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FACTORS OF MANGROVE DESTRUCTION AND MANAGEMENT OF MANGROVE ECOSYSTEM OF KERALA, INDIA

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Abstract: Mangroves are invaluable treasure of our biodiversity with immense ecological and economic significance. 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 erroneous description as 'waste land' along with direct and indirect anthropogenic activities has considerably altered the mangroves of tropical countries in the world. Mangroves wealth of the world is depleting at an annual rate of -0.34 per cent. Mangroves in Kerala, constituting 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 push and pull factors of conservation and development motives, most often favours the development options. This facilitates the conversion of mangrove ecosystem. This paper analyse the factors that influence the status of mangrove wealth in the state of Kerala and suggest a management plan based on stakeholder responses and socioeconomic dimensions. The study was conducted in the mangrove areas of Ernakulam and Kannur districts of Kerala which account nearly 65 per cent of the mangroves of the state. 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 Mangrove destruction were reported as anthropogenic, climatic forces, status of property rights, legal status and level of community efforts and institutional support. The developmental interventions like LNG Petronet Terminal, Puthuvypeen, ICTT (International Container Transshipment Terminal) Vallarpadam has 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 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. In Kerala, an effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources and conflicting interests.

Key words: Mangroves, Conservation, Management plan, Socio-economic dimensions

INTRODUCTION

Globally wetlands are considered as one of the most prolific and life supporting ecosystems. Coastal resources such as coral reefs, mangroves and other wetlands are one among the richest store houses of biological diversity and primary productivity. 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.

It was reported that 35 per cent of the world's mangroves are lost in between 1980 and 2000 (MEA, 2005). In 2007, Duke *et al*. (2007)

predicted the complete loss of mangroves by 2100 mainly due to the destruction in Asian countries. 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.

Mangroves in India are spread over an area of 4,66,156 hectares (in 5700 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; FSI, 2011; Kathiresan, 2010; Singh *et al*., 2012). 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).

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 high species diversity of mangroves is reported from the state.

The development activities in the land limited coastal state of Kerala is mostly taking place at the cost of wetlands especially mangroves. The push and pull factors of conservation and development motives, most often favours the development options. This facilitates the conversion of mangrove ecosystem. This paper analyse the factors that influence the status of mangrove wealth in the state of Kerala and suggest a management plan based on stakeholder responses and socioeconomic dimensions.

METHODOLOGY

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 Sunder Bans in the eastern part of the country. The palynological studies revealed that the state had excellent mangrove cover, 11,000 years ago. Due to natural catastrophe, climatic changes and anthropogenic factors there was 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. Nine and eight grama panchayths, respectively in Kannur and Ernakulam where mangroves seen were selected.

The study was initiated by holding informal discussions with local residents, officials of 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 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 general public. They were people who resided away from these ecosystem and do not directly depend on them for livelihood. Thus, there were four stakeholder groups. The primary data was gathered from 480 respondents who were selected randomly from among these four stakeholder groups. Data was collected through personal interview using structured pretested interview schedule along with direct observation. The data collection was conducted during June 2012 to January 2013.

The primary data was gathered from 480 respondents who were selected randomly from among four stakeholder groups (residents who live close to mangroves, inland fishermen, paddy farmers-*Pokkali* and *Kaippad*, and general public). Data was collected through personal interview using structured pretested interview schedule along with direct observation. The data collection was conducted during June 2012 to January 2013. 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.

The relative influence of socioeconomic, institutional, climatic and anthropogenic forces on the destruction of mangroves was done using tabular method, percentage and average. The technique of Choice Experiment (CE) (Hanley *et al*., 1998) was employed in developing the management plans based on respondents responses. It is a stated preference method which elicits public/individual preferences by asking respondents to choose among a series of alternatives. In resource/environmental economics where 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).

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 (Table 1). 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).

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.

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 2. The

Table1. Description of management options

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 private 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

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.

RESULTS AND DISCUSSIONS

Mangroves across the globe had been subjected to various biotic and abiotic pressures which have lead 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.

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 more than two thirds of the general public 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.

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. From the respondents' perception, it was found that anthropogenic factors (85%), major factor attributed for the conversion of mangroves followed by the status of property rights (15%) and to a lesser extent (3%) by climatic factors.

Table 2. Details of the selected attributes for the management options for mangrove conservation

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

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 per km^2 (2011). The state exhibited 15 per cent GDP growth during 2012 and leads in social development indices in the country (GoK, 2012). 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 firewood/ timber 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 hectares 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 hectares 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 20 acres 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 hectares 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.

Status of 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, 2006). 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 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 hectares 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 communities' 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.

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 2004 (Purushan, 2005).

The impact of climate change is often experienced slowly and the awareness level among the people is rather limited. Most of the respondents were not sure about the potential 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.

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.

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 hectares 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 hectare 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 occured mainly due to the reduction in rice 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 department usually collects seeds during the monsoon period from local seed collectors at the rate of 'five per 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, 2012).

Management of mangrove ecosystem

One of the aims of any management option of natural resources is biodiversity conservation and enhancement (Sudtongkong and Webb, 2008). The Sunderban mangroves were 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. 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 3. 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 prevent further degradation and participate in the awareness campaign and encourage their neighbours to participate in conservation drives. Hence community management provides a socially desirable mechanism to achieve the goal of mangrove ecosystem conservation. However 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.

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. 29.2 per cent preferred public management, 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. 21.4 per cent suggested the existing system as the preferred choice. 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 372448 hectares in 1960 to between 167500 and 244000 hectares in late 1990's (Wilkie and Fortuna, 2003).

Table 3. Relative preference of management alternatives

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

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.

CONCLUSIONS

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. 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. The major factors responsible for the same were reported as anthropogenic, climatic forces and status of property rights. The contradictory forces of development and conservation lead to destruction of mangrove ecosystem. 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. 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.

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