ECONOMIC VALUATION OF MANGROVE ECOSYSTEMS IN KERALA

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Economic valuation of mangrove ecosystems in Kerala"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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CERFICATE

Certified that this thesis entitled **"Economic valuation of mangrove ecosystems in Kerala"** is a bonafide record of research work done by Ms. Hema M. under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ABBREVIATIONS

ADAK	Agency for Development of Aquaculture, Kerala
CUSAT	Cochin University of Science And Technology
CDB	Community Development Block
CE	Choice Experiment
CVM	Contingent Valuation Method
FAO	Food and Agricultural Organisation
GI	Geographical Indication
GDP	Gross Domestic Product
ha	Hectare
ICTT	International Container Transhipment Terminal
KAU	Kerala Agricultural University
KCA	Kerala Cricket Association
kg	Kilogram
km	Kilometer
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
M ha	Million hectares
MNL	Multi-Nomial Logistic Regression
MNREGA	Mahatma Gandhi Rural employment Guarantee Act
NOAA	National Oceanic and Atmospheric Administration
NRI	Non-Resident Indian
Sq. m	Square meter
WTA	Willingness to Accept
WTP	Willingness to Pay

Dedicated to my family

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INTRODUCTION

1. INTRODUCTION

Globally wetlands are considered as one of the most prolific and life supporting ecosystems. The complex interaction between water, soil, topography, micro-organisms, plants and animals makes wetlands one of the most productive ecosystems (Barbier, *et.al.*, 1997). Coastal resources such as coral reefs, mangroves and other wetlands are one among the richest store houses of biological diversity and primary productivity. The significance and value of wetlands was first brought to the notice of the world through a Convention on Wetlands held at the Iranian city of Ramsar, in the year 1971. The Convention was an inter-governmental treaty that provided the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources.

The direct and indirect anthropogenic activities has considerably altered the nature of wetlands especially mangroves of tropical countries in the world. Despite its important role in maintaining the ecological balance and providing livelihood for the local communities, mangroves do not receive the conservation attention or effort that it deserves. The importance of mangroves has been underestimated despite being a critical and fragile ecosystem (Maguire *et al.*, 2000). Climate change, nutrient loading, habitat degradation, food web alteration and pollution threaten their existence (Silliman *et al.*, 2005; Orth *et al.*, 2006; Halpern *et al.*, 2005). The coastal ecosystem and its services are under global siege (Koch *et al.*, 2009).

The categorization as 'waste lands' has led to the conversion of mangroves to agricultural, industrial or residential uses. This erroneous description made it easier to exploit mangrove forests as cheap and unprotected sources of land for urbanization and other economic activities. Increased market integration and the modernizing traditional economies in recent decades have led to more intensive mangrove exploitation and destruction (Gilbert and Janssen, 1998). This has happened in various part of the globe (Sathirathai and Barbier, 2001; Barbier, 2006b).

However, the havoc created by the tsunami of 2004, has created the occasion for realizing the ecological significance of mangroves. The reports from across the globe confirmed the storm protection function of this coastal bio-shields (Das, 2007, 2009; Kathiresan, 2010). Moreover, the life of mangrove inhabited coastal areas depends on various goods and services provided by mangroves (Walton *et al.*, 2007).

With this understanding there have been legal, institutional and policy interventions on the conservation of this fragile ecosystem. Naturally, the understanding of the Total Economic Value (TEV) of these resources was required for economically justifiable policy decision making. There has been attempts on the economic valuation of wetland ecosystem in general (Costanza *et al.*, 1997; Barbier, 2001; Benson, 2006; Binilkumar, 2010) and mangroves in particular (Lal, 2003; Sathirathai, 2003; Gunawardena and Rowan, 2005), in different parts of the globe. But such attempts are rather limited in India (Hirway and Goswami, 2007; Hussain and Badola, 2010) and scanty in Kerala. Swarupanandan and Muraleedharan (2010) in their report on assessing the feasibility of alternate developmental options along the coastal tracts in Kochi destroying the rich mangrove ecosystem, has highlighted the importance of such studies in Kerala.

This study was undertaken in this background, with the specific objectives of:

1. Identifying the stakeholders of mangrove ecosystems of Kerala
2. Quantifying the level of dependence of local communities for their livelihood and estimating the aggregate demand for products and services
3. Identifying and quantifying the relative influence of socioeconomic, institutional, climatic and anthropogenic forces on the destruction of mangroves
4. Assessing the Total Economic Value (TEV) of mangrove system
5. Making policy prescriptions for the conservation and management of mangroves in Kerala.

Limitations of the study

The study was conducted through primary survey method by personal interview using a pretested questionnaire. The stakeholders furnished some of the information based on their memory and there was every possibility of a recall bias. There were also instances of prejudiced judgments against the mangroves. However, maximum possible efforts were taken to minimize the bias through cross checking. There were no official documentation on the status/ownership and spread of mangroves in the state. This was mainly due to property rights and the general neglect of the ecosystem. This was a major problem while developing the sampling frame.

Organisation of the thesis

The thesis is organized in the following chapters:

Chapter I *Introduction*: Brief description on the background, objectives and limitations of the study.

Chapter II *Review of Literature*: It presents review of past studies on wet lands and mangroves conducted in India and abroad.

Chapter III *Methodology*: The design of the study, study area, method of investigation and tools of analysis employed are described in this section.

Chapter IV *Results and Discussions*: The results obtained in the study are presented and discussed to draw meaningful conclusions.

Chapter V *Summary and Conclusion*: It summarizes the findings drawn from the study and make policy prescriptions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

This chapter reviews the relevant studies available in India and abroad, having direct or indirect bearing on the objectives of the present investigation. The review includes studies mostly done in other parts of the world and also a few available studies from the country. The reference literature was collected through online journals, data bases, libraries, online valuation reference inventories and contact with authors. The collected literature included journal articles, working papers and professional reports.

The reviews of different studies are presented under the following headings:

2.1 Mangrove ecosystem-The support to life and livelihoods

Ecosystem services

Ecosystem services are those goods and services provided by the ecosystem for human welfare (Daily, 1997) or those services provided by the ecosystem for the human well being. It is regarded as the life supporting activities that ecosystem provide us largely in an unrecognized and unpriced way (Proctor, 2001).The Millennium Ecosystem Assessment (2005) defined it in terms of benefits derived from the ecosystem.

Costanza *et al.* (2011) defined ecosystem services as the relative contribution of natural capital to the production of benefits in combination with the three other forms of capital. These benefits include use, option and existence value of natural capital. There are multiple users who simultaneously benefit from using various ecosystem services and it is difficult to exclude people benefitting from them. However most of the ecosystem goods and services are not traded, and always fail to capture full economic value in commercial market.

Pagiola *et al.* (2004) defined ecosystem economic valuation as a technique used to compare the diverse benefits and costs associated with ecosystems by measuring and

expressing them in monetary units. To quantify the value of ecosystem services in a precise way Boyd and Banzhaf (2007) came up with a more quantifiable definition with focus on final goods and services. The authors defined ecosystem services as "components of nature directly enjoyed, consumed or used to yield human well being". Atkinson *et al.* (2012) analysed different studies on valuation of ecosystem and diversity, around the globe.

Mangrove wetlands are the characteristic features of the tropical coastal areas. The luxuriant mangrove forests are mostly seen in the estuarine regions where large amount of freshwater is discharged for longer period in a year. The mangrove ecosystem is generally renowned as providers of various kinds of services such as fisheries, wood, honey, storm abatement, sediment trapping, nutrient uptake and transformation. There are reports that 29.5 per cent of net primary production of a mangrove forest is exported to the marine ecosystem (Duarte and Cebria`n, 1996).

The annual waste disposal service provided by the mangroves was estimated at US$ 5820/ha and US$ 1193/ha in Fiji and Mexico, respectively (Lal, 1990; Cabrera, *et al.*, 1998). Mangroves have the capacity to metabolize organic waste and can be considered as natural sewage treatment plant (Upadhyay *et al.*, 2002). The microbes in the mangrove mudflats fix 20g nitrogen/m^2 (1250kg/ha). It is capable of removing excessive nutrients in the shrimp farms up to 70 per cent for NO_3-N and NH_4^+-N, reducing PO_4^+-P fluctuation and producing bio active compounds (Ahmad *et al.*, 2003).

Among the mangrove species, *Rhizophora* sp. has the greatest ability of carbon sequestration (Fujimoto, 2004).The total organic carbon stock in mangrove ecosystem on a ground area basis is 62 Mg/ha/year (Khan *et al.*, 2007). Scientists have also highlighted role of mangroves in sequestering carbon from the atmosphere and serving both as a source and repository of nutrients and sediments for other inshore marine habitats, such as sea grass beds and coral reefs. Mangroves are one among the most

carbon rich forests in the tropics, containing on an average 1.023 Mg carbon/ha (Donato *et al.*, 2011).

The Gujarat Ecology Commission (2011) reported that mangroves as the nature's best ways for combating global warming through its higher potential for sequestering carbon. Mangroves are carbon factories with highest net productivity of carbon at the rate of 45kg/acre/day. One per cent mangrove loss per annum would lead to around 225000 tons of carbon sequestration potential lost each year together with an additional release of approximately 11 million tons of carbon from the disturbed mangrove soils each year.

Mangroves are considered as one of the most productive terrestrial ecosystem which can produce 29-75 tons/ha of biomass (Palot and Jayarajan, 2007). Traditionally local communities in mangrove ecosystems collect fuelwood, fodder, honey, medicinal plants, timber and other products (Pattanaik *et al.*, 2008). One ton of mangrove fuelwood is equivalent to 5 tons of Indian coal, generating heat without smoke. The local people around the Sunderbans (both India and Bangladesh) used to extract honey from mangroves. Mangroves especially *Avicennia* and *Sonneratia* are cheap nutritive feed for cattle (Kathiresan, 2010).

The local people in the coastal area of Kerala collect the nutrient rich mud from the marshy mud flats of mangroves for manuring the coconut plantation with the belief that it will promote yield for the palms (Nambiar and Raveendran, 2009).

As mangrove ecosystem represents a substantial connection between coastal habitat and terrestrial system, their degradation affect the ecological stability of the coastal zone. Macintosh (1983) recommended that a mangrove strip of at least 100 m wide should be left as a buffer zone on more exposed shores. Mangrove forests are natural buffers against storm surges (Maltby, 1986), protecting tropical shores from erosion by tides and currents. The protection and replanting of mangroves would provide

immediate protection to coastal communities from associated storm surges and erosion.

Evidences suggested that the coastal area with dense and thick mangrove shield has suffered fewer losses and less damage to the property than those areas in which mangroves had been degraded or converted to other alternate uses (Dahdouh- Gurban *et al.*, 2005; Harakunarak and Aksornkoae, 2005; Kathiresan and Rajendran, 2005; Wetlands International, 2005). Selvam *et al.* (2005) analysed the effect of mangrove forests and associated wetlands in mitigating the impact of Tsunami which struck on the southern coast of Indian Ocean in the year 2004. The local communities in Tamil Nadu (Pichavaram) realized that mangroves protected their life and property against the mighty waves. A similar type of protection by intact mangroves was experienced in Hambanthotta in Southern Sri Lanka. So, the mangroves act as speed breakers under the conditions of coastal storms, cyclones, Tsunamis and other comparable situations.

After Asian tsunami, in the year 2004, there has been a mounting call for re-establishing protective greenbelts along coastlines. Understanding the importance of mangroves in dissipating the storm surge/Tsunami impact the government of Sri Lanka and Thailand had initiated rehabilitation and replanting of mangroves trees (Harakunarak and Aksornkoae, 2005; UNEP, 2005). The sacrificial belt or coastal bio shield gave protection to lives of thousands of people in Bangladesh during Chakaria Sunderbans in 1960, Super cyclone of Orissa, 1999 and Wukong typhoon in Vietnam, 2000 (Das, 2011). Mangroves can attenuate the wave energy (Shuto, 1987; Mazda *et al.*, 1997; Massel *et al.*, 1999; Komiyana *et al.*, 2008).

It was found that 1.5 km of six years old mangrove forest can reduce 75 per cent of the sticking impact of 1m tidal waves (Harada *et al.*, 2002). The density of mangrove species and their complexity and flexibility of aerial root systems influence the sedimentation and wave reduction capacity (Kathiresan, 2003). Mangroves with its

high regenerative capacity act as effective coastal bio shield to make the estuarine area a nutrient rich environment. The dense network of prop roots, pneumatophores and stilt roots not only give mechanical support to the plant, but also trap the sediments (Sasikumar, 2009).

The positive association of mangroves with fisheries productivity is well established. The presences of mangroves act as index of shore fertility and fishery resources. The different rates of productivity of fisheries in the mangrove areas were reported. According to Gedney *et al.* (1982) the productivity of finfish was 550 kg/ha. While Kapetsky (1985) reported the average yield of fish and shellfish in mangrove areas as 130 kg of shrimp/ha/year and for Pauly and Ingles (1986) reported the productivity at 350 kg of shrimp/ha/year. The destruction of mangrove area leads to the decline in fish catch to the tune of about 480 kg/year (MacKinnon and MacKinnon, 1986). The local fishermen in Thailand had suffered substantial loss in the coastal fish stock and yield which was attributed to destruction of mangroves (Aksornkoae *et al.*, 1992; Sathirathai and Barbier, 2001).

The long term ecological and genetic value of the mangroves outweights the direct use as fodder, fuelwood and sinks to anthropogenic pollutants. The undervaluation of the contribution of mangrove ecosystem to coastal environment, biodiversity and to livelihood of coastal community has led to the indiscriminate destruction of these vital ecosystems. The necessity of developing a management plan for the sustainable extraction of resources from mangrove ecosystem was underlined by many authors (Brenda *et al.*, 1998; Thivakaran, 1998; Kathiresan and Sivasothi, 2002; Kathiresan and Rajendran 2005).

Ronnback (1999) identified and synthesized ecological and biophysical links of mangroves that sustain capture fisheries and aquaculture production. The interaction of fish, crustaceans and mollusks species with mangroves were presented and the ecology of direct use value was reviewed. The economic value of mangroves was usually underestimated owing to the failure to acknowledge the relationship between

fish species and the mangroves. The annual market value of capture fisheries supported by mangroves was in the range between US$ 750-16,750/ha. The study also highlighted the significant contribution of mangroves to the local and national economies. Primavera (2000) reported that the positive relationship between near shore yields of fish and mangrove area based on the studies from Philippines, Indonesia, Malaysia and Australia.

Adger and Luttrell (2000) argued that successful conservation of wetlands was fundamentally determined by the institutions and property rights associated with resource management decisions. An understanding of property regimes, the constraints imposed on users of wetland resources and the distribution of use benefits among users and non users were essential for the realization of the economic values of wetland ecosystems and functions. The conversion of wetlands to agriculture and other urban uses had profound ecological as well as socio-economic impact at both local and global scale. The wetlands were often regarded as 'waste lands' by policy makers. This negative image had resulted in under valuation of its potential, which together with the incentives for conversion given in some countries led to uncontrolled exploitation, conversion and degradation. The authors explained the property right regimes through case studies from Indonesia and Vietnam. In both the countries wetland resources were managed as common pool resources and the government sanction for the imposition of private property rights have led to unsustainable utilization or conversion of wetlands to other uses.

Badola and Hussain (2003) had studied the level of understanding of local communities about the contribution of mangroves surrounding the Bhitarkanika mangrove ecosystem of Orissa. The people could appreciate direct contribution in the form of increased production of fish and prospects for better tourism and the indirect role in cyclone and flood mitigation. However, there was poor participation of local people in the management programmes started by the forest department.

Barbier (2006b) studied the impact of shrimp farming in Thailand. Shrimp farming has been considered as one of the highly lucrative businesses in Thailand and frozen shrimp forms the major item in the export basket. The intensive shrimp farming in the coastal areas led to the rapid conversion of mangroves in Southern Thailand. The unclear or ill defined property rights also aggravated the situation. More than half of the country's mangroves had been lost. The study analysed the direct dependence of local communities on mangroves for various goods like fish, wood products and firewood. In addition, there were indirect benefits of coastal protection. The awareness of environmental damage motivated the households to participate in the community conservation efforts. A negative relationship was obtained for the distance to the mangroves from the household, resulted in less participation of far away households in conservation activities.

Primavera (2006) detailed the environmental impacts caused by the aquaculture on the coastal zone in Asia. The severe impact was happened on mangroves during the collection of wild seeds and brood stock, introductions and transfers of species, spread of diseases and release of chemicals and wastes from the farms. The total economic value of mangrove forests in Thailand was US$ 60,000/ha which was reduced in long run to US$16,700/ha when converted to shrimp farms. The author put forward holistic recommendations for the integrated coastal zone management based on stakeholder needs, mechanisms for conflict resolution, assimilative capacity of the environment, protection of community resources and rehabilitation of degraded habitats.

Ocampo-Thomason (2006) examined the impact of African Palm culture and commercial shrimp farming on the mangrove ecosystem and the local communities in Ecuador. There was a rapid expansion of shrimp farms in Ecuador within 30 years which had resulted in loss of 57 per cent of mangrove area. The massive expansion was due to the incentives given by the government to shrimp farmers, the absence of clear property rights and effective management regimes for mangroves. More than 85 per cent of the local households depended on the fishing and cockle gathering for

livelihood. The local communities were residing in the sheltered area behind the mangrove stands. The shrimp farms resulted in the destruction of cockle gathering and caused damages to the nearby agricultural lands. For the scientific management of mangroves in Ecuador, community reserve was created. The stewardship practice based on custodianship had been implemented in the community reserve.

Saravanakumar *et al.* (2009) established the direct effect of mangroves on fishery wealth based on the study in Gujarat coast. Hussain and Badola (2010) made an extensive study to capture the benefits contributed by mangroves to local livelihoods in Bhitarkanika Conservation Area of Orissa, located in the East Coast of India, which harbors the second largest mangrove ecosystem of India. It was well evident that number of fish species as well as income to the local communities was higher in areas of good mangrove vegetation (US$ 44.61/ha) than in those without mangroves (US$ 2.62/ha). The market price of the forestry and fishery produets used by the local people was estimated as US$ 107/household/annum. The resources extracted from mangrove forests contributed about 15 per cent to the total household income. The study concluded that provisioning services provided by the mangrove forests were of significant importance to the coastal communities as it increases the resilience and sustainability of the local economy.

2.2 Economic value of ecosystems

Desvousges *et al.* (1987) confirmed the capability of contingent surveys in providing the extent of magnitude of the benefits realized from one or many aspects of the environmental quality, in their attempt to study option price estimates for the water quality of the Monongahela River in Pennsylvannia.

Costanza *et al.* (1989) employed Willingness to Pay (WTP) and energy analysis techniques to estimate the economic value of natural wetland in Louisiana. The result of the study had provided the total present value of an average acre of natural wetland was in the range between US$ 2,429 – 6,400 and US$ 8,977- 17,000. The authors

discussed the discounting problem as applied to natural resources and argued for lower discount rates for valuing natural resources.

Costanza and Folke (1997) defined Ecosystem Service Valuation (ESV) as the process of assessing the contribution of ecosystem services when managing for sustainable scale, fair distribution and efficient allocation. In the same year, Costanza *et al.* made a concrete and maiden attempt to capture the economic value of Earth's natural capital stock in its entirety. It was considered as the first scientific attempt in this direction. The authors tried to capture the value of 17 groups of ecosystems. Only renewable ecosystem services were considered. The various services include coastal protection, nutrient recycling, food production and recreation value. The economic value of the entire biosphere was estimated in the range of US$ 16- 54 trillion/year with an average of US$ 33 trillion/year. Sixty three per cent of the estimated value was contributed by marine ecosystem alone.

Gregory and Slovic (1997) argued that constructive approaches provide a way to trace the differences in an individual's or group's expressed desires for specific management options backed by the underlying values, which resulted in opening a perspective on the cognitive and reasoning processes. The authors were very positive that constructive techniques were largely useful in environmental management situations where the goal is to understand why citizens support or oppose a suggested resource policy. There was a visible clash between holistic contingent valuation approaches that claim new grounds for the dominant economic paradigm and integrative approaches which rely on value construction techniques and thus fundamentally different conception of preferences and evaluation was emerged.

The study by Hadker *et al.* (1997) tried to capture the willingness to pay by the residents of Bombay for maintenance and conservation of Borivli National Park (BNP) using the CVM. The authors gave due attention to different kinds of biases such as hypothetical, starting point, embedding effect and part-whole. Income level of

the residents did not limit their interest in environmental conservation. The households were ready to pay on average ₹ 7.5/month for five years. Hence, the city of Bombay was ready to expense ₹ 29 million/month.

Chopra (1998) conducted the economic valuation of biodiversity in Bharatpur National Park and found that cost incurred locally could be the better index of the price paid by the tourists to visit the National Park. The stakeholders, other than tourist, placed high value on livelihood and ecological functions of the park.

Verma (2001) conducted a detailed valuation exercise in Bhoj wetlands of Bhopal, Madhya Pradesh. The values of different services provided by the wetlands such as supplying drinking water to the city and the benefits accruing to Trapa cultivators, fishermen, boatmen, washer men and sellers whose livelihood depended upon the wetland was estimated. The value of preventive measures that people used to avoid water borne diseases and the willingness to pay of the people for enjoying better recreational facilities from the Bhoj Wetland was also calculated. The willingness to pay of Bhopal city population was ₹ 241/household on voluntary payment basis towards Bhoj Wetland Management Society while it was ₹ 29.5/ household if it was taken as tax.

Abaza and Mc Cracken (1998) did multi criteria analysis (MCA) for the preference of multiple stakeholders' trade-off between conservation and development. The edge of MCA over the cost benefit analysis in revealing and solving the complex interest between stakeholders and the government was given in detail. The additional methodological approaches like MCA act as complement to the conventional valuation techniques.

Turner *et al.* (1998) did the economic valuation as an effort to estimate the value of the various ecosystem services with the assumption of the sustainability of ecosystem and their interrelationships between themselves and with the abiotic environment.

Seidl and Moraes (2000) estimated the value of ecosystem services of natural resources in Brazil following the pattern followed by Costanza *et al.* (1997). The study found that there was spatial variation in data from global to regional levels. The ecosystem service value of the Pantanal watershed was US$ five million/resident.

Turner *et al.* (2000) argued that for the meaningful conduct of ecosystem valuation the sequential analytical process should be encompassed with spatial context of ecosystem service provision, beneficiaries and appropriate application of the concept of marginal analysis. A typology of environmental values based on use and non use value categories would be capturing more or less human related instrumental and intrinsic values of nature. The study concluded that there was a legitimate and meaningful role for regulated market transactions and related human behavior in the environmental domain.

Kreuter *et al.* (2001) estimated the changes in land use and ecosystem service values as a result of urbanization in Texas. There was 15 per cent decrease in annual ecosystem service value between 1976 and 1991. The study tried to quantify the negative effects of urban sprawl on ecosystem service.

Boyer and Polasky (2004) reviewed recent literature on non market valuation as applied to wetlands, with particular focus on the value of urban wetlands. The authors argued that private landowners did not typically receive a return on preserving wetlands, even though the wetlands provide valuable services to society. A landowner could earn large returns by draining wetlands to build houses, a shopping center, or some other type of urban development. In the absence of regulation, most private landowners would decide to fill wetlands because the private benefit from development was typically far greater than the value captured from preserving the wetland.

Drew *et al.* (2005) tried to capture the direct use value of goods and services provided by *Terminalia* forest of fresh wetlands in the Kosrae. The respondents were interested in capturing the direct benefits accrued rather than the ecological links between *Terminalia* and the mangrove forests. The *Terminalia* forest provided goods worth US$ 2,505/ha/year and the gross value of agricultural products grown on the land was US$ 1,946/ha/year. The overdependence of natives on *Terminalia* had created immense pressure on the adjacent fresh land forest ecosystem. The proper understanding of the numerous roles played by the fresh wetlands to coastal landscape and to the dependent societies was essential for framing suitable policy options.

Hein *et al.* (2006) studied the spatial dimensions of ecosystem services and analysed how different stakeholders at different spatial scales attach different values to ecosystem services. The authors argued that it was highly important to consider the scales of ecosystem services when valuation of services is applied to support the formulation or implementation of ecosystem management plans.

Wattage and Mardle (2008) studied the total economic value of wetland conservation in Sri Lanka using analytical hierarchy process (AHP). The total value of wetlands was ₹ 110, of which ₹ 60 and ₹ 50 respectively were use values and non use values. The failure to properly account the total value of wetland resources had resulted in negative effects on the environment and the society. The study showed that willingness to pay values for the use and non use value of conservation of wetlands using the AHP had wide applicability.

Raheem *et al.* (2009) examined the gaining importance of valuation of environmental goods and services in framing policy decisions. In California, the State Ocean Protection Council would be incorporating non market values into legitimate proposals, budgets proposals, regulating and permitting processes. The policy decisions for different ecosystem services would depend on the valuation exercise.

The prioritization of ecosystems and ecosystem services would increase the efficiency of credible collection and analysis of data on non market values.

Remoundou *et al.* (2009) examined whether information from the valuation studies could help in the design of policies for the effective management of marine and coastal ecosystems of the Mediterranean and the Black Sea. The authors realized that there were very few published studies within the Mediterranean and the Black Sea region which highlighted the potential for future research on coastal and marine ecosystems. The valuation studies provide policy makers with the necessary economic information for the development of efficient and effective strategies for sustainable marine and coastal ecosystem management. The results from the studies on valuing the marine and coastal ecosystem services of the region revealed that there were substantial positive economic values attached to marketed and non marketed services provided by the marine and coastal ecosystems.

Bateman *et al.* (2011) attempted to overview the issues arising from the economic analysis of ecosystem service assessments. Economic analysis of the role and value of ecosystem service began through isolating its contributions to welfare bearing goods. The authors dealt with various issues associated with the economic analysis of ecosystem services.

Jenkins *et al.* (2010) assessed the value of restoring forested wetlands through the U.S. government's Wetlands Reserve Programme (WRP) in the Mississippi Alluvial Valley by quantifying and monetizing ecosystem services. The efforts to maintain and restore ecosystems require an improved understanding of how human beings obtain benefit from ecosystem as well as how human behavior could be influenced through conservation payments and other policy tools. The estimate for annual market value was US$ 1035/ha. The study concluded that from the tax payer's perspective, the social benefits of restoring wetlands via. WRP would exceed social cost. There were considerable surplus in conservation effects generated by WRP payments and there

could be substantial opportunity for mitigation of markets in the region to supplement conservation programme payments. The potential market value was substantially greater than landowner opportunity cost. Hence payments to private landowners to restore wetlands would be profitable for individual landowners.

Turner *et al.* (2010) made ecological and economic analysis of wetlands with focus on scientific integration for management and policy. An integrated wetland research framework was suggested with a combination of economic valuation, integrated modeling, stakeholder analysis and multi-criteria evaluation This could provide complementary insights into sustainable and welfare optimizing wetland management and policy.

Tianhong *et al.* (2010) studied the variations in ecosystem service value in response to land use changes in Shenzhen, China. There were rapid changes in woodland, cropland, wetland and unused land due to rapid urban sprawl. The total ecosystem service value of Shenzhen was about US$ 498 million in 2004. There was a decline in ecosystem value from 2000 to 2004 caused by the decrease in wetland and woodland ecosystem. Land use could be used as a proxy measure of ecosystem services through matching the land use categories with equivalent biomass.

Wang *et al.* (2010) attempted to value ecosystem as it economically plays an important role in linking human activities and natural systems. The authors focused on the valuation of coastal ecosystem service losses caused by land reclamation in Xiamen, China. The study developed a frame work for selecting relevant valuation methods for different ecosystem services. The result of the land reclamation showed that the cost associated with ecosystem damage was significantly higher than the internal cost of land reclamation. The land reclamation cost in Xiamen was US$ 88.24/m^2 and the internal cost was US$ 5.75/ m^2. The integration of ecosystem losses in to the total cost accounting would help the decision makers to realize the full cost of land reclamation.

Barbier *et al.* (2011) examined the significant and unique services provided by the Estuarine and Coastal Ecosystem (ECE) existed at the interface between the coast, land and watersheds. The authors tried to determine which services would provide one or more reliable estimate and which did not. It also helped to identify future areas of ecological and economic research to further progress in valuing ECE services. The study found that net present value of mangroves as breeding and nursery habitat in support of fisheries was in the range from US$ 708 to US$ 987/ha and the storm protection service was US$ 8,966 to US$ 10,821. They suggested policy measures to curb the destruction of ECE including mangroves and prescribed to collect levy from the coastal polluters. The extensive and rapid loss of mangroves globally reinforces the importance of measuring the value of its ecological services and employing those values for the appropriate coastal management and planning.

de Groot *et al.* (2012) gave an overview of the value of ecosystem services of 10 main biomes in monetary units. The authors argued that biodiversity and its associated ecosystem services could no longer be treated as inexhaustible and free goods and its true value should be properly accounted. The total value of ecosystem services of open ocean and coral reef were US$ 490 and US$ 350,000/ha/year respectively. The continued over exploitation was usually occurring at the expense of the livelihood of the poor and future generations.

Mendoza-Gonzalez *et al.* (2012) studied the land use change and its effect on the value of ecosystem services along the coast of the Gulf of Mexico. The expansion of agriculture, livestock and urban sprawl had a direct impact on ecosystem services and their non market economic values. The estimated ecosystem service value of the Island was US$ 106,000/ha. The results showed that the development policies of tourism and urban sprawl did not consider the environmental impacts of land use changes in terms of ecosystem services.

Moreno-Sanchez *et al.* (2012) estimated the willingness to pay higher fees from hydrological service buyers in an ongoing Payment for Environmental Services (PES) initiative in an Andean watershed in Columbia. Two heterogeneous water user groups existed: small holder peasants and recreational house owners. For improved water services, environmental service (ES) buyers were willing to pay monthly about US$ 1 premium over existing flat PES rate. However willingness to pay was strongly influenced by the distance to the water distribution point and to the town center. The results helped in designing user driven PES schemes in line with efficiency and equity objectives.

2.3 Valuation of mangrove ecosystem

The importance of mangroves was realized from 19th century onwards. However, the significance of mangrove ecosystem got prime importance among the policy makers and people after the Tsunami of the year 2004. On understanding the unique features and immense services provided by the ecosystem, different researchers initiated research on mangroves worldwide. However such studies are mostly restricted to floral or botanical aspects further limiting the socio-economic dimension of the rich ecosystem.

Mitsch and Gosselink (1993) studied about the various interactions of mangrove wetlands, which have direct relationship with topographic diversity, variations in river discharges, amount of fresh water flow, sediment deposition and the type of mangroves at the intertidal site.

Barbier and Strand (1997) explored the value of mangrove systems as breeding and nursery habitat for off-shore fisheries with focus on mangrove-shrimp production linkages in Mexico. Low price of mangrove area together with lucrative shrimp aquaculture had led to the large scale conversion of the mangrove areas. The

mangrove deforestation between 1980 and 1990 had resulted in annual revenue loss of US$ 2,78,704.

Gilbert and Janssen (1998) studied the use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes in the Philippines. Even though the intensive aquaculture of prawns alternating with milk fish produced 66 and 175 tons/year of milk fish and prawns respectively, the under estimation of total value of mangrove ecosystem was resulted in the widespread loss and degradation of mangrove ecosystems.

Naylor and Drew (1998) explained the value of mangrove resources in Kosrae, Micronesia. The life of the people in that coastal area was heavily dependent on mangroves for fuelwood and other ecological services such as erosion control, storm protection and nutrient sink for fishes. The study showed that population put some value on indirect services apart from the direct use values. The respondents were willing to pay between US$ 1 million and 1.26 million/year to protect and use the mangrove swamps indefinitely.

A study was attempted by Kairo *et al.* (2001) at Gazi Bay, Kenya to examine the economic benefits accrued from 12 year old Rhizophora sp. which were planted under restoration scheme/project. The estimated costs of reforestation and maintenance were US$ 70.48/ha/year, while the estimated net benefits were calculated as US$ 2902.87/ha/year. The benefit cost ratio for the reforestation and maintenance was more than one. The government initiative for the mangrove reforestation programme could hence be justified in order to sustain the supply of mangrove goods and services.

Kathiresan (2002) gave the details of mangroves ecological functions. Mangroves protect shoreline erosion by acting as a buffer and catch alluvial materials thus stabilizing land elevation by sediment accretion that balances sediment loss.

Mangroves preserve water quality and reduce pollution by filtering suspended materials and assimilating dissolved nutrients.

Sathirathai (2003) attempted an economic valuation of mangroves and the roles of local communities in the conservation of natural resources in Thailand. The mangroves in Thailand were rapidly disappearing owing to the expansion of lucrative shrimp farming. The villagers could clearly observe a sharp decline in the yields of fishery products after the clearing of vast areas of the mangroves. The average annual gross returns per household from products collected from mangroves were US$ 4,000. The economic value of mangroves based on direct use by local communities and indirect use value (off-shore fishery linkages and coastline protection) was in the range between US$ 13.05 to US$ 654.67 per rai (6.25 rai= 1 ha).

Gunawardena and Rowan (2005) conducted an economic valuation of mangrove ecosystem which was threatened by shrimp aquaculture in Sri Lanka. The total economic value of the mangrove ecosystem was estimated using the contingent valuation method with an open ended approach. The annual net value of mangrove lagoon fisheries per hectare of mangroves was US$ 268/ha/year and the total value of the coastal mangrove dependent coastal fishery was US$ 754/ha/year. The value of the mangrove buffer in coastal protection was US$ 300/ha/year. The total economic value of Rekawa mangrove ecosystem in Sri Lanka was US$ 1,088/ha/year and the projected external cost of the shrimp culture was US$ 34,798/year. The economic analysis for the proposed aquaculture projects revealed that the ratio of the external benefit to external cost lies between 1:11 and 1:6. The authors concluded that conversion of mangroves to shrimp ponds led to a significant loss in the traditional livelihood practices.

Santhakumar *et al.* (2005) attempted an economic analysis of mangroves in three location of South Asia viz. the Sunderbans- Indian and Bangladesh part and Cochin (Kerala). The authors reported that the economics of positive externalities between

fish production and mangroves was very complex. The positive relation was nullified by the excessive degeneration of water body caused by the degradation of biomass generated from mangroves. The limited accessibility to the dense mangrove forest often aggravated the risk and cost of collecting fish and led to a situation in which thick mangroves was not conducive for enhanced fish production in the mangrove area. Benefits accrued to mangroves users could not be taken for justifying conservation of the quality and quantity of mangroves in private or public ownership. The authors reported shrimp farms were the key culprits in the destruction of more than 50,000 acres of mangroves in Cox's Bazar of Bangladesh. The per capita annual benefit of around ₹ 12,500 were there for the West Bengal people who had limited access to the Sunderbans. The expected benefit to the local people when one sq. km of the core area of the Sunderbans was being conserved as a biosphere was around ₹11,000/annum.

Barbier (2007) focused on valuation approaches applied to nursery and breeding habitat for near-shore fisheries and in providing storm protection for the coastal communities based on a case study of mangrove ecosystems in Thailand using production function, replacement cost and expected damage function. The excessive mangrove deforestation in South Asian countries was clearly related to the failure to capture the values of habitat and storm protection services of mangroves. The author argued that unless the value to local communities of the ecosystem services provided by protected mangroves was estimated, it would be difficult to convince policy makers to consider alternative land use policies. Valuing the non market benefits of ecological regulatory and habitat services was increasingly important in assisting policy makers to manage critical environmental assets. The results also highlighted that 1 km^2 decline in mangroves area had increased the expected number of natural disaster by 0.36 per cent. A change in mangrove area had a significant influence on the incidence of coastal natural disaster in Thailand.

Aburto-Oropeza *et al.* (2008) attempted to analyse the positive relationship between fishery yield and mangroves in California. The study found that the potential irreparable damage to fisheries because of mangrove loss had been neglected and was greatly underestimated. Mangrove related fish and crab species account for 32 per cent of the small scale fisheries landing in California. The annual economic value of the fisheries was US$ 37,500/ha of mangrove fringe. The study concluded that extreme undervaluation of the benefits of coastal development and aquaculture revealed a management crisis in coastal areas in the Gulf of California.

Maler *et al.* (2008) explicitly undertook marginal analysis in estimating the accounting price for the habitat service provided by a mangrove ecosystem to a shrimp population. Their model evaluated changes to fisherman well-being for a 10 ha change in the stock of a mangrove forest of 4,000 ha in size, obtaining an accounting price of US$ 200/ha.

Walters *et al.* (2008) reviewed ethnobiology, socioeconomic and management of mangrove forests based on review of previous works across the globe. Though there were a large number of studies on the local resource utilization and valuation of mangroves, the coverage was very limited to a relatively small number of sites especially in South East Asia and the Indian subcontinent and was conducted over short time periods. The traditional use of mangrove resources by the local communities was intimately connected with the health and functioning of the mangrove ecosystem. Mangroves filter the discharged sewage water effectively, the value of bio filter functions of mangroves had estimated at US$ 1,193 to US$ 5,820/ha/year depending on the types and extent of mangroves.

Ghasemi *et al.* (2010) studied the values, functions and attributes of mangrove ecosystem and the importance of the local people in biodiversity conservation in the mangroves of Gas and Hara Rivers Delta (GHRD) of Iranian coastline of Oman Sea. The dependence of the local community for various goods and services of mangroves

such as forage, tannins and wood for construction and firewood and the nursery ground for marine creatures were highlighted. The total economic value accrued to the local population was US$ 10,000- 20,000/ha/year.

Kamali and Hashim (2011) studied the efforts of mangrove restoration in Malaysia. A mangrove restoration effort was undertaken in Malaysia using 5 million mangrove seedlings of *Avicennia marina* and found that none of the transplanted seedlings survived on account of infestation of barnacle, active sedimentation and fishermen disturbance of the restoration site. However after three years there was a good stand of natural regenerated *Avicennia marina* when the disturbance to the site was minimized.

Brander *et al.* (2012) examined the value of ecosystem services provided by mangroves in South East Asia using value transfer system. The different valuation studies conducted in Southeast Asia were examined and the value had been converted to US$/ha of mangroves. The average mangrove value was US$ 4,185/ha/ annum. The expected annual value of lost ecosystem services from mangroves in South East Asia was estimated to be US$ 2.16 billion in 2050.

O' Garra, (2012) presented estimates of the economic value of the main goods and services provided in a traditional Fijian fishing ground. The value of fisheries bequest value and coastal protection function provided by the coral reefs and mangroves were estimated at US$ 1,795,000/year. The coastal protection provided by the coral reefs and mangroves contributed the largest component of the total economic value (55%) followed by fisheries (44%).

Salem and Mercer (2012) provided an overview of the literature on mangroves through a meta regression analysis. The annual per hectare value of mangroves and GDP per capita in places around the globe were regressed. The weighted robust regressions found that CVM and replacement methods were produced higher values than other methods of valuation. The study found that mangroves exhibited

decreasing returns to scale i.e. marginal value was found to be lower than average value. The GDP per capita had a positive effect on mangrove values.

Tantu *et al.* (2012) examined the value of total mangrove resources in Indonesia, the country with largest mangrove area in the world. Fishery and wood were the main harvested resources from the mangroves. The total value of mangrove resource was US$ 6,049/ha/year. The capture fishery accounted about 98 per cent to the total value of mangrove usage rate.

2.3.1. Studies on mangroves in India

Badola and Hussain (2005) reported that monetary losses due to repair and reconstruction of personal property in Orissa, India was in the range between US$ 32/household in mangrove protected villages to US$ 154/household in villages that were not protected by mangroves.

Bhattacharya *et al.* (2006) had analysed the impact of controlled mangrove regulatory regime adopted by the state on the local communities surrounding the Bhitarkanika wildlife sanctuary (BWS) in Orissa. The resource poor coastal populations were heavily dependent on mangroves for their livelihood. The imposed restrictions had led to instability of the local economy and it undermined the holistic management approach of the state government. The study indicated that the tendency of forest resource exploitation was at a scale higher than sustenance livelihood requirements, among the people from villages with very low (i.e. less than ₹150) per capita monthly income.

Das (2007) had conducted an extensive study on the storm protection function of mangroves in the Kendrapada district of Orissa with respect to human causalities and damages to house and livestock during the super cyclone of 1999. Mangroves were efficient in reducing human causality and damages to residential houses and cattle. The total protection benefits of mangroves in terms of averted damages to residential

property in Kendrapada were estimated to ₹ 592,647,800 (US$ 14,110,662). The study also suggested that mangrove forests provided protection benefits to houses to the extent of ₹ 975,800 (US$ 23,233) per km width of forests or ₹ 51,168 (US$ 1218) per hectare of forests. Later in 1999, she has reported the total protection benefits of mangrove averting damage to property at US$ 14,110,662. If the mangrove cover had remained at the level of that in 1950's, the area would not have suffered any fully collapsed houses at all.

Hirway and Goswamy (2007) studied the impact of mangroves on the local communities in Gujarat. Agricultural labourers and fishermen constituted the major mangrove dependent communities. The direct use value and the indirect use value (based on 2003 prices) of mangroves in Gujarat were ₹ 1,603 million/year and ₹ 2,858 million/year respectively. The total use value (direct and indirect) of mangroves was thus estimated at ₹ 7,731.3 million/year.

Stone *et al.* (2008) analysed the factors that influenced household willingness to contribute towards mangrove restoration among three subsistence user groups in West coast of India: fishermen, fisherwoman and rice farmers. The contingent valuation technique was employed to measure the economic value of perceived benefits of mangroves. The results indicated that each user group would be willing to make substantial contribution of labour or cash each year owing to different reasons. The annual mean willingness to pay was ₹ 626/year for rice farmers while it was ₹ 342 and ₹ 395/year for fishermen and fisherwomen respectively. The annual mangrove benefits based on household willingness to pay was ₹ 5 million and the benefit cost ratio was 3.48. The study concluded that the restoration drive must carefully consider user's need and perceived mangrove benefits while selecting mangrove species for restoration in order to enhance community participation.

Mathew *et al.* (2010) detailed the mangrove ecosystems in India. The authors highlighted the enormous functions provided by the mangrove ecosystems. The

authors urged for community and industrial partnership form of management for protecting the mangroves. They also recommended the setting up of an all India level coordinated project for the conservation of mangrove species.

Ekka and Pandit (2012) conducted a study to capture the WTP for restoration of natural ecosystem of the Gosaba Islands of the Sundarban mangroves. Owning to anthropogenic activities, grazing by domesticated animals and natural catastrophes the area of the Sunderban mangroves had been dwindling. About 65 per cent of the respondents have agreed to pay for conservation and restoration of mangroves at different bid levels. The low income and poor standards of living forbids the respondents from bidding higher value even if they wanted to pay more.

DebRoy and Jayaram (2012) had conducted economic valuation of mangroves of MGR Thittu Island, Pichavaram, Tamil Nadu. The study had reviewed the current status of mangroves in Tamil Nadu and assessed the livelihood dependency of fisher folks on the mangroves. The island was recreated after the Asian Tsunami of the year 2004. It found that villagers were willing to pay for the conservation of mangroves in the Island and the WTP/person/year was ₹ 13. However experts were not ready for payment and opined that it was the sole responsibility of the government to pay for the conservation and management of mangroves. The direct use values of fishery contribution and ecotourism values were estimated to be ₹ 16.5 million for 1,110 ha of Pichavaram mangroves (₹ 14,932/ha). The WTP obtained through CVM was ₹ 1,05,185 and the total economic value was ₹ 3,535 million (DebRoy *et al.*, 2012).

2.3.2 Studies on mangroves from Kerala

There are several studies conducted on the botanical, biochemical and physical aspects of mangroves in Kerala. But realistic estimates of the area and the socio-economic interlinkages of the ecosystem are scanty (Basha, 1991; Kurien *et al.*, 1994; Mohanan, 1997; Radhakrishnan *et al.*, 2006; Swarupanandan and Muraleedharan, 2010).

The Central Marine Fisheries Research Institute (2005) reported that there was large scale deforestation, reclamation and conversion of mangroves in Cochin. The mangroves in Cochin are highly degraded both in the case of morphology and biodiversity. The encroachment and overexploitation of forest and aquatic resources were the reasons for large scale destruction of mangroves. The seed collection of fry and fingerlings of *Penaeus indicus*, *Chanos*, *Etroplus* etc. from wild had adversely affected the brackish water capture fisheries of Kerala. The mangroves remained as the dumping places directly or indirectly or act a sink for pollutants. The strict enforcements of forest rules to prevent unlawful entry encroachment and indiscriminate exploitation were recommended.

Radhkrishnan *et al.* (2006) have detailed the botanical aspects of mangroves and faunal associates in four northern districts of Kerala viz. Malappuram, Kozhikode, Kannur and Kasargode. These districts harbour about 489 faunal species including 144 species of invertebrates. Many of the economically important species of mollusk and crustaceans were identified in the region. The maximum biodiversity was available in Kannur, occupies 83 per cent of state's mangrove area.

Khaleel (2009) had done a detailed study on the ecosystem services of mangrove wetlands of North Malabar. The study identified 14 true mangrove species and 27 mangrove associates. An economic valuation was conducted to access economic activities and environmental-ecological services of the region. The ecosystem service value/ha/year was US$ 10,960 and the total value of mangroves in North Malabar was US$ 41.1 million. The result of the study highlighted the higher amount of potassium and phosphorus in mangrove soil compared to non mangrove soil. It proved the nutrient retention capacity of the mangroves. The socio-economic details showed that most of the local communities along the river banks were in the below poverty line (BPL) category. The study also highlighted the high level of pollution due to waste accumulation, badly affecting the mangrove ecosystem of the region.

Muraleedharan *et al.* (2009) provided the detailed mangrove distribution and associated economic activities like shrimp farming and rice cultivation in Kerala. The coastal stretches are the natural homes of mangroves, have high pressure on land owing to increased population and resultant urbanization. The willingness to pay (WTP) for conservation of mangroves in Kannur was also estimated and was ₹ 31 and the total willingness to pay was ₹ 73,25,734 for the five blocks of Kannur district. The study concluded with recommendation of further thorough studies on economic valuation of benefits of mangroves and cost of replacement of the mangrove ecosystem.

2.4 Valuation methods

2.4.1 Contingent Valuation Method (CVM)

Le Goffe (1995) examined the cost of eutrophication in coastal water in France using CVM. The merits of reducing eutrophication in coastal water were studied. The residents of France were willing to give, on an average US$ 42.53 and 31.65/ household/year respectively for improved water quality and preservation of the ecosystem against eutrophication. The chosen payment vehicle for WTP was the annual water bill.

Carson (1998) attempted valuation of tropical rainforest to investigate the likelihood of using a large scale multi country contingent valuation method to make decisions regarding the global resource management. The author has clearly specified the method of framing and enforcing contingent valuation questions.

Loomis and Gonzalez- Caban (1998) tried to calculate the willingness to pay function for protecting spotted owl habitat from fire in the California and Oregon. The contingent valuation survey had been conducted to estimate the economic value for implementing a fire management plan. The average willingness to pay to reduce catastrophic fire on 275 acres was US$ 56/household. The cost per acre was well

below the lowest benefit per acre. The extent of habitat protected could be used to evaluate the incremental benefits of different fire management plans that reduce additional acres burned. The reduction in burned area would be used as justification for the funding of fire management plan to protect spotted owls.

Amigues *et al.* (2002) undertook a study for assessing the welfare losses to land owners resulting from the implementation of preservation programme along the Gaonne River in France. The study found that willingness to pay with open ended question formats gave more conservative values as well as imbedding effect for a significant portion of the respondents. The willingness to pay estimate was US$ 7/ person. The willingness to accept analysis could be effectively used to estimate welfare loss particularly when the respondents have knowledge about the market conditions similar to the hypothetical situation. The adjusted willingness to accept per hectare was US$ 198 and 23 for farmers and non farmers respectively.

Pouta *et al.* (2002) evaluated the actual decision making situation of the Finnish citizens' willingness to pay for increased nature conservation. Two policy planning methods were analysed: the actual planning method and a hypothetical participatory planning method combined with an environmental impact assessment. Forty one per cent of respondents supported actual planning of Natura 2000 and 49 per cent supported hypothetical participatory planning. Respondents in the participatory planning group were more willing to support an increase in nature conservation areas than supporters of actual planning method.

Wiser (2007) studied the willingness to pay (WTP) for renewable energy under collective and voluntary payment vehicles and under the government and private provision of the good using split- sample, dichotomous choice contingent valuation survey of U.S. residents. The responses were sensitive to payment and provision context. The contingent valuation responses were strongly correlated with expectations for the willingness to pay of others. The elicited WTP for renewable

energy was higher under a collective payment method than under a voluntary method. Similarly, stated WTP under a private provision arrangement exceeds WTP under government service. The study concluded that with survey setting, U.S. residents did not recognize the need for collective action for renewable energy to the degree that one might expect.

Verbic and Slabe-Erker (2009) employed the classical contingent valuation method with a close version of discrete choice method for the economic valuation of the landscape development and protection area in Slovenia. The respondents' decision to contribute towards the realisation of the targeted development scenario was positively affected by income, consciousness, visitation rate, perception of potential damage in the area and preferences for particular environmental goods. The study used the adjusted average individual value of willingness to pay to calculate the aggregate willingness to pay. The aggregate willingness to pay values obtained were US$ 1.94 initially and at the follow up value of US$ 2.26. The aggregate value obtained seemed to provide a relatively good reflection of the inhabitants and visitors perception of use and non use value.

Turner *et al.* (2010) argued that the full commoditization of the environment and the assignment of monetary values to all aspects of its multifarious functioning and existence had not any sound scientific or moral basis for sustainable environmental management and policy. The authors introduced a concept of safe minimum standard (SMS) which represents the minimum level of a well-functioning ecosystem that was capable of producing a sustainable supply of service.

Venkatachalam and Narayanamoorthy (2012) estimated economic valuation of irrigation water of the Bhavani River Basin, Tamil Nadu. The study employed a contingent valuation method within a repeated experiment for estimating the economic value of irrigation water among the potential buyers and sellers. Around 82 per cent of the sample farmers were willing to participate in the water trade.

Willingness to Pay (WTP) values had been elicited from the potential buyers and Willingness to Accept (WTA) from the potential sellers was estimated to capture the accrued benefits from the water allocation under trade regime. The elicitation was conducted in three rounds which enabled the farmers to revise the WTP/WTA values. The buyers revised their values upward while the sellers revised their values downward. The mean WTP and WTA were ₹ 312 and 300 respectively. The study concluded that diverting water from the willing sellers to willing buyers under an alternative institution arrangement would generate larger net benefits in the river basin.

Dikgnag and Muchapondwa (2012) attempted the valuation of biodiversity conservation by the Khoman San Bushmen community in South Africa. The contingent valuation method was used to investigate the economic values that communities assign to biodiversity conservation under different land tenure arrangements. The winners of land tenure arrangements were benefitted more than the cost losers suffered. The net worth for biodiversity conservation under various land tenure regimes was around US$ 110, 423 and 497 respectively for municipal, park land and communal land.

Mamatha (2010) conducted an economic valuation of Kolleru Lake of Andhra Pradesh using CVM. The entire stakeholder who depended on the lake for their livelihood was aware of the extent of the pollution level and was concerned about the conservation of the lake. The estimated direct use value and indirect use value of the lake system was ₹ 9410 million and ₹1 million/annum respectively and the total economic value was ₹942 million/ annum.

2.2.3 Choice experiments

Kuriyama (1998) measured the environmental value of the ecosystem in the Kushiro wetland in Japan using choice experiments. The survey was conducted among the

residents and visitors in the wetland. The mean willingness to pay of the Japanese household was US$ 206/year.

Kuriyama and Ishii (2000) estimated the environmental value of recycled wood wastes using conjoint analysis. The authors highlighted the merits of conjoint analysis over contingent valuation. The value of recycling was US$ 12/ household, when estimated by employing choice experiment.

Carlsson *et al.* (2003) analysed wetland attributes using a choice experiment. The study was done among the local population of the municipality of Staffanstorp, Sweden. The different attributes of wetland such as surrounding vegetation, biodiversity, fish, fenced waterline, cray fish and walking facilities were analysed. Biodiversity and walking facilities were the highest valued attributes while fenced waterline and the introduction of cray fish were regarded as negative attributes.

Bennett *et al.* (2004) conducted choice modeling to estimate the society's willingness to pay to maintain viable rural communities in Australia. Two studies were carried out. One was to value the out migration in Murrumbiger River flood plain and the second, the value of maintaining the rural population in national and regional perspective. The society was willing to pay US$ 4.5-7.5/household/ annum to prevent a farmer leaving from the Murrumbiger River flood plain. The willingness to pay in the above perspective was US$ 1-2.5 household/annum.

Nunes *et al.* (2004) used the conjoint valuation framework to estimate the fishermen willingness to pay (WTP) for alternative clam fishing management practices in the Venice Lagoon in Venice, Italy. The unsustainable fishing practices and increased pollution from nearby industrial activities had threatened the existence of the lagoon. Willingness to Pay method was employed to capture the management attributes such as cost of permits, the size of the fishing area, fishing cost of the permit and regime

system. The WTP for improved fishing practices was in the range between € 1.005 and € 2.456.

Toma and Mathijs (2004) studied farmer's trade-offs between environmental quality i.e., water pollution from agricultural sources (mainly from farm animals), and environmental conservation efforts using choice experiment, in the Cazanesti agricultural region of Romania. The results revealed that although farmers' preferences were heterogeneous, 57 per cent preferred the *status quo*, i.e., low environmental quality in the form of polluted water and no investment in environmental conservation efforts.

Travisi and Nijkamp (2004) investigated groundwater contamination from fertilizers and pesticides as an attribute in a choice experiment from Milanese residents' WTP for agricultural environmental safety. The results revealed that impact of groundwater contamination attribute on utility was highly significant and reducing groundwater contamination by 50 per cent raised the probability of choosing the agricultural scenario by 2 per cent. The residents were also found to value improvements in biodiversity levels and reductions in impacts on human health significantly and highly. The WTP for the above parameters were € 24 and 3/ household/month respectively.

Willis *et al.* (2005) employed the choice experiment method to estimate water company customers' WTP for improvements in several services they provide in Yorkshire, England. The study estimated customers' (both residential and business) WTP for improvements in the levels of 14 services. The customers placed the highest value on maintaining a good water supply with minimal interruptions and the considerable value on drinking water quality. The findings of the study were directly relevant to water industry regulation policy in the U.K.

Birol *et al.* (2006a) conducted choice experiment to find the preferences of farm families for agricultural production that generate multifunctional agricultural activity in Hungary. The data were collected from 22 communities to value agricultural practices which generate several agro-biodiversity components. The results revealed that farmers located in the most isolated communities derived the highest values from crop variety diversity, and among those, elderly derive the highest values from landraces. The households preferred least cost agri-environmental schemes that generate environmental, cultural and historical benefits.

Birol *et al.* (2006b) employed choice experiment to analyse the heterogeneity preference in wetland attributes to Cheiaditida wetland in Greece. The results revealed that there was considerable preference heterogeneity across the public and they derived positive and significant values from sustainable management of wetland. The mean WTP for the low impact management scenario of biodiversity was € 107.56, while the mean WTP for medium and high impact scenario was € 116.49 and 134.46 respectively. The net benefit estimates revealed that social welfare maximization was achieved under the high impact scenario of wetland management which provided higher level of ecological, social and economic attributes.

Birol and Cox (2007) conducted a pilot valuation study to investigate the positive economic values of Severn Esturay, U.K. to its local public. The choice experiment was used to capture the socially optimal policies for sustainable management of the estuary. The public has derived positive and significant benefits from wetlands and have assigned the lowest values (€0.06/respondent) from irrigation related employment in the site compared to the environmental attributes provided by the wetlands (€ 47/respondent).

Taylor and Longo (2009) studied the impact of algal bloom on the tourism industry of Varna Bay, Bulgaria. The authors employed choice experiment approach to elicit the value placed on the algal bloom by the local residents. The ecosystem value was

estimated through the Willingness to Pay (WTP) for the reduction in the intensity of the algal bloom. The respondents were willing to pay about US$ 25.5 for high visibility and US$ 16.2 and 6.9 respectively for medium and low visibility.

Westerberg *et al.* (2010) conducted a valuation of social and ecological functions of the Marais de Baux wetland in Southern France. The study employed Choice experiment to estimate the values for potential changes in ecological and social functions. The mean WTP for the small scale wetland restoration was € 14.6/ respondent. The environmentally concerned respondents were ready to pay € 36.7/ respondent for the highest level of biodiversity.

Kenter *et al.* (2011) tried a new participatory, deliberative choice experiment approach in the Solomon Islands for valuing the ecosystem services from the forest. The study employed group-based participatory approach instead of a conventional individual survey, which helped to overcome many of the practical difficulties associated with valuation in developing countries. The initial willingness to pay for a number of tropical forest ecosystem services amounted to 30 per cent (US$ 73) of household income. Following deliberative intervention exercises, key ecosystem services effectively became priceless as participants were unwilling to trade them off in the choice experiment scenarios, regardless of the financial cost. The study concluded that key ecosystem services and money were not of the same order of importance and numerous essential services would remain priceless.

Koundori *et al.* (2012) presented the results of a choice experiment conducted to value different characteristics relating to the construction of a public high way in Greece. The experimental design consists of five attributes such as time saving, decreased percentage of accidents, decreased percentage of emissions, type of crossing and toll. Thirty one per cent of the respondents expressed negative preference for travel time savings while 37 per cent selected alternatives with lower percentage of pollution reduction.

The choice experiment was employed to gain the respondents willingness to pay for the increase in population levels of endangered species as well as general wildlife in three habitats in Denmark (Jacobsen *et al.*, 2012). None of the responses showed consistently higher willingness to pay for higher population levels of wildlife. The existence values were given more importance and the willingness to pay was affected by the warm glow effect.

In depth research has been conducted at various points of time on the economic valuation of mangrove ecosystems. The literature review could bring out those references of the different studies done on the economic values of mangrove ecosystem mainly in the tropical countries of Asia and very few studies done in India and especially in Kerala.

METHODOLOGY

3. METHODOLOGY

The chapter describes the study area, background, sampling design, data collection methods and tools of analysis followed in the present study.

3.1. THE STUDY AREA

Kerala with a coastal line of about 590 km (370 miles) and 41 rivers emptying into the Arabian Sea, was once very rich in mangrove formations, perhaps next only to the Sunderbans, in the eastern part of the country. The palynological studies revealed that the state had an excellent mangrove cover, 11,000 years ago. Due to natural catastrophe, climatic changes and anthropogenic factors, there was a gradual decline in mangrove wealth. Kerala coast, covering 10 per cent of the country's coastal line has only less than 1 per cent of India's total mangrove ecosystem currently. As per the latest reported information by Madhusoodhanan and Vidyasagar (2012), Kannur (44%) and Ernakulam (24%) districts are the major areas where mangroves are seen. This study is undertaken in these two districts. Figures 3.1 to 3.5 depict the study area.

Fig. 3.1 Political map of India showing Kerala

Fig. 3.2 Political map of Kerala showing the mangrove grown districts

Fig. 3.3 Political map of Kerala showing the study area- Kannur and Ernakulam

3.1.1 Mangroves in Kannur district

Kannur district (11^0 46' N Latitude and 75^0 29' E Longitude) can be christened/ designated as 'land of mangrove' of Kerala. Around 44 per cent of the total mangroves in Kerala are reported in Kannur. The protected shores, vast mud flats and sandy/muddy ridges of the coast in Kannur serve as an excellent condition for the luxuriant growth of mangroves. The important mangrove ecosystems in the districts are mangroves in and around Thalassery-Dharmadam area, Ezhimala- Kavvayi Kayal complex and in Madakkara estuary. Mangroves in the district are mainly found in the grama panchayats belonging to five blocks namely Kannur, Edakkad, Payyannur, Thaliparamba and Thalassery. The grama panchayats with sizeable area of mangroves are located in Kunhimangalam, Ezhome, Madakkara, Cherukkunnu, Kannapuram, Pattuvam, Edakkad, Valappattanam and Dharmadam.

The area from Peruvamba to Chengoolichal of Kunhimangalam grama panchayat shelters the largest as well as the richest mangrove genetic stocks of the state. The tallest tree of *Avicennia officinalis* in the state was reported from the region (Radhakrishnan *et al.*, 2006). The maximum mangrove species diversity in North Kerala is reported from Kunhimangalam. Very rare and endangered mangrove tree, *Luminitzera racemosa* was recorded from there (Khaleel, 2009). To combat the large scale depletion of mangroves, the Forest and Wildlife department, the Government of Kerala, has initiated afforestation drive in the district and recorded about 80 per cent success rate in Dharmadam. A sacred grove and a temple in Thekkumbad island of Mattol grama panchayat harbours rich mangrove stocks. The presence of endemic and threatened species highlights the conservation value of mangroves at Kannur (Muraleedharan *et al.*, 2009). Thus, the mangrove wealth in the district can be considered as the stock of rich floral and faunal diversity.

The study was conducted in the locations mentioned in the Table 3.1.

Table 3.1: Major centres of mangrove vegetation in the Kannur district

Sl No.	CDB Block	Grama panchayat	Location
1	Payyannur	Kunhimangalam	Kunhimangalam, Kandamkulangara
2	Payyannur	Ezhome	Ezhome, Pazhayangadi, Chengal
3	Payyannur	Mattool	Mattool, Dhalil, Thekkumbad
4	Thalipparamba	Cherukkunnu	Cherukkunnu, Kattakalam
5	Thalipparamba	Kannappuram	Kannappuram
6	Thalipparamba	Pattuvam	Pattuvam, Kottilla
7	Edakkad	Edakkad	Edakkad
8	Thalassery	Dharmadom	Dharmadom
9	Kannur	Valappattanam	Valappattanam

3.1.2 Mangroves in Ernakulam district

Ernakulam district lies at the 9^0 58' N Latitude and 76^0 17' E Longitude. The major rivers draining in to the Cochin Backwaters are Manimalayar, Muvattupuzhayar, Periyar and Chalakkudi puzha. During the South West monsoon the estuary is filled with fresh water. Salinity is very high during the post monsoon season and may exceed the level of 30 per cent. Mangrove vegetation in Cochin area are seen along the Cochin back waters (lakes which have access to the sea through bar mouth), particularly along the banks of estuarine water bodies, in the form of small patches or narrow continuous belt. The latest field investigation by Madhusoodhanan and Vidyasagar (2012) made a rough estimate of 600 ha of mangroves in the district. The major areas of spread are Mulavukad, Elankunnapuzha, Narakal, Nayarambalam, Edavanakad, Kuzhupilli (Vypeen block), Chellanam and Kumbalanghy grama panchayats (Pallruthi block) (Table 3.2).

Table 3.2: Major centres of mangrove vegetation in the Ernakulam district

Sl No.	CDB Block	Grama panchayat/Municipal corporation	Location
1	Vypeen	Elankunnapuzha	Puthuvypeen
2	Vypeen	Narakal	Narakal
3	Vypeen	Edavanakad	Edavanakad
4	Vypeen	Elankunnapuzha	Elamkunnapuzha
5	Pallruthi	Kumbalanghi	Kumbalanghi
6	Vypeen	Mulavukad	Mulavukad
7	Pallruthi	Chellanam	Chellanam
8		Cochin Corporation	Mangalavanam

The mangroves in Puthuvypeen and Mangalavanam are unique, due to its social and ecological significance. The mangrove formation in Puthuvypeen is reported to be unique in the state as the largest continuous mangroves close to the sea in Ernakulam, district. Mangalavanam which is in the heart of Kochi city is considered as 'lungs of the city' and a roosting ground for migrant and resident birds. About 98 species of birds are reported from the area (Jayson, 2004). Being the industrial capital of the state, the threat to mangroves in Ernakulam is reported to be high owing to developmental pressures. The study was conducted covering all the eight grama panchayats of the district namely Mulavukad, Elankunnapuzha, Narakal, Nayarambalam, Edavanakad, Kuzhupilli, Chellanam and Kumbalanghi.

Fig. 3.4 Political map of Kannur district showing the mangrove area

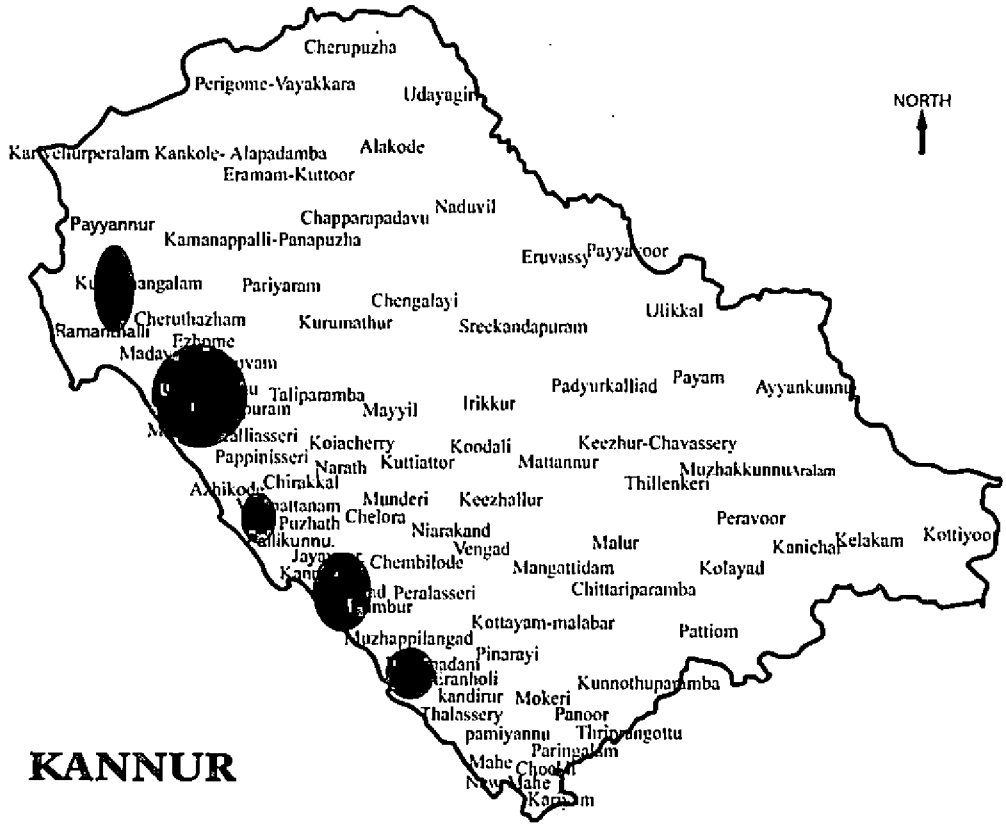
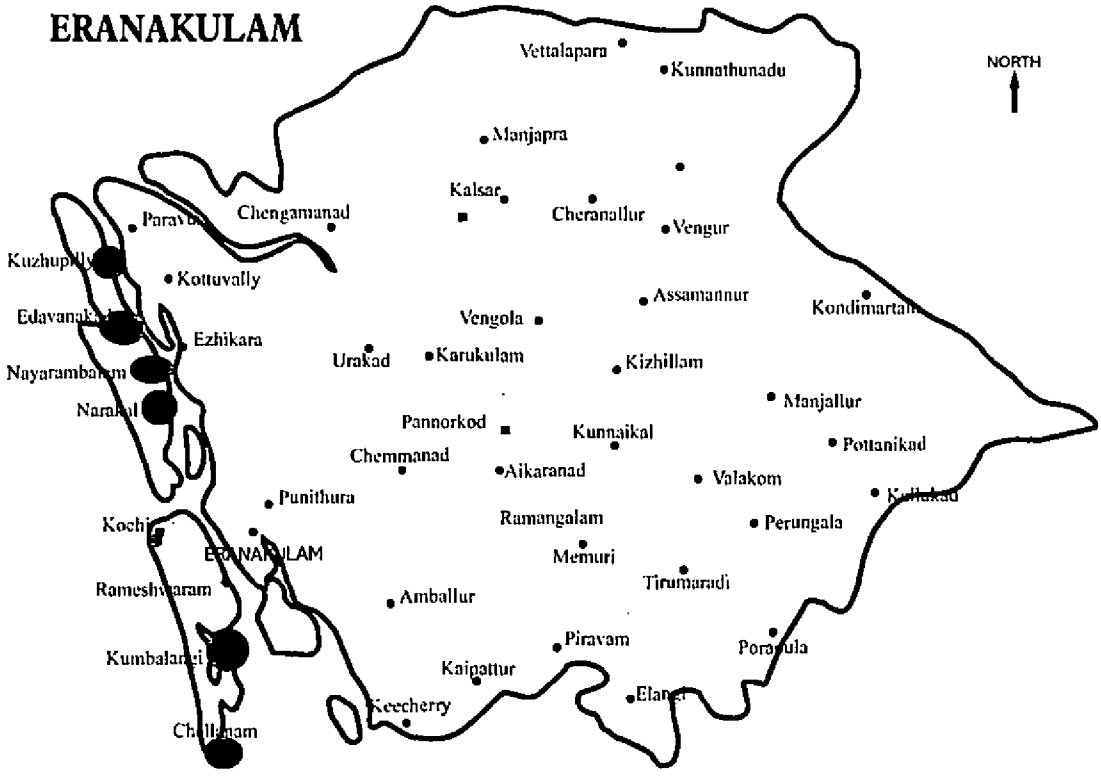


Fig.3.5 Political map of Ernakulam district showing the mangrove area



3.2 The sample selection

The study was initiated by holding informal discussions with local residents, officials of the forest/agriculture/fisheries department, members of local self governments and elderly people in the locality and also by direct observations. Through this process, three groups of stakeholders who depended on the ecosystem directly were identified. They were categorized as residents living close to the mangroves and population depending on mangrove related livelihood options. They were mainly fishermen and paddy farmers (*Kaippad* in Kannur and *Pokkali* in Ernakulam). Further one more stakeholder group to represent the indirect beneficiaries was identified as the general public. They were people who resided away from these ecosystems and do not directly depend on them for livelihood. Thus, there were four stakeholder groups.

Group 1. Residents

The residents selected are those who live very close to mangroves or with mangroves as one of the boundaries of the homestead (0-1 km distance). The list of households along the coastal areas of the study area was gathered from the respective village/grama panchayat office and random samples of 60 each from the two districts was drawn from the list.

Group 2. Fishermen

This group comprised of the fishermen households who depended on the wetlands for their livelihood. They included fishermen and women (hand pickers), engaged in shell mining and clam collection and also commercial shrimp farmers. The sample frame for this group was prepared depending on the information from the Kerala State Fisheries department and through local enquiry. A random sample of 60 each from the two districts was drawn for the study.

Group 3. Paddy farmers

The paddy fields in these study areas follow peculiar cultivation practices, due to geographical and soil peculiarities. The system followed in Ernakulam district is known as *Pokkali* cultivation and that in Kannur as *Kaippad* cultivation. Traditional wisdom and modern science indicate strong complementary linkages between the mangroves and rice farming in these areas. The list of the farmers (Pokkali and Kaippad) was collected from the local Krishi Bhavans (Agricultural Office) and a random sample of 60 each in Ernakulam and Kannur was identified.

Group 4. General public

This group represents the beneficiaries of ecosystem services for mangrove (though themselves not aware perhaps) is drawn from people who are away from the wetlands. The interdependence of man and mangroves may not be directly realized

by the group and they derive intangible benefits and services which are ecologically significant. The people in the group were drawn randomly from schools, service organizations, Non Governmental Organisations (NGOs), public and private institutions. The respondents (120) were equally distributed among three districts, Ernakulam, Kannur and one district outside the study area (Thrissur).

The study, thus, was based on primary data from 480 respondents (120 x 4).

3.3 Method of data collection

The study was conducted based on both primary and secondary data. The NOAA (National Oceanic and Atmospheric Administration) review panel suggested that the personal interviews among the respondents in a professional manner will yield most reliable results (Arrow *et al.*, 1993). For natural resources like mangroves, non use values are more important than direct use values and hence personal interviews are considered as the best method to elicit responses. Personal interview method employing structured pretested interview schedules was adopted for primary data collection. A pilot study was conducted in Kadalundi-Vallikkunnu Community Reserve for mangroves for pretesting and finalizing the interview schedule during February, 2011.

The schedule comprised of three parts: Part I dealt with socio-economic status, occupation and other basic information about the respondents, which is common for all the respondent groups. Part II is stakeholder specific, in which separate schedules were prepared for each group. Part III dealt with valuation, attitudinal aspects and management options and was common for all stakeholders. To capture the qualitative aspects, the responses from the respondents were gathered in a descriptive way. The valuation part of the schedule was developed by referring the instructions on the websites of Asian Development Bank (ADB) and South Asian Network for Environmental Economics (SANDEE) and Gunathilake (2003). The survey

instrument for data collection for this purpose involves three sections as follows, as suggested by Mitchell and Carson (1989).

1. A comprehensive description of the good/ goods being valued and the hypothetical situation under which it is made available to the respondent.
2. Questions which elicit the respondents' WTP for the good/ goods being valued.
3. Details of socioeconomic profile of the respondents, their preferences and uses about the good/ goods being valued.

A survey method using structured questionnaires was implemented to elicit WTP (Willingness to Pay) values. The elicitation formats for the valuation has employed close ended format. The close ended format provided a specific range of values from which respondents could choose. A dichotomous choice format was given in which the respondent could either accept or reject a proposed payment for the conservation of mangrove ecosystems. A double bound approach was used in the dichotomous survey method.

For eliciting WTP, respondents was given the option to choose positive response (accepting the bid), negative response (rejecting the bid) or no response. The WTP question was asked as whether the respondent would like to pay a certain amount for conservation of the ecosystem under given conditions. Depending on the answer, second question with higher or lower value was asked (Wattage and Mardle, 2008). In the study, the starting value was fixed at 5 per cent of the annual income. At the higher end it extends up to 25 per cent, and the lower limit was 1 per cent of annual income. If the answer to the lower limit value was no, the respondent was asked to state the maximum amount he/she is willing to pay (Markandya *et al.*, 2002; Binilkumar, 2010). A copy of the schedule is furnished in Appendix I.

The survey was conducted during the period from June 2012 to January 2013.

The secondary data were collected from the following universities/departments/ institutions and published sources:

1. Cochin University of Science and Technology (CUSAT), Cochin
2. Kerala Agricultural University, Thrissur
3. University of Calicut, Malappuram
4. Department of Fisheries, Government of Kerala
5. Department of Forest and Wildlife, Government of Kerala
6. Department of Irrigation, Government of Kerala
7. Kerala Forest Research Institute (KFRI), Peechi
8. Published articles and reports including electronic sources.

3.4 Analytical framework

3.4.1 Valuation of mangrove ecosystem

The quantitative aspects of the study are presented in a descriptive way, basically estimating the averages and percentages and presenting in a tabular form. The valuation of an ecosystem is a complex process that depends on the availability of relevant and accurate biophysical data on ecosystem processes and functions and the appropriate applications of economic valuation (Morse-Jones *et al.*, 2011). Different econometric techniques have been developed for assigning monetary value to the benefits and losses that is caused by the changes in the quantity and quality of the environmental amenities. However, these goods are not marketed and are believed to be free goods and are often undervalued or inadequately quantified in commercial markets (Costanza, *et al.*, 1997).

The Total Economic Value (TEV) conceptual framework views ecosystem goods and services as the flow of benefits to mankind by nature. TEV is broadly classified into use values and non use values, based on the benefits derived from the present and

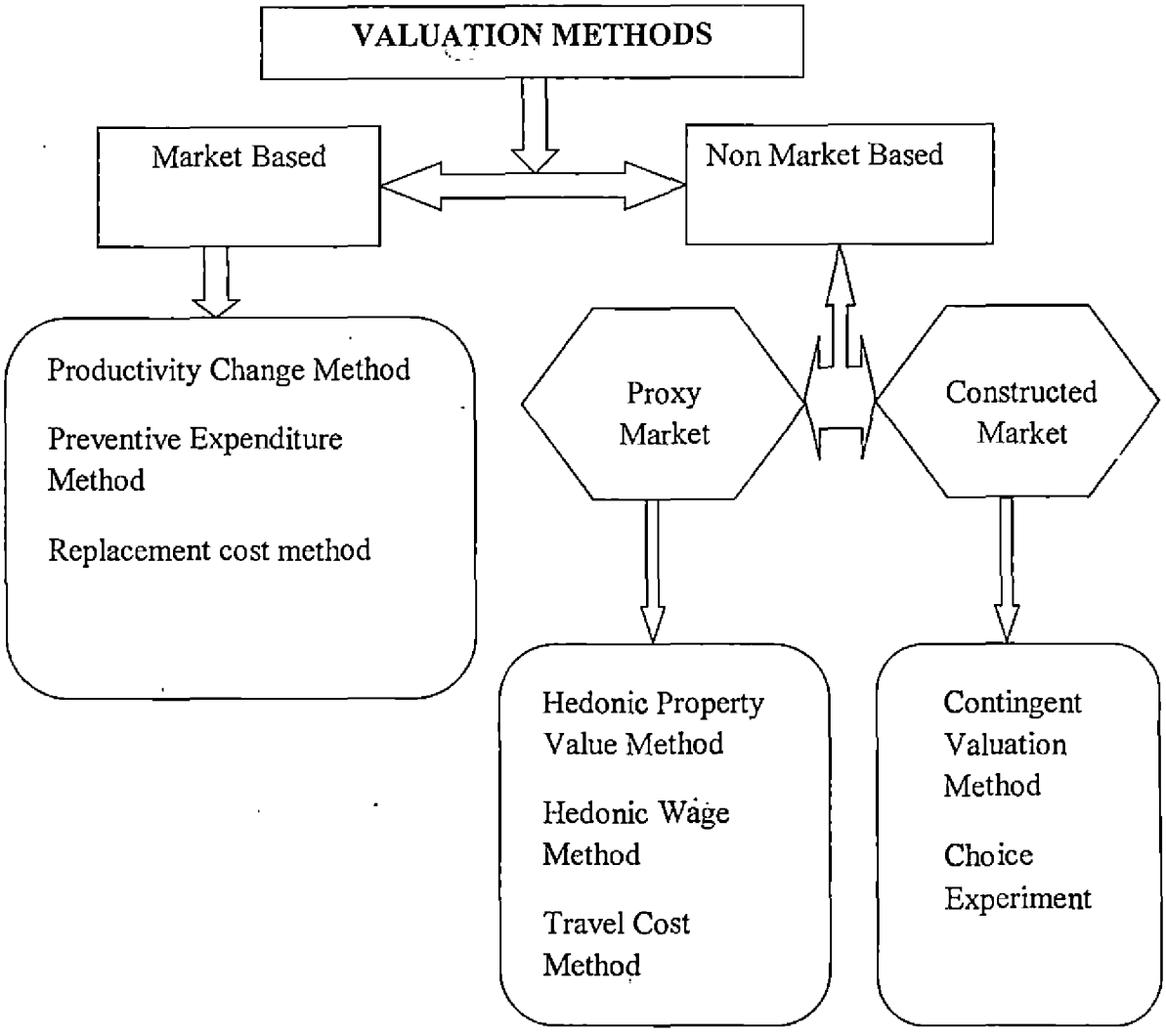
future generation (Barbier, 1994). Under this framework, the TEV of mangrove ecosystem can be depicted as in Table 3.3.

Table 3.3: Total Economic Value of mangrove ecosystem

Use values		Non use values
Direct use value	**Indirect use value**	**Existence value**
• Fish • Fuel wood • Fodder • Medicine • Timber • Honey • Tannins • Recreation and aesthetic	• Nutrient sink • Flood control • Breeding and nursery ground for fishes, crustaceans • Shoreline protection • Storm protection • Micro climate stabilization • Water purification • Roost for the birds	• Biodiversity conservation

Methods of valuing the ecosystem are broadly categorized into conventional market approaches, implicit market approaches and constructed market approaches (Munasinghe, 1993; Gunathilake, 2003). Fig. 6 provides an overview of the methods.

Fig. 3.6: Classification of valuation methods



Source: Gunathilake, 2003

This study adopts both the market based methods and non market based methods. Market based methods are adopted, employing the market prices for the goods directly derived from the system. Thus, for valuing the direct benefits, prevailing market prices of goods in the respective areas were employed. In the case of goods which were used for household consumption, the prevailing consumer price in the

market was computed for valuation. Table 3.4 details the prices used for the valuation.

Table 3.4 Price used for the valuation of direct benefits from mangroves

Sl No.	Item	Price
1	Fuel wood	Purchase price of fuel wood by the households
2	Wooden poles	Purchase price of wooden poles by the households
3	Fodder	Purchase price of fodder by the households
4	Fish/Paddy	Sales price in the nearest local market

The avoided cost or replacement cost method estimates the economic value of an environmental good/service by calculating the cost of replacing the same with a man-made equivalent. It estimates the value of a change in ecosystem service by calculating the cost of substitute or the cost of restoration of ecosystem. In the present study, the replacement cost is employed to compare the cost of man-made sea wall with the cost of mangrove bio shield along the coastal line. UNEP (2011) reported that mangroves in coastal areas can provide the same protective effect of the man made sea wall.

The non market based methods in valuation were employed in the case of ecosystem services which were not traded in the market. Contingent Valuation Method (CVM) is one of the most widely employed techniques in the valuation of ecosystem services (Mitchell and Carson, 1989; Bann, 1999; Lal, 2003; Gunawadena and Rowan, 2005; Gupta and Mythily, 2007; Stone *et al.*, 2008; Yacob *et al.*, 2009; Binilkumar, 2010; Ekka and Pandit, 2012). In this method, the individuals are asked directly about their Willingness to Pay (WTP) or Willingness to Accept (WTA) for maintaining or compensating for the loss of environmental goods and services. This method is called 'contingent' valuation method, since people are asked to express their willingness to

pay or accept, dependent on a particular hypothetical situation for environmental goods and services (Brookshire and Eubanks, 1978).

Willingness to Pay is the maximum amount of money an individual is willing to pay for obtaining/enjoying certain ecosystem goods and services. His /her preference is based on the utility he/she derives from the good. It represents an individual's perceived values on a particular good or service. Willingness to Accept (WTA) is the amount of money which is considered as compensation for foregoing a benefit and represents the value of such a benefit or loss (Bateman, 1993).

The CVM has been based on two major principles of neo- classical economics (Hoevenagel, 1994):

i. Value of any good depends on its utility to different users
ii. Individuals who behave rationally, will try to maximize their utility

The concept was believed to be originated in 1947 when Ciriacy-Wantrup used various questions to obtain economic values of soil conservation. He mentions "Individuals may be asked how much money they are willing to pay for successive additional quantities of a collective extra-market good. The choices offered relate to quantities consumed by all members of a social group. If every individual of the whole social group is interrogated, all individual values (not quantities) are aggregated. The results correspond to a market demand schedule". The first recorded attempt on CVM was done by Davis (1963) for valuing outdoor recreation benefits of Maine woods, USA. Contingent valuation has been very useful especially in ex-ante and ex-post assessment of conservation policy (Pearce and Moran, 2001).

CVM has been an important tool in environmental economics and large number of studies is reported employing the tool (Bateman *et al.*, 1992; Stevens *et al.*, 1995; Oglethorpe and Miliadou, 2000; Wattage and Mardle, 2008).The technique is specifically used in valuation of wetlands by Binilkumar (2010) and mangroves by Ekka and Pandit (2012). The present study adopts the method employed by Bann

(1999); Lal (2003); Gunawadena and Rowan (2005); Gupta and Mythily (2007); Stone *et al.* (2008); Yacob *et al.* (2009); Sathya and Sekar (2012) with appropriate modifications to suit local socioeconomic settings.

The model specification and identification of the independent variables for the analysis were done based on previous research (Bann, 1999; Gunathilake and Tachiiri, 2012; Sathya and Sekar, 2012) and experience derived from the field situation. The factors influencing the WTP of the respondents were estimated using multiple regressions with WTP as dependent variable with a set of explanatory variables. Wherever necessary the functional transformations were done to improve the goodness of fit. The explanatory variables include socioeconomic variables and respondent's perceptions.

The model used for the present study was in the following form and the description of the variables is furnished in Table 3.5.

WTP = f {AGE, EDN, MI, OI, LHS, DIS, AI }

Table 3.5 Description of variables for WTP for conservation of mangrove ecosystem

Variable name	Description
Dependent variable	
WTP	Willingness to Pay for the conservation of the mangrove ecosystem (₹/household/year)
Explanatory variables	
AGE	Age of the respondents (Number of years)
EDN	Years of schooling (Number of years)
MI	Annual income derived from mangrove related activities (₹/household/year) (Fisheries, Rice farming)
OI	Annual income derived from other sources (₹/household/year)
LHS	Land holding size (ha)
DIS	Distance between respondent household and the nearest mangrove area (km)
AI	Awareness Index

In the case of multi period payments, the WTP was discounted as suggested by Nelson *et al.* (1973). The discount rate was taken at rate of 6 per cent based on the current inflation rate of the country.

$$V = \frac{I(1+i)^n - 1}{i(1+i)^n}$$

Where,

V= Present value

I= Future value

i= Discount rate (6%)

n= number of years

In the case of the responses in favour of kind payment, the corresponding value was calculated based on the proportionate earnings of the respective respondent.
The analysis is done using software package of SPSS 17.

Each respondent was asked to assign a value (1-5) reflecting the relative importance assigned to good/service received from mangroves for calculating awareness index (Question 1 from Part 3 of the schedule). There were 17 statements depicting the details of goods and services from the mangrove ecosystem. Each statement is assigned value according to Likert scale with a value ranging from 5- for strongly agree, 4- for agree, 3- for neutral, 2- for disagree and 1- for strongly disagree (Edward, 1963; Singh, 1998). The respondent's awareness index was calculated by adding up the response to all the seventeen statements. Thus, the highest value for an index can be 85 and lowest value can be 17. The higher the value, the better informed is the respondent of the various goods/ service of mangroves.

3.4.2. Management options

The technique of Choice Experiment (CE) was employed in developing the management options based on respondents' responses. Choice experiment was first employed in the transport and marketing economics by Louviere and Hensher (1982) and Louviere and Woodworth (1983). It is a stated preference method which elicits public/individual preferences by asking respondents to choose among a series of alternatives. The theoretical foundations of the CE method lie on Lancaster's Characteristic Theory of Value according to which individuals derive utility from the characteristics of the good rather than from the good as a whole (Lancaster, 1966), and the random utility theory (McFadden, 1974). In resource/environmental economics, where the markets of environmental/ecological services are not developed or absent, by using CE, hypothetical markets are constructed to allow individuals to choose their most preferred option from a set with two or more than two choice

options, defined as alternatives (Veettil *et al.*, 2011). Each alternative comprises of certain specific characteristics and each alternative is termed as an attribute. These attributes can have more than one level according to the situation. CE relies on the basic idea that an individual can choose a particular alternative rationally by maximizing utility among choice sets comprising different attribute levels (Hanley *et al.*, 1998).

The initial step in designing CE is to identify choice alternatives and their relevant attributes (Hanley *et al.*, 2002; Hensher *et al.*, 2005). The profile of the good in question is developed based on its attributes and level of these attributes using the theory of experimental design (Birol *et al.*, 2006a). Various alternative management options of goods and services which are described by a set of attributes are presented to the respondents and are asked to choose the most preferred option (Hanley *et al.*, 2001).

As mentioned above, the individuals were given hypothetical scenarios and were asked to choose their most preferred alternative among several alternatives in a choice set. It comprises of the following elements (Bennett *et al.*, 2001):

- A set of fixed choice options that have explicit names
- A set of attributes that describes potential difference in the choice options
- A set of levels or values assigned to each attribute of each options to represent a range of variation in that attribute

Through this, it makes possible to determine the relative importance of the attributes to people and hence can be used for developing socially desirable management options. CE is more suitable for understanding the acceptability or adoptability of new intervention policies.

CE is based on the assumption that utility of the stakeholder depends on the set of available choices of the mangrove management alternatives (C). The stakeholder's utility function will take the form

$$U_{nj} = V(Z_j, S_n) + e(Z_j, S_n) \quad i \in C$$

where for any stakeholder n, a given level of utility will be associated with chosen management alternative i. Alternative i will be chosen over some other option j if and only if $U_i > U_j$. The utility depends on the attributes of mangrove ecosystem (Z) and the socio-economic characteristics (S) of the stakeholder. According to the random utility theory, the utility of the choice is comprised of a deterministic component (V) and an error component (e) that is completely independent of the deterministic part and follows a predetermined distribution (Birol *et al.*, 2006b). The probability that stakeholder n chooses option i over other options is given by

$$Prob(i/c) = Pr\{V_{in} + \epsilon_{in} > V_{jn} + \epsilon_{jn}, all\ j \in C\}$$

The above equation can be estimated only by assumptions made over the distribution of the error terms. The important assumption is that error terms follow the extreme – value (Gumbel) distribution and are independently and identically distributed (McFadden, 1974). Multi-nomial logistic regression is a regression model that is used to predict the probabilities of different probable outcomes of a categorically distributed dependent variable given a set of independent variables. The probability of choosing i using Multi-nomial logistic model is given by

$$Prob(i/c) = \frac{exp(\mu V_{in})}{\sum_{j \in C} exp(\mu V_{in})}$$

where μ is a scalar parameter which is normally assumed to be equal to one. Multinomial logistic model assumes that choice set obey the Independence of Irrelevant Alternatives (IIA) property (Luce, 1959), which states that the relative probabilities of two options being chosen are unaffected by the introduction or removal of other alternatives.

In the present study, dependent variable (categorical) was the mangrove management scenario. Four alternative management options were considered namely: community management, public management, private management and public-private partnership management. Those respondents who do not opt any of these is assumed to be maintaining the *status quo* position. This is included because one of the options must always be in the respondent's currently feasible choice (Hanley *et al.*, 2001). Table 3.6 details the management options considered in the study.

Table 3.6: Description of management options

Sl No.	Management options	Descriptions
I	Community management	The local communities who depend on the mangrove ecosystem for their livelihood forming democratic institutional form to manage the resource
II	Public management	The state takes the ownership rights over the resources and manages the resource and provides user rights to communities who depend on the system for livelihood
III	Private management	The private ownership rights and management of the resource as per the owner preferences
IV	Public private partnership	An institutional form in which private ownership/user rights are protected and the state takes an active role in the management through an institutional form where there are representatives from both private owners and the government

The identification of relevant attributes and levels were decided based on literature review and focus group discussions along with expert consultations. Four attributes were selected with different levels. The selected attributes were mangrove area equivalent, fish wealth, ecological services and level of payment. Table 3.7 details these options.

The mangrove area in the state has been declining over the past and hence is significant attribute in determining the management option. This attribute is considered in three levels: decrease in area, expansion of the area and the *status quo*.

The inland fish wealth has direct interactions with the mangrove stand. It is assumed that inland fish wealth improves with the improvement in mangrove area. Two levels are considered, increase and decrease in the fish wealth from the current level. The fish wealth is directly correlated with the sustenance and livelihood of the local communities in the wetland area. An attribute on the ecological services is also included as mangroves are providing valuable ecological services like storm abatement, reduction in soil and embankment erosion and micro climate stabilization. The respondents, residents and fishermen living along the coastal tract, are directly benefitted by the ecological services provided by the mangroves such as reduction in storm surges and also the reduction in soil and embankment erosion along the boundary of their households. The monetary attribute (WTP) allows for estimating the payment for marginal changes in the levels of other attributes. It is the amount that respondents are ready to offer for the better management of mangroves. The higher and lower levels of these four attributes were included.

Using the attributes and levels mentioned in Table 3.7, an experimental design technique (Louviere *et al.*, 2000) and SAS software were used to obtain an orthogonal design which consisted of the main effects. An efficient design is developed using SAS and resulted in 36 choice sets of alternative mangrove management scenario. However, administering 36 choice sets to each individual was

very time consuming and difficult for a sample respondent to comprehend. So, in the present study, these choice sets were randomly blocked into 12 blocks each with 3 choice sets. Each group of choice set was administered randomly to 40 respondents (each version was presented to ten respondents each in all the four stakeholder groups).

Each choice set contains five management scenarios. The respondents were asked to exhibit their preferred option among the five alternative scenarios (four proposed and one *status quo*). The options in each choice set are described using four attributes which take on various levels as mentioned in Table 3.7. The selected option was assumed to provide the highest utility for the respondent. The data on choice is binary in nature, i.e. when a respondent chooses an alternative option; the choice takes the value of 1, otherwise zero. Therefore, corresponding to each choice set there will be single entry of 1 and four zero entries. The analysis of data was done using SAS software.

Table 3.7: Details of the selected attributes for the management options for mangrove conservation

Sl No.	Attributes	Definition	Levels
1	Area under mangroves	Mangrove area in area equivalent	1. Low: Depletion from current level (2% and 5%) 2.Remains same 3. High: Improvement from current level (2% and 5%)
2	Fish resources	Fish wealth in the wetlands	1. Decrease: Depletion of fish wealth from current level (1%) 2. Increases: Increase in fish wealth (1%)
3	Ecological services	Various ecological services provided by mangrove ecosystem	1. Low: Deterioration in quality of the ecological services 2.High: Improved ecological services
4	WTP	Amount that the respondent is ready to pay for the conservation of mangroves	1.2% of monthly income 2. High: 5% of monthly income

RESULTS AND DISCUSSIONS

4. RESULTS AND DISCUSSIONS

The results of the study are presented in five main sections viz.

1. The status of mangroves
2. Stakeholder groups and their level of dependence on the mangrove ecosystem
3. The factors that influence the mangrove wealth
4. Economic valuation of mangroves
5. Management options

4.1. The status of mangroves

4.1.1. Global- Distribution

Two zones of mangrove distribution had been identified across the world viz. the eastern zone consisting of the East Africa, Thailand, Philippines, Southern Japan, Australia, New Zealand and the western zone consisting of the Atlantic coast of Africa and the America (Chapman, 1970; 1975). The first attempt on estimating the total mangrove area in the world was undertaken as part of the FAO/UNEP Tropical Forest Resources Assessment in 1980, where the area was estimated at 15.60 M ha spread in 51 countries (FAO/UNEP, 1981) (Table 4.1). Later, Tomlinson (1986) reported the presence of mangroves in almost 124 countries. FAO (2006) furnished an account of the area and distribution of mangroves globally. Asia accommodates the largest mangrove area of the world with 42 per cent (5.79 M ha) followed by Africa (20%). The rest of the areas are located in North and Central America, Oceania and South America (Fig. 4.1).

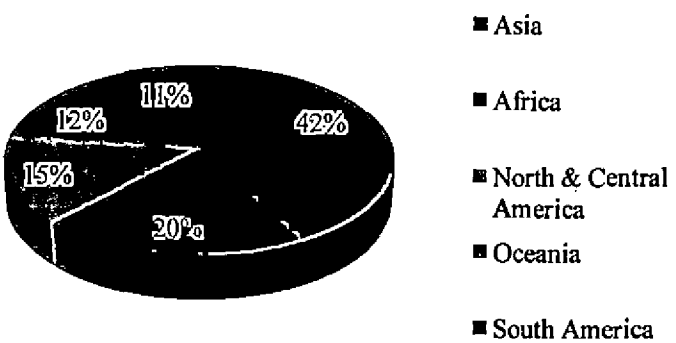
Palot and Jayarajan (2007) reported nearly 14 M ha of mangroves distributed in about 80 countries. However, Giri *et al.* (2010) using earth observation satellite reported that mangroves are seen in 118 countries with an area of 13.78 M ha. Five countries (Indonesia, Brazil, Nigeria, Australia and Mexico) together account for about 48 percent of all mangrove area and 75 percent of the total mangrove area is found in

just fifteen countries. The total mangrove area represents 0.7 per cent of the total tropical forest of the world. The area estimates from these countries was based on ground surveys, remote sensing data and expert estimates.

Table 4.1: Global distribution of mangroves

Sl No.	Source of information	Year	No. of countries	Area (M ha)
1	FAO/UNEP Tropical Forest Resources Assessment	1981	51	15.60
2	Fisher and Spalding	1993	91	19.80
3	Aizpuru *et al.*	2000	112	17.00
4	FAO	2006	-	13.79
5	Palot and Jayarajan	2007	80	14.00
6	Giri *et al.*	2010	118	13.78

Fig 4.1: Worldwide status of mangroves



Source: Adapted from FAO (2006).

Mangroves of South and South East Asia form the world's most extensive and diverse mangroves accommodating 41.4 per cent of global mangroves i.e. nearly six M ha (GEC, 2011; ITTO, 2012) (Table 4.2). Mangroves are present in almost all coastal nations of the Asian continent. The continent is an abode of species diversity of mangroves and more than 56 species were reported (FAO, 2007). Mangroves offer livelihood for numerous rural communities in Indonesia, Malaysia, Bangladesh and India.

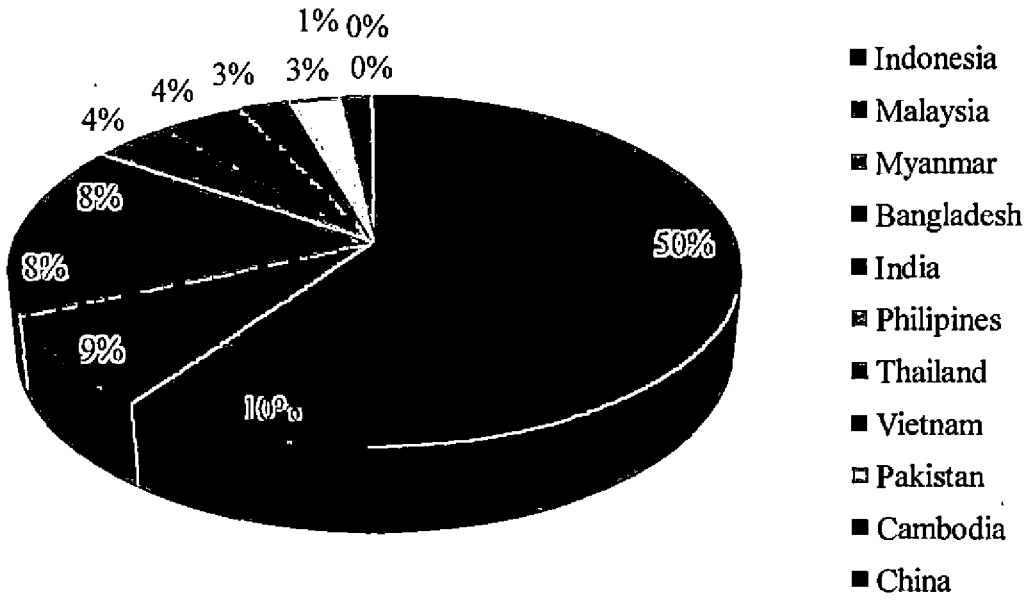
Indonesia, Malaysia, Myanmar, Bangladesh and India together house more than 80 percent of total Asian mangroves (Fig. 4.2). Indonesia occupies the largest area with 50 percent share (20% of world mangrove) followed by Malaysia and Myanmar. India with 4.66 lakh ha occupies fifth position in mangrove area among the Asian countries. The Sunderbans, the largest mangrove ecosystem in the world (covers about 7% of global mangroves) is jointly shared by India and Bangladesh. Bangladesh also has an equal mangrove area as in India. The rest of the Asian mangroves are located in West Asian countries such as Bahrain, Oman, Saudi Arabia and United Arab Emirates.

Table 4.2: Distribution of mangroves in Asia

Sl No.	Country	Year	Area (ha)	Area (ha) (2005)
1	Bangladesh	1995	476215 (8)	476000 (8)
2	China	2001	22480 (0.4)	22480 (0.4)
3	India	2003	446100 (7)	448000 (8)
4	Indonesia	2003	3062300 (51)	2900000 (50)
5	Malaysia	2005	564971 (9)	565000 (10)
6	Pakistan	2001	158000 (3)	157000 (3)
7	Sri Lanka	1996	9530 (0.2)	8800 (0.2)
8	Thailand	2000	244085 (4)	240000 (4)
9	Vietnam	2000	157500 (3)	157500 (3)
10	Cambodia	1997	72835 (1)	69200 (1)
11	Myanmar	1999	518646 (9)	507000 (9)
12	Philippines	2003	247362 (4)	240000 (4)
	Asia	**2002**	**60,47,798** (100)	**58,57,575** (100)

Source: Adapted from FAO (2006). Figures in parentheses represent percentage to total. The estimates are from different years. However percentage is calculated based on area estimate of Asia in 2002 and 2005.

Fig. 4.2: Distribution of mangroves in Asia (2005)



Source: Adapted from FAO (2006).

4.1.2. Mangroves: the shrinking resource

Estuarine and coastal ecosystems are one among the most threatened natural systems in the world. World's mangroves are under pressure from both human's encroachments and nature's furies. Regardless of the numerous services and benefits provided by mangroves, these coastal bio shields are repeatedly undervalued and viewed as wastelands, nuisance or unhealthy environments. To enhance food security, boost national economies, alleviate poverty and improve living standards, many countries have encouraged the development of shrimp and fish farming, agriculture and salt production in mangrove areas (Lotze *et al.*, 2006; Worm, 2006; Halpern *et al.*, 2008). In addition, high population pressure in coastal areas has also led to the conversion of many mangrove areas to alternate uses such as tourism, industrial uses and urban development.

It was reported that 35 per cent of the world's mangroves are lost in between 1980 and 2000 (MEA, 2005). Duke *et al.* (2007) predicted the complete loss of mangroves by the year 2100 mainly due to the destruction in Asian countries while Mathew *et al.* (2010), feared it to occur at an earlier date i.e. by 2050. FAO attributed high population pressure, the large scale conversion of mangrove areas for shrimp and fish farming, agriculture, infrastructure and tourism, as well as pollution and natural disasters as the major causes for the destruction of mangroves.

The rate of loss of mangroves exceeds the loss of the rainforest at 2.1 per cent per annum. A whopping 36 per cent of Asian mangroves have been deforested at the rate of 1.52 per cent per year (Valiela *et al.*, 2001; MEA, 2005; FAO, 2007). The change in the status of mangrove ecosystem across the globe is compiled and presented in Table 4.3. The loss in the total mangrove area around the globe was around 3.6 M ha since 1980, equivalent to an alarming 20 percent. The worst affected area is Oceania, where 28 per cent of mangroves were lost between 1980 and 2010. The continent with a largest mangrove area, Asia, lost 1.6 M ha of mangroves mainly due to changes in land use. Indonesia, Mexico, Papua New Guinea, Vietnam, Malaysia and Madagascar are reported to be the countries which have lost major area, between 1990s and 2000-2005 (FAO, 2007).

The rate of change in mangrove area over the years is presented in Table 4.4. The slowdown has occurred in the rate of mangrove depletion in the world from 18.8 M ha in the 1980 to 16.9 M ha in 1990 and later to 15.2 M ha during 2010. It is relieving to note that, the rate of decline has slowed down from 1.04 to 0.32 per cent over the three decades. The progressive afforestation and rehabilitation measures and conservation of the existing mangrove ecosystem have been attributed as the reasons for the improved global growth rate. The change reflects an increased awareness of the value of mangrove ecosystems and it is clearly visible in case of the Sunderbans in Bangladesh and Ecuador. A significant reduction in the scale of destruction of

mangroves occurred in South America with an impressive growth rate of 1.81 per cent per year during the period 2000-10. Nearly one M ha of mangroves is planted between 1980 and 2010 due to adoption of sound conservation strategies.

Table 4.3: Global distribution of mangroves over the decades (M ha)

Region	1980	1990	2000	2010
Africa	3.67 (20)	2.42 (15)	3.21 (20)	2.79 (18)
Asia	7.79 (41)	6.74 (42)	6.16 (39)	6.22 (41)
North & Central America	2.95 (16)	2.59 (15)	2.35 (15)	2.24 (15)
Oceania	2.18 (11)	2.09 (14)	2.01 (13)	1.58 (10)
South America	2.22 (12)	2.07 (14)	1.99 (13)	2.38(16)
World	18.79 (100)	16.9 (100)	15.74 (100)	15.23 (100)

Figures in parentheses represent percentage to total. Source: FAO, 2007; ITTO, 2012

Table 4.4: Average annual growth rate of global decline of mangroves

Region	Annual growth rate (%)		
	1980-90	1990-00	2000-10
Africa	-4.05	2.86	-1.40
Asia	-1.44	-0.89	0.10
North & Central America	-1.29	-0.97	-0.49
Oceania	-0.43	-0.38	-2.33
South America	-0.69	-0.38	1.81
World	-1.04	-0.72	-0.32

Source: Author's estimation

The pattern is similar in Asian region too. North and Central American region is also slowly showing improving situation, even though the rate of decline still continues. An impressive growth rate in the area (2.86%) has taken place in African countries during 1990-2000 compared to the previous decade (-4.05%). But they lost the momentum in the next decade and ended up with a negative growth rate of 1.40 per cent in 2000-2010. Oceania, however exhibits increase in the rate of mangrove destruction. The recent rate of decline has reached a level of 2.33 per cent per annum.

In relative terms, countries with high deforestation rates include Singapore, Benin, Dominica, Brazil and Côte d'Ivoire in the 1980s and Côte d'Ivoire, Honduras, China, Congo and Barbados in the 1990s. Conversely, a number of countries have registered a positive change over time, including Bangladesh, where the world's largest mangrove area (The Sundarbans Reserved Forest) is well protected and substantive and successful efforts have been made in coastal afforestation. The relatively large mangrove deforestation rates in Asia, the Caribbean and Latin America in the 1980s reflect large scale conversion of mangroves for aquaculture and tourism infrastructure.

The major cause of global mangrove loss has been the coastal economic development especially the aquaculture expansion (Barbier and Cox, 2003). Aquaculture contributes 58 per cent to mangrove loss with shrimp farming alone accounting for 41 per cent of total deforestation (Valiela *et al.*, 2001). The extraction of forest products from mangroves causes 26 per cent of global mangrove loss and 16 per cent in Asia, fresh water diversion accounts for 11 per cent of loss globally and 14 per cent in Asia and reclamation of land for other uses cause 5 per cent and 7 per cent of loss globally and in Asia respectively (Barbier, 2006a). Apart from these, herbicide impacts, agriculture, salt ponds and other coastal developments also resulted in mangrove deforestation. The unsustainable levels of grazing and fishing activities, land reclamation and waste disposal are also the reasons for the large scale destruction and depletion of the mangrove areas. The wide spread depletion of these coastal bio

shield has occurred mainly in Asian countries like Thailand, Vietnam, Malaysia and Indonesia.

The Asian region has lost almost 20 percent of mangroves in the period during 1980 –2010 and the 90 percent of the loss occurred in Indonesia, Pakistan, Vietnam, Malaysia and India. It is a positive sign that growth rate in Asia has improved between 1980 (-1.44%) and 2010 (0.10%). The rural masses of Asia depend on mangroves for timber, fish, fodder, fuelwood, thatching materials, medicine and honey. The main reason for the over exploitation and depletion of mangrove area in Indonesia and Thailand was a large scale development of shrimp farms. Owing to the lucrative economic return, shrimp farming has been promoted by the governments to boost national economies, as a latent source of earnings for local communities and as a method of poverty alleviation. In later years, realizing the negative impact on the ecosystem, the governments of these countries have initiated corrective measures to restore the lost mangroves in the last few years.

The self-sufficient food production drive in India and Myanmar led to the conversion of mangrove lands to rice fields. Mangrove areas in China, Indonesia, Philippines and Vietnam have been used for salt production. While in Singapore and Pakistan, construction of dams and diversion of water for irrigation increased soil salinity, which damaged the surrounding mangroves (FAO, 2007). Anthropogenic pressure and subsequent urbanization drive caused damage to the mangroves, throughout the world, currently. Besides these human factors, natural hazards such as cyclones, storms, tsunamis and floods which frequently occur in this region, have been threatening several coastal ecosystems, including mangroves. However, different Asian countries have initiated conservation of mangroves through rehabilitation and management and the decade 2000-10 witnessed a small improvement in mangrove area to 6.2 M ha.

4.1.3. Mangroves in India

Globally, one of the rarest and the richest mangrove ecosystems are seen in India which is located in 69–89.5^0 E longitude and 7–23^0 N latitude. The Indo-Malayan region is considered to be the cradle of the evolutionary process of mangrove vegetation (Upadhyay *et al.*, 2002). The Indian mangroves comprise approximately 59 species in 41 genera and 29 families (Singh *et al.*, 2012). In India, major mangrove species diversity is reported in the Sunderbans (West Bengal) and Bitherkanika (Orissa) followed by Godhavari coast of Andhra Pradesh and Andaman & Nicobar Islands. The mangrove families viz. *Rhizophoraceae*, *Avicenniaceae*, *Acanthaceae* and *Meliacea* are reported from India (Thothathri, 1981). Three diverse types of mangroves are seen in India, the first being *deltaic mangroves* located on the east coast, Gulf of Kuchh and Khambhat Gulf on the west coast, covering more than 50 per cent of the total Indian mangroves. The second type is *coastal mangroves*, which are found along the intertidal coastal lines, minor river mouths, sheltered bays and backwaters of the west coast. The *island mangroves* are found along shallow protected intertidal zones of bay islands such as Lakshadweep and Andaman & Nicobar (Ingole, 2005).

India has a long coastal belt of more than 7,500 km including Andaman & Nicobar Islands. Mangroves in India are spread over an area of 4.66 lakh ha along the 5,700 km coastal line (FSI, 2011) occupying 0.14 percentage of the geographical area of the country with 3.1 percent of the global and 8 percent of Asian mangrove coverage. (FAO, 2007; Kathiresan, 2010; FSI, 2011; Singh *et al.*, 2012). The distribution of mangroves in India is presented in Table 4.5. Mangrove cover in India has been categorized according to canopy density of more than 70 per cent as very dense, between 40-70 per cent as moderately dense and between 10-40 per cent as open mangroves. Twenty six per cent of mangroves belong to the very dense category whereas moderately dense and open mangroves constitute 36 and 38 per cent, respectively in India. West Bengal and Andaman & Nicobar Islands are the places

where very dense mangroves are seen whereas moderately dense and open mangroves exist in other states. In Union territories of Daman & Diu and Pondicherry, open mangroves only are seen (Singh *et al.*, 2012).

About 52 per cent of the total Indian mangroves are located along the east coast of the country, primarily in West Bengal and Orissa. The rest is distributed along west coast (34%) and the Andaman & Nicobar Islands (14%) (Fig.4.3). The Sunderban mangroves, the largest mangrove delta of the world is located in India and Bangladesh. It occupies 30 per cent of mangroves in India. The Sunderbans got its name from a mangrove species *Heriteira fomes* called *Sundari* in local language. Over 1,600 plant and 3,700 animal species have been identified in the Indian mangrove ecosystem.

West Bengal occupies the maximum mangrove area (47.65%) followed by Gujarat (21.06%) and the Union Territory of Andaman & Nicobar Islands (14.33%). Rest of the mangroves of the country are scattered in other coastal states like Andhra Pradesh, Orissa, Maharashtra, Tamil Nadu, Goa, Kerala and Karnataka and in two Union Territories.

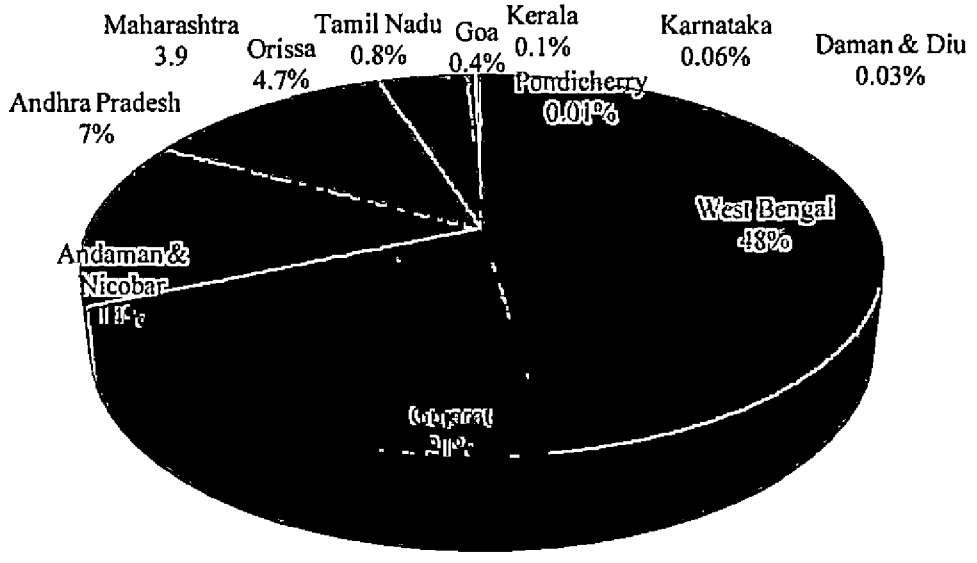
Table 4.5: Mangrove distribution in India

(Area in ha)

Sl No.	State/UT	Very dense mangrove	Moderately dense mangrove	Open mangrove	Total	% to total area
1	Andhra Pradesh	0	12600	22600	35200	7.54
2	Goa	0	2000	200	2200	0.47
3	Gujarat	0	18200	87600	105800	22.69
4	Karnataka	0	300	0	300	0.06
5	Kerala	0	300	300	600	0.13
6	Maharashtra	0	6900	11700	18600	3.99
7	Orissa	8200	9700	4300	22200	4.76
8	Tamil Nadu	0	1600	2300	3900	0.84
9	West Bengal	103800	88100	23600	215500	46.21
10	Andaman & Nicobar	28300	26100	7300	61700	13.23
11	Daman & Diu	0	12	144	156	0.03
12	Pondicherry	0	0	100	100	0.02
	Total	140300	165812	160144	466256	100

Source: FSI, 2011.

Fig. 4.3: Distribution of mangroves in India



Source: Adapted from FSI, 2011.

Similar to the situation elsewhere, mangroves in India are also under threat. The National Remote Sensing Agency report showed that 40 per cent of mangroves in India as destroyed. The destruction was to the tune of 7,000 ha between 1975 and 1981 (Madhusoodhanan and Vidyasagar, 2012). Anthropogenic pressures, expansion of agricultural and salt making lands, development of industries and ports and the expansion of coastal aquaculture are the critical factors for the depletion and destruction of mangroves in India. The economic and ecological significance of mangroves are not properly perceived by the public. Hence the conservation approach was generally absent, though the legal protection is there. For sustainable use and conservation of mangrove areas the Supreme Court of India has included mangrove environment under the Coastal Zone Regulation-1(CRZ-1). Mangroves have been declared as ecologically sensitive areas under the Environmental Protection Act, 1986 as well.

4.1.4. Mangroves in Kerala

Kerala with a coastal line of about 590 km, 35 to 120 km in width and 41 rivers emptying into the Arabian Sea, was once very rich in mangrove formations, perhaps next only to the Sunderbans. Kerala has more than 900 km^2 of interconnected waterways, rivers, lakes and inlets that together constitute the Kerala backwaters. In the state, mangroves are seen as narrow strips confined to the mud flats of delta, on the leeward faces of estuaries and also the embankments of the coast. The mangrove ecosystem of Kerala is nested within the upper reaches of estuaries, lagoon, backwaters and creeks along the coastal belt. This interlinked network of waterways forms an excellent matrix for the dispersal of mangrove propagules and the regulation of soil salinity, the two crucial factors determining mangrove presence and long term persistence in a landscape. From time immemorial these rich wetlands have been providing livelihood to thousands of people especially in the coastal areas in the form of fish, fuelwood, fodder and other key ecological services. The first report of existence of mangrove vegetation along Kerala coast was given in the illustrious work Hortus *Indicus Malabaricus* (Van Rheede, 1678-1703).

Kerala coast, covering 10 per cent of the country's coastal line has only less than one per cent of India's total mangrove ecosystem. All along the coast, occurrence of small mangrove is seen in isolated patches along the fringes of estuaries and backwaters (especially in South Kerala) and also along the river lines in the coastal areas. Mangroves of the state are less complex in terms of tidal creek networks compared to the dense complex networks of mangrove ecosystems along the east coast of the country (Naskar and Mandal, 1999).

The scientific estimates of the area under mangroves in Kerala are scanty. An estimate based on authentic record (Blasco, 1975) indicated that there were about 70,000 ha of mangroves in the state, have now reduced to few hundred has and observed that only the remnants or vestigial stock of mangroves existed in many parts of the state largely confined to some estuaries and creeks. A compilation of reports on

the area by different authors is presented in Table 4.6. Ramachandran and Mohanan (1987) reported that until a few centuries ago, backwaters of Kerala were fringed with extensive mangrove vegetation. The mangrove area estimate based on observations and local enquiry by Basha (1991) reported that it was 1,671 ha. The estimate of Kurien *et al.* (1994) was in conformity with this report. Mohanan (1997) estimated the mangrove spread as 4,200 ha which showed significant improvement. This might be due to the methodological differences in estimation.

In 2003, the Forest Survey of India reported it as 800 ha. But, Unni in the same year reported double the area which is similar to 1991 study. Later in 2006, Radhakrishnan *et al.* reported the area as 4,118 ha. However area estimate using remote sensing by FSI (2009, 2011) reported only 500-600 ha. Based on the latest field investigation by the Kerala Sasthra Sahitya Parishad (KSSP), Madhusoodhanan and Vidyasagar (2012) reported about 2,502 ha of mangroves in the state. But the estimates are based on visual judgments and lack scientific basis. The most authentic report on the area under mangroves in Kerala is by FSI (2003, 2005, 2009 and 2011) based on remote sensing data. However this needs to be validated through ground level survey. Thus, realistic scientific estimation of mangroves in the state is highly warranted.

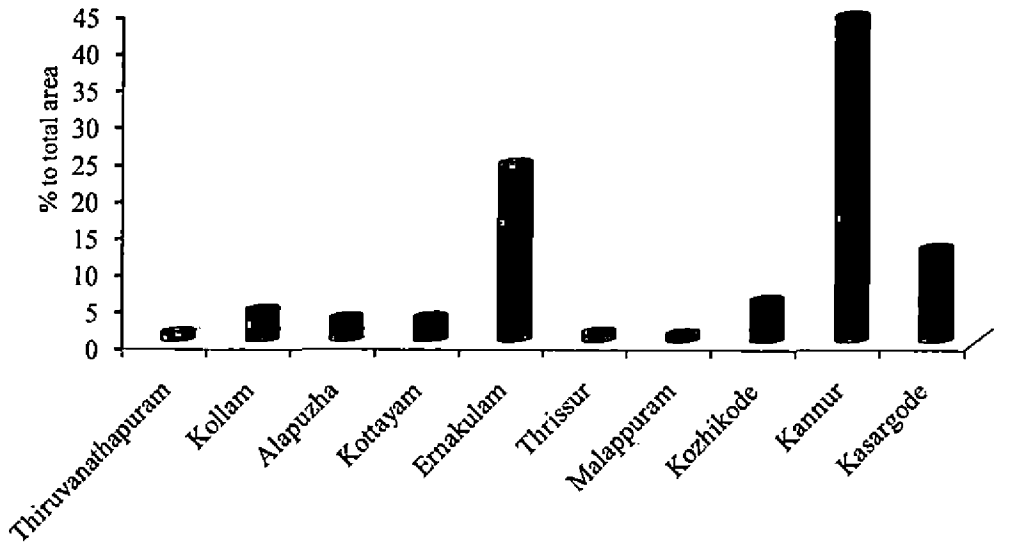
Table 4.6: Area under mangroves in Kerala

Sl No.	Authors	Area (ha)
1	Basha, 1991	1671
2	Kurien, 1994	1095
3	Mohanan,1997	4200
4	FSI, 2003	800
5	Unni, 2003	1650
6	Radhakrishnan *et al.*, 2006	4118
7	FSI, 2009	500
8	FSI, 2011	600
9	Madhusoodhanan and Vidyasagar, 2012	2502

A journey particularly in train from Thiruvanathapuram to Kasargode along the coastal belt provides ample evidence for the presence of mangroves along the coast and in some pockets mangroves have still not lost their natural regeneration capacity. Mangroves are present in all the coastal districts of Kerala. Majority of mangroves in Kerala are mainly seen in Kannur (44%) followed by Ernakulam (24%) (Table 4.7). The four northern districts, Malappuram, Kozhikode, Kannur and Kasargode, account for more than 60 per cent of the mangrove area of the state, imparting higher heterogeneity in the ecosystem than the Southern part (Fig. 4.4). After comparing the two studies, Basha (1991) and Madhusoodhanan and Vidyasagar (2012), a sizeable area reduction has noticed in Kozhikkode district (17.5% to 5.6%). However, overall mangrove area seems to have increased. But both of these studies are not based on scientific methods of area estimation.

Mangroves in Kerala are spread mainly in the districts of Kannur, Ernakulam and Kasargode. Even scanty presence of mangroves in the other districts plays important ecological functions and economic role in the local economics. Mangroves of Kollam (Ashramam) and Kottayam (Kumarakom) has prominent place in the tourism map of Kerala. Mangroves of Kumarakom (Kottayam), Mangalavanam (Cochin) and Kadalundi (Kozhikode) are the hot spots of birds, especially migratory birds. The first Community Reserve for Mangroves in South India was established in Kadalundi (Hema and Devi, 2012). Mangroves there acted as protective shield in the area during Asian tsunami of the year 2004. The local communities depend on this ecosystem for livelihood activities.

Fig. 4.4: Distribution of mangroves in Kerala, 2012



Source: Madhusoodhanan and Vidyasagar, 2012

Table 4.7: District wise area distributions of mangrove vegetation along Kerala coast (ha)

Sl No.	Districts	1991	1994	1997	2003	2012	% to total area (2012)
1	Thiruvanathapurm	23	-	15	23	28	1.1
2	Kollam	58	-	15	58	105	4.2
3	Alapuzha	90	-	25	90	78	3.1
4	Kottayam	80	-	20	80	80	3.2
5	Ernakulam	260	89	250	260	600	24.0
6	Thrissur	21	41	25	-	30	1.2
7	Malappuram	12	-	100	12	26	1.0
8	Kozhikode	293	23	200	293	140	5.6
9	Kannur	755	939	3500	755	1100	44.0
10	Kasargode	79	-	50	79	315	12.6
	Total	1671	1095	4200	1650	2502	100

Source: Basha,1991; Kurien *et al.*, 1994; Mohanan, 1997; Unni, 2003; Madhusoodhanan and Vidyasagar, 2012

The species diversity of mangrove vegetation in the state is considered to be high. Unni (2004) and Khaleel (2009) reported 18 true mangrove species and 23 associates from the state. Anupama and Sivadasan (2004) reported only 15 true mangroves. But, the mangrove associates were nearly three times, i.e. 49 in number belonging to nine genera and seven families. Madhusoodhanan and Vidyasagar (2012) also found 15 species but could locate only 33 associates. Table 4.8 furnishes the common

mangrove species in Kerala and its major uses. The important mangrove families commonly seen in Kerala are *Rhizophoraceae*, *Avicenniaceae* and *Sonneratiaceae*. *Avicennia officinalis, Avicennia marina, Bruguiera cylindrica, Excoecaria agallocha, Kandelia candel, Rhizophora mucronata* and *Sonneratia caseolaris* are the commonly seen mangrove species in Kerala. *Sonneratia alba* is the species very rarely seen in the state and it is reported from Tirur (Malappuram) in the year 2012. Two species *Derris trifoliate* and *Acrostichum* are also reported from the state, but scientific community is yet to make conclusions on these two.

Majority of these mangrove species are either used for fuelwood or timber. The most preferred species for the fuelwood is *Rhizophora* sp. especially its stilt roots. The local communities prefer mangrove species for their fuelwood requirement owing to its easy accessibility, high fuel efficiency and easy drying nature. Mangrove species in Kerala have medicinal properties as well. *Avicennia officinalis*, *Bruguiera cylindrica*, *Excoecaria agallocha* and *Excoecaria indica* are generally used in home remedies. The fruit of *Avicennia* sp. are used in the treatment for rheumatism. The wood of *Bruguiera cylindrica* and *Excoecaria agallocha* are used for cork making. However the younger generation among the local communities has only limited knowledge on these aspects.

Table 4.8: Major species of mangroves in Kerala

Sl No.	Scientific name	Family	Local name & distribution	Uses
1	*Acanthus illicifolius*	Acanthaceae	Chulli, C*	Medicinal properties
2	*Aegiceras corniculata*	Myrsinaceae	River mangrove, Pookandal, M*	Fuelwood
3	*Avicennia officinalis*	Avicenniaceae	White mangrove, Uppatti, C*	Fuelwood, Fodder, Medicinal properties, Tannin
4	*Avicennia marina*	Avicenniaceae	Cheru upputti, C*	Fodder
5	*Bruguiera cylindrica*	Rhizophoraceae	Kuttikandal, C*	Timber, Cork making, Medicinal properties, Tannin
6	*Bruguiera gymnorrhiza*	Rhizophoraceae	Karakandal O*	Timber, Medicinal properties, Live fence
7	*Bruguiera parviflora*	Rhizophoraceae	O*	Fuelwood
8	*Bruguiera sexangula*	Rhizophoraceae	R*	Fuelwood, Timber
9	*Excoecaria agallocha*	Euphobiaceae	Kanambhotti, Komatti, C*	Cork making, Medicinal properties
10	*Excoecaria indica* / *Shirakiopsis indica* (new name)	Euphobiaceae	R*	Medicinal properties

Sl No.	Scientific name	Family	Local name & distribution	Uses
11	*Kandelia candel*	Rhizophoraceae	Cherukandal, Ezhuthanni kandal, C*	Fuelwood, Medicinal properties
12	*Lumnitzera racemosa*	Combretaceae	Black mangrove, Kadakandal, O*	Timber
13	*Rhizophora mucronata*	Rhizophoraceae	Peekandal/Prathankandal, C*	Timber, Medicinal properties
14	*Rhizophora apiculata*	Rhizophoraceae	Vallikandal, O*	Fuelwood, Medicinal properties
15	*Sonneratia caseolaris*	Sonneratiaceae	Mangrove apple, Blathi kandal, C*	Fuelwood, Medicinal properties
16	*Sonneratia alba*	Sonneratiaceae	Nakshathra kandal, R*	Fodder, Fuelwood, Timber

Source: Anupama and Sivadasan, 2004; Radhakrishnan *et al.*, 2006; Pattanaik *et al.*, 2008; Khaleel, 2009; Madhusoodhanan and Vidyasagar, 2012.

M*- Malabar Coast, C*-Common, R*-Rare, O*- Occasional

4.2. Stakeholder groups and their dependence on the mangrove ecosystem

Stakeholders in the study can be defined as the group of people living in and around the wetland, who directly or indirectly depend on the wetland for their living and who directly or indirectly are affected by any change of process occurring in the wetland, be natural or human induced process. The stakeholders in relation to the mangrove ecosystem are identified by direct site visits, focal group discussions and interactions with the local community. The four stakeholder groups identified are the residents living close to mangroves, fishermen, paddy farmers and general public.

4.2.1. Residents

4.2.1.1. Description and socioeconomic status

The group of people called 'residents' are those living within one km radius of mangrove areas. The residents are thus living very close to mangroves or with mangroves as one or more of the boundaries of their households. They are very poor people residing in highly fragmented lands, of average size of 0.04 ha and are highly vulnerable to flood and storm surges. Here, mangroves act as bio shield for the life and property. They also harvest fuelwood and small timber from the mangroves. In addition, the residents catch fish from the nearby water bodies for their household consumption. The poor sanitation and inadequate access to potable water are usually experienced in the area especially in Ernakulam.

The distribution of stakeholders according to the proximity to mangroves is presented in Table 4.9. In 42 per cent cases mangroves formed a fence in at least one of the boundaries of their land property. More than half of the respondents in Ernakulam belonged to this category especially in areas like Edavanakkad, Nayarambalam and Vypeen. In the case of one third respondents mangroves were seen at a maximum of 50 m away from their residence, though it was not their boundary wall. For the rest 25 per cent of the respondents it was 100 m-1 km.

Table 4.9: Distribution of respondent households according to proximity of mangroves

Sl No.	Distance (km)	No. of respondents		
		Ernakulam	Kannur	Overall
1	Mangroves as boundary of land property	32 (53)	18 (30)	50 (42)
2	Residence within 50 m away from mangroves	22 (37)	18 (30)	40 (33)
3	Mangroves 50-100 m away	6 (10)	10 (17)	16 (13)
4	Mangroves 100 m away	0	14 (23)	14 (12)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

The ownership status of mangroves in Kerala is reported as mainly private (Unni, 2003). However private owned mangroves are relatively less in Ernakulam. Mangroves in Ernakulam are spread in land mainly owned by public enterprises and is extensively reclaimed for developmental projects of Cochin Port Trust, International Transhipment Container Terminal (ICTT) Vallarpadam and LNG Petronet, Puthuvypeen. The private ownership with highly fragmented lands is mainly observed in areas like Thanthonni Thruth, Edavanakkad, Vypeen, Mulavukad and Panambukad. On the contrary, in Kannur district, most of the mangrove spread is in agricultural lands/ residential area, which are privately owned.

The study area in Ernakulam district is very close to the city of Cochin, hence the pressure on land for development/ construction activities is very high. According to Census, 2011, the per capita land availability in Kerala is reported as 0.13 ha and 94 per cent of people in the state are categorised as marginal land holders (< 1 ha). The average holding size of respondents is 0.04 ha and 0.16 ha in Ernakulam and Kannur respectively with an overall average of 0.1 ha (Table 4.10). A study by

Ramachandran *et al.* (2005) confirmed that the average land holding size of coastal villages of Kerala is below 0.04 ha especially in Ernakulam district. Fifty per cent of the respondents possessed only less than 0.04 ha and their proportion is more in Ernakulam (62%). About 23 per cent possessed 0.04 to 0.2 ha with an average of 0.12 ha. None of the respondents in Ernakulam have larger land area of size greater than 0.2 ha. The land ownership in Kannur district was comparably more distributed than Ernakulam. Majority (45%) belonged to the marginal group with less than 0.04 ha average holding. The land area between 0.2–0.4 ha was possessed by 22 per cent while 18 per cent have 0.04–0.2 ha.

About 20 per cent of the respondents in both districts owned mangrove lands; thus the average size of mangrove area equivalent per household (who possess mangroves as boundary) in Ernakulam and Kannur is calculated as 0.04 and 0.1 ha respectively. These households have mangrove areas within the total owned land and in most cases mangroves remain as one of the boundaries and these were estimated separately for calculating mangrove area equivalent.

Table 4.10: Details of the landholding size

Sl No.	Size of land holdings (ha)	No. of respondents		
		Ernakulam	Kannur	Overall
1	< 0.04	37 (62)	27 (45)	64 (53)
2	0.04 - 0.2	23 (38)	11 (18)	34 (28)
3	0.2 – 0.4	0	13 (22)	13 (11)
4	0.4 – 1.2	0	9 (15)	9 (8)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

The socio economic status of the selected respondents is presented in Table 4.11. The important factors considered are age, education and family size. Majority of the respondents in Ernakulam district belongs to the middle aged category (35-50 years

of age) while 22 per cent are in the older age group. Only 5 per cent respondents are aged above 65 years. On the contrary, in Kannur, 40 per cent belongs to older age group (50-65 years) and 30 per cent in the middle aged group of 35-50 years. The percentage of aged respondents is higher in Kannur compared to Ernakulam. The average age of the respondents in Ernakulam is 42 years while it is slightly higher in Kannur with an overall average age of 45 years.

Kerala state is known for the high literacy level and majority of the respondents in this group is formally educated. Most of the respondents in the two districts have attained secondary level of school education. The percentage of illiterate (those who cannot read/write) is very small in Ernakulam while it was 17 per cent in Kannur, who were mainly aged people. The younger generation is more exposed to higher education, even though their parents are illiterate.

Among the Indian states, Kerala holds first rank in Human Development Index (2011) owing to better living standards. It is primarily attributed to the small family size. The average family size among the respondents in this group is five. Most of the families constitute the pattern of parents and two children. Very few respondents have larger family size (more than six members). Nearly one third of the respondents in Kannur have less than 4 members in the family, mainly parents only. The educated offspring's have migrated due to occupational reasons. There are instances where the economic status has facilitated migration to urban centres. This is more prominent in Kannur region. The sex ratio of the sample respondents is pro-male. This is mainly due to the male domination in the society where the head of the family is often a male.

Table 4.11: Socio-economic details

I. Age class (Years)	**Ernakulam**	**Kannur**	**Overall**
18-35	8 (13)	8 (13)	16 (13)
35-50	36 (60)	18 (30)	54 (45)
50-65	13 (22)	24 (40)	37 (31)
Above 65	3 (5)	10 (17)	13 (11)
Total	60 (100)	60 (100)	120 (100)
Average age	42.5	47.5	45
II. Level of education (Years of schooling)	**Ernakulam**	**Kannur**	**Overall**
No formal education	3 (5)	10 (17)	13 (11)
1 - 7	19 (32)	15 (25)	34 (28)
8 - 10	32 (53)	21 (35)	53 (44)
10 - 12	6 (10)	9 (15)	15 (13)
12 - 15	0	5 (8)	5 (4)
Total	60 (100)	60 (100)	120 (100)
III. Family size (Number)	**Ernakulam**	**Kannur**	**Overall**
< 4	7 (12)	19 (32)	26 (22)
4 - 6	50 (83)	39 (65)	89 (74)
> 6	3 (5)	2 (3)	5 (4)
Total	60 (100)	60 (100)	120 (100)
Average family size	4.3	4.6	4.5

Figures in parentheses represent percentage to total

The livelihood pattern of these stakeholders is clearly associated with the nearby water bodies. Thus, nearly half of the respondents in Ernakulam are fishermen (Table 4.12). The rest are engaged in casual wage labour and private jobs, in the nearby urban centres. Majority of the respondents in Kannur are casual wage labourers in

agriculture or in construction sectors. About one third of the respondents in Ernakulam and Kannur respectively are women who mainly confine to household works and do not earn monetary income. Fishing is the major occupation for respondents in Ernakulam whereas in Kannur it is casual wage works. Boys in the early age start helping their parents in fishing and slowly get involved and fail to attend school and the circumstances are similar among the casual wage workers.

Table 4.12: Details of the occupational status of the respondents

Sl No.	Occupation	No. of respondents		
		Ernakulam	Kannur	Overall
1	Agriculture	1 (2)	9 (15)	10 (8)
2	Fishermen	30 (50)	4 (7)	34 (28)
3	Casual wage labour	7 (11)	30 (50)	37 (31)
4	Private job	9 (15)	3 (5)	12 (10)
5	Govt. employee	0	2 (3)	2 (2)
6	Pensioner	0	5 (8)	5 (4)
7	Housewife	12 (20)	7 (12)	19 (15)
8	No full time employment	1 (2)	0	1 (2)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

The details of occupation of the members of the respondent households are furnished in Table 4.13. The total number of members in the respondent households was 273 and 247 in Ernakulam and Kannur respectively. Males outnumbered females in Ernakulam while it is the reverse in Kannur. The family members include people in the age group ranging from 85 years to infants (3 months old). The major group among the households in Ernakulam is students and housewives while casual wage labourers form the largest in Kannur. However, the family members, especially younger generation is getting formal education and some of them are working as

salaried employees in public and private sector. It is a positive sign that the number of students is very high in both districts. This may lead to a shift in social hierarchy through better education. In conformity with the respondent status, majority worked as fishermen in Ernakulam while in Kannur it was casual wage labourers.

Table 4.13: Occupational/activity status of the respondent families

Sl No.	Occupation	No. of respondents		
		Ernakulam	Kannur	Overall
1	Agriculture	0	9 (4)	9 (2)
2	Fishermen	47 (17)	2 (1)	49 (9)
3	Casual wage labour	25 (9)	69 (28)	94 (18)
4	Private employee	18 (7)	12 (5)	30 (6)
5	Govt. employee	0	5 (2)	5 (1)
7	Student	77 (28)	62 (25)	139 (27)
8	Pensioner	0	5 (2)	5 (1)
9	Housewife	77 (28)	62 (25)	139 (27)
10	Unemployed	5 (2)	6 (3)	11 (2)
11	Aged	17 (6)	11 (4)	28 (5)
12	Infants	7 (3)	4 (1)	11(2)
Total		273 (100)	247 (100)	520 (100)

Figures in parentheses represent percentage to total

The occupational diversification among the respondent households is reflected in the annual family income. Most of the respondents were in the income group ₹ 1-2 lakhs/annum. Majority in Ernakulam belonged to this category with an average income of ₹ 1,56,947 (Table 4.14). But in Kannur it was less than ₹ one lakh/annum for most of them. It is to be noted that the average annual income do not differ significantly in the two districts. The average annual income per person among the respondents in Ernakulam and Kannur is ₹ 1,65,078 and 1,66,450 respectively with

overall average income per person being ₹ 1,65,764 per year. Not having full time employment among the respondents (17%) in Kannur is attributed to be one of the reasons for the lesser family income and most of them are self earning even in their old age days. The age factor of these respondents prevents them from regular 8 hours employment and mostly ends up with half day labour. Nearly one third of the respondents in Ernakulam have annual income below ₹ one lakh with an average of ₹ 78,286.

About 40 per cent of the respondents in Kannur have annual income in the range between ₹ 1-2 lakhs with an average of ₹ 1,60,682. The higher income category of the respondents of Kannur (15%) are with annual family income of ₹ 2-4 lakhs with an average income of ₹ 2,76,667, while the same is only 2 per cent in Ernakulam. The higher income is contributed either by government employees or NRI members in the family.

Further, an analysis of the asset position of the households provides more insight into the living standards. The value of different assets owned by respondent families (land, buildings, vehicles, consumer durables such as television, refrigerator, washing machine, sewing machine, computer and farm animals) are estimated. Majority of the respondent families in both the districts have asset worth ₹ 15-30 lakhs with average value of ₹ 19.75 lakhs and ₹ 23.30 lakhs in Ernakulam and Kannur respectively (Table 4.14). Twenty per cent of the families in Kannur have asset less than ₹ 4 lakhs while it is very small per cent in Ernakulam (3%).

The variation in the land price between two districts is considered as one of the factors for the sound asset position in Ernakulam even though the land holding size is less among the respondents in the district compared to Kannur. The respondents in Kannur have higher holding size compared to those in Ernakulam and land appears to be the main contributor for the sound asset base. Hence 18 per cent of the respondents in Kannur have assets worth more than ₹ 50 lakhs. Among the total respondents of

the two districts majority have an asset base within the range of ₹ 4-8 lakhs (31%) followed by the category with lowest asset base (₹< 4 lakhs). Overall, the average value of assets possessed by the respondent families is ₹ 19.71 and ₹ 24.22 lakhs respectively in Ernakulam and Kannur. It is primarily attributed to the larger land area among the respondents of Kannur.

Table 4.14: Details of annual family income and asset base

Income (₹ lakhs/year)	**No. of respondents**		
	Ernakulam	**Kannur**	**Overall**
< 1	21 (35)	28 (47)	49 (41)
1 - 2	38 (63)	23 (38)	61 (51)
2 - 4	1 (2)	9 (15)	10 (8)
Total	60 (100)	60 (100)	120 (100)
Asset value (₹ lakhs)	**Ernakulam**	**Kannur**	**Overall**
< 4	2 (3)	12 (20)	14 (12)
4 - 8	10 (17)	8 (14)	18 (15)
8 - 15	13 (21)	11 (18)	24 (20)
15 - 30	21 (35)	15 (25)	36 (30)
30 - 50	13 (22)	3 (5)	16 (13)
> 50	1 (2)	11 (18)	12 (10)
Total	60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

4.2.1.2. Stakeholder dependence on mangroves

The economic and ecological benefits of mangroves are detailed by many authors (Barbier, 2006b; Radhakrishnan *et al.*, 2006; Barbier, 2007; Hirway and Goswamy, 2007; Das and Vincent, 2009; Hussain and Badola, 2010; Kathiresan, 2010; Khaleel, 2012). However, the dependence on mangroves by the local communities of Kerala is

limited compared to their counterparts in the Sunderbans (India and Bangladesh). It was estimated that in Bangladesh and India, around 9 million people are dependent on the mangroves for their livelihood (ICZM, 2004; GoI, 2005).

The intensity and the nature of dependence of mangroves have changed substantially over time among the stakeholder groups. A similar study was reported by Stone *et al.* (2009). The mangrove vegetation was extensively used in the past for various purposes like fuelwood, building materials for constructing houses and poles for spreading nets or anchoring canoes in water. Owing to the socio-economic changes and technological factors, the dependence for these purposes is currently limited. The stakeholders have more realistic perception towards mangrove ecosystem and hence the life supporting services rather than direct uses are given more emphasis often. The direct benefits from mangroves by this stakeholder group are detailed in Table 4.15. The life of all the respondents is closely linked with the nearby mangroves in one way or the other. All the respondents in Ernakulam and 92 per cent in Kannur opined that they are receiving beneficial effects either direct or indirect from mangroves.

Mangroves were a major source of food, fodder, medicines and wood and many other goods for the local communities of Ernakulam and Kannur. Owing to the changes in the demand (social and economic behaviour) and the supply (depletion of mangroves) conditions, this dependence has been reduced substantially. Still there exists some level of dependence, for fuelwood, fodder and poles.

Traditionally the local population extracted wood products from mangroves, which included wood for construction purpose (poles) and fuelwood. Fuelwood collected from mangroves was considered to have high energy efficiency (expert opinion). Since, the source of household energy for cooking has been changed to LPG, the use of fuelwood is limited now. A similar reduction in use of fuelwood was reported from Thailand (Sudtongkong and Webb, 2008) as well. Further, the stringent forest laws restrict mangrove destruction and hence currently extraction is restricted to that of

dried branches, twice or thrice a year. In Kannur the patrolling of forest officials and vigil of the environmental activist groups against mangrove destruction is intense. So the people are not daring to harvest even though they wanted to.

Among the respondents of Ernakulam and Kannur, 27 and 37 per cent respectively are depending on mangroves for their fuelwood requirements (Table 4.15). They spend average five hours/day for fuelwood collection, extracting an average of 15.5 kg for 20 days an year. Generally, *Rhizophora* sp., particularly its stilt roots are preferred as fuelwood. The species is preferred owing to its availability, easy accessibility, heat generating capacity and easy drying nature. Even the fresh green wood is directly used as fuelwood. The roots of this species are normally collected during summer months (April and May) and kept along the river bank for drying. It is a regular practice in summer and they store it for the rainy season. To certain extent, *Sonneratia* sp. is also harvested for fuelwood. But hardiness of the wood limits the harvesting.

Generally, fuelwood collection is the mandatory activity of rural females in India. Mostly the females collect the roots during summer months and store it for the lean rainy season. Unlike the fuelwood collectors in other parts of India especially North and East India, respondents in this case are collecting wood from the nearby places individually and hence the distance travelled for the fuelwood collection is practically absent. If the purchase price of similar fuelwood species in the locality is applied, the average value of the collected fuelwood per year in both the districts was found to be ₹ 1,228.

Mangroves were a major source of fodder in traditional days. Elder generation of people especially in Kannur recollects the dependence on mangroves for fodder in their earlier age. Mangrove leaves were used as fodder in coastal areas especially the species like *Avicennia marina* and *Sonnertia* sp. (Table 4.15). The most common species is *Avicennia* owing to its high palatability (salty in taste). In addition, the

calcium content in the leaf is very high which directly increases the milk yield. The species became more acceptable among the local communities since 1990's following the confirmation of the local veterinary surgeon. The milk enhancing property of *Avicennia* was also reported from Gujarat and Pakistan (Baba *et al.*, 2013).

The paddy cultivation was prevalent all over in Kerala till 1980's and correspondingly livestock was integral component of homesteads of the state. The increasing mechanisation in paddy cultivation and reduction in cattle population reduced the demand for fodder in the state. The cattle population of the state has drastically reduced to 17.40 lakhs (2007) from 33.96 lakhs (1996) (GoK, 2011). In addition, the practice of feeding the cattle with manufactured cattle feed is more common now.

Presently, the fodder gathered is meeting one quarter of the fodder requirement per household. Based on the market price, it is valued at ₹ 2,560 per year. On an average 128 days equivalent is spent for the collection of the same, mainly by the womenfolk. The constant vigil of the environmental activist groups and Forest and Wildlife department officials limits the fodder collection from mangroves in Kannur. However, the fodder properties of mangrove species are not properly understood by the respondents in Ernakulam district and none of the sample respondents were reported to be collecting fodder.

The poles from mangroves (*Rhizophora, Avicennia, Bruguiera*) were commonly used for constructing thatched houses. Currently most of the houses have concrete roofing and hence use of poles is limited. Some 10-20 per cent of the respondents reported to be collecting poles of *Rhizophora* and *Bruguiera* which amounted to 12–15 numbers of poles worth ₹ 720-900 per year. Thus fuelwood, fodder and poles collected from mangroves were equivalent to 3 per cent of the annual household income, which otherwise should have spent on these items.

Table 4.15: Level of dependence of mangroves

Sl No.	Particulars	Ernakulam			Kannur		
		No. of respondents	Quantity/ person/ year (kg)	Value/ person/ year (₹)	No. of respondents	Quantity/ person/ year (kg)	Value/ person/ year (₹)
1	Fuelwood	16	306	1224	22	308	1232
2	Fodder	-	-	-	6	1024	2560
3	Poles	5	12 (No.)	720	11	15 (No.)	900

The indigenous technical knowledge in traditional home remedies is closely linked with the local flora and fauna. The mangrove species, *Avicennia*, *Excoecaria, Bruguiera gymnorrhiza, and B. cylindrica* were used in home remedies. The fruit of *Avicennia* was used against rheumatism and also as cattle medicine. The woods of *Excoecaria agallocha* and *Bruguiera cylindrica* were mainly extracted for cork making and were traded in domestic and export market. Presently, none of the respondents were engaged in this activity. A village called Korom, near Payyannur in Kannur district was famous for this small cottage industry. The use of mud deposited in mangrove ecosystem as manure for coconut palms is also prevalent in Kannur. It is confirmed by the studies of Nambiar and Raveendran (2009).

Though the extent of extraction of goods from mangroves has shrunk over the years, the ecosystem services from them has been recognised and valued much. Mangroves act as green fence in areas like Nayarambalam, Edavanakkad and Narakkal of Ernakulam district. The mangrove species, *Bruguiera gymnorrhiza* (*Ezhuthani kandal*) is planted along the boundary of homesteads to prevent soil and embankment erosion in the fragile coastal areas. About 30 per cent of the respondents have planted them in the boundaries of household. The green belt of mangroves offer protection against storm surges in the coastal area. The respondents in Edavannakkad of

Plate I: Mangroves planted as live fence along the boundary of household

Ernakulam district had experienced the effect during Asian tsunami of the year 2004 and the regular annual cyclones. Hence mangroves offer protection to the life and property of coastal communities.

The respondents from Thazhe Kavu in Thekkumbad Island in Mattool grama panchayat of Kannur also mentioned the role played by mangroves in preventing the entry of saline water intrusion to the coconut farms. The island is characterised by the presence of a biodiversity rich coastal sacred grove namely Thazhekavu. This place along the Valapattanam estuary is rich in mangroves, which was also reported by Sreeja and Khaleel (2010).

Along with the benefits from mangroves, some negative aspects are also reported by some respondents which often lead to the destruction of the ecosystem. The increase in the number of mammals like stray dogs, foxes, mangoose, otters and poisonous reptiles in the mangrove area was mentioned as an important concern. The incidents of otter attacks and the poaching of domesticated fowls by dogs, foxes and mangoose hiding in the mangrove area were reported from some parts of Ernakulam. The stakeholders responded that otter, whose number has declined, has been slowly increasing in recent years especially in Ernakulam region.

It was evident that in some areas of Edavannakad and Narakkal of Ernakulam, there was large scale succession of mangroves especially *Exceocaria agallocha* into the unattended coconut orchards which facilitated the animals to take shelter in the area. In addition, milky latex of the *Exceocaria agallocha* was causing allergies like skin rashes, irritation and respiratory problems. Asthmatic patients are more prone to it. The widespread infiltration of this particular species of mangroves has created a strong negative feeling among the native residents towards mangroves. The land value is declining in places where there is rapid succession of mangroves and hence sale of land at prevailing market prices is not possible in areas with mangroves compared to non-mangrove areas of Ernakulam.

Plate II: Succession of mangroves into coconut orchards

The solid waste management is one of the biggest challenges in Kerala in recent years. Mangrove areas are the preferred locations for dumping solid waste and an ultimate point for discharging untreated industrial and domestic effluents together with waste from slaughter houses and poultry farms. A study by Gopalan (1987) and Nambiar and Raveendran (2009) in Ernakulam and Kannur respectively also reported the same. This can be one of the prime reasons for the increase in the number of mammals in the mangrove areas. The resorts constructed along the river banks with luxuriant mangroves dump waste in huge quantities. These wastes float and get deposited in the mangroves causing hindrance to breeding of fishes and also affecting the pneumatophores of mangrove trees (expert opinion).

The existence of hanging latrines over the dykes is a common phenomenon. The drainage pipes of the dwellings are discharging into the dykes. The mosquito menace in the mangrove areas is another concern. The respondents expressed their anxiety over incidence of mosquito borne diseases.

The natural rate of regeneration of mangroves is reported to be very high if left undisturbed and this leads to expansion or succession of mangroves to the fertile paddy lands. In such cases, the farmers have to incur additional cost for clearing the field prior to the paddy crop. In some areas of Pazhayangadi, respondents, especially elder females expressed their anguish against the troubles created by anti-social persons hiding near luxuriant mangrove areas.

The extent of urbanisation is well evident in cities compared to towns. More number of respondents (58%) in Ernakulam is ready to move from the current place of residence to some other location while it was only 23 per cent in Kannur. For instance, an island called Thanthonni Thuruth, in the Vembanad Lake, is very close to the High Court of Kerala, Ernakulam near the Goshree Bridge, is devoid of any kind of accessibility except the State run boat services that operate twice a day. There are 64 families residing in that mangrove covered area. Majority of houses are with

mangroves in their courtyard. Majority of the folks are fishermen/women and the rest are casual wage labourers. In the island, there are only residential houses and majority of them are pucca buildings with concrete roofing. Inhabitants need to depend on outside area for all the household requirements. All the houses are in fragmented lands with area ranging between 80-160 sq. m. The households depend on mangrove trees and poles for their fuelwood and building purposes. The commonly seen mangroves are *Avicennia officinalis* and *Rhizophora* sp. The residents expressed their interest to migrate to urban centres.

The respondents of both the districts are ready to relocate only against appropriate compensation, proper rehabilitation or alternate employment options. Majority of respondents in Kannur and about one fifth of the respondents in Ernakulam are willing to relocate and are ready to leave against appropriate compensation (Table 4.16), while about 71 per cent of the respondents in Ernakulam are ready to relocate only against appropriate compensation and proper rehabilitation arrangements.

Majority of the respondents (77%) in Kannur are not willing to relocate to any other region. This may be due to social, economical and cultural reasons. Living in the current locations for generations, doing jobs in those premises and earning sufficient income are the reasons cited by them. Even if they are facing hardships in the current location of residence, they were totally against the concept of relocation to any other place. A remarkable attitude difference can be observed among the respondents in both the districts. Most of the respondents in Ernakulam preferred to relocate, while only 23 per cent in Kannur did so.

Plate III: Solid waste accumulated in the mangrove area

Table 4.16: Responses on the relocation possibilities

Sl No.	Particulars	No. of respondents		
		Ernakulam	Kannur	Overall
1	Against appropriate compensation (1)	7 (20)	8 (57)	15 (31)
2	Proper rehabilitation (2)	2 (6)	4 (29)	6 (12)
3	Alternate employment option (3)	1 (3)	0	1 (2)
4	1+2	25 (71)	2 (14)	27 (55)
Total		35 (100)	14 (100)	49 (100)

Figures in parentheses represent percentage to total

4.2.2. Fishermen

4.2.2.1. Description and socioeconomic status

Mangroves are unique habitats which function as nursery ground for several species of fishes and play a vital role in supporting marine food chains and protect coastal areas (Kripa *et al.*, 2011). The major group of fauna associated with the mangrove system is fishes. The large scale fishery activity includes collection of bivalves, shrimps, shell fishes, fin fishes and crabs. The life of fishermen near the mangrove wetlands is closely associated with it deriving both direct and indirect benefits. Mangrove 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 marginalised fishermen communities to commercial aqua culture. Mangroves and fisheries are generally interconnected. A study by Sathya and Sekar (2012) in Pichavaram mangroves of Tamil Nadu has reported the level of direct and indirect benefits derived by the fishermen from mangroves.

A positive correlation between offshore fishery yields and amount of mangroves in the nursery area was reported by Pauly and Ingles (1986); Sathirathai and Barbier (2001) and Khaleel (2009). The positive relationship between mangroves and fish species are proven scientifically (Kapetsky,1985; MacKinnon and MacKinnon, 1986; Aksornkoae *et al.*, 1992; FAO, 1994; Sathirathai and Barbier, 2001; Khaleel, 2009; Muraleedharan *et al.*, 2009; Madhusoodhanan and Vidyasagar, 2012). The direct dependence between maximum sustainable shrimp yield and the area covered by mangroves was proven from countries like USA and Thailand. The mangrove dependent shrimp yield was in the range of 756 kg/ha in Thailand (Mastaller, 1996), while it was 500 kg/ha in Vietnam (De Graaf and Xuan, 1997). Hence mangrove system is nature's own aquaculture system with a number of advantages (Moberg and Ronnback, 2003).

The mangrove carbon introduced into the coastal ocean is in the order of 46×10^{12} g C/year, which accounts about 11 per cent of the total input of terrestrial carbon into the ocean (Jennejahn and Ittekat, 2002). The mangrove fringed coast and the extensive mud flats provide excellent habitat for fishes. The fallen leaves of mangrove trees enrich the mudflats and the environment creates an ideal nursery ground for fishes.

Fishing community of Kerala, comprise of distinctive group of people geographically located along the coastal tracts of the state with their own way of life and culture. Fishing industry occupies unique and significant place in Kerala economy. The fishermen, fishing in the brackish water in the sprawling estuaries at the confluence of river system with the sea, brackish water lakes and vast area of mangrove swamps are generally called inland fishermen.

The inland water area in Kerala with its dynamic environment together with rich fauna and flora are known to be potential source of fishery resources. About 40 per cent of the fishermen in North Kerala have been deriving income directly from

mangrove related fishing (Nayak, 1997). Inland fish production provides significant contribution to cheap animal protein supplies in Kerala particularly in the coastal areas of the state (Kurien, 2001; GoK, 2013b). The number of inland fishermen is more in Ernakulam and Kannur districts compared to their marine counterparts (Department of Fisheries, 2005). Most of the inland fish production is marketed domestically and consumed locally. Among the total fishermen population of Kerala, 23 per cent are inland fishermen fishing in rivers, backwaters and reservoirs (GoK, 2011). Onshore fishing is done by the inland fishermen using country boats or traditional canoes, who cannot afford expensive offshore fishing gears. The welfare of these people is ensured through Kerala Fishermen Welfare Fund Board (acronym 'Matsyafed').

The total population of inland fisher folk in the state is about 2.50 lakhs and among them 0.42 lakhs are active fishermen (Khambete, 2012). The inland fish production amounts to 0.78 lakhs metric tons of fish annually with a net value of ₹ 30,000 lakhs (GoK, 2012a). In addition to the registered inland fishermen, large numbers of marine fishermen and local people are also engaged in fishing in mangrove areas.

Inland fishing activities also involve the active presence of women, who catch fish manually (without help of any gadgets) from the mangrove wetlands and small dykes (canals) surrounded by the mangroves. This method is locally known as '*Thappal*' where these women have expertise in hand picking small fishes, *Etroplus* and shrimps. It is a unique method of fishing practiced in Kannur, Kasargode and Ernakulam districts of Kerala (Beegum, 2006). The fisherwomen sit in knee deep water with neck just above the water surface and search for fishes with both hands. The fish is collected in *Kuriya* (traditional bag made out of pandanous leaves in Kannur) or in a metal pot (in Ernakulam). The people living close to the dykes are mostly engaged in this activity. The daily catch varies from one to three kg/person. It consists of shrimps, *Etroplus* and other small fishes. They have to spend 6-8 hours in water during the low tide hours. These fisherwomen consider the luxuriant growth of

Plate IV: Fisherwomen engaged in *Thappal* (Handpicking)

mangroves on the river banks and dykes as a hindrance to their traditional fishing activity.

Apart from the traditional fishermen, the people from neighbouring and far off places come to the mangrove rich river coast and engage in fishing either as economic activity or a leisure time activity during the monsoon period starting from June to August. The casual wage labourers in their lean employment season are also engaged in fishing to earn some extra income.

According to the officials' opinion, nearly 25 per cent of the inland fishermen are not registered. The respondents include 106 males and 14 females. The women respondents of Kannur constitute those who are engaged in traditional methods of fishing by hand picking (*Thappal*). The traditional hand pickers are mainly from Vypeen, Narakkal, Edavanakkad and Nayarambalam of Ernakulam and Dharmadom, Valappattanam, Kunhimangalam, Pattuvam and Pazhayangadi of Kannur. The general socio economic background of the respondents is furnished in the Table 4.17. The respondents in Ernakulam are in the age group of 18 to 65 years. Only eight per cent of the respondents in Kannur are above 65 years of age. It shows that aged people who are still engaged in fishing as their means of survival is apparently low. Majority of the respondents (73%) in Ernakulam belong to the age category of 35-50 years while major share in Kannur (53%) lies in the upper age category of 50-65 years. Young people are also seen involved in fishing, mostly following family occupation. The average age of respondents in both districts is 45 years.

The educational status of fishermen community is comparatively lower as they engage in fishing in early age itself. Educational backwardness is the prime factor for the marginalisation of fishing community (Beegum, 2006; Sathiadhas, 2006). The average literacy among fishermen community in Kerala is reported as 73 per cent (CMFRI, 2005) with the highest literacy rate in Ernakulam followed by Alapuzha and Kannur districts. Majority of the respondents in both Ernakulam and Kannur have

only primary education (1-7 years) and some in Kannur have 12-15 years of schooling. There were people who were not formally educated, in Kannur. Among the illiterate respondents of Kannur, majority are females who are engaged in traditional hand picking practices (*Thappal*). Boys start their fishing activity by helping their fathers. In general, number of school dropout is very high among fishermen community. A study by Beegum (2006) reported that average dropouts rate among the children of inland fishermen as about 52 per cent. The low educational status, together with weak economic bargaining power, acts as pulling force in following family occupation.

The size of the respondent families in Ernakulam reflects the typical nuclear family trend in Kerala (husband, wife and one or two children). Majority of households are with four or less than four members while 57 per cent of the respondents in Kannur have family size between four and six. None of the families in Ernakulam have family size greater than six while 5 per cent of respondent families in Kannur belong to this group. The average family size is four. The sex ratio among the respondent families shows that males outnumbered females in Ernakulam. It is in line with the sex ratio pattern of fishing community in Kerala. But it is contrary to general pattern of pro-female trend.

Being fisher folk, the main occupation of the family head is fishing. The occupational diversification of the family members is given in Table 4.18. Apart from the fishermen, (family head) students and housewives comprise the major sections of the family. The total number of family members in Ernakulam and Kannur were 262 and 238 respectively with an average of 250. Of the total family members in Ernakulam one third are students which are a positive sign. A few are government employees. Some are working as casual wage labourers (4%), employed in private sector (4%). The rest are aged, infants or unemployed person.

Among the respondent family members, 10 per cent in Ernakulam and 2 per cent in Kannur are housewives involved in secondary fishing activities such as fish retailing or processing (dry fish production). Generally housewives contribute to family income by fish processing (dry fish production) or fish retailing. The participation of women in secondary fishing sector is more concentrated towards South Kerala than North Kerala (Sathiadhas, 2006). In general, women folks have expertise in selling and often outnumber male vendors in inland fishing (Beegum, 2006). However in Kannur the involvement of fisher women folk in fish vending is very limited or rather absent. Fish vending in the city and its outskirts is the regular practice of the fisher women in Ernakulam.

Table 4.17: Socio-economic details

I. Age class (Years)	**Ernakulam**	**Kannur**	**Overall**
18-35	7 (12)	1 (2)	8 (7)
35-50	44 (73)	17 (28)	61 (51)
50-65	9 (15)	32 (53)	41 (34)
Above 65	0	10 (17)	10 (8)
Total	60 (100)	60 (100)	120 (100)
Average age	42.5	47.5	45
II. Level of education (Years of schooling)	**Ernakulam**	**Kannur**	**Overall**
Illiterate	0	11 (18)	11 (9)
1 - 7	30 (50)	32 (53)	62 (52)
8 - 10	29 (48)	13 (22)	42 (34)
10 - 12	1 (2)	1 (2)	2 (2)
12 - 15	0	3 (5)	3 (3)
Total	60 (100)	60 (100)	120 (100)
III. Family size (Number)	**Ernakulam**	**Kannur**	**Overall**
< 4	36 (60)	23 (38)	59 (49)
4 - 6	24 (40)	34 (57)	58 (48)
> 6	0	3 (5)	3 (3)
Total	60 (100)	60 (100)	120 (100)
Average family size	4.4	4	4.2

Figures in parentheses represent percentage to total

Table 4.18: Occupational/activity status of the respondent families

Sl No.	Occupation	Ernakulam	Kannur	Overall
1	Agriculture	0	11 (5)	11 (2)
2	Fishermen	67 (25)	63 (27)	130 (26)
3	Casual wage labour	7 (3)	11 (5)	18 (4)
4	Private employee	8 (3)	13 (5)	21 (4)
5	Govt. employee	0	3 (1)	3 (1)
6	Business	0	1 (1)	1 (1)
7	Student	84 (31)	62 (25)	146 (29)
8	Housewife	71 (27)	53 (22)	124 (25)
9	Unemployed	4 (2)	4 (2)	8 (2)
10	Aged	6 (3)	7 (3)	13 (3)
11	Infants	15 (6)	10 (4)	25 (5)
Total		262 (100)	238 (100)	500 (100)

Figures in parentheses represent percentage to total

The fishing community mostly lives in closely built houses generally known as fishing villages. These villages are characterised with high density of population along the coast and often lack basic facilities. Table 4.19 furnishes the details of land holdings. Majority of respondents in both districts have land holding size less than 0.02 ha. Compared to Ernakulam, respondents in Kannur have relatively larger land holding size. The average land holding size of fishermen in Ernakulam and Kannur was found to be 0.03 and 0.07 ha respectively. All the respondents in Ernakulam own the houses they reside in, while 97 per cent in Kannur posses own house. Shrimp farmers form one fourth of the respondents in Kannur. They are economically well off and possess an average of 0.4 – 1.2 ha of land.

Kannur occupies the largest mangrove area in the state followed by Ernakulam. Similar to this pattern, higher percentage of respondents (13%) in Kannur have an average 0.4 ha mangrove area equivalent while only 3 per cent in Ernakulam with an average of 0.04 ha. Mangroves remain in patches along the boundary line of the households in Ernakulam while those in Kannur have larger mangrove area away from their household. The vast majority in both districts have land area less than 0.04 ha.

Table 4.19: Details of landholding size

Sl No.	Size of land (ha)	No. of respondents		
		Ernakulam	Kannur	Overall
1	Landless	0	2 (3)	2 (3)
2	< 0.04	48 (80)	38 (64)	86 (71)
3	0.04 - 0.2	12 (20)	5 (8)	17 (14)
4	0.2 – 0.4	0	0	0
5	0.4 – 1.2	0	15 (25)	15 (12)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

General living conditions and economic standards of fishing community in the state can't be considered on par with the rest of the population (Beegum, 2006). The family income of the respondents clearly depicts the poor financial background among the traditional inland fishermen. The family income and asset values of the respondent families are presented in Table 4.20. In most of the cases, family head is the sole bread earner. More than two third of the respondents in Kannur have annual income less than ₹ one lakh with average of ₹ 59,714. However the respondents in Ernakulam have a better position compared to their Kannur counterparts. The annual income of majority of respondents in Ernakulam is between ₹ one and two lakhs with

the average value of ₹ 1,27,459 and about one third have annual income less than ₹ one lakh with average of ₹ 88,091.

Thus the average annual family income is almost same in both districts (₹ 1,16,100 and 1,15,617 respectively) though the distribution pattern is different. Two distinct classes are observed in Kannur; the resource poor fishermen including traditional hand picking women and the economically well off shrimp farmers who have means for highly capital intensive aquaculture. The annual income of the shrimp farmers varies between ₹ 2-6 lakhs with average of ₹ 3.37 lakhs.

The durable assets here include the land, buildings, vehicles, consumer durables and farm animals. In the study the value of different assets owned by respondent families namely land, buildings (houses and commercial buildings), vehicles, amenities such as television, refrigerator, washing machine, sewing machine, mixer grinder, computer and farm animals were taken into consideration. Most of the families possess the durable consumer assets. But only five per cent have farm animals and poultry.

Majority of the respondents own asset worth ₹ 4-8 lakhs with average of ₹ 5.98 and ₹ 5.38 lakhs in Ernakulam and Kannur respectively (Table 4.20). One quarter of respondent families in Ernakulam have assets worth ₹ 8-15 lakhs with average of ₹ 10.61 lakhs. 27 per cent of the respondent families in Kannur have assets less than ₹ 4 lakhs with average of ₹ 2.16 lakhs while it is only 13 per cent in Ernakulam. This shows that the lower strata of fishermen in Kannur are more marginalised than in Ernakulam. There were two families in Kannur who don't have any assets. Though only 6 per cent of the respondents in Ernakulam have assets worth more than ₹ 50 lakhs, in Kannur it was more than three times. They are the shrimp farmers. The average value of assets owned by the respondents in both the districts is ₹ 19.97 lakhs.

Table 4.20: Details of annual family income and asset base

Sl No.	Income (₹ lakhs/year)	No. of respondents		
		Ernakulam	Kannur	Overall
1	< 1	22 (36)	42 (70)	64 (53)
2	1 - 2	37 (62)	9 (15)	46 (38)
3	2 - 4	1 (2)	7 (12)	8 (7)
4	4 - 6	0	2 (3)	2 (2)
Total		60 (100)	60 (100)	120 (100)
Sl No.	**Asset value (₹ lakhs)**	**Ernakulam**	**Kannur**	**Overall**
1	< 4	8 (13)	16 (27)	24 (20)
2	4 - 8	16 (27)	22 (36)	38 (31)
3	8 - 15	14 (24)	8 (13)	22 (19)
4	15 - 30	12 (20)	0	12 (10)
5	30 - 50	6 (10)	1 (2)	7 (6)
6	> 50	4 (6)	13 (22)	17 (14)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

4.2.2.2. Dependence on mangroves

Fishermen mostly reside in coastal hamlets. The nature of work and time varies according to tidal influxes. Traditionally fishermen start their work in the early morning by 5 A.M. and one or two men go in one country boat. Most of them are residing close to the wetlands. Table 4.21 details the distance of their dwelling houses to the wetland ecosystem. Almost 60 per cent of them reside within one km distance. The respondent fishermen residing at a distance above five km are mainly the commercial farm operators. The average distance travelled by the respondent fishermen for fishing activity in the two districts is 1.4 and 2.3 km respectively. About one fourth live within a radius of 1- 3 km of wetlands.

Table 4.21: Distance to fishing ground (wetland) from residence of the respondents

Sl No.	Distance (km)	No. of respondents		
		Ernakulam	Kannur	Overall
1	< 1	43 (72)	29 (48)	72 (60)
2	1 - 3	14 (23)	15 (25)	29 (24)
3	3 - 5	3 (5)	4 (7)	7 (6)
4	>5	0	12 (20)	12 (10)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

Inland fishermen are fishing individually using country boats or canoes. Two types of canoes are normally used, in inland fishing: dugout canoes and plank built canoes. Mango tree timber is mostly used for canoe building. It requires regular oiling with cashew kernel oil and sardine oil. If properly maintained canoes last for about 15-20 years. The fishermen in Ernakulam use boat of size 7–9 feet while smaller boat of size 5–6 feet is used in Kannur. Very small canoes of less than 5 feet are mainly operated by elderly respondents of Kannur (15%). Thus the main capital investment in fishing involves the cost of boat. The details are furnished in Table 4.22. The average expense towards this worked out to be of ₹ 14,583 (₹ 15,783 and ₹ 13,382 respectively in Ernakulam and Kannur). The current market value of the boat primarily depends on the type of wood used for construction and the age of boat.

All the respondent fishermen in Ernakulam possessed own boat while it is only 57 per cent in Kannur. The rest in Kannur include traditional hand pickers and crab catchers. The hand pickers normally use only bag/basket (*Kuria*/aluminium pot) for storing fish while crab catchers use special crab nets and hooks. Both these groups do fishing by walking through water during low tide.

Table 4.22: Expenses in fishing: Capital investment

Sl No.	Cost of boat (₹)	No. of respondents		
		Ernakulam	Kannur	Overall
1	< 10,000	2 (3)	5 (15)	7 (7)
2	10,000 -15,000	4 (7)	13 (38)	17 (18)
3	15,000 – 20,000	45 (75)	12 (35)	57 (61)
4	> 20,000	9 (15)	4 (12)	13 (14)
Total		60 (100)	34 (100)	94 (100)

Figures in parentheses represent percentage to total

The operating expenses or variable expenses in fishing include cost of fishing net, labour, ice, and repair and maintenance expenses (Table 4.23). Presumably labour constitutes the single major item of expenditure (93%). However, this is mainly family labour and is not a paid out cost. Fishing nets are the next major component of cost. Each fishermen need to buy annually 3 to 4 fishing nets (mainly nylon) as the net gets destroyed frequently due to crabs. It often gets entangled in floating plastics or wooden logs in the water.

The different types of net used by the respondents were drift gill net (*Ozhukku vala*), cast net (*Veessu vala*) and other gill nets (*Loop vala*, *Odakku vala*). Drift gill nets are bigger nets that float freely on the water surface. The gill net with floats attached to a rope along the top of the net and weights are attached to another rope along the lower side of the net to keep it vertical in the water. A special type of net is used for shrimp and crab (*Njandu vala*), in addition hooks are also used for catching crabs.

On an average the cost of net was ₹ 9284/year. (₹ 1,427 and ₹ 2,700 per net in Ernakulam and Kannur respectively) i.e. annually the total expenditure towards this is estimated at ₹ 10,644 and ₹ 7,923 in Ernakulam and Kannur respectively.

Marketing cost (₹ 80-250 per day) and harbour commission (7%) for selling their fish in the wholesale fish market (Vypeen harbour) was incurred for 40 per cent of the respondents in Ernakulam. Almost all the respondents in Ernakulam sell their catch in Vypeen harbour. Contrary to this in Kannur the catch is sold to the local market, without paying commission. Thus they save the cost of preservation also. In Ernakulam the preservation cost amounts to ₹ 2,480/person/year. The total variable expenses in inland fishing is estimated as ₹ 1,61,149 for a fisherman in one year. The cost in Ernakulam is higher by about 2 per cent, which is mainly due to the higher cost of fishing nets and preservation.

Table 4.23: Expenses in fishing: Variable (recurring) expenses

Sl No.	Particulars	Expenses/person/year (₹)		
		Ernakulam	Kannur	Average
1	Fishing net (3 No.)	10644	7923	9284
2	Labour (Own)	148800	150150	149475
3	Ice	2480	0	1240
4	Repair & maintenance	1200	1100	1150
Total		163124	159173	161149

The total expenditure of any operation includes both fixed and recurring expenses. The total expenditure in inland fishing which includes the fixed and variable components is presented in Table 4.24. The total expenditure per fisherman per year is estimated at ₹ 1,82,592 and 1,77,766 respectively. The average is estimated as ₹ 1,80,179 per person.

Table 4.24: Expenditure incurred

Sl No.	Particulars	₹/person/ year		
		Ernakulam	**Kannur**	**Average**
1	Depreciation on fixed capital @ 10%	1578	1338	1458
2	Interest on fixed capital @ 10%	1578	1338	1458
3	Recurring expenses	163124	159173	161149
4	Interest on recurring capital @ 10%	16312	15917	16115
Total		182592	177766	180179

The income from fishing is highly seasonal in nature (July-December). During the lean periods, the income may be very less and they opt for alternate income generating jobs (casual work). During the peak season, they work six days a week, spending 5-8 hours in the activity. The older generation, however works 7 days a week.

The traditional fishermen in Kerala are using age old fishing techniques and have expertise in fishing with their greatest asset being the indigenous traditional wisdom on fish, fish habits, waves, currents and stars (Khambete, 2012). The working hours of fishermen depend heavily on factors such as season and tidal influxes since fish availability is very much dependent on these. Normally peak fish catch is realised in five days preceding and succeeding full moon and new moon (*Ekadashi* to *Panjami* in Malayalam calendar). The working hours of fishing primarily depend on high tide and low tide activity since these inlands in Ernakulam and Kannur are connected to Arabian Sea. Normally, fishing hours range between 4–10 hours per day with average of 6-8 hours. The fish catch is better in early morning or in late evening hours.

The increased competition due to more number of active fishermen, the average catch per fishermen is reported to be decreasing. This may also be due to the declining quality of ecosystem or quantity of the resource stock or either. Simultaneously, the increase in number of boats and fishermen and technological improvements lead to over harvesting. This is manifested as longer fishing hours with lower fish catch. The inland fish production in the state is reported to be declining at a faster rate. The average fishing area in Kerala is the lowest compared to its output. This highlights the mounting pressure on the coastal areas of the state (Aerthayil, 2000; Dietrich and Nayak, 2002). The population depending on fishing has steadily increased over the years thus resulting in fast depletion of fishery resources in the wetlands. The overexploitation and unsustainable collection of fish juveniles have led to the drastic reduction in fish catch.

Traditionally fishing communities have maintained social and economic relationship on the basis of common property resources. The livelihood of fishermen heavily depends on natural resources and changes in the environmental situation largely impacted the community's well being. However, the pressure on fish resources mounts, with increased number of fishermen and reduced catch, creating social tensions in coastal villages. The people depending on fisheries for their livelihood has increased many fold over the years and resulted in drastic reduction in their per capita earnings (Sathiadhas, 2006).

The inland fishermen normally collect fish, shrimp, crab and mollusk. Shrimps like *Penaeus monodon* (Tiger shrimps) and *Fenneropenaeus indicus* (Indian white shrimp) are the commonly seen species in mangrove areas. Shrimp larvae reach the mangroves during high tide. Further, growth is facilitated by the tidal backwaters including mangrove ecosystems. Later on, they return to the sea.

The people in certain pockets of Kannur district especially Madakara and Mattul are exclusively engaged in the collection of shells of clams (mollusks). It was the

important economic activity of the area during 1980's. The material was used by Mavoor Gwalior Rayons factory, Kozhikode, during processing of rayon. The shells of the clams like *Meretrix meretrix, Metrix casta, Metrix ovum, Sanguinolaris* sp., *Placenta placenta, Paphia malabarica, Mactea* sp. and *Suetta* sp. were normally harvested. The mollusks congregate in plenty to form thick beds. This formation accreted in thick deposits and become the raw material for the lime industry. The shell mining was done in the sub fossil deposits and the peak collecting season starts from February to July. The activity almost ceased following the lockout of Mavoor Gwalior Rayons in 2001.

Shell mining is revived in the recent years following the demand for shells from poultry feed factories in the Namakkal area of Tamil Nadu. Currently large scale mining occurs in the area. The daily wage rate (5 hours) is varying from ₹ 450-500. The knowledge about the shells and its mining are passing from generation to generation and the present generation is following the path of their forefathers. Mostly, shell mining is practised as hereditary occupation in the area.

Mollusks are generally filter feeders constituting an important fauna associated with the mangroves in marsh wetlands. Mangroves produce large quantity of organic matter in the form of decomposed leaves. The clams (*Elembakka* in local parlance) are usually humus feeders; hence the growth of clam beds is directly linked with the existence of mangroves. Local people collect and market the clams. The edible mollusks available in the mangroves include *Meretrix meretrix, Metrix odum, Villorita* sp., *Teloscopium teloscopium, Cirithidea cingulata, Crassostrea madrasensis, Littorine* sp.and *Saccostrea cucullata.*

Crabs are one of the important inhabitants in the mangrove area. They are the first feeders in the mangroves. Crabs of the mangrove environment are called 'ecosystem engineers' since they facilitate air circulation in the soil and thereby influencing growth and productivity of the mangrove vegetation. Khaleel (2012) has reported the

higher catch of crabs from mangrove areas thus indicating the direct association. Mangrove crab (*Scylla serrata*) depends on mangroves both for breeding and for food. These crabs normally weigh from 800 gm to one kg and are mostly exported to Thailand, Indonesia and Japan, earning foreign exchange. These crabs are reported to be available in plenty, in the newly planted mangrove areas of Kannur, which confirms the close association between *Scylla serrata* and the mangroves. Live crabs have great demand in the export market and usually fetch an average price of ₹ 800-1000 per kg in the domestic market. *Scylla serrata, Scylla trancubarica, Neptunia pellagica,* are the common large mud crabs. These crabs are reported to damage the fishing nets.

Table 4.25 details the common species harvested by the respondents. About 8 species of fishes are normally harvested by the respondents from the mangrove areas of Ernakulam and Kannur. Four types of shrimps are commonly available namely *Penaeus monodon* (Tiger shrimp), *Metapenaeus monoceros* (Brown shrimp), *Fenneropenaeus indicus* (White shrimp), and *M. dobsoni* (Flower tail shrimp) (*Kara, Choodan, Naran and Thelli* respectively in local language). Among these, Tiger shrimps are the largest and *M. dobsoni* the smallest. Shrimp larvae reach the mangroves during high tide and further growth is promoted by the peculiar marshy environment till they return to the sea for breeding as the life cycle gets completed. The price of the shrimps depends on the size or count.

There is variability in species availability in Ernakulam and Kannur. *Etroplus*, shrimps and Tilapia are the most common fishes in Ernakulam while *Etroplus*, shrimps, crabs and Ambassus sp. in Kannur. Common Catopra are reported only from Kannur. Common Catopra is restricted to mangrove areas and owing to the decline in the mangrove area, the catch is rare and highly dwindling over the years. Similarly the Orange Chromide and Ambassus sp. are also common in Kannur. The elder fishermen/women of Kannur reported traditional medicinal value of the same.

Table 4.25: Commonly harvested fish species

Sl No.	English name	Scientific name	Malayalam name
1	Pearl spot	*Etroplus suratensis*	Karimeen
2	Shrimps	*Penaeus monodon, Fenneropenaeus indicus, Metapenaeus monoceros, M. dobsoni*	Chemeen
3	Crabs	*Scylla serrata*	Njandu
4	Milk fish	*Chanos chanos*	Poomeeen
5	*Tilapia*	*Oreochromis mossambicus*	Tilopi
6	Orange Chromide	*Etroplus maculatus*	Pallathi
7	*Ambassus* sp.	*Ambassus* sp.	Nandan
8	Common Catopra	*Pristolepis marginata*	Chuttachi

The fish catch varies in terms of both species and quantity. *Etroplus* and shrimps are caught on almost all days though the catch varies. As much as 93 per cent of the respondent fishermen in Ernakulam have caught *Etroplus* during the previous year of the survey while it is 70 per cent in Kannur. Shrimps are very common in Kannur and 82 per cent of the respondents are getting it while only 58 per cent get the catch of shrimps in Ernakulam (Table 4.26). Some fishermen exclusively go for shrimp harvest. There are exclusive crab catchers as well. The *Etroplus*, signature fish of Kerala, is more common in southern part of Kerala. Vembanad Lake is considered as the heritage abode of *Etroplus* (Padmakumar *et al.*, 2012). It occupies a special status among the tourist delicacies in South Kerala. So it fetches a higher price in South Kerala.

Table 4.26: Per capita fish catch

Sl No.	Types of fish	No. of fishermen getting the fish species (%)		
		Ernakulam	Kannur	Average
1	*Etroplus*	93*	70	81.5
2	Shrimps	58	82	70
3	Crab	20	30	25
4	Milk fish	12	20	16
5	*Tilapia*	87	5	46
6	Orange Chromide	2	13	7.5
7	*Ambassus* sp.	2	25	13.5
8	Common Catopra	-	3	1.5

*Percentage will not add to hundred as the same fisherman will be catching more than one species

The income from fishing is a function of the species and the quantity of catch. The average fish catch and income realised by the respondents are given in the Table 4.27. The catch (excluding shell mining) is higher in Ernakulam (9.02kg) compared to Kannur (4.47kg). *Etroplus*, shrimps and *Tilapia* are the common fishes and the most priced among the daily catch. The shell mining and clam collection are active during post monsoon period.

The average sale price of fishermen differs in both the places. For instance there is a difference of ₹ 30/kg for *Etroplus*, shrimps and milk fish and ₹ 20/kg for crab. The proximity to city and potential market being the industrial capital of Kerala creates a vibrant market for the fishermen in Ernakulam. Consequent to the better catch and relatively higher prices, the average daily income realised by fishermen in Ernakulam is 15 per cent higher than that in Kannur. Taking into consideration the days of fishing, annual gross income is estimated at ₹ 2,05,994 in Ernakulam and ₹ 1,48,334 in Kannur, the average being ₹ 1,78,629.

Table 4.27: Income from fisheries (equivalent per day)

Sl No.	Fish	Quantity (kg)/day		Average price/kg*		Income/day (₹)		Annual Income (₹)	
		E*	K**	E*	K**	E*	K**	E*	K**
1	Etroplus	2.45	1.20	130	100	318.5	120	78988	32760
2	Shrimps	1.15	1.68	130	100	149.5	168	37076	45864
3	Crab	0.25	0.55	100	80	25	44	6200	12012
4	Milk fish	0.25	0.32	150	120	37.5	38.4	9300	10483
5	Tilapia	3.68	0.18	50	60	184	10.8	45632	2948.4
6	Orange Chromide	0.02	0.17	40	30	0.8	5.1	198.4	1392.3
7	*Ambassus* sp.	0.02	0.21	20	20	0.4	4.2	99.2	1146.6
8	Common Catopra	-	0.03	-	40	-	1.2	-	327.6
9	Shell mining	40	60	4	4	160	240	24000	36000
10	Clams	1.2	1.8	25	20	30	36	4500	5400
Total		49.02	86.27	-	-	905.7	667.7	205994	148334

E*- Ernakulam K**- Kannur

The income from fishing constitutes 90 per cent of total income of the respondents. The subsidiary activities during lean periods generate an income of ₹ 30,700 in Ernakulam and ₹ 2,100 in Kannur (Table 4.28). The level of subsidiary income generating activities is less in Kannur compared to Ernakulam.

Over the last few years, fishermen in Ernakulam work as casual wage labourers in the construction site of ICTT, Vallarpadam and LNG Petronet, Puthuvypeen. With

establishment of LNG Petronet in Puthuvypeen, traditional fishermen are prevented from undertaking fishing activities in the region. The development activities in the thick mangrove pockets of Vypeen Island in Ernakulam district, lead to increased exposure of fingerlings to larger predator fishes in the area where ramifying prop roots and erect standing breathing roots of mangroves are found to be absent. The place was otherwise safe hiding place for juveniles with less predator attack (Muraleedharan *et al.*, 2009).

The cost and returns from fishing in the study area is presented in Table 4.29. The net income from fishing activity was estimated as ₹ 13,385 per year. The income was three times higher in Ernakulam and found to be negative in Kannur. When the implicit cost of own labour is subtracted from the expenditure, the farm business income turned out to be 10 times higher at ₹ 1,62,860. This was 25 per cent lower than the average value in Ernakulam and 33 per cent less in Kannur.

Table 4.28: Details of main and subsidiary income

Districts	**Income / person / year (₹)**		
	Fishing	**Other source of income**	**Total Income**
Ernakulam	205994 (86)	30700 (14)	236694 (100)
Kannur	148334(98)	2100 (2)	150434 (100)
Average	177164 (92)	16400 (8)	193564 (100)

Figures in parentheses represent percentage to total

Table 4.29: Economics of fish catch/person/year

Districts	Income/person/annum (1) (₹)	Expenditure (2) (₹)	Net income (3) (₹)	(1) - (2-LC*) (₹)
Ernakulam	236694	182592	54102	202902
Kannur	150434	177766	-27332	122818
Average	193564	180179	13385	162860

*Labour charge

The popularity and profitability of the reared shrimps give utmost motivation for the shrimp farmers to undertake shrimp farming extensively. The cultured shrimp accounts to about 60 per cent of total shrimps exported from India and are exported mainly to Japan and United States (Shakir *et al.*, 2010). Out of the total respondents in the two districts, 8 per cent are involved in shrimp farming and mainly from Kannur district. All of them are owner cum operators and have above 10–15 years of experience in shrimp farming. The size of the farm varies from 0.4 to 2 ha.

The economics of the shrimp farm was given in the Table 4.30. The input cost/ha is ₹ 2.8 lakhs which includes cost of seed, feed, lime and water management. Labour cost is estimated at ₹ 77,000. Hence total cost and returns of shrimp farming per ha are ₹ 3.27 and 4.75 lakhs respectively with net income of ₹ 1.48 lakhs.

Attractive income from shrimp farming led to large scale destruction of mangrove areas especially in and around Thalassery, Dharmadam and Valappattanam. The widespread conversion of mangroves to accommodate shrimp farms removes the natural bio-filter functions of surrounding mangroves (Walters *et al.*, 2008). This may result in accumulation of hazardous waste in the ecosystem. The discharge of residues of shrimp farms like chemicals, medicine and feed waste to rivers resulted in eutrophication and large scale death of fishes. The study by Primavera *et al.* (2007) found that 1.8-5.4 ha of mangroves are required to remove nitrates from effluents of

one ha of shrimp pond. The soil texture of the wetland may change irreversibly and the discharge of harmful effluents of shrimp ponds causes pollution to coastal water and neighbouring communities.

The negative impact of shrimp farming on mangroves is reported from different parts of the world (Lal, 1990; Gunawardena and Rowan, 2005; Primavera *et al.*, 2007). The mangrove land which is converted to shrimp farms can be used only for about 5 years (Gujja and Finger- Stich, 1996; Stevenson *et al.*, 1999; Sathirathai and Barbier 2001; Barbier 2006b; Khaleel 2009) after which it has to be abandoned due to high level of contamination of the system with chemicals, pesticides and antibiotics. However, the cost of rehabilitation of mangroves in such cases was reported to be very high. Hence, the conversion to mangroves to commercial shrimp farms is not economically viable in the long run. The rehabilitation of the abandoned shrimp farms with replanting mangroves, maintaining and protection of mangrove seedlings for several years required restoration cost of US$ 8,812 –9,318 per ha (Barbier, 2007).

Table 4.30: Economic of shrimp farming

Sl No.	Particulars	₹/ha
1	Material inputs	280000
2	Labour	77000
3	Interest on fixed expenditure @ 10%	13500
4	Interest on variable expenditure	28500
5	Total cost	327000
6	Production (kg/ha)	1581
7	Total returns	474500
	Net income	147500

4.2.2.3. Stakeholder perception on mangrove-fisheries association

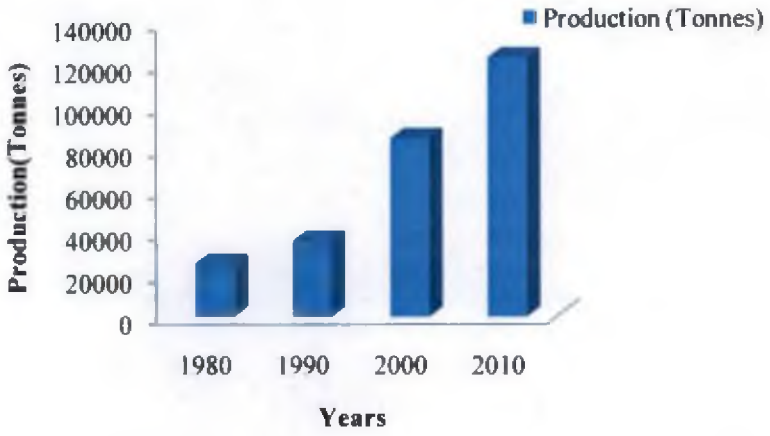
There are a large number of studies that prove the positive association between mangroves and fish wealth. However, the perception of the practitioners on this aspect was examined. The inland fish landing in Kerala is steadily increasing over the decades from 1980 to 2010 (Fig. 4.5). This is largely due to the aquaculture activities under *Janakeeya Matsya Krishi* (JMK) of the state. Incentive based schemes of the government both central and state are promoting aquaculture especially brackish aquaculture. The fish landing per year is growing; in 2010 the total inland fish landed in the state was 1,23,449 t while it was only 25,526 t in 1980. However the share of traditional fishermen in total fish landing has declined substantially. Thus, the composition of inland fish production is changing in favour of culture fisheries from capture fisheries (Beegum, 2006).

Similarly, the fish landing of species commonly seen in the mangrove area such as *Etroplus*, shrimps, crabs and *Tilapia* are rising while the share to the total catch is declining (Fig 4.6). The fresh water aquaculture is gaining momentum. The fish availability to the traditional fishermen is declining over the years on account of pollution and destruction of habitats. The yield of capture fishery is declining whereas culture fishery is flourishing. With the destruction of mangroves along the river and the backwaters, the favourable breeding and nursery ground of finfish and shell fish have been lost. According to the forest officials of Kannur, the availability of *Etroplus* and shrimps has improved substantially in the mangrove rehabilitated areas of Thalassery.

The disappearance of the once luxuriant mangrove formations along the backwaters of Kerala is directly correlated with the poor breeding recruitment of *Etroplus* and the indigenous fish varieties (Padmakumar *et al.*, 2012). The share of *Etroplus* to the total inland fish production in Kerala has declined to 6 per cent in 2002-03 from 10 per cent in 1990-91 (GoK, 2012a). It was reported that around 30-50 million post larvae

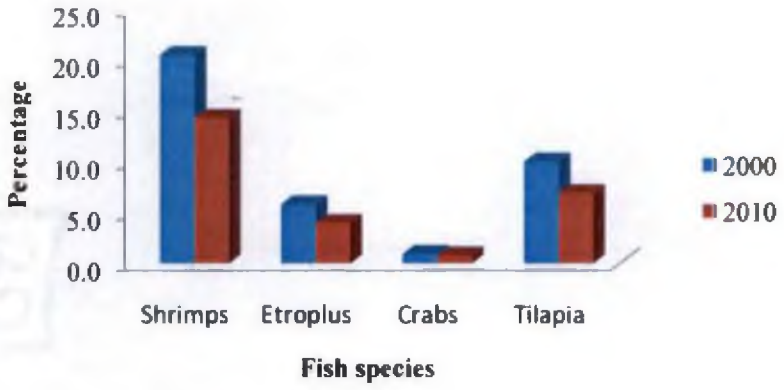
of *Penaeus indicus* and *Metapenaeus dobsoni* were collected annually from mangroves of Kerala (Kaladharan *et al.*, 2005).

Fig 4.5: Inland fish production in Kerala, 1980-2010



Source: GoK, 2012a

Fig 4.6: Species wise landing of inland fish in Kerala, 2000 and 2010



Source: GoK, 2012a

Even though, it is a scientifically proven fact that mangroves and fish wealth are interconnected widespread difference in perceptions were obtained from the

respondents of the study area. The perception of the respondents fishermen on the association of mangroves and specific fish species are given in Table 4.31. A clear distinction was observed in the perception among the respondents in the two districts. A close association between few species namely *Etroplus*, shrimps, crabs and *Tilapia* and mangroves were perceived by the fishermen in Ernakulam. Only shrimps and crabs were perceived to be associated with mangroves in Kannur. To a lesser extent *Tilapia* and *Etroplus* also believed to be associated with mangroves. Some of the respondents in Kannur, especially elders opined that Common Catopra is seen in places where mangroves are abundant and currently catch is very limited due to large scale destruction of mangroves.

But, most of the respondents in Kannur do not agree with the scientifically reported relationship between mangroves and fishes. The elder fishermen in Kannur have opined that expansion and growth of mangroves led to decline in fish catch. Fishing became more laborious and costly on account of net damage. Mangroves created hindrance to the free movement of traditional fisherwomen hand pickers.

The wide spread notion among such respondents was that the fish stock was abundant due to the presence of small plants and grasses in the river bed rather than the mangroves in the river fringes. Khaleel (2009) also made an observation that succession of mangroves over the last few years has resulted in depleting fish stock which contradicts the positive correlation between fish and the mangroves. More scientific studies are needed to validate the relationship between the mangroves and the fish species in Kerala.

The intensity and the nature of dependence of mangroves have changed substantially over time among the stakeholder groups. It was confirmed by a study of stone *et al.* (2008) too. The mangrove vegetation which was exploited indiscriminately in the past years for various purposes like fuelwood, building materials for constructing houses and poles for spreading nets or anchoring the canoes in water has been

reduced in the current scenario. The dependence of mangroves for timber and fuelwood is practically very limited in both places. None of the stakeholder depends on mangroves for spreading nets or anchoring the canoes in water.

Most of the traditional fishermen were of the opinion that mangroves are more harmful than beneficial to fishing. They think that the rapid expansion of mangrove could pose threat to the fishing in the long run. According to them, fishes are breeding inside the grasses (locally known grass 'Karuka') at the bottom of river. The study of Cochin mangroves by Santhakumar *et al.* (2005) revealed that extent of mangroves had negative impact on the level of fish production in inland capture fisheries in Cochin. However, studies from other countries contradicts with this observation (Sathirathai and Barbier 2001; Barbier 2006a). This underlines the importance of location specific studies to determine the optimum level of conservation of mangroves.

Apart from the chemical pollution, mangrove ecosystem holds the floating waste materials (degradable and non degradable). These cause hindrances to the fishermen in free movement. The mangrove trees especially *Acanthus* sp. ('Chulli' in local language) is damaging the traditional fishing nets. The thorny branches prevent the free movement of the fishermen and also damage the fishing nets. The Forest and Wildlife department, Government of Kerala, is normally planting mangroves trees in all mud flats. Experts have argued that planting should be done based on technical feasibility. Hence the choice of mud flats for mangrove planting is highly significant and the same was reported by Moberg and Ronnback (2003). The department is doing the planting activity after obtaining sanction from the respective local self-government but in recent years the grama panchayats are declining to accord permission on account of the social problems created by the mangroves in the locality. This highlights the importance of socioeconomic feasibility studies in conservation management.

Table 4.31: Fishermen perception on association between mangroves and fish species

Sl No.	Fish species	% of fishermen*		
		Ernakulam	Kannur	Average
1	*Etroplus*	85*	45	65
2	Shrimp	95	70	83
3	Crab	90	70	80
4	Milk fish	40	5	23
5	*Tilapia*	65	50	68
6	Orange Chromide	10	15	23
7	*Ambassus* sp.	10	10	10
8	Common Catopra	-	70	35

*Percentage will not add 100 as it is the percentage for individual species

4.2.3. Paddy farmers

4.2.3.1. Description and socioeconomic status

The low lying areas of Kerala are potential areas of paddy cultivation. About 25 per cent of total paddy lands in Kerala are water logged namely Kuttanad, Pokkali, Kole and Kaippad (Jayan and Sathyanathan, 2010). Integrated rice cum fish culture is practiced in these areas. Pokkali and Kaippad agricultural systems are rich in customs, traditions and local wisdom which are reflected in the beliefs and practices of local people, primarily owing to their proximity to the natural resource base. Majority of the respondents in Ernakulam (98%) opined that rice cultivation is benefitted owing to the presence of mangroves in the fringes of the field. *Bruguiera* sp. and *Aegiceras* sp. are the most prevalent mangroves seen around the Pokkali paddy fields while *Avicennia* sp., *Acanthus* sp. and *Rhizophora* sp. are the common

ones in Kaippad. The paddy fields with mangroves on the fringes provide a special habitat for the rice cultivation (Chandramonahan and Mohanan, 2012).

The humus from mangrove leaves is considered as the source of the rich nutrient status of both Pokkali and Kaippad soil. The fallen leaves of the mangroves in the field fringes act as nutrient reserve for the paddy crop and the presence of the fungi colonies in the marshy soil aggravates the speed of the decomposition. The high degrading capacity of marine fungi (*Lulworthia grandispora*, *Aniptodera chesapeakensis*, *Trichocladium alopallonellum*, *Savoryella paucispora*, *Cirrenalia pygmea*) makes the coastal paddy lands very fertile. These marine fungi are found abundant in the wood litters of mangroves (Nambiar and Raveendran, 2007). This proves the positive interaction between mangroves and the coastal paddy. The nutrient rich water floods the paddy field and subsequently enhances the fertility of the field. The incidence of pest and disease is very limited in this peculiar microclimate of the paddy. In the paddy-aquaculture rotation there is sufficient nutrient recycling as well (Vijaya, 1998).

The area is swampy and water logged experiencing floods during monsoon and salinity during summer owing to the nearness to the backwater/ river that merges into the sea (Nair *et al.*, 2002). The tidal waves enter the field through the backwater/river and the fields remain flooded. So they get rich deposits of highly fertile organic matter. The external input application (manures, chemical fertilizers and plant protection chemicals) is almost absent in these lands due to practical constraints. But the rich organic deposits and biodiversity favour the production in the system. The seasonal rainfall followed by flooding leaves both Pokkali lands and Kaippad wetlands inundated for some days. Soil becomes very fertile owing to the deposition of large scale fertile top soil. The pest and disease occurrences are normally absent in both Pokkali and Kaippad during the regular season.

Paddy, in these areas is grown during July to October, followed by shrimp/fish farming. Juvenile shrimps and other fishes are trapped using sluice gates fixed at the bunds of the fields. The complete harvest of the entire stocks of shrimps and fishes is done by middle of April and is called *Kettukalakkal* (Sathiadhas and Joseph, 2001). One rice crop followed by shrimp/fish culture provides substantial subsidiary income to the farmer. This crop rotation has sustained the rural economy of both Pokkali and Kaippad areas.

The Pokkali field is a unique ecosystem prevailing in the coastal saline tracts (Ernakulam and Alappuzha). The fields are naturally connected to the Arabian Sea through backwaters and canals. The area has a fabulous history of Pokkali cultivation of about 3000 years (here onwards "Pokkali" means Pokkali cultivation). However a drastic decline is reported in area under Pokkali over the last few decades. According to Pokkali Land Development Agency, the cultivation has reduced from 25,000 ha to 8,500 ha (Jayan and Sathyanathan, 2010). The local agricultural officers reported that only about 60 per cent of the reported area is actually under cultivation and the rest is either left fallow or under the monocropping of shrimps.

The wide spread disappearance of paddy fields in Kerala over the last two decades mooted the government to implement a scheme 'fallow free villages' by the Department of Agriculture, Government of Kerala. The paddy cultivation has started in fallow fields with the help of financial support through the respective Krishi Bhavans (local level agricultural office) and the mandatory requirement of the MGNREGA labourers to work in the paddy fields for stipulated days in a year. The above two measures have led to area expansion under paddy in the State and the similar situation has occurred in Pokkali lands and Kaippad region too.

The Kaippad cultivation is practised in three districts of Kerala namely Kannur, Kasargode and Kozhikode. The complex and diverse wetland ecosystem includes the extensive body of estuarine waters near the coastline with its river proximity and the

vast area of tidal marsh land together with adjoining highly fertile flood plains that constitutes the ideal ecosystem for rich and diverse flora and fauna (Vanaja *et al.*, 2009). Kaippad lands are seen mainly in Kannapuram, Kunhimangalam, Ezhom and Pattuvam grama panchayat located on the shores of Pazhayangadi river, Valappattanam river and Kavyai river. The Kaippad area was once known as 'second Akiab' due to the extensive rice cultivation in the region.

There were more than 2,500 ha of Kaippad lands in Kannur in the 1960's which was dwindled to about 600 ha or less in recent years (Jayan and Sathyanathan 2010; Chandramohanan and Mohanan, 2012). The past generation of farmers practised rice-urd system in the Kaippad lands, which presently follows rice-fish/shrimp culture. Like Pokkali, Kaippad is also the flood plain paddy cultivation undertaken in a highly congenial condition with rich diversity of both flora and fauna. The area is swampy and water logged, experiencing floods during the monsoons and salinity during summer owing to the nearness of rivers. The tidal currents from the Arabian Sea move through the rivers and enter the Kaippad fields during high tide and flow out during low tide.

The socio-economic profile of the respondents in Pokkali and Kaippad are given in Table 4.32. Out of the total respondents, 20 and 13 per cent respectively in Pokkali and Kaippad belong to middle age group (35–50 years). The majority of respondents in both the places are in the age category between 50–65 years. Younger respondents were not observed in this category, which makes it different from the other group of stakeholders. Above one fourth of the respondents are elders of age above 65 years with rich farming experiences. The average age of respondents in Pokkali and Kaippad is 57 and 58 respectively with overall average of 57.

Majority of the respondents who undertake farming have schooling of 1-7 years. Less than 5 per cent of the respondents have higher level of education. Above 20 per cent have 8-10 years of schooling in both Pokkali and Kaippad. 15 to 25 per cent have

higher secondary level of education. About 13 and 2 per cent respectively of Pokkali and Kaippad did not have formal education. An inverse relationship is observed between farming and level of education. The educated youth prefer to undertake professions realizing better income and social recognition. Hence with higher education, youth are moving away from farming especially paddy. Further farm families are discouraging their children to take up farming as occupation since they themselves want to quit the same. This trend is visible in the study area too.

A difference from the normal nuclear family pattern of Kerala (husband, wife and two children) is observed in the Pokkali area. Out of the total respondents in Pokkali, 85 per cent have family size between four and six with minimum of three children while 10 per cent have extended family of above six members. The pattern is almost the same in Kaippad samples as well. The average family size was five in Pokkali and was four in Kaippad area.

A wide variation is observed among the occupation of the respondents in the study area of Ernakulam and Kannur (Table 4.33). Most of the respondents in this group in Pokkali area earn as income from fisheries (42%) and some 20 per cent work as casual wage workers. Only for 10 per cent agriculture forms the major source of income. In Kaippad majority (63%) depend on agriculture as major income source.

Table 4.32: Socio-economic details

	No. of respondents		
I. Age class (Years)	**Pokkali**	**Kaippad**	**Overall**
35-50	12 (20)	8 (13)	20 (17)
50-65	30 (50)	36 (60)	66 (55)
Above 65	18 (30)	16 (27)	34 (28)
Total	60 (100)	60 (100)	120 (100)
Average age	57	58	57
II. Level of education (Years of schooling)	**Pokkali**	**Kaippad**	**Overall**
Illiterate	8 (13)	1 (2)	9 (8)
1 - 7	29 (48)	25 (42)	54 (45)
8 - 10	13 (22)	14 (23)	27 (22)
10 - 12	9 (15)	15(25)	24(20)
12 - 15	1 (2)	5 (8)	6 (5)
Total	60 (100)	60 (100)	120 (100)
III. Family size (Number)	**Pokkali**	**Kaippad**	**Overall**
< 4	3 (5)	27 (45)	30 (25)
4 - 6	51 (85)	31 (52)	82 (68)
> 6	6 (10)	2 (3)	8 (7)
Total	60 (100)	60 (100)	120 (100)
Average family size	5	4	5

Figures in parentheses represent percentage to total

Table 4.33: Details of the occupational status of the respondents

Sl No.	Occupation	No. of respondents		
		Pokkali	Kaippad	Overall
1	Agriculture	6 (10)	37 (63)	43 (35)
2	Fisheries	25 (42)	2 (3)	27 (22)
3	Casual wage labour	12 (20)	5 (8)	17 (14)
4	Private job	2 (3)	5 (8)	7 (6)
5	Govt. employee	0	1 (2)	1 (1)
6	Business	1 (2)	2 (3)	3 (3)
7	Pensioner	2 (3)	6 (10)	8 (7)
8	Aged	9 (15)	0	9 (8)
9	Housewife	3 (5)	2 (3)	5 (4)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

The total number of family members of respondents in Pokkali area is 324 and in Kaippad area is 223 (Table 4.34). The males outnumbered females in Ernakulum while reverse is the case in Kannur. Number of students is less among the family members of the respondents in Kannur. It may be attributed to the higher percentage of aged respondents and fewer grand children in the family. Most of the family members in Pokkali area work as fishermen or casual workers. But in Kannur, farming and other employment are the major options.

Table 4.34: Occupational/activity status of the respondent families

Sl No.	Occupation	No. of respondents		
		Pokkali	Kaippad	Overall
1	Agriculture	10 (3)	43 (19)	53 (10)
2	Fishermen	44 (14)	2 (1)	46 (9)
3	Casual wage labour	40 (12)	17 (7)	57 (10)
4	Private employee	26 (8)	32 (14)	58 (10)
5	Govt. employee	0	4 (2)	4 (1)
6	Business	2 (1)	4 (2)	6 (1)
7	Student	67 (22)	29 (13)	96 (18)
8	Pensioner	2 (1)	8 (4)	10 (2)
9	Housewife	91 (28)	69 (31)	160 (29)
10	Unemployed	8 (2)	0	8 (1)
11	Aged	26 (7)	13 (6)	39 (7)
12	Infants	8 (2)	2 (1)	10 (2)
Total		324 (100)	223 (100)	547 (100)

Figures in parentheses represent percentage to total

The details of the land holdings of the paddy farmers in the two districts are given in the Table 4.35. Majority of the respondents possessed total land holding size in the range of 0.4 to 1.2 ha. In Pokkali areas, slightly more than one third of them had the holding size in the range of 0.2 to 0.4 ha. But in Kaippad area, 47 per cent possessed more than 1.2 ha and are doing large scale cultivation over the years. The average holding size in Pokkali area was found to be 0.67 ha and that in Kaippad was 1.48 ha. Thus the average farm size in Kaippad was 2.2 times that of Pokkali.

Mostly the paddy fields (*Padasekharams*) are lined by mangroves in these areas. Mangroves were in the boundary of the paddy fields of nearly 55 per cent of respondents in Pokkali area and 30 per cent in Kaippad. On area equivalent terms this

was estimated at 0.02 ha and one ha respectively in Pokkali and Kaippad. This confirms the vast difference in the area extend of mangroves between two districts.

Table 4.35: Details of the landholding size

Sl No.	Size of land holdings (ha)	No. of respondents		
		Pokkali	Kaippad	Overall
1	0.04 - 0.2	1 (2)	3 (5)	28 (23)
2	0.2 – 0.4	19 (31)	1 (1)	29 (24)
3	0.4 – 1.2	34 (57)	28 (47)	53 (45)
4	>1.2	6 (10)	28 (47)	10 (8)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

The family income and asset value of the respondents are furnished in Table 4.36. A clear disparity is seen in the family income realisation of respondents in the two districts, the average annual income being ₹ 1.49 lakhs in Ernakulam and 1.99 lakhs in Kannur with overall average of ₹ 1.74 lakhs. The respondent families of Kannur comprised of higher number of salaried people compared to Ernakulam. About 30 per cent families in Kannur have minimum one member in Middle East countries which is reflected as higher family income.

One third of the respondents in Kannur possessed annual family income in the range of ₹ 2-4 lakhs. Some respondents in Kannur falls in the income category ₹ 4-6 and above ₹ 6 lakhs while such households are absent in Ernakulam. Land holding forms the major asset among this group of stakeholders. Above 60 per cent of the asset value is contributed by land alone. The livestock and paddy cultivation have mutual relationship from time immemorial. However such dependence is coming down. Nearly 15 per cent of the respondents of Kannur have farm animals while it was only 5 per cent in Ernakulam.

Two third of respondents in Pokkali area possessed assets worth ₹ 30–50 lakhs and 23 per cent possessed assets worth ₹ 15–30 lakhs. The average was estimated at ₹ 37.35 lakhs. In Kaippad region nearly half of the respondents (42%) were having asset worth ₹ 50 lakhs or more. The average was ₹ 49.88 lakhs i.e. 34 per cent higher than that of Pokkali area. Though the holding size and economic status of respondents were much better in Kaippad the difference in asset value was not very striking due to the higher land prices in Pokkali.

Table 4.36: Details of annual family income and asset base

Sl No.	Income (₹ lakhs/year)	No. of respondents		
		Pokkali	Kaippad	Overall
1	< 1	4 (7)	17 (28)	21 (17)
2	1 - 2	53 (88)	21 (35)	74 (62)
3	2 - 4	3 (5)	18 (30)	21 (17)
4	4 - 6	0	3 (5)	3 (3)
Total	> 6	0	1 (2)	1 (1)
Total		60 (100)	60 (100)	120 (100)
Sl No.	**Asset value (lakhs)**	**Pokkali**	**Kaippad**	**Overall**
1	8 - 15	0	8 (17)	8 (6)
2	15 - 30	14 (23)	16 (23)	30 (25)
3	30 - 50	41 (69)	11 (18)	51 (44)
4	> 50	5 (8)	25 (42)	30 (25)
Total		60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

4.2.3.2. Dependence on mangroves

Out of the total respondents in Ernakulam about 45 percent are involved in farming for more than 20 years and 43 per cent had 10- 20 years of experience (Table 4.37). About 8 per cent of the respondents in Kannur have less than 5 years of farming experiences and most of them are retired public sector employees who undertake farming since retirement and such category is absent in Ernakulam. More than three fourth of the respondents in Kannur are aged above 50 years and hence possess fairly good farming experiences. A total of 62 per cent have farming experiences of above 20 years. One fifth of the respondents in Kannur have 10–20 years of farming experience. Average farming experiences of the respondents in both places is 14 years.

Even though respondents in Kannur have larger holding size of wetlands than counterparts in Ernakulam, the area under cultivation is less in former compared to the latter place. Majority of the respondents in Ernakulam are cultivating in an area varying from 0.2 to 0.4 ha while it is less than 0.2 ha in Kannur. Nearly one third of the respondents in Kannur have 0.2 to 0.4 ha of paddy land under cultivation. Only very few farmers do farming in more than 1.6 ha. The average area under cultivation is 1.3 and 0.7 ha respectively in Ernakulam and Kannur.

Table 4.37: Details of farming

Farming experience (No. of years)	No. of respondents		
	Pokkali	Kaippad	Overall
< 5	0	5 (8)	5 (4)
5- 10	7 (12)	6 (10)	13 (11)
10 – 20	26 (43)	12 (20)	38 (32)
> 20	27 (45)	37 (62)	64 (53)
Total	60 (100)	60 (100)	120 (100)
Area under cultivation (ha)	**Pokkali**	**Kaippad**	**Overall**
< 0.2	2 (3)	30 (50)	32 (27)
0.2 – 0.4	31 (52)	20 (33)	51 (42)
0.4 – 0.8	17 (28)	8 (14)	25 (21)
0.8 - 1.6	8 (14)	0	8 (7)
>1.6	2 (3)	2 (3)	4 (3)
Total	60 (100)	60 (100)	120 (100)

Figures in parentheses represent percentage to total

All the sample respondents in Ernakulam are cultivating local variety named *Pokkali* while varieties like *Kuthir*, *Kayamakuthir*, *Ezhome* 1 and *Ezhome* 2 are prevalent in Kannur. *Kuthir* is the widely used local variety of Kaippad, while *Ezhome* 1 and *Ezhome* 2 are the recently released saline resistant high yielding Kaippad varieties released by Kerala Agricultural University (KAU). The released varieties are slowly becoming popular in the region.

Paddy cultivation is highly labour intensive and the labour supply problem in this sector is discussed in detail by Susha *et al.* (2012). It is found that about 52 and 27 per cent respectively in Pokkali and Kaippad depended entirely on hired labour for cultivation whereas the remaining 38 and 63 per cent in the two districts utilised both

family and hired labour. The employment diversification among the traditional farm families to non- agricultural activities and reluctance of younger generation to take up farming activities are the main reasons for the increased dependence on hired labour for cultivation. In the family labour depended households, the family members engaged in other activities (public and private sector and casual wage labourers) are involved in farming operations in their leisure time. On an average, cultivation of one ha of Pokkali requires 45 and 63 man days of male and female labour respectively. In Kaippad area it is 48 male and 64 female days. Thus the total labour use is 108 in Pokkali and 112 in Kaippad.

The external input application (manures, chemical fertilizers and plant protection chemicals) are rather absent in the system. Lime is applied in Pokkali areas. The input wise cost of cultivation of Pokkali and Kaippad are given in the Table 4.38. The average cost of cultivation (A_1) per ha of Pokkali is ₹ 47,535 and that of Kaippad is ₹ 37,652. About 82 per cent of the total cost is incurred as labour cost. The average yield per ha was 3530 kilograms in Pokkali and 2408 kilograms in Kaippad.

The gross returns from Pokkali area were ₹ 60,007 which was 47 per cent higher that of Kaippad and the net returns in latter was only one fourth of former. The average yield was 3530 kg in Pokkali and 2408 kilograms in Kaippad. Marketed surplus in Pokkali was 28 per cent of the yield whereas Kaippad production was mainly consumed domestically. After getting GI (Geographical Indication) registration, a society was formed by the farmers for marketing the rice under the trade name 'Pokkali'. This facilitated them to fetch premium price in the market. There is ample scope for similar effort in Kaippad.

Table 4.38: Input-wise cost and returns of paddy cultivation (Pokkali and Kaippad)

Particulars	₹ /ha		
	Pokkali	**Kaippad**	**Average**
Seeds	2559	2572	2565
Labour	39035	31547	35291
Transportation	120	110	115
Lime	1500	0	750
Interest on working capital	4321	3423	3872
Cost A_1	47535	37652	42593
Average yield (kg/ha)	3530	2408	2969
Gross returns	60007	40935	50471
Net returns	12471	3283	7877
B: C ratio	1.26	1.08	1.18

Source: Survey data

Most of the respondents in Kaippad opined that mangroves are causing harm to the paddy cultivation. Over the past few years many of the Kaippad fields were left fallow (may be for 4-5 years) and subsequently the mangroves in the fringes of the rice fields especially *Acanthus* sp. (*Chulli* in local language) had intruded into the paddy field. The farmers are incurring additional cost for removing the mangrove trees to rejuvenate the paddy cultivation. Further, the stringent regulation as per CRZ-1, which classify mangroves over 100 m^2 spread as protected poses legal restriction on the removal of mangroves for paddy cultivation.

In such cases conservation efforts are not necessary since luxuriant growth of mangroves is there. A study by Kamali and Hashim (2011) also has reported the same. The luxuriant growth of the mangroves gave a favourable nesting and roosting place for the granivorus birds like weavers, pigeons and other birds. These birds are

feeding the sprouted rice seedlings and thus the farmers have to incur additional cost for warding off the birds. Similarly, rodents that are harbouring in the vicinity of mangroves are creating additional menace to the paddy crop. This situation creates a diverging interest of mangrove conservation and paddy cultivation. The situation demands a management plan, where the relation is retained as complementary and not competitive.

In the present situation most of the respondents in Kaippad do not acknowledge the complementary interaction between paddy and mangroves. But scientific studies (Nambiar and Raveendran, 2007; Chandramonahan and Mohanan, 2012) show that mangroves form the basis for the rich nutrient deposition in both Pokkali and Kaippad soils which make it unique organic production system. According to Pokkali farmers, the growth of mangroves around the paddy field is good for paddy and for the ecological well being of the region. Mangroves along the bunds of the rice field provide protection against soil and embankment erosion and increase the stability of field bunds. It was found that mangroves species are planted along the bunds of Pokkali fields for strengthening it.

4.2.3.2. Crop rotation- Shrimp/fish culture

The integration of paddy cum shrimp cultivation is cost effective farming system with consistent economic returns. It not only reduces energy inputs but also help to reduce environmental degradation (Sathiadhas and Najumudeen, 2006). This duo culture can be undertaken with minimum level of inputs. In the system, the recycling of wastes/ by products of one crop is used as input for the production of other i.e. the biomass residues of the paddy crop forms the feed for the shrimps and the residues of the shrimp culture forms the manure for the paddy.

Paddy alternating with fish/shrimp culture is a mutual symbiotic association. Different species of shrimps together with fishes such as *Mugil* sp., *Chanos chanos*, *Etroplus suratensis*, *Tilapia*, *Liza macrolepis* and crabs enter in to the field along

with inflow of tidal water. Even though shrimp is the dominant one, in most of the areas less commercially important species like *Metapenaeus dobsoni* and *M. monoceros* dominate in comparison to the commercially important species like *Penaeus monodon* and *Fenneropenaeus indicus*. The average yield of shrimps reported from the traditional paddy cum shrimp culture is usually between 500 -1,000 kg/ha (Sathiadhas *et al.*, 2009).

Majority of the respondents in Ernakulam (85%) are doing aquaculture after the rice crop where it is only 13 per cent in Kannur. *Etroplus*, shrimps (white and tiger), *Tilapia* and *mullet* are the commonly reared ones. Mangroves provide nursery and breeding ground for the shell and fin fishes. Hence the presence of mangroves in the fringes of the paddy field supplements aquaculture (Sathirathai and Barbier, 2001; Khaleel, 2012).The fields are traditional shrimp filtration fields in which paddy and shrimp/fish cultivation is practised in rotation during monsoon and summer seasons respectively.

The economic analysis of shrimp cultivation in the traditional paddy cum shrimp/fish system of Pokkali and Kaippad is given in the Table 4.39. The aquaculture activity in the region usually uses shrimp seeds. Other economically important species like *Etroplus*, *Tilapia*, *Chanos* and other species get into the field when water is let in through sluice gates. The inputs include seeds, lime, feed and medicines.

The aquaculture yield from Pokkali and Kaippad areas was almost the same, averaging at 1075kg/ha. The gross returns realised in Kaippad region is about 40 per cent higher than that in Pokkali area mainly due to better price realisation. The average price in Pokkali was ₹ 148/kg and that in Kaippad was ₹ 200/kg. The difference in species may also be a reason for the price difference. The stocking density is higher in Kaippad compared to that of Pokkali. Commercially important species are used in Kaippad (Tiger prawns). Thus in the crop rotation of rice-fish (shrimp) system the gross returns/ha/year was ₹ 1.56 and 2.19 lakhs respectively in

Pokkali and Kaippad. The net income in Kaippad is 48 per cent higher than in Pokkali.

Table 4.39: Economics of fish culture

Sl No.	Particulars	₹ /ha		
		Pokkali	**Kaippad**	**Average**
1	Material inputs	14331	18750	16541
2	Labour	20686	21406	21046
3	Interest on variable expenditure	3502	4026	3759
4	Total cost	38519	44182	41346
5	Production (kg/ha)	1056	1094	1075
6	Gross returns	156495	218750	187623
7	Net income	117976	174568	146277

Due to the comparative advantage, currently the tendency is to go for two crops of fish/shrimp, avoiding paddy crop. In Pokkali lands mono-cropping of fish and shrimp, is becoming more common. This type of intensive shrimp farming is not only unsustainable but also non-viable in a long point of time (Gujja and Finger-Stich, 1996; Stevenson, 1997; Sathirathai and Barbier 2001; Barbier 2006a; Khaleel 2009). Considering this, there are public funded initiatives to bring back the traditional rotation of paddy and shrimp through projects like *Nellum meenum* (one paddy one fish). It is reported that Agency for Development of Aquaculture, Kerala (ADAK) is planning to implement paddy cum shrimp farming organically in the Kaippad lands of Kannur, Kasargode and Kozhikode districts through self help groups in 90 ha of land. The integrated paddy cum shrimp culture would offer the paddy farmers a better return without affecting the sustainability of the ecosystem.

4.2.4. General Public

4.2.4.1. Description and socioeconomic status

The conservation and sustainable management of natural resources are vital for the very existence of mankind. Participation and attitude of direct beneficiaries together with the rest of the population is vital for the conservation of ecosystems. This stakeholder group comprises people who reside away from the wetlands and do not have direct dependence on the mangrove ecosystem for livelihood. They do not have direct link with the wetland system, either for livelihood or for other direct services. The stakeholder group 'general public' comprised of people who are engaged in diversified field of activities. The group includes scientists, researchers, teachers, private sector employees, students, lawyers and people engaged in other occupations, and represent the society in general. Thirty three per cent members in this group resided at a distance of 2 km from the mangrove ecosystem and 41 per cent farther away. Table 4.40 gives the details. The average distance of residence was 2 km.

Table 4.40: Distance between respondents' residence households and nearest mangrove ecosystem

Sl No.	Distance (km)	No. of respondents
1	< 2	40 (34)
2	2 - 5	49 (41)
3	5 - 20	10 (8)
4	> 20	20 (18)
Total		120 (100)

Figures in parentheses represent percentage to total

The details of age and educational level of the respondents is given in Table 4.41. Most of the respondents were in the two age groups of 18–35 and 35–50 i.e. 34 and 37 per cent respectively. The average age of the groups is 42 years. The respondents comprised largely of educated people, graduates to professionals. Majority of the

respondents have studied above secondary level. One third was professionals including scientists, lawyers, research scholars and professional students. Nearly one fourth has 12–15 years of schooling while 13 per cent are post graduates.

Table 4.41: Socio-economic details

I. Age class (years)	**No. of respondents**
18-35	41 (34)
35-50	45 (37)
50-65	32 (27)
Above 65	2 (2)
Total	120 (100)
Average age	42
II. Level of education (years of schooling)	**No. of respondents**
Illiterate	1 (1)
1 - 7	6 (5)
8 - 10	9 (8)
10 - 12	22 (18)
12 - 15	29 (24)
15 - 17	16 (13)
Professional	37 (31)
Total	120 (100)

Figures in parentheses represent percentage to total

Table 4.42 details the occupational status of the respondents. More than one fifth was public sector employees and researchers followed by the major group of private sector employees. There were casual workers, business people, students, retired hands, housewives and unemployed persons in this section. Males outnumbered females (69%).

The occupation of respondents' family members is furnished in Table 4.43.The sex ratio of family members of the respondents is typically following Kerala pattern, wherein females outnumbered males (52%). Similar to the other stakeholder groups, students and housewives comprised the largest group in the family. The government and private employees occupy the next position. The rest of the family members include farmers, casual wage labourers, businessmen, pensioner, unemployed and aged persons and infants.

Table 4.42: Details of the occupational status of the respondents

Sl No.	Occupation	No. of respondents
1	Casual wage labour	12 (10)
2	Private employee	14 (12)
3	Govt. employee	28 (22)
4	Business	8 (7)
5	Students	9 (8)
6	Pensioner	12 (10)
7	Professional's self employment	11 (9)
8	Research	23 (19)
9	Housewife	1 (1)
10	Unemployed	2 (2)
Total		120 (100)

Figures in parentheses represent percentage to total

Table 4.43: Occupational/activity status of the respondent families

Sl No.	Occupation	No. of respondents
1	Agriculture	3 (1)
3	Casual wage labour	29 (6)
4	Private employee	57 (13)
5	Govt. employee	61 (14)
6	Business	10 (2)
7	Research	25 (6)
8	Student	124 (29)
9	Retired	21 (5)
10	Housewife	77 (17)
11	Unemployed	9 (2)
12	Aged	7 (2)
13	Infants	14 (3)
Total		437 (100)

Figures in parentheses represent percentage to total

The per capita land availability in Kerala is declining over the years with the increase in number of nuclear families. The same is reflected among the land holding size of the selected respondents. About 40 per cent of the respondents are residing in urban areas and hence holding size is very low. Majority of the respondents (42%) have land area lesser than 0.04 ha (Table 4.44). Nearly one third and one fifth of the respondents possessed land holdings of sizes varying from 0.04 to 0.2 and 0.2 to 0.4 ha respectively. Very small percentage has landholding of size between 0.4 and 1.2 ha. The average land holding size is 0.04 ha.

Table 4.44: Details of the landholding size

Sl No.	Land holding size (ha)	No. of respondents
1	Landless	2 (2)
2	< 0.04	51 (42)
3	0.04 - 0.2	39 (33)
4	0.2 – 0.4	24 (20)
5	0.4 – 1.2	4 (3)
Total		120 (100)

Figures in parentheses represent percentage to total

The income of the individual or family is directly proportional to the type of occupation and hence this stakeholder group has the highest annual family income among the four groups. Higher income realization is the result of the secured job with stable salary. Compared to other three stakeholder groups, the spouses of the respondents are highly educated and earning income that contributes to the family income.

Out of the total respondents 24 per cent has family income in the range from ₹ one to two lakhs with an average of ₹ 1.67 lakhs while the highest income group with an average of ₹ 9.18 lakhs (Table 4.45). Majority of the respondents have annual family income above ₹ two lakhs. The lower income category mostly comprised of casual wage labourers and students and has income below ₹ one lakh with average of ₹ 85,800. The annual family income ranges from ₹ 48,000 to 21 lakhs with an average of ₹ 3.93 lakhs.

The sound economic background leads to better asset possession. About 94 per cent of respondents have assets worth ₹ 8 lakhs or above. Out of the total respondents 27 per cent have assets worth more than ₹ 50 lakhs with average of ₹ 100 lakhs. The assets worth ₹ 30-50 lakhs was possessed by 26 per cent of the respondents with an

average of ₹ 40 lakhs (Table 4.45). Very few possessed farm animals. The asset value of the general public was in the range from ₹ 55,000 to 420 lakhs, the average being ₹ 45 lakhs.

Table 4.45: Details of annual family income and asset base

Sl No.	Income (₹ lakhs/year)	No. of respondents
1	< 1	20 (17)
2	1 - 2	29 (24)
3	2- 4	25 (21)
4	4- 6	17 (14)
5	> 6	29 (24)
Total		120 (100)
Sl No.	**Asset value (₹ lakhs)**	**No. of respondents**
1	< 4	3 (3)
2	4 - 8	4 (3)
3	8 - 15	21 (18)
4	15 - 30	29 (23)
5	30 - 50	32 (26)
6	> 50	33 (27)
Total		120 (100)

Figures in parentheses represent percentage to total

4.2.4.2. Stakeholders' perception

Kerala is the land blessed with various natural resources and is the hot spot of biodiversity. However, the pressure on the natural resources especially wetlands started with urbanisation and its subsequent need for land for alternate development activities. This resulted in large scale conversion of wetlands including paddy lands. This was manifested as several climatic effects like increasing drought. This situation

has led to people awareness on importance of conservation in the interest of sustainable life and livelihood aspects. With the focus on wetlands, the mangroves also got increasing attention. Mangroves were not very familiar to the common mass of Kerala except those in coastal areas till last decade (till Asian tsunami of the year 2004). Later on, the controversies over the destruction of mangroves gained mass media attention. About half of the selected respondents have learnt of mangroves through mass media and do not have clear understanding of the ecosystem. Those respondents involved in research activities were aware of mangroves and its services.

In general, the respondent awareness on mangroves is mainly through reports on the controversies related to ecosystem destruction for various commercial activities. Even though the entire respondents have heard of mangroves, only 35 per cent knew the exact location of mangroves in the state. Most of them knew the mangrove locations in their respective district of domicile i.e. Ernakulam residents knew mangroves pockets in the district and was not aware of the spread in other areas. However, all of them have visited the ecosystem for one purpose or other.

Majority of respondents have made deliberate efforts to visit the location when there were conservation-development controversies involving destruction of mangroves. Developmental projects such as construction of hi-tech city in Valanthakad, KCA International cricket stadium at Edakochi, LNG Petronet Terminal and National Oceanarium, Puthuvypeen, Pappinissery Ecotourism Park Kannur etc are always subjected to different controversies owing to the large scale destruction of mangroves in these. In addition to these, there are instances of large scale mangrove destruction for shrimp culture in various parts of Kannur, especially in Kunhimangalam, Dharmadom and Valappattanam. Coupled with this, unauthorised reclamation of mangrove lands are reported from different mangrove locations of Kannur, Ernakulam and Kumarakom (Kottayam).

One fourth of the respondents never visited any mangrove locations and rest three fourth visited various mangrove locations in the state for varied purposes (Table 4.46). Those engaged in research on marine/wetland systems, visit mangroves regularly (22%) while 11 per cent have visited the ecosystem as tourists. Major centres of tourist interests where these ecosystems are seen are Ashramam (Kollam), Kumarakom (Kottayam) and Mangalavanam (Ernakulam). 31 per cent of respondents have attended nature study camps, at least once, when they got an opportunity to visit the ecosystem. They attended camps at Ashramam (Kollam), Kumarakom (Kottayam), Mangalavanam (Ernakulam), Chettuva (Thrissur), Kadalundi (Kozhikkode), Kunhimangalam, Dharmadom and Valappattanam (Kannur).

The respondents' perception on the status of mangroves in Kerala is presented in Table 4.47. Reports show that the mangrove area in the state has depleted from 70,000 ha in yesteryears (Mohanan, 1997), to about 2500 ha (Madhusoodhanan and Vidyasagar, 2012). The vast majority (89 %) is aware of the depletion of mangroves and opined that mangroves are getting depleted over the years however, 8 per cent of respondents mainly from Kannur, perceived an improving status. 2 per cent feel no change in coverage over the years and 2 per cent was not sure about the status.

Table 4.46: Purpose of visit to mangrove ecosystem

Sl No.	Particulars	No. of respondents
1	Research	20 (22)
2	Tourism	10 (11)
3	Nature study	28 (31)
4	During controversies	32 (36)
Total		90 (100)

Figures in parentheses represent percentage to total

Table 4.47: Perception of the general public about the status of the mangroves in Kerala

Sl No.	Particulars	No. of respondents
1	Depleting	107 (88)
2	Maintaining status quo	2 (2)
3	Improving	9 (8)
4	Do not know	2 (2)
Total		120 (100)

Figures in parentheses represent percentage to total

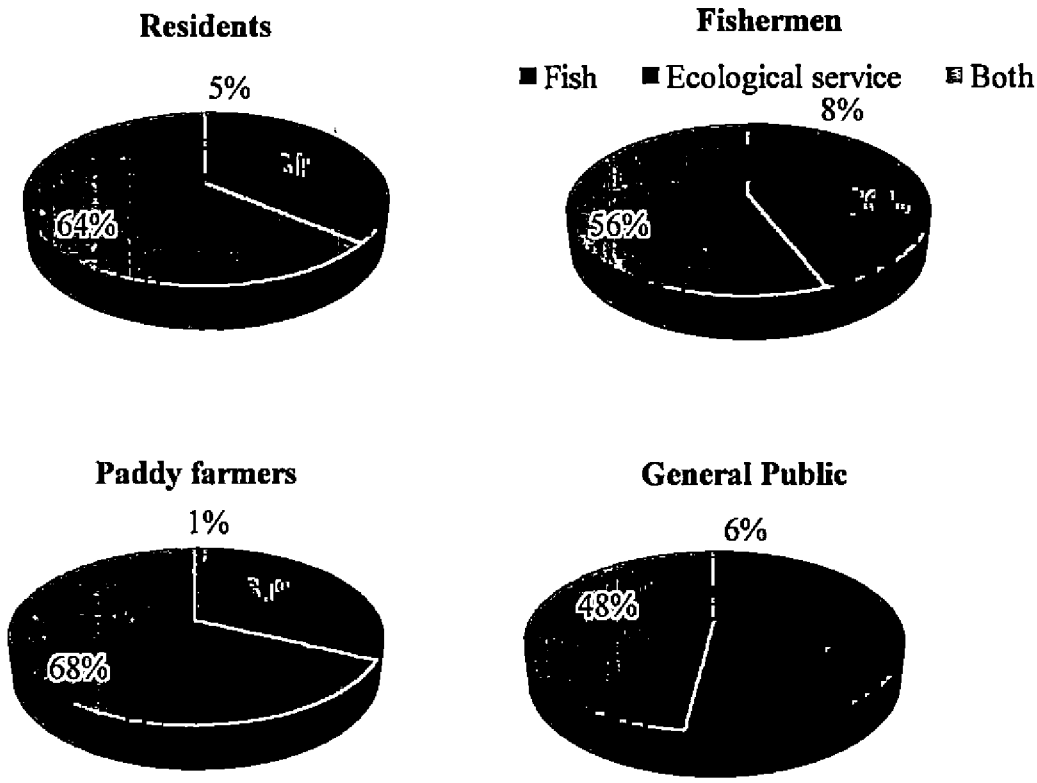
4.3. Stakeholder perception on mangroves status and factors influencing it

Mangroves which were seen along the coastal belt of the state, has been a source of livelihood for large section of rural population. Hence, the traditional knowledge and local customs have been closely linked to these ecosystems. Thus, the local population has perceived the merits and demerits of mangrove destruction, either through observation or through experience. This section analyses the micro level attributes, assessments on mangrove status and awareness on the mangrove wealth, primarily based on respondent's perception.

To gather information on the perceived significance of mangrove ecosystems, direct benefits (goods- (fisheries, fuelwood)) and indirect benefit (ecological services) were considered singularly and in combinations. The results are furnished in the figure 4.7. The respondents in all four stakeholder groups gave highest importance to combined benefits. More than 60 per cent of the residents and paddy farmers and about 50 per cent of the other two groups positively responded to this statement. In all the categories, less than 10 per cent of the respondents favoured the direct benefit of fish wealth. About one third of residents, fishermen and paddy farmers and 46 per cent general public attributed more significance to ecological services.

Among the stakeholders first three groups, residents, fishermen and paddy farmers have more awareness and experience about the ecological functions of the mangroves. These groups directly interact with mangroves in one way or other. Fishermen and a section of residents are depending mangroves for fish wealth. The respondents among these groups in certain pockets of Ernakulam have known the significance of coastal shield of mangroves since Asian tsunami of the year 2004. Majority of the respondents among the general public have only heard or read about the ecological functions of mangroves.

Fig. 4.7: Respondents perception about the significance of mangroves



Mangroves across the globe had been subjected to various biotic and abiotic pressures which have led to its depletion. Demographic factors, socio economic changes, institutional aspects and climatic factors have individually and collectively caused the destruction of the ecosystem (Farnsworth and Ellison, 1997; Twilley, 1998; Allen *et al.*, 2001). Available data in the status of mangrove population in Kerala indicate a decline in area over years. In the absence of realistic data at the micro level, an attempt was made to assess the stakeholders' perception in this regard. Further the factors that contribute to the changes in mangrove wealth are also explored. The respondents' perceptions on the present status of mangroves are presented in the Table 4.48.

Nearly 50 per cent of the respondents felt that mangrove wealth has depleted over time. One third of the residents, fishermen and paddy farmers and majority of the general public (78%) perceived that mangroves are undergoing depletion and degradation. Though there is widespread concern over the depleting status of mangrove ecosystems, at micro level, some believe that there is not much change in the mangrove area. Roughly one fifth of the stakeholders (residents, fishermen and paddy farmers) believe that the mangroves maintain the status over the years. However the general public opinion is different, only 2 per cent opined so.

More than 46 per cent of residents, 54 per cent of fishermen and 40 per cent of paddy farmers expressed that the mangrove area has improved over the years. The residents and fishermen attribute natural regeneration as the major reason for this. Paddy farmers acknowledge the efforts of people's organizations in conservation programmes.

The area improvement of mangroves in certain pockets can be attributed to government's initiative for mangrove conservation through people's participation. There was awareness creation programmes were conducted on the significance of mangroves. Since the Asian tsunami of the year 2004, people became more aware about the storm protection function of the mangrove ecosystem. Hence larger number of people are participating in conservation drives and planting mangroves along the boundary of the homesteads to reduce soil and embankment erosion. Natural regeneration in the less disturbed pockets contributes to an increase in the area. On an average about 39 per cent perceived that mangrove area is expanding in the state.

Table 4.48: Status of mangroves- stakeholders' perceptions

Sl No.	Particulars	No. of respondents				
		Residents	Fishermen	Paddy farmers	General public	Average
1	There is destruction and degradation of mangroves	42 (35)	37 (31)	46 (38)	95 (78)	55 (46)
	Reasons					
	Developmental activities (1)	*23*	*23*	*34*	*83*	*41*
	Tourism (2)	*2*	-	-	-	*1*
	Collection of fuelwood (3)	-	-	-	-	-
	1+3	*14*	*12*	*5*	*5*	*8*
	1+2+3	*3*	*2*	*7*	*7*	*5*
2	Maintaining status quo position	20 (17)	18 (15)	26 (22)	2 (2)	17 (15)
3	Improvement in the mangrove status	56 (46)	65 (54)	48 (40)	20 (17)	47 (38)
	Reasons					
	The government's initiative for mangrove conservation (1)	*3*	*4*	*3*	-	*3*
	People participation in conservation programmes (2)	*15*	*12*	*11*	-	*10*
	Planting along the borders of households to prevent soil erosion(3)	*1*	*1*	*4*	-	*2*
	Area expansion due to natural regeneration (4)	*22*	*15*	*4*	-	*10*
	1+2	-	*5*	*13*	*5*	*6*
	1+4	*6*	*17*	*5*		*7*
	2 + 3	*2*	-	*2*		*1*
	2+4	*5*	*2*	*4*		
	1+2+3	-	-	-	*2*	*1*
	1+2+4	*2*	*9*	*2*	*13*	*7*
4	Not aware	2 (2)	-	-	3 (3)	1 (1)
Total		120 (100)	120 (100)	120 (100)	120 (100)	120 (100)

Figures in parenthesis represent percentage to total

Plate V : Destruction of mangroves due to anthropogenic activities

The elders of the group expressed that conservation initiatives are needed only if the ecosystem is disturbed. The propagules have high survival rate and hence expansion is very rampant, if undisturbed. During the study it was observed that in the undisturbed pockets of Kannur district the growth is very fast with flourishing of thick mangrove stands. However the expansion is posing threat to Kaippad paddy cultivation to certain extent. Hence permission was granted for the regulated removal of mangroves in the cultivating paddy fields. Similar undisturbed pockets are rarely seen in Ernakulam district. Some cases were noticed in the unattended coconut orchards of Edavanakad where the *Excoecaria agallocha* was seen spreading.

There was distinct difference in perception, between the respondents in Kannur and Ernakulam districts in the case of residents, fishermen and paddy farmers. Most of the respondents in Ernakulam perceived a decline in mangrove wealth whereas, it was reported as increasing by many in Kannur. Thus, there seems to be significant difference in the status of mangroves in the two areas. Further, the changes at micro level vary according to the situation. Similarly the responses of the general public were also quite different from the other three groups. This may be due to the fact that this group usually depends on the mass media for information and the case of destruction are often highlighted by the media. Most important reason for the depletion was reported as developmental activities. The anthropogenic, climatic, social and institutional factors were found to be influencing the changing status of mangroves.

4.3.1.1. Anthropogenic factors

The demographic and socio-economic indicators of the state reflect a situation of mounting pressure on natural resources. These factors alone or in combination have resulted in destruction in various degrees. The density of population has increased from 819 (2001) to 859/km^2 (2011). The state exhibited 15 per cent GDP growth during 2012 and leads in social development indices in the country (GoK, 2012d). These

forces naturally result in urbanization and consequent development pressures, which cause severe toll in the quantity and quality of natural resources.

A regional disparity was observed in stakeholders perception regarding the status of mangroves. Majority in Ernakulam perceived that massive destruction of mangroves was occurring in the region whereas this was not so in Kannur. Ernakulam region witnessed massive destruction of mangroves for various development projects and hence the people perceived that destruction is rampant. It is evident from the study that the destruction of mangroves on account of direct dependence for fuelwood is very much reduced in the current scenario. The destruction was mostly for alternate development activities such as national projects, residential and commercial complexes, shrimp/fish ponds, roads and railway lines.

Earlier, 90 per cent of mangroves in Kerala were destroyed either for paddy cultivation, coconut orchard or for land reclamation (Ramachandran *et al.*, 2005). The increased demographic pressure along with industrial needs has resulted in large scale reclamation of many productive wetlands like paddy fields and the marshy tracts along the coastal line.

Mangroves in Ernakulam district are mostly grown along the Cochin backwaters under the strong influence of Vembanad Lake (Ramsar site). Being the commercial hub of the state, major developmental activities in Ernakulam are concentrated along the backwaters. The mangroves along the Cochin backwaters are increasingly subjected to large scale destruction for different developmental projects such as International Container Transshipment Terminal (ICTT) Vallarpadam, LNG Petronet Terminal and residential projects in suburban areas. More than 100 ha of the Government's land (mangrove ecosystem) (those of the Fisheries Research Station, of erstwhile Kerala Agricultural University) was cleared for the establishment of LNG Petronet Terminal. There are reports of regular conflicts between local fishermen and the security personnel of CISF (Central Industrial Security Force). Fishing and fishermen were not

allowed to travel through the nearby creeks to their fishing grounds which severely affected their livelihood. The situation is similar to that of ban imposed by the Government of Orissa around the marine wildlife sanctuary in the mangrove zone of Paradeep (Venkatesh, 2006).

Mangroves were also cleared for the construction of roads and bridges while implementing Goshree Island development project in Ernakulam. An International cricket stadium was proposed by Kerala Cricket Association (KCA) at Edakochi, in the outskirts of Cochin Corporation (Ernakulam) in 9.3 ha of land. The site is a wetland (Pokkali lands with mangroves in the fringes of the field). More importantly, the area is a rich pool of *Avicennia* sp., a variety of mangroves which separates salt content from saline water and deposits it on its leaves there by reducing the salinity in water. The scientific studies need to be initiated in this regard to elicit the particular gene of *Avicennia* sp. which enables this separation and inculcate it into crops to make them saline water resistant. The research on development of saline water resistant crops can be gained through this gene. KCA has initiated the preliminary works with clearing mangrove habitats in the field. However, with the intervention of environmental groups and other activists, the court intervened in the issue and later the work has been withheld after an order from Union Ministry of Environment and Forests (MoEF). This conflict is yet to be resolved.

About 8 ha of mangrove land was recently acquired from the Fisheries Research Station, Puthuvypu for the establishment of National Oceanarium. The State Fisheries Resource Management Society (FIRMA), implementing agency of the project has offered to plant, nurture and maintain mangroves either at Vypeen or Valanthakadu Island (alternate sites) in lieu of the mangroves that would be lost or disturbed while the project is being implemented. Kerala State Coastal Zone Management Authority (KSCZMA) has decided to give in-principle approval for the project. The actual extent of destruction of mangroves can be estimated only after Environment Impact Assessment (EIA).

Similar instances of massive mangrove destruction are also reported from North Kerala (Kannur), though on a lower scale. A mangrove theme park was opened up by the Pappinnisserri Ecotourism Society in an area of 4.85 ha in ecologically fragile mangrove area in Kannur district. Later the park was closed following the directions of the Honorable Supreme Court of India, due to social and ecological reasons.

The maximum genetic diversity of mangroves in the state is reported from Kunhimangalam in Kannur where large scale deforestation of mangroves in lieu of shrimp farming and other developmental activities were reported (Khaleel, 2009 and local opinion). The mangrove lands are effortlessly reclaimed after purposeful human inflicted damages to the stem and subsequent drying up of trees.

Mangrove vegetation along the coast especially in the riverside had been cleared from early period for agriculture and human settlements and currently the vestiges of mangrove bushes are seen along the coast. Unplanned and unscientific bund construction in the mangrove areas has resulted in reduction of organisms dependent on mangroves. These bunds affect the natural habitat and affect the fish wealth. In Kerala, railway lines pass through coastal areas. There was large scale destruction of mangroves in Kozhikode, Kannur and Kasargode districts for the doubling works of Mangalore- Shornur railway line.

Coastal Kerala was harboring luxuriant growth of mangroves in the past which is now being depleted in extent and quality. This has occurred due to illegal cutting of mangrove trees for fuelwood, over grazing for fodder, fish and shrimp culture, indiscriminate encroachment of land for developmental activities, conversion of mangrove lands into coconut plantations and sand mining. The change in the land use pattern has led to the degradation of wetlands including mangroves. Apart from the erratic and insufficient runoff to the coastal area, excessive sand mining from the river bed especially in the coastal tracts of Malappuram and Kozhikode district has heavily

threatened the very existence of the unique mangrove ecosystem. (Radhakrishan *et al.*, 2006).

One reason for the large scale land filling in the coastal areas and other water bodies in Kerala is the absence of clear cut boundary line. Nearly 80 per cent of the mangroves are owned by the private people and the absence of marked boundary in the marshy mangrove area aggravates the reclamation activity. When water recedes in the summer months exposing the mud flats the reclamation is easy.

The mangrove flora which has high natural regenerative capacity has remained stunted in many pockets in the coastal area. This is primarily due to pollution from urban and rural areas. The mangrove depletion in the state has reached to the extent that the functional role of the mangrove ecosystem in both hydrological and biotic terms has been narrowed down. Many wetlands are over loaded with heavy metals, other toxic substances, plastics and other degradable and non degradable substances. In many places eutrophication has inhibited the growth of the biota in the natural habitat.

4.3.1.2. Climatic factors and mangrove wealth

Increase in temperature, CO_2 emission, storm surges and sea level are the probable factors of threats for mangroves in the long run. The change in the conversion of mangrove wetlands leads to reduction in biodiversity and also contributes to changes in carbon cycle (Michener *et al.*, 1997). Mangroves are considered as nature's best system for combating global warming because of their high capacity for carbon sequestration and role as a nutrient sink. The global climate change and resultant sea level rise threatens the natural withstanding ability of mangroves especially island mangroves. The life and livelihood of coastal population is at risk owing to the sea level rise and increased incidence of storm surges. The greenhouse effect on the impact of hydrological cycle may cause increasing scarcity of fresh water in the coastal region. Climate induced changes are likely to affect livelihood options of the coastal

people of Kerala (Sundaresan and Patel, 2011). In depth long term studies from different regions of the world are needed to get more precise conclusions.

Ellison and Studdart (1991) reported that mangrove habitats are the first to be directly affected from global climate change owing to the location at the interface of sea. The grave impact of sea level rise on mangrove community was reported from Southeast Asian countries (Aksorakaoe and Paphavasit, 1993). The increased sea level rise may drastically impact mangrove habitats by altering the hydrological features and related processes. The vertical rise of water column due to sea level rise would result in water logging and destruction of mangroves and associate fauna such as bivalves, crabs and juvenile fishes (Jagtap *et al.*, 2004). The highly erosive and dynamic nature as well as sea variations indicates high vulnerability of the Kerala coast to sea level rise. Sea erosion and inundations would destroy the traditional paddy fields and shrimp and fish farms and have negative impact on the coastal population of the state. There were suggestions to establish mangrove bio shield to mitigate storm surges and offer protection to the coastal belt after the Asian Tsunami of the year 2004 (Purushan, 2005).

The impact of climate change is often experienced slowly and the awareness level among the people is rather limited. The response in this aspect is furnished in Table 4.49. Most of the respondents in all the categories were not sure about the potential impacts of climate change on mangroves (79%). Nearly one fifth perceived negative impacts of climate change on mangroves. Drying of mangroves during summer months were observed and large scale destruction of mangrove seedlings owing to prolonged water stagnation. The elders among the respondents opined that this as a recent phenomenon. The mangroves require regular alternate flushing of fresh and saline water. With the reduced annual rainfall in the last few years, the period of fresh water availability has reduced and hence mangrove seedlings remain in the saline water for longer period resulting in large scale destruction. The salt water intrusion to the rivers

and backwaters usually take place in November–December. Of late the intrusion has advanced to early September. This may cause adverse effects on mangrove vegetation. However scientific validation is needed in this aspect.

Table 4.49: Perception on climatic impacts on mangroves

Sl No.	Particulars	No. of respondents				
		Residents	**Fisher men**	**Paddy farmers**	**General public**	**Average**
1	Climate change impact the mangrove wealth	25 (21)	26 (22)	28 (23)	20 (17)	25 (20)
	Drying of mangroves in summer (1)	*17*	*16*	*18*	*9*	*15*
	Destruction of mangrove seedlings due to prolonged water stagnation (2)	*8*	*8*	*1*	*1*	*5*
	1+2	-	*2*	*9*	-	*3*
2	No impacts	-	-	-	-	-
3	Not aware	95 (79)	94 (78)	92 (77)	100 (83)	95 (80)
Total		120 (100)	120 (100)	120 (100)	120 (100)	120 (100)

Figures in parenthesis represent percentage to total

4.3.1.3. Property rights

The property regime of mangroves in the state is different from rest of the country. The land holding and ownership of mangroves are the significant factors in utilization, conservation and management of mangroves (GEC, 2011). Kerala is the only state in India where mangrove area is not under the control of state forest department. The

mangrove patches in the state are owned by Government departments (Fisheries, Revenue, local self governments, Forest & Wildlife and Tourism), quasi government agencies (Kerala Agricultural University), Central government (Railways) and major share under private ownership. More than 85 per cent of mangrove area in Kerala is under the private holdings/ownership (Lakshmi, 2002; Unni, 2003). Rough estimates show only 200 ha as under government or quasigovernment ownership. The mangroves under public ownership have been largely converted for developmental activities like ICTT, Vallarpadam, expansion of Cochin Port Trust and LNG, Petronet, Puthuvypeen. The mangroves in private lands (mainly as boundary) face the conflicting situation. The marginalized low income resource poor land owners try to protect the ecosystem, while the owners of larger holdings try to destroy the mangroves. Presence of mangroves reduces the property value. Because of the surging land prices, the private owners, especially in urban areas prefer to clear off the mangroves to fetch better price in the land market. (Mangrove ecosystems are generally considered as waste lands and hence low priced). Simultaneously the local community's dependence on mangroves for livelihood is slowly declining as the younger generation is migrating, both occupationally and geographically. This slowly prompts the traditional stakeholders also to sell the property.

4.3.1.4. Legal aspects

Institutional efforts in conservation through legal and financial support are considered as a reason for improvement in the status of the mangroves. The government of India has notified mangrove ecosystems under CRZ-1 category. Hence, destruction of mangroves or conversion of mangrove areas for alternate purpose is prevented. Further, the CRZ rules (1991) and Kerala Conservation of Paddy land and Wetland act (2008) also limits the conversion process. Kerala State Coastal Zone Management Authority is the nodal agency to give in-principal approval for the projects involving destruction of mangrove resources. The private owned mangrove theme park, Kannur

was closed following the legal battle between the owners and the authorities. Likewise the legal issues are pending against the proposal for the International cricket stadium at Ernakulam.

4.3.1.5. Community efforts and institutional support

Mangrove conservation and management will be successful only with the active participation of the local communities. It was confirmed by the study of Barbier (2006b) and Stone *et al.* (2008). The residents along the river banks are doing small scale mangrove restoration drive against river bank erosion. An environmentally active organization called SEEK (Society for Environment Education in Kerala) had purchased more than 2 ha of mangrove lands in Kannur district. The leading Malayalam daily, *Mathrubhumi* initiates an environmental programme called SEED (Students Environmental Education and Development). Under the programme they have purchased 0.4 ha of mangrove land (formerly Kaippad land) in Kannur in 2012 and has undertaken conservation programme. The area expansion of mangroves in Kannur especially in Kaippad lands occurred mainly due to the reduction in paddy cultivation. Paddy fields are left fallow and subsequently the natural succession of mangrove in the fringes to the field has resulted in area expansion. Destruction of mangroves is more visible in Southern part of Kerala especially in and around Cochin backwaters compared to Northern part of Kerala. The presence of environmental activist groups (SEEK, Kerala Sastra Sahitya Parishad, Malabar Natural History Society are few to cite from north Kerala) restrict the chances of destruction.

The social forestry wing of Department of Forests and Wildlife, Government of Kerala is the nodal agency for afforestation programme of mangroves in the coastal belt of Kerala. The environmental activist groups are also engaged in the programme especially in Kannur districts. These groups are very vigilant against the destruction. The Forest and Wildlife department usually collects seeds during the monsoon period from local seed collectors at the rate of ₹ five/seed and raises the nursery in the suitable

mud flat and the seedlings are planted in the coastal mud flats. However, the survival is dependent on the type of mudflats and management aspects. Generally the attempts to restore mangrove ecosystems through restoration projects are reported as not very successful in achieving its goal (Elster, 2000; Lewis, 2005). For the successful mangrove restoration programme, site selection is of prime importance. The site depends on local environmental factors, socio cultural context, suitability and adaptability of species (Kairo *et al.*, 2001). The scarcity of land and private ownership status pose severe challenges to the conservation efforts by the government. However, the Department of Forests and Wildlife has initiated a project to pay for conservation of mangroves under private ownership. The project is being implemented in Kollam, Ernakulam, Thrissur, Kozhikkode and Kannur districts (GoK, 2012c).

4.3.2. Loss of mangroves- consequences

The consequences of mangrove destruction around their premises as perceived by the respondents were gathered through a set of statements (Question II (1) in Part 3 of Questionnaire). The results are presented in Table 4.50. It is important to note that 75 per cent of the stakeholders expected a negative impact. The proportion was the highest for the residents (93%) who perhaps are the group associated with mangroves in their day to day life. They associate the main ecological service to them as protection to their life and property by preventing the furious waves and high velocity winds along with unidentified ecological services.

The fishermen group, associate the ecological benefits with their livelihood option (income from fishing). The paddy farmers, however differ in their opinion on the potential impacts. Roughly 50 per cent reported negative impacts on ecosystem services. More than one fourth was of the opinion that destruction of mangroves around their premise has positive effects. This opinion was expressed by paddy farmers in Kaippad area. Mangroves in this area have been spreading through natural regeneration. This unregulated growth has caused expansion of these plants to

cultivating fields causing the farmers to incur additional cost for clearing the field. Naturally this adversely affected the profitability and many a times farmers are forced to leave paddy cultivation. Moreover, the adjoining mangroves harbor different birds and they feed on the germinating seeds/seedlings and mature grains. Hence, the practising paddy farmers in the area demand a regulated management of mangroves. It seems that, at least in some pockets the complementary relation between two ecosystems has crossed the border and has become competitive. There should be an appropriate micro level management strategy to solve the problem and to ensure complementary relationship.

Mangroves provide shelter to several avian fauna which feed on its fruits and nest in the branches. Rare and endangered birds including migratory birds have been reported from the mangrove tracts of Kerala. Migratory birds are roosting for about 8 months in a year.Madakara, Chemballikundu and Kunhimangalam in Kannur and Mangalavanam in the heart of Cochin are the important wetland bird habitats. The destruction of mangroves leads to the loss of roosting location for the birds and results in decline in number of the winged creatures in the coastal tracts.

Otters are the most important mammals seen in mangroves. The destruction of mangroves leads to the large scale reduction in the number of these animals. The indiscriminate poaching of otters for soft leather is wide spread and these animals are almost in an endangered condition. However, increased presence is reported in certain coastal tracts of Ernakulam.

A section of the respondents (13%) believed that reduction of mangroves from the existing level would not cause any impact and four per cent was not sure about the consequences. The analysis highlights the micro level situation that the ecosystem is under great threat of destruction and the local population is aware and concerned about the potential threats. This situation reflects the necessity for scientific conservation efforts which ensure people's participation. The necessity for micro level area

assessment and identification of areas of conservation based on participatory approaches is underlined.

Table 4.50: Perceptions of social impacts of mangrove destruction

Sl No.	Particulars	No. of respondents				
		Residents	Fisher men	Paddy farmers	General public	Average
1	There is negative impact	112 (93)	90 (75)	58 (48)	103 (86)	91 (75)
	Ecologically harmful (1)	*72*	*62*	*58*	*99*	*73*
	House/property damage (2)	-	-	-	-	
	Loss of employment (3)	-	-	-	-	*11*
	1 + 2	*36*	*2*	-	*4*	*6*
	1 + 3	*2*	*23*	-	-	*1*
	1 + 2+ 3	*2*	*3*	-	-	
2	There is positive impact	2 (2)	-	32 (27)	-	8 (8)
	Beneficial to paddy cultivation (4)	*2*	-	*32*	-	*8*
3	No impacts	6 (5)	18 (15)	25 (21)	13 (11)	16 (13)
4	Don't know	-	12 (10)	5 (4)	4 (3)	5 (4)
Total		120 (100)	120 (100)	120 (100)	120 (100)	120 (100)

Figures in parenthesis represent the percentage to total

4.4. Economic valuation of mangroves

The efforts towards economic valuation of ecosystem services have been under great deal of criticism due to ethical reasons. At the same time, the necessity of such an exercise is also underlined by many authors (Barbier *et al.*, 1997; Hirway and Goswami, 2007; Bateman *et al.*, 2011). The economic values of service flows from resource-environmental systems can be viewed as a product of the sets of functional roles (Freeman, 1993). Valuing the services of natural capital at the margin consists of determining the difference that relatively small changes in these services make to human welfare. In this section the results of the valuation attempts by replacement cost and contingent valuation methods are discussed.

4.4.1. Replacement cost method

The application of replacement cost method indirectly helps to assess the value of the ecosystem and has been employed by many authors (Bartik, 1988; Gunawardena, 2003, Sundberg, 2004). The method uses the cost of a perfect substitute to estimate the value of the environmental good. The cost of replacing an ecosystem service (mangroves) with a man-made substitute (sea wall) is used as a measure of the economic value of ecosystem service (mangroves).

The role of natural bio shields like mangroves is proved to be successful in preventing or minimising the damage cost in many cases (Das, 2007, 2009). Primavera (1991) reported the incident of increased life and property damage along the coastline of Philippines as a result of mangrove clearance. The construction of sea walls and bay buildings were not effective as mangroves, in bringing down the fury of invading sea tides or tsunamis over its cost and impact on environment and aesthetic values (Walters, 2003; Badola and Hussain, 2005; Barbier, 2006b; Kurien *et al.*, 2006; Muraleedharan *et al.*, 2009). Mangroves act as natural belt in the coastal areas, exerts protection against encroachments of sea, destructive forces of tides and storms (Francis, 2007).

The protective role of mangroves along the coastline was estimated through the replacement cost method, by many authors. The value of the mangrove ecosystem was estimated in relation to the costs incurred to construct man made coastal defences (Gunawardena and Rowan, 2005). It was reported that the cost of construction and maintenance of stone piled embankments in Malaysia was US$ 13,842/ha/year while the cost of planting of mangroves was US$ 36/ha/year (Leong *et al.*, 1999). The unit cost of constructing break waters of 1m width was US$ 875 whereas mangrove forest of 75 m width along the coast produces the same effect with a cost of US$ 11.67/m^2 (Sathirathai and Barbier, 2001). The Sri Lankan Coastal Zone Management Plan estimated cost of installing erosion and storm control as US$ 300/ha (Gunawardena and Rowan, 2005). Kathiresan (2010) and Debroy and Jayaraman (2012) reported that cost of constructing tsunami wall in Pichavaram was between ₹ 1600 to 3200 million for 8000m compared to minimal cost for planting and maintenance of mangroves, while functionally the service from mangroves were much high.

The 560 km coastal line of the state is spread across nine districts namely Thiruvanathapuram, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikkode, Kannur and Kasaragod. But sea wall is constructed in 355 km only. The cost of sea wall construction is primarily depends on the design of sea wall. The structure and thickness of sea wall varies in different places based on the intensity and frequency of tidal action. Rubble mount sea walls are commonly constructed. The sea walls are constructed in Kerala using both central and state government funds. The average cost of construction is ₹ 55,565/m (GoK, 2012b). Aftermath of Asian tsunami of the year 2004, 7.1 km of sea wall was constructed in the state under Tsunami Rehabilitation Programme (TRP) in the districts of Thiruvananthapuram, Alappuzha, Thrissur, Kozhikkode, Kannur and Kasaragod. Hence, the expenditure incurred for seawall construction as part of TRP was ₹ 395 million. At the same time, Department of Forests and Wildlife, Government of Kerala is incurring ₹ 22,000 to 25,000/km of mangrove planting along the coastal mud flats. Thus, if mangrove

planting is to be undertaken atleast in 300 km of sea shore, the total cost should have been 7.05 million against ₹ 16,670 million i.e. the cost for sea wall construction for the same distance. In addition to the rehabilitation undertaken by the government departments in the state, various organisations like NGOs, local clubs, school children and individuals are also involved in planting the mangroves. The cost involved in those activities is not properly accounted.

4.4.2. Contingent valuation method (CVM)

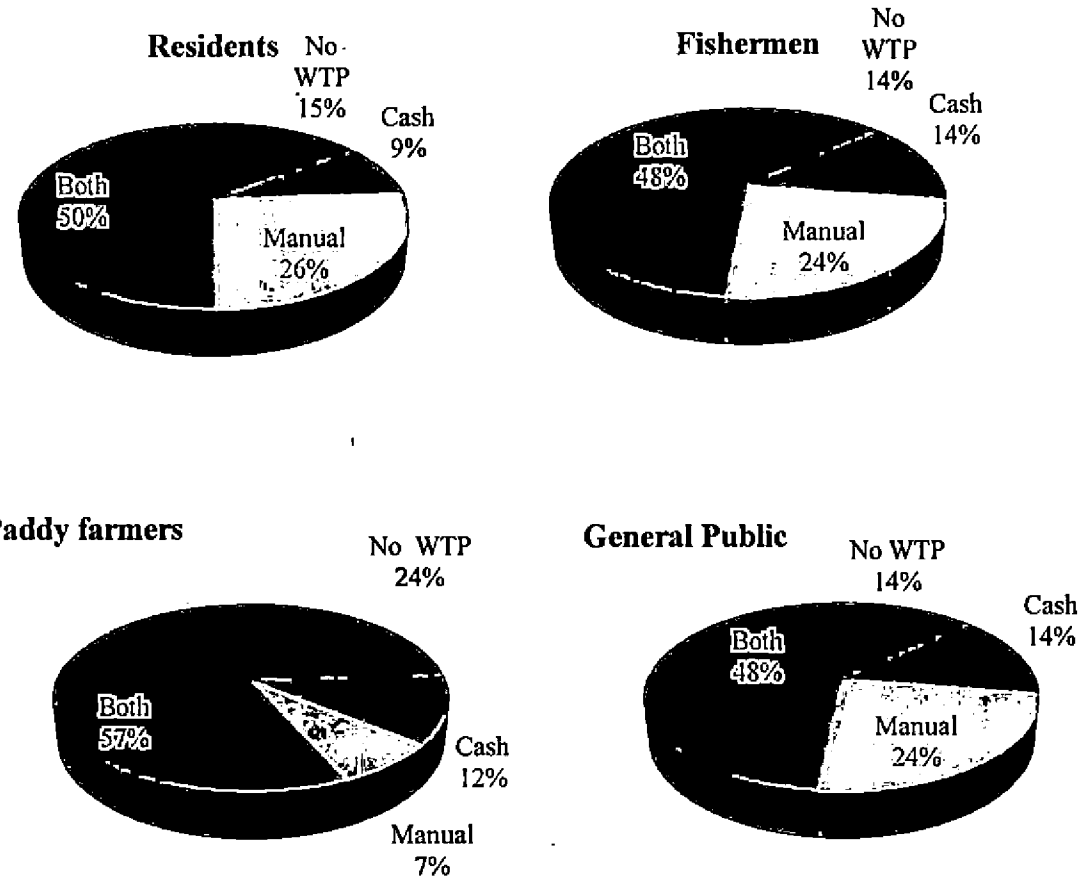
The valuation techniques are based, either directly or indirectly on the estimation of 'Willingness to Pay' (WTP) of individuals for ecosystem services (Costanza *et al.*, 1997). Willingness to pay is the amount of money a person is willing to part for any commodity/service. It is associated with the utility of that particular commodity/service.

Adopting the method as explained in the methodology section, the WTP for conservation of the mangroves was gathered from the respondents. The response of the stakeholders is furnished in Fig. 4.8. The respondents expressed their willingness to contribute towards conservation both in cash and kind (cash payment and manual participation as labour and as volunteer in awareness programmes) and in combination.

On an average 50 per cent of the stakeholders expressed their willingness to contribute towards conservation efforts. About 15 per cent of residents, fishermen and general public and one fourth of the paddy farmers were not willing to contribute, either cash or kind. This may be due to the situation of competition between paddy cultivation and prevailing mangroves in certain areas like Ezhome and Chengal (Kannur). Some of these respondents opined that it was the responsibility of the government to conserve the natural ecosystems. Few among the general public observed that those deriving direct benefits from the mangroves are to be taxed rather

than the population at large. The poor economic status may also be a reason that restricts their willingness to pay.

Fig. 4.8: Pattern of WTP



On an average less than 15 per cent of the stakeholders were willing to contribute in cash. Among them, the proportion was lowest with residents, mainly because of the poor financial status. More than one fourth of the residents and nearly one fourth of the fishermen and general public were willing to contribute manually through offering labour for the planting/replanting measures and participating in awareness campaigns to increase the level of consciousness among the society towards mangrove conservation. The residents and fishermen were willing to offer labour for the replanting efforts and conservation of the existing mangrove stand. They were

ready to offer one day labour/month for the same. The respondents among the general public were more interested in participating in awareness drives. The group expressed their willingness to offer 4- 6 hours/month for the awareness campaigns for mangrove conservation. This disparity may be attributed to the level of educational attainment and the nature of occupation. Among the stakeholder groups, paddy farmers showed minimum interest to contribute manually. This may be primarily attributed to the age factor (majority of them were above 55 years of age) and the involvement in paddy cultivation which by itself is highly labour intensive. Nearly half of the respondents expressed their interest in combining cash and kind payments towards conservation.

The willingness to cash payment differed with respect to mode and pattern. The perusal of Table 4.51 revealed that the most of the residents, fishermen and paddy farmers opted for a onetime payment while the general public preferred payment in installments (81%). Irrespective of the stakeholder groups, majority opted for a five year installment. 68 per cent residents, 48 per cent fishermen, 43 per cent paddy farmers and 74 per cent general public were in this category. The respondents in the general public group were assured income earners, which perhaps explained the behaviour.

The willingness to pay is also influenced by the mode of payment. The respondents were given two options; one was the eco-tax, which is to be collected for the conservation and sustainable management of natural resource. Second option was the system of direct payment to a government organization set up for the conservation of mangroves. The preference to mode of payment among the stakeholder groups are presented in Table 4.52. Majority preferred direct cash payment. Large section (95-97%) of residents, fishermen and paddy farmers preferred direct cash payment. There was some difference in the case of general public category (73%).

The trust and confidence of people in parting their hard earned money for the conservation of natural resources is an important element in determining the WTP.

The notion of improper management in the government machinery hampers the people's willingness to pay. The respondents emphasized that there should be stringent norms to ensure the proper utilization of the funds for mangrove conservation programmes.

Table 4.51: Pattern of cash payment

Sl No.	Particulars	No. of respondents				
		Residents	Fishermen	Paddy farmers	General public	Average
1	Onetime payment	48 (69)	45 (59)	52 (63)	14 (19)	40 (53)
2	Installments	22 (31)	31 (41)	30 (37)	61 (81)	36 (47)
	Two years	4	7	4	3	5
	Three years	1	9	13	7	8
	Five years	15	15	9	45	20
	Ten years	2	-	4	6	3
Total		70 (100)	76 (100)	82 (100)	75 (100)	76 (100)

Figures in parentheses represent percentage to total

Table 4.52: Preferred mode of payment

Sl No.	Particulars	No. of respondents			
		Residents	Fishermen	Paddy farmers	General public
1	Cash	68 (97)	72 (95)	80 (98)	55 (73)
2	Eco tax	2 (3)	4 (5)	2 (2)	20 (27)
Total		70 (100)	76 (100)	82 (100)	75 (100)

Figures in parentheses represent percentage to total

The WTP expressed by each section of the respondent group for the conservation was calculated by converting the kind component to value terms in proportion to their monthly income. Further, in the case of payments in installments the present value was estimated through discounting. Thus, the estimated value in monetary terms is furnished in Table 4.53.a. to 4.53.d.

The average WTP among the residents was found to be ₹ 1640 (₹ 100– 8219). Residents (38%) expressed their willingness to provide ₹ 1,000–2,000/annum for the conservation measures of which, 85 per cent as manual labour. The number of man days varied from 3 to 15 days/annum. A section of the respondents in both Ernakulam and Kannur, especially residing at the embankment of canals and rivers are currently involved in mangrove conservation initiatives by planting mangroves along the boundary line of the household or along the coastal mud flats. The mangrove species *Bruguiera gymnorrhiza* (Ernakulam) and *Rhizophora mucronata* (Kannur) are commonly planted.

Similar to resident population, most of the fishermen were also willing to pay less than ₹ 2,000/annum. About 90 per cent of the WTP was expressed to be provided by the manual component. Fishermen were also willing to offer their labour for the restoration and conservation initiatives. A section of the respondents in Kannur, most of them, the shrimp farmers denied to contribute even though they occupy the highest income strata among the respondents. The maximum and minimum WTP was ₹ 5,544 and 100 with an average of ₹ 1,525/annum. The dependence on mangrove ecosystem, either direct or indirect is higher for both residents and fishermen compared to other stakeholder groups. However, the fishermen expressed their apprehension over their ability to participate during the day time owing to the peculiar nature and working hours of their livelihood activity i.e. fishing.

Among the four stakeholder groups, paddy farmers expressed their negative attitude towards the payment. The negative attitude among a section of the respondents in the group may be attributed to competitive relation prevailing in the paddy-mangrove ecosystem and relatively poor economic returns from paddy cultivation. The average WTP of the group was ₹ 979/annum. Even though mangroves are indirectly providing the nourishment to paddy, a few respondents were not convinced. They opined that conservation efforts are not required since natural rate of regeneration of mangroves is very high.

The maximum WTP was offered by the general public. About one third of the respondents were willing to pay above ₹ 6,000/annum, maximum being ₹ 28,615/annum with minimum of ₹ 50/annum. The higher value of WTP of the group was primarily on account of the higher income/salaried class in the public and private sector. Contrary to the other stakeholders, majority of the respondents who were ready to pay, were willing to contribute their time and energy for the awareness campaigns and similar conservation efforts. Very small percentage in this group was willing to contribute physical labour for the restoration activities.

Table 4.53.a: Details of WTP of the residents

Sl No.	Payment (₹/household/year)	No. of respondents	% of payment		Man days/annum
			Cash	Manual	
1	< 1000	27 (26)	28	72	3
2	1000 – 2000	39 (38)	15	85	6
3	2000 – 3000	15 (15)	10	90	8
4	3000 – 4000	13 (13)	3	97	12
5	4000 – 5000	3 (3)	2	98	13
6	5000 – 6000	2 (2)	77	23	5
7	> 6000	3(3)	12	88	15
Total		102 (100)			
Average	1640				

Table 4.53.b: Details of WTP of the fishermen

Sl No.	Payment (₹/household/year)	No. of respondents	% of payment		Man days/annum
			Cash	Manual	
1	< 1000	46 (38)	22	78	2
2	1000 – 2000	33 (28)	7	93	7
3	2000 – 3000	28 (23)	6	94	8
4	3000 – 4000	8 (6)	6	94	9
5	4000 – 5000	3 (3)	2	98	12
6	5000 – 6000	2 (2)	1	99	14
Total		100 (100)			
Average	1525				

Table 4.53.c: Details of WTP of the paddy farmers

Sl No.	Payment (₹/household/year)	No. of respondents	% of payment		Man days/annum
			Cash	Kind	
1	< 1000	39 (43)	24	76	3
2	1000 – 2000	37 (41)	21	79	5
3	2000 – 3000	10 (11)	3	97	7
4	3000 – 4000	3(3)	36	64	6
5	4000 – 5000	2 (2)	30	70	8
Total		91 (100)			
Average	979				

Table 4.53.d: Details of WTP of the general public

Sl No.	Payment (₹/household/year)	No. of respondents	% of payment		Man days/annum
			Cash	Manual	
1	< 1000	14 (13)	85	15	1
2	1000 – 2000	21 (20)	26	74	5
3	2000 – 3000	11 (11)	26	74	4
4	3000 – 4000	8 (8)	25	75	9
5	4000 – 5000	9 (9)	51	49	3
6	5000 – 6000	7 (7)	23	77	9
7	> 6000	34 (32)	23	77	9
Total		104 (100)			
Average	5086				

Figures in parentheses represent percentage to total

The WTP for conservation efforts are influenced by various social, economic and personal factors. Going by various studies in this aspect (Hadker *et al.*, 1997; Gupta and Mythily, 2007; Ekka and Pandit, 2012; Sathya and Sekar, 2012; Venkatachalam and Narayanamoorthy, 2012), and researcher's observation, the WTP was estimated, regressing the same with a set of variables. Various functional forms were tried and the one which was statistically best among the alternatives was chosen for discussion. The results are furnished in Table 4.54.a to 4.54.d. The explanatory power of regression equations fitted was rather modest.

Semi-log multiple regression form was found to be the best fit in the case of residents. The education level (years of schooling) was positively related to WTP of the residents and was found to be statistically significant at 10 per cent level. Higher education provides better awareness about the necessity of the mangrove conservation for their well-being. Better education may also facilitate better jobs and higher income. The awareness index, that reflected the level of awareness on

importance of mangroves, was also found to be having a positive influence at 1 per cent level. This stakeholder group often possesses mangrove ownership and experiences the direct ecological benefits (storm protection, reduction in soil and embankment erosion). The benefits received through direct and indirect goods and services provided by the mangroves thus influenced the WTP positively. The result highlights the importance of organizing awareness programmes in mangrove rich areas.

The model fitted for the fishermen group was better in the explanatory power. Education, income from fisheries and total holding size of the respondents are the major determinants of WTP. It was found that education and income from mangroves are significant and positively related to WTP. The fishermen with higher years of schooling are willing to pay more than their counterparts. The average years of schooling for the fishermen were 8 years. Hence it can be concluded that higher educational levels enhance the understanding in conservation and can positively influence the WTP. Among the respondent fishermen nearly 90 per cent have only single source of income i.e. income derived from mangrove dependent activities, and they are resource poor. Hence, the importance of mangrove conservation and the economic value attached to mangroves by fishermen are highly influenced by their income from the major livelihood activity. The studies by Hadker *et al.* (1997), Binilkumar (2010) and Ekka and Pandit (2012) also have reported similar results.

The holding size of the respondents exhibited significant negative influence. The average holding size of fishermen was less than 0.05 ha. The fishermen with larger holding size would be economically well off and hence their dependence on mangroves may be rather low. It is implicit that fishermen with lesser area are more concerned about the mangrove conservation. They were more prone to the natural vagaries and were directly benefitted by the ecological services of mangroves. So the value they attach to the mangroves may be higher.

In the case of paddy farmers, apart from the three factors for fishermen, other household income was also found to be significantly influencing the value they attach on mangroves. Contrary to the general behaviour, educated farmers have shown lower willingness to pay for the conservation of the mangroves. The problem of succession of mangroves to the paddy fields has aggravated the constraints in paddy cultivation especially in Kaippad area. This may be one of the reasons for this behavior. However, the respondents' total income was found to be positively influencing the WTP.

The explanatory power of regression equation fitted for the general public category was 30 per cent. It was observed that age, educational level and awareness index had significant positive influence on WTP. Education, generally has expressed positive influence on valuation of mangroves except in the case of paddy farmers. Awareness index was an important attribute in the case of general public and the residents. Income from mangrove dependent activities exerted significant positive influence on WTP by fishermen and farmers. The results highlight the importance of awareness creation efforts in natural resource conservation. Further the importance of mangrove conservation ensuring the livelihood security of the marginalized section of the society like resource poor fishermen and paddy farmers is also understood.

Table 4.54.a: Estimation of willingness to pay for mangroves by residents

$lnY= a - b_1X_1+ b_2X_2- b_3X_3+ b_4X_4- b_5X_5+ b_6X_6+ b_7X_7$			
Variables	**Co-efficient**	**Standard error**	**t-ratio**
Constant (a)	0.879	0.740	1.188
Age (X_1)	-0.006	0.009	-0.670
Education (X_2)	0.052*	0.032	1.608
Holding size (X_3)	-0.292	0.218	-1.340
Income from mangrove dependent activity (X_4)	2.524E-6	0.001	0.870
Other income (X_5)	-5.516E-7	0.001	-0.368
Distance (X_6)	0.273	0.476	0.573
Awareness index (X_7)	0.049***	0.014	3.491
R^2	0.222		

Table 4.54.b: Estimation of willingness to pay for mangroves by fishermen

$lnY= -a + b_1 lnX_1+ b_2 lnX_2 - b_3 lnX3+ b_4 lnX_4- b_5 lnX_5- b_6 lnX_6+ b_7 lnX_7$			
Variables	**Co-efficient**	**Standard error**	**t-ratio**
Constant	-5.773	3.441	-1.678
Age (X_1)	0.072	1.050	0.069
Education (X_2)	1.312**	0.449	2.920
Holding size (X_3)	-2.358***	0.530	-4.448
Income from mangrove dependent activity (X_4)	1.440*	0.538	2.678
Other income (X_5)	-0.044	0.064	-0.696
Distance (X_6)	-1.039	0.794	-1.309
Awareness index (X_7)	0.466	0.634	0.735
R^2	0.431		

Table 4.54.c: Estimation of willingness to pay for mangroves by paddy farmers

$\ln Y = -a - b_1 \ln X_1 - b_2 \ln X_2 - b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 - b_6 \ln X_6 + b_7 \ln X_7$			
Variables	**Co-efficient**	**Standard error**	**t-ratio**
Constant	-6.304	5.997	-1.051
Age (X_1)	-2.060	1.592	-1.294
Education (X_2)	-0.700*	0.421	-1.664
Holding size (X_3)	-2.696***	0.799	-3.375
Income from mangrove dependent activity (X_4)	02.247**	0.971	2.211
Other income (X_5)	0.938*	0.547	1.716
Distance (X_6)	-1.888	1.215	-1.554
Awareness index (X_7)	0.126	0.922	0.137
R^2	0.217		

Table 4.54.d: Estimation of willingness to pay for mangroves by general public

$\ln Y = -a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 - b_6 X_6 + b_7 X_7$			
Variables	**Co-efficient**	**Standard error**	**t-ratio**
Constant	-9717.180	3100.912	-3.134
Age (X_1)	172.760***	39.431	4.381
Education (X_2)	266.372**	133.550	1.995
Holding size (X_3)	231.282	471.695	0.490
Income from mangrove dependent activity (X_4)	0.027	0.047	0.574
Other income (X_5)	0.001	0.002	0.141
Distance (X_6)	-642.001	434.695	-1.477
Awareness index (X_7)	115.727**	39.180	2.954
R^2	0.304		

*** 1 per cent level of significance, ** 5 per cent level of significance,* 10 per cent level of significance respectively

The aggregate value of mangrove ecosystem in the state was extrapolated from the WTP estimates and is presented in Table 4.55. The mean annual WTP of each stakeholder group was estimated and found that WTP varies between ₹ 28,820 and 50. Being the salaried class, general public expressed maximum WTP. The minimum was also expressed by them. One fourth of paddy farmers were not willing to pay, and the proportion was the highest among the four groups. The lowest average WTP was also expressed by the farmers.

The TEV (Total Economic Value) of the stakeholder groups were estimated based on the average annual WTP of the sample stakeholders and their respective population. The population of each category was obtained by assessing the proportion of population WTP in the respective category. The population of residents, fishermen and general public were calculated based on Census (GoI, 2011) and Ramesh *et al.* (2013). Farmer population was calculated based on per capita land availability of Pokkali/Kaippad area and the total area under cultivation.

TEV of each stakeholder group is the multiplicative value of average WTP and their respective population. Being the largest group, general public has highest TEV of ₹ 1,04,855 million and lowest being paddy farmers (₹ 13 million), the smallest group. Hence the TEV of the mangrove ecosystem of the state was ₹ 1,17,947 million and was 0.14 per cent of the GSDP. This highlights the economic importance of the ecosystem in our economy. The forests in the state currently account for only less than 1 per cent of GDP while taking into consideration the direct benefits. Even with very high pressure on land resources, the people of Kerala is attaching very high value to the ecosystem presumably owing to the high environmental awareness.

Table 4.55: Estimated TEV of the mangrove ecosystem

Sl No.	Stakeholder group	WTP (₹/household/year)			Proportion of population having WTP	Estimated value of TEV (₹ million)
		Maximum	Minimum	Average		
1	Residents	8219	100	1640	7770721 (85%)	12744
2	Fishermen	5544	100	1525	219816 (86%)	335
3	Paddy farmers	4642	100	979	13304 (76%)	13
4	General public	28870	50	5086	20616390 (86%)	104855
TEV						1,17,947

Figures in parentheses represent percentage of willingness for payment (cash/manual) expressed by each stakeholder group

4.5. Management of mangroves

One of the aims of any management option of natural resources is biodiversity conservation and enhancement (Sudtongkong and Webb, 2008). The Sunderbans mangrove was the first scientifically managed mangroves in the world (Kumar, 2000). In Kerala, an effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources. This section focuses on the available management alternatives and suggests the socially acceptable model employing scientific methods. An effective management plan to protect the biodiversity together with safeguarding the needs of mangrove dependent local communities is proposed.

Multinomial Logistic Regression model (MNL) was employed in solving the choice experiment exercise administered on the respondents. The MNL regression was fitted to choose the most favoured management option for mangrove ecosystem (Community management, public management, private management, public-private partnership and *status quo*).The response variable (management options) is a categorical variable with no natural ordering. The reference group was chosen as the *status quo* position.

The stakeholders' preferences of management alternatives are presented in the Table 4.56. The probability estimate of the model explained that the respondents preferred community management (41.6%) over public management (29.2%), *status quo* position (21.4%), public private management (6.8%) and private management (1%). Community management refers to a system where a locally derived formal governance structure has been developed to manage, protect, and use of the resources (Sudtongkong and Webb, 2008). This arrangement requires the active participation of existing local communities and would allow them to express their opinion and make decisions regarding the management plan and regulations related to the utilization of mangrove resources. The community management of the mangrove ecosystem provides opportunity for the local community to participate in management decision

process. Through this, local community became aware of the importance of the conservation of the mangrove ecosystem and prevents further degradation and participates in the awareness campaign and encourages their neighbours to participate in conservation drives. Hence community management provides a socially desirable mechanism to achieve the goal of mangrove ecosystem conservation.

Barbier (2006a, 2008) reported the efficient management of mangroves during post tsunami through the participation of local communities in Thailand. The study found that local communities exert effective control over the management and protection of their local mangrove forests. A study by Sudtongkong and Webb (2008) in Thailand pointed out that community management was the principal factor in protecting, managing, and conserving the mangrove ecosystem in a manner superior to conventional state management of protected areas. Anthropogenic interferences could be minimised by encouraging community participation in mangrove management (Biswas *et al.*, 2009). GEC (2011) and ITTO (2012) reported the success of community based mangrove restoration activities in Gujarat and Philippines respectively. The choice of community management among the five alternatives given by the stakeholders was similar to the people perception for the same in the Kadalundi-Vallikkunnu Mangrove Community Reserve (Hema and Devi, 2012).

Same was the case with the management of Mantang mangrove wetlands (Othman *et al.*, 2004) where, the respondents preferred the management option with more area devoted to environmental forest, more employment and more migratory bird species. However the community management of mangrove ecosystem will be successful only when more local dependence on mangroves, collective action and mutual agreement on regional and political arena are favourable (Sudtongkong and Webb, 2008).

Public management of mangrove was envisaged as a system where the ownership and management as under the government, like in the case of forests. Public management was preferred by 29.2 per cent of the resondents', who mainly belonged to the general

public category. They had opined that it was the duty of the state to conserve and manage the natural resources to ensure the welfare of the people. The existing system was the preferred choice for 21.4 per cent. The privately owned mangroves are to be managed by the owners and the mangroves under the ownership of public management institutions are to be managed by the respective organisation. The existing rules and regulations (CRZ-1) in this regard are to be strictly implemented. But some studies report the limited success rate in the public management. Public management of mangrove without the participation of local people would result in decline of the natural resources (Ganjanapan, 2003). A study by FAO, observed that public mangrove management had resulted in a decline in global mangrove area from 372,448 has in 1960 to between 167,500 and 244,000 has in late 1990's (Wilkie and Fortuna, 2003).

The public-private partnership (PPP) model of management was suggested as a choice by only 6.8 per cent and complete private management by only 1 per cent. The possibility of meeting the conservation objectives of mangroves under these management options were doubted by the respondents.

The probability of chance of choosing the community management is influenced by the expected outcome of some attributes like mangrove area equivalent, fish resources, ecological services and WTP. The results of the MNL estimated to capture the influence is furnished in the Table 4.57. The choice probability is significantly and positively influenced by mangrove area and ecological service. The coefficient of mangrove area (3.5) implies that the choice probability of community management option will increase by 3.5 per cent for each ha of incremental mangrove area compared to that of the status quo option. Similar is the case with ecological services. People, who expected higher levels of ecological service, stand a higher probability of preferring community management. The coefficient for WTP variable is negative and statistically significant, i.e as the payment for mangrove conservation increases, the choice probability of that particular management option will reduce. This implies

that the people have to incur expenses towards management, the chances of their participation become limited.

Table 4.56: Relative preference of management alternatives

Sl No.	Management alternatives	% of preferences by the stakeholders
1	Community management	41.6
2	Public management	29.2
3	*Status-quo*	21.4
4	Public private management	6.8
5	Private management	1.0
Total		100.0

Table 4.57: Parameter estimates of discrete choice for the management of mangrove ecosystem

Attribute	Coefficient	Std. Error	t	*p*-value
Mangrove area equivalent	3.497**	0.947	3.694	0.002
Fish resources	0.332	0.209	1.580	0.114
Ecological services	0.338***	0.046	7.298	0.001
WTP	-4.398*	1.609	-2.734	0.006
Log-Likelihood	-2045.081			
Chi square	383.430			

***Significant at 1 per cent level, ** significant at 5 percent level and * significant at 10 percent level

A matrix of direct and cross price elasticity estimates for the mangrove management alternatives derived from the probability weighted individual effects of multi-nomial

logistic model is presented in the Table 4.58. The elasticity measures the extent to which the choice probabilities vary in response to a unit change in price. The direct elasticity estimate of community management implies that one percent increase in WTP for community management option will reduce the probability of choosing community management by 0.18 per cent. At the same time this scenario induces people to shift to other three alternatives (public management, private management and public-private) where in an equal 0.13 per cent is observed. The price sensitivity (both direct and cross price elasticity) of public management, private management and public-private management are found low compared to that of community management. The result thus underlines the importance of public financial support for the management of mangroves.

Table 4.58: Direct and cross elasticity estimates of price in different management options

Choice	Community management	Public management	Private management	Public-private management
Community management	-0.1883	0.0114	0.0003	0.0068
Public management	0.1346	-0.0425	0.0003	0.0063
Private management	0.1297	0.0130	-0.0424	0.0066
Public-private management	0.1320	0.0130	0.0003	-0.0344

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

Mangroves are invaluable treasure of our biodiversity with immense ecological and economical significance. But, the ecosystem was often considered as economically unproductive. This situation has resulted in taking most of the policy decisions in favour of other sectors, leading to the destruction and depletion of the natural mangrove ecosystems. Realistic estimation of the economic value of the system supports the scientific decision making when confronted with problem of conservation versus development. No scientific publications are seen in this aspect from Kerala, dealing with mangrove resources. This study on 'Economic valuation of mangrove ecosystems in Kerala' was undertaken in this background.

The study identified the stakeholders of mangrove ecosystems of Kerala and quantified the level of dependence of local communities for their livelihood and estimated the aggregate demand for products and services. Further, it identified and quantified the relative influence of socioeconomic, institutional, climatic and anthropogenic forces on the destruction of mangroves and finally assessed the Total Economic Value (TEV) of mangrove system and suggested policy prescriptions for the conservation and management of mangroves in Kerala.

The study was conducted in the mangrove areas of Ernakulam and Kannur districts of Kerala. These two districts accounted for nearly 65 per cent of the mangroves of the state. The study was based on primary and secondary data. The primary data was gathered from 480 respondents belonging to four identified stakeholder groups (residents, fishermen, paddy farmers and general public), selected through simple random sampling method. Data was collected through personal interview using structured pretested interview schedule along with direct observation. The major tools of data analysis were Contingent Valuation Method (CVM) and Choice experiment (CE).

The status and distribution of mangroves of the world was analysed by compiling the secondary data from various sources. A slowdown has occurred in the rate of mangrove depletion in the world from 18.8 M ha in the 1980 to 16.9 M ha in 1990 and later to 15.2 M ha during 2010. The rate of decline has slowed down from 1.04 to 0.32 per cent over the three decades. A significant reduction in the scale of destruction of mangroves occurred in South America with impressive growth rate of 1.81 per cent per year during the period 2000-10. The pattern was found to be similar in Asian region too. North and Central American region was also showing improving situation, even though the rate of decline continued. An impressive growth rate in area (2.86 %) has taken place in African countries during 1990- 2000 compared to the previous decade (-4.05%). But they lost the momentum in the next decade and ended up with negative growth rate of 1.40 per cent in 2000-2010. Oceania, however exhibits increase in rate of mangrove destruction. The recent rate of decline has reached a level of 2.33 per cent per annum.

Asia accommodates the largest mangrove area of the world with 5.79 M ha (42 per cent) followed by Africa (20%). India with 4.66 lakh ha occupies fifth position in mangrove area among the Asian countries. About 52 per cent of the total Indian mangroves are located along the east coast of the country, primarily in West Bengal and Orissa. The rest is distributed along west coast (34%) and the Andaman & Nicobar Islands (14%). Mangroves of Kerala constitute less than 1 per cent of the total mangroves in the country. However, very high species diversity is reported in the mangrove ecosystem of the state. They are seen as narrow strips confined to the mud flats of delta, on the leeward faces of estuaries and also the embankments of the coast, mainly in Kannur and Ernakulam districts. There are contradictory reports on the status of mangrove area in Kerala, mostly based on personal judgments. The recent scientific estimates are not seen reported.

The major stakeholder groups of mangrove ecosystem in the study area were identified as residents living close to mangroves, fishermen, paddy farmers and

general public. The residents were people living within 1 km radius of mangrove wetland with an average landholding of 0.1 ha. The mangroves were often one or more of the homestead boundaries with an area equivalent to 0.07 ha. The average age of the group members was 48 years with eight years of schooling. The average family size was five and males outnumbered females. The average annual income per household was ₹ 1.66 lakhs possessing assets worth ₹ 22 lakhs. The residents were depending on the mangroves for extraction of fuelwood, fodder and poles. On an average the level of extraction was 307kg of fuel wood, 1024kg of fodder and 14(no.) of poles/year valued at ₹ 4628/household. This amounted to 3 per cent of their annual household income. This stakeholder group has attributed more importance to indirect benefits of mangroves i.e. ecological service (storm protection, reduction of soil and embankment erosion).

Fishermen comprised of inland fishermen who include those fishing in inland water, women engaged in hand picking (*Thappal*), clam collectors and those engaged in shell mining. The respondents were in the age group between 18 to 65 years and majority has only primary education. The average family size was four and males outnumber females. The average landholding size was less than 0.04 ha and the average annual household income was ₹ 1.16 lakhs. The respondent fishermen were residing within 2 km from the mangrove wetlands and were using country canoes for fishing.

Scientific studies elsewhere have established the direct association of mangroves and fisheries. The respondents of the study area perceive a complementary association between mangroves and species like *Etroplus*, shrimp, crab and *Tilapia*. But there were differences in the perception of respondents. The changing scenario of mangrove ecosystem often causes hindrance to the fishing activity which caused a damage cost to them.

The major species of fish catch by the fishermen were *Etroplus*, shrimp, crab and *Tilapia* which was quantified at 9354 kg/ year valued at ₹ 1,50,165. The women who

were in this livelihood activity could extract mainly *Etroplus,* shrimps and *Ambassus* sp. Shell mining which was found to be a major economic activity in Kannur region could generate an income of ₹ 30,000 per annum through the extraction and sale of 7500 kg of shells. Clam collected was quantified at 225 kg/year valued at ₹ 5625. Thus, the average gross income from these activities was estimated at ₹ 1,85,790. Hence almost entire household income of this group was realized through the fishing activity.

About 8 per cent of the fishermen are involved in shrimp farming and are mainly from Kannur district. All of them are owner cum operators and have above 10–15 years of experience in shrimp farming. The size of the farm varies from 0.4 to 2 ha. The input cost/ha is ₹ 2.8 lakhs which includes cost of seed, feed, lime and water management. Labour cost is estimated at ₹ 77,000. Hence total cost and returns of shrimp farming per hectare is ₹ 3.27 and 4.75 lakhs respectively with net income of ₹ 1.48 lakhs.

Pokkali and Kaippad agricultural systems are proved to be closely interconnected with the mangrove ecosystem. Compared to other three stakeholders, average age of the paddy farmers was higher (57 years) and majority has only primary education. The average annual household income was ₹ 1.74 lakhs. The average farm size in Kaippad was 2.2 times that of Pokkali. Majority of them were engaged in farming for the previous 20 years. The average cost of cultivation (A_1) per hectare of Pokkali was ₹ 47,535 and that of Kaippad was ₹ 37,652. About 82 per cent of the total cost was incurred as labour cost. The average yield/ha was 3530 kg in Pokkali and 2408 kg in Kaippad and with a gross return of ₹ 60,007 and ₹ 40,935, respectively. This amounted to average 30 per cent of their household income.

The stakeholder group, general public comprises of people who resided away from the wetlands and did not have direct dependence on the mangrove ecosystem for livelihood. The group included scientists, researchers, teachers, private sector employees, students, lawyers and people engaged in other occupations, and

represented the society in general. The average age of the group members was 42 years. The respondents comprised largely of educated people, graduates to professionals. The average land holding size was 0.04 ha. This stakeholder group has the highest annual family income among the four groups. The awareness about mangroves by the group was mainly that gathered through mass media. Majority of respondents have made deliberate efforts to visit the location during conservation-development controversies involving destruction of mangroves.

The respondents' perception on the pattern of change and the major factors that effected the change in mangrove ecosystem was studied based on their responses. 46 per cent of the respondents were of the opinion that the mangrove ecosystem has declined over years and are facing threat. The major factors responsible for the same were reported as anthropogenic, climatic forces and status of property rights. The developmental interventions like LNG Petronet Terminal, Puthuvypeen and ICTT Vallarpadam have resulted in large scale conversion of mangrove areas. An average 48 per cent of the respondents were of this view. The contradictory forces of development and conservation lead to destruction of mangrove ecosystem. One fifth of the respondents opined that climatic factors were responsible for the decline. Nearly 85 per cent of the mangroves in the state were reported to be under private ownership and rest under public. The property right status along with economic status influences the rate of depletion. The legal interventions and community and institutional efforts also influence the status of mangroves, most often positively.

The economic valuation of ecological benefits of mangroves was attempted employing the Contingent Valuation Method. The respondents expressed their willingness to contribute towards conservation both in cash and kind (cash payment and manual participation as labour and as volunteer in awareness programmes) and in combination. Three fourth of the respondents were willing to contribute and the rest included those who expressed negative attitude towards mangroves and the group which believed that it was the state's responsibility to conserve the natural ecosystems.

Onetime payment was the preferred option for the payment and was mostly in the form of direct cash payment.

The average WTP expressed by the respondents was ₹ 2,308 the range being ₹ 50 – 28,870. The Total Economic Value (TEV) was estimated from this, based on the proportion of stakeholder group who were willing to pay and their total population in the state. The estimated TEV was ₹ 12,744 million (residents), ₹ 335 million (fishermen), ₹ 13 million (paddy farmers) and ₹ 1,04,855 million (general public). The TEV of the mangrove ecosystem of the state was thus ₹ 1,17,947 million, which was 0.14 per cent of the GSDP (2011-12). Educated people generally expressed their WTP, as evidenced by the positive value of the coefficient in the case of three stakeholder groups. Awareness index was an important factor in the case of general public and the residents which influenced the WTP. Income from mangrove dependent activities exerted significant positive influence on WTP by fishermen and farmers. The results highlight the importance of awareness creation efforts in natural resource conservation as well as the importance attached by the direct dependent population.

In Kerala, an effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources and conflicting interests. A socially preferred management plan was identified among a set of alternatives, employing the choice experiment method. Among the management options given, the stakeholders preferred community management (41.6%) followed by public management (29.2%) and *status quo* (21.4%). The community management of the mangrove ecosystem provides opportunity for the local community to participate in management decision process. At the same time, the importance of public funding for such activities is revealed in the analysis.

Policy suggestions and future line of work

1. Scientific attempts on realistic area estimation and mapping of the mangrove resources in the state are to be initiated.
2. There should be attempts to identify and classify the species and document the traditional wisdom associated with them. The scientific validation of the same may also be undertaken.
3. Even with high level of urbanization, there are local communities (including women) who depend on mangroves for direct benefits for their livelihood (residents, fishermen). The stakeholders who live closest to the mangrove ecosystem attribute more importance to the ecological benefits. Hence, their role in conservation efforts should be appropriately utilized.
4. The Pokkali and Kaippad rice farming systems are also supported by the mangrove system. However, there seems to be differing perceptions regarding the extent of association. There should be region specific studies to establish and quantify the extent of association between mangrove ecosystem and the livelihood activities. Based on that, the level of mangrove cover for each area can be scientifically determined. This forms the first step in conservation programmes. It was reported that *Bruguiera cylindrica* is very slow growing mangrove species and hence can be recommended in areas where constrained complimentary relationship between mangroves and paddy exists. However, indepth study in this regard is needed to validate the same.
5. The monetary value attached to the mangrove ecosystem signifies the economic importance and can justify the resource allocation for the conservation efforts.
6. The community management system can be implemented as the institutional form for mangrove management. Efforts should be in place for awareness creation programmes. There should be public funding for the conservation efforts.

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APPENDIX

APPENDIX- I

KERALA AGRICULTURAL UNIVERSITY (KAU)
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ECONOMIC VALUATION OF MANGROVE ECOSYSTEMS IN KERALA

Survey Questionnaire

This study is conducted as a part of Ph.D programme by Hema, M. in the Department of Agricultural Economics. The information gathered will be used only for the research work.

The questionnaire will be divided in to three sections.

I. To gather information on the general socioeconomic background of the respondents.
II. To assess the level of dependence of each stakeholder group on mangrove system (separately prepared for each group)
III. To measure the level of awareness, attitude and quantify the WTP of the respondents in each group.

Part I

Code:

1. Name & Address of the respondent :

   Contact No.
2. Family details:

Sl No.	Family members *	Sex	Age(Yrs)	Education(Yrs of schooling)	Main Occupation**

*1-Self, 2-Spouse of head, 3-Married child, 4-Spouse of married child, 5-Unmarried child, 6-Grand child, 7- Father- in-law, 8- Mother-in-law, 9- others (Specify)

**1-Agriculture, 2- Fisherman, 3 –Wage labour, 4- Private employee, 5- Govt. employee, 6- Business, 7- House wife, 8-Pensioner, 9- Student, 10- Others

3. Land holdings(Acres)

Sl No.	Particulars	Wetland	Garden land	Mangrove area	Residing in fragment Y=1 N=0
1	Area owned: Fragments				
	1				
	2				
	3				
2	Area leased in				
	1				
	2				
	3				

4. Family Income (Include subsidiary occupation also)

Family members	Occupation	Income (₹)	
		Monthly	Annual

5. Family asset position

Sl No.	Type	Particulars	Present market value (₹)
1	Land		
2	Buildings		
3	Durables		
	Vehicles		
	Machinery		
	Farm animals		
4	Others		

Part II-Stakeholder dependence on mangroves

Residents

1. Distance of your residence from the mangrove area (km):

2. Are you getting any benefit from mangrove area?

3. Ranking of goods/services provided by mangroves

Goods/services	Importance				
	Highly relevant	Moderately relevant	Less relevant	No decision	Not relevant
Fuel wood					
Fodder					
Fisheries					
Medicine					
Shoreline protection					
Sedimentation and nutrient retention					
Ground water recharge					
Act against high tide					
Recreation and tourism					
Education and scientific value					
Biodiversity conservation					

4. Collection of fuelwood, fodder and other products

Sl No,	Particulars		Number/Qty			
			Fuelwood	Fodder		
1	Plant part					
2	Period of availability a. Peak season b. Lean season					
3	No. of days of collection/ year	Peak season				
		Lean season				
4	No. of hours of collection/ day	Peak season				
		Lean season				
5	Quantity collected/ day(kg)	Peak season				
		Lean season				

6	Distance travelled for collection	Peak season				
		Lean season				
7	Method of collection	Individual collection				
		Group collection				
8	Marketing					

5. Are you experiencing any difficulties/ problems due to the presence of mangroves near your residence? Yes/ No

5a. If yes, Please list down

6. In your opinion whether the mangroves should be conserved or not? Yes/No

6a. If no, why?

7. Are you willing to move out of your current place of residence due to any alternate developmental activities in the area? Yes/ No

7a. If yes, is there any conditions?

Sl No.	Particulars	Responses
1	Against appropriate compensation	
2	Proper rehabilitation is needed	
3	Alternate employment option	
4	Others if any (specify)	

7b. If no, why is it so?

Sl No.	Particulars	Responses
1	I am getting more satisfaction in living here as we are inhabiting in this area from many generations	
2	Doing what I do at this place is more important to me than doing it in any other place	
3	I am getting good amount of earning in terms of employment from this area	

Part II-Stakeholder dependence on mangroves

Fisher men

1. Distance of mangrove area from your place of residence (km)

2. Fishing activity

Period	Hours/day	Days/week	Average catch/day	Major species	Species associated with mangroves
Jan-March					
April-June					
July-Sept					
Oct-Dec					

3. Fish catch and income

Species	Whether associated with mangroves or not	Season	Catch/day	Market price (₹) (Range)

4. Cost of fishing

a. Capital investment in fishing

Sl No.	Items	Nos.	Year of purchase	Current market value (₹)
1	Boat			
2	Net			
3	Others			

b. Variable expenses

Particulars	No.		Wages (₹)
	Owned	Hired	
Labour			
Materials 1.			
2.			
Marketing cost			

5. Any other member in the family engaged in fishing? Yes /No

5a. If yes, please explain

Activity	Quantity	Value (₹)

6. Details of income

Particulars	Income (₹)
Fishing in mangrove areas/month	
Other activities/month	
Total income/month	

7. Are you getting any assistance from institutional sources for fishing activities? If yes, give details.

Part II-Stakeholder dependence on mangroves

Rice farmers (Kaippad/Pokkali)

1. How long have you been doing rice farming?

Less than 5 years
5-10 yrs
10-20 yrs

2. How many crops are you raising annually? 1 / 2 / 3

3. Details of the land under study

Sl No.	Season	Area(ha)	Variety
1			
2			
3			

4. Labour use pattern per crop

Sl No.	Particulars	Family labour		Hired labour		Prevailing wage rate/hrs of work (₹)		
		Men	Woman	Men	Woman	Hours of work	Men	Woman
1	Pre sowing operations							
2	Sowing							
3	Intercultural operations							
4	Harvesting							
5	Post harvest operations							
	Total							

5. Whether your family members are participating in farming activities? Yes/No

6. Details of input use

Sl No.	Input used	Quantiy applied	Rate (₹)	Subsidies		Transportation cost (₹)	Other expenses if any (₹)
				Rate/unit	Total amount (₹)		
	Seeds						
	Manures						
	Fertilizers						
	Pesticides						
	Soil ameliorants						

7. Details of yield obtained

Yield	Qty(qtl)	Personal consumption(qtl)	Quantity marketed		Total returns (₹)
			Qty (qtl)	Rate (₹)	

8. Cost of marketing

Particulars	Value (₹)
Rice	
By products	
Total cost	

9. Distance of your farm land from mangrove area (km)

10. In your opinion are you getting any benefits out of mangroves for your rice farming? Yes/No

10a. If yes, please rank the benefits

Sl No.	Benefits	Rank
1	Nutrient deposition	
2	Prevents salt water intrusion	
3	Green leaf manures	
4	Reduced pest & disease attack	
5	Any other please specify	

11. Compared to other conventional rice farming area are you using less quantity of manures in cultivation? Yes/ No

11a. If yes, is it due to mangroves? Yes/No

11b. If yes, how much reduction in manure quantity?

11c. What are the reasons for the less use of manures?

Sl No.	Particulars	Responses
1	Particular nature of Pokkali/Kaipad land	
2	Presence of mangrove trees near the field	
3	Residues of aquaculture provides sufficient manures	

12. Are you experiencing salt water intrusion in your paddy fields? Yes/No

13. What are the common mangrove species seen around your rice field?

14. Are you practicing fish culture after rice harvest, yes/ no.

14a. If yes, details

Sl No.	Species	Catch/season	Average price (₹)	Annual income (₹)
1				
2				
3				
4				
5				
6				

15. Cost of fish culture

Sl No.	Particulars	₹
1	Input cost	
2	Labour charges	
3	Harvesting charges	
4	Marketing charges	
5	Total cost	

Part II-Stakeholder dependence on mangroves

General public

1. Have you heard of mangroves? Yes/ No
If yes, in what context?

a.

b.

c.

2. Do you know whether mangroves exist in Kerala? Yes/ No

2a. If yes, do you have any idea on the places where mangroves are there in Kerala

3. Distance to nearest mangrove area from your residence (km) :

4. Have you ever visited a mangrove area? Yes/ No

4a. If yes, 1- Frequently, 2- Occasionally, 3- Very rarely

Name the place	Purpose of visit	Times/year of visit

5. The expenditure incurred for visiting the place

Name of place	Purpose	Cost(₹)			
		Travel	Food	Stay	Others

6. Do you think that it is of any relevance/importance/use to you? Yes/No If no, go to Q.8, if yes continue with Q.7

7. What are the perceived benefits from mangrove systems?

Sl No.	Particulars	Rank
1	No benefits	
2	Fish source	
3	Storm protection	
4	Shoreline protection	
5	Protection from natural calamity	
6	Bird's resting place	
7	No idea	
8	Any others(please specify)	

8. If answer to Ques.6 is No, do you think that mangroves in any way cause any harm/difficulties? If yes, give details

a.

b.

c.

9. Do you think that the mangroves are to be conserved/?Yes/ No

10. In your opinion, what is the status of mangroves in Kerala?
1-Depleting, 2- No change, 3- Improving

11. What are the suggestions for the conservation and management of mangroves?

Sl No.	Suggestions	Are you willing to participate in this? Yes=1, No=0	If yes, state how?
1			
2			
3			
4			

Part III
Knowledge level, awareness and attitude of stakeholders towards mangrove ecosystem management

I Knowledge level

1. Ranking of goods and services provided by mangroves

Sl No.	Goods/Services	SA	A	N	D	SD
1	Carbon sequestration					
2	Shoreline protection					
3	Combating climate change					
4	Roosting place for birds					
5	Protection from Tsunami waves/cyclones					
6	Reducing soil erosion					
7	Protecting coast from UV-B radiation					
8	Protection against sea level rise					
9	Nutrient sink					
10	Fish wealth					
11	Sources of food					
12	Sources of fodder					
13	Sources of fuel wood					
14	Sources of medicinal uses					
15	Sources of honey					
16	Sources of tannin					
17	Sources of materials for thatching roofs, mats & baskets					

SA-Strongly agree, A-Agree, N-Neutral, D-Disagree and SD- Strongly disagree

2. What are the effects of human interactions on the mangroves?

Sl No.	Particulars	Reasons
1	Destruction of mangrove areas	Developmental activities
		Tourism
		Collection of fuel wood/other materials
2	*Status quo* position	
3	Improves the status	Restoration activities
		Area expansion
		People recognize the importance of mangroves

3. Are you doing any measures to conserve the mangroves? Yes/No

3a. If yes, please give details

4. Is there any climatic impact on mangroves over the years? Yes/No

4a. If yes, please explain

II Awareness questions

1. In your opinion why mangroves are so significant?
1- Fisheries and allied production, 2- Ecological value, 3- Other uses (Please specify)

2 In your opinion, what is the current status of mangroves in Kerala?
1-Depleting, 2- No change, 3- Improving

2a. If the answer is 3, what are the possible reasons?

Sl No.	Particulars	Rank
1	Policy change towards conservation (Govt. initiative)	
2	People's participation due to better awareness	
3	Any other reasons (please specify)	

3. Is there any destruction in mangroves in your area. Yes/ No.

3a. If yes, what are the reasons?

Sl No.	Particulars	Rank
1	Climate change	
2	Destruction of mangroves for alternate uses	
3	Large scale exploitation of mangrove trees for fuelwood and fodder	
4	Cutting of mangroves trees for promoting tourism	

4. Suppose if the mangroves are completely destroyed, do you think that it will affect you? Yes/No

4a. If yes, state how?

5. Are you interested in better conservation and management of mangroves in your area?
1- Very much interested, 2- Moderately interested, 3- Not interested

5a. If you are interested, how do you proceed?

Sl No.	Particulars	Rank
1	Undertake planting	
2	Conserve existing area	
3	Try to give awareness to others about importance of mangroves	
4	Others (please specify)	

III. Willingness to Pay (WTP) for the conservation of mangrove areas

Mangroves are vital components in coastal area, doing numerous ecological functions like shoreline protection, preventing salt water intrusion, breeding ground for fishes and crustaceans, act as coastal bio shield. Even though mangrove provides many tangible and intangible benefits it is generally considered as unproductive. This, along with developmental pressures have resulted in wide spread decline in coverage and quality of mangroves in Kerala. The situation warrants urgent intervention for conservation of existing mangrove wealth.

1. Suppose the government makes a request for a voluntary contribution from all the citizens for the better conservation and management of mangroves with the assurance that the fund will be properly utilized for the same, are you willing to contribute for the same? Yes/ No

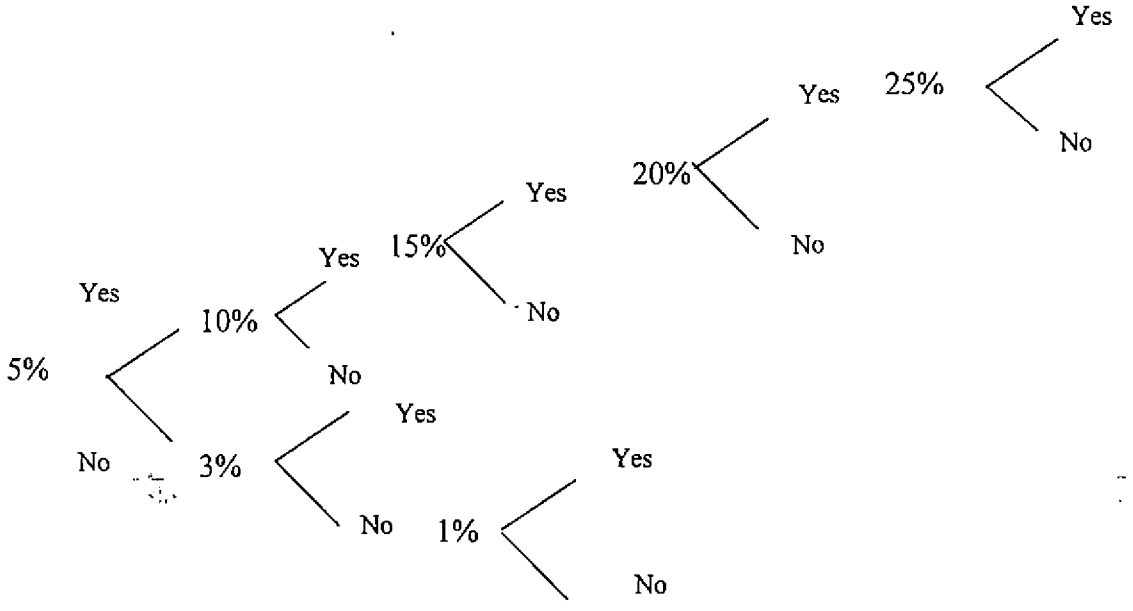
1a. If yes, would you like to effect payment

a. one time
b. Installments

1b. If installments

a. Regular payments for 2 years
b. Regular payments for 3 years
c. Regular payments for 5 years
d. Regular payments for 10 years

2. What is the maximum amount you are willing to pay (% of monthly income)



2a. If you are not willing to pay 1 % of your monthly income, what is your maximum willingness to pay?

3. Reasons for willing to pay

Sl No.	Particulars	SA	A	N	D	SD
1	I think conservation of mangroves is good for me and the society					
2	I feel it is my moral duty to conserve mangroves for future generation					
3	I feel this is a reasonable amount I can afford to pay					
4	I am concerned about the degradation of mangroves					

SA-Strongly agree, A-Agree, N-Neutral, D-Disagree and SD- Strongly disagree

4. Reasons for not willing to pay

Sl No.	Particulars	SA	A	N	D	SD
1	Additional income is not there to spare for mangroves					
2	Don't think that mangroves are to be conserved					
3	It is the government's responsibility to conserve the mangroves					
4	Citizens are not concerned about conservation activities					
5	Those who are using mangroves should pay					
6	Others if any (Please specify)					

SA-Strongly agree, A-Agree, N-Neutral, D-Disagree and SD- Strongly disagree

5. What is your preferred method of payment?
1- Direct payment, 2- Indirect tax

6. Are you willing to contribute in conservation efforts in any other way?
Yes/ No

6a. If yes,

Sl No.	Particulars	No. of days/month
1	Contribution as labour	
2	Participation in conservation and management activities	
3	Any other (please specify)	

IV Management options

1. Given the above conditions and contexts, which management options would you chose.

1.a.

Outcome	Management options				
	Community Management	Public Management	Private Management	Public-Private Management	Status Quo
Area of Mangrove	2% increase	Remains same	5% decrease	2% increase	Remains same
Fish Resource	1% increase	1% decrease	1% decrease	1% increase	Remains same
Eco Services	High	Low	Low	Low	Remains same
WTP	5% of monthly income	5% of monthly income	5% of monthly income	2% of monthly income	0
I choose					

1.b.

Outcome	Management options				
	Community Management	Public Management	Private Management	Public- Private Management	Status Quo
Area of Mangrove	5 % increase	Remains same	5% decrease	2% increase	Remains same
Fish Resource	1% increase	1% decrease	1% decrease	1% decrease	Remains same
Eco Services	High	High	Low	Low	Remains same
WTP	5% of monthly income	5% of monthly income	2% of monthly income	2% of monthly income	0
I choose					

1.c.

Outcome	Management options				
	Community Management	Public Management	Private Management	Public- Private Management	Status Quo
Area of Mangrove	2% increase	5% decrease	2% decrease	2% increase	Remains same
Fish Resource	1% increase	1% increase	1% decrease	1% decrease	Remains same
Eco Services	Low	Low	Low	Low	Remains same
WTP	2% of monthly income	2% of monthly income	2% of monthly income	2% of monthly income	0
I choose					

*Like this 11 more choice sets are there.

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(2010-21-102)

ABSTRACT OF THE THESIS

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ABSTRACT

Mangroves are invaluable treasure of our biodiversity with immense ecological and economic significance. But mangroves wealth of the world is depleting at an annual rate of -0. 34 per cent. Mangroves in Kerala, constitute 0.3 per cent of that in India, is reported to be high in species diversity. The available reports indicate the depleting status of the ecosystem in Kerala too. The socio-economic and ecological significance of this ecosystem is to be studied in detail for assisting policy decisions when confronted with the conservation-development debate. This study was undertaken in this background.

The study identified the stakeholders of mangrove ecosystems of Kerala and quantified the level of dependence of local communities for their livelihood and estimated the aggregate demand for products and services. Further, it identified and quantified the relative influence of socioeconomic, institutional, climatic and anthropogenic forces on the destruction of mangroves and finally assessed the Total Economic Value (TEV) of mangrove system and suggested policy prescriptions for the conservation and management of mangroves in Kerala.

The study was conducted in the mangrove areas of Ernakulam and Kannur districts of Kerala. These two districts accounted for nearly 65 per cent of the mangroves of the state. The study was based on primary and secondary data. The primary data was gathered from 480 respondents belonging to four identified stakeholder groups (residents, fishermen, paddy farmers and general public), selected through simple random sampling method. Data was collected through personal interview using structured pretested interview schedule along with direct observation. The major tools of data analysis were Contingent Valuation Method (CVM) and Choice experiment. The data collection was conducted during June 2012 to January 2013.

Four stakeholder groups of the mangrove ecosystem in the study area were residents living close to mangroves (<1 km from mangroves), fishermen (inland fishermen and women, engaged in shell mining and clam collection, shrimp farmers), paddy farmers (Pokkali and Kaippad) and general public (resides away from the mangroves).

The residents were depending on the mangroves for extraction of fuel wood, fodder and poles. On an average the level of extraction was 307 kg of fuel wood, 1024 kg of fodder and 14(no.) of poles per year valued at ₹ 4628/household. This amounted to 3 per cent of their annual household income. The major species of fish catch by the fishermen were *Etroplus*, shrimp, crab and *Tilapia* which was quantified at 1553 kg/ year valued at ₹ 1,41,045. Shell mining which was found to be a major economic activity in Kannur region could generate an income of ₹ 30,000/annum through the extraction and sale of 7500 kg of shells. Clam collected was quantified at 225 kg/year valued at ₹ 5625. Thus, the average gross income from these activities was estimated at ₹ 1,77,164 per year which was the main source of income for the household. About 8 per cent of the fishermen were involved in shrimp farming and were mainly from Kannur district. The size of the farm varied from 0.4 to 2 ha. The input cost/ha was ₹ 2.8 lakhs which includes cost of seed, feed, lime and water management. Labour cost was estimated at ₹ 77,000. Hence total cost and returns of shrimp farming/ha was ₹ 3.27 and 4.75 lakhs respectively with net income of ₹ 1.48 lakhs. Pokkali and Kaippad agricultural systems are proved to be closely interconnected with the mangrove ecosystem and the per hectare gross returns was ₹ 60,007 and ₹ 40,935 respectively. This amounted to average 30 per cent of their household income.

The respondents' perception on the pattern of change and the major factors that effected the change in mangrove ecosystem was studied based on their responses. 46 per cent of the respondents were of the opinion that the mangrove ecosystem has declined over years and facing threat. The major factors responsible for the same were reported as anthropogenic, climatic forces and status of property rights. The

developmental interventions like LNG Petronet Terminal, Puthuvypeen and ICTT Vallarpadam has resulted in large scale conversion of mangrove areas. The contradictory forces of development and conservation led to destruction of mangrove ecosystem. One fifth respondents opined that climatic factors were responsible for the decline. Nearly 85 per cent of the mangroves in the state were reported to be under private ownership and rest under public. The property right status along with economic status influences the rate of depletion. The legal interventions and community and institutional efforts also influence the status of mangroves, most often positively.

The economic valuation of ecological benefits of mangroves was attempted employing the Contingent Valuation Method. The respondents expressed their willingness to contribute towards conservation both in cash and kind (cash payment and manual participation as labour and as volunteer in awareness programmes) and in combination. The average WTP expressed by the respondents was ₹ 2308/annum the range being ₹ 50–28,870. The TEV of the mangrove ecosystem of the state was thus ₹ 1,17,947 million, which was 0.14 per cent of the GSDP (2011-12).

A socially preferred management plan was identified among a set of alternatives, employing the choice experiment method. Among the management options given, the stakeholders preferred community management (41.6%) followed by public management (29.2%) and *status quo* (21.4%). The community management of the mangrove ecosystem provides opportunity for the local community to participate in management decision process. At the same time, the importance of public funding for such activities is revealed in the analysis.

The study suggests initiating scientific attempts on realistic area estimation and mapping of the mangrove resources in the state. There should be attempts to identify and classify the species and document the traditional wisdom associated with them. Region specific studies are needed to establish and quantify the extent of association

between mangrove ecosystem and the livelihood activities of local communities. The TEV justifies the increased resources allocation for the conservation efforts. Further, the implementation of community management system as institutional form for mangrove management in the state is suggested.