal preference in distribution. The former is distributed between 900 m to 1500 m; whereas, the latter is distributed in the elevation range between 500 to 900 m. The trees grow up to a height of 10 m at low elevations in the scrub forest and up to 15 m in the dry deciduous forest. The fruits of both the species are berries that dehisce after falling on to the ground. The inner wall of the fruit is hard and encloses about six small seeds. The fruits are dispersed by ungulates such as Sambar deer *(Cervix unicolor),* Spotted deer *(Axis axis),* Barking deer *(Muntiacusmuntjak),* four horned Antelope *(Tetracerusquadricornis),* Mouse deer *(Tragulusmeminna)* and Indian gaur *(Bosgaurus)*. Fruits are used extensively in the traditional Indian medicine system known as Ayurveda and are important ingredients in several medicinal preparations such as Triphala, Amalakyadichurna, Chawanprash etc. Fruits are also used for making dyes and hair shampoo. The bark is also used in tanning and making hair-dye and ink material.

Contribution of Nelli to the cash income of Soligas

Nelli is the main NTFP collected from the forests. Average collection of nelliis is about 486.3 tons/year. Lowest quantity of 104 tons per year was collected during 1994-95 and the highest was 1492 tons per year during 2001-02. According to LAMPS 10 year's data, extraction levels peak once in four years, indicating mast fruiting in four-year cycles. An average rate received by the harvesters is Rs. 3 per kg and LAMPS in turn sells them for Rs. 4.5 per kg to the traders. Average money earned by LAMPS per year from Nelli was Rs. 22.2 lakhs out of which Rs. 15.4 lakhs was distributed to the harvesters. The quantities of fruit collection varied from 12.9 kg/ha/yr from the dry deciduous forest of *P. emblica,* to 23.2 kg/ha/yr from scrub forest for *P. indofischeri*. Harvesting of fruits from two *Phyllanthus* species alone contributes approximately 6-11% of the total cash income in a Soliga household. Nelli may account for 10-20% of the total cash income for a podu as a whole. If, however, one considers only those households that are actually involved in Nelli collection 70-85% of households are involved in 87-95% of podus.

Rock bee

Apisdorsata, commonly known as rock bee,is distributed in South and Southeast Asia. Local people in forest areas have commercially harvested honey since ages. The rockbee coloniesare mainly found on trees and rock cliffs in the forest. These social bees are known for their aggressive defense behavior. Indigenous people such as Soligas have been harvesting honey and wax using their traditional practices. Honeybees are important for regeneration of many flowering plants through their role as pollinators. Honeybees are abundant flower visitors of tropical and temperate vegetation (Seeley 1994). The giant honey bee *Apisdorsata* of tropical Asia (Seeley 1985, Ruttner 1988) has the largest natural colony size of all the honey bee species (Dyer and Seeley 1991). Bees and hive products such as honey and pollen are eaten by many species of birds and mammals in tropical forests. Honey from various bee species is a prized food item in India dating back to over 2000 years. In many tropical forest areas, indigenous people collect honey to use as supplemental food, medicine, and also for cash income.

Community

The Soliga tribe is one among the many tribes that have been living and depending on the forest for their livelihood. The Soligas ('people of the bamboo'),are an aboriginal forest tribe inhabiting largely in Chamrajnagara, Kodagu, Mandya, Ramanagara, and Mysore districts of Karnataka and the adjacent districts of Salem, Dharmapuri, and Erode of Tamil Nadu state.Until the middle of the last century, the Soligas practiced shifting agriculture, which was banned when the area was declared as wildlife sanctuary in 1976. They are now settled in small villages, called podus, which may contain up to 120 households. Many households practice settled agriculture on the lands around the podus. The Soligas are traditionally engaged in shifting agriculture. In addition, they also collect a wide range of non- timber forest produce forboth their subsistence needs and to obtain cash income.

Resource assessment

The resource distribution of the NTFP species harvested by the Soliga communities was assessed. The resource distribution map of NTFP's was carried out using two methods. First, the traditional ecological knowledge of theSoliga communities was used to map the distribution of NTFP species. This was carried out through focus group discussions. Second approach, was based on laying transects and quadrats in all the field sites.

Estimation of fruit productivity

Estimation of *P. emblica* fruit productivity was carried out through transects of 1 km length and 10 m width using systematic sampling techniques with the help of survey of India toposheet. Diameter at breast height (DBH) of the trees were measured and tagged for monitoring the yearly fruit productivity and extraction. Number of fruits in each tree

was enumerated before the fruits were harvested. Average fruits per tree and average fruits per site were calculated on an average sized branch using a Nikon binocular (10 X 25). A number of 5 similar sized fruit branches were selected and the fruits counted, average fruits produced by each branch was then multiplied by the total fruiting bunches on the tree to obtain the total fruits per tree.

Estimation of *P. indofischeri* fruit productivity was undertaken in both BRT and MMHills. Transects of 1 km length and 10 m width were established using systematic sampling techniques. Similar methods were used, as mentioned above to estimate fruit productivity and extraction. Data was gathered during the same period to estimate average fruits per tree and sites. However, since the trees in scrub forest are short, fruit estimations was done by counting the number of fruits on the tree without the help of binoculars. The yield per tree ranged from few to thousands of fruits. The fruit production of *Phyllanthusemblica* and *P. indofishceri* was done for the year 2014-15 and 2015-16. The *P. emblica* fruit production increased by 3 fold in 2015-16, when compared to 2014-15.

Extent of harvest

Transects established for the purpose of estimation of *P.emblica* and *P. indofischeri* fruit productivity was used for to assessthe extent offruit harvested. After the harvest was carried out by the community, transects were revisited and the number of the fruits left on the trees were observed and documented to understand the level of extraction at regional level of dry deciduous and scrub forest separately for both x. The extraction pattern of NTFP species by the harvesters was assessed for all the species across the sites. This was done to assess the impact of harvesting on the productivity. One of the destructive methods of harvest is the cutting the branches to obtain the fruits. The extent of destructive harvest was also recorded at each site.

Regeneration

To understand the population structure and regeneration in *P. emblica* and *P. indofischeri* transects of 100 meter long and 10 meter wide were plotted for each species in dry deciduous forest (for P.emblica) and scrub forest for *(P. indofischeri)* population. For the studies 10 transects of 100 meter long and 10 meter wide were established in dry deciduous and scrub forests. Total area sampled was 2 hectare for both the species. Stems less than 1cm DBH were considered as seedlings, 1 to 10 cm DBH were considered as juveniles and stems > 10 cm DBH were considered as adults. All individuals in the plot or transects were permanently tagged. The diameter of all individuals was measured using diameter tapes and vernier calipers as appropriate. Diameter was measured at breast height (DBH at 1.3 m) for adults and juveniles and at the base for seedlings.

Preliminary analysis (of the data from MM Hills) indicate that the percentage of seedling, sapling and adult trees are quite dissimilar in both the species; *P. emblica* (Seedlings- 47 %, Saplings -18%, Trees-35%) and *P. indofischeri* (Seedlings- 36 %, Saplings -26%, Trees-38%). About 25% of the seedlings are re-sprouts from the rootstock. High regeneration and survival rate was found in moist deciduous forest than in dry deciduous forest in case of *P. emblica*. More regeneration and seedling survival rate was observed in dry deciduous forest than in scrub forest in case of *P. indoficheri*.

Impact of branch cut on fruit productivity

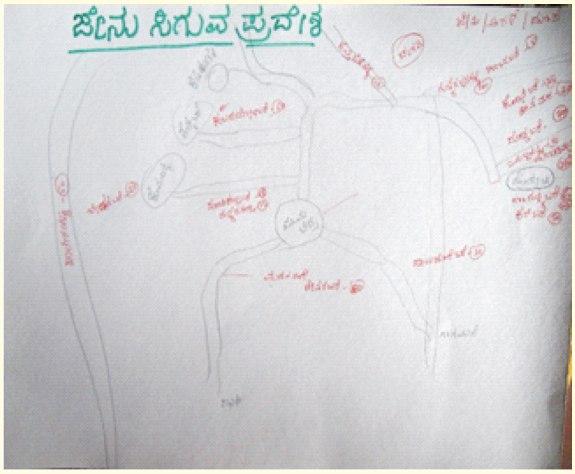
Cutting branches of trees not only affects the productivity of the trees the following year but also makes the trees susceptible to hemiparasitic infections. Both *Phyllanthus* species had branch cuts, especially the primary branch that provides space for hemiparasite to establish. Branch cuts have been recorded more in *P.emblica* (7.5% of total fruiting trees) than *P. indofischeri* (2.1% of total fruiting trees). Primary branch cuts (*P.emblica*- 44%, *P. indofischeri*- 57%) are more compared to secondary and tertiary branch cuts. Primary branch cuts are more frequent due to fruit harvesting and to feed the livestock during grazing in the forest. However, overall the frequencies of branch cuts were relatively less.

Honeybee distribution

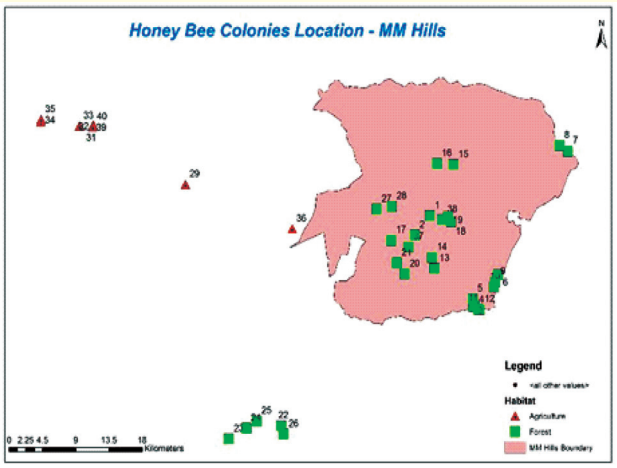
The rock honeybee's colonies were mapped and monitored in BRT, and MMHills. The site reconnaissance was conducted for checking the different habitats of rock bee colonies and notable observations were made on the various aspects like the number of colonies, tree species (with colonies), flowers visited by bees, resource availability, and water source in proximity. At each site, the GPS recording were also collected. Three types of habitats were recorded: rock cliffs, trees and agricultural lowlands. Apart from ecological monitoring, interviews and surveys were conducted among veteran honey harvesters. The sites visited for monitoring in M M Hills had 22 cliffs and 25 trees. The rock honeybee colonies were mapped and are being monitored in BRT and MM Hills.

For long-term monitoring, the marked rock bee colonies were revisited before and after honey harvest, in each harvest season (May-June and Oct-Nov). Sample sites were marked in three major habitats such as forest rocky cliffs, forest trees, and in agricultural land, where maximum bee colonies were found and frequent honey collection was done.

Rock Honey Bee Colonies are being monitored in 50 locations in and around MM Hills Wildlife Sanctuary, in both forest and agriculture land. Bee colonies are monitored in both rocky cliffs and trees where majority of beehives are found. The number of bee colonies in both forest and agriculture land are declining gradually every year.



Participatory resource map as baseline to locate rock honeybee colonies at MM Hills



Location of bee colonies being monitored in MM Hills

Enterprise development

Three decentralized processing units were established with community participation, adding value to honey and gooseberry by making number of products. Participatory resource monitoring was conducted and activities consisted of assessments of resource production, extraction, regeneration and adaptive management at village level. Several training programmes were conducted for people who work in the units on NTFP processing, value addition and marketing strategies.

Economic Valuation

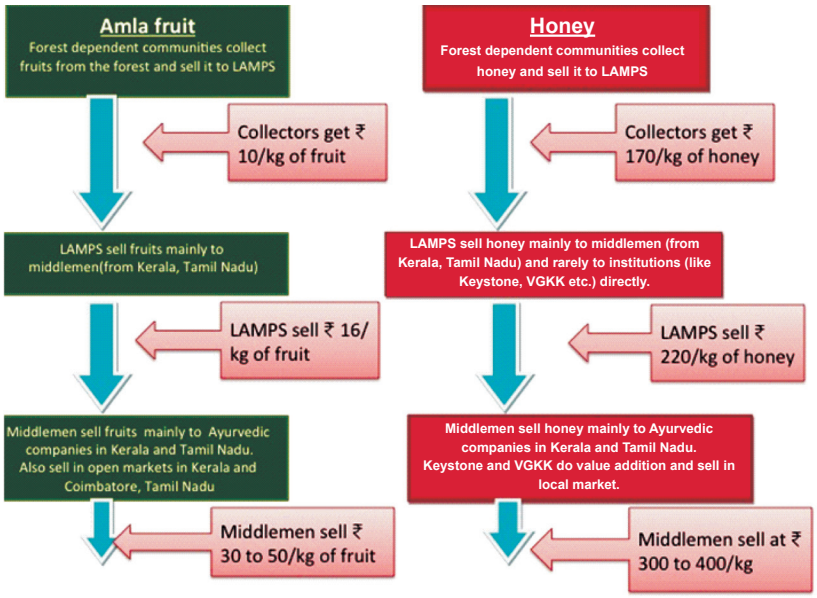
In general, Non-timber forest products (NTFPs) including medicinal and aromatic plants have been an integral part of the rural life style. Nelli and honey harvesting was need-based and traditionally regulated in such a way that sustainability was inherently ensured. Marketing of NTFPs for local needs does notimpact the regeneration of the species. But increased demand at regional,national and international levelhas altered population structure and sustainable harvest practices have been ignored. Theextensive global market would affectthe vital traditions. In the name of essential commoditization and intellectual property rights, profit-making multinationals are creating demands for NTFPs that go way beyond the possibilities of sustainable production(Ticktin 2004; Gaoue, andTicktin2010). Many studieshave revealed that market forces would threaten NTFPs species to extinction and natural ecosystems will be put in danger beyond recovery (Sinha&Bawa, 2002). Consequently the unprincipled growth of NTFP markets, without taking into consideration the basic needs and the essentiality of the product is causing great damage to natural ecosystems. For instance, traditional harvesting practices for Nelli and honey have not been practiced in many forest areas. It has been observed from the study that Nelli population structure has been severely affected in these study areas. Honeybee colonies number has been affected severely in both the protected areas.

Role of cooperatives

In the study area, thecommercialization of NTFPs was led by cooperative marketing societies,called Large-scale Advise Multi-Purpose Societies (LAMPS). LAMPS were set up by the government in regions with significant tribal population to facilitate marketing of NTFPs and tribal development. LAMPS held the rights of harvesting on lease from the Forest Department. Harvesters sell their NTFPs through the LAMPS. LAMPS market the products directly to the traders and in some cases they process and market the products at the highest price. The income obtained from such sales is tobe distributed to the harvesters in the form of loan, social welfare schemes, education etc. But LAMPS ideal functioning has been obstructed by many factors (Lele et al. 1996), which in turn has severely affectedharvester's income. In practice, harvesters receive a lower income than the potential cash income that they could receive from the value added NTFPs. The Forest Department controls NTFPs collection and grant license, permits and passes to harvesters. It has been observed that private traders buy NTFPs from the harvesters for low price and sell it for highest price and they receive maximum income (Lele et al, 1996).

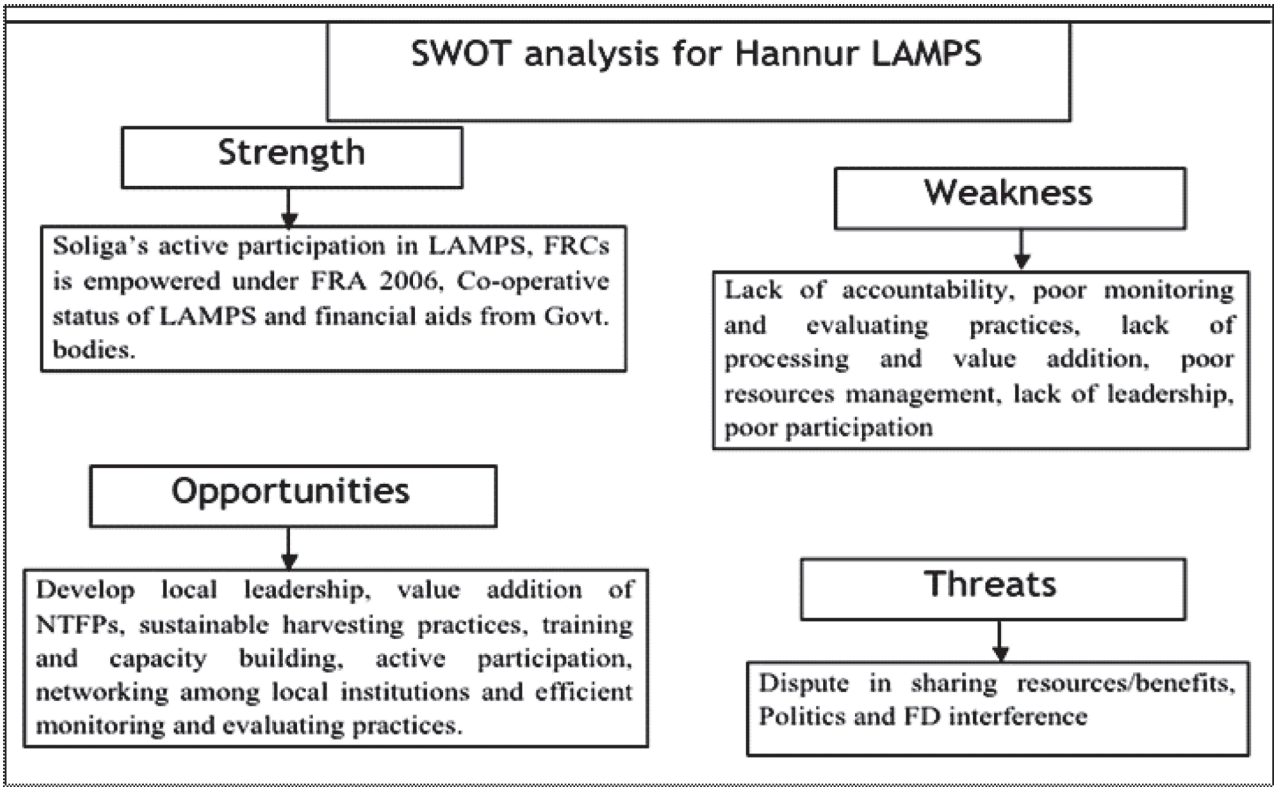
Role and impact of middlemen

When harvesters collect huge quantity of NTFPs from the forest, it requires immediate processing; transportation and marketing that need investment. Harvesters do not have the capital to invest in processing these NTFP's. This has led to the involvement of middlemen who intervene by investing and marketing the products. Further, most of the harvesters do not have the skill of market oriented value addition, and understanding the marketing strategy is quite challenging for them. Involvement of middlemen in marketing opens up commercialization, which has very less scope for sustainable harvest and conservation of NTFPs species in the forest. It has been observed that there is a huge impact on income of NTFPs harvesters (Lele et al. 1996).



Resource flow chart for Amla and honey

In both MM Hills WLS and BRT, in the last three decades, harvesters collectNTFPs and sell it to the middle men with minimum price fixed by the LAMPS. For instances, Nelli fruit collection price per kilogram was just Rs.3.00 in the year 1998 and increased to Rs.5.00 in 2009. But middlemen sold Nelli in the market for Rs. 40.00 per kilogram. Similarly, honey sold to LAMPS is Rs.100per kilogram in 1998 and increased to Rs. 130in 2009 and Rs.170in 2017. However, middlemen sold rock honey for Rs.400 per kilogram.



Strength, Weakness, Opportunities and Threats (SWOT) analysis of Hannur LAMPS

Value addition

Value addition for NTFPs is an important intervention to maximize the income of harvesters or dependent households in forest areas. However, many attempts in different forest areas for different NTFPs have been tried with limited success. The studies have foundthat cost for establishing value addition unit, maintaining the quality of the products and competing with market are the great challenges for community based value addition units across the globe.

Decentralized enterprises

Community based enterprise model wouldhelp in improving the livelihoods of NTFP dependent households and addressing the conservation issues in the region resulting in awin-win situation. For instance, as part of a USAID funded project,threeNTFPs value addition units (VAUs) were established by ATREE in two protected areas of Southern Karnataka. The major objective was to enhance the income by facilitating the NTFPs harvesters to form a co-operative to process the collected nelli and Honey and in marketing the products. Theproject has been orienting harvesters to monitor the nelli and bee colonies in the forestusing relevant scientific or traditional methods. This initiative helps the harvesters to understand their responsibility of sustainable use and manage resources wisely and regulate the use of resources and protect from the outsiders.

Livelihood priorities and NTFPs commercialization

The dependency on NTFPs by the communities has changed from 78% in 2007 to 33% in 2017. Lack of access and volatile market keeps the local people away from harvesting NTFPs (Table 1). The contribution of NTFPs to the household's income also decreased from 80% to 38% in a span of 10 years.

Table 1: Communities livelihood priorities

Livelihood option	1st priority (% of hh.)	2nd priority (% of hh.)	3rd priority (% of hh.)
Agriculture	64	32	4
Migration (stone quarry, Coffee estate and jobs in cities)	78	14	8
NTFPs collection	2	14	84
Others (FD, PWD, farming field, MNRGEA, temple and business)	34	49	17

The changing dependency of forest dwelling communities on NTFPs is associated with new opportunities, state sponsored welfare schemes and new developments activities in the region. NTFPs collection was the first livelihood priority for Soligas in 1980s, in these protected areas. But in 2017 it was a last livelihood priority for about 90% of Soliga households in the region. In addition to accessibility issues and availability of NTFPs in the forest, migrant labour and new livelihood opportunities have replaced the first priority.

The occupation choice has changed significantly between gender and age class, which was not so earlier when they had limited occupation options (Harish et al 2015). More than 80% of young people migrate as laborers to granite quarries and cities throughout the year. Around 45% of the women migrate seasonally to coffee estate as laborers. About 60% of old age people do farming and local labor work. Only about 10% of households do NTFPs collection if they are able to obtain collection passes issued by the LAMPS.

Socioeconomic welfare schemes (such as public distribution scheme, special nutritional food scheme, pension schemes for old age, widows, physical and mentally challenging people, subsidized sowing seeds and fertilizers, MNREGA schemesetc), increased development activities, tourism and modernization (improved transport faculties, communication, education, business and increase in migration of young people to cities) has changed the importance of NTFPs to local community livelihoods. Overall NTFPs collection has become an opportunistic rather thanneed-based activity in forest fringe communities in protected areas such as BRT and MM Hills WLS.These developments at the local level have opened avenue for outsiders who have poor understanding on the interrelationship of NTFPs and forest health in the region and have tried to maximize their income rather than sustainable harvest.

Conservation Challenges

Harvest and biodiversity change

The case studies illustrated that NTFP harvest can affect ecological processes at many levels, from individual and population to community and ecosystem (Shaanker et al., 2004; Prasanna et al., 2006). Variation in life history of species, harvest methods, environmental conditions, land use and management practices have significant impact on change of local biodiversity (Sinha&Bawa, 2002). However, traditional harvest practice does not have significant impact on NTFPs species (Siddappa et al 2004). Traditional harvesting practices have evolved locally and have been best practices for the local environmental conditions. However, there is a need for long-term studies that focus on multiple factors and their underlying impacts to validate the current practices. Co-management system with multiple stakeholders must be in place to design effective management practices that can mitigate the impact of harvest on species as well as on the biodiversity of the region.

Traditional knowledge and opportunities

Across the world, traditional knowledge system is well recognized and defined as an intellectual activity in a wide range of social, cultural, and environmental context (Pieroni, 2001). Many researchers also define traditional knowledge as a design of people- centered resource management approach (Shacklet on et al., 2004; Puri et al., 2006).In the developing world, traditional knowledge is a key element of the social capital to produce food, in shaping local visions and perceptions of the environment and society (Puri et al., 2006). Moreover, local traditional knowledge and management practices can provide both, long-term local observations and insight, to understand the ecosystem services (FAO, 2014), governance, and dynamics of the interrelated socio-ecological system and adaptive management systems.

However, there has been definite erosion of traditional knowledge over time. Traditional knowledge has an important role to play in biodiversity conservation and sustainability in an era of global climate change. Nevertheless, it is underestimated and not recognized in any of the conservation and sustainability issues, and neglected in economic assessment at the state and national level. Numerous studies have shown that local knowledge derived from long-term nature-society interactions have been extremely useful in validating scientific hypothesis and suggesting new research directions. The combined potential of traditional and scientific knowledge should be harnessed to enhance the environment and human well-being.

Therefore, there is an essential need for empowerment and self-motivation among local communities, in understanding the status and scope of traditional knowledge in bio-resource management. Recognizing the customary values and determining the concept of knowledge, ownership would be beneficial in benefit-sharing and decision-making process, which would result in designing local tools to protect traditional knowledge based on customary laws and practices. Mechanisms for incorporating local knowledge into region specific policy should be developed. The participation of local people and their knowledge in the process of sustainable development should be recognized and validated.

Institutional mechanism

There is a need to establish an institutional structure that involvescommunity in enterprise conservation. Thisin turn would increase community stake in the conservation. Participatory resource monitoring exercise by the community on assessment of resource production, extraction, regeneration and adaptive management would be an important document fordeveloping management plan for sustainable use. Community based enterprisemodel has been established in MM Hills and BRT and have received positive response from the community as well as from forest department.

Conclusion/Recommendation

NTFP use and conservation under the co-management practices could be the best strategy for the forests that are traditionally open to local communities as common pool natural resources for their livelihoods. Changes in biophysical or socioeconomic conditions have often been stated as the leading cause of forest management failure.The co-management approaches are particularly suitable in forests where local communities are dispersed throughout the sanctuary. The underlying assumption is that communities will conserve and protect forest resources if they receive tangible benefits from sustainable utilization of forests.Enterprise linked conservation involves community in conservation and monitoring of forest resources. PRM was helpful to understand the resource status, their variations and helps to undertake conservation measures. It would help community to understand dynamics of NTFP resources and adopt sustainable harvest techniques. Enhancing income from the sustainable harvest of NTFPs can help to maintain local

livelihoods and provide economic incentives to conservation.Long-term maintaining of NTFPs resources by community participation requires resource tenure. This enables us to undertake a relatively comprehensive program, consisting of a series of research-and-action components that together will yield a broad picture of the multifaceted changes that Indian forests are undergoing. It allows us to pilot solutions to some of the problems.

The study recommends integration of scientific knowledge and local community knowledge for co-management of natural resources. Recent policy changes (for instance, RFRA 2006)provides considerable space for potential applications that arerelevant to the management of many forest landscapes in India.

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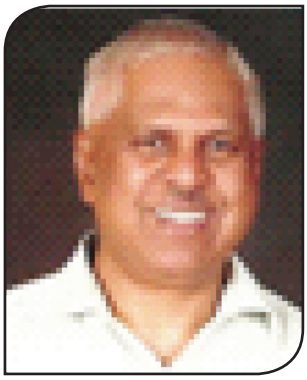


Dr. M. G. Chandrakanth

Director, Institute for Social and Economic Change, Bangalore
Email: mgchandrakanth@gmail.com
Phone number: 9449486018

Other contributing authors are: Shrikantha Mulimani[1], H Karibasappa[1], H Sadhana[2], RS Kulkarni[3], Khalil Shah[4], AV Manjunatha[4], MH Tatagar[5], A Mohan Rao[6], Mahadev G Bhat[7] and Ramachandra Bhatta[2]

1. Department of Agricultural Economics, University of Agricultural Sciences, Bangalore 2. Department of Fishery Economics, Fishery College, Mangalore 3. Professor of Genetics and Plant Breeding (Retd), UAS Bangalore 4. Institute for Social and Economic Change, Bangalore 5. Professor of Entomology, University of Horticultural Sciences, Bagalkot 6. Professor of Genetics and Plant Breeding, UAS Bangalore 7. Professor of Environmental Economics, Florida International University, Miami

Chapter 6

Economics of value addition in Oleoresin: Framework for Access and Benefit Sharing of Byadagi Chilli in Karnataka

Introduction:

The Ministry of Law and Justice (Government of India), promulgated the Biological Diversity Act, 2002 in order "to provide for conservation of biological diversity, sustainable use of the components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidence thereto". According to the Chapter 1, Section 2(f) of The Biological Diversity Act, 2002; The Biological Diversity Rules, 2004 and The Karnataka Biological Diversity Rules, 2005 (with effect from 29th June 2006)[1], "commercial utilization" (of biological resources) means end uses of biological resources for commercial utilization such as drugs, industrial enzymes, food flavours, fragrance, cosmetics, emulsifiers, **oleoresins,** colours, extracts and genes used for improving crops and livestock through genetic intervention, but does not include conventional breeding or traditional practices in use in any agriculture, horticulture, poultry, dairy farming, animal husbandry or bee keeping;". And therefore, the firms / industries involved in "commercial utilization" of biological resources need to share a certain percentage of their annual turnover as Access and Benefit Sharing (ABS) with the generators (or gatherers) of biological resources respecting the information, sustenance and sustainability of flow of biological resources. In order to appreciate ABS, it is crucial to estimate the returns obtainable from commercial utilization of biological resource towards commercial utilization.

[1]Karnataka Biodiversity Board, Vanavikas, Malleshwaram, Bangalore, http://www.karnataka.gov.in/kbb

Origin of Chilli

Chilli originated as a wild crop in New Mexico and Guatemala around 7500BC, and was domesticated in 5000 BC. In 1493 AD, the chilli seeds were carried by Columbus to Spain. Hence, cultivation of chilli spread rapidly in Spain and Europe. During 1584 AD, Portuguese carried capsicum from Brazil to India and the crop became popular in Asia as the south Asia climate was appropriately suited to Chilli. Currently in India, Chilli is the cheapest spice and popularly growth in Andhra Pradesh, Maharashstra, Karnataka and Tamil Nadu, which account for 75 per cent of the total area. AP produces the maximum chilli output followed by Tamil Nadu, Maharashtra, Orissa and Karnataka. Guntur in AP and Byadagi in Karnataka are the two large markets in the descending order of magnitude of arrivals and transactions of chilli.

India leads in Chilli exports

India isthe world's leader in the export of chillies with 25% share followed by China with 24% share in global export. Indonesia and US are the major markets. The exports *inter alia* are influenced by production in competing countries, domestic production, influence of monsoon determining the productivity, demand for value added products and the market forces. India exported 16.4% of its total chilli production in 2007-08. Out of the total export of spices, chilli accounts for 48% in quantity and 28% in value. India is the main source of red chilli in the international market traded as chilli powder, dried chilli, pickled chillies and chilli oleoresins. Malaysia is the largest buyer of Indian chilli with a share of 29%, followed by Bangladesh (19%), Sri Lanka (15%), the US (9%), the UAE (8%) and others (19%). Aflatoxin content in chilli has to be necessarily below 10 PPB for exports. Several consignments of Indian chillies have been rejected recently as Aflatoxin content exceeded the permissible limits and this highlights how vital is the level of Aflatoxins in chilliesas well as other quality parameters in international trade. Countries such as US, UK, Germany and Sweden use chilli for oleoresins and extracts on a large scale.

Study objective

This study is a modest attempt to estimate the costs and returns involved in chilli oleoresin considering Byadagi Chilli in Karnataka. The study highlights the issues involved in value addition in chilli oleoresins in view of the ABS evolved by the Karnataka Biodiversity Authority. The Pictures 1 to 50 in Appendix *inter alia* capture the shift in crop pattern from Byadagi Chilli, problem of Murda leaf curl disease, facilities in Byadagi APMC market yard, Grinding units for chilli, cold storage units, and oleoresin units captured through a reconnaissance survey (during Aug 2015).

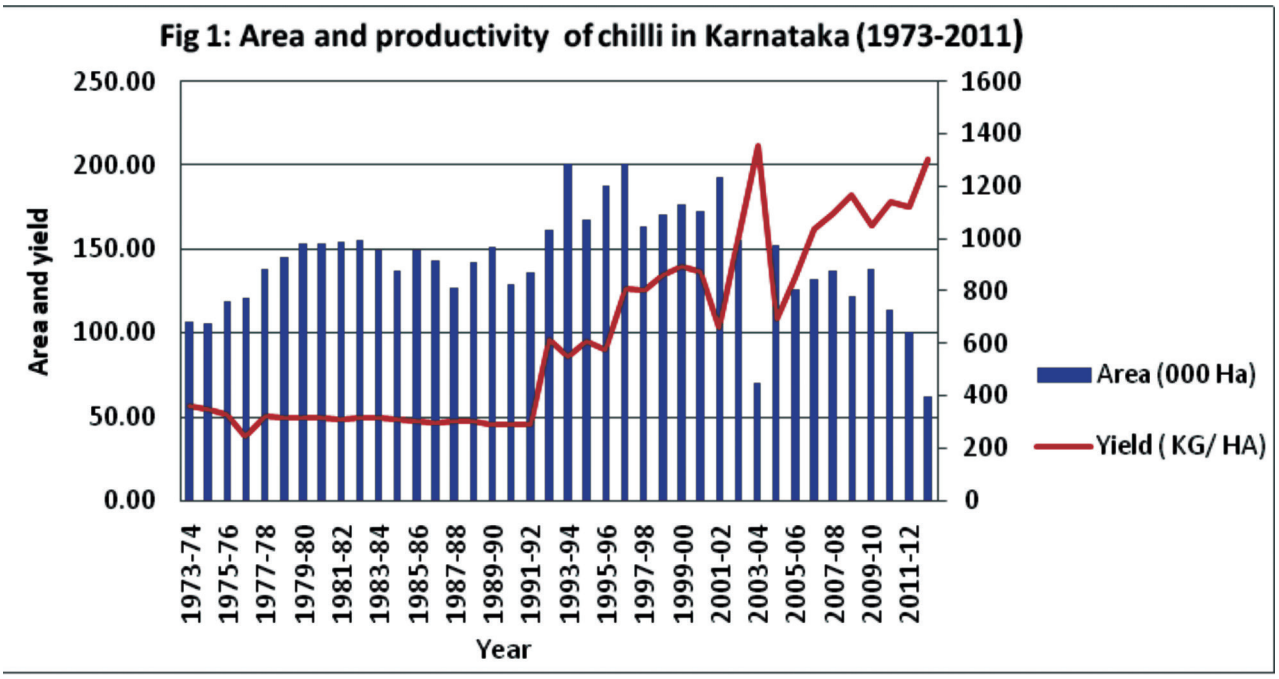
Oleoresin

Theoil-soluble extract from the fruits of Capsicum annuum / Capsicum frutescensis called paprika oleoresin or paprika extract. This is used for colouring, flavouring as it has capsaicin, the flavoring compound with pungency in different concentrations,

and capsanthin and capsorubin responsible for the red color along with carotenoids. Oleoresin, the viscous liquid, with aroma and flavor, is also extracted from finely ground chilli powder. Oleoresin is used in medicine internally as a stimulant and carminative and externally as a counter irritant in rheumatism.The extraction of oleoresin is usually by percolation using solvent such as hexane. Paprika oleoresin is commonly used as coloring agent in orange juice, spice mixtures, sweets, sauces. It is also used in poultry feed in order to intensify the colour of egg yolk. According to FAO[2], 1 kg of paprika extract can substitute 12-15 kgs of paprika powder with regard to intensity of color. However, there has not been an established relationship between the intensity of color and pungency[3]. The oleoresins from red pepper are used as spice as they have pungency ranging from 80000 to 500,000 scoville units. The paprika extracts are viscous, homogenous red liquids which can be used to colour foods, while oleoresin is a flavoring agent with low capsaicin withlittle pungency. Chillies in food processing are used both for colour and pungency.

Trends in Area and productivity of Chilli in Karnataka

The area and productivity of chilli in Karnataka (Fig 1) indicate highly fluctuating area and production since 1973. The area under chillies was around one lakh ha in 1973, increased to 1.5 lakh ha in 1983, and fluctuated between 1.25 lakh ha and 1.5 lakh upto 1992. Area rose to an all time high of around 2 lakh ha in 1993 and 1996 and then fell to around 1.6 lakh ha in 2000, reaching a considerable low of 0.65 lakh ha in 2003. Though the area picked up since 2004, again surpassing 1 lakh ha upto 2009, the area reduced to below 1 lakh ha since 2010 reaching the all time low of around 0.6 lakh ha in 2011.



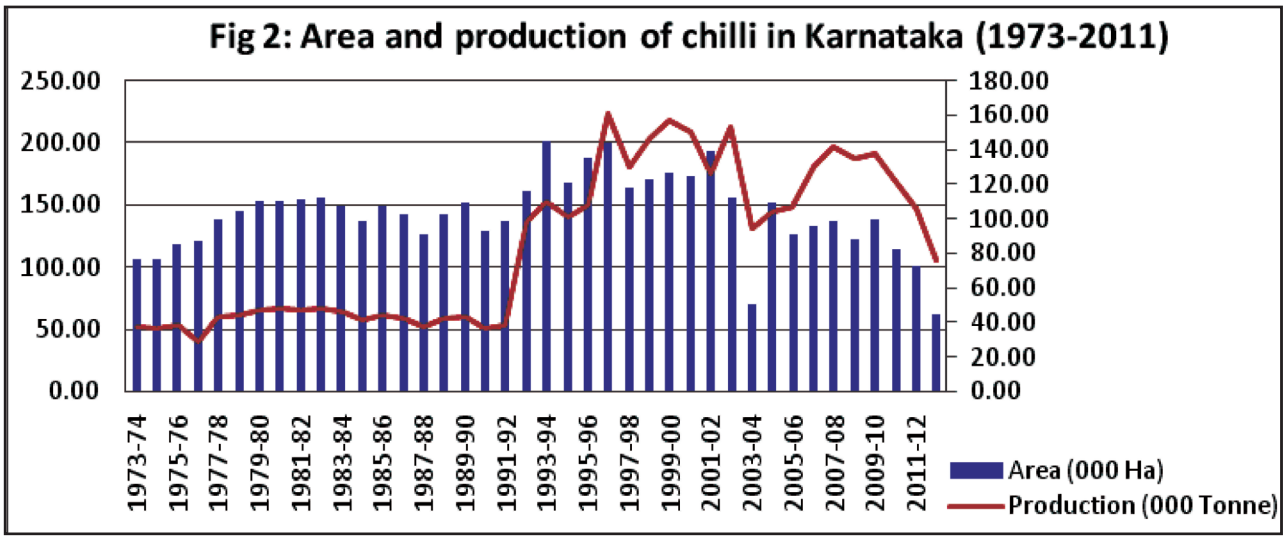
[2]http://www.fao.org/fileadmin/templates/agns/pdf/jecfa/cta/69/Paprika_extract.pdf

[3]http://www.fao.org/fileadmin/templates/agns/pdf/jecfa/cta/69/Paprika_extract.pdf

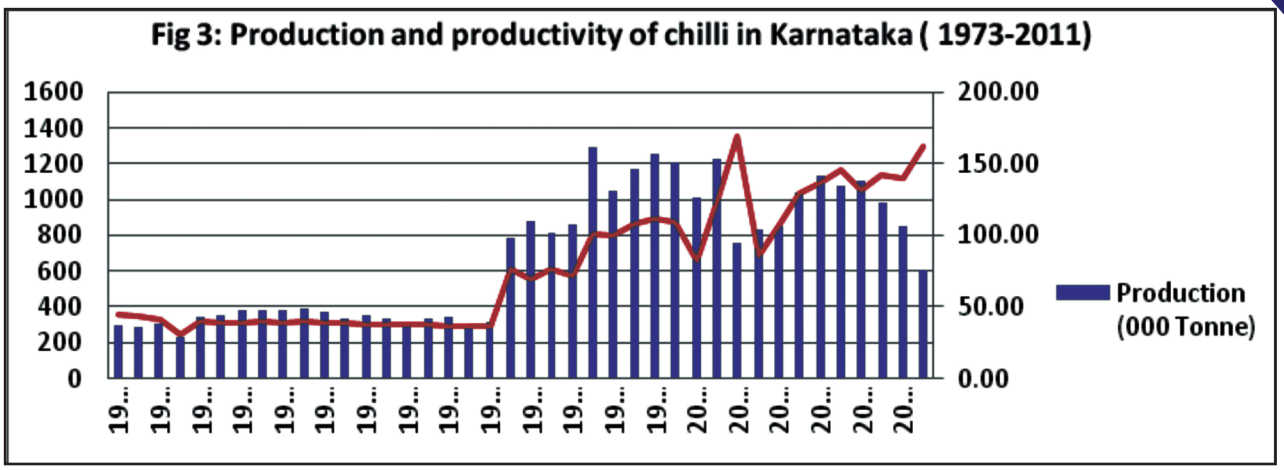
The productivity of chilli began from around 0.3 quintal per ha in 1973 sustaining upto 1991, with a spurt in 1992 to 0.6 quintal per ha. The productivity surpassed 1 quintal per ha in 1996, reaching an all time high of around 1.3 quintal per ha in 2003 and has sustained at this level till 2011. Thus, a comparison of Area and productivity of Chilli in Karnataka since 1973, indicates that the productivity is rising over the period, the area is falling, both with substantial fluctuations due to both agroclimatic factors and market forces, even though the demand for chilli is relatively inelastic.

Spurt in production of chilli due to demand for Oleoresins since 1991

The production of chilli,rose with the area at a slow pace from 1973 to 1991, with a steep increase (in production)from 1991. The production remained around 1.40 lakh tonnesfrom 1995 and it fell to around 0.8 lakh tonnesin 2011,and the area also fell, despite increase in productivity (Fig 1). Therefore, the productivity growth in Chilli has not been impressive enough to increase production or reduce the area. The area however reduced due to the relative profitability of competing crops such as cotton and maize. Nevertheless, the overall compound growth rate of production of 4.7 % between 1973 and 2011 is different from the growth rate of production of 7.7 percent between 1991 and 2011. Thus the overall growth rate (of 4.7%) in production hides the spurt in the growth rate from 1991 being (7.7%). The spurt in the production since 1991, can be attributed to spurt in the increase in demand for Oleoresins since then.



Despite increase in productivity, the production fell as area reduced and hence productivity gain has not been substantial in Chilli (Fig 3). Accordingly farmers are suggesting to develop improved varieties / hybrids in Chilli with low Aflataxin and especially tolerant / resistant to the Murda leaf curl virus and at the same time meeting the pungency and color requirements, due to raise in demand for oleoresins all over the world.The productivity of chilli is increasing from 1973 from a bear 40 kgs per ha in 1973 to 140 kgs per ha in 2011, registering a simple growth rate of 5.82 percent. However this growth rate is not economically substantial to sustain growth in area and production.



Major chilli producing districts of Karnataka

The major chilli producing districts in Karnataka are Bellary, Dharwad, Haveri, Raichur and Gadag (Table 1). The districts of Bellary,Dharwad and Haveri contribute to 46% of the State's area and 38% of the State's production. Raichur and Gadag are the districts which are focusing on Chilli. With the availability of improved Chilli varieties and hybrids, and increased tolerance / resistance to Chilli leaf curl Murda disease, other areas in Northern Karnataka have the potential to grow chilli.

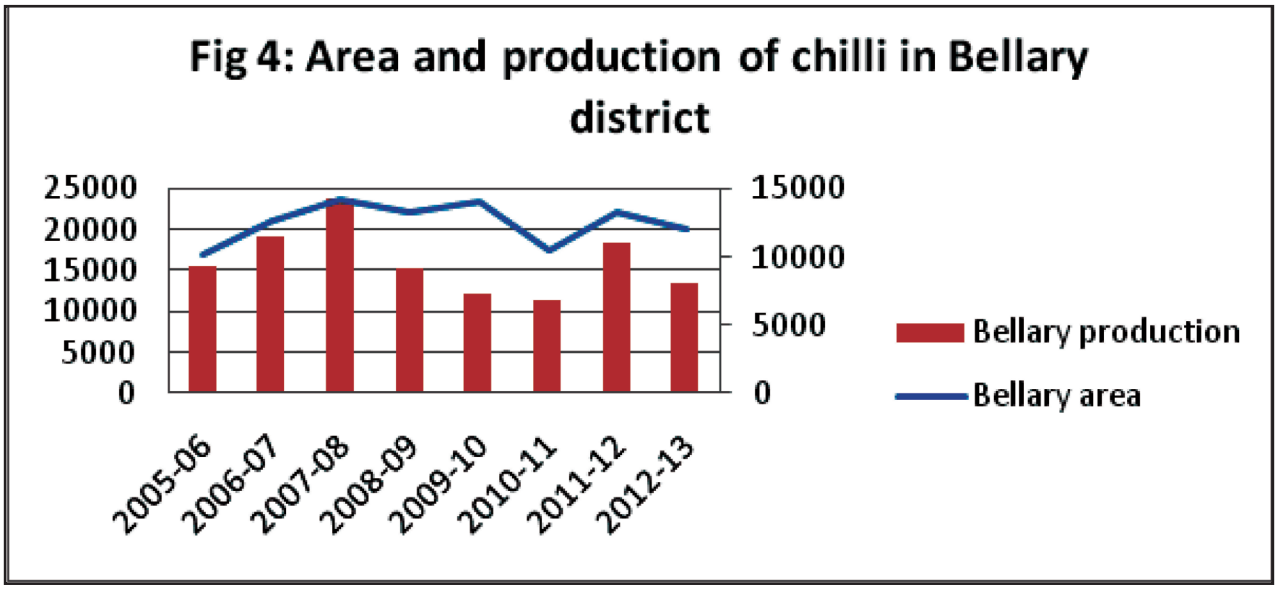
Table 1.Area (ha) and Production (tonnes) of Dry Chillies in major five districts of Karnataka

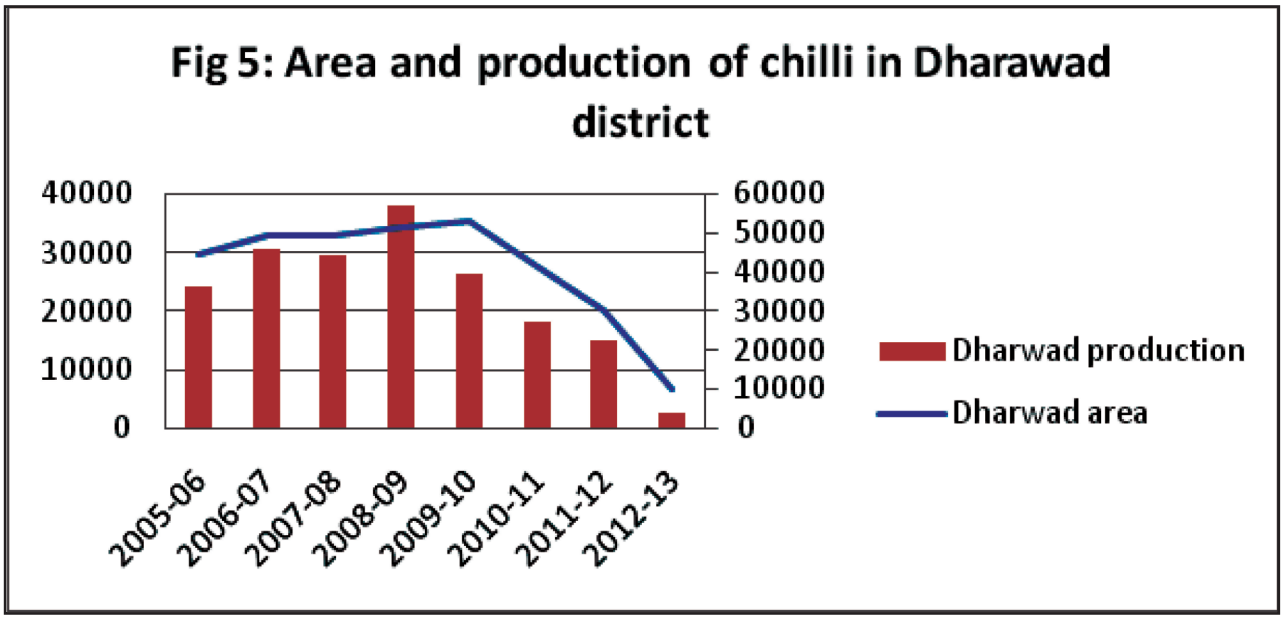
year	Bellary		Dharwad		Haveri		Raichur		Gadag	
	area	production	area	production	area	production	area	production	area	production
2005-06	10196	15394	44513	23973	18180	10722	1116	955	16624	11326
2006-07	12714	19139	49399	30513	20421	28525	1799	1788	18798	5526
2007-08	14226	23690	49032	29393	19638	25588	3336	1821	18132	11399
2008-09	13274	15189	51070	38030	13763	29606	3300	2523	8610	4987
2009-10	14072	12040	52855	26153	15512	25938	2184	2230	21213	10480
2010-11	10451	11450	41230	18205	11053	14932	2124	3064	17240	15348
2011-12	13320	18236	30347	14759	8161	15951	3483	3703	15010	6939
2012-13	12042	13347	9979	2629	6653	13268	4440	5108	3660	2556

Area and production in Bellary

Area and production of Chilli in Bellary (Fig 4), Dharwad (Fig 5), Haveri (Fig 6), Raichur (Fig7) and Gadag (Fig 8) indicate different trends. Bellary district has been a leader in mainintaining at least 10000 ha under chillies fluctuating between 10000 and 14000 ha. The production has been widely fluctuating from around 11,450 tonnes to 23,690 tonnes, Dharwar district which was the leader in Chili with around 50000 ha has seen a consistent fall in area since 2009. The major reason is the murda leaf curl disease attack on chillie. Haveri district too exhibits fall in area. Except Raichur district, which is showing an increasing trend in both area and production, there is a threat to Chilli cultivation in Karnataka due to Murda leaf curl disease which has virtually reduced the area and production by fifty percent compared with the situation in mid nineties.

The Chilli *murda* complex disease is due to thrips, mites and a virus, the most serious disease of chilli. Due to the disease, there will be severe leaf curling inupward and downward directions leading to wrinkling elongated petiole and finally sterility. The leaves exhibit dark green mottling with vein banding symptoms.





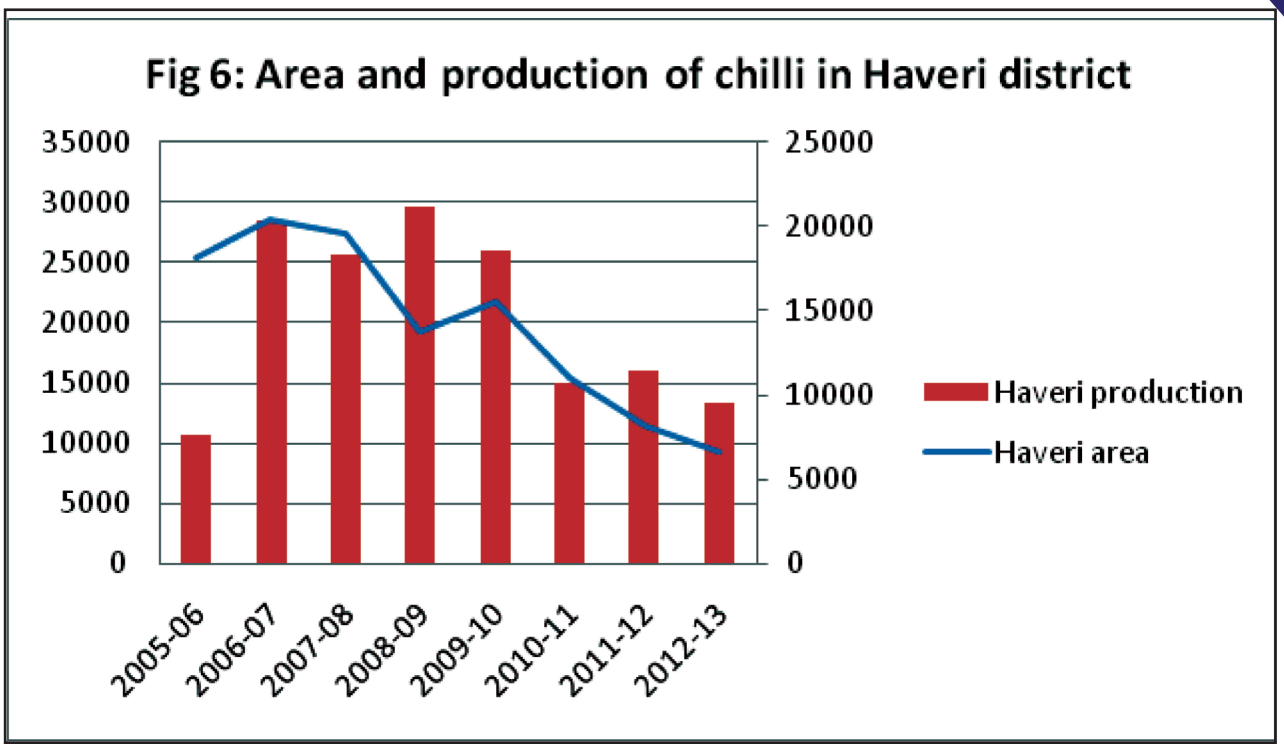


Fig 6: Area and production of chilli in Haveri district
35000
30000
25000
20000
15000
10000
5000
0
25000
20000
15000
10000
5000
0
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
Haveri production
Haveri area

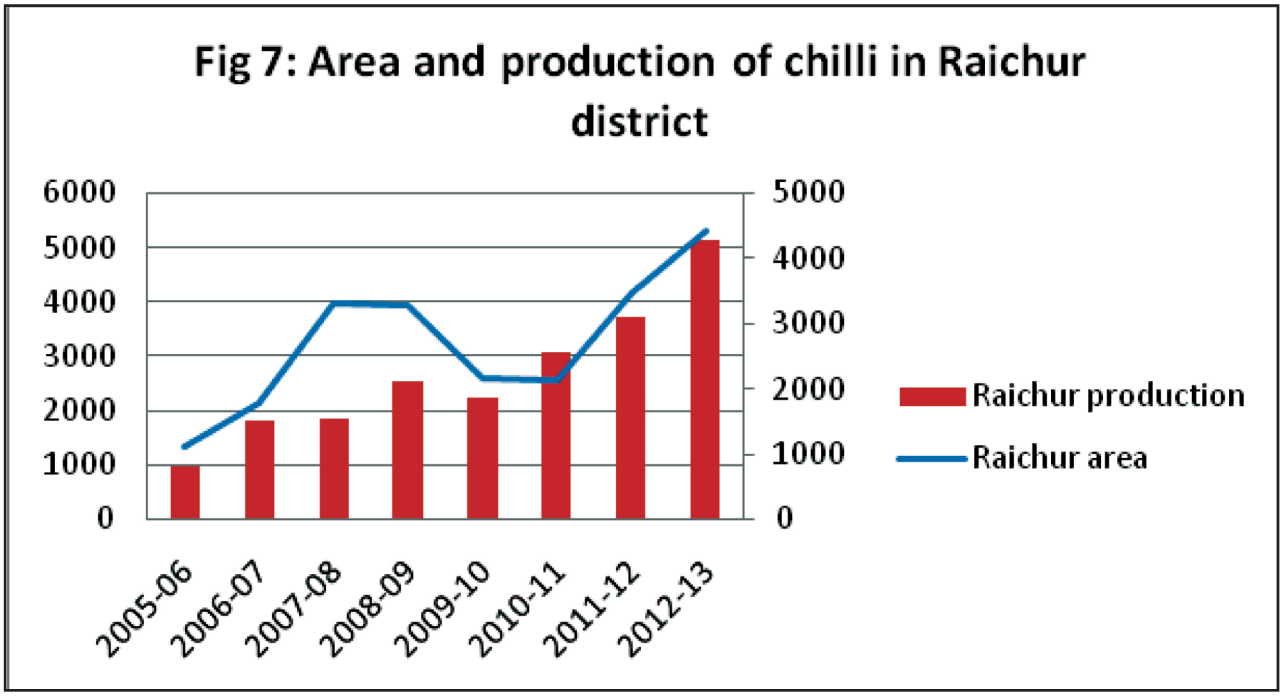
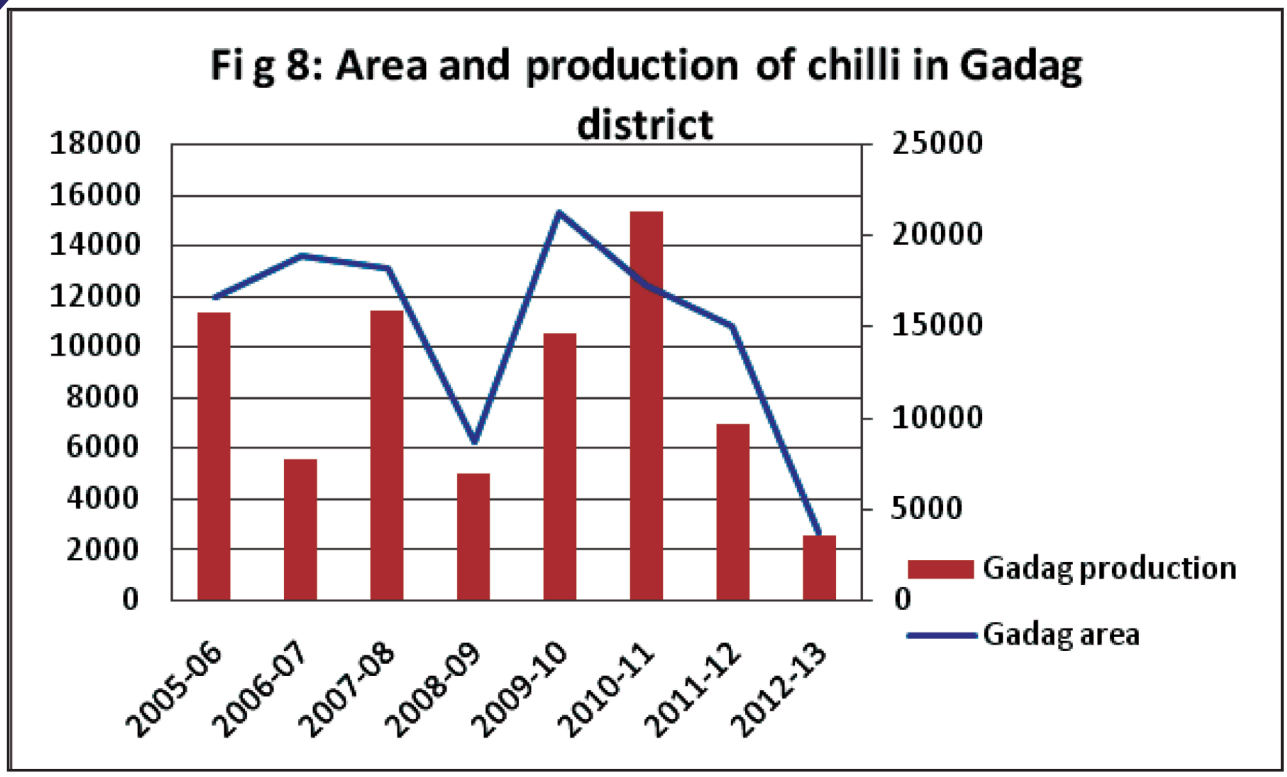


Fig 7: Area and production of chilli in Raichur district
6000
5000
4000
3000
2000
1000
0
5000
4000
3000
2000
1000
0
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
Raichur production
Raichur area



Economics of chilli cultivation under rainfed conditions

Among the different items of expenditure in the cultivation of dry land chilli (Table 2), the labor cost including the payment to bullock labor forms around 40 percent of the total cost of cultivation of Rs. 40134 per acre followed by capital required spent on fertilizers, FYM, seeds, plant protection chemicals. The rental value of land is around 13 percent. With the realization of 5.5 quintals per acre, the gross returns at the price of Rs. 9182 per quintal works to Rs. 50,500, yielding a net return of Rs. 10366 per acre. This works to the cost of production of Rs. 7297 per quintal of chilli. Thus, with the realization of the market price of Rs. 9182 per quintal, deducting the cost of production of Rs. 7297 per quintal of chilli, the net return of chilli under rainfed condition works to Rs. 1885 per quintal.

Table 2. Cost of cultivation for dry land chilli inByadagi area Rs. Per acre (2015)

Sl. No	Particulars	Quantity	Average cost	% of total cost
1	FYM	2 tractor loads @Rs. 2000 per load	4000	9.97
2	Seed quantity	90 grams @ Rs. 27.7 per gram	2500	6.23
3	Chemical fertilizer	2 bags of DAP+1 bags of urea=150 kgs	3000	7.48
4	Plant protection chemicals		2000	4.98
5	Tractor ploughing	2 hours per acre @ Rs. 750 per hour	1500	3.74

Sl. No	Particulars	Quantity	Average cost	% of total cost
6	Bullock Ploughing	one bullock pair day @ Rs.1000 per day	1000	2.49
7	Harrowing	one bullock pair day @ Rs.1000 per day	1000	2.49
8	Inter cultivation	one bullock pair day @ Rs.1000 per day for 3.5 days	3500	8.72
9	Transportation of FYM	1.5 tractor loads @ Rs. 500 per load	750	1.87
10	Labor for Spreading of FYM	3 mandays of labor @ Rs. 233 per man day	700	1.74
11	Labor for Seed bed preparation	1 man days @ Rs. 250 per man day	250	0.62
12	Labor for Transplanting of seedlings	Piece work	950	2.37
13	Labor for Fertilizer application	3 man days @ Rs. 233 per man day	700	1.74
14	Labor for Weeding	Piece work (say 10 women days @ Rs.150 per women day	1500	3.74
15	Labor for PPC spraying	6 man days	1350	3.36
16	Labor for Harvesting	21 man days	4200	10.47
17	Labor for Drying	3 man days	600	1.50
Working capital			29500	73.50
1	Rental value of land		5250	13.08
2	Interest on working capital at 12.5 % for 6 months		1843.75	4.59
3	Risk premium @ 2 % of working capital		590	1.47
4	Managerial cost @ 10% of working capital		2950	7.35
Total cost			**40133.75**	100
Gross returns		5.5 quintals @ Rs. 9182 per quintal	**50500**	
Cost for production of 1 qtl chilli			**7297.04**	
Net returns			**10366.25**	

Economics of chilli cultivation under irrigated conditions

Byadagi Chilli is also cultivated under irrigated conditions. Considering the different items of the cost of cultivation (Table 2), it works to Rs. 75441 inclusive of interest on working capital,

Table. 2 Cost of cultivation of borewell irrigated chilli in Byadagi area Rs. Per acre 2015

No	Particulars	Quantity	Total cost	% of total cost
1	FYM	2 tractor loads @ Rs.2500 per load	5000	6.63
2	Seed quantity	100 grams @ Rs.31.5 per gram	3150	4.18
3	DAP (Rs.1250 per bag), Urea (Rs.350 per bag) and Complex fertilizers (Rs. 950 per bag)	4 bags of DAP+2 bags of urea+3 bags of complex=450 kgs	8750	11.60
4	Plant protection chemicals		7500	9.94
5	Tractor ploughing - land preparation	4 hours per acre @ Rs. 750 per hour	3000	3.98
6	Bullock Ploughing - land preparation	one bullock pair day @ Rs. 1000 per day	1000	1.33
7	Harrowing - land preparation	one bullock pair day @ Rs. 1000 per day	1000	1.33
8	Inter cultivation	one bullock pair day @ Rs. 1000 per day for 4.5 days	4500	5.96
9	Transportation cost FYM (from source to destination)	2 tractor loads @ Rs. 550 per load	1100	1.46
10	Labor for Spreading of FYM	5 mandays of labor @ Rs. 260 per man day	1300	1.72
11	Labor for Seed bed preparation	2 man days @ Rs. 200 per man day	400	0.53
12	Labor for Transplanting seedlings	Piece work	1100	1.46
13	Labor for Fertilizer application	4 man days @ Rs. 225 per man day	900	1.19
14	Irrigation charges	5 irrigations @ Rs.550 per irrigation	2750	3.65
15	Labor for Weeding	Piece work (say 21 women days @ Rs.150 per women day	3250	4.31
16	Labor for PPC spraying	6 man days	1350	1.79
17	Labor for Harvesting	32 man days	6500	8.62
18	Labor for Drying	7 man days	1100	1.46

Working capital		53650	71.12	
1	Rental value of land		12000	15.91
2	Interest on working capital at 12.5 % for 6 months		3353.12	4.44
3	Risk premium At 2 % of working capital		1073	1.42
4	Managerial cost at 10 % of working capital		5365	7.11
Total cost			**75441.12**	100
Gross returns		**11.5 quintals @ Rs.9270 per quintal**	**106600**	
Cost for production of 1 qtlchilli			**6560.10**	
Net returns			**31158.88**	

managerial cost, risk premium as well as rental value of land. Considering the proportion of total cost, labor component forms around 30 percent of the cost of cultivation followed by fertilizers (11.6%) and plant protection chemicals (10%). In the irrigated conditions, chemical fertilizers, FYM, PPC and seeds account around 30 percent of the cost of cultivation. The rental value of land forms around 16 percent of the cost. Byadagi Chilli comes to flowering 40 days after transplantation although the majority of flowers bloom 60 to 80 days after transplanting.In chilli, around 65 to 75% by weight is pericarp (skin), 30% is seeds by weight. After deseeding, the pericarp is powdered, pelletized before extraction for oleoresin content of around 6%.

With the realization of an average yield of 11.5 quintals per acre as output under irrigated condition, at the average price of Rs. 9270 per quintal, the net return works to Rs. 31159 per acre. This amounts to the cost of production of Rs. 6560 per quintal of chilli and net return of Rs. 2710 per quintal. In comparison of the net return per quintal under rainfed conditions being Rs. 1885 per quintal of chilli, the irrigated chilli offers 44% higher net return. The irrigated chilliis picking up in Raichur district distinctly. It is also being cultivated under irrigated conditions using canal water in Bellary district, as also in other districts.

Reservation price for Chilli

Considering the total cost of cultivation of Rs. 40,000 per acre under dry land cultivation to around Rs. 75,000 per acre under irrigated condition, farmer has to realize atleast Rs. 7300 per quintal in the case of rainfedchilli and at least Rs. 6600 per quintal in the case of irrigated chilli, to be economically worthwhile. Thus, Rs. 7300 per quintal can be designated as reservation price of rainfedchilli and Rs. 6600 per quintal can be considered as reservation price of irrigated chilli, below which the supply of chilliis not

worthwhile, as the price below the reservation price will not be able to recover the total cost of cultivation. However, if the working capital alone is considered, then the cost of production of rainfedchilli works to Rs. 5364 per quintal and that of irrigated chilli works to Rs. 4665 per quintal, in which case the reservation price would be lower than that by considering the total cost of cultivation.

Byadagi APMC

Byadagi Chilli is well known for color richness and modest pungency. The Agriculture Produce Market Committee commenced in Byadagi in 1948, rendering it as one of the oldest markets in the State. It is also the second largest market for chillies in India.The marketing activities gain momentum from December to April. Here, chilli is transacted Monday through Thursday in the market. A majority of the farmers who bring their produce to the market belong to small and marginal category who bring around 20 bags (of 30 kgs) weighing around 6 quintals. In the marketing season, thus, there will be around 10,000 farmers who bring their produce to the Byadagi market, served by around 200 to 300 middlemen who facilitate the transactions. The market is highly competitive and has electronic facilities bringing transparency in bidding and other functions. This is the very reason as to why farmers, traders, middlemen want to buy and sell the Chilli in Byadagi market, due to high degree of market regulation. The price of chilli also depends upon the proportion of chilli used for oleoresin and that used directly for spice. At present about 70% of the chilli is coming from irrigated chilli from Bellary, Raichur, Sindhanur and 30% is the rainfedchilli from Gadag, Lakshmeshwar, Kundagol.

For each lot, there may be around 30 to 40 bidders and the highest bidder will get to purchase the produce. As soon as farmer brings produce to APMC (Agriculture Produce Market Committee), he is issued an entry pass and an unique lot number. His product is weighed and put on a platform, ready for sale. This is followed by bidding across the lots available. After finalization of bids, SMS is sent to the concerned farmer indicating the highest bidder. Later on issue of sale bill is made with payment the same day, delivery of the lot, and e-permitting. Thus, farmer after displaying his produce by 2 pm on trading day can find details about the price in an hour.

In addition to market being competitive, the farmers as well as functionaries have fairly good information about the quality of chilli demanded / supplied. For instance, price of chilli sold / bought depends upon the color with ASTA rating (say 2000) and pungency 30,000 units. This chilli is called high color high capcaicinchilli. High capcaicinis colloquially referred to by merchants as Highcapchilli, which has high pungency. There is a variety Theja from Andhra Pradesh which is a high cap chilli and fetches Rs. 85 to Rs. 100 per kg. Namdhari variety has ASTA of 100 with 16000 pungency which fetches Rs. 65 to Rs. 80 per kg of chilli. During 2014-15, the annual turnover of Byadagi market surpassedRs. 700 crores.

There are different estimates regarding the proportion of chilli which goes towards different types of oleoresin. According to RG Patil traders in Byadagi, 75% of the chilli is processed for pungency and 25% of the chilli is processed for oleoresins. According to a cold storage worker in Byadagi, about 60% of the storage space is being utilized by the processors of chilli oleoresin and 40% of the space is being utilized by chilli for spices. Those who use the cold storage space *inter alia* are largely for oleoresins such as SynthiteHarihar, Kancor Ingredients, Motebennur, AK Flour, Thadsa, Plant lipids, Doddaballapur, Kolancheri, Kerala, Eastren company, AVThomas, Cochin. Synthite[4] the world's largest producer of value added spices has patented the process to make oleoresins has Commission Agents who buy Byadagi Chilli for the company, which has processing units in Harihar, Doddaballapur.

The Chilli is stored in cold storage before processing. There are differing estimates regarding what proportion of chilli marketed is stored in cold storage. The opinion survey indicated that the volume stored is increasing over time along with arrivals in APMC. The awareness among traders, buyers including industries which are involved in value addition such as oleoresin are aware of the ASTA color units, that Byadagi Chilli with 200 ASTA is of fine quality and that with 100 ASTA[5] is of low quality. The moisture content in chilli has to be 10 to 12 percent, but sometimes farmers sprinkle water bringing the moisture to the level of 16 to 18 percent. This has become a major problem for traders, who cannot reject the lot easily once it is accepted.

The buyers such as Mccormick[6], MTR[7] are the world leaders in preparation of ingredients for food preparation as also the buyers of chilli insisting on ASTA color standards. Hence it is crucial for even farmers to be aware of international standards in Chilli and incorporate the steps and strategies in cultivation of chilli in order that they can cater to International standards as India exports around 15 to 20 percent of its domestic production. Since quality chilli requires that the source needs to be identified, it is to the advantage of farmers cultivating Byadagi Chilli to adopt the package of practices for cultivating quality chilli.

Quality of Byadagi Chilli

The name Byadagi is associated with Byadagi Chilli with its deep red color with (American Spice Trade Association or ASTA) color unit values of 160 to 300 and thus has higher color compared to any other type of chilli in India. The chilli is also wrinkled and the quality also depends upon the wrinkled chillies. The higher the wrinkle, higher

[4]http://www.synthite.com/synthite.html

[5]http://measuretruecolor.hunterlab.com/2014/06/04/asta-color-and-ic-color-of-paprika-and-oleoresin-spices/

[6]http://www.mccormick.com/Food-Coloring-and-Extracts/Food-Coloring-Guide

[7]http://www.mtrfoods.com/products/masala-powders

is the quality. The pungency value of Byadagi Chilli is low ranging from 9000 to 15000 SHU (Scoville Heat Units). Thus, the price offered for red chilli is associated with ASTA color units, and higher the ASTA color units, higher is the price. Compared with other chilli varieties, the use of plant protection chemicals for Byadagi Chilli is low.

With the modest content of capsaicin, its relatively low pungency, unique flavor, as also having the GI tag (144), the Byadagi Chilli, has high demand for both as spice and as oleoresin. The oleoresin (oil) from Byadagi chili is popular and used in cosmetics, food preparations, in pharmaceuticals.

Why Oleoresin demand is responsible for economic expansion of Byadagi Chilli market

The oretically the demand for chillifor culinary purpose (for use as spice in sambar making for instance) has to be perfectly inelastic, since, similar to salt, the quantity of use as spice cannot depend upon the price. Thus, irrespective of the price, the consumption of chilli as spice (chillipowder put in sambar powder) may vary around 3 to 5 grams per day (a relatively constant quantity)**(Fig 1).**

Heuristic Inelastic demand for Chilli used for culinary purposes

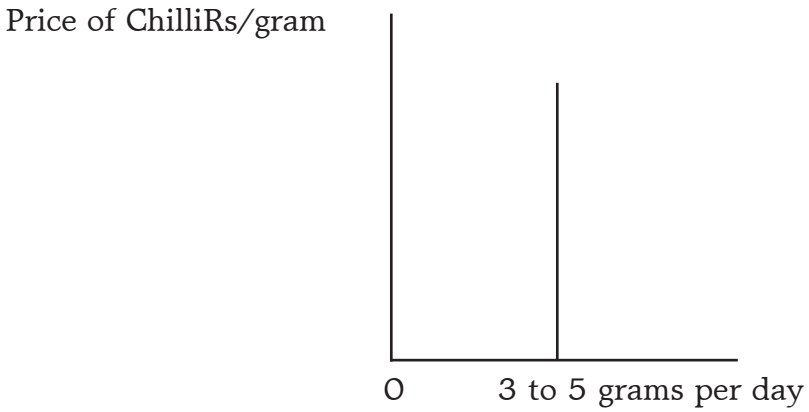


Fig 1:Quantity demanded of Chilli for culinary purpose

Therefore, the demand for Byadagi Chilli for the purpose of use as spice (chilli powder or sambar powder) has to be theoretically perfectly inelastic (with an elasticity value of zero). However in reality even if this is assumed to be a small figure of -0.05, which means, for a one percent increase in price there is. 0.05 percent fall in quantity demanded, it is relatively inelastic demand for chillies used in culinary purposes.

Heuristic elastic demand for Chilli used for oleoresin

The demand for chilli used for Oleoresin purposes, theoretically has to be relatively elastic, since oleoresin can be made from different sources (and hence has substitutes) on the one hand and on the other, is used for cosmetic preparations, pharmaceuticals, coloring which may have different

Price of Chilli

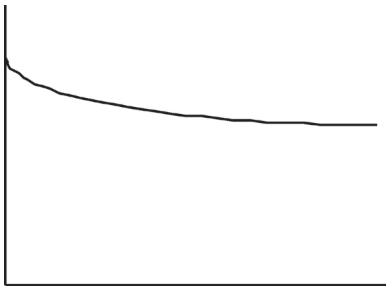
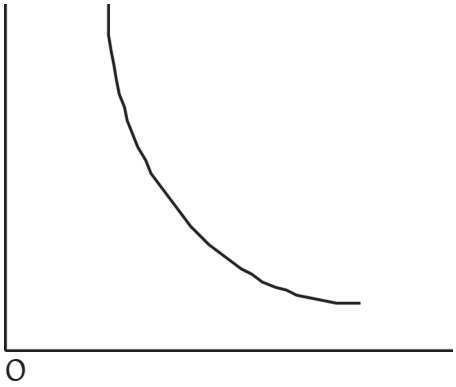


Fig 2: Quantity demanded of Chilli for non-culinary purposessubstitutes for chilli. Thus, the demand for chilli for non-culinary purposes must be highly price sensitive or price elastic and accordingly the quantity of chilli which is consumed or used for oleoresin making may fluctuate relatively widely, when compared with that used for spice purposes.

Heuristic inelastic demand for Byadagi Chilli for Oleoresin

While demand for chilli for use as oleoresin is heuristically relatively elastic, Byadagi Chilli has a special place in the oleoresin economy, due to its special characteristics such as a high ASTA value of 150 to 200, low pungency, high color intensity with the GI granted. Thus, the demand for Byadagi Chilli used for Oleoresin making theoretically has to be relatively inelastic.

Price of Byadagi Chilli



Quantity demanded of Byadagi Chilli for Oleoresin

The prima facie evidences for relatively inelastic demand for Byadagi are as under:

1. Byadagi inHaveri district houses the APMC with the second largest trading market turnover of around Rs. 700 crores (2014-15) compared with other varieties of chillies due to its demand both as a spice and for oleoresin. In addition the turnover of Byadagi APMC is increasing over time.
2. In Byadagi, there are currently 17 cold storages, all in private sector (largely by chilli traders) each with a capacity to store 1 lakh bags of 30 to 35 kgs each, implying storage capacity of 35000 quintals (or 3500 tonnes) of Byadagi Chilli per year. In addition the number of cold storages to store Byadagi Chilli is increasing year by year, due to increase in demand for cold storage. Also at least 50% of the storage space in cold storages, is used by Oleoresin processors.

3. The number of cold storages being built to store chilli are increasing over time in Byadagi and Bellary.

4. In addition to cold storages in Byadagi, there are 15 cold storages in Bellary for dry chillies[8] for transporting chilli to the Byadagi market, depending upon the market price fluctuations, a function of the relative proportion of chilli used for culinary and oleoresin purposes.

5. The cold storage capacity is almost fully utilized due to relatively inelastic demand for Byadagi Chilli for both culinary and oleoresin purposes.

6. According to a cold storage operator, there is virtually no space to store extra chilli in Byadagi. This impressive performance, in itself is a *prima facie* indicator of the potential for Byadagi Chilli cultivation, production, cold storage and processing. Byadagi Chilli received Geographical indication (tag 144) in Feb 2011. The quality of chilli is measured by the extractable red color pigment which is measured in ASTA (American Spice Trade Association) color units. Kaddi (for oleoresin) and Dabbi (for spice) are the popular Byadagi varieties of chilli. Currently Namdhari and Teja varieties are also ruling the market.

Since 1990s, due to spurt in the demand for oleoresin both in domestic market and in international market, Byadagi Chilli is also being cultivated / processed for oleoresin extraction used in the preparation of nail polish and lipsticks, cosmetics, medicinal purposes[9]. The demand for chilli for extraction of oleoresin has also attracted the private sector (traders of chillies) to establish cold storage units with 24 hour power supply generators, since chilli is usually stored for 6 months to one year before sale for any purpose. Incold storage units in Byadagi Chilli pods are maintained at a low temperature of 4 to 6-degree Celsius to maintain the colour and purity.According to a trader, storing in cold storage units also increases the amount of oleoresin extracted from chilli by about 30–40%. However according to another trader, there will be a loss upto 10% due to cold storage. Hence, this aspect needs further study. According to an estimate, about 50 litres of oleoresin can be extracted from about 1 tonne of Byadagi Chillies. Companies have been set up in and around Byadagi that are involved in the extraction of oleoresin. Chilli cultivation is also popular in Madhya Pradesh in the areas of Dhamnod, Kukshi. In Karnataka the cultivation of Byadagi Chilli has reached Hubli, Ron, Gadag, Samshi, Raichur, Sindhanoor.

Byadagi market attracts traders from all over Karnataka and from neighboring Andhra Pradesh because of favorable conditions for business like fair price, immediate payment and accurate measurement of the chilies. The recent uprise of sales of low-priced, more-pungent chilli varieties into the market have cause a dent in the price of Byadagi Chillies as well. Byadagi Chilli with its GI (Geographical Indication) is known

[8]http://www.horticulture.kar.nic.in/Design_final/Horticulture%20Services/LIST_OF_COLD_STORAGES_ NAMES_11-12.pdf for list of cold storages in Karnataka

[9]http://www.thehindubusinessline.com/economy/agri-business/karnataka-leads-drive-for-online-integration-of-farmmarkets/article7146929.ece

as one of the best varieties of chilliand is also known as Kashmiri Chilli in other states and as paprika in other parts of the world. The unique characteristics of Byadgi chilli is its low pungency with high color value which is widely used for extraction of oleoresin, in manufacturing of spice blends and seasonings in cuisines. It is also used as a lead ingredient to manufacture poultry food products in foreign countries and also in food industry.

It is named after the town of Byadgi which is located in the Haveri district of Karnataka. The business involving Byadgi chilli has the second largest turnover among all chilli varieties of India. Byadgi chilli is also known for its deep red colour, less spicy, with aromatic flavor and is used in many food preparations of India.

Oleoresin extracted from these chillies is used in the preparation of poultry feeds. It is widely used in food industry in foreign countries as food ingredient. Some part is used to manufacture cosmetics like nail polish and lipsticks. Due to this there is great demand for Byadgi chilli in international market. The special character of this chilli is its unique flavor. This has its own perception in the mind of Indians. This flavor is different from any other chilli available in India which has the taste of pungent, sweet, and even has the Indian traditional taste.

Economics of Cold storages for storing High volume High value Bydadagi chillies

Chillies need to be stored as the crop is seasonal and the major production is from the rainy or kharif season and comes to market from December onwards. Obviously Chillies have to be stored for catering to its different needs throughout the year. Storing chilli in dry weather leads to loss of color, flavor and pungency. All the cold storages in Byadagi are constructed under private sector. The cost of storage is Rs. 100 per month per bag of chilli and will be charged for at least 6 months, even if the chilli is removed earlier. Cold storages are called A/C colloquially by the local traders in Byadagi. There are 18 cold storages in byadagi and each cold storage has capacity to store 1 lakh to 1.5 lakh bags = 35000 quintals (or 3500 tonnes). This year (2015) the Chilli crop in MP failed and hence the chilli prices increased in Byaadagi. There are cold storages in Bellary and other parts also. Chillies can be stored upto a maximum of one year in order to maintain the pungency and color.

In order to process Byadagi Chilli for use as spice as ingredient in sambar powder, there are 30 grinding units and 17 cold storages all in private sector. The charges of cold storage vary with the user. Oleoresin companies keep 40000 to 50000 bags (1400 tonnes to 1750 tonnes) and are charged Rs. 20 per bag per month and are charged according to actual period of storage (since they store in bulk, and hence are offered discount). For all others, the charge is Rs. 80 to Rs. 100 per bag for six months and are charged for a minimum of 6 months, even if stored for a day or month. The peak season of storage is Dec to May (chilli season) and June to Nov is lean season. According to a cold storage operator, 60% of cold storage space has been used by oleoresin companies;

20% by farmers, 20% by merchants. For instance AV Thomas is oleoresin maker keeps 50000 bags for one year contract. The seeds left over after extraction of oleoresin are used for pain killer balms amrithanjan, vicks, also for pickels. Oleoresin makers pay Rs. 70 to Rs. 100 per kg of chilliand not beyond. In cold storage, 60% is the cost of expenditure involved in cold storage, 40% is the profit. The demand for cold storage in byadagi is ever increasing the 17 cold storage space does not suffice.

Economics of processing chilli to Oleoresin

In the survey, attempts were made to obtain the actual costs and returns from processing chilli to oleoresins. However, as this involves the physical and chemical processes, which may have been patented, it was difficult to assess the profitability. Following the aphorism "it is better to be roughly right than exactly wrong" of British Philosopher Carveth Read, the cost and return involved is presented[10]. Considering 100 kgs of Byadagi Chilli worth Rs. 8,000 (or Rs. 80 per kg), the oleoresin content ranges from 6% to 8%.Considering the conservative basis of 6% of chilli to be oleoresin, 6 kgs of oleoresin is extractable from 100 kgs of chilli. Oleoresin is priced at around (30 USD or) Rs. 1800 per kg. Thus, from 100 kgs of chilli, 6 kgs of oleoresin valued @Rs. 1800 per kg = Rs. 10,800 worth of oleoresin is extracted. In the process of making oleoresin, 40 kgs of seeds are obtained and are valued at Rs. 50 to Rs. 70 per kg. These seeds are used in manufacture of Namkeens, lipstick, chemical industries, medicinal pharmacies.

At a conservative price of Rs. 60 per kilo for seeds, the value of 40 kgs of seeds extracted is Rs. 2400. In addition to chilli, in the process of making oleoresin, 30 kgs of BOC are realized. Each kg of BOC is worth Rs. 15 per kg and is valued Rs. 450 per quintal of chilli. Thus, from each quintal of chilli worth Rs. 8000, 6 kgs of oleoresin worth (6 kgs X Rs. 1800 =) Rs. 10,800 + 40 kgs of chilliseeds valued at Rs. 60 per kg worth Rs. 2400 + 30 kgs of BOC valued at Rs. 15 per kg, worth Rs 450, totaling Rs. 13650 are obtained. Thus, in all from 100 kgs of dry chilli worth Rs. 8000, Rs. 10800 (of oleoresin) + Rs. 2400 (of seeds) + Rs. 450 (of BOC) = Rs. 13650 imply the value addition of (Rs. 13650 minus Rs. 8000) = Rs. 5650 or around 70 percent. The cost involved in these processes is around Rs. 2500 plus the raw material cost of Rs. 8000 per 100 kgs of chilli totaling Rs. 10500. Therefore the cost of processing 100 kgs of chilli to oleoresins is Rs. 10500, and the return is Rs. 13650. The profit from processing chilli to oleoresin value addition (oleoresin plus seeds plus BOC) is Rs. 3150 per quintal of chilli. Since 6 kgs of oleoresin are extracted from 100 kgs of chilli, the profit is Rs. 525 per kg of oleoresin.

ABS from Oleoresin

According to the Biological Diversity Act, 2002, a modest percentage of 0.1% to 0.5% of (the annual gross exfactory) sale of product is recommended as ABS. This works to ten to fifty paise out of Rs. 100. Considering the annual gross exfactory sale value of Rs. 13650 (from processing 100 kgs of chilli to 6 kgs of oleoresin), the ABS works to

Rs.13.65 which needs to be shared with the farmers by oleoresin processors by processing every quintal of Byadagi Chilli. The actual gross return is a function of the percentage of oleoresin which varies from 6 to 10 percent. The demand for oleoresin is increasing domestically. For instance, Delhi metropolitan alone demands around 100 tonnes of oleoresin per month, which translates to 1666 tonnes of chillies creating a substantive demand.

Six challenges for Byadagi Chilli and oleoresin processing

Challenge 1: Monoculture of chilli

Due to relatively high profitability of chilli, farmers resort to continuous cropping avoiding crop rotation. This leads to susceptibility to attack by Murda leaf curl disease, termed as Murda complex due to combination of action by Thrips, Mites and Viruses. Extension efforts are required to educate farmers regarding monocropping of chilli, crop rotation and organic farming methods, including biological control of the virus as reported by Pandey, Mathur and Srivastava[11] (Table 1)

Table 1: Effect of plant seed extracts on the incidence of chilli leaf curl disease

		Percent mean	
Name of plant seed extracts	Conc. (%)	Disease incidence	Reduction in disease incidence in comparison to untreated check*
Neem seed kernel extract	5	27.78 (31.81)	60.00 (50.77)
Tumba seed extract	5	33.33 (35.26)	52.00 (46.15)
Karanj seed extract	5	36.11 (36.94)	48.00 (43.85)
Untreated check	-	9.44 (56.44)	0.00 (0.00)
SEm±		6 1.18	0.91
CD at 5%		3.76	2.91

*Average of four replications. Values in parentheses are angular transformed values

Challenge 2: Increasing incidence of Murda Leaf Curl Disease thereby depleting area under chilli in traditional areas of Haveri, Dharwar districts

The Murda leaf curl disease has intensified in conventional areas of Byadagi Chilli thereby reducing the area under chilli substantially in Karnataka (Figs 4,5,6 above). The chili leaf curl complex *(Murda complex)* is caused by leaf curl gemini virus (CLCV) transmitted by chilli mite *(Polyphagotarsonemuslatus),* whitefly *(Bemisiatabaci)* and thrips *(Scirtothripsdorsalis)* and the control measures are complicated as more than one agent is involved in causing and spreading the disease. The following pictures[12] indicate the different aspects of Murda leaf curl virus.

The area under chilli and the associated production are under threat in Karnataka,due to lack of suitable varieties which are tolerant / resistant to Murda leaf curl disease. A survey of Haveri, Dharwad, Belgaum and Gadag districts indicated[13] that Haveri district has the maximum average disease incidence (of 45.86%) followed by Dharwad (39.36%), Belgaum (31.68%) and Gadag (30.81%). Obviously the area under chilli in Haveri and Dharwad districts has been considerably affected. Unless

Challenge 3: Climate change is exacerbating population of insect vectors and their distribution

Challenge 4: Pesticide resistance

Challenge 5: Absence of varieties tolerant/resistant to Murda Leaf Curl Disease of Chilli

Improved varieties are the need of the hour which are tolerant / resistant to Murda leaf curl disease and resistant to leaf sucking pests such as thrips and mites are the need of the hour. Byadagi area is already devoid of chilli due to Murda leaf curl disease incidence which reduced the profitability of chilli cultivation. It is desirable to develop varieties withthick and long fruit size.

Challenge 6: Mechanization for harvesting chilli

Since labor for cultivation of chilli is prohibitive, mechanical harvesting is the need of the hour and vastly reduces the labor cost of harvesting since picking is frequent. Thus, harvesting machinery needs to be developed to reduce the cost of harvesting chilli. China is a competitor for India in exports as well as in oleoresin processing. The prima facie indicator of China's competition is that Synthite, the major oleoresin producer of India has already opened its factory in China[14] to process chilli to oleoresin, since the chilli is available at a lower cost than in India.

Challenge 7: Maintenance of proper level of Aflatoxin in Chilli

Aflatoxin content in chilli has to be below 10 PPB for exports. Any consignment with aflatoxinmore than 10 PPB,will be rejected by the importing countries.

Phenomenonal rise in the price of Byadagi Chilli

During the survey, while discussing with aged farmers, it was reported that in 1963 price of Byadagi Chilliwas Rs. 150 per quintal. And in 2015 price is Rs. 10000 per quintal. Therefore the growth in the price works to 8.41 percent, a phenomenal rise in the price. With the peduncle removed, the price of Byadagi chili is Rs. 12500 per quintal.There are three major areas of chilli cultivated in India, namely Madhya Pradesh, Guntur and Byadagi.

Efforts towards contract farming

In order that farmers get an assured price and that the contracting company gets quality produce, the Synthitecompany did contract farming experiment in 1980s. However farmers did not cooperate and due to moral hazard, the company halted its contract farming operations.

End use pricing

Often price is being dictated by the end use. Chilli can be put largely to spice and oleoresin. Oleoresin manufactures usually buy chilli at Rs. 9000 per quintal, but will not buy at Rs. 12000 to 13000 per quintal. The higher price is offered by those who choose to convert chilli to spice. The major buyers are MDH, MTR, Mayya, Everest, who buy for 12000 to 13000 per quintal for spice purpose. It was reported that Ralleigh variety, Theja[15] variety from Khammam, Andhra Pradesh with high pungency command high prices. Other varieties are Kaddi, Dabbi, Guntur, Local (or byadagi), DB, Namdhari traded in Byadagi market. After 1990, oleoresin industry picked up the market and increased the economic and export potential of farmers cultivating Chilli.

Pepper Spray and Chinese venture

The Pepper Spray the essential component of which is the Oleoresin is extracted from Teja variety of chilli grown in Khammam extensively. Considering the popularity of Teja variety for its by-products, a Chinese company has set up unit in Mudigonda

mandal for extraction of Oleoresin and export. Khammam with black soil and fertile lands is the leading producer of chilli followed by Warangal. Teja variety with striking red colour and pungency, is widely grown here

Recommendations

1. Monoculture of chilli needs to be avoided by encouraging crop rotation. This will also control the spread of Murda leaf curl disease
2. Need to develop suitable improved varieties of Chilli with thick and long fruit size, tolerant / resistant to Murda leaf curl disease, and resistant to leaf sucking pests (thrips, mites), in order to sustain the area under chillies. Currently the area under chilli is threatened and Climate change is also exacerbating population of insect vectors and their distribution
3. Mechanization for harvesting chilli, since labor for cultivation is prohibitive, hence, mechanical harvesting vastly reduces labor cost of harvesting. Thus, harvesting machinery needs to be developed to reduce the cost of harvesting chilli to enable India to face stiff competition from China
4. There is need to maintain proper level of Aflatoxin in Chilli as the current content (10 PPB) is prohibitive and is affecting exports
5. Contract farming: In order to maintain quality for exports, contract farming can be encouraged which needs the perfect understanding of quality control by farmers by maintaining standards in cultivation including plant protection.

Summary and conclusion

The Karnataka Biodiversity Act stipulates that commercial utilization of biological resources which leads to incomes by processors, need to be shared with those who are responsible for generation of the resource. Else the processors would not be assured of appropriate supplies and this mutually affects production and processing. In this study, the economics of processing Byadagi Chilli into oleoresins has been considered, since Oleoresins are characterized as commercial utilization of Byadagi Chilli.

The Biological Diversity Act, 2002, prescribes a modest percentage of 0.1% to 0.5% of (the annual gross exfactory) sale of product as access and benefit sharing. The annual gross exfactory sale value obtained by processing 100 kgs of chillli to 6 kgs of oleoresin is Rs. 13650. Accordingly the ABS works to 0.1% of Rs. 13650, equal to Rs. 13.65. This needs to be shared with the farmers by oleoresin processors.

The study highlights the challenges in maintaining a sustainable supply of Byadagi Chilli in Karnataka such as evolving a tolerant / resistant variety for Murda leaf curl virus disease and has offered recommendations to promote cultivation and trade. The challenges of avoiding monocropping, pesticide resistance, adopting organic control methods are also discussed.

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Pic : 1 and 2: Byadagi area with cotton and maize as dominant cropping pattern, replacing Chilli

Pic : 3 and 4: Income inequality despite Byadagi market influence handling high value chilli crop

Pic: 5 and 6: Byadagi with ideal banking and marketing infrastructure for chilli trade


Pic :6 and 7: Chilli for drying in Byadagi market area with tarpaulin facility in the wake of rain


Pic: 7 and 8: Coding / Numbering of chilli in storage, transportation in Byadagi market


9and10: Largely women labor involved by traders in removing peduncle from Byadagi Chilli


Pic: 11 and 12: Modest facility for women labor removing peduncle in Byadagi market yard


Pic: 13 and 14: Removal of peduncle from chilli meticulously by women labor in Byadagi


Pic :15 and 16: Removed peduncle of chillito be used for cattle feed in Byadagi


Pic: 17 and 18: Drying yard facilities for drying of purchased chilli in Byadagi

Pic: 19 and 20: Transport facility for Byadagi Chilli in market yard and discussion with traders

Year	Area (000 Ha)	Productivity (KG/ HA)	Production (000 Tonnes)
1973-74	106.50	356	37.90
1974-75	105.60	348	36.80
1975-76	118.90	324	38.50
1976-77	121.20	241	29.20
1977-78	138.00	316	43.60
1978-79	145.00	310	45.00
1979-80	153.60	311	47.80
1980-81	153.80	315	48.50
1981-82	154.30	308	47.40
1982-83	155.70	312	48.60
1983-84	149.50	311	46.50
1984-85	136.80	304	41.60
1985-86	148.90	297	44.20
1986-87	143.10	296	42.40
1987-88	126.60	297	37.60
1988-89	142.20	298	42.30
1989-90	151.60	287	43.50
1990-91	128.70	285	36.70
1991-92	136.60	287	39.20
1992-93	161.40	609	98.30
1993-94	201.10	548	110.30
1994-95	167.90	604	101.50

Year	Area (000 Ha)	Productivity (KG/ HA)	Production (000 Tonnes)
1995-96	188.50	574	108.10
1996-97	200.80	803	161.20
1997-98	163.60	800	130.80
1998-99	170.30	860	146.50
1999-00	176.70	890	157.20
2000-01	172.90	874	151.00
2001-02	193.10	655	126.40
2002-03	155.50	987	153.40
2003-04	69.88	1352	94.50
2004-05	152.32	687	104.58
2005-06	125.67	850	106.81
2006-07	132.52	1032	129.95
2007-08	136.70	1092	141.79
2008-09	122.31	1162	135.04
2009-10	138.71	1048	138.15
2010-11	113.87	1136	122.87
2011-12	100.42	1116	106.50
2012-13	61.77	1297	76.14

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We are thankful to Sri MallikarjunKenvi, Chilli trader, grinder and owner of cold storage in Byadgi for this estimate.

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Dr. N. Nagaraj

ICSR National FellowFormer Professor and Head,
Dept of Agricultural Economics, UAS, Bangalore - 64
Former, Principal Scientist, ICRISAT
No. 1082, 15th B Cross, Newtown, Yelahanka, Bangalore - 64
Email: nagaraj.nareppa@gmail.com Ph:9880004823

Chapter 7

Value chain Analysis of Groundnut for Enhancing Income and Livelihood Security of the farmers: Economic Implications for Access and Benefit Sharing in Groundnut Value Addition in Karnataka

Introduction:

The National Biodiversity Authority (NBA) is a statutory autonomous body of India established in 2003 by the Ministry of Environment and Forests, Government of India to implement the provisions under the Biological Diversity Act, 2002, after India signed Convention on Biological Diversity in 1992. The NBA vision is to conserve and make sustainable use of India's rich biodiversity and associated knowledge with people's participation, ensuring the process of benefit sharing for well being of present and future generations. According to the Biological Diversity Rules, 2004 and The Karnataka Biological Diversity Rules, 2005 (with effect from 29th June 2006)1, "commercial utilization" (of biological resources) means end uses of biological resources for commercial utilization such as drugs, industrial enzymes, food flavours, fragrance, cosmetics, emulsifiers, oleoresins, colours, extracts and genes used for improving crops and livestock through genetic intervention, but does not include conventional breeding or traditional practices in use in any agriculture, horticulture, poultry, dairy farming, animal husbandry or bee keeping;". And therefore, the firms/ industries involved in "commercial utilization" of biological resources need to share a certain percentage of their annual turnover as Access and Benefit Sharing (ABS) with the generators (or gatherers) of biological resources respecting the information, sustenance and sustainability of flow of biological resources. In this regard, this study is a modest attempt to estimate the returns accrued from commercial utilization of biological resource (Groundnut value chain) in relation to the ABS evolved by the Karnataka Biodiversity Authority.

Importance of Value Chain in agriculture

A value chain involves a set of actors and activities that add value to agricultural produce before it reaches to the end users/consumers. During 1990's the concept of commodity chains emerged with the writings of Michel Porter (Kaplinsky and Morris, 2001). In agriculture, the structure of a value chain is that of a pyramid comprising the producers at the upstream, the firms/processers and various intermediaries in the middle and finally the consumers at the downstream. Thus with improvement value addition, the benefits will trickle down to consumers (Chengappa, 2018). The value chain evolved from porters generic value chain (Fig-1), indicates activities such as development and dissemination of plant and animal genetic material, input suppliers, farmers organizations, farm production, post harvest handling, processing, provision of technology, grading packaging, local and industrial processing, storage, transport and finance and feedback from markets.

The traditional marketing system in India is very defective characterised by several middlemen between producer and the final consumer. Hence, the producer share in the consumer rupee is very low. Thus development of an efficient and effective value chain is very crucial from the view point of increasing producers share in the consumer rupee. After liberalisation, the economy witnessed significant changes in the agricultural marketing system with evolving of contract farming and integrated value chains for several high value commodities for domestic and export needs that coordinate farmers, processors, retailers and other stakeholders.

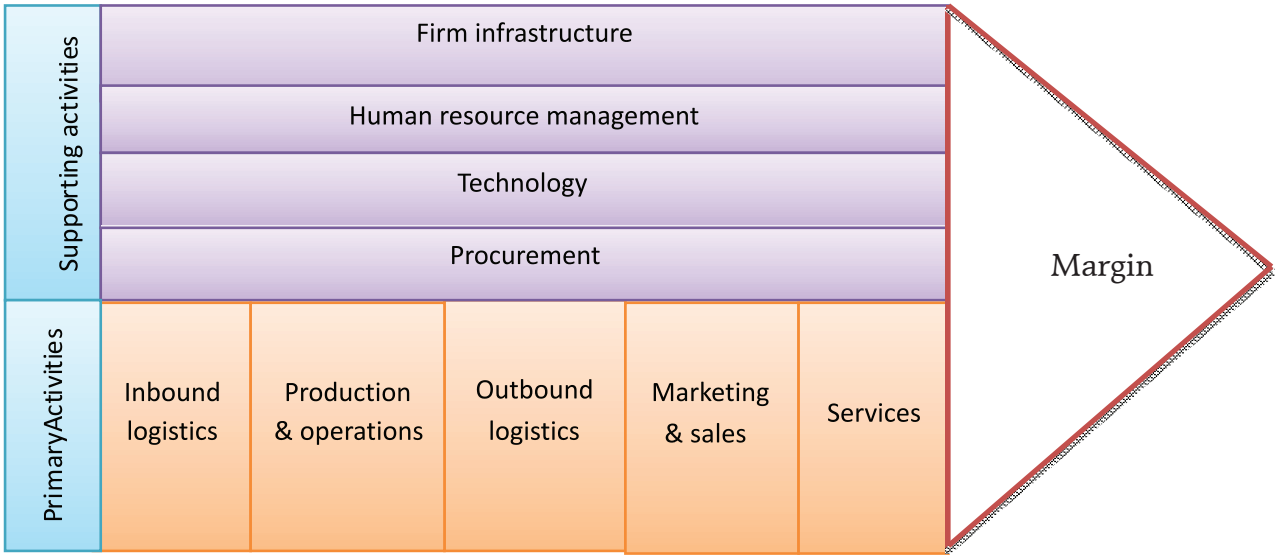


Fig-1 : Structure of generic Value Chain

Some of the globally well developed competitive value chain includes basmati rice, cashew, coffee and tea. The value chain development of groundnut and their benefits will be discussed in this study.

The centre of origin for groundnut

The centre of origin for the cultivated species of groundnut is native of South America. Since South America was discovered in early 1500 AD, it was probably then groundnut was introduced into India during the first half of 15th century (John et. al., 1955). The South American origin of cultivated groundnut was disseminated to Europe, to both coasts of Africa, to Asia (China, Indonesia, India) and to the Pacific islands and finally to the south eastern United States. The credit for the introduction of groundnut into India goes to Spaniards. It reached eastern Asia from South America and from there came to India on the east coast of Tamil Nadu and Andhra Pradesh by Spaniards. (http://www.ikisan.com/tn-groundnut-history.html).

Among oil seeds production, groundnut occupied a premier position accounting for over 25 per cent of the total oil seeds production in the country. Groundnut (Arachishypogaea L.) is one of the most important pecuniary crop and complementary food crop in India. It is being grown in semi-arid regions under rainfed conditions. Since groundnut is a commercial crop, it plays a crucial role for enhancing the income and livelihood security of farmers in semi arid regions of the country. Cultivation of this crop provide multiple tangible and intangible benefits to the farming community right from improving the fertility of soil to providing fodder to livestock and income to the farmers. It has to be noted that only the tangible benefits from the biological resource of groundnut crop is quantified. But, the intangible benefits in terms of biological nitrogen fixation and others is not precisely valued since they are not reflected in the market. Therefore, the non market benefits of groundnut are ignored.

Global Scenario:

Groundnut is one of the most important commercial oil seed crops cultivated in tropical and sub-tropical warm temperate regions of the world. By and large, the production of groundnut is concentrated in Asia and African countries. Globally, it is cultivated in 24.7 million ha of area with an output of 40.4 million tons with a productivity of 1.6 tonnes/ha (table-1). Groundnut is the 3rd largest oil seed crops cultivated in the world and second largest in India. In terms of area share under groundnut cultivation, India (18.4 %) and china (18.6) occupied almost equal space in the world followed by Nigeria, Sudan and Senegal. In terms of production, India is the second largest producer of groundnuts (16.77 %) after China. In terms of productivity, USA ranks top position followed by China, Indonesia, Myanmar, Nigeria, Cameroon and India. As evident from the table, despite highest area under groundnut cultivation in India, the productivity remained below world average. Thus there is huge scope for augmenting productivity of groundnut in India through improved production technologies with good management practices with efficient value chain.

Table-1.The global area, production and productivity of groundnut for the year 2014-15

Sl. No	Country	Area (lakh ha)	Production (lakh tonnes)	Yield (kg/ha)	Area share (%)	Production share (%)
1	China	46	165	3590	18.6	40.87
2	*India	45.55	67.71	1486	18.42	16.77
3	Nigeria	25	30	1200	10.11	7.43
4	USA	6.3	27.2	4310	2.55	6.74
5	Sudan	21.8	18.7	860	8.82	4.63
6	Myanmar	8.9	13.8	1550	3.60	3.42
7	Indonesia	6.2	11.3	1840	2.51	2.80
8	Senegal	11.4	10.7	940	4.61	2.65
9	Niger	7.4	3.5	470	2.99	0.87
10	Cameroon	4	5.5	1380	1.62	1.36
	Others	64.75	50.29	777	26.18	12.46
	World	247.3	403.7	1630		

Source: DOE, Ministry of Agriculture and Farmers welfare, GOI (2017)

With respect to cultivation of groundnut under different agro-climatic conditions, it fits into a range of farming systems and crop rotations. Being a legume, it enriches the soil with nitrogen through biological nitrogen fixation ranging from 100-120 kg of nitrogen in the field per hectare per season and thus there has been significant cost saving on nutrient application (https://www.google.co.in/search?q=Chapter+IV+in+groundnut). It maintains the fertility of soil and helps in reducing soil erosion and each and every part of groundnut has commercial value.

Commercial importance of the crop:

Groundnut is an important commercial enterprise in the farming system providing income and nutrition security to the farmers. It is considered as poor man's almond and eaten as roasted/boiled. It is the fourth most important source of edible oil and third most important source of vegetable protein. Almost every part of groundnut has commercial value. Groundnut contains 48-50 % of oil and 26-28% of protein, and a rich source of dietary fibre, minerals, and vitamins. Of the total output produced, around 60 % is used for oil extraction and oil cake, 13% is consumed as edible nuts; 10% is towards seed and for other industrial uses, and 9 % exported as shelled products. A variety of value added products are obtained like peanut butter, *chikki, burfi, bhujia* and biscuits. Groundnut hauls are also valuable by-products in terms of fodder for livestock. The groundnut shell is used in various industries as fuel, filler in fertilizers and cattle fields, preparation of particle boards/papers (DOD, National Mission on Oil Seeds, 2017).

Multiple uses of groundnut and its by-products:

Groundnut oil has several uses but it is mainly used as cooking oil. It is also used in making vanaspati ghee and in fatty acids manufacturing. With respect to groundnut kernels, whole kernels are widely used for table purpose by roasting in different types of namkeens. It is a very popular snack and is also used in confectionaries. Kernels are also used as a spice in vegetables and as sprouts for salad (ICRISAT-VDSA, 2013). The groundnut cake obtained as by-product during the process of oil extraction has significant additional value and it is exclusively used as animal and poultry feed owing to its high nutritive value and palatability. The groundnut shell has commercial use in different forms like fuel, filler in cattle feed, hard particle board, cork substitute, activated carbon and so on. Despite groundnut crop huge potential towards enhancing the incomes of the farmers, the biological/genetic resources of this crop has not been fully exploited due to several factors, inter-alia lack of suitable high yielding varieties, inadequate seed production, incessant droughts and imperfections in marketing systems, weak and fragmented value chain.

Study objective

The main focus of this study is to estimate the costs and returns involved in the value chain of groundnut, right from production, processing and value addition considering multiple products like groundnut oil, groundnut cake, kernels and groundnut shell. Further, the study analyses the valuation of bio-resource issues involved in value addition of groundnut in relation to the ABS evolved by the Karnataka Biodiversity Board.

Indian Scenario:

In India, groundnut crop is predominantly (> 80 %) cultivated during kharif season (June to October) under rainfed conditions. Since it is a legume grown in rainfed, farmers normally apply low level of inputs due to monsoon and market related risks. The proportion of groundnut area in Rabi season (October to March) is insignificant mostly cultivated under protective irrigation and on residual moisture. During summer groundnut is cultivated under assured irrigation with high input use intensity.

Area, production and productivity:

In India, groundnut is cultivated in area of around 4.6 million hectares with a production of 6.73 million tonnes having a productivity level of 1465 kgs/ha during 2015 as indicated in the table 2. However, the area under groundnut cultivation remained stagnant between 2001-02 to 2010-11 and thereafter, it was slightly decreasing (Fig 1). The growth rate of area under groundnut was negative; implying the area under groundnut cultivation was decelerating at the rate of 2.2 % per annum. The reasons for the declining trend of area under groundnut cultivation was mainly shifts in cropping pattern towards other competing crops like soybean, cotton, gram, sunflower and maize and frequent droughts in southern states. The production and productivity trends exhibited cyclical movements and wide fluctuations between 2001 to 2015 due to several reasons like sensitiveness of crop to moisture stress, inadequate precipitation

during crop growth, untimely rains during peg formation, pod maturity and severe drought (DOD, GOI 2017). Moreover, groundnut is cultivated in a low resource base and input use resulting lower production and productivity.

For successful cropping of groundnut under rainfed condition proper distribution is most critical than the quantum of rainfall received. Hence, protective irrigation is required to get a bumper crop. Even though there has been shrinkage in acreage under groundnut production, the productivity has improved modestly. Thus the enhanced productivity has contributed to increased production share of the groundnut, in spite of decreased area.

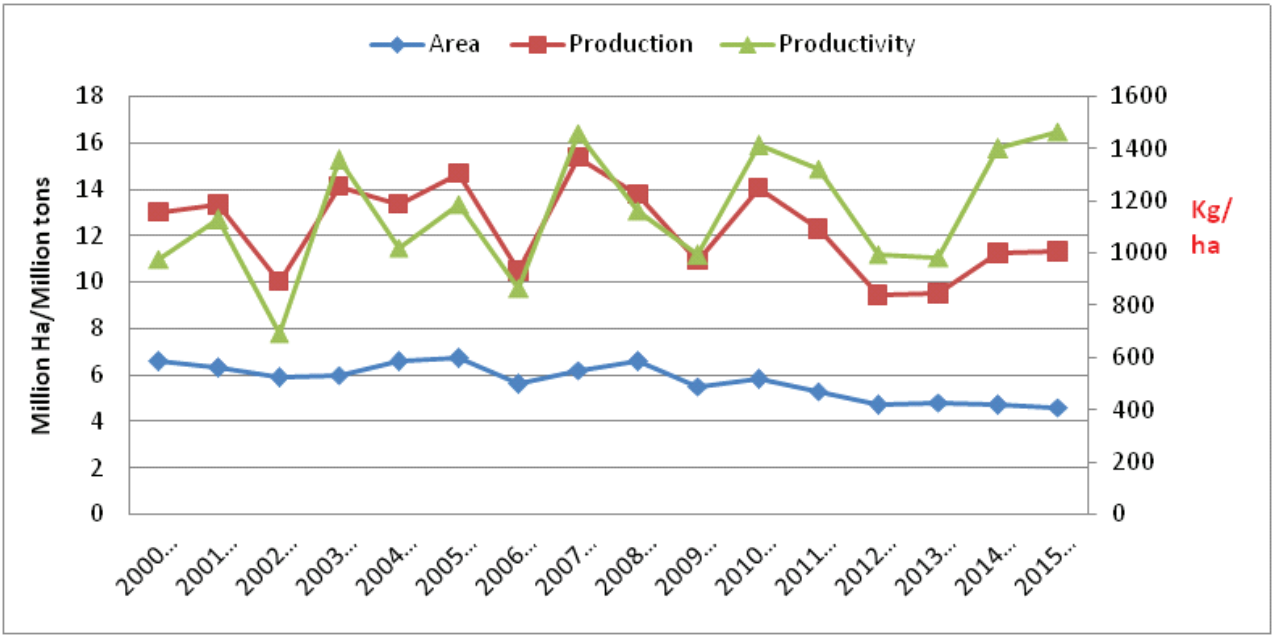
Within India, majority of the groundnut area and production are concentrated in five states viz., Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Rajasthan (Table 3) accounting for 80 % of the total production of the groundnut in the country. Among the states, Gujarat is the single largest producer accounting for over 34 % of the total groundnut production in the country (Table-3). In states like Gujarat and Maharashtra, groundnut is predominantly grown in Kharif season (June to Sept), while in southern states, it is mainly grown in Kharif as well as in rabi. It is also being grown in summer (Jan to May) under irrigation. The three southern states of Andhra Pradesh, Tamil Nadu, Karnataka and the western state of Gujarat and Rajasthan together accounted for over 80 per cent of the annual groundnut output in India. The state wise area and production shares of groundnut are provided in the appendix II.a and II.b

Table 2, Trend in Area, production and productivity of groundnut in the country

Year	Area (Million hectares)	Production (Million tonnes)	Productivity (Kg/hectare)
2000-01	6.6	6.41	977
2001-02	6.3	7.03	1127
2002-03	5.9	4.12	694
2003-04	6.0	8.13	1357
2004-05	6.6	6.77	1020
2005-06	6.7	7.99	1187
2006-07	5.6	4.86	866
2007-08	6.2	9.18	1459
2008-09	6.6	7.17	1163
2009-10	5.5	5.43	991
2010-11	5.8	8.26	1411
2011-12	5.3	6.96	1323
2012-13	4.7	4.72	995
2013-14	4.8	4.69	984
2014-15	4.7	6.56	1400
2015-16	4.6	6.73	1465
CGR	-0.024	0.003	0.026

Source: *DOE, Ministry of Agriculture, Government of India (2017-18)*

Fig: 2. Trends in area, production and productivity of groundnut in India



As evident from the figure 2, the area under groundnut has experienced a decelerating trend due to its low profitability compared to its competing crops like soybean, maize, cotton and gram under the prevailing conditions of monsoon and market risk.

Table-3: Area, production and productivity of groundnut across major states in India (2015-16)

Sl. No	States	Area (lakh ha)	Production (Lakh tonnes)	Yield (Kg/ha)	Area share (%)	Production share (%)
1	Gujarat	14.14	23.58	1668	31.04	34.82
2	AP	7.75	8.02	1035	17.01	11.84
3	Rajasthan	5.21	10.56	2028	11.44	15.60
4	Tamil Nadu	3.52	8.82	2509	7.73	13.03
5	Karnataka	5.91	4.85	821	12.97	7.16
6	MP	2.36	3.5	1483	5.18	5.17
7	Maharashtra	2.4	2.37	988	5.27	3.50
8	Telangana	1.27	2.06	1622	2.79	3.04
9	West Bengal	0.84	2	2372	1.84	2.95
	Others	2.15	1.95	907	4.72	2.88
	All India	**45.55**	**67.71**	**15433**		

Source: *DOE, Ministry of Agriculture, Government of India (2014-15)*

Improved groundnut varieties recommended

All India Co-ordinated Research Project (AICRP) on Groundnut (presently the Directorate of Oil Seeds) has a mandate of development of new varieties and improved production technologies for different agro-climatic zones of India. After establishing

AICRP at ICAR, >150 varieties of groundnut have been released to suit to different agro-ecological situations, out of which old varieties like TMV-2, TMV-7, GG-11, Chitra Kaushal, SV-xi, JL-24 Polachi-1, GAUG-10, and new varieties like K-6,K-9, TG37-A, GBPD-4, GBPD-5, Narayani, ICGV-91114, TPG-41, TG-38, VRI-6 have become popular among the farmers for large scale cultivation (DOD, 2017)

Exports Scenario

In terms of exports, among oil seeds groundnut has highest share in agricultural exports. India is one of the leading exporters in the world and competes closely with Argentina, USA and China by commanding a share of 20-25% in global markets. Groundnut kernels of Hand Picked Selection (HPS) grades are exported in bulk quantities for table purposes. In addition to the groundnut kernels, other value added products of groundnut like oil, peanut butter and oil cakes are also exported in substantial quantity. The details of quantity and value of export of different groundnut value added products are provided in the table-4 as well as in Appendix-I. The monitoring and enforcement of quality controls, the good crop quality and a robust international demand contributed to India's export performance (DOE, 2017). The other factors like lower freight rates and weaker rupee also helped exports. Countries like Vietnam, Indonesia, Malaysia and the Philippines are accounting together for about 71% of the total Indian exports of groundnuts. Major export destinations include Vietnam, Indonesia, Malaysia, Philippines, Thailand and Ukraine. The major trading centres of groundnut in India include Rajkot, Ahmadabad, Mumbai and Delhi.

Ground nut production largely caters to the needs of domestic consumption and only 6% of it is traded internationally. China and Argentina are the largest exporters of ground nut and European Union is the largest importer.

Table-4: Percentage share of groundnut and its products exports from India

Products	2012-13		2013-14		2014-15	
	Qty	Value	Qty	Value	Qty	Value
Groundnut	94.40	92.20	99.76	99.11	87.42	94.38
Food Products	0.85	0.93	0.08	0.41	2.93	1.38
Groundnut oil	4.04	6.64	0.07	0.34	8.72	3.98
Oil cakes	0.71	0.24	0.09	0.13	0.93	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00

Agriculture in Karnataka:

Over 56 % of the population of Karnataka state depends on agriculture for its livelihood. A majority of these are small and marginal farmers with land less than 2 ha. Out of the total geographical area (19 million ha), the total cultivable area in the state is around 64 % with a cropping intensity of 121 %. Karnataka is one of the states having largest proportion (79%) of the drought prone area in the country. Hence rainfed

farming is predominant in the state with heavy dependence on monsoon. The state has comparative advantage to grow a variety of crops due to salubrious climate, long growing-season, diversity in soils and other natural endowments, markets, infrastructure and favourable government policies. Karnataka is also known for sericulture and dairy as they provide assured source of income and employment to the small and marginal farmers. Of late, horticultural led growth has been witnessed very rapidly due to economic liberalization, availability of infrastructure, and incentives provided by the central and state governments for the promotion of horticultural crops.

Normally, about 65 percent of the net sown area is in Kharif depending on distribution of southwest monsoon precipitation. Similarly, about 30 % and 5 % of the area is sown during Rabi, the northeast monsoon season (November to March) and the summer season (April to June), respectively, depending on the quantum of residual moisture and availability of irrigation. According to 2014-15 data, the cereals occupied 47 percent of the net sown area, followed by pulses 19 %, oil seeds 13.4 % and other commercial crops like sugarcane, cotton and tobacco 13 %.

Why groundnut value chain:

The Karnataka Biodiversity Act specifies that commercial utilization of biological/ genetic resources that leads to incomes by processors, need to be shared with those who are responsible for generation of the resource. Otherwise, the processors may not get assured supplies and this mutually affects production and processing. In this regard, groundnut is one of the commercial crops and the final product serve as a raw material for several agro-oil industries with substantial amount of processing and value addition which are characterized as commercial utilization of biological resource. Hence groundnut value chain is considered.

Karnataka Scenario:

Karnataka is one of the leading states in oil seeds production including groundnut. According to the latest data available (2016-17), the area under groundnut is to the tune of 6.6 lakh hectares with a production of around 4.2 lakh tonnes with a productivity of 662 kgs/ha. In the state, groundnut crop is mainly grown as commercial crop in Kharif and Rabi under rainfed as well as under irrigation in summer. More than 70 % of the groundnut area is concentrated in kharif season under rainfed. Groundnut is one of the prime cash crops of the state mainly grown in northern, central, southern and eastern agro-climatic zones.

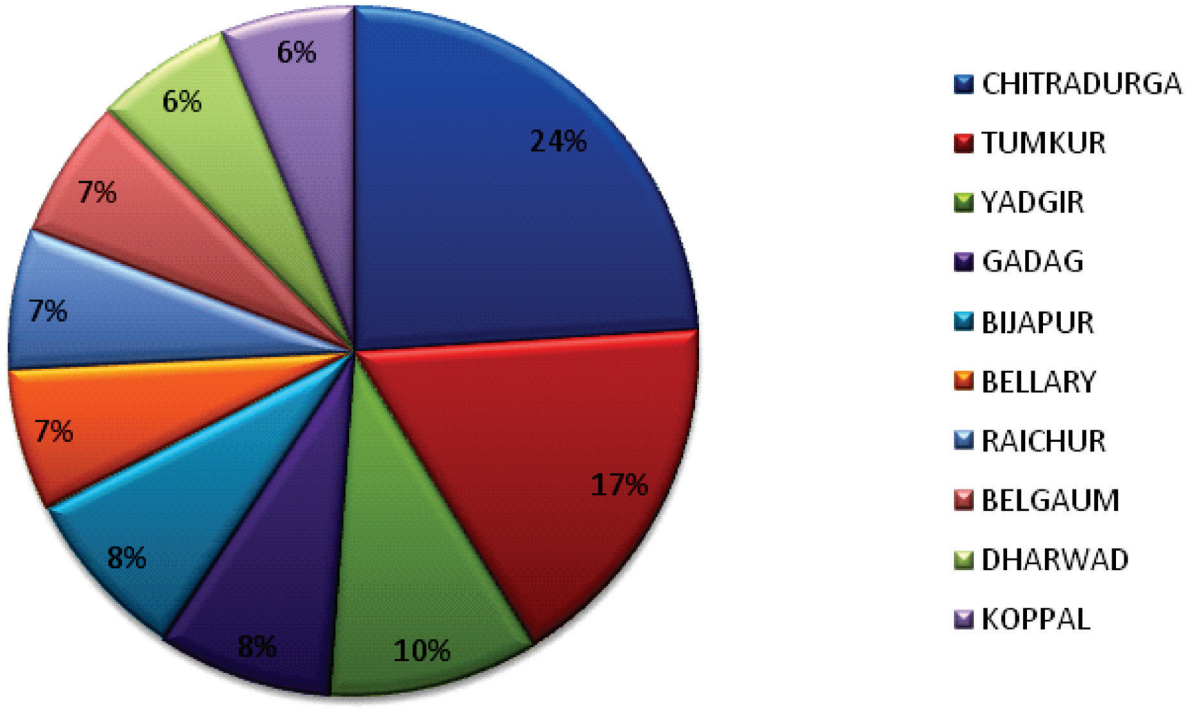
Some of the districts have regional and relative comparative advantage in growing groundnut over other crops because of specific natural resource endowments which are best suited for the cultivation of groundnut. In these districts, groundnut is grown as mono-crop without proper crop rotation. Since groundnut is predominantly a dry land crop, its productivity in the state is low as compared to other groundnut growing states. Based on the acreage share, the major districts in Karnataka where groundnut crop is

being grown are Chitradurga, Tumkur, Yadgir, Gadag, Bijapur and Bellary (Fig-3). About 70 percent of the crop is grown in black cotton soil and the remaining in red sandy loams (Rathod, 2013). All the districts grow both Spanish and Virginia varieties. More than 50 % of the production share is contributed by the 5 districts viz., Yadgir, Bellary, Raichur, Belgaum and Tumkur (Table-5). Some of the groundnut varieties recommended and adopted across different districts of Karnataka include GPBD-4, K-6, TAG-24, TG-37-A, TMV-2, JL-24, ICGV-91114 and TPG-41

Table-5. District wise area, production and productivity of groundnut - 2016-17

Sl. No.	District	Area Lakh ha	% share	Production Lakh tonnes	% share	Yield Kgs/ha
1	CHITRADURGA	129484	19.45	27892	6.66	227
2	TUMKUR	93249	14.01	31252	7.46	353
3	YADGIR	53292	8.01	47830	11.42	945
4	GADAG	44075	6.62	26527	6.34	634
5	BIJAPUR	44001	6.61	30113	7.19	720
6	BELLARY	36382	5.47	42738	10.21	1,237
7	RAICHUR	35610	5.35	43995	10.51	1,300
8	BELGAUM	35357	5.31	34661	8.28	1,032
9	DHARWAD	34746	5.22	17556	4.19	532
10	KOPPAL	33626	5.05	17986	4.30	563
	Karnataka State	**665709**		**418723**		**662**

Fig-3, District-wise Area share of groundnut 2015-16



Methodology

Study area:

For studying the value chain analysis of groundnut, Tumkur district was chosen as it is one of the leading districts in groundnut area and production. Besides, there are good numbers of processing units located in and around Tumkur district. Groundnut is predominantly cultivated as a dry land crop in 3 taluks of Tumkur district viz., Sira, Madhugiri and Pavagada. In these Taluks, the red sandy loam soils are best suited to cultivate groundnut crop. Invariably, farmers allocate majority of their dry land area towards cultivation of groundnut, as it thrives well even with low rainfal; provided the rainfall distribution is even during the cropping season (Appendix IV). In order to work out production economics of groundnut, the database generated from the ICRISAT-VDSA Project located in Madhugiri Taluk was used.

Database and Sampling framework:

The database to compute costs and returns of groundnut production pertains to the year 2015-16 from the ICRISAT VDSA project located in Belladamadugu village, which is in 6 Kms proximity to Muadhugiri town in Tumkur district. For value chain analysis, the different stakeholders located in Sira were interviewed and data was elicited for the case study. The major markets for groundnut in Tumkur district are Sira, Pavagada and Madhugiri APMC's. The data relating to the procurement of raw material, processors and their logistics, investments on plant and machinery and cost of processing, returns realised from processing of value added products and key constraints in the functioning of processing units were collected from the sample processors through personal interview. Secondary data pertaining to area, production and productivity of groundnut for Karnataka state and India were collected from different sources. For the detail case study on processing of groundnut into oil and cake the Nagaraja oil Industry, Sri Balaji Oil Mills and Srinivasa Oil mills located in Industrial estate of Sira were interviewed and the data was collected.

Production/Economics of groundnut crop at farm level

In Madugiri area, rainfed agriculture is predominant with groundnut mono cropping, as it has regional comparative advantage in groundnut production. Still majority of the farmers are growing TMV-2 and Spanish improved varieties of groundnut and the productivity of groundnut under rainfed conditions is very low due to low input use intensity and non-adoption of improved varieties. Groundnut in the selected sample villages is grown both in rainfed as well as under bore-well irrigation. Under rainfed conditions, the total cost incurred towards cultivation of groundnut per acre works out to be Rs. 14600/- including inter crop of pigeon pea **(Table-6).**

Table-6: Economics of groundnut cultivation under rainfed conditions

Sl. No	Particulars	Unit	Qty	Value (Rs)	% to the total cost
1	Bullock Labour- ploughing, harrowing and inter-cultivation,	BP	2	2000	13.7
2	Human Labour	Mds	15	6000	41.0
3	FYM	Tones	1.5	1500	10.0
4	Fertilizers	Kgs	45	700	4.7
5	Seed	Kgs	35	2450	17.0
6	Machinery power	Rs/Hr	1	500	3.4
7	Gypsum	Kgs	1	10	
8	Intercrop seed cost			150	
8	Plant protection chemicals			500	3.4
9	Interest on working capital @ 12 %	Rs	6 months	828	5.6
10	Total cost	Rs		14,638	
11	Main Product	Qtls	4.5	18,000	
12	Income from intercrops			1500	
13	Bye-product	Tonnes	0.75	1200	
14	Gross returns			20,700	
15	Net returns			6,062	
16	Returns per rupee of expenditure			1.42	

Out of the total cost, the major share of the cost was towards labour component accounting 41% followed by seed cost, preparatory cultivation and nutrients cost. Normally farmers use more seed in rainfed conditions than recommended, as compared to irrigated conditions, because of germination problems under moisture stress. Thus seed is the most expensive input after labour component in the total cost of cultivation. Majority of the farmers use purchased seed hence the seed replacement ratio is relatively high (30 to 40 %) in the area. The expenses towards plant protection are insignificant. On an average, farmers realized an output of 4.5 quintals worth Rs 18,000 plus an additional income derived from the groundnut haulms (fodder) and inter crop of Rs. 2700/ considering the farm harvest price. The net returns derived after deducting all the cost is around Rs. 6062/acre. On an average, the cost incurred to produce a quintal of output was Rs. 3253/, while the returns realised per quintal was Rs 4600/ with a net returns of Rs 1347/quintal.

Economics of processing of groundnut into oil and cake

Value chain concept

The concept of "agricultural value chain" (Ag VC) covers the full range of activities and participants involved in moving agricultural products from farm gate to the consumer's table (Farm to Fork). A value chain is often defined as sequence of value adding activities, from production till consumption, through processing and commercialization. In other words, value chain simply refers to the flow or 'the path through which value has been added on the produce or product by a number of actors along the chain as it moves from the farm to the consumer. One of the purposes of the value chain is to understand activities, which add value during creation of the end product (Hellin & Meijer, 2006). Of late, the value chain concept of developmental approach through private sector investment is gaining momentum across the world.

In the study area, the existing value chain for groundnut is not well organised and it is highly fragmented and the firms at farm level focus more on domestic markets. In the present study, the typical value chain of groundnut is classified into three categories viz., primary, secondary and tertiary level. The primary or farm level comprising pre-production and production activities, secondary level consist of logistics of moving commodity from farm to market, distribution and finally the tertiary level comprising value addition and delivery to the end users (Fig-3). A value chain approach helps to identify weak points in the chain and accordingly take corrective actions to add more value. Precisely, value chain approach aids in understanding what needs to be done to bring more value on farm and offer competitive products to the different markets. The goal is to deliver maximum value to the end user at least cost.

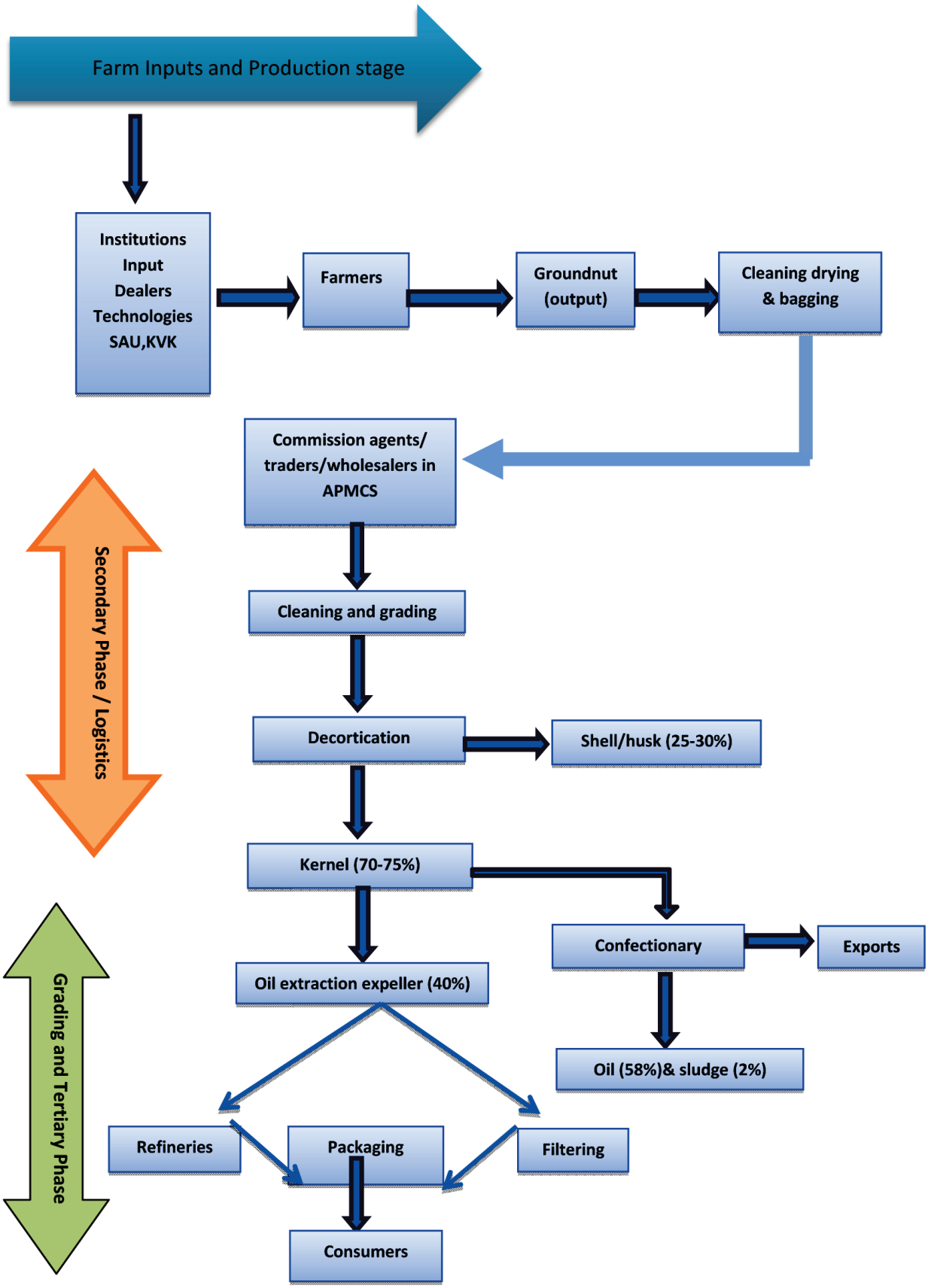
Main actors in groundnut value chain:

In a generic value chain, the main actors include service providers/input supplier's producers, local traders, Commission agents, wholesalers, retailers, exporters, processors and consumers. These actors are responsible to bring a product from conception to its end use.

Value chain mapping

The structure of a typical value chain is provided in the Figure-4, is based on the data elicited from different actors/players in the chain and is explained below. The value chain comprises the key input suppliers, technology delivering agencies, scientists engaged in developing and evolving appropriate technologies and outreach personnel involved in capacity building and providing various services to the farmers.

Fig-4 :Value chain map for groundnut



Primary level (producers/):

This phase mainly deals with farmer-producers, input and technology suppliers and the supporting services required for undertaking the production. At primary stage, farmers are the key stakeholders involved in the production of groundnut by allocating their scarce resources viz., land, labour and capital. The technology generation and delivery to the farmers is done by both private and public agencies. In some districts, the Karnataka Co-operative Oilseeds Growers Federation Limited (KOF), distributes quality seeds to the farmers under the department of agriculture subsidy programmes. The service providers like Krishi Vignan Kendra, Department of Agriculture, agro-input dealers provide services like technical support and guidance on production technologies, besides inputs. R and D Institutes like CFTRI provided technologies for processing and value addition. The financial institutions provide crop loan and the GICI extends crop insurance support. The commission agents, wholesalers and traders in the APMC regulated market act as trade facilitators by providing space for marketing of groundnut. In groundnut value chain, the horizontal integration in multiple functions is evident like input agent acting as a seed cum fertilizer cum pesticide supplier and also credit facilitator to the farmer leading to interlinked markets (Gowda, 2010). Farmer also cleans, stores groundnut for seed purposes and for various processed foods that include chutney powder, confectionary and daily use. Farmers usually dispose of their groundnut pods (apart from the quantities retained by them for seed and edible use) within three to four weeks after harvesting, although some rich farmers store the pods for three to four months expecting favourable market prices. Pods used for seed purpose are stored for seven to eight months and those intended for edible purposes are stored till the commencement of the next harvesting season.

Secondary level (Logistics):

This phase starts soon after the produce leaves the farm gate to other centres/markets. The key players/actors involved in the secondary activities (logistics) are the agencies organising collection, grading, storage, transportation, processing and marketing of the produce. In this chain, the commission agents and traders play a major role in adding further value by way of cleaning, drying, grading and so on. Agencies like financial institutions and market information centres are also part of the value chain. Efficient linkage of various stakeholders improves production, price realisation and profitability (Shakunathala Devi, 2017). The marketing of groundnut gains momentum from Dec till April-May. The APMC market in Tumkur and Chitradurga has electronic facilities facilitating transparency in bidding and other functions. Farmers sell their produce in the APMC market through open bids/auction and further, the Commission agents and traders sell to the processors. Most of the small and marginal farmers sell groundnut to the commission agents/traders, as they have borrowed working capital from them. When there is a glut in the market and the market price is below Minimum Support Price, the market intervention programme by the Government of India procures the groundnut at MSP. In the state, the KOF as NAFED agent also intervene in the market and procure oilseeds under price support scheme when there is distress in the market. The Minimum

Support Price is worked out based on cost of production and it ensures farmers a baseline price protecting against drastic falls in output prices in the event of excess production.

Most of the farmers trade groundnut at APMC market, however some of the agencies/ firms also procure groundnut directly from farmers for processing into value added products. These include:

1. Karnataka Co-Operative Oilseeds Growers Federation Limited
2. Sree Susheel Oil Industries, Bellari Road, Opposite SJM College, Opposite SJM College, Bellari Road, Challakere
3. Laxmi Mills, Near State Ware House, Hospet Road,Haveri,
4. Sri Balaji Oil Mills, Sira, Tumkur district

Tertiary level:

At tertiary level, the main players involved are the processors who purchase raw material from the market or directly from the producer. After cleaning and drying of groundnuts to safe moisture content, they have to be stored to keep them dry and have to be protected against storage pests to prevent loss of natural colour and flavour and development of rancidity. Since groundnut production is seasonal, its procurement is based on size of plant capacity. Hence, proper storage of groundnut pods is an important step whether the pods are used for oil extraction or seed or for edible purposes. After cleaning, drying and grading the produce, it will be decorticated to remove the shell. Further, it will be processed into various value added groundnut products like kernels of grade-1 for exports and grade -2 for snack industry and grade-3, for oil and its by-products (Dinesh, 2013).

Extent of value addition

The value addition done at the trader‘s level involves- Cleaning, sorting, drying, decortication, oil extraction and packing. Grade 1 and Grade 2 kernels are sent to confectionary market and Grade 3 sent to oil crushers. Grade 1 and Grade 2 are regarded as exportable qualities, while grade 3 is meant for sweet manufacturers in Mumbai or oil millers in local area. Grade 4 and other grades that are not suitable for Mumbai markets are usually sold to the oil millers in the local area (ICRISAT-VDSA 2014, downloaded from vdsa.icrisat.ac.in/Include/Internrep/Report2.pdf).

Kernel processing

Value addition	**Rs/Kg**
Cleaning and sorting	0.8 – 1
Drying	0.5 – 0.8
Decortication	4 – 6
Bagging	0.30- 0.6

Source :(ICRISAT-VDSA,2014)

Processing system

The processing of groundnut is done keeping the purpose of its end use in view. Broadly processing has two components viz., processing unit for decortication of the produce into kernels after removing the shell and the second one processing unit meant for crushing to get oil and cake. In kernel processing, groundnut seed (kernel) is the main product and husk is the bye-product. While in the oil processing, groundnut oil is the main product; and cake and sludge are the bye-products. In the study area, based on the processing capacity per day, processing units were classified into small, large and ghanis. The processing units with capacity less than 10-15 quintals per day were considered as ghanis units, below 60 quintals per day were considered as small units and more than 60 quintals per day were considered as large units. Traditionally most of the oil millers had a decortication unit to decortify the produce before crushing it. However with the emergence of the confectionary market, many new traders are now involved only in the decortication and sale of the produce. In this case study, the processor used the simple technology of small scale expeller using electric power. The solvent extraction involves use of modern technologies which are common in Chellakere, Chitradurga district. A typical groundnut processing unit for this study is provided in the appendix III.

The cost of processing groundnut into different value added products is provided in the table 7. In order to establish a medium size processing unit comprising land, machinery, electrical installations and other items entails an investment of around 50 to 75 lakhs depending on the size of the plant. Normally overheads are amortised considering a life span of 20 years to get the annualised amortised cost. But, in this case study, the actual processing cost and annual amortised cost is directly taken from the figures given by the owner based on his estimates.

Table-7: Cost of processing of groundnut into different value added products (Rs/Qtl)

Particulars	Groundnut-kernels	Groundnut-Oil	Cake/ sludge	husk
Average cost of raw material (Rs/qtl)	3950	4890	-	-
Processing cost (Rs/qtl)	75	150		
Overheads (Rs/qtl)	125	70		
Total cost (Rs/qtl)	4150	5000		
Out-turn (kgs)	70	40	59	30
Average selling price (Rs/kg)	80	120	32	2.50
Gross margin	9750	4800	1888	75
Gross margin considering by-product value/qtl	9825	6688		
Net margin/qtl	5675	1680		
Net margin/kg	56.75	16.80		
Cost to return ratio	2.36	1.33		

The recovery of processing units in terms of oil, oil cake, husk and kernel was worked out per quintal of groundnut processed. A perusal of table reveals that on an average, to process a quintal of shelled groundnut into kernels, a total cost of Rs. 4150/ qtl is incurred, of which the share of processing cost is around 5 %. The out turn or recovery percentage of kernels is around 70 kgs and husk is 30 kgs for every qtl of shelled groundnut processed. Out of the 70 kgs kernel, around 90 % is C grade (grade-1) and 20 % is D grade (grade-2). Considering an average output price of Rs 80/kg, the total gross margin realised was Rs.9825. Upon deducting all the costs the net margins realised was Rs. 5675/qtl.

The oil content of the groundnut kernel varies with the variety and quality of the nuts. On an average, it varies from 35 to 45 % depending on the variety. Crushing by expeller generally yield higher oil than the traditional method. In case of groundnut processing into oil and cake, for every quintal of kernels processed resulted into 40 kgs of oil and 59 kgs of cake and 1 % as sludge. On an average to process each quintal of groundnut incurred a cost of Rs. 5000, of which the processing cost accounted over 4.5 %. Considering the oil price of best quality Rs 120/kg, the gross margins realised from the oil was Rs 4800 and from the cake was Rs. 1880. Thus, considering oil and cake together, for every quintal of groundnuts, the gross margins generated was to the tune of Rs 6680 and the net margins was Rs. 1680. The cost to return ratio indicated that in case of kernels, for every rupee of expenditure towards processing of groundnut into kernels yielded a net return of Rs. 2.36, while in case of processing groundnut into oil and cake for every rupee of expenditure generated a return of Rs. 1.33. Thus processing of groundnut into kernels is more profitable than oil and cake. In the entire value chain, processors are the receivers of highest returns due to the higher extent of value addition.

Thus it is clear that from each quintal of groundnut worth Rs. 3950 processed into kernels, yielded a gross return of Rs. 9825 and a net return of Rs. 5675 implying the value addition from 100 kgs of groundnuts is more than 100 %. In case of groundnut oil, it is clear that from each quintal of groundnut valued Rs 4890, yields a gross return of Rs 6688 and a net return of Rs 1680 implying the value addition from 100 kgs of groundnut seed is around 35 %.

ABS from Groundnut value chain

According to the Biological Diversity Act, 2002, a modest percentage of 0.1% to 0.5% of (the annual gross ex-factory) sale of product is recommended as ABS. Thus from each quintal of groundnut processing into kernels the ABS works out to be Rs 9.85 to 49. Similarly in case of oil and cake it works out to be 6.6 and 33.4 respectively which needs to be shared with the farmers by the processors.

As the groundnut moves from farm to processing centres along the chain the value of groundnut gets altered and this process is value addition.

Decline trend in the crushing of groundnut oil and consumption

In Chitradurga district, Challekere is considered to be groundnut oil bowl of Karnataka known for groundnut production and oil extraction from groundnut. According to groundnut millers, a decade ago, there were 130 groundnut crushing units in Challekere alone. Currently this number has dwindled drastically and only a few units are involved in oil extraction. The main reasons for the sharp declining of groundnut crushing units in the state is cheaper imports of palm oil and adulteration of other cheaper oils. Since palm oil is cheaper than groundnut oil, the demand for groundnut oil has drastically declined. In addition, oils like sunflower and soyabean are competitive for groundnut oil. Thus the groundnut economy is severely impaired by government policy of importing palm oil. According to processors crushing groundnuts into oil is not economically viable under present situation. There is a plentiful supply of cheaper oils such as palm, sunflower and soybean which is pulling down the groundnut oil prices.

Key Challenges and recommendations

Production:

Availability of quality seed is a major constraint, since the private sector is not interested to invest in seed production due to low seed multiplication ratio. In this regard, strategies in increasing good quality seed production and distribution of newly released varieties need to be drawn and implemented by the concerned stakeholders. Groundnut crop by and large continued to depend on rainfed production system leading to wide fluctuation in area and yield with larger variation in groundnut output and also the quality of the produce. This is affecting both groundnut exports and oil industry. Both sectors require reliable and dependable source of quality raw material. Further, in spite of several high yielding varieties with high oil and oleric content developed by ICAR – Directorate of oil seeds and ICRISAT, farmers are not being benefited due to inefficient supply chain and poor outreach. Thus, aggressive outreach from both public and private agencies is required to deliver the technologies specific to each zone and make supply chain more efficient so that both farmers and processors will be benefited. The R and D institutions should focus more on developing varieties which are multiple resistance like biotic and abiotic constraints to suit different agro-climatic zones.

One of the major concern of groundnut is minimizing post-harvest losses especially aflatoxin contamination, which severely affect the nutritional qualities and export of groundnut. Hence, cost effective affordable best storage structures are vital. Groundnuts always should be stored as pods rather than as kernels since kernels are subjected to rapid quality deterioration.

Marketing:

Marketing should focus at three levels. The export market creates strong international demand for Indian groundnuts and hence drives the production. We have to first harvest low hanging fruits especially in export trade by proper grading, packing and make sure

the crop is aflatoxin free. There is a need to focus on quality of Groundnut as many importing countries are applying stringent norms regarding quality standards.

Secondly, domestic markets need to function efficiently to benefit small and marginal farmers. The market support immediately after harvest is inadequate and hence farmers are forced to sell their produce to the commission agents/local traders who lend working capital to the small and marginal farmers. Thus farmers are trapped in a interlocked markets hence not able to realise the best price resulting in lower investment on productivity augmenting inputs. Further high volatility in the groundnut price was witnessed in the short run, which need to be addressed through financial support.

Processing:

Government policy of importing cheaper vegetable oil with admissible blending depressed domestic markets of oilseeds leading to area deceleration and un-economical milling of oil. Thus, improving milling efficiency of groundnut oil through introducing 'High Oil' and High Oleic' trait groundnuts is vital in order to enhance the profitability of oil extraction business. For food and confectionery uses, 'High Oleic' trait is a priority trait as it is good for health and benefits the industry as it enhances the shelf-life. Sourcing of best quality raw material suitable for different uses is a challenge. The spoilage of produce during storage, processing and after processing is another bottleneck faced by the processors. Capital inadequacy to modernize the mill is also a burning problem. If the industry fails to uptake the increased production and any collapse of oil industry business will lead to disastrous consequences on production front. Groundnut being a rich legume, its cultivation has plenty of intangible and tangible benefits to the farming community. With the poor performance of oil industries, the benefits from the crop will petered. Unless the farm industry collaboration strategies are developed for improving quality of the produce and value addition the value chain will remain weak and less competitive. Thus, developing a good worthy value chain for groundnut with both backward and forward linkages will boost both farm and non farm economy.

Consumption

The demand for groundnut is derived and normally influenced by the price of groundnut oil prevailing in the wholesale markets. The factors that determine the price of groundnut and groundnut products are also associated with the growers, oil industry, and consumers. Variations in quality of matured groundnut, size of shell, Groundnut content, oil content, marketing cost, marketing methods of fresh groundnut production are also deciding factors for the price received by the groundnut farmers (Sangeetha et al 2017). The groundnut crop has diverse uses and consumption pattern varies across states. The size, shape and maturity of the nuts have more considerations of consumer preference. The bulk of the processed groundnut oil goes to the consumer in filtered form, and only a small portion is refined. The small part of groundnut oil routed through refineries mainly goes through brokers. The channel is refineries-wholesalers-

retailers-consumers. The bulk of the oil, which is only filtered, goes through the brokers-wholesalers-retailers-consumers for sale. The KOF union is also marketing groundnut oil under the flagship brand "SAFAL". It is also the brand leader for AGMARK.

Summary and conclusions

The Biological Diversity Act, 2002 clearly states that commercial utilization of any biological resources through processing and value addition generates incomes to the processors that has to be shared with those who are involved in generating the resource. This sort of incentive to the supplier of raw material is required in order to ensure the study supply of resource to the processors. This study is a modest attempt to analyse groundnut value chain and work out the economics of processing of groundnut into different value added products along the value chain. The ABS Guidelines, 2014, prescribes a modest percentage of 0.1% to 0.5% of (the annual gross ex-factory) sale of product as access and benefit sharing. Thus each quintal of groundnut processing into kernels the ABS works out to be Rs 9.85 to 49. Similarly in case of oil and cake it works out to be 6.6 and 33.4 respectively which needs to be shared with the farmers by the processors. Further, the study highlights the deficiencies/weak points in the chain along with the key challenges and opportunities in developing an efficient and competitive value chain with the participation of producers. Groundnut is playing an important role as oil seed and food crop in providing substantial direct and indirect benefits to the farming community and other stakeholders in the value chain. There is a good potential for developing farmers producers organisation in groundnut crop production and value addition for both domestic and international trade. Hence, the value chain needs to be vertically integrated with backward and forward linkages. Thus strong collaboration among different stakeholders for strengthening groundnut value chain through partnerships focussing on production efficiency, processing, milling and end user needs is vital.

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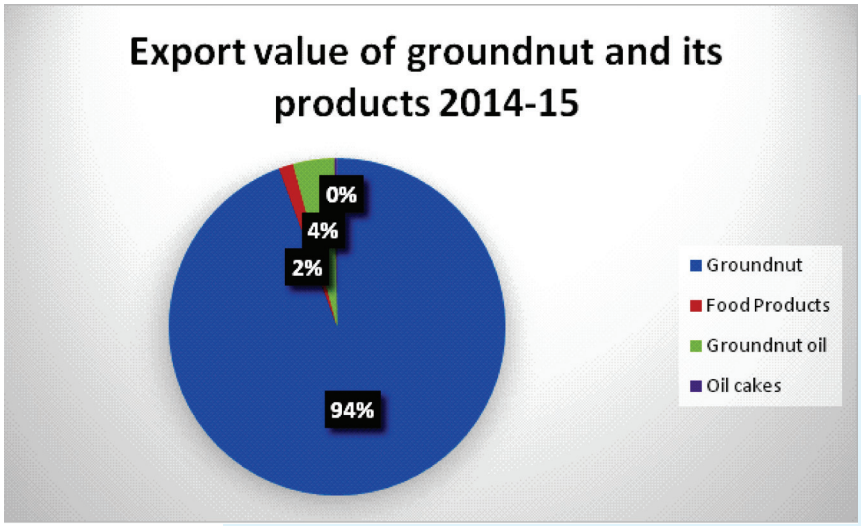
Appendix:

I.



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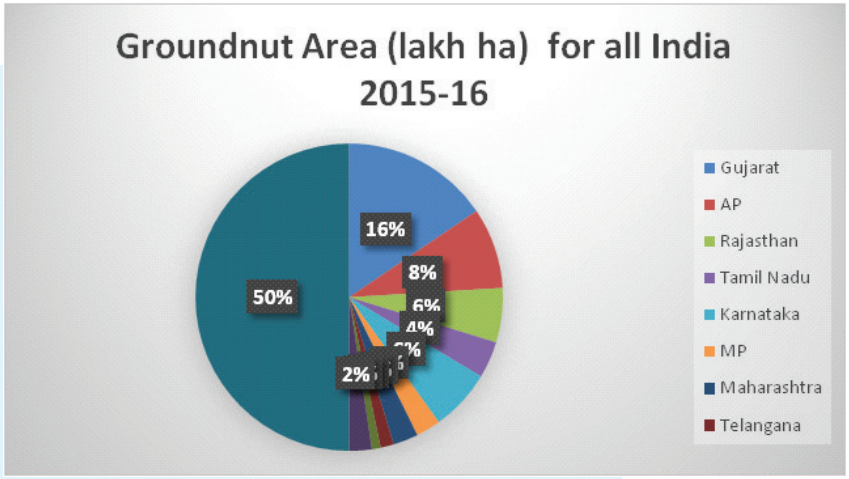

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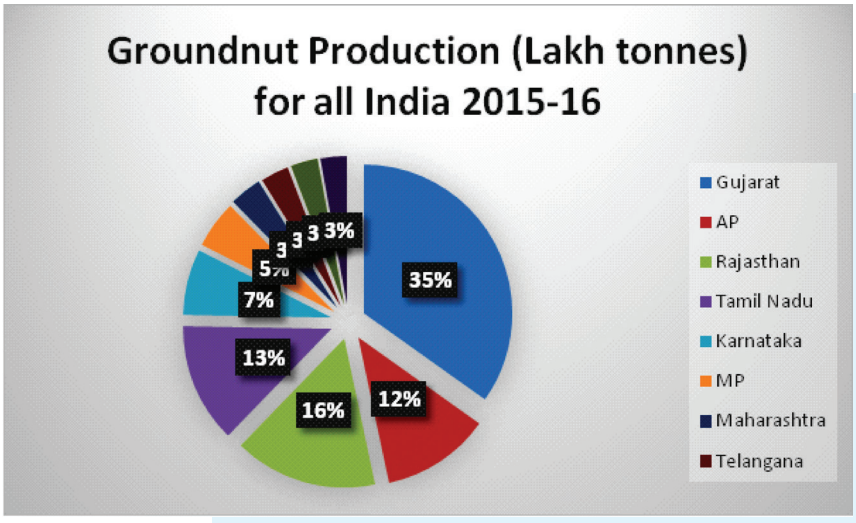


III. Groundnut processing unit at Sira, Tumkur district

IV. Groundnut mono-cropping in the study area

Dr. D. Seenappa

Former Chief Scientific Officer, Inland Fisheries
University of Agricultural Sciences, Bangalore, Karnataka, India
E-mail drdseenappa@gmail.com

Chapter 8

Economic valuation of commercially important food fishes of mangrove wetlands

Introduction:

Wetlands are the unique ecosystems providing diverse bio-resources and are contributing to the environmental protection, livelihood security and economic growth of community and multiple stakeholders involved in the activities. Wetland resources were initially classified as coastal, estuarine (including deltas, tidal marshes, and mangrove swamps), lacustrine (lakes), riverine (along rivers and streams), and palustarine ('marshy' – marshes, swamps and bogs) based on their hydrological, ecological and geological characteristics (Cowardin *et al.,* 1979). But, as per "Ramsar Convention, any area of "marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" are to be considered as wetland. Accordingly, all the natural water bodies (such as rivers, lakes, coastal lagoons, mangroves, peat land, coral reefs) and man-made wetlands (such as ponds, irrigation tanks, open dug-wells, farm ponds, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals) are now regarded as wetlands.

In the country context, the wetland ecosystems are represented by natural inland wetlands that include lakes, ponds, cut-off meander, high altitude wetlands, riverine wetlands, waterlogged areas. The man-made inland wetlands include surface reservoirs and canals, tanks, water logged areas, sewage farms, farm ponds, irrigated fields, sacred groves, gravel pits and such others. The natural coastal wetlands comprise lagoons, creeks, sand beaches, mud flats, salt marsh, mangroves, and coral reefs, and the man-made once are mainly salt pans and aquaculture ponds (Bassi *et al.,* 2014).

Wetland resources

Globally, the areal extent of wetland ecosystems ranges from 917 million hectares (m ha) (Lehner and Döll, 2004) to more than 1275 m ha (Finlayson and Spiers, 1999) with an estimated economic value of about US$15 trillion a year (MEA, 2005). The total number of natural wetlands in the country as per National Wetland Atlas is to the tune of 55,862 numbers. The overall inland wetlands have an estimated water spread area of 7.4 million ha during post monsoon and 4.8 m ha in pre-monsoon. Whereas coastal wetlands accounts for 1.2 m ha and one m ha in post monsoon and pre monsoon, respectively (SAC, 2011). Wetlands associated with floodplains of rivers (floodplain wetlands) cover an estimated area of 3.54 lakh ha and are a common feature of the Indian landscape, especially along the Ganga and Brahmaputra river systems. They also form a major inland fisheries resource in the country.

Mangrove wetlands

Mangroves are regarded as shoreward ecosystems, account for about 4628 km2 (FSI, 2013) representing 0.14% of land area and 3% of the global mangrove area. The resources are functionally linked to neighboring coastal ecosystems and the ecosystem services are globally well documented. Coastal resources such as coral reefs, mangroves and other wetlands are one among the richest store houses of biological diversity and primary productivity. The diversified habitat like core forests, litter-forest floors, mud flats, water bodies (rivers, bays, creeks, etc.), coral reefs and sea grass ecosystems are contributing significantly to the coastal water quality, biodiversity, fish and crustacean nurseries and improving adjacent coastal habitats. These services are supporting livelihoods of communities and contributing to both local and national economies. The mangrove swamps are one of the world's dominant coastal ecosystems and the habitats formed are mainly of saline tolerating mangrove trees and shrubs nurturing bio-resources ranging from brackish water to seawater.

The distribution pattern of mangroves in the country indicates about 60% along the east coast (Bay of Bengal), 27% is along the west coast (Arabian Sea) and the remaining 13% is in Andaman and Nicobar Islands. State of West Bengal has maximum spread (2,097 km2), followed by Gujarat (1103 km2) and Andaman and Nicobar Islands (604 km2). Mangroves are mainly deltaic, backwater-estuarine and insular types. The mangroves of east coast are mainly deltaic and of west coast mainly estuarine. Insular type is commonly found in Andaman and Nicobar Islands.

Wetland resources in Karnataka

The state has an estimated wetland area of about 2.72 million ha, of which inland wetlands cover about 2.54 million ha and coastal wetlands cover 0.18 million ha. The area of 682 wetlands, scattered throughout the state of Karnataka, is about 2718 sq

km (Ramachandra et al, 2005). The coastal area in the state accounts for over 320 kilometers and the area covered by mangroves are limited. Most mangroves are of the fringing type in linear formations and located all along the river or estuarine banks, spread across Swarna-Sita-Kodi, Gangoli, (towards the mouth of Haladi-Chakra-Kollur rivers), Aghanashini and Kali. The mangrove area witnessed a decline from 6000 ha in 1987 to mere 300 ha in 1997 mainly due to conversion of mangrove wet lands for shrimp farming and reclamation for other activities (Ramachandra et al, 2005).

Economic Importance of wetland ecosystem

Ecosystem services of wetlands

Wetland resources are recognized for wide range of ecological goods and services and are regarded as one of the productive ecosystems (Barbier, et.al., 1997 Ghermandi *et al.,* 2008; Wetlands Rules, 2010) with high economic benefits. Besides being rich in bio-diversity also provides multiple services including irrigation, domestic water supply, agriculture, fisheries, water for recreation and tourism, supporting subsistence and livelihood of community (MEA, 2005; Jain *et al.,* 2007, Ramsar Convention on Wetlands and WTO, 2012). The product service mainly includes fuel wood and timber, non-timber forest products, and the regulating services are mainly flood control, storm buffering, erosion control, coastal protection, prevention of salt water intrusion, silt trapping, surface and groundwater improvement (Spaninks and van Beukering, 1997; UNEP, 2006; Teeb, 2010). The other major ecosystem services include carbon sequestration (Kathiresan and Thakur, 2008), pollution abatement viz., nutrient removal, toxics retention (Bystrom *et al.,* 2000; Rai, 2008), water quality improvement and biodiversity maintenance (Turner *et al.,* 2000, Kumar *et al.,* 2013). Recently, Samyuktha Ashok kumar and Zareena Begum Irfan,(2018) reviewed Indian works on mangroves and highlighted the current status of mangrove ecosystem, its direct and indirect benefits, threats that are being witnessed and suggested conservation needs to be linked with active community.

Mangrove wetland- support to fisheries

Mangrove swamps have proven ecological and biophysical links with the coastal ecosystem and constantly support both capture fisheries and ongoing aquaculture production in the region. The habitats formed are mainly of saline tolerating mangrove trees and shrubs nurturing fisheries bio-resources ranging from brackish water to seawater. Similarly, the inland marsh wetlands are directly or indirectly linked to rivers and are playing pivotal role in habitat support for breeding, spawning and nursery grounds to wide range of indigenous and commercial fish species sustaining biodiversity. These water bodies are also supporting wide range of aquaculture activities viz., seed rearing, cage /pen farming.

The life-support functions of mangroves set the framework for sustainable aquaculture in the tropical coastal seascape. The role of mangroves for its richness in detritus, which help in feeding, and serving as favorable habitat for breeding and nursery grounds for the juveniles of many commercially important shrimps and fishes, existence and health of coral reef, support to endangered species by providing habitats and safety from predators are well recognized. These services are crucial for the sustainability of aquaculture systems.

Impact of policy gaps on management and conservation of wetlands

Despite wide range of ecological and economic benefits, and potential as natural capital capable of producing a wide range of goods and services for coastal environments and livelihood support to communities and society as a whole, both management and conservation of wetlands have not received adequate attention in the national water sector agenda. As a result, many of the wetlands are subject to anthropogenic pressures, including land use changes in the catchment, pollution from industry and households, encroachments for alternative activities including agriculture, tourism etc. Smaller wetlands in urban and rural areas which perform important socio-ecological functions are under severe threat. This has warranted for institutional and policy interventions.

Need for economic valuation

Although the qualitative beneficiary contribution of this unique ecosystem is well documented, quantitative aspects based on scientific studies are very much lacking. Estimation of economic value of wetland ecosystem will help in determining the realistic benefits, which should be shared by the providers or local communities. Hence, economic valuation is needed for wide range of fishery bio-resources from different aquatic ecosystems that are presently in use for production of fish and value added products and those having potential to bring under the purview of the ABS.

The paper focuses mainly on economic valuation of commercially important food fishes from mangrove wetland ecosystem and briefs on (i) review of approaches/ methodologies adopted by various workers for estimating value of ecosystem services in section one, and highlight their study findings; section two briefs on commercially important bio-resources (fish and shellfish) of mangrove wetland that have potential for value chain and highlights existing harvesting and marketing practices. Attempt is made to estimate the returns accrued from commercial utilization of mangrove bio-resource (white prawn value chain) that has export demand and market label as wild caught for establishing Access and Benefit Sharing Provisions. The details are briefed in section three. Final section briefs on observations, limitations, and strategies for development of these productive ecosystems from the view point of ABS, and suggestions for way forward. The terminology of fish includes both fish and shell fishes.

Economic valuation of mangroves

Global scenario

Mangroves associated fisheries and aquaculture have worldwide importance in providing subsistence food and income as well as commercial benefits for a wide range of stakeholders including poor and marginalized fishermen communities to commercial aquaculture. These wetlands also play a vital role in the interconnected nature of coastal ecosystems (such as coral reefs, ornamental fishes, several invertebrates of ornamental to pharmaceutical values, mangrove forests and sea grasses) which provide joint benefits to small fishers or major companies and contribute to the economy at varied levels. Several marine species use mangroves as nursery grounds and are supporting capture fisheries and aquaculture.

Estimation of the real value of mangrove bio-resources will help in determining the realistic benefits, which should be shared by the providers or local communities and provide policy makers with necessary economic information for the development of efficient and effective strategies for sustainable marine and coastal ecosystem management. Recognizing the wide range of direct and indirect benefits offered by mangrove wetlands, economic valuation using several study methodologies have been attempted by different workers. The study approaches include relating the role of mangroves as habitat for breeding and nursery grounds for several species of fish and shell fish, marine food chains and protection to coastal areas (Barbier and Strand, 1997; Kripa *et al.,* 2011); establishing correlation between offshore fishery yields and extent of mangroves as nursery area (Pauly and Ingles,1986; Sathirathai and Barbier,2001 and Khaleel 2009); estimation of direct use (by local communities) and indirect use value (off-shore fishery linkages and coastline protection) (Sathirathai, 2003); Contingent valuation method (CVM) with an open ended approach (Gunawardena and Rowan, 2005); Value Transfer System(VTS) (Brander *et al.,* 2012); stakeholders Willingness To Pay (WTP) for management practices and fishermen WTP for alternative clam fishing management practices (Nunes et al., 2004); Choice Experiment Approaches (CEA) for willingness to pay for ecosystem services, conservation etc (Jacobsen *et al.,* 2012); estimation of Total Economic Value (TEV) of mangrove ecosystem goods and services based on use values and non use values (Barbier, 1994) and such others.

Indian studies on economic valuation of mangroves

The studies were mainly related to estimation of direct and indirect use value by local communities based on Total Use Value (TUV) approach (Hirway and Goswamy, 2007); Contingent valuation method for willingness to pay by households for mangrove restoration (Stone et al. 2008; DebRoy and Jayaram, 2012), direct use values of fishery contribution and ecotourism values (DebRoy *et al.,* 2012) and such others.

Studies assessing the economic values of human-made wetlands are limited. A study by Ramachandra et al., (2005) assessed the value of fish catch harvest from tank wet lands using Total Valuation method. The array of valuation methods used in the primary studies to assess wetland values include market-based methods, revealed preference methods, and stated preference methods. In the variable valuation methods approaches of contingent valuation, hedonic pricing, travel cost method, replacement cost, net factor income, production function, market price, operational cost etc were used (Ghermandi et.al, 2010).

Highlights of global Studies

- Mangroves and fisheries are generally interconnected and mangroves serve as breeding and nursery grounds for several species of fish and shell fishes contributing for enhancement of both resource productivity and community benefits. Annual revenue loss of US$ 278,704 was estimated due to mangrove deforestation in Mexico between 1980 and 1990 (Barbier and Strand, 1997).
- Productivity of marine fisheries is closely associated with the health of adjoining mangroves. A positive correlation between offshore fishery yields and extent of mangroves was established in the nursery area. Mangrove dependent shrimp yield was estimated in the range of 756 kg/ha in Thailand (Mastaller, 1996), and 500 kg/ha in Vietnam (De Graaf and Xuan, 1997).
- Annual market value of capture fisheries supported by mangroves was estimated in the range between US$ 750-16,750/ha based on ecological and biophysical links of mangroves (Ronnback, 1999). Similarly, for crustaceans (penaeid shrimp, sergestid shrimps and mangrove mud crab), fish and mollusks that use mangroves as habitat, the annual market value of fisheries per hectare mangrove ranges was estimated to vary from US$ 750 to 11 280. If discarded catch in shrimp fisheries and other trawl fisheries subsidized by the penaeid fishery are included, the marketed value of fisheries dependent on mangroves ranges from US$850 to 16 750/ha per year.
- Positive relationship between near shore yields of fish and mangrove area based on the studies from Philippines, Indonesia, Malaysia and Australia (Primavera, 2000).
- Reported fin fish productivity of 550 kg/ha (Gedney *et al.* 1982); shrimp productivity of 130 kg /ha/year (Kapetsky, 1985) and 350 kg /ha/year (Pauly and Ingles,1986) in mangroves.
- Economic value of mangroves in Thailand estimated based on direct use by local communities and indirect use value (off-shore fishery linkages and coastline protection) was in the range between US$ 81.6 to US$ 4092.

- Mangrove related fish and crab species account for 32 per cent of the small scale fisheries landing in California. The annual economic value of fisheries was US$ 37,500/ha of mangrove fringe (Aburto-Oropeza *et al.* 2008).
- Net Present Value (NPV) of mangroves as breeding and nursery habitat in support of fisheries was estimated in the range between US$ 708 to US$ 987/ha and the storm protection service was US$ 8,966 to US$ 10,821 (Barbier *et al.* 2011).
- Estimated total value of mangrove resource in Indonesia was US$ 6,049/ha/year and capture fishery accounted about 98 per cent to the total value of mangrove usage rate and the rest by forest wood (Tantu *et al.* 2012)
- Estimated value based on 'Willing to pay' to protect and use mangrove swamps indefinitely by both direct and indirect users was between US$ 1 million and 1.26 million/year (Naylor and Drew,1998)
- Total Economic Value of Rekawa mangrove ecosystem in Sri Lanka was estimated at US$ 1,088/ha/year, annual net value of mangrove lagoon fisheries was estimated at US$ 268/ha/year, and total value of coastal mangrove dependent coastal fishery was US$ 754/ha/year (Gunawardena and Rowan, 2005). Further they opined that conversion of mangroves to shrimp ponds led to a significant loss in the traditional livelihood practices.
- Average mangrove value in South East Asia was estimated at US$ 4,185/ha/annum (Brander *et al.* 2012)
- WTP for improved clam fishing practices in Venice Lagoon in Venice, Italy was estimated in the range between € 1.005 and € 2.456. (Nunes *et al.* 2004)
- Under estimation of total value of mangrove ecosystem has resulted in the widespread loss and degradation of mangrove ecosystems in Philippines (Gilbert and Janssen, 1998; Aburto-Oropeza *et al.* 2008)

Highlights Indian Studies

- Direct and indirect use value (based on 2003 prices) of mangroves in Gujarat were estimated at Rs. 1,603 million/year and Rs.2,858 million/year respectively. The total use value (direct and indirect) of mangroves was estimated at Rs.7,731.3 million/year (Hirway and Goswamy, 2007; Saravanakumar et al,. 2009; Hussain and Badola, 2010; Kavi Kumar *et al.,*2016).
- Reported higher income to the local communities (US$ 44.61/ha) in areas of good mangrove vegetation than in those without mangroves (US$ 2.62/ha) (Hussain and Badola,2010).

- Annual mean willingness to pay for mangrove restoration by user groups in West coast of India was Rs. 626/ year for rice farmers while it was Rs. 342 and Rs.395/year for fishermen and fisherwomen respectively.
- Annual mangrove benefits based on household willingness to pay was Rs. 5 million and the benefit cost ratio was 3.48.(Stone *et al.,* 2008)
- Villagers were willing to pay Rs. 13/person/year for the conservation of mangroves in the Island of Tamil Nadu (Deb Roy and Jayaram,2012)
- Direct use values of fishery and ecotourism were estimated to be Rs.16.5 million for 1,110 ha of Pichavaram mangroves, Tamil nadu (Rs.14,932/ha). The WTP obtained through CVM was Rs.1,05,185 and the total economic value was Rs. 3,535 million (Deb Roy *et al.,* 2012)
- Total Economic Value (TEV) of mangrove ecosystem of Kerala state was estimate at Rs. 1,17,947 million and was 0.14 per cent of the GSDP (Hema,2013). Contributed fish catch of 9354 kg/year/fishing unit (Etroplus shrimp, crab and Tilapia) valued at Rs.1,50,165/year
- Significant contribution of mangroves (1.86 tons/ha/year) to the enhancement of fish production in the coastal states of India, which translates into 23% contribution of mangroves to commercial marine fisheries output in India (Anneboina and Kavi Kumar, 2017)
- Rapid decline of 40% mangrove area in the country due to agriculture, aquaculture, tourism, urban development and over-exploitation during the last century (Sahu *et al.,*2015)

Fishery bio-resources of mangrove wetlands

Mangrove ecosystems inhabit diverse groups of aquatic and terrestrial organisms. The mangrove swamps are generally rich in detritus and highly suitable ecosystem for range of bio-resources viz., fish, crustaceans, mollusk, sea grass, coral reefs and such others that form main basis of artisanal and commercial fisheries. Fishes are the major groups that dominate the daily catch of fishers. The other large scale fishery activity includes shrimps, shell fishes and crabs. Majority of commercially important marine fish species are mangrove dependent and the total marine fish catch is significantly influenced by the extent of adjoining mangroves. The fish species richness has been reported to be as high as 200 species in mangrove-dominated estuaries and embankments in Australia and India (Robertson and Blaber, 1992).

In India approximately 60% of the commercially important coastal fish species are directly associated with mangrove environments and the contribution of mangrove-related species to total fisheries catch are significant (Rajendra, 1991). Mangrove ecosystems are favorable environments for a number of economically important species and is conducive environment for crustacean (crabs and shrimps) since it is shallow, rich in silt and nutrients. Capture fisheries production is believed to constitute the major value of marketed products from an unexploited mangrove apart from supporting commercial, recreational and subsistence fisheries in India (Untawale, 1986). Commercially important species inhabiting muddy bottom of mangrove estuaries, as well as coastal brackish water are highlighted in Table-1

Table-1 commercially important species

Sl. No.	Fauna*	No. of Spp
1	Fin fishes: Important brackish water species viz., Sea bass, milkfish, mullets, pearl spot, tilapia, sand whiting, grouper, sea breams, red snappers, Mud skippers, catfishes, pomfrets, croakers, barramundi, *Polynemus, Sciaena, Setipinna, Pangasium, Hilsa, Ilisha and such others*	543
2	Tiger prawn, white prawn, *Metapenaeus dobsoni,* small shrimp *Acetes spp.,* freshwater prawn in the upstream regions, mud lobster	55
3	Crabs *Scylla serrata,* Stomatopods	138
4	Mollusks - bivalves and gastropods, mussels, edible oysters and clams	305
5	Other invertebrates-snails squids, cuttlefish and octopus	745
6	Sea grass vegetation	11

* Major constituents of this group in mangrove wetland of India are 105 species of fishes, 20 species of shellfishes and more than 225 species of crustaceans (Ref.: Kaladharan et al.2005; Singh et al., 2012;Sahu et al.,2015).

Mangrove estuarine areas support mollusk fisheries to a larger extent and are supporting community livelihood during non-fishing seasons also. Edible species of oysters, mussels, clams and gastropods are collected extensively for local consumption, usually by the families of local fishermen. Mangrove swamps and other low-lying areas along the estuaries are generally preferred for brackish water fish farming. Land based pond farming of fish and crustaceans in mangrove areas have a long tradition in the country and the species cultivated are *Liza parsia, L. tade, Mugil cephalus, Chanos chanos, Penaeus monodon*. In recent decades, aquaculture activities have intensified dramatically in mangrove wetlands, particularly for high-value crops dominated by vannamei shrimp.

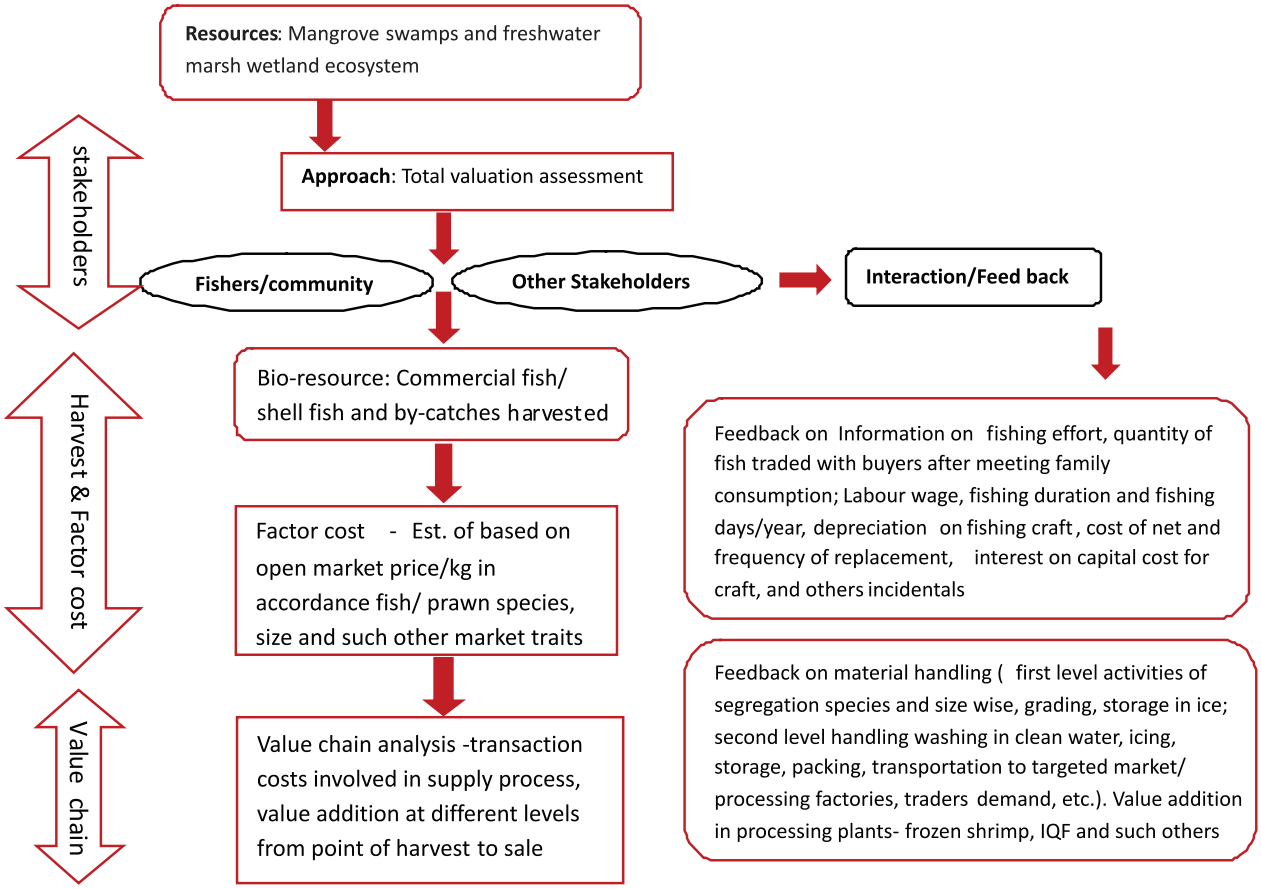
Fishing and marketing practices

Fisheries activities in mangroves are generally traditional in nature, and the livelihoods of fishers are invariably depending on the output of fishing on day to day basis. The fishers generally live within the catchment of mangroves in coastal hamlets and take up fishing as a major profession. The fishing operation mainly depends on the tidal influxes, and traditionally activities are focused during early morning hours. In the west coast mangroves, locally made country boats or dugout canoes of size <8-12 m are used as major craft for reaching the fishing sites and to bring the harvested catch. Fishing operations generally last for 6-8 hrs. /day and fishing is done for 6 days a week during fishing season. Nylon fishing net (gill nets) of varied sizes depending on fish species and location of fishing are in common usage. Use of cast net, seine nets, special crab nets and hooks, fish traps are also in practice. The nets are replaced once in 2-3 months during the fishing season that generally last for 6-8 months. Usually one or two fishers/boat take part in fishing operation and generally men fishers take active participation in fishing and fisherwomen in marketing. During the lean season they take up secondary activities of shell mining, agriculture labour, fish marketing, dry fish making and such others depending on the opportunities. The produce is marketed either locally if the quantity is small or through fish marketing centres.

Methodology

The scope of present effort has been limited to mapping of ongoing fisheries activities and economic valuation of commercial fish and shell fish harvested by individual fishers from the mangrove wetlands of coastal Karnataka. By-catch harvested as incidental during fishing operation is also included for valuation. For valuing the direct benefits, market price-based approach was employed and purchase price offered by primary buyers at the first point sale (generally resource site/landing spots or landing centers) is used for estimation of total sale value. The price varied in accordance to fish/prawn species, size and such other market traits apart from market demands and supply (Willingness to pay by buyer) and is mainly location specific. The cost computation is realistic as it mainly represents the actual/real trade value of bio-resource on site. The valuation of benefits has been restricted to estimated average annual production output of fishers that are visible and tangible products coming out from the ecosystem. In the case of fish and shellfish which were used for household consumption, the prevailing price at consumer market price was used. Income from the activity is estimated based on factor cost that includes viz., labour wage, fishing duration and fishing days/year, depreciation on fishing craft, interest on capital cost for craft and other incidentals. The flow chart of methodology is given in **(Fig.1)**

Fig.1



White Prawn *(Penaeus indicus)*

Value chain of white prawn

Value chain is often defined as sequence of value adding activities, from production till consumption, through processing and commercialization. The prevailing fisheries activities going-on in mangrove wetlands are generally focused towards domestic markets and the value chain for the produce is not well organized. The reasons include inter alia, small quantity harvest by individuals/day, uncertainty of catch and species composition, difficulties of ensuring continued supply to processors/exporters involved in the value

chain. These factors have been constraining towards the establishment of an efficient value chains in this segment. Only high value species of fish, prawn and mud crab harvested from mangrove wetlands finds channels of value addition and exports / high end domestic markets.

For the study, white prawn harvested from mangrove swamps is selected as it has demand of both international market and high end domestic markets and hence generally enters into value chain. The focus of present efforts are mainly to (i) document the prevailing value chain for white prawn a bio-resource of mangrove wetlands that is being exported, (ii) analyze and estimate the likely monitory benefits to be realized at different levels of chain keeping in view the ABS concepts, and (iii) assess the benefit sharing mechanism in order to protect/conserve bio-resource and also plow back certain share of profit to community in recognition of their service to ecosystem.

The economic benefit in the value chain was analyzed based on feedback from stakeholders involved in the process till the frozen prawn is exported for international consumption. It covers supply process, value addition at different levels from the point of harvest viz., on board handling (species and size wise segregation and grading, storage in ice box with ice); operations at landing spots/centers that include segregation, grading, washing in clean water by fishers/buyer after purchasing, icing, storage, packing; transportation by public / private / exclusive vehicles (including refrigerated / insulated vehicle) depending on distance to processing plant/market destination, processors/ exporters demand etc.).

Limitation of methodology

- Biological resources of mangrove wetland are mainly fish and shell fishes and though has market demand, they are imperfect and experience market distortions/ failures. The very perishable nature of raw material is a major concern and in most instances warrant for quick disposal irrespective of its true value.
- Bio-resources are output from water bodies that are with common property rights, multiple ownership and experience several uncertainties.

Study results and findings

Economics of production and harvesting of fishes in wetland ecosystem

The cost incurred towards production of fish and its harvesting includes operational and fixed costs. The fixed cost include cost of boat (fixed cost) that vary depending on size, material and region (Rs.15,000-30,000) and operational cost viz., nets (Rs. 9000-10,000), labour (1.3-1.4 lakh), ice (Rs.1500-2000), repair and maintenance expenses (Rs.1500-2000), including miscellaneous expenses. Interest on fixed and operational cost was calculated at @12%/ year and also the depreciation cost for the fixed asset (Table-2). Indicative cost and returns has been worked out based on feedback from fishers

and technical service providers working at different levels of supply/value chain. Out of the total annual operational cost of fishing unit that worked out to Rs. 171,880/fishing unit/year, the major share of expenditure was accounted for labour (79%), followed by interest on both operational (10.4%) and fixed cost (1.6%) respectively. The cost for replacement of net accounted for 5.5% of total expenditure incurred. Though labour component is the major cost in the fishing activity, the benefits will be shared within family, as activity is mainly carried out by fisher and his family members. The expenses incurred towards use of ice, maintenance and other miscellaneous are insignificant. Generally fishers harvest about 5-7 kgs. of fish and shell fish/day apart from significant quantity of miscellaneous by-catch that contribute about 30% in total sale value. The average net return/fishing unit is estimated at Rs. 20,611/year and with implicit cost of own labour, the estimated return is Rs. 156,611/year supporting family financial requirement (Table-2).

Shrimp account for about 25% share in the total harvest and in value terms nearly 35%. The estimated production of shrimp/year/fishing unit works out 255kg with a value of over Rs. 48,450 at the first point sale benefiting fish farmer.

Table-2. Economics of fish and shell fish production* from mangrove wetlands

Components	Av. operational cost (Rs.)	% share to total expenditure
Fishing net (Rs/yr.)	9500	5.5
Labour @Rs.400/day for 170 daysx2	136000	79.0
Ice	1750	1.1
Maintenance and other miscellaneous expenses	1750	1.1
Total operational cost	149000	86.7
Interest on operational cost @12%	17880	10.4
Interest on ** Fixed cost @12%	2750	1.6
Depreciation cost on boat (@12%/year)	2250	1.3
Total Expenditure/year	171880	100

* Virtually there is no production cost, it is only harvesting/ fishing cost.

** Fixed cost (cost of boat, Rs.15000-30000)

Catch composition details	Av.Quantity (kg)/day	Av.sale price/ kg(in Rs.)	Total Revenue/ fishing day (in Rs.)
Etroplus	1.8	160	288
Tilapia	1.9	60	114
Milk fish	0.3	230	69
shrimp	1.5	200	300
Crab	0.4	250	100
Total	5.9		871
Other Misc. species including collection of clams, shell mining etc. (30% contribution to total revenue/day)			261
Overall Total			1132
Gross returns/fishing season			192491
Total expenditure			1,71880
Net returns			20611
implicit cost of own labour			156611

Supply chain

Generally supply chain is defined by the nature of catch (species caught, quantity of catch and size of the catch and seasonality), kind of gears used and ultimately their bargaining power with the middlemen. Traditional fishers use country crafts for coastal fishery and operate at short range from the coast (within 5 kms) and having altogether different supply chain. Country crafts normally cater to low and average value segment and sell their produce to the local markets. Fishers mainly meet their family consumption and dispose surplus to market for trading at different levels of marketing chain. The stakeholders of supply-value chain in natural resource based fisheries are minimal and generally include fishers, local venders, traders, retailers or wholesalers. Excepting for shrimp, crab and high value fishes, the involvement of processors, product developers, companies etc. are very limited. Unlike other specialized high value agricultural commodities, in case of fisheries, the value chain is highly fragmented.

In small scale fisheries, the sale points are mainly direct market at point of resource, local market, and direct supply to fish vendors / retailers / whole sellers. The harvest fish is marketed in fresh form right from first point of sale which is generally the landing spot/ centre close to the water bodies to the terminal market. The point-to- point margins of trade range between 5-30% of procurement value. The logistic cost generally varies from 5-10% depending on the distance from point of procurement to sale outlets. Wherever the material moves outside state, the margins between procurement and last

point sale price will be more than 40-50% as it has to make good the transportation cost, ice, handling cost etc.

While for shrimp, the produce is targeted for high end market and hence is segregated from the general harvest, handled separately for supplying to agent/aggregators of processors or exporters for meeting the demands of export market.

Value chain

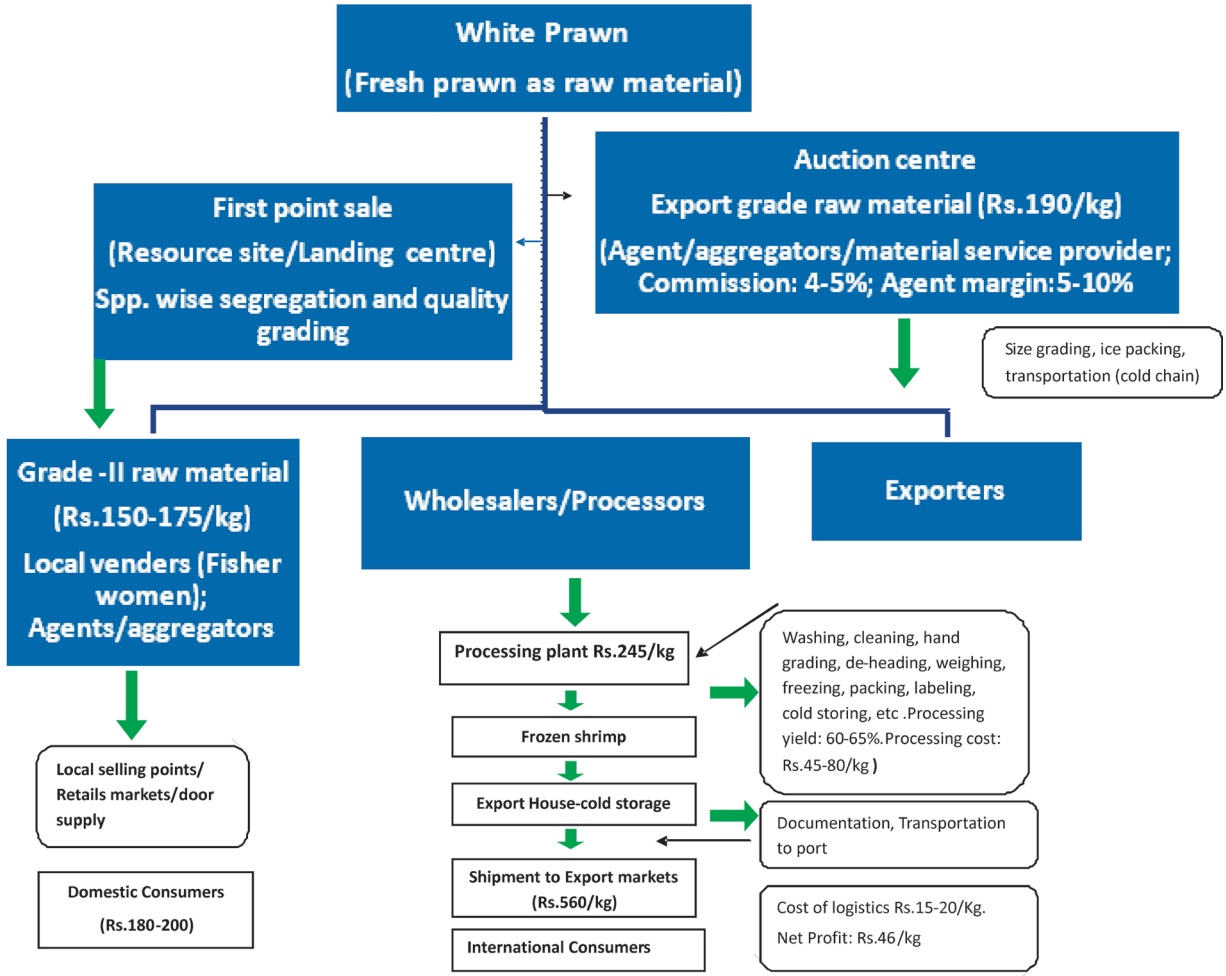
In the context of shrimp value chain, the key stakeholders involved includes fishers, auctioning agents; aggregators/material procurement and supply agents; wholesalers, service providers viz., ice manufacturers, transport and other logistic service providers; processors; exporters, importers and consumers. The primary activities of production are limited to fishing/harvesting, handling and catch segregation. The cost involved is mainly family /hired labor, depreciation on craft and gears. Generally, the catch composition of mangrove wetlands includes fish, shrimp, crabs and mollusks and after harvest, it is segregated at the first point of landing /landing centre by the fisher in accordance to variety and size. The cost for secondary level of activities includes mainly ice and transport logistics for moving commodity from landing centre to auctioning point/market for further distribution if the distance is long. Fish and shell fish being highly perishable, it has to be handled hygienically and stored in low temperature. The fishers will be compelled to dispose of the produce at the earliest due to limitations of infrastructure for handling and cold storage at landing centers. In the absence of defined demand and price, the marketing of produce is highly dynamic and will vary on a day to day basis. Hence depending on the quantity harvested and the price offered, they will be sold on-site to retailers (invariably to fisher women who are into trading at local markets) or will be manually carried/transported to nearby centralized fish auction centre (with/without ice depending on the distance) for marketing purpose when the harvested quantity is substantial. This forms the second level of activities in the value chain.

The mangrove wetlands being natural resource with multiple activities and stakeholders, uncertainty in terms of species composition and quantity prevails and is driven by season, fishing locations, intensity of activities by other fishers and such other factors. As the produce is from nature caught, it enjoys niche demand in the international market. Further, production from aquaculture for this species is also limited and hence as such there is no much competition from the aqua farming side for the produce. The players at auctioning point are mainly agents/ aggregators/ representatives of wholesalers/ processors/ companies/exporters etc. They participate in the auction and bid for the produce. The handling and commission charges generally vary from 4-6% of bid value depending up on the quantity, payment arrangement and such others. Generally the aggregators/ agents will have 5-10% profit margins for the service delivered by way of procuring material and supply for the next level of value addition at processors level.

The logistic cost includes icing at point of procurement of raw material, transportation, handling, labour etc from auctioning/landing centre point to processing plant. This will be generally met by the processor as per agreed terms with agent/material service provider. Depending on the quantity for processing, technical requirement of importer, meeting compliance to international food safety standards and certifications etc, the product processing will be carried out by exporters either in their own infrastructure/outsourced to approved processing plants on job contract with agreed terms and conditions.

The general protocol of processing includes washing, cleaning, hand grading, de-heading, weighing, freezing, packing, labeling, storing in cold storage, documentation and transportation to port under cold chain etc. The general export demand for the white prawn is for headless style and the recovery from whole prawn to headless is about 60-65%. The export rates are quoted based on counts (number of pieces/kg) and the general demand is for size grade of 70-120 nos./kg. The processing cost varies from Rs. 45-80/kg material depending on the volume of material processed and the scale of processing plants employed for frozen shrimp. The average net profit margin to exporter is estimated at Rs. 46/kg. The process flow chart for the white prawn value chain is given in Fig.2

Fig.2



Extent of value addition

Generally, value addition to harvested prawn takes place at three stages. The first level of value addition happens at the first point of sale near the mangrove/landing point/ landing centre by way of species segregation, separating good quality prawn in terms of size, freshness etc. The second level mainly for size grading as per the requirement of processors and ice packing takes place at the auction centers by the aggregator/material service provider. The final value addition happen at the processor plant before the raw material is used for final freezing.

The share of different stakeholders in gross returns indicate major benefit to of 57% to fishers, followed by exporter 13.7%, agent/material supplier 9% and commission agent 4.5%. With regard to operational cost, processing cost has major share of 13.4% followed by handling cost 3% (ice, transportation, labour and other miscellaneous).

ABS from shrimp value chain

Benefit sharing is generally based on fixation of a percentage of gross sales of products. According to the Biological Diversity Act, 2002, a modest percentage of 0.1% to 0.5% of (the annual gross ex-factory) sale of product is recommended as ABS. Thus for each Kg of white prawn processed and exported the ABS works out to Rs. 4.6 to Rs.23 which needs to be shared with the farmers by the processors **(Table-3).**

Table-3: Economic analysis of shrimp value chain (in Rs.)

Sl. No.	Particulars	Av. cost/100kg. (in Rs)	Per cent share in gross returns	Remarks
1	Price at first point sale (Fishers point)	19000	57.0	Segregation and First level grading
	Transportation cost and Commission agent cost	1500	4.5	@4-5%. Commission cost; 3.4% transportation cost.
2	Price at Auction centre	20500		
3	Supply price by agent/ material supplier	23500	9.0	2nd level size grading, margin of 8-10%
4	Handling cost	1000	3.0	Including logistic (Ice, labour transportation, other Misc.)
5	Price at processing site	24500		Nearly 29% of additional cost from resource point price
6	Processing cost	4500	13.4	
7	Total cost	29000		Nearly 53% of additional cost from resource point price
8	Product yield (%)	60		

9	Product output (Frozen shrimp) (Kg)	60		
10	Product selling cost (90-110 count)/kg	560		Nearly 77% additional cost from resource point for value addition as Headless frozen shrimp for export market.
11	Gross Return	33600		
12	Net margin to exporter	4600	13.7	
13	Net margin/kg to processor	46		
14	Cost to return ratio	1.16		
15	ABS share @ 0.1%/kg	4.6		
16	ABS share @ 0.5%/kg	23.0		

Key challenges in supply –value chain

Fisheries activities in mangrove wetlands is under open access regimes and fishing is an essential part of the livelihood strategies for fisher communities identified and associated with these ecosystems. Traditionally, fishers are the major stakeholder at the resource level. Local fisher communities residing in the catchment over generation are mainly into the fishing activities and are field level custodian of resources. By virtue of their long involvement in the activity and the awareness on ecosystem, family knowledge flow over generation etc., the local communities are the key providers of bio-resources.

Mangrove wetlands being predominantly common property resource with multiple stakeholders' participation for diversified benefits and expectations, the per capita fish harvest depends on the fishing intensity and the very productivity of water body. Hence uncertainty in day –to- day fish catch is one of the major challenges to ensure regular supply of prawn to the traders.

Resource productivity as a challenge for production

The harvest of fish depends primarily on biological productivity of mangrove wetlands. Being open water body, resources is prone for vagaries of nature, climate change, marine and coastal pollution, several anthropological stresses viz., deforestation, habitat fragmentation, siltation, sedimentation and such other. Damage to breeding and nursery grounds of fish and shell fish that form important fishery resource is a major constraint. In the absence of stock enhancement through ranching programs, the fishery production is predominantly depends on the natural recruitment and is governed by the quality of ecosystem in terms of abiotic and biotic parameters of water bodies.

The catch composition of daily harvest indicated share of about 30% small and low value fish that is being disposed at the resource site for low price. This is one of the

major concern and an opportunity to explore product development by taking up solar drying and development of dry fish. Presence of ornamental fish in the by-catch could also be explored for marketing prospectus.

Fishing net account for 5.5% of operational cost and fishers could be mainstreamed to the on-going supportive schemes of NFDB to reduce his financial burden. Similarly for support of fishing boat, and these two interventions are expected to minimize operational cost and enhance fisher's net return from the activity.

Challenges of Marketing

The white prawn is mainly processed for meeting export market needs and high end domestic requirement. Maintaining freshness and quality is the key in the entire value chain from point of harvest to final destination till it reach consumers. Prawn being highly perishable produce, focus needs to be on hygienic post harvest handling right on board of boat, at landing centre and auctioning hall by proper segregation, grading, use of quality ice, holding material in plastic crates, and transportation in cold chain system (insulated/ refrigerated containers) throughout the value chain is one of the major challenge to ensure export market.

Challenges of Processing

Meeting quality processing standards of international markets is a challenge in shrimp exports and starts with sourcing of best quality raw material suitable for processing. Avoiding contaminations, retaining freshness, complying food safety standards of importing countries, HACCP certification, traceability, free from antibiotics, green certifications and such others continued to be major challenges for the processors and exporters to remain in the business. Utilization of processing plants to its designed capacity is another major challenge witnessed due to shortage of raw material supply on a continued basis. The high operational and overhead costs, competition from smaller processing plants who are carrying out job works on contract basis for reduced price etc are the other constraints limiting capacity utilization of bigger plants. The volatile nature of business, competition from other shrimp producing countries, fluctuations in prices, changing currency values, rampant disease out breaks devastating the entire crop cycle, unforeseen natural calamities in coastal areas damaging production infrastructure and activities are the major threats that affect functioning of processing plants and the associated value chain business globally. Prawn being an internationally traded commodity, is subjected to global competition and changed consumer behavior resulting in high market risks.

Challenges of Consumption

The white prawn is mainly exported to various countries in frozen format and the supply is made in blocks of different weight. Various styles of material viz., head less and shell on, peeled and deveined, Butterfly, Individual Quick Frozen (IQF) etc are exported

as per the requirements of importing countries. The new trend of consumer is towards smaller sized prawn and preference for wild caught as they will be free from chemicals and drugs that are generally used in aquaculture. In this context, the white prawn caught from mangrove wetlands have higher consumer demand. But the challenge lies in consolidation of catches from different harvesting points, maintaining hygienic handling of raw material in the entire value chain from harvest to consumer point and meeting the changing consumer's need of importing countries.

Strategies to improve value chains

Enhancing resource productivity

Mapping of breeding and nursery grounds of white prawn and other valuable bio-resources need to be carried out to develop action plan for protection. Promotion of GMP to prevent likely damage to brood stock, avoiding fishing during breeding season, declaring no fishing zone, mesh size regulation and such other conservation measures in support of nurturing better fishery in the resource are to be planned collectively and implemented under the community management platform. The ongoing supportive programs of fisheries development institutions could be converged and integrated on a broader institutional frame with appropriate monitoring systems to instill accountability and performance efficiency. Capacity building efforts are needed to prepare fishers and their local institutions for better management of resource and efficient functioning of production supply chain.

Raw material handling, processing and marketing

Prawn being highly susceptible for spoilage, hygienic handling and maintenance of cold chain in the entire value chain is the key. Chill-killing of prawn immediately after harvest is the new concept being promoted by the processers/exporters to maintain high quality of produce by way of offering premium price to fishers. There is need to educate and skill farmers and other stakeholders involved in the process of handling on the new developments in handling and processing, facilitate small and marginal fishers who are in the activity to adopt good management practices in post harvest handling and facilitate exporters to comply the stringent quality standards/norms of the importing countries. The fishers in the activity could be mainstreamed to the benefits of on-going schemes for purchase of ice box and plastic crates, and also for availing institutional finance support to upgrade the infrastructure. Further, this will also facilitate minimizing operational cost and enhance profit margins of fishers. The better quality of produce will ensure demand and high price for the prawn apart from minimizing exploitation by market intermediaries (commission agents/local traders/ aggregators) who generally advance money and in bargain purchase material at lower price.

Promotion of domestic market for prawn is another alternative strategy to minimize export market risk and country is making efforts in this direction. In this context, for an efficient value chain, addressing issues of backward and forward linkages need constant attention of all the stakeholders involved in the chain.

Observations

Access to Resource

Fisheries activities in mangrove wetlands is under open access regimes and fishing is an essential part of the livelihood strategies for fisher communities identified and associated with these ecosystems. Traditionally, fishers are the major stakeholder at the resource level. Local fisher communities residing in the catchment over generation are mainly into the fishing activities and are field level custodian of resources. By virtue of their long involvement in the activity and the awareness on ecosystem, family knowledge flow over generation etc., the local communities are the key providers of bio-resources.

Indigenous Technical knowledge (ITKs)

Harvesting different genetic materials including indigenous edible and ornamental fish and shell fish are being pursued with the help of their unique traditional knowledge on their use and are being sold to prospectors. Secondary fishing activities such as fish retailing or processing (dry fish production etc) and such others are being pursued mainly by the housewives of fishers contributing to family income.

General observations

- Maximum willingness to pay for bio-resources by the user at their collection point will reveal their possible 'real value'. But is not being witnessed as the fishery produce of mangrove wetlands are mainly targeted for human consumption despite some of the bio-resource having nutraceutical values.
- Efforts on valuation of fishery bio-resources by relating to economic activities are very minimal and scientific documentation are lacking. Hence sharing of benefits under ABS provisions for development of targeted bio-resource and community will be far from reality.
- There is lack of awareness on the part of fishers involved in the activities both on economic value of his produce at consumer point and also demands & supply for the material.
- Mechanism for fixing minimum supportive prices for the wide range of bio-resource harvested from these ecosystems either at national/ regional/ state/ local levels are lacking. This has limited the bargaining power of community in getting remunerative/realistic prices for the produce and resulted in exploitation by the traders
- There is lack of networks between producers and processors/manufacturers of value added products, limited openness and guarded secrecy in operations and dealings maintained by both producers and manufacturers

- Implementation of biodiversity conservation of water bodies are very limited and in many states Local level Biodiversity Management Committees (BMCs) to protect aquatic fauna and flora are non existing. Promotion of conservation measures, sustainable use and documentation of biological diversity including preservation of habitats, conservation of domesticated stocks and breeds of fishes and chronicling of knowledge relating to biological diversity are lacking
- Mangrove wetlands are continued to be seen in isolation with no clear cut regulatory framework for conservation figuring in the water resources management and development plans
- From the development perspective of ecosystem, due to lack of documentation on economic values of mangroves highlighting sociological, ecological and environmental costs of resource, it is not gaining the needed attention of planners and policy makers at national and State levels.

Limitations

Limitations for carrying economic valuation of bio resources lack database on catch composition, share of different bio-resource to total production, operational cost, gross and net returns from the activity, details on material flow in the market for tracking value chain, information on value addition at different levels of the chain, commercial utilization etc. Ecological illiteracy of stakeholders, absence advisory services and technical handholding for monetary value on generated natural products and ecological services.

Limitation for levying market cess or tax etc on the produce sold due to absence of sale of produce through regulated markets or any other organized marketing system for fishery bio-resources.

SWOC analysis of value chain

Strengths

- Wild caught shrimp has good export market demand and of late gaining importance at consumers both in international and domestic markets
- Except harvesting cost no other production related expenditure is involved to fishers
- Value share of fishers in the value chain is higher (57%) followed by exporters (13.7%)
- Market price of white prawn is lesser and affordable to consumers than other prawns viz., monodon and vannamei
- Traditional knowledge (TK) about bio-resources exists with local communities and is the key for bio-prospecting and establishment of new business activities of scale

Weaknesses

- Limited fishing days (150-170 days) during the year
- Poor financial status of fishers as most of them are small and marginal, prone for exploitation by market intermediaries (agents/aggregators)
- Lack of infrastructure closer to landing points for hygienic handling and marketing
- Lack of institutional support for technologies, inputs (boat and nets), capacity building, institutional finance and such others
- Tidal dependence nature of fishing activity and poor safety during fishing operations
- Poor awareness of stakeholders on the benefits side of conservation and habitat restoration
- Lack of organizational capacity and limited local institutions for handholding
- Lack of programs to enhance resource productivity and to improve ongoing value chain for the key fishery bio-resources
- Poor governance to protect the ecosystem Degradation of wetlands

Opportunities

- Development of value chain for other species that are being harvested (ex. crabs, high value fishes, ornamental fish and shell fish, other species of importance in by-catch etc)
- Documentation of ITKs on fishery bio-resource for exploring new value chain opportunities
- Exploring new dimensions for industrial utilization of fishery bio-resource with convergence of ITKs and new knowledge developed elsewhere
- Skill development of fishers on hygienic handling (on board handling, chill-kill etc) to avail benefits of technology for better price
- Capacity building of stakeholders on value chain, co-management, benefit sharing for 'win-win' and sustenance of value chain
- Awareness and training on fishery bio-resource protection, conservation, bio prospecting values, market opportunities and new potentials
- Organizing farmers under local institutional frame and strengthening mechanisms for participatory community management of resources
- Mainstreaming fishers dependent on mangrove resource to programs and initiatives of government and other institutions/ organizations
- Growing markets for quality fish

Challenges

- Natural disasters viz., floods, tsunami, climate change etc. negatively affecting the fishery operations and bio-resource
- Unforeseen ecological collapse due to change in land use pattern, destruction of mangrove forest, pollution, and other anthropological stresses
- Changing preference for food in international and domestic markets- market dynamics
- Outbreak of diseases with unknown etiology
- Changed policies and programs of State, national and international governments, political issues and decisions

Suggestions

Value chain

- Scouting for ongoing new commercial/Industrial activities related to fishery bio-resources of mangroves and valuation for benefit sharing
- Explore new opportunities for development of value chain viz., ornamental fishes, indigenous species of fish and shell fish with nutraceutical and pharmaceutical values; specialized products viz., biogenic food preservatives, food additives etc using processing waste of shrimp, crabs etc., ready-to-use products as dry fish/ prawn, fish/prawn/clam pickle etc.
- Promotion of small-scale fish value chains in community's viz., post harvest handling, use of solar dryer, packaging and marketing etc by facilitating fisher women/men
- Development of additional support of market and finance for small-scale operators

Conservation and biodiversity

- Promoting participatory community-based management / co-management system as institutional form for mangrove fisheries management viz., protecting breeding grounds of indigenous species, habitat restoration, enhancement of biodiversity and abundance, participatory stock enhancement with high-value indigenous fishes and such others
- Organizing awareness building, trainings and skill development programs and promote adaptive co-management of fish conservation zones (FCZs) for conservation of mangrove wetlands and protect biodiversity
- Ensure public funding for the conservation efforts
- Position effective governance structures, better planning and participatory implementation for rehabilitation of degraded mangroves

General suggestions

Valuation of mangrove fishery bio-resources that find entry into value chain requires insight into the flow of produce into different segments of value chain within the operational system and how they are linked and influenced by domestic and international market forces and institutions. Although it will not be possible to place a monetary value on all relevant factors, they must be recognized explicitly and incorporated.

- Develop mechanisms for collection of ABS on selected bio-resource of mangrove ecosystem on participatory process and interaction with relevant stakeholders
- Scientific valuation assessing economic and related potential of identified bio-resources of mangroves that facilitate development of appropriate mechanism of benefit sharing

Summary and conclusions

Mangrove wetlands are potential resources capable of producing a wide range of goods and services for coastal environment, communities and society. The resource sustains both capture fisheries and aquaculture production. Although the qualitative beneficiary contribution of this unique ecosystem is well documented, quantitative aspects based on relevant studies are very much lacking. Fish, shell fish and other aquatic bio-resources harvested from the mangrove wetlands have multiple uses and value generation in the entire supply-value chain. However due to the absence of information generated based on scientific valuation of potential bio-resources, there is limitation for bringing the transactions under ABS provisions. The prevailing fisheries activities of mangrove wetlands are generally focused towards domestic markets and the value chains for the produce are not well organized.

In the present study, effort is made for economic valuation of commercial fish and shell fish harvested by individual fishers from the mangrove wetland including the by-catch harvested as incidental during fishing operation. Value chain for white prawn harvested from mangrove wetlands has been worked out and analyzed for the likely monitory benefits happening at different levels of chain keeping in view the ABS concept. The estimated benefit sharing by exporter/processor was worked out at Rs. 4.6 (0.1%) to Rs.23.0 (0.5%)/kg of prawn exported and need be shared to protect/ conserve bio-resource, and also enhance share of profit to community in recognition of their service to ecosystem.

The study also highlighted Key challenges in supply –value chain at production, processing, marketing and consumption, and suggested strategies to improve resource productivity, raw material handling, processing and Marketing. SWOC analysis of supply –value chain has been carried out and identified new opportunities for establishing value chains for several other fishery bio-resources of mangrove wetland. Suggestions are made for improving both value chain and conservation of resources along with fish bio-diversity for the benefits of ecosystem, community and other participating stakeholders.

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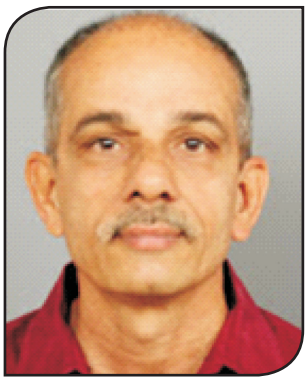


Dr. Ramachandra Bhatta

ICAR-Emeritus Scientist (Economics)
College of Fisheries, Mangalore 575 002
Email: rcbhat@gmail.com

Chapter 9

Economic Valuation of Marine Biological Resources: A Basis for Access and Benefit Sharing

Abstract:

The value of biodiversity arises not merely from its species richness but also from a large number of its ecosystem functions. These functions, among others, include its potential for restoring marine productivity, stability and sustainability. For this study, we are focusing on the commercial value of certain fish species, and making a point that their share in the consumer's Rupee is under-appreciated. The issue of value is needed in the entire range of ecosystem services of biodiversity in order to articulate more credible justification for conservation management plans. The two-fold objectives of this paper are to identify the range of values of services that marine biodiversity provides and to develop a benefit sharing mechanism of value between different stakeholder groups. The introduction of multi-day trawling resulted in harvesting of a large quantity of biodiversity-rich by-catch in addition to commercially important fishes. The major problem with the current system of accessing the marine resources is that the users of marine bio-products in the value chain receive marine products at a throw away price unlike their counterparts in the oil, minerals, timber industry. The results show that one ton of certain raw fish procured at a cost of Rs.7500 generates after processing and value addition up to four joint products of worth Rs. 76710. The net profit earned by the fish meal producer per ton of raw fish was Rs. 69210. Thus the value of the final products is almost 10 times the value of raw material which is exclusively enjoyed by the fish oil/meal companies. Furthermore, the final retail value does not include the cost of non-target species lost unintentionally during the fish harvest. In this regard regulating the access to biological resources by imposing a cess based on the net value realized by the users is a significant step. Additionally, limiting the loss of non-target species would go a long way in sustaining marine biodiversity.

I. FRAMEWORK FOR ASSESSMENT AND VALUATION OF MARINE BIODVERSITY

Introduction:

The India's marine environment consists of unique ecosystems known for their aesthetic beauty and ability to produce numerous commercially important biological species. Spread along the coastline of 7500 km of the main land and island territories, the marine ecosystems also are the cultural and economic backbone of many communities that live in the region. However, the rapid expansion of industrial, touristic, urban and other land-based activities on the coast has threatened the health of some marine ecosystems and led to dramatic decline in marine biodiversity.

The significance of bio-resources in general and marine biodiversity in particular is not fully understood and valued because of the limited knowledge of their role. Most studies on biodiversity often focus on the number of species in an ecosystem (Tilman, 1997). The value of biodiversity arises not merely from its species richness but also from a large number of its ecosystem functions. These functions, among others, include its potential for restoring marine productivity, stability and sustainability. A conservation plan the sole objective of which is to protect species richness will unlikely stand the test of economic net benefits, when compared to alternative plans of development and ecosystem conversion. We argue in this study that the conventional market for marine-derived commercial products undervalues the vast richness of biodiversity that is often critical to the long-term supply of such commodities in the first place. Therefore, we aim to focus on the commercial value of certain fish species, and attempt to measure the share of grassroot raw material harvesters in the consumer's Rupee. The issue of value is needed in the entire range of ecosystem services of biodiversity in order to articulate more credible justification for conservation plans. The two-fold objectives of this paper are therefore to identify the range of values of services that marine biodiversity provides to human society and to develop a benefit sharing mechanism of value between different stakeholder groups. While a number of studies have been conducted on the economic valuation of different attributes of marine ecosystems (Hoagland et al., 1995), no study would examine the economic value attributable to biodiversity, *per se*.

We make a distinction between the value of marine biological resources and the value of biological diversity. The former is a direct function of the physical quantity or volume of biological stocks. Therefore, conservation plans designed to enhance only the stock value of biological resource may offer protection to a limited number of commercially viable species. There have been attempts to estimate the commercial value of fish stocks based on certain market value of marine products (Polunin and Roberts, 1993). On the other hand, the value of biological diversity arises from species diversity or richness, which makes a marine ecosystem more stable, productive, ecologically functional, socially valuable, and aesthetically pleasing. We focus our discussion on the value of biodiversity, and not of the biological resources.

Background on Marine Ecosystems in India and Karnataka

Biodiversity is a key ecological attribute of an ecosystem, and the same varies widely across ecosystems. It is necessary to identify three types of marine ecosystems that have special relevance to biodiversity: estuarine, inter-tidal and coral reef. Estuarine system is a fresh water ecosystem comprising estuary, mangroves and other wetlands rich in microscopic plant life and abundant in vegetation. They are the rich breeding grounds for larvae of some commercial species, a broad range of algae, fungi and lichens among others. More than 75 percent of the commercial fish catch in India is dependent on estuaries for part of their life cycle. India ranks 14th in the list of the world's major mangrove area and fifth in the Indo-Pacific regions. India's major mangrove areas include the northern Bay of Bengal and the Sunder Bans (approximately 690 sq km together), which is the world's single largest contiguous block of mangrove forests. India's total mangrove areas is approximately 6700 sq km, which is 7% of world's mangrove area. India has about 3.9 crores hectare (3.9 lakhs sq km) of estuarine wet lands (Sahai, 1993). The second type of coastal ecosystem is Inter-tidal ecosystems which consist of areas that are inundated by seawater during high tides. This saline zone is home to crustaceans (crabs) and molluscs. The third type is the coral reef ecosystems in India. India is reported to have coral reef area of 1270 sq kms mainly in the Gulf of Kuchchh, the Gulf of Mannar, and Lakshdeep. Coral reef plays an important role in fisheries and can be 10-100 times as productive per unit area as the open seas. Reefs harbor a quarter of all marine species and one fifth of the known fish species thriving here. Some species have medicinal value. The utilities from these resources are varied such as medicines, nutrition, cosmetics and other industrial products apart from providing sea transport and tourism.

Karnataka's marine ecosystem primarily consists of the first two systems: estuarine and inter-tidal ecosystems. Fishing is carried out throughout the year along the Karnataka coast except during the seasonal fishing ban for mechanized vessels imposed by the Government of Karnataka. Generally, the non-motorized traditional sector has the least amount of discards, while the mechanized trawlers have larger amounts of discards. A study on low value by-catches (LVB) and discards conducted by CMFRI during 2007-12 found that the rate of discards is high in key fishing centres such as Visakhapatnam and Mangalore.

Uniqueness of Marine Biodiversity Valuation

In developing a framework for valuation, it is essential to first reflect on some of the unique attributes of marine biodiversity. These attributes not only influence the scope and method of valuation, but also the way the biodiversity is used and managed. These attributes distinguish marine biodiversity from its land-based counterpart. Hoagland et al., 1995 identified the following important attributes:

- Resource fugitive: The mobile nature of most marine animals makes it difficult to define the geographic scope of biodiversity measurement. The specific scale of marine biodiversity, unlike forests or cropland, is less definite.
- Nature of uses: Use of marine biodiversity is subtler than its land-based counterparts, (e.g., forests, grass, wetlands.) Uses are not direct like agricultural or pharmaceutical uses of plant diversity. Most uses are indirect, non-consumptive, and non-use nature. Also, because of its under-water nature, people do not come in direct contact with marine biodiversity in their day to day life. The lack of familiarity and understanding might greatly influence the economic value that people attach to biodiversity.
- Open access: Both access to and the uses of marine ecosystems are difficult to control because of the problems in marking boundaries. This presents a problem for enforcement and management.
- Public good nature: Certain components of the benefits of marine biodiversity are of public-good nature in the sense that all potential users enjoy these benefits the same at same level without any conflict among them. Some of the benefits are global in nature. Presence of a large external benefit gives little incentive to individual users for protecting the resource. The global nature of its benefits makes valuation less reliable and more cost-prohibitive.
- Presence of non-market goods and opportunity costs: A large extent of marine diversity, specially the coral reef, is not reflected in the traditional market transactions.
- Potential for benefit transfer application: Because of its international in character, the resources can be viewed from the international perspectives using the benefit transfer methods for valuation.
- Resource pricing: Due to its nature as a renewable resource, it calls for a proper understanding of resource pricing under optimal renewability or recyclability.
- Issues of geographic scale: Certainly, the resources are of massive scale in their management.

Sources of Benefits from Marine Biodiversity

The main focus of this report is the value of marine biodiversity but not the value of the larger marine ecosystem itself. In the latter case, marine ecosystem can be viewed as "factories" generating fisheries and other consumptive and non-consumptive products and services. However, we are interested in the contribution of the richness of biodiversity to the ability of an ecosystem in producing different use and non-use values. Simply put, we are comparing the economic values of biodiversity-rich and biodiversity-poor marine ecosystems, but not the total value of any one given marine ecosystem. To estimate the contribution of biodiversity, we first need a good definition of biodiversity itself. Solow and Polasky (1994) have described diversity as the *joint dissimilarity* of a set of species. Dissimilarities are based upon the differences between species, known as *distances,* in genetic, behavioral, morphological, or other characteristics relevant to

management or valued by society. This variable can be constructed first by defining a set of characteristics of a benchmark species and then adding up the distances of characteristics of all individual species in an ecosystem. Obviously, the higher the *distance* value, the richer the biodiversity of that system.

Before we approach the economic valuation of biodiversity, it is important that we clearly identify the nature and type of eco-system services that marine biodiversity contributes to humanity and the ecosystem. The valuation studies often use the following Total Economic Value (TEV) framework to classify values from environmental resources. This framework allows us to properly identify the main sources of use and non-use values of marine biodiversity and then identify appropriate valuation techniques.

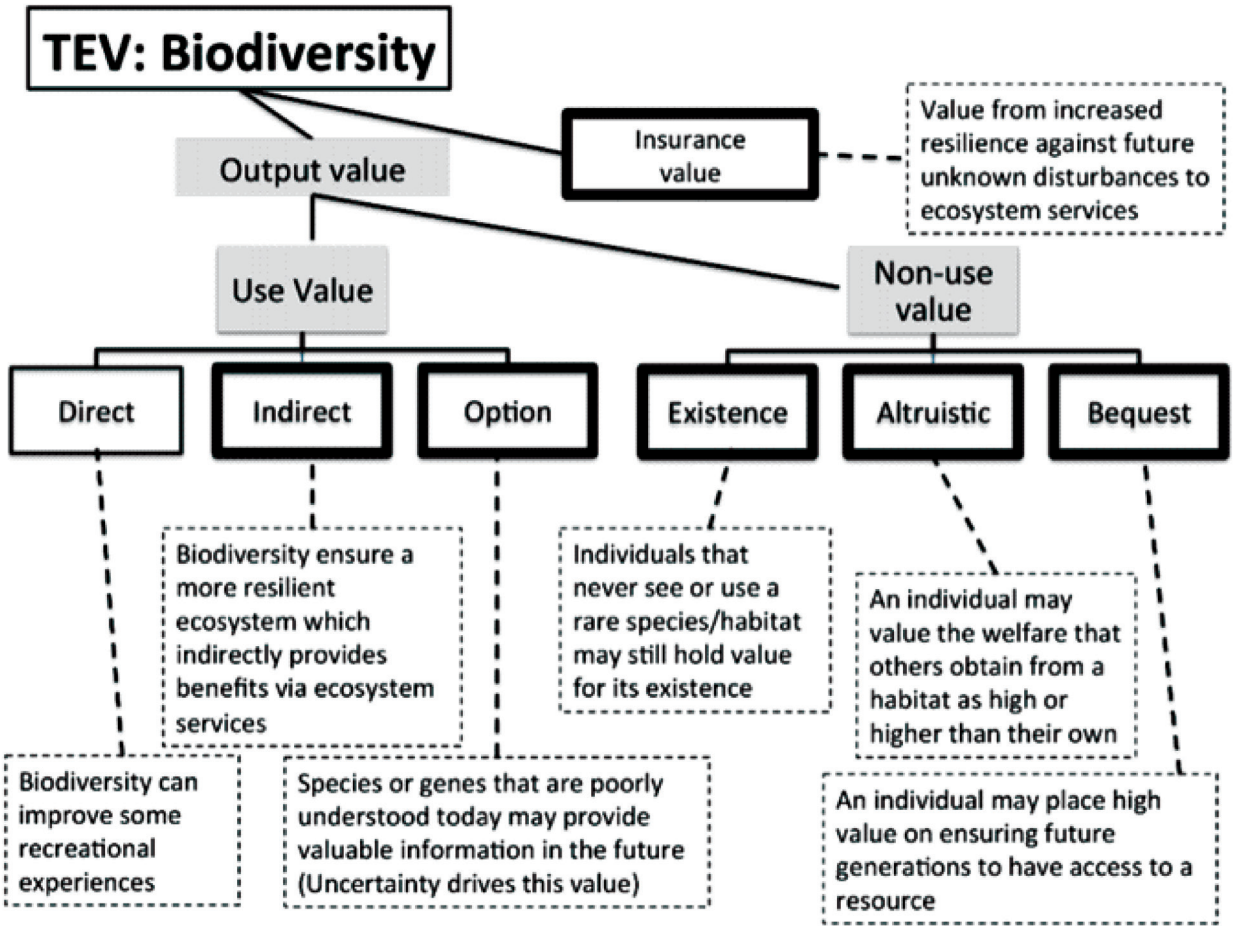


Fig: 1

Source: Gisselman et al. (2017)

Fredrik Gisselman, Scott Cole, Josefin Blanck, Matleena Kniivilä, Nora Skjeerna Hansen and Elin Fornbacke (2017). "Economic values from the natural and cultural heritage in the Nordic countries Improving visibility and integrating natural and cultural resource values in Nordic countries." TemaNord 2017:522, Nordic Council of Ministers, Denmark.

http://dx.doi.org/10.6027/TN2017-522

Consumptive Direct Use Value: Pharmaceutical Use of Marine fisheries

The marine resources provide lot of utilities such as medicinal, nutritional, cosmetics and industrial products. Many diseases such as tumors, cancer (ovarian, colon etc) are treated by using sea squirts, sea sponges, jellyfish, chitosan and ocean floor fungil. The extracts from marine resources such as micro algae, cyaobacteria, krill etc provide nutritional products such as vitamins and anti-oxidants, vital amino acids, proteins, gelatin and food colours. The seaweeds and micro algae are being used for manufacturing cosmetics such as toothpaste, gels lipsticks and lotions. Some of the industrial products such as paper and pulp enzymes, befouling agents and adhesives are manufactured from the extracts of marine resources such as sponges, chitosan from crustaceans and molluscans.

Table 1 Marine biotechnology linked corporate sector

Biodiversity linked resources	Utility of the of the final products	Major industries involved
Sea squirts	Tumors, viruses, suppression of immune responses	Pharmaceutical industries
Encrusting invertebrates	Ovarian cancer	Pharmaceutical industries
Sea sponges	Herpes, simple, cancer, pain, inflammation	Pharmaceutical industries
Jelly fish	Neurological disorders, cancer, inflammation, anesthesia	Pharmaceutical industries
Chitosan	Burns	Pharmaceutical industries
Ocean floor fungi	Human colon cancer	Pharmaceutical industries
Micro algae and fungi	Vitamins and anti-oxidants and vital amino acids, gelatin and food colours	Nutrition related companies
cyanobacteria	Fluorescent tags and tracers	Nutrition related companies
Krill apart from fish, algae, plants	Proteins	Nutrition related industries
Seaweed (carrangenan)	Toothpaste and gels	Cosmetics
Pigments and cynobacteria	Lipsticks	Cosmetics
Sponges	Paper and pulp products	Industrial products
Chitosan and crustaceans, fungi	Bio-fouling	Industrial products
Molluscans	Adhesives	Industrial products

The marine organisms produce unique bioactive compounds for their reproduction, communication and against predation, infection and competition. This genetic material and chemicals in marine plants, animals and microorganisms constitute an extraordinary resource for pharmaceuticals, industrial enzymes, agricultural products and bioremediation and so on. However, there is a need to evolve laws and statutes for the exploration, protection and sustainable development of marine resources. For example dredging of sea for various industrial purposes such as construction of ports, thermal power plants and other explorations severely damage coral reef and marine resources. The restrictions on tapping the wild marine resources are also required to prevent over harvesting of these resources.

Non-Consumptive Direct Use Values

Source of tourism, recreation and retirment

That beach and sea have become sources of tourism and recreation is a recent phenomenon in our country. In Karnataka, the Government has identified Mangalore, Someshwar, Ullal, Panambur, Suratkal, Malpe, Bhatkal, Karwar, Murdeshwara, Kundapur, Honnavar, Gokarna, Kumta and Mulki as coastal tourism centres. The adverse effects of mass tourism on coastal ecology have many facets: construction of resorts, highways, destruction of coastal habitats like sand dunes, coastal vegetation, mangroves for landscaping and recreation, contamination of water bodies from fertilizers and pesticides, disturbing coastal and marine life by mass human pressure could affect the livelihood of traditional communities.

Cultural values and future scientific values

1. Basis of many cultures.
2. Cultural information regarding the habits of marine animals and ecosystem forms a center piece of traditional societies.
3. Enrich body of scientific knowledge.

Indirect Use Value

Biodiversity and productivity

There are differences among species in methods of resource capture. Species of more diversity are capable of fully utilizing their limiting resources. For example, seasonal and time diversity in species has certain benefit; some species do well in summer while some in winter. Some are shallow water living; some are deep water. With more diversity, it is more likely that one or more species come to dominate the ecosystem. That leads to an overall increase in the productivity. This is called “sampling competition” effect. There is also complementarity in resource use. Different species are able to occupy different regions of the ecosystem. Regions mean area with different bio-geo-chemical properties within a given ecosystem (e.g., BOD, pH, zooplankton, temperature, nutrients). Diverse system will fully utilize the ecosystem.

Biodiversity and stability

Less diverse system means less resistance to disturbance and less resilience after a disturbance. The extinction probabilities of individual species would very high with low diversity. Less diverse system may also be readily invaded by less productive exotic species.

Biodiversity and global material cycling

Marine biota serves as a vehicle for the transfer of atmospheric CO2 to the sea floor. The atmospheric carbon dioxide reacting with rainwater turns into bicarbonate, which in turn gets absorbed by marine biota. As marine organisms die, the biocarbonate stored in their skeletons and tissues become part of sedimentary rocks.

Nutrient and organic matter transformation

Phytoplankton absorbs inorganic nutrients and organic matter released to oceans through sewer discharge, industrial pollution and rain water. Similarly the calsium produced from the manufacturing of bivalve shelves harvested in the estaury, goes back to plantation crops in the upghat as mannure which flows back into rivers in the rainy season as agricultural run off providing nutrients to bivalve animals.

Detoxification

Microbial community on the ocean floor detoxify petroleum hydrocarbons and break them into CO2 and water. Microbes need oxygen for this aerobic process since oxygen is the source of electron.

The Convention on Biological Diversity (CBD,1993) identifies mariculture as one of the fastest growing food industry. However, CBD cautions the disadvantages of using high nutrients, antibiotics, the disposal of mariculture wastes, accidental releae of alien species, trasmission of diseases to wild stock, and the displacement of local communities. The studies show that the shrimp farming which gained popularity during 1990s-2000 could not be regulated by using water Act 1974 and also Environmental (Protection) Act 1986 and did not address the problems of degradation of coastal ecosystems.

II. MARINE BIOLOGICAL RESOURCES OF KARNATAKA

India has a long coastline of 8118 km (including its island territories), along which 25 percent of its population resides within one kilometer of the coast. The Indian Coastal Regulation Zone (CRZ 2011) notification lists a comprehensive set of ecosystems that play a critical role in maintaining the integrity of coasts providing ecosystem services. This study has chosen nine coastal ecosystems among 13 listed in the CRZ Notification to assess the economic valuation of the services they provide. Further based on an opinion survey of 120 coastal ecologists, conducted during 2014 at the National Centre for Sustainable Coastal Management in a series of technical consultation meetings, the most important ecosystem services were delineated and prioritized using the pair-wise ranking method. The reasons for this valuation exercise are two–fold:

i. the destruction and degradation of coastal ecosystems necessitates the accounting for ecosystem service losses in terms of the benefits foregone to human beings, such that appropriate decisions and actions regarding the extent to which coastal ecosystems are to be conserved may be taken; and

ii. Very few studies exist in the literatures that have comprehensively valued coastal and marine ecosystem services in India.

World Bank (2013) has put together the value of ecosystem services from the major biomes in India. The total value has been estimated as Rs. 1.4 trillion in 2009, which is about 3 percent of India's GDP in that year. Note that although the atmosphere provides a 'provisioning' ecosystem service in the form of clean air and water, the ecosystem service valuation exercises (including World Bank, 2013) do not typically account for such services. This partly explains the divergence between the cost of environmental degradation and the value of ecosystem services estimated for India in 2009. Among the ecosystems and their services valued by the World Bank (2013), wetlands including coastal wetlands, account for the highest percentage (48 percent), followed by coral reefs (22 percent).

Costanza et al. (2014) estimated that the annual value of ecosystem services across the globe at $125 trillion, including ecosystem service value of $50 trillion from open ocean and coastal ecosystems. This value was significantly higher than the global GDP at the time. Their study and their earlier work have promoted substantial research interest on the contribution of ecosystem services, specifically ocean and coastal wetland ecosystem services, to human wellbeing (de Groot et al., 2012). As per the analysis reported by de Groot et al. (2012), the monetary value of the ecosystem services for the marine and coastal biomes have been estimated as (expressed in $/ha/year, in 2007 prices): open oceans – 491; coral reefs – 352,915; coastal systems – 28,917; and coastal wetlands – 193,845.

The State of Karnataka located in the Southwest coast of India, has 300 km of coastaline with rich marine bidoversitry and with a total population of 6,11,30,704 and the three coastal districs comprising of Dakshina Kannada, Udupi and Uttara Kannada consist of around 40 lakh population. The Table 2.1 presents the demographic profile of the three coastal districts in comparision with the state. The growth of Karnataka's fisheries sector can be seperated into three phases. In phase one (1950-1966) landings were mainly non-mechanized traditional crafts and gears such as hook and line, gillnets, seines, bag nets and traps. During the second phase (1967-1986) these vessels were modified to be fitted with out board engines of 5-9 hp in order to travel further and increase fishing effort. In the third phase from 1990-2012 major developments were initiated to mechanize and introduce fishing with capacity to fish I deeper waters. Despite these developments India's fisheries continued to be dominated by small-scale fishermen. Table 2.1 presents the socio-demographic features of coastal regions with high levels of per capita income.

1http://www.moef.nic.in/downloads/public-information/CRZ-Notification-2011.pdf

Table 2 Demographic profiles of the coastal districts of Karnataka

Details	State	D.K	Udupi	Uttara Kannada
Total population	6,11,30,704	20,83,625	11, 77,708	14,40,000
Decadal population growth rate (per cent)	15.67	9.80	5.90	9.20
Area (in sq. km)	1, 91,791	4,866	3,575	10,291 km^2
Density of population (persons per sq. km)	319	457	287	
Literacy level (per cent)	75.60	88.62	86.29	70
Percentage of workers to total population	44.3	50.0	44.0	
Net District total income 2007-08 (in lakh) at current price	2,11,66,253	9,69,984	4,73,922	560503
Per capita income (in Rs.) 2007-2008 (at constant price 1999-2000)	36,945	47,151	39,307	36243
Rank based on Human Development Index	7	2	3	5
Net district income from fishing 2007-08 (in Rs. Lakhs) at constant price	79, 773	22, 534	20, 529	19743
Percentage contribution of fishing to total income	0.38	2.32	4.33	4.2

Source: 1.GOK (2010). Karnataka at a Glance Bangalore: Directorate of Economic and Statistics.

2.GOI (2011). Census of India 2011, Provisional population totals. Bangalore: Directorate of Census Operations

Economic Exploitation of Marine Biological Resources

The marine fisheries sector is also an important source of revenue contributing to regional growth. The contribution of fishing industry to the development of the economy may be measured in terms of its contribution to Gross Domestic Product (GDP)/Net Domestic Product (NDP). Its contribution to the national income is estimated at Rs. 78,053 crores at 2012-13 current prices, which constitutes 0.83 per cent of total GDP and 4.75 percent of the agricultural GDP (GOI 2014). The exports of marine products from Karnataka increased from 4,408 tons valued at Rs. 11.43 crore in 1980-81 to 33000 tons valued at Rs.1426.53 crore in 2014-15. But, the contribution of the state to the total exports of marine products from the country has declined from 4.87 per cent in 1980-81 to 4.27 per cent in 2014-15 in terms of value. The decline in the share of fish exports is mainly due to the decline in the capture-shrimp-fisheries and cultured-shrimp production.

Table 3 Population Density of Coastal States in India

No	States	Total			Coastal Villages (<1km)		
		1991	2001	2011	1991	2001	2011
1	Andhra Pradesh	242	277	308	278	514	542
2	Karnataka	235	276	319	764	1065	1228
3	Orissa	203	236	269	317	412	457
4	Tamil Nadu	429	480	555	303	803	905
5	Maharashtra	257	315	365	340	373	372
6	Gujarat	211	258	308	416	510	589

Table 4 presents that the population density is much higher in coastal areas and has been increasing in spite of the restrictions on development

Table 4 Coastal Populations within 1 Km from the Coast

District	Area in Sq.km	Villages	Total Population		% Growth Rate			Population Density		
			1991	2001	2011	1991-2001	2001-2011	1991	2001	2011
Dakshina Kannada	211	11	324143	477980	569584	47.46	19.16	1536	2265	2699
Udupi	307	39	196249	206363	222302	5.15	7.72	639	672	724
Uttara Kannada	391	57	174167	283307	324750	62.66	14.63	445	724	830

The average annual production of marine fish in Karnataka has increased from 0.5 million tons to 1.60 million tons during the last 60 years with increased investment in mechanization and other coastal infrastructure facilities. The average annual production is 532 tons against the national average of 360 tons. The average annual production of Andhra Pradesh per coastal km was only 270 tons indicating the rich marine resources of the Karnataka coast.

Table 5 Average marine fish production per km of coastline in Karnataka to the national average (in metric tons)

Period	Karnataka		India		(2) as per cent of (4)
	Average annual production	Average production per km of coastline	Average annual production	Average production per km of coastline	
1	2	3	4	5	
1950-60	57400	191.33	634200	84.4	9.05
1960-70	93318	311.06	812600	108.1	11.48
1970-80	107312	357.71	1249200	166.2	8.59
1980-90	151401.4	504.67	1697300	213.8	8.92
1990-2000	184419.3	614.73	2252300	299.6	8.19
2000-2009	159833.0	532.78	2924000	360.19	5.47
2009-2015	340138	1062.93	-	-	-

Source:1. Government of Karnataka (2009). Statistical bulletins of fisheries various issues, Bangalore: Directorate of fisheries.

2 Mohamed, K. S., Muthiah, C., Zacharia, P.U., Sukumaran, K.K., Rohit, P., & Krishanakumar, P. K. (1998).

Marine fisheries of Karnataka State, India. Naga, 21, 10-15.

3. CMFRI (2011). CMFRI annual report. Cochin: Central Marine Fisheries Research Institute.

Table 6 Per Capita household NDDP from Agriculture and Fishing in Dakshina Kannada for the year: 2004-13 (in million).

Year	Agriculture			Fishing		
	NDDP from Agriculture	Total Agricultural household	Per capita household NDDP	NDDP from Fishing	Total Fishing household	Per capita household NDDP
2004-05	8484.8	41033	0.207	1824.1	3686	0.495
2005-06	9963.2	42661	0.234	1757.1	3833	0.458
2006-07	9620.9	44289	0.217	1228.1	3980	0.309
2007-08	9479.6	45916	0.206	1243.3	4127	0.301
2008-09	8316.3	40137	0.207	1628.4	4274	0.381
2009-10	7483.6	40978	0.183	1430.4	4421	0.324

Year	Agriculture			Fishing		
	NDDP from Agriculture	Total Agricultural household	Per capita household NDDP	NDDP from Fishing	Total Fishing household	Per capita household NDDP
2010-11	8866.4	41819	0.212	2113.1	4570	0.462
2011-12	5959.7	40978	0.145	2007.1	4717	0.426
2012-13	10014.6	40137	0.250	1974.3	4864	0.406

Source: Directorate of Economics and Statistics Karnataka; Government of Karnataka Department of Agriculture; Government of Karnataka Department of Fisheries;

Note: At Constant (2004-05) prices.

Table 7 Per Capita household NDDP from Agriculture and Fishing in Udupi for the year: 2004-13 (in million).

Year	Agriculture			Fishing		
	NDDP from Agriculture	Total Agricultural household	Per capita household NDDP	NDDP from Fishing	Total Fishing household	Per capita household NDDP
2004-05	5283	38898	0.136	1261.6	10143	0.124
2005-06	5764.9	39480	0.146	872	10297	0.085
2006-07	5747.8	39603	0.145	931.8	10219	0.091
2007-08	5413.9	39727	0.136	1138.3	10141	0.112
2008-09	5180.2	39850	0.130	1801.8	10063	0.179
2009-10	4911.2	39973	0.123	1599.8	9985	0.160
2010-11	5516.3	40097	0.138	1922	9907	0.194
2011-12	4567	40220	0.114	1808.2	9829	0.184
2012-13	4691.4	40344	0.116	1804.9	9751	0.185

Source: Directorate of Economics and Statistics Karnataka; Government of Karnataka, Department of Agriculture; Government of Karnataka, Department of Fisheries;

Note: At Constant (2004-05) prices.

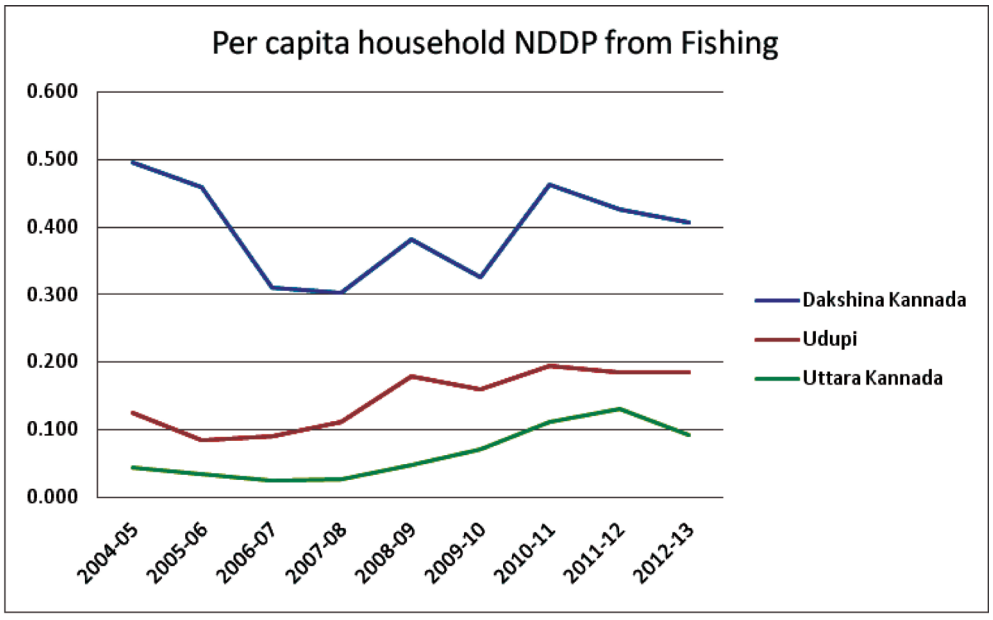
Table 8 Per Capita household NDDP from Agriculture and Fishing in Uttara Kannada for the year: 2004-13 (in million).

Year	Agriculture			Fishing		
	NDDP from Agriculture	Total Agricultural household	Per capita household NDDP	NDDP from Fishing	Total Fishing household	Per capita household NDDP
2004-05	4264.7	34729	0.123	683.3	16008	0.043
2005-06	5208.9	35174	0.148	548.8	16046	0.034
2006-07	5441.1	35852	0.152	383.8	16084	0.024
2007-08	5480.2	36530	0.150	426.1	16122	0.026
2008-09	4594.8	37208	0.123	771.4	16160	0.048
2009-10	4817.7	37886	0.127	1126.4	16198	0.070
2010-11	5772.6	38564	0.150	1788.4	16236	0.110
2011-12	4030.5	39242	0.103	2110.9	16274	0.130
2012-13	7091.1	39920	0.178	1498.6	16312	0.092

Source: Directorate of Economics and Statistics Karnataka; Government of Karnataka, Department of Agriculture; Government of Karnataka, Department of Fisheries;

Note: At Constant (2004-05) prices.

Figure 2 Per capita household NDDP from Fishing in Dakshina Kannada, Udupi and Uttara Kannada for the year: 2004-13 (in million).



Source: calculated from the data from the Directorate of Economics and Statistics Karnataka; Government of Karnataka, Department of Agriculture; Government of Karnataka, Department of Fisheries;

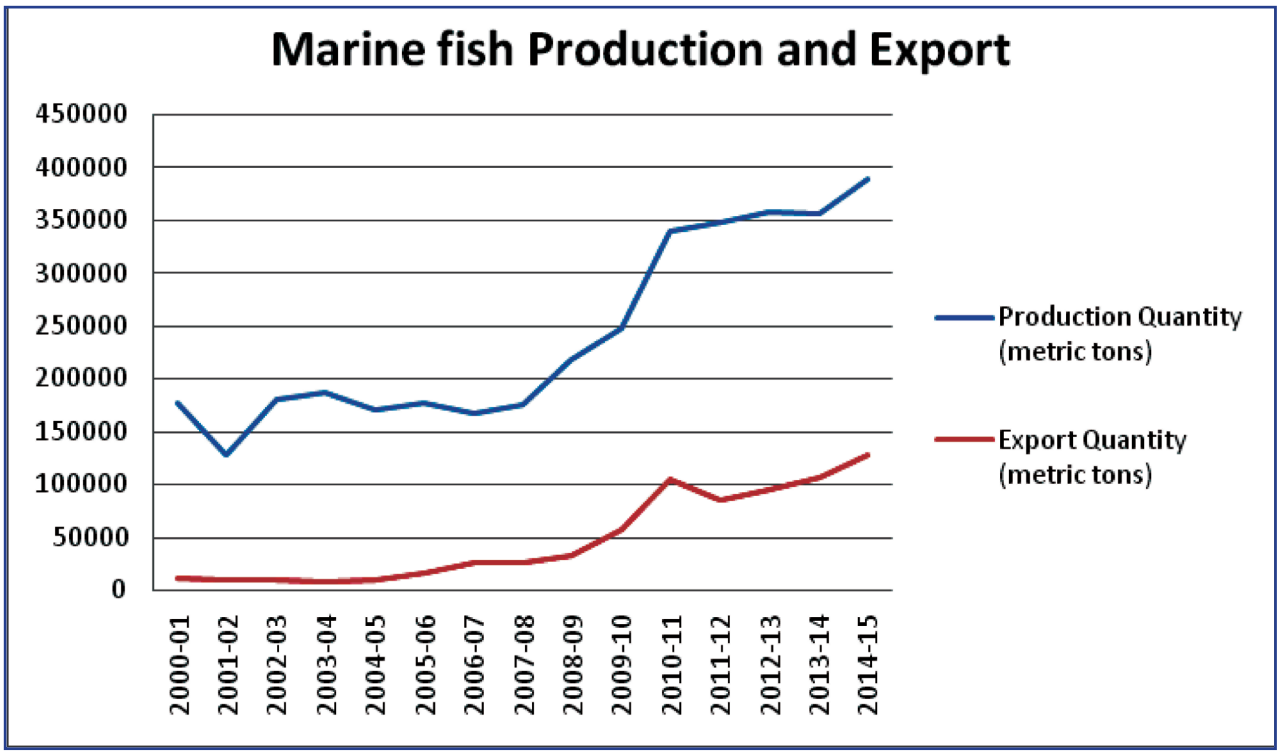
Note: At Constant (2004-05) prices.

Table 9 Marine fish Production and Export in Karnataka

Year	Production Quantity (metric tons)	Export Quantity (metric tons)	Share of Export Quantity in Production (%)	Production Value (Rs. In Lakhs)	Export Value (Rs. In Lakhs)	Share of Export Value in Production (%)	Unit value of Production per Kg (in Rs.)	Unit value of Export per Kg (in Rs.)
2000-01	177907	11823	7	24829	9446	38	14	80
2001-02	128416	9430	7	19942	6338	32	16	67
2002-03	180161	9788	5	33653	6270	19	19	64
2003-04	187003	8474	5	40498	6447	16	22	76
2004-05	171227	10349	6	45873	7692.39	17	27	135
2005-06	176974	15965	9	46598	10327	22	26	65
2006-07	168545	26723	16	55143	14949	27	33	56
2007-08	175566	26155	15	51787	16261	31	30	62
2008-09	218137	33000	15	82024	26400	32	38	80
2009-10	248729	57359	23	90198	39112	43	36	68
2010-11	340571	104795	31	133565	68813	52	39	66
2011-12	347383	86299	25	150630	65846	44	43	76
2012-13	357325	96333	27	201668	85495	42	56	89
2013-14	357000	106693	30	204102	121037	59	57	113
2014-15	389000	128415	33	265093	142653	54	68	111

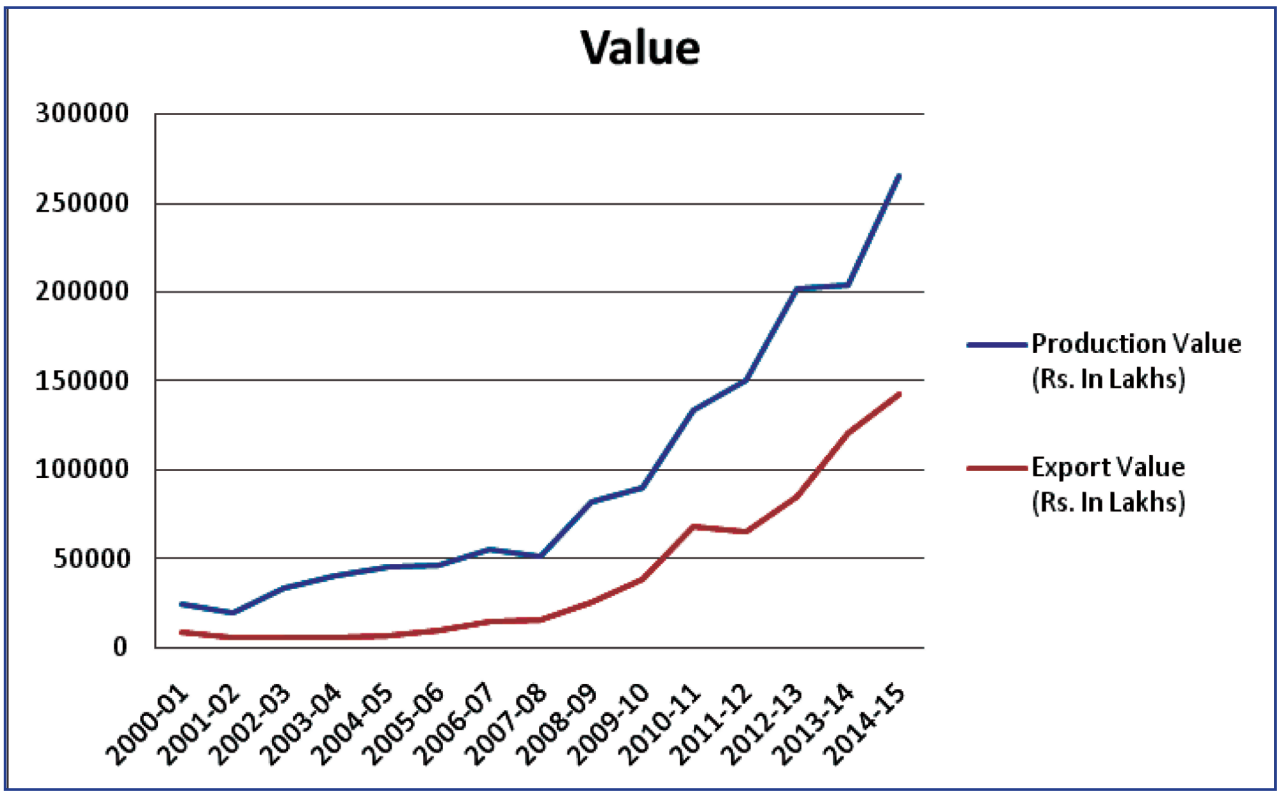
Source: Government of Karnataka Department of Fisheries.

Figure 3 Marine fish Production and Export in Karnataka



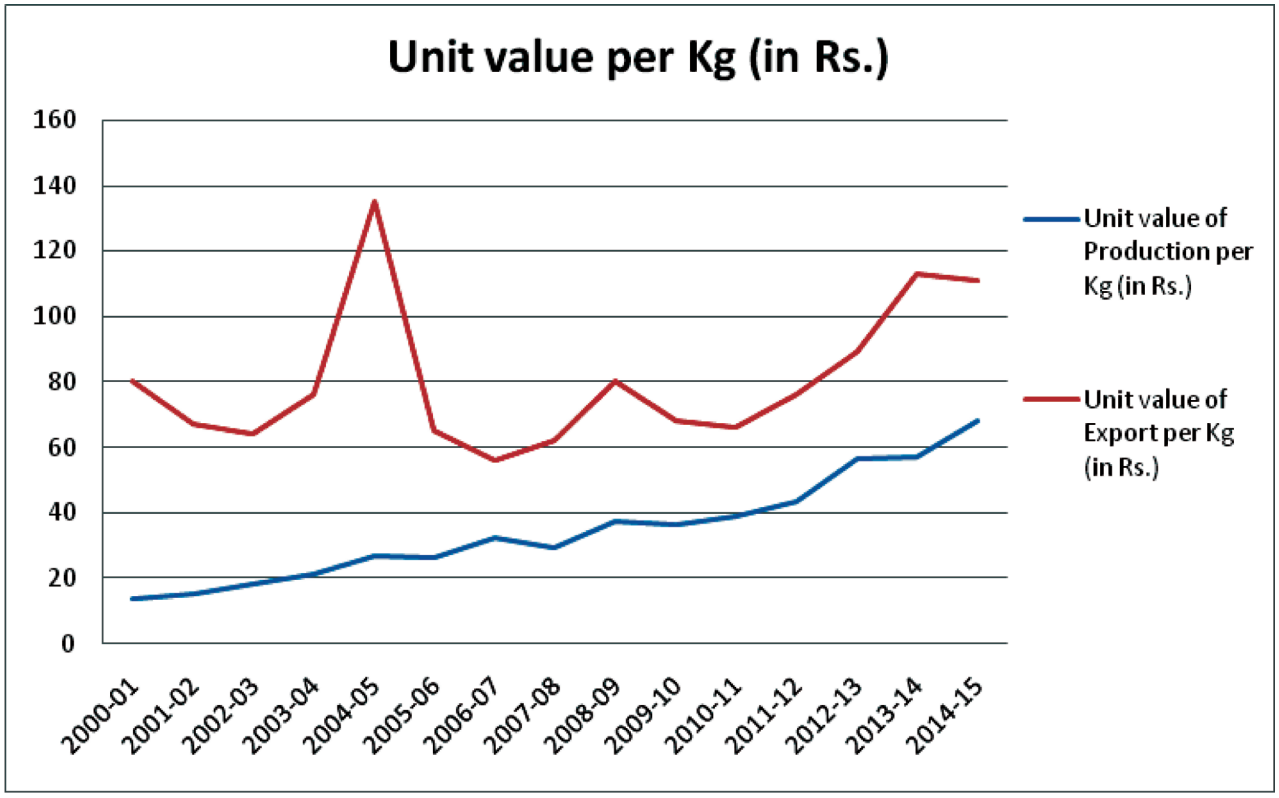
Source: Government of Karnataka Department of Fisheries

Figure 4 Value of Marine fish Production and Export in Karnataka



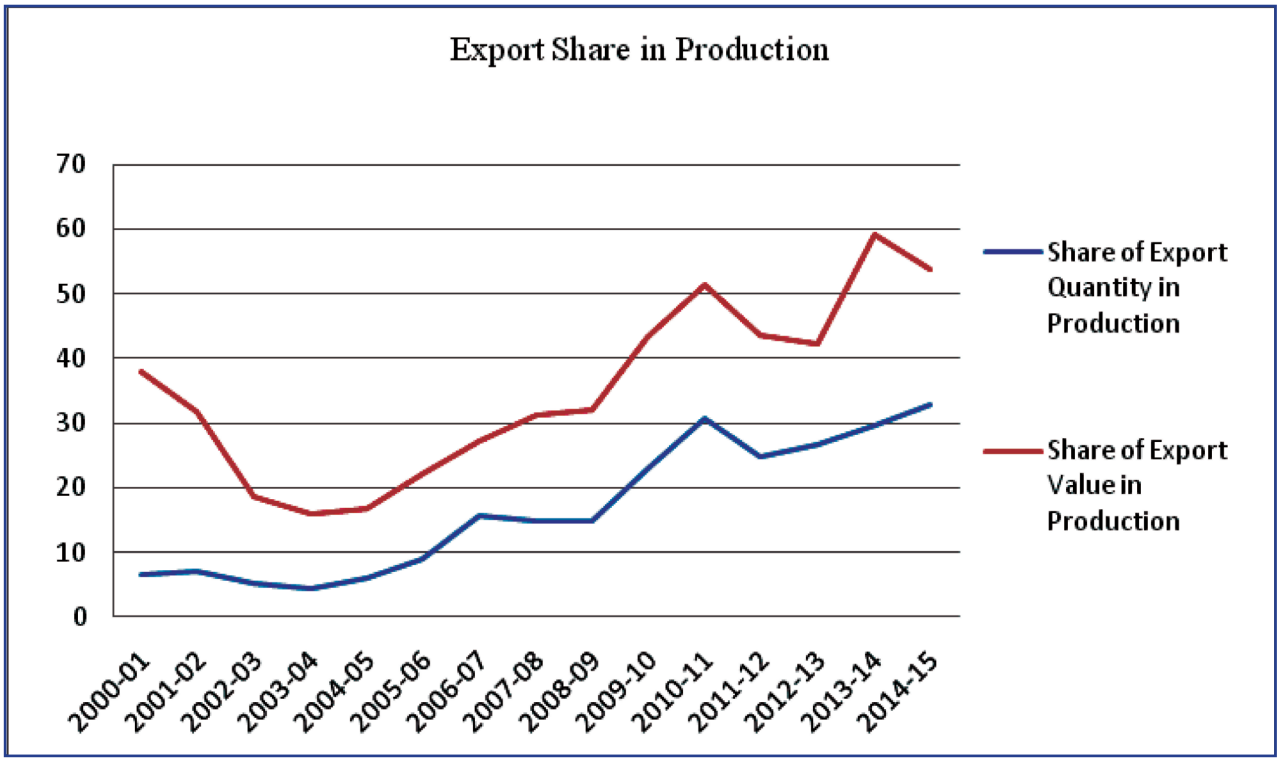
Source: Government of Karnataka Department of Fisheries

Figure 5 Unit Value per Kg of Marine fish Production and Export in Karnataka



Source: Government of Karnataka Department of Fisheries

Figure 6 Export share in Quantity and Value in Production.



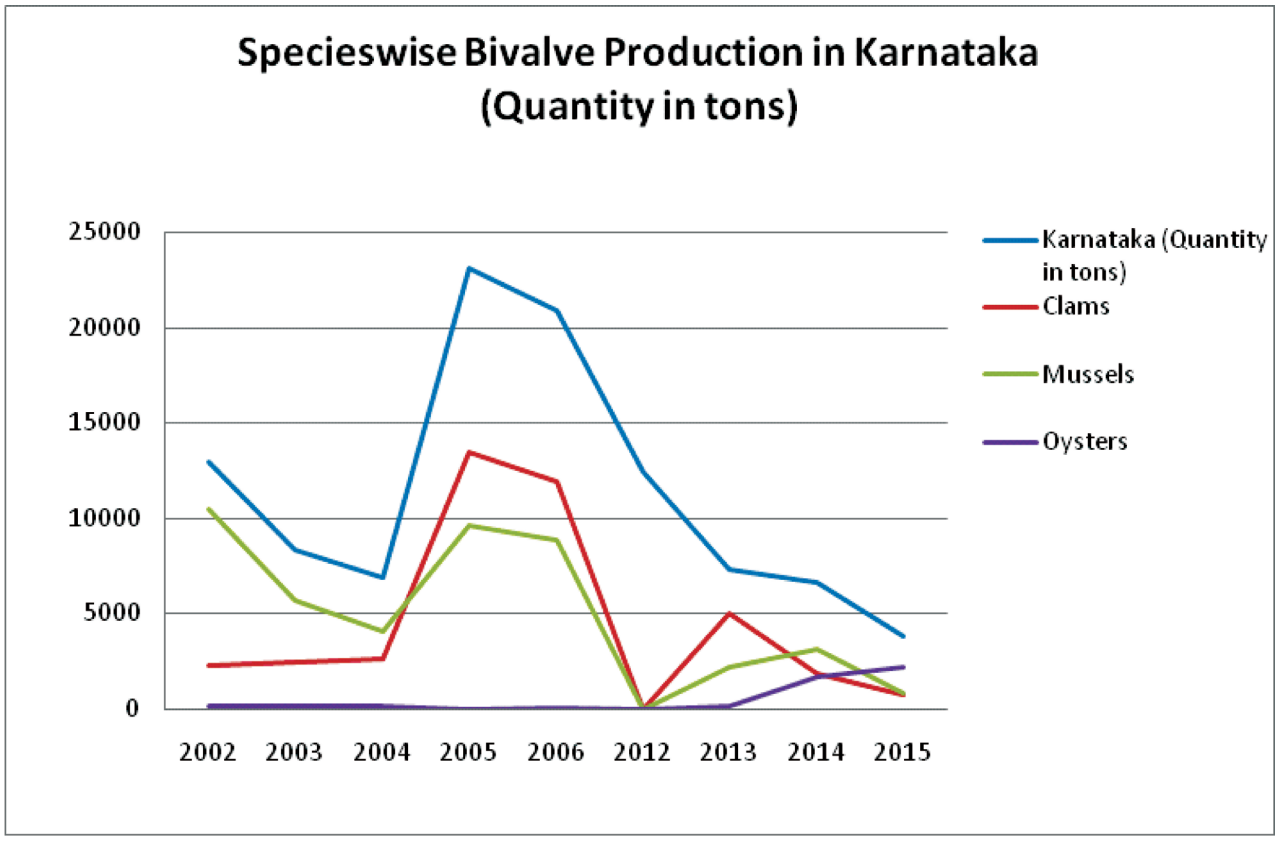
Source: Government of Karnataka Department of Fisheries

Table 10 Coastal water quality index: Bivalve Production

Year	Karnataka				
	Total Qty (in tons)	Clams	Mussels	Oysters	India Qty (in tons)
2002	12952	2284(18)	10471(81)	197(2)	55343
2003	8348	2438(29)	5722(69)	188(2)	58702
2004	6948	2669(38)	4077(59)	202(3)	48792
2005	23115	13488(58)	9627(42)	0	63283
2006	20928	11971(57)	8842(42)	115(1)	85582
2012	12462	NA	NA	NA	89897
2013	7361	5041(68)	2180(30)	140(2)	113858
2014	6681	1882(28)	3129(47)	1670(25)	134235
2015	3845	800(21)	861(22)	2184(57)	92513

Source: CMFRI annual report. Note: Figures in the brackets are parentage; NA: Not available; Data during 2007-2013 are not available.

Figure 7 Species wise Bivalve Production in Karnataka



Source: CMFRI annual report. Note: Data during 2007-2013 are not available.

Table 11 Fishing conflicts

	HP Range		
Variables	**<140**	**141-300**	**>300**
Average Commercial Catch (Kg)/Trip	698.5	4150.5	5221
Average Trash (Kg)/Trip	81	973.5	2280
Total (Kg)/Trip	779.5	5124	7501
Per cent loss of biodiversity (Trash fish)	10.39	19	30.4
No. of Commercial Species	40	93	90
No. of Trash species	4	18	30
Per cent loss of biodiversity (Trash fish)	3.15	16.22	25
Diversity Index			
Total No. of Species	44	111	120
No. of Family	31	53	60
Richness (d)	8.7518	17.8125	18.5186
Shannon Index [H'(log10)]	1.5171	1.8521	1.8866
Simpson Index [1-Lambda']	0.9651	0.9805	0.9818

A comparison of the various biodiversity and economic indicators of increasing fishing effort and intensity is presented in Table 2.10. The results based on the primary data collected during 2014 shows that as the fishing intensity represented by increase in engine horse power represent alarming differences in the by-catch quantity and loss of biodiversity shown by Shannon index. The percentage of trash fish quantity increases from 3.1 percent for smaller sized fishing vessels (<140 HP) to 25 percent of the total catch with higher HP boats (>300 HP).

Drivers of Biodiversity loss and policy implications

In this section, we present some of the causes of biodiversity loss such as resource use changes, conversion of habitat, pollution, climate change, and invasive alien species etc., while the underlying causes are social, economic, political, cultural, and technological processes, which ultimately define the proximate drivers of biodiversity loss.

The fishery resources are renewable but exhaustible assets of mankind. The state policy should promote sustainable use of these resources for the current and future generations. It implies that the current generation has an obligation to pass on the marine resources to the future generations following inter-generational equity principle. Therefore overharvesting of resources leading to exhaustible nature of the resources through destructive fishing practices does not ensure sustainability. If we start mining of fishing resources, the loss is not only to the current generation but also to future

generations. Note that the public trust doctrine flow from Article 21 and 295/297 ensures inter-generational equity principle and Article 14 Right to Equality. From an economic theory perspective all are related with property rights. Any loss of species and biodiversity due to overharvesting and pollution are permanent. We observe that in Karnataka around 30-40 of rich marine biodiversity is lost annually due to fishing speed boats compared to less than 5 % by the traditional sector. Most of these resources are sold to fish-meal companies for feed manufacturing to aquaculture, Mariculture and poultry industries. The loss of marine bio resources through such conversion into feed for culture of aquatic animals is 2-3 times greater than the value of aquaculture production, in addition of subsidized fuel spent on deep sea vessels. Data indicate similar trend across the country. The loss of marine resources affects everyone while benefiting a few fish meal and oil companies rich in the short run. In the long run even the marine-based value-addition industries also might get affected.

Windfall-gain by the deep sea fishing companies and fish meal companies is treated as private profits and not the sale of common inherited assets and were spent on consumption. However fishing policy should treat this revenue from deep sea fishing and fish meal companies as inherited assets. The immediate impact of such change would be that the government will not have any money from the fishing industry to provide subsidized fuel and other capital input which further encourages over-harvesting of resources. All the super normal profits earned by the vessels should be deposited in a biological permanent fund. This fund could be distributed among traditional fisheries following sustainable fishing practices. This will reduce poverty among the fishers and promote equality among fishing community. The biodiversity is also protected with lower incentives to extract the resources, higher price to fish and it could reduce fishing conflicts also. Based on a study of primary data collected for two years (2013-14 and 2014-15) Jyothis (2015) reveal that 14.5 percent of the total biomass is harvested in the form of by catch which is nearly 35 percent of the land value of Rs. 20.42 billion and 318,827 tons. One of the major attraction for harvesting by catch and juveniles is the increasing demand from the poultry, and aqua feed industry to manufacture feed for mariculture and shrimp farming sectors.

III. CASE STUDY ON VALUE CHAIN OF FISH MEAL INDUSTRY

Understanding the economic value of coastal ecosystem services in general and biodiversity in particular is useful for informed decision making in the coastal zone. The regulatory framework governing coastal zone (CRZ 2011) and Environmental Policy (MOEF, 2006) contain the directions for considering all types of benefits and costs both market and non-market to the extent they are quantifiable. The assessment of economic value of ecosystem services is relatively a new phenomenon. Incorporating non-market values into ICZM requires both mapping of ecosystems and services provided by them, and conducting research on the valuation of those services. Another reason for estimating non-market values is to be able to develop proper market for biodiversity attributes.

Several criteria are used for the purpose of estimating the non-market economic value of the coastal resources. However, the relative scarcity and human appreciation of the resource are most important. The researchers view the value as the capacity of the resources to generate a flow of goods and services and ecological functions that can satisfy human needs of various kinds. In other words, resources are considered in economic terms only in their capacity to provide satisfy human needs.

Economic Basis of Pricing Marine Bio-resources

The basic economic value of a bio-resource refers to the scarcity value of the physical product and value in exchange. The total economic value of a resource product is classified into four categories:

A. The price received by the primary harvester when they sell the physical product

B. The price reflecting the value added services by the market intermediaries when it reaches the final consumers which includes the cost of marketing services and profit margin

C. The lost value of alternative direct uses: When a bio-resource/fish is used for producing fishmeal, the alternative direct uses such as direct human consumption in the form of fresh fish/dry fish or pharmaceutical uses are lost which could have contributed more for human wellbeing

D. Lost indirect and non-use values: The harvested bio-resource also has indirect and non-use values such as conservation values and existence values; biodiversity richness provides resilience and stability to the ecosystem, which are indirect values.

The sum total of these values represents the true or full value of the bio-resource. However, the market may not be able to capture all these values and normally only reflects the direct price received by the primary producer and value added by the market intermediaries. However, even in this value chain, there are lots of imperfections and the primary producer is deprived of his due share in the final price. Creating policy- and market-based solutions are necessary to ensure that primary resource harvesters receive the due share in the consumers' price, and in return, engage in a more sustainable harvesting of biodiversity rich marine resources in ways that results in minimal loss to the ecosystem and the society. The first logical step towards this goal is to have a clear

understanding of the amount of value addition throughout the value chain of a given bio-resource. We present the case study of the value chain in the fishmeal manufacturing process.

The fishmeal industry is one of the most thriving industries in India. The introduction of multi-day trawling resulted in harvesting of a large quantity of biodiversity-rich by-catch in addition to commercially important fishes. India produces around 65000 tons of fishmeal and 34000 tons of fish oil with 35 fishmeal plants approximately (Ponnusamy 2012). The present study is based on the field work carried out by the authors in June-July 2015. Fish meal is recognized as a valuable animal protein supplement and a source of vitamins, minerals and unknown growth factors. Fish meals are added to the diet as high quality supplements to obtain efficient diets, particularly for aquaculture and animal feed. Fish oil is highly refined, long-chain omega-3 specifically formulated as a food ingredient. Fish oil is used in the food applications such as bakery products, beverages, confectionery, dairy products, fish and meat products etc. The Indian Sardine Fish *(Sardinella longiceps)* is the main raw material used for the manufacture of fish meal and fish oil.

The following section provides a description of the fish meal and fish oil industry utilizing small pelagic fishes in Karnataka, west coast of India. The analysis is based on the data collected from 4 fish meal/oil companies out of around 22 plants located along the coastal Karnataka during 2015-16. Except during the monsoon ban period, one of the regulatory measures by the state (closed seasons) which extends over a period of 60 days during June-July the fish meal and oil plants operate throughout the year. Due to variability in the species composition and harvest quantity, these companies depend upon each and every species supplied to them by the agents/fishers at multiple landing centres. The fish meal plants also commission fishing boats directly which works with the plant and ensures that the other companies do not compete with price offers. Since most of these plants are export oriented they maintain international standards and regulations.

The primary data was collected from the documents maintained by the companies directly. The records maintained by these companies were accessed and average quantity and price was estimated. Table 3 presents the major species procured by the fish meal/oil companies along the coast of Karnataka

Table 12 Procurement cost of Raw materials (Rs/Ton/Year)

Fish type	Quantity in Tons	Price (Rs./Ton)	Cost of raw fish (Rs. Lakh)
oil sardine	20000	8000	1600
Chemmeen	15000	5000	750
Tuna	15000	8000	1200
Ribbon fish	10000	7000	700
Mackerel	10000	10000	1000
Silver bellies	10000	8000	800

Anchovies	10000	8000	800
miscellaneous	10000	6000	600
Total/overall	100000	7500	7450

Source: primary data 2015

The average price was highest for oil sardine due to its higher yield followed by other species such as tuna and mackerel. Thus the price mainly depends on the expected yield in terms of oil and fishmeal. Thus the average cost of procuring raw material by the fish meal companies was Rs. 7500/ton which varied between Rs.1200/ton for tuna to Rs. 600 /ton for miscellaneous fishes. The miscellaneous fishes which represent rich biodiversity are sold at the least price which is based on the commercial value and not on the biodiversity value.

Table 3.2 shows the fixed and variable costs incurred by the fishmeal/oil companies (four plants, two each in Dakshina Kannada and Udupi district) for processing and extracting the products. The fixed costs constitute around 40 percent of the total cost and the rest constitutes variable costs except raw material costs.

Table 13 Cost of producing fishmeal/fish oil and other products

Sl. No.	Particulars	Processing cost (Rs/per ton)	Per cent
	Fixed cost		
1	Bank interest	600	6.63
2	Depreciation	810	8.95
3	Machinery maintenance	990	10.94
4	Plant maintenance	200	2.21
5	Staff salary	720	7.96
6	Staff welfare	260	2.87
	Total fixed cost	3580	39.56
	Variable cost		
7	Electricity	1250	13.81
8	Generator	250	2.76
9	Labour	950	10.50
10	Loading and unloading	370	4.09
11	Fire wood	1500	16.57
12	Fishmeal oil	390	4.31
13	Packing materials	360	3.98
14	Others	400	4.42
	Total variable cost	5470	60.44
	Grand Total	9050	100.00

The machinery maintenance and staff salary constitutes the major fixed expenses followed by others such as bank charges, depreciation and staff welfare etc. Among the variable costs the cost of energy constitutes 30-35 percent followed by labour. The table shows that the machinery depreciation, maintenance and electricity are some of the major expenses. Table 14 shows the estimated value addition and net profit per ton of raw fish processed and production of different value added products.

Table 14 Value addition and Net profit (Rs. per Ton)

Fish products	% yield	Quantity fish product for 1000 Kg raw fish (Kgs)	Price (Rs/ kg)	Gross returns	Processing costs	Value addition	Raw materials cost	Profit
1	2	3	4	5 (3*4)	6	7 (5-6)	8	9 (5-(6+8)
Fish oil	15	150	170	25500	1215	24285	1125	23160
Fish meal	25	250	130	32500	2025	30475	1875	28600
Fish paste	50	500	50	25000	4050	20950	3750	17200
Fertilizers	10	100	10	1000	0	1000	750	250
Total	100	1000	-	84000	7290	76710	7500	69210

The column 1 in the above table 3.3 shows the range of products produced by the companies by using one ton of fresh fish. Column 2 shows the average yield of each product produced by using the same one ton of fish. Column 4 presents the average market price of the products realized by the companies. The gross returns from the sale of each product were estimated by multiplying the average production with the market price. The total processing cost of 9050 (table 7) was divided between four products based on their yield rates (column 2). Column 7 was arrived by deducting the processing costs from the gross returns. The column 8 was generated by dividing the total raw material cost in proportion to the yield rate. The net profit was arrived by deducting raw material and processing costs (column 6 and 8) from the gross returns (column 5).

Table 3.4 shows the results of the profitability analysis of the fish oil/meal firms. The firms in general add substantial values to the raw materials and share a huge profit also. It could be observed that the raw material of one ton procured at the cost of Rs.7500 is processed and value is added to the extent of Rs. 76710 by producing four joint products. The net value added (profit) per ton of raw fish was Rs. 69210. Thus the value of the final products is almost 10 times the value of raw material which is exclusively enjoyed by the fish oil/meal companies

IV. WHY ACCESS FEE FOR UTILIZING MARINE BIOLOGICAL SERVICES

Historically fisheries economists developed the notion of common property problem of marine fisheries and there is a constant tendency to overexploit the rich fishing ground until the total revenue is equal to total cost the fisheries economists suggested that privatization or sole ownership would lead to economically efficient allocation of fishing effort among grounds of different productivity. Thus most economists started believing that natural resources such as fisheries should be either privatized or managed by the government. Since governments are expected to be relatively less efficient, private participation was the only choice before the social planner.

With the introduction of Exclusive Economic Zone under the Law of the Seas, in 1982 the coastal nations started increasing their fishing capacity through modern fishing methods and technology for exploiting fishing stocks within their extended jurisdiction of 200 mile economic zone. However, soon it was realized that the increase of fishing capacity of most coastal nations was excessive given the limited fish stocks. Thus there were no programs and policies which address the core issue of over exploitation of marine resources namely free access to limited natural fishery resources unlike with timber, minerals, oil and other non-living marine resources. There are rules for harvesting and pricing of other common property resources such as forest products (timber), minerals and oil from land and oceans. The developing countries such as India tried to encourage commercial and small-scale fishing by subsidizing capital and fuel, and in turn, reducing fishing costs, developing port infrastructure, and introducing licensing scheme. In more recent years, the introduction of deep sea fishing policy of the government provided further scope for accessing marine resources by bigger firms, which could out compete thousands of small-scale fishers. The major problem with the current system of accessing the marine resources is that the users of marine products namely exporters, processors, hotels, and other players in the value chain receive marine products at a throw away price unlike their counterparts in the oil, minerals, timber industry. For example the oil exploration companies pay huge royalties for accessing petroleum resources in the high seas. Therefore, an appropriate government response would be to design a public policy which assures sustainable and fair share of the consumer rupees for the primary resource harvesters of valued fish biodiversity. Thus the large users of marine bio resources such as exporters and processing companies may be made to pay a royalty /access fee for the opportunity to utilize the rich bio resources. The Biodiversity Act 2004 specifies a fixed amount to be paid by the processing companies. Over the years such a system could be replaced by a bidding system to access specific resources based on their biodiversity value. The Access and Benefit sharing rules for biological resources of 2014 imposes a 5% fees on the proceeds of benefit sharing. It may include an upfront payment of not less than 5% on the proceeds of the auction or sale amount of a high economic value bio-product, and the successful bidder or the purchaser may pay the amount to the designated fund, before accessing the biological resource.

Laws, Regulations and Institutions for conservation of Marine Biodiversity:

Various laws and regulations in India are dealing with aspects of marine biodiversity under the broad goal of environment protection. These are the Environment (Protection) Act, 1986, the Water (Prevention and Control Pollution) Act, 1974 as well as the Fisheries Act, 1897, the Wild Life Protection Act, 1972 and the Forest Conservation Act, 1980. For instance, it appears that under the Environment (Protection) Act, 1986, effluents discharged by commercial shrimp farms could be covered by the definition of environmental pollutant, environment pollution and hazardous substance. The Water (Prevention and Control Pollution) Act 1974 has been enacted to provide the prevention and control of water pollution and maintaining or restoring of wholesomeness of water. The term trade effluent under this Act includes "any liquid, gaseous or solid substance which is discharged from any premises used for carrying on any (industry operation, or treatment and disposal system), other than domestic sewage". Shrimp farmers should obtain from the Pollution Control Boards an authorization to set up any treatment and disposal system, which is likely to discharge sewage or trade effluent into a stream or well or on land.

In January 2011 the Government of India enacted the new Coastal Zone Regulation Notification. It applies to "coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action." It is further limited by boundaries, which reduce the regulated core area to the inter-tidal zone and an adjacent 500-meter wide strip of land from the high tide line. The seaward line is the low tides line. It regulates a whole series of activities and uses. India's Coastal Regulation Zone is a good example of a coastal management law, which is built around a set of exiting development realities. The core of the regulation is a moratorium on new construction, such as in ecologically sensitive area, and a prohibition of most development activities between the Low Tide Level (LTL) and the high tide level (HTL). The formulation of the rules is complex and sometimes unclear as if the Government did not want to compromise all economic development activities. The annex to the Notification classifies the inter tidal zone and the landward area from the High Tide Line into four zoning categories, with fixed upland and offshore dimensions, and with different corresponding restrictions on construction and land use. Shrimp culture activities in these categories could either be excluded or authorized under special terms and conditions. In 2014 Government of India notified access and benefit sharing (ABS) rules which is broadly summarized as follows:

Any person who intends to access any biological resource and /or traditional knowledge should seek permission from the biodiversity board. If the buyer is a trader / manufacturer the benefit sharing obligation will be on buyer and in the range of 1-3% of the purchase price of the bio-resource. Collection of fees, if levied by Biodiversity Management Committee (BMC) for accessing or collecting any biological resource for commercial purposes from areas falling within its territorial jurisdiction under

sub-section (3) of section 41 of the Act, shall be in addition to the benefit sharing payable to the NBA/SBB under these regulations. ABS is like CSR (corporate social responsibility) where benefits are not direct and CSR is just 2% of profit while ABS is 2% of purchase value, so 7-10 times higher. International trade in many marine species is prohibited under various Acts and notifications. The exports of some of the species such as marine turtles, shells, gastropods (except the giant clams) are banned under the Wildlife Protection Act 1972 (WPA) and the Convention on International Trade in Endangered Species (CITES). The sea cucumber *(Beche-de-mer)* is another commercially important marine species that has very high export value. In 1982 Government of India put a ban on the export of *Beche-de-mer* below the size of 7.5 cm. In Andaman and Nichobar Islands fishing for sea cucumber is totally banned. Corals and associated species like sea-fans and sea-sponges are heavily exploited for their known sources of bio-active substances with wide application in the pharmaceutical industry. Especially sea-fans *(Gorgonids),* which constitute only source of prostoglandins and terpenoids (Hanfee, 2001). Black corals were listed in CITES Appendix II in 1981 to protect the highly exploited stony corals. However, control of coral trade is difficult since they are often collected in offshore areas not directly controlled by the coastal nations. Further, it is difficult to identify the species origin of final coral products. The urgency for protecting marine biodiversity seems to have been realized at the international and national levels. However, the anthropogenic activities that lead to biodiversity losses at the local levels are often influenced by state and local decisions. Tougher standards at the local levels are lacking. Even at the national level, only high-profile species get more protection. The part of the reason for this lop-sided or inadequate legal protection is the excessive emphasis on the market or export values of marine resources. In reality, market prices, and in turn, harvesting decisions may not take into account the societal value of the impairment inflicted on the biodiversity's ecological functions while harvesting marine biota. The following is an attempt toward developing a more comprehensive valuation framework that captures both market and non-market values of marine biodiversity

Suggestions for Implementing ABS

1. Identify the most important biological resources accessed for commercial utilization from the end point such as leather industry, paint industry, pharmaceutical industry, hospital suppliers, medical professionals, fish meal and oil companies, nutraceutical companies, exporters, cosmetic producers.

2. Identify the companies/firms involved in the production of such products in the state through personal enquiries with medical, pharmaceutical/nutraceutical and other related sources.

3. Engage a chartered accountant to identify the firms involved in producing identified products and analyzing/evaluating/verifying their balance sheet which is an open access document

4. Call for a stakeholder consultation meeting of the short listed representatives of the identified companies.

5. The resources /brochures and developing a communicating strategy is very important to convince all stakeholder groups including examples of successful ABS mechanism such as Madurai based Grama Muliga Company etc. How to replicate such examples in the marine sector. Organize expert consultation meetings.

6. Bring out a comprehensive list of final products and associated marine biological resources manufactured by the Indian and foreign companies

7. Create a scoring card system that will record the compliance with ABS and other regulations and provide incentives to the companies with partial and /or full compliances

8. Utilize chambers of commerce and local businesses to develop and share a project-specific list of relevant regulations. Create an electronic register listing potential partner companies and organizations involved in accessing marine biological resources

9. Ensure a most transparent way of utilizing the ABS funds in consultation with stakeholders. The biggest advantage of such a system is that rates are determined based on pure demand and supply factors and the process is transparent.

10. Call it a Business Forum of Marine Biological Resources

Conclusion and Recommendations

The importance of coastal and marine ecosystems in providing provisioning, cultural/recreational, supporting and regulating services has been known to society for many decades. However, there have been limited efforts to quantify their values objectively.. Inadequate knowledge of the magnitude true values of marine biodiversity and biological resources limits the ability to design effective and appropriate policies to address ecosystem overexploitation and degradation. In this report we have tried to assess the value generated at different stages of marine fish harvesting and processing and value added at different levels. In order to address threats to costal ecosystems many developed countries adopt a combination of command and control and market based (charges/subsidies) methods. In India there are only regulatory controls to protect wetlands and there is no scope for market based approach within the existing legal framework. It is important that the existing regulatory system should incorporate rules to introduce market based approaches. In this regard regulating the access to biological resources by imposing a cess based on the net value realized by the users is a significant step. The present study provides a case study of value chain and the net value received by the processing companies that could be included within the scope of access and benefit sharing. The products can be listed by their manufacturing industries and fees could be levied. They may pay on for the bio-resource product fees, not for others. Patanjali for instance markets many non-bio products too. A product listing is easy but the issue is whether to use agri-products in it or only wild/ forest. The later has small scope. The Biodiversity Board could also start marking system like Green line/ triangle for bio-products & fees paid, red/ orange if unpaid. A bio-declaration form may be

introduced for export at airports/ shipping ports at airports/ flight, to declare bio-goods & if ABS fee is paid. The NBA/state biodiversity boards could begin to screen all bio-resource products exported/processed for its contents to check if any bio-resource has been used. If any bio-resource elements were found the royalty payable could be some percentage the market value of the product. The Board could insist on all processors/ exporters to execute an agreement/declaration that the product does/doesn't consist of any bio-resource before it was shipped out of the country. The Board could also finance laboratories to detect the contents of the bio products at a few selected ports and also enter into an agreement with Export Inspection Authority.

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Dr. B.U. Supreetha[1] and B. A. Shamasundar [2]

Former Professor and Head[2],
Department of Fish Processing Technology,
College of Fisheries, Mangalore -575 002[1,2].
Email: bashamasundar@gmail.com

Chapter 10

Economic evaluation of marine fishery resources of Karnataka State and value realization of different processed products

Abstract:

The ocean, which is called the 'mother of origin of life', is also the rich source of food for humans. The biodiversity of marine environment far exceeds that of terrestrial environment and offers vast potential for exploitation of nutritious food forever increasing human population. The diverse flora and fauna from marine environment offers valuable products for pharmaceutical and food industry. Fish and shellfish form the traditional source of animal protein for coastal population. With present trend of preference for health foods, demand for aquatic products is rapidly increasing. The supply of fish has not kept pace with the demand. Being highly perishable, the supply of quality fish has compounded the problem. Fresh fish is the central point in fish as food utilization and for commercial activity. The economic valuation of fisheries resources will assume significance for better management of marine eco-system. In the present paper the economic evaluation of marine fishery resources meant for food along Karnataka coast have been evaluated. Though there are different methods available for economic evaluation of eco-systems, in the present study the economic valuation has been arrived at based on the market price. An attempt has also been made to understand how the fishes are being used for different processing and the value realized by freezing the fish and shellfishes. A case study of assessing the value chain of processed surimi has been explained. Future utilization of fish for food and industrial products minimizing post harvest loss has also been highlighted.

Introduction:

The coastal India comprising of nine maritime States and two Union territories supports 30% of 1.30 billion populations. The Indian coastal system comprises of estuaries, lagoons, mangroves coral reefs, marshes, sea grass beds, and rocky and sandy beaches that extend to 40,808 sq ft. They are known for high biological productivity providing range of habitat for many aquatic flora and fauna. The marine eco-system

apart from providing the food also offers many non food uses and pharmaceuticals. It is apparent that the inventory of marine eco-system is extensive but not exhaustive. The human society is reaping many economic benefits without assessing the actual value. The coastal and marine eco-systems are among the most productive eco-systems in the world and greater economic value to human society. Hence it is important to assess both the nutritional and economic value of the marine system for better understanding and sustainable exploitation.

Importance of fish in Nutritional Security in Indian Context

Nutritional security is the physical and economic access by all people to the nutritionally adequate food they need. Therefore, it embodies stable, sustainable and predictable supply of nutritionally adequate food for life functions and equity through access for all with reference to the means of production and/or purchasing power. Ensuring sustainable nutritional security is the major challenge confronting all the developing countries. In India 16% of world population has to be sustained on 2.4 % of global land area. It is imperative to look for alternate sources of nutritious food to feed increasing population. The rich bio-diversity from marine environment offers protein rich food and other products of use to mankind. Fisheries are emerging as one of the fastest growing food production system all over the world. The potential for fisheries development in India is highly promising in view of physical and biological resources available in the country coupled with technological developments.

Fish is a highly perishable commodity and supply of acceptable quality is a challenging task to the all concerned in fisheries sector. This is compounded further with the world fish production from capture fisheries is not showing significant increase in catches. As human population is ever increasing, the stagnation in fish production implies that less and less fish will be available every year. Nevertheless, a large fraction of this valuable commodity is wasted due to discard at sea and deterioration after landing and this post harvest loss is estimated to be 20-25% of total catches landed (FAO, 1995). Better utilization of aquatic resources should therefore aim primarily at reducing this enormous loss by improving preservation of fish and fishery products and upgrading the discarded low value fish to high value fishery products. At an International Convention of 100 maritime nations at Tokyo in 1996 discussed future plans on 'Sustainable contribution of fisheries to food security' and adopted a set of immediate actions for conservation and management of fishery resources. These included minimizing post harvest loses and optimal use of the resources to increase the available supply of fish and fishery products for human consumption.

India has extensive coastline of 8129 Km and exclusive economic zone of 2.02 million Km^2 . The Indian marine eco-system has been identified as one of the rich sources for major flora and fauna. In India, the total fish production has crossed 10 million mt. during the year 2016-2017. The present annual yield from marine fisheries is about 4 million mt and only additional production that can be expected in future is about 0.9

million mt from un-fished off shore waters The diversity of fish species is varied and if exploited optimally, the resources from sea will add new dimension to the nutritional security of the country. The projected requirements of fish by 2020 are 15 million mt. This huge deficit has to be made by some other sources. In the present circumstances the only available source of mooting national, as well as global requirements is the reduction in wastage of fish caught and rapid expansion of aquatic farming.

There are several unique features about fish that inhibit or plague trade and development. The major one is that it is very perishable and requires special attention and facilities if quality is to be maintained. This remains as a major problem in the marketing of fish even today and results in major losses throughout the industry in both developed and developing countries. Another handicap is that fish, unlike agricultural produce, must be transported from place of harvest to distant places. It is recognized that protein from aquatic sources could drastically reduce famine in the world today if distribution system could be set up to transport available fish resources to where they are most needed..

Need for Economic Evaluation of Marine Ecosystem

The importance of coastal ecosystems to human society has many dimensions and economics is the major concern. Taking into account the nutritional needs, socio-economic and non food uses, and the marine ecosystem plays a major role in human activities. Hence, expressing the value of coastal ecosystem services in economic terms or more specifically, in monetary units, is important. This is because it not only helps raise awareness among citizens of the (relative) importance of these resources, but it also assists policy-makers in the efficient use of limited government budgets by identifying where protection and restoration is economically most important and can be provided at least cost. Monetary values of coastal ecosystem services are also useful in providing incentives for their conservation and sustainable use (for example in a Payment for Ecosystem Services scheme). Further, they can also help determine the extent to which compensation should be paid for the loss of coastal ecosystem services in liability regimes.

Economic valuation is a means to describe how valuable the natural world is to us. Estimating an economic value for the natural environment, including the marine environment, begins with understanding the many different services that the environment can provide and the contribution these services make to the wellbeing of people. The concept of ecosystem services provides a framework for identifying and quantifying the variety of benefits that we obtain from the environment. Often, decisions to support economic development negatively affect the functioning or health of ecosystems. Although such decisions are intended to enhance human welfare, they can also reduce the supply of ecosystem services that are critical to human wellbeing and sustainable development. Every time we make a decision that affects the way in which the natural environment functions we are implicitly putting a value on the environment.

With a broader focus on valuing the benefits provided by ecosystems, policy options that enhance the natural environment are also more likely to be considered that demonstrate that investing in natural capital can make economic sense.

In the present paper an attempt has been made to evaluate marine fishery resources of Karnataka state with reference to value and how these resources are being used for different processing. It is aimed to get the estimate of value of different fishes that are harvested and its realization by using in different processing operations.

Methodologies Available to Assess the Economic Value of Eco-System

Many methodologies to evaluate the economic value of a particular eco-system with biological diversity have been developed. An important step in discussing the notion of biodiversity value is defining biodiversity. The United Nations Convention on Biological Diversity (UNEP, 1992) defines it as the variability among living organisms from all sources, including terrestrial, marine and the ecological complexes of which they are part (Nunes, *et al.,* 2001).

Biodiversity encompasses four levels that include genetic, species, eco-system and functional features. At the most basic level is genetic diversity, which corresponds to the degree of variability within species. Roughly speaking, it concerns the information represented by genes in the DNA of individual plants and animals (Wilson, 1994).

Species diversity refers to the variety of species. Empirical estimates of this are characterized by a large degree of uncertainty. In fact, only about 1.5 million species have been described so far (Parker, 1982; Arnett, 1985), while scientists estimate that the earth currently hosts 5–30 million species (Wilson, 1988). Less than half a million have been analyzed for potential economic uses (Miller et al., 1985). Since genetic and species diversity are directly linked, the distinction between them is sometimes blurred. In this sense, phenotypic diversity vs. genotypic diversity is relevant.

Ecosystem diversity refers to diversity at a supra-species level, namely, at the community level. This covers the variety of communities of organisms within particular habitats as well as the physical conditions under which they live. A longstanding theoretical paradigm suggests that species diversity is important because it enhances the productivity and stability of ecosystems (Odum,1950). However, recent studies acknowledge that no pattern or determinate relationship needs to exist between species diversity and the stability of ecosystems (Johnson et al., 1996). Folke et al. (1996) instead suggest that a system's robustness may be linked to the prevalence of a limited number of organisms and groups of organisms, sometimes referred to as 'keystone species'. It is also possible that the specific relationships depend very much on whether the abiotic environment is stable or not (Holling et al., 1995).

Functional diversity refers to the capacity of life-support ecosystems to absorb some level of stress, or shock, without flipping the current ecosystem to another regime of behavior, i.e. to another stability domain (Turner et al., 1999).This has been originally referred to as 'resilience' (Holling, 1973). Unfortunately, a system's functional robustness is still poorly understood and we often do not know the critical functional threshold associated with the variety of environmental conditions at different temporal and spatial scales (Perrings and Pearce, 1994).

The economic value of an eco-system comprising of different levels of bio-diversity can be approached by different methods. Several techniques have been developed over the years to value environmental resources and ecosystem services. They are commonly categorized into three broad approaches, namely direct market valuation approaches, revealed preference approaches and stated preference approaches. Direct market valuation approaches use market

information to value ecosystem goods or services where markets for these goods/ services exist (Kavi kumar et, al., 2016). Revealed preference approaches use information on prices that individuals are willing to pay in markets for related goods to value ecosystem services that may not be directly bought or sold in markets. Stated preference approaches use surveys to ask In India, there have been only few attempts to estimate the value of coastal and marine resources. However, there is now a growing literature of micro-studies that look at either A few studies in India that are linked to coastal and marine ecosystems have been presented. Anoop and Suryaprakash (2008) have used revealed preference method where the people what they are willing to pay for an environmental service based on a hypothetical scenario. This approach is used when ecosystem services are neither traded in markets nor are they closely related to any other marketed goods such that people cannot 'reveal' what they are willing to pay for them through their market purchases or actions.

In the present study the economic value of food fishes harvested from the coast of Karnataka, was evaluated by direct marketing price approach The catch statistics and value of fishes harvested were obtained from Department of Fisheries of Government of Karnataka. The data on the different fish processing facilities in Karnataka coast was obtained from MPEDA.

Marine Fishery Resources of Karnataka.

The fisheries fact profile sheet of Karnataka state is given in Table 1. The length of coastal line of Karnataka is 320 Km with an Exclusive Economic Zone are of 87,000 square Km. The coastal belt of Karnataka comprises of three districts, Dakshinna Kannada, Udupi and Uttara Kannada. The coastal belt supports direct livelihood for 1.7 lakh fishe rfolk residing in 144 marine fishing villages. The fishing activity is mainly carried out with mechanized fishing boats. Out of total 19,937 fishing vessels in operation nearly

40% are non mechanized. The remaining 60% is either partially or fully mechanized. The number of fishing harbors along the coast is 8 and there are 22 fishing jetties to land the harvest. All these infrastructure has been translated to a total fish production of 5,29,523 t during 2016-2017 (Table 2) . The marine catch from the Karnataka coast has shown steady increase in catches over past five years. Karnataka occupies the sixth position in the country in marine fish production. Among the three coastal districts of Karnataka, Dakshina Kannada and Udupi districts contributed 38% each, followed by the Uttara Kannada (24%). The Mangalore and Malpe Fisheries Harbors are the main contributors in the Dakshnina Kannada and Udupi districts respectively.

The major resources in different fishing villages landed is given in Table 3. The main characteristics of marine fisheries in Karnataka is the predominance of pelagic resources. In the year 2016 the estimated pelagic landing of 2.84 lakh t accounted for 54% of the total marine fish

Table 1: Marine fisheries profile of Karnataka

1	Exclusive Economic Zone	87000 sq.km
2	Continental Shelf	27000 sq.km
3	Coastal length	320 km.
4	Fishermen population	3.29 lakhs
5	Active fishermen population	1.58 lakhs
6	Fishermen villages	156
7	Harbours	8
8	Number of fishing vessels	
	• Mechanized	2776
	a) Multi day trawlers	775
	b) Small trawlers	270
	c) Purse-seine boats	205
	d) Others	
	• Boats with out- board engines	7469
	• Country crafts (Non-mechanized)	8442

Source: *Department of Fisheries, government of Karnataka 2017*

Table 2: Fish production in Karnataka state during last five years*

Year	Marine (MT)	Inland (MT)	Total (MT)
2013-14	357358	197952	555310
2014-15	389822	223419	613241
2015-16	411762	168828	580590
2016-17	529523	51047	580570
2017-18**	508470	49020	557490

*Source: Fisheries Department, Government of Karnataka (2017)

**2017- 2018 data provisional

Table 3 : Major fishery resources landed along the Karnataka coast

Resources	Landings (tones)	
	2015	2016
Indian Mackerel	65,699	88,219
Big eye	21,347	68554
Indian oil sardine	43,489	62,609
Thread fin breams	40,609	53,858
Lizard fish	28,399	33,972
Lesser sardines	6445	18990
Ribbon fish	17,866	16,808
Scads	42,890	25.275
Tunas	6640	16,801
Penaeid prawns	16,218	15,292
Cephalopods	26,344	26,604

Source: Marine Information Services, CMFRI report 23, 2017

landings (Somy Kuriakose and Sijo Paul,2017). An increase of 17% was noticed in the pelagic landings compared to 2015, mainly due to rise in the catch of Indian mackerel,oil sardine and lesser sardines. Demersal fish resources contributed 36% of the total landings. The spurt in the demurral fish landing was mainly due to heavy landings of *Priacanthus* spp. by trawlers. The crustacean and molluscan resources contributed almost equally (5%) to the total landings for the year 2016. Estimated catches of oil sardine was 62,609 t showing an increase of about 19,000 t over the previous year with major share (80%) coming from purse seiners. The landings of lesser sardines increased nearly threefold amounting to 18,990 t as a result of increased landings from trawlers and purse seiners. In 2016, landings of threadfin breams amounted to 52,858 t, 97% of which was caught in trawl nets that indicated an increase of 3%. There was a drastic drop of 40% in landings of scads. Marginal decline in the landings of

ribbonfishes, penaeid prawns and cephalopods was recorded. Mechanised and motorised sectors contributed 91% and 8% respectively of the estimated marine fish landings in Karnataka. Non-motorised sector contributed relatively little (1%) to the total marine fish landings in the state.

Processing of Fish in Karnataka

The principal aim of fish preservation is to delay, reduce or inhibit the microbial spoilage. In the case of fatty fish, the preservation may also aim at reducing or inhibiting oxidation and other undesirable changes in the fish lipids, which are highly unsaturated and capable of going rancid at various stages of processing. Among different methods of fish preservation, it is short-term preservation by chilling which has attracted worldwide attention. Perhaps, this is mainly because of preference for fresh fish by consumers. The other methods of fish preservation, which have commercial relevance, are freezing, canning, salting and drying, smoking and mince production. These preservation techniques are basically for human food and processing of fish into non-food items includes production of fishmeal and oil, silage and other industrial products.

The Indian seafood industry is mainly dependent on the export trade of frozen products. The export trade of frozen seafood started in 1953, with the first shipment of frozen shrimp to USA by M/s. Cochin Company from the port of Cochin. Since then the growth of frozen seafood industry is phenomenal. India's seafood exports have crossed Rs. 45,000/ crores during the year 2017-2018 (MPRDA 2018) Frozen shrimp, frozen finfish, frozen cuttle fish and surimi contributing to more than 80% of the earnings. Among the various seafood processing, it is the freezing industry in India that has occupied pre-eminent position. The scenario is no different in Karnataka, and it is the freezing industry that drives the export trade followed by fish meal and oil. At present, in Karnataka state major quantity of fish caught is being consumed either in fresh or chilled condition. The remaining proportion of the catch is consumed in frozen, salted and dried and to a small extent in ready to cook form. The processing facilities mainly exists along the coastal Karnataka which mainly includes freezing plants, a few canning plants, fish meal plants, drying yards and one surimi plant

The number and type of fish processing facilities in Karnataka state is given in Table 4. The number of freezing plants for processing of shrimp, fin fish and surimi has raisin to 14... The number of reduction units (for making fish meal and oil and fish protein hydrolysates) units is 21. The export value of fishes sent through Mangalore port is given Table 5. Of late, emphasis is being given for value addition to frozen products thereby realizing higher unit value. The freezing plants in Karnataka mainly produce bulk frozen products barring a few surimi plants. Concern over the safety of food is on the increase because of the probability of the hazardous pesticide residues, harmful chemicals, heavy metals, toxins, antibiotics, pathogenic microorganisms etc. As a result, there has been major shift in the quality control of food from the end product inspection to prevention, elimination or reduction of hazards. This is reflected

in mandatory regulations of the European Union (EU) and the United States of America (USA). Quality assurance in respect of products exported from India was introduced systematically with the enactment of Export (Quality Control and Inspection) Act, 1963. Quality assurance in fishery products was introduced in 1965 when frozen and canned shrimp was brought the purview of the Export (Quality Control and Inspection) Act, 1963. Subsequently, frog leg, lobster tail, squid, cuttlefish, canned crab meat, pomfret, beehede-mer, dried shrimp and dried fish also brought under the compulsory quality control and pre-shipment inspection scheme. By 1995, new quality concepts based on assessment of risk to human health and life, particularly the risks on account of harmful chemicals, antibiotics, pesticide residues, heavy metals, additives and disease causing organisms came into prominence. This quality management termed as Hazard Analysis Critical Control Point (HACCP). The HACCP with stress on safety based on a systematic approach to hazard identification, assessment and control which makes it different from the traditional inspection and quality control procedures. In HACCP system control is transferred from end product testing to on-line checking, that is a change from 'testing to failure' to 'preventing failure'. EC and USFDA have introduced a regulation making HACCP based seafood quality assurance system mandatory for its domestic industry as well as for all countries, which export seafood to EU and USA.

Economic valuation of fishery resources

The value of marine fishes harvested during different periods is given in Table 5. The quantity of fish landed during the period 2013-14 to 2015-16 has increased by 49%. The unit value realized per Kg of fish during the same period has increased from Rs 57.5 to 81.70. This price increase of 42% during the 3 years period is likely due to higher operating cost of fishing operations. Though catches comprises of different varieties fish and shell fish, the average price has been calculated for evaluating the total economic value.

The export of fishes from Mangalore port (in quantity and value) during the period 2013-14 to 2017-18 is given in Table 6. There was a steady increase both in quantity and value during the period 2013-14 to 2017-18. The export quantity as a percentage of total fish harvested fluctuated from 23 – 29% during the period 2013-2018. These fluctuations could be due to many extrinsic and intrinsic factors. It also should be pointed that in export trade, many times the fishes

Table 4: Fish processing plants in three coastal districts of Karnataka

Sl. No.	Fish processing plants	Numbers	Metric tons
1.	Ice plants	263	5609.0/day
2.	Cold storage	49	2925
3.	Freezing plants	11	1255
4.	Canning Plants	8	528.5
5.	Fish Meal	21	424.5

Source: Karnataka State Department of Fisheries (2014-15)

Table 5. The value of Marine fish produced (in Crores) at the market price during 2011-12 to 2015-16

Year	Value (Rs in Crores)
2011-12	1506.29
2012-13	2016.68
2013-14	2014.01
2014-15	2650.93
2015-16	3424.33

Source: Karnataka Fisheries Department statistics (2016-17)

Table 6 : Marine products export from Mangalore port

Year	Quantity(T)	Rs (Crores)
2013-14	98230	1114.64
2014-15	115470	1363.68
2015-16	83954	1048.60
2016-17	126405	1584.08
2017-18	144325	1783.41

Source: Marine Products Export Development Authority (2018)

processed in Mangalore may be exported from Kochi port. Also the raw material used for processing may arrive from different places other than Mangalore. In such circumstances it will be difficult to quantify the value of export that has taken place from Mangalore port.

ASSESSING THE VALUE CHAIN IN THE PROCESSED FISHERY PRODUCTS: A CASE STUDY WITH SURIMI

The fresh fish harvested from marine eco-system is used for human consumption immediately or processed to different products to extend the shelf life by value addition in the process. The processed fishery products realize higher value by several fold compared to the value of fresh fish. This value addition in the supply chain system will be the basis for Access and Benefit Sharing In this study an attempt has been made for economic valuation of the processed frozen product – Surimi, wherein, different groups of fishes are used as raw material. A complete economic analysis has been made considering the International market prize, profitability, challenges and opportunities in the industry.

Introdction

The term Surimi is a Japanese word used for deboned, minced, and washed fish flesh, an intermediate product in the manufacture of imitation products such as crab legs. The surimi industry demands white fish mainly because of the importance of the whiteness and textural properties of the resulting products. Surimi is a traditional product of Japan

consumed worldwide and production has reached about 830,000 MT during 2017 with the major contribution of 400,000 MT from South Asian and South East Asian countries. Alaska Pollack is the single major species contributing 21% of the total surimi production whereas the tropical species like threadfin bream, croaker, lizard fish, ribbon fish and bigeye snapper together contributing about 60%. (www.future-seafood.com). Increasing consumption and demand of surimi based products may be attributed to the wholesomeness, nutritious nature and affordable price.

Surimi processing

Surimi is prepared from fish by gutting, heading, filleting, mincing, water washing and refining (Figure 1). Major step in conventional surimi processing is repeated washing of fish mince with chilled water (5-10°C) resulting odorless and colorless product. Depending on the condition of fish upon processing and the fish species, the temperature of water used for washing, washing cycle and volume of water may be varied. Washing cycles and meat to water ratio varies from 2 to 4 times and 5:1 to 10:1 respectively. The purpose of water washing is to remove the lipids and water soluble sarcoplasmic proteins such as blood, enzymes, and the heme compound causes lipid oxidation. As a result, this process concentrates myofibrillar proteins. Washed fish mince is then pumped to a refiner to remove connective tissues and small pin bones. As a final dewatering step, washed meat is subjected to a screw press before mixing with cryoprotectants. Cryoprotectants commonly used in a commercial application for cold water species are 4% sugar, 4-5% sorbitol and 0.2-0.3% polyphosphate with approximate moisture contents at 74-76%. However, for surimi from warm water species such as threadfin bream manufactured in SE Asia and India, only 6% sugar and 0.2-0.3% polyphosphates are used without sorbitol. Even though fish proteins from warm water are having better frozen stability, addition of equal amount of cryoprotectants is desired to maintain the consistency in sweetness and longer shelf life. Finally surimi is stuffed into 10Kg plastic bags before subjecting to a plate freezer. After freezing blocks with their core temperature at -20°C, two blocks are packed in a carton box for frozen storage (Park and Lin 2005).

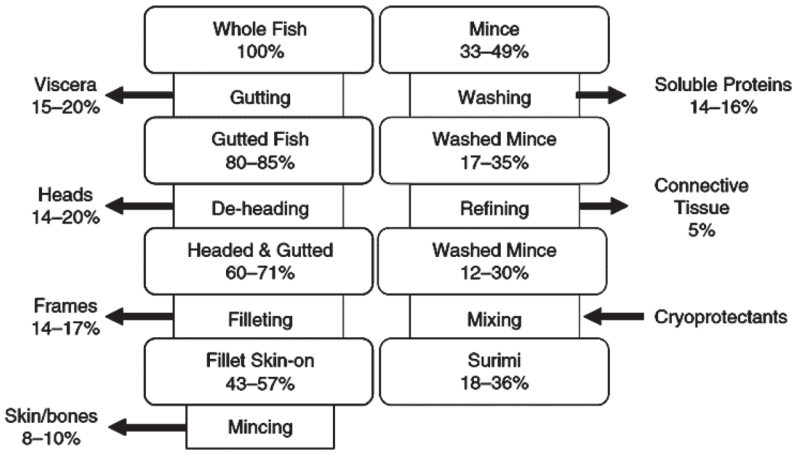
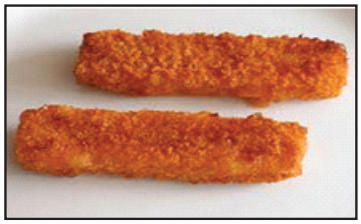
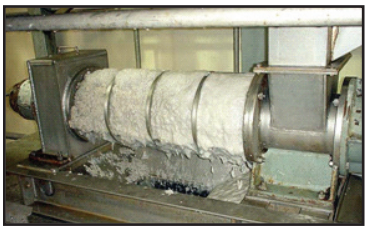
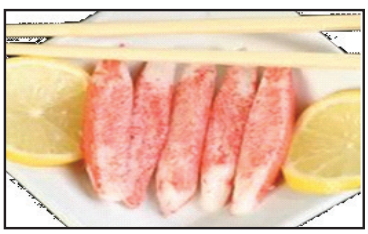


Fig 1: Flow line for the production of surimi

A pictorial representation of surimi production and different surimi products are represented in Fig 2.

		
Threadfin bream	Surimi Filling	Fried - Satsumaag
		
Processing of Fish	Surimi blocks	Fried - Hampen
		
Bowl cutter chopper machine	Surimi sausage	Broiled - Chikuwa
		
Meat washing /Leaching Machine	Surimi Shrimps	Steamed - Kamamboko
		
Refining Machine	Surimi Crab sticks	Breaded surimi products
		
Dewatering/Screw pressing	Surimi fish sticks	Surimi fish balls

During the production of surimi a considerable quantity of high value by-products may be generated. The proportion of waste generated in a typical surimi industry is given in the following Table 7

Table 7: Proportion of waste generated to the whole fish during the course of surimi processing.

Processing Steps	By products	Proportion of whole fish
Gutting	Viscera	15-30%
Deheading	Head	14-20%
Filleting	Frame	17%
Mincing	Skin/bone	8-10%
Washing	Wash water	14-16%
Refining	Connective tissue	4-8%

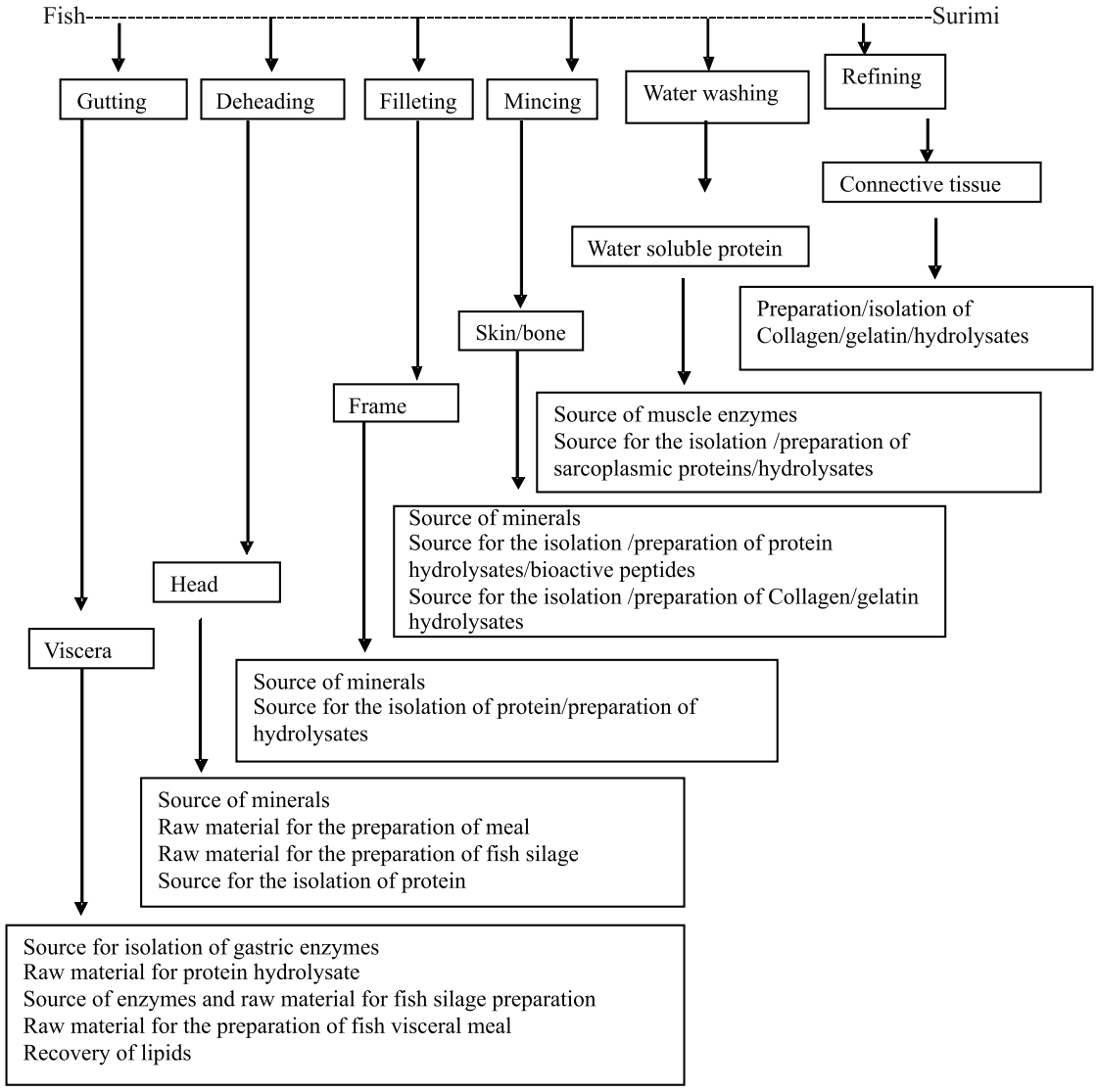


Figure 3. Generation of surimi processing byproducts and possible uses

Surimi production in India

There are about 10 surimi processing plants in India and are mostly situated on the western coast of India. About 8-10% of world's production is produced in India. The average production of surimi during the last five years is around 60,000 t. The Karnataka state has 4 surimi plants out of which 3 are active. Two surimi plants are situated in Mangalore and other two are in Udupi district. The fish species used for surimi production in India includes threadfin breams, croakers, ribbon fish, bull;s eye fish and to some extent lesser sardines,. The plant capacities of surimi plant varies from 30 -100 t of final product /day. Normally the yield of surimi varies from 30-45% depending on the size of fish. On an average the yield varies from 35-40%.

Cost evaluation of surimi from marine fishes

While calculating the cost of surimi from a few marine fishes following parameters are taken as standards.

Cost of fish / ton	**Rs 45,000- 50,000/**
Yield of Surimi from whole fish	**35-40%**
Production capacity	**35 t /.day of final product**
Quantity of whole fish fish /day	**100 t**
Number of days plant can operate	**180 days in a year**
International Market price of surimi	**Rs 150-230/Kg (Rs150,000–230,000/ ton)**
Interest on capital cost	**12% pa**
Interest on working capital	**12% pa**

Investment distribution

Capital cost: Land, machineries, building, cold storage, ETP and quality control laboratory	Rs 5.0 crores
Fixed cost including cost of production, salary, maintaince of plant, ETP running cost, Quality control analysis depreciation and interest and principal amount servicing /year	Rs 10.0 crores

Cost analysis details

Cost of 100 t of fish @ Rs 45,000/t/day for the period of 180 days	**Rs 81 crores**
Cost of final product surimi at Rs 150,000/ t. Total quanity of surimi produced 35 t / day. Cost realized for 35 t x 180 days	**Rs 94.5 crores**
Cost of sale of processing waste for a period 180 days @ Rs 5.Kg of waste generated. Total waste generated for a period of six months is 30 t. The price realized by the sale of waste at Rs 5000/t	**Rs 15,00,000/**

Profitability

Cost of production = cost of fish + fixed cost : Rs 81+ 10 crores = Rs 91 crores

Price realized by sale of 6300 t of surimi = Rs 94.5 crores

Total profit for one year: Rs 3.5 crores

Add price by sale of waste: Rs 0.15 crores

Total profit: Rs 3.65 crores.

Payback period

36-40 months. Once the loan is cleared, the profitability will increase substantially.

The above calculation has taken into account the reasonably lowest price for sale of surimi. It is not uncommon to find the price of surimi in the International market exceeding Rs 200,000 / ton.

Challenges and opportunities in realizing the higher price for surimi

Challenges:

a) The major challenges for surimi industry are the supply of raw material at a constant price for more than 200 days of operation. The profitability gets eroded if the raw material cost is fluctuating. Also, the vagaries of nature make a very poor fishing season. The quality of raw material arriving at surimi plant will determine the export value. Most often the multi day trawl boats are used wherein, the fishing extends for 10-15 days impacting the quality of raw material. Though insulated boxes are used during fishing, a better strategies need to be evolved for keeping the quality of fishes

b) The International prices too often fluctuate from USD 2-5/Kg. The stocks of frozen surimi cannot be held for a longer period, as cold storage costs becomes prohibitive.

c) If raw material is not available at the factory site, it has to be obtained from other states which makes raw material expensive.

d) The non-existence of domestic market for surimi is another reason for over dependence on International market leading to price fluctuations.

e) The surimi Industry is highly capital intensive and many a times the margins are so thin and it is the volume that matters for trade.

f) The stringent quality standards stipulated by importing countries will add to operational costs .

g) As surimi industry requires huge quantity of freshwater, efficient recycling and reuse for the processes will be critical.

Opportunities

a) Innovations in improving the yield by 3-5% will increase the profit margin.

b) Use of different raw material for surimi production is a potential source for innovation.

c) Efficient waste utilization for high value product like gelatin, enzymes, and fish protein hydrolysates.

d) Newer and efficient ETP should be looked into to minimize environmental pollution in and around the plant.

Future Utilization of Fish

Considering the higher demand for fish and fishery products with less availability of raw material, it is imperative that great attention has to be given to appropriate post harvest technology. The fresh fish market is of greater importance in developing countries like India, as infrastructures for distribution of frozen products are not well developed. It is likely distribution of chilled fish will have a major role in catering to fish eating population. Recent advances made in the bulk handling of small fish indicate that the chill preservation at sea may be greatly improved. A number of small and medium size fish, which up to now have been reduced to fishmeal and oil, will be preserved for food in the future. This will require new and improved preservation methods both at sea and ashore.

The domestic market for frozen seafood is at a very low level. It is time that our freezing industry should explore the means to strengthen the domestic market. Though it calls for higher capital investment to establish cold chain system, in the long run it will be beneficial in the event of fluctuations in the International market. With increase in fish production from aquaculture, distribution of these fishes in frozen form will be very much on the cards. Therefore, it is reasonable to except that future frozen seafood trade will be more balanced between domestic and export market. This will also ensure certain stability in aquaculture.

Nearly 13–15% of the total fish landed goes for salting and drying. There is a strong internal demand for salted and cured products. There is a need to improve the curing process to cater hygienic and wholesome dried product. The exports of salted and dried products from India is on the declining trend, mainly due to quality related problem and there is an urgent need to improve the quality by adopting better available technology to boost the export trade in this sector. Attractive packaging meeting international standards will also help in better trade both for domestic and export market.

Production of surimi is an efficient process for obtaining fish flesh separate from skin and bones. It is likely to be used more commonly than it is now because it reduces waste through recovery of edible flesh from small fish that do not lend themselves to market as whole fish. The scope for utilizing small varieties of fishes from fresh water

aquaculture for surimi production should be though off, as at present there is no demand for these fishes. Strong points in this use for surimi are that such products are consistent with the growing demand for convenience foods such as fish sausage, fish sticks and cakes. Each product should stand on its own and be judged solely on the palatability, nutrition and convenience and price.

The canning industry in India at present is in poor shape owing to the lack of suitable containers and process. The cost of the canned products is prohibitive even for urban middle class consumers. It is worthwhile to note that recent technology developed by Central Institute of Fishery Technology, Cochin, with locally available reportable pouches should pave way for popularization of canned fishery products. With exploitation of tuna resources from Indian Ocean region optimally, which is more suited for canning process, there is a higher potential for export market.

Conclusion

The marine fishery resources are huge and diverse. The fishery resources are mainly supported by pelagic fishes. The average total quantity of fish and shellfish landed during 2016-18 is around 5 lakh tons/ year with the total value ranging from Rs 3500-4000 crores. The disposition of catch indicates major quantity is consumed in fresh/ chilled form and 20-29% goes for processing meant for export. Among the products that are exported, it is frozen shrimps, cuttle fishes and small quantity of fin fishes dominates the list. The export earnings during the last five years average to 1380 crores / year. The schemes for conservation of marine resources for optimum exploitation should be strengthened for constant supply of raw material for food and non food purposes. An estimate of Rs 5000 crores worth fish and shellfishes are being harvested from the marine eco-system of Karnataka. A nominal amount may be levied both from the harvesters and processors which can be made use for conservation of marine eco-system. A case study of economic valuation of value added fishery product like surimi has been presented. By converting the whole fish to frozen surimi the primary producers and the industry benefits immensely.

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About the Project:

The Objective of the UNEP-GEF MoEF project on ABS is to increase the institutional, individual and systemic capacities of stakeholders to effectively implement the Biological Diversity Act, 2002 and the Rules 2004 to achieve biodiversity conservation through implementing Access and Benefit Sharing Agreements in India. This project is being implemented in 10 states of India namely Andhra Pradesh, Gujarat, Goa, Karnataka, Odisha, Telangana, Tripura, West Bengal, Himachal Pradesh and Sikkim. The executing organisation includes NBA in collaboration with the 10 SBBs, Botanical Survey of India (BSI), Zoological Survey of India (ZSI), United Nations Development Programme (UNDP), United Nations Environment Programme - Division of Environmental Law and Conventions (UNEP/DELC), United Nations University – Institute of Advanced studies (UNU-IAS) and Global Environment Facility (GEF).

The main components of the project are:

- Identification of biodiversity with potential for ABS and their valuation in selected ecosystems such as forest, agriculture and wetlands.
- Development of tools, methodologies, guidelines, frameworks for implementing ABS provisions of the Biological Diversity Act.
- Piloting agreements on ABS
- Implementation of policy and regulatory frameworks relating to ABS provisions at national level and thereby contribute to international ABS policy issues.
- Capacity building for strengthening implementation of the ABS provisions of the BD Act.
- Increase public awareness and education programmes.

For more details please contact:

KARNATAKA BIODIVERSITY BOARD
Department of Forests, Ecology and Environment
Vanavikas, Ground Floor, 18th Cross,
Malleshwaram, BANGALORE- 560003
Email: kbb-ka@nic.in
Website: http://www.karnataka.gov.in/kbb
Ph: 080-23448783, Fax: 080-23440535