Sustainable management of mangroves: Developing a socially acceptable management plan

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Abstract

Mangroves are the invaluable treasure of our biodiversity with immense ecological and economic significance. The unique mangrove ecosystems of Kerala are under threat due to policy and social factors and property right status (public and private property rights). An effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources and conflicting interests among the stakeholder groups. The purpose of this paper is to suggest a sustainable management plan for the mangrove ecosystems in Kerala based on stakeholder responses and socio-economic dimensions employing the choice experiment approach.The stakeholders chose community management from among the five management options which provides an opportunity for the local community to participate in the management decision process.

Key words: Community management, Conservation, Mangroves.

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. Coastal resources such as coral reefs, mangroves and other wetlands are one among the richest store houses of biological diversity and primary productivity.Mangroves act as a green shield against storm surges, protect shorelines from high tide waves, prevents soil erosion by stabilizing the shore with the interconnected root system, filters pollutants and maintains water quality (Maguire et al., 2000;Badola and Hussain, 2005; Das and Vincent, 2009; Kathiresan, 2010).

Despite its important role in maintaining the ecological balance and providing a livelihood for the local communities, mangroves have not received the conservation attention or effort that they deserve (Muraleedharan et al., 2009.) Climate change, nutrient loading, habitat degradation, food web alteration and pollution threaten their existence (Silliman et al., 2005; Orth et al., 2006).The erroneous description as 'waste land' along with direct and indirect anthropogenic activities have considerably altered the mangroves of tropical countries in the world (Suman, 2019). This situation has resulted in most of the policy decisions being taken in favour of other sectors, leading to the destruction and depletion of the natural mangrove ecosystems. The lack of awareness of the ecological benefits of mangrove ecosystem has led to its widespread depletion in one way or other (Castellanos et al., 2017). Mangrove wealth of the world is depleting at an annual rate of -0.34 per cent. Globally mangroves are undergoing reduction, approximately to the tune of 20 per cent since 1980, and the present mangrove area is only about 15 million ha (FAO, 2007; FSI, 2017). However, the havoc created by the tsunami of 2004 has created the occasion for realizing the ecological significance of mangroves.

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Mangroves in Kerala constitute 0.19 per cent of that in India, with high species diversity (Radhakrishnan et al., 2006; Khaleel, 2012; FSI, 2017). This is evident from the massive reduction in the mangrove area to about 900 hectares in the state from 70,000 hectares as per historic records (Blasco, 1975). Apart from the factors that generally lead to mangrove destruction across the globe, the existing property regime in the state of Kerala also contributes to the destruction. 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 the government departments (fisheries, revenue, local self-governments, forest and tourism), quasi government agencies (Kerala Agricultural University and Kerala University of Fisheries and Ocean Studies), central government (railways) and more than 80 per cent is under private ownership (Radhakrishnan et al., 2006).

The mangroves under public ownership have been largely converted for developmental activities like International Container Transhipment Terminal, Vallarpadam, Cochin, expansion of Cochin Port Trust and LNG, Petro net, Puthuvypeen, Cochin. The nature of land holdings and ownership of mangroves are the significant factors in utilization, conservation and management of mangroves (Viswanathan, 2013). The marginalized,resource poor land owners try to protect the ecosystem as a source of livelihood and as coastal shield, while the owners of larger holdings try to destroy the mangroves. Mangrove ecosystems are generally considered as waste swampy lands and hence low priced in the real estate market. Because of the surging land prices, the private owners, especially in periurban areas prefer to clear off the mangroves to fetch better price. 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 their property.

This situation coupled with the rising pressure on land, warrants the need for developing a socially desirable and sustainable plan for the conservation and management of mangrove ecosystem of the state.This study is an attempt to 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 the Sunderbans, in the eastern part of the country. Due to natural catastrophes, 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 currently only less than 1 per cent of India's total mangrove ecosystem. 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. The study was conducted in the mangrove areas of Ernakulam and Kannur districts of Kerala by initiating informal discussions with local residents, officials of the forest/agriculture/fisheries departments, members of local self-governments and elderly people in the locality and also by direct observation. Through this process, three groups of stakeholders who depended on the ecosystem directly were identified. They were residents living close to the mangroves and population depending on mangrove related livelihood options (fishermen and paddy farmers). The below sea level paddy lands of *Pokkali* in Ernakulam are bordered by mangroves and a resource recycling is reported in this region. 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 did not directly depend on them for livelihood. Thus, there were four stakeholder groups.

The data was gathered from 480 respondents belonging to above four identified stakeholder

groups selected through simple random sampling method. Data was collected through personal interview using structured pretested interview schedule. The supporting secondary data was gathered from the various government departments of Kerala such as Department of Agriculture Development & Farmers' Welfare, Forest and Wildlife, Fisheries and Irrigation and also from Cochin University of Science and Technology (CUSAT), Cochin, Kerala Agricultural University, Thrissur, University of Calicut, Malappuram, Kerala Forest Research Institute (KFRI), Peechi and published articles and reports including electronic sources.

Choice Experiment (CE) method was employed in developing the management options based on respondents' responses. It is a stated preference method which elicits individual preferences by asking respondents to choose among a series of alternative management options. 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 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 (Chellattan et al., 2011). The 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., 2006). 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

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

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

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 (Chellattan et al., 2011).

In the present study, dependent variable (categorical) was the mangrove management scenario. Four alternative management options were considered namely, community management, public

*Table 1.*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 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

management, private management and public-private partnership management. Those respondents who did not opt for any of these were assumed to be maintaining the status quo position (majority of the area were privately owned). This was included because one of the options had to be always in the respondent's currently feasible choice. Table 1 details the management options considered in the study.

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. The details of the options are given in Table 2.

The mangrove area was considered in three levels, a decrease in area, expansion of the area and the status quo. The inland fish wealth had direct interactions with the mangrove wealth. It was assumed that inland fish wealth improved with the improvement in mangrove area. Two levels were considered, increase and decrease in the fish wealth from the current level. The fish wealth was directly correlated with the sustenance and livelihood of the local communities in the area. An attribute on the ecological services was included as mangroves were 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 were 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. Since these people were getting direct ecological benefits, they were aware about the ecological significance of the mangroves and its role in protecting their life and property, as well as providing livelihood.

The monetary attribute allowed for estimating the payment for marginal changes in the levels of other attributes. It was the amount of money that respondents were ready to offer for the management

*Table 2.*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. Remains same 3. High:Improvement from current level
2	Fish resources	Fish wealth in the wetlands	1. Decrease: Depletion of fish wealth from current level 2. Increases: Increase in fish wealth
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	Level of payment	Amount that the respondent is ready to pay for the conservation of mangroves	1. 2% of monthly income 2. 5% of monthly income

of mangroves. The respondents (residents and fishermen) both belonging to lower economic strata were ready to contribute their service. Hence their service hours was converted to economic terms and their monetary contribution level were estimated. The levels were fixed based on expert opinion and literature review. The selected option was assumed to provide the highest utility to the respondent.

Using the attributes and levels mentioned in Table 2, an experimental design technique employing SAS software (Chellattan et al., 2011) was used to obtain an orthogonal design which consisted of the main effects. An efficient design was 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 the respondent to comprehend. So 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 contained 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 were described using four attributes which took on various levels as mentioned in Table 2. The data on choice was binary in nature, i.e. when a respondent choss an alternative option; the choice took the value of 1, otherwise zero. Therefore, corresponding to each choice set there would be a single entry of 1 and four zero entries.

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 (community management, public management, private management, public-private partnership and status quo).The response variable (management options) was a categorical variable with no natural ordering. The reference group was chosen as the status quo position.

Results and discussion

Anthropogenic factors have led to massive destruction of mangroves in Kerala in lieu of development.The perception of the sample respondents on the mangrove status in the state was gathered and nearly half of the respondents felt that mangrove wealth had depleted over time. One third of the residents, mainly fishermen and paddy farmers, and more than two thirds of the general public perceived that mangroves were undergoing depletion and degradation.

Some believed that there was not much change in the mangrove area. The rest expressed the opinion that the mangrove area had improved over the years. The residents and fishermen attributed natural regeneration as the major reason, while paddy farmers acknowledged the efforts of civic organizations in conservation programmes.The area improvement of mangroves in certain pockets could be attributed to the government's initiative for mangrove conservation through people's participation. The storm protection function of the mangroves was well documented after the Asian tsunami of 2004. Since then, therewas an increased participation in conservation drives and planting mangroves along the boundary of the homesteads to reduce soil and embankment erosion. The proven effect of mangroves during tsunami together with ineffectiveness of mechanical embankmentsled to mangrove planting gaining acceptance among coastal communities (Badola et al., 2012)., Generally, thepropagules had high survival rate and hence expansion was very rampant.

The mangroves in Kerala were either under public regime or private ownership. The largely private ownership status of mangroves in the state favoured the conversion of mangrove areas for other development activities, both by the resource poor and rich, due to differing reasons. The low land value of mangrove area motivated the private

owners to clear off mangroves, to fetch better worth. The responses to the preferred management option among the respondents yielded results as presented in 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 the resources (Sudtongkong and Webb, 2008). The arrangement involved a democratic setup with the active participation of existing local communities and allowed them to express their opinion and make decisions regarding the management plan and regulations related to the utilization of mangrove resources. This would provide opportunity for the local community to participate in management decision process. Through this, awareness and community participation could be ensured.

Community based management should provide increased benefits to local community and reduce their economic vulnerability (Suman, 2019) and it provided a socially desirable mechanism to achieve the goal of mangrove ecosystem conservation. Community management incorporated local communities' involvement in resource identification, prioritizing activities, choice adoption formulation and implementation of sustainable management practices. Most earlier works underlined the strong linkages between the mangrove ecosystem and local community (Walters et al., 2008; Badola et al., 2012). The participation of the local public was a prime factor determining success or failure of any ecosystem conservation project. There were successful models of community management in Thailand and Indonesia while it repealed mixed response from India, Philippines, Vietnam and Tanzania (Datta et al., 2012). It was also reported that the success of community management was dependent on involvement of the state government and the efficiency of implementation agency as evidenced by reports from countries like Bangladesh (Islam and Wahab, 2005), Sri Lanka (Wattage and Mardle, 2008), Philippines (Primavera and Esteban, 2008), Iran (Ghasemi et al., 2010) and Brazil and Eucador (ITTO, 2012) . The study by Maskey et al. (2006) found that community based natural resource management with labour contributions was the common resource management strategy in developing countries including Nepal. It was also seen that the efficiency of the system was influenced by government support as financial, educative and supportive interventions.

Being resource and economically poor, local communities would find it difficult to offer any sort of payment for the conservation of mangroves. This acted as major hindrance for the implementation of the community management unless there was ample public funding. Local communities could acknowledge the ecotourism potential of mangrove habitat and resultant economic growth, which had positive influence on perception and attitude towards participating in the conservation initiatives of mangroves (Datta et al., 2012). The mangroves fell under the purview of Ecologically Sensitive Area (ESA), hence any disturbance on the ecosystem would be penalised. It was observed that the local communities formerly dependent on mangroves for fuel wood requirements did not have any access in the current scenario resulting in conflicts between them and the enforcing authorities and hence a negative attitude was developed towards mangroves in the study area.

Barbier (2008) reported the efficient management of mangroves during post tsunami through the participation of local communities in Thailand. The study found that local communities exerted effective control over the management and protection of their local mangrove forests. Another study from Thailand by Sudtongkong and Webb (2008) 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). The experimental model of community reserve showed that community management could be designed as an effective management policy for the conservation of natural resources.Similar 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 forest, more employment and more migratory bird species. However the community management of mangrove ecosystem would be successful only when more local dependence on mangroves, collective action and mutual agreement on regional and political arena were favourable (Sudtongkong and Webb, 2008).

Public management of mangrove was envisaged as a system with the ownership and management under the government, as in the case of forests. 29.2 per cent (who mainly belonged to the general public category) preferred public management. 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 were to be managed by the owners and the mangroves under the ownership of public management institution were to be managed by the respective organisation. But some studies reported the limited success rate in public management. Public management of mangrove without the participation of local people, would result in decline of the natural resources (Ganjanapan, 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.

*Table 3.*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	Private management	21.4
4	Public-private management	6.8
5	Status quo	1.0
	Total	100.0

The probability of choosing the community management is influenced by the expected outcome of some attributes like mangrove area equivalent, fish resources, ecological services and the payment. The results of the multi nominal logit estimated to capture the influence are furnished in Tables 4 a and 4 b. The community management had positive estimates while the other three had negative ones, making it clear that community management was the widely preferred option. The choice probability was significantly and positively influenced by mangrove area and ecological service. The coefficient of mangrove area (3.5) implied that the choice probability of community management option would increase by 3.5 per cent for each hectare of incremental mangrove area compared to that of the status quo option. Similar was the case

Table 4a. Parameter estimates of discrete choice for community 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
Amount of payment	-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

Table 4b. Parameter estimates of different management options for those who have opted

Attribute	Community Management	Public Management	Private Management	PPP
Mangrove area equivalent	0.057***	-0.019**	-0.051**	0.019**
Fish resources	0.028**	-0.053	-0.039***	-0.011**
Ecological services	0.965	-0.486	-1.600	-0.410
Amount of payment	0.076***	-0.012**	0.015***	0.11**
Area*Fish Resource	0.002***	-0.000***	0.002***	0.000***

Table 5. Direct and cross elasticity estimates of price in different management options

Choice	Community management	Public management	Private management	PPP 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
PPP partnership	0.1320	0.0130	0.0003	-0.0344

with ecological services. People who expected higher levels of ecological service, stood a higher probability of preferring community management. The coefficient for amount of payment variable was negative and statistically significant, *i.e.,* as the payment for mangrove conservation increased, the choice probability of that particular management option reduced. This implied that the chances of participation were limited if they had to pay at higher levels.

A matrix of direct and cross price elasticity estimates for the mangrove management alternatives derived from the probability weighted individual effects of multi-nominal logistic model is presented in the Table 5. The elasticity measured the extent to which the choice probabilities varied in response to a unit change in price. The price effect was predominant in community management. The direct elasticity estimate of community management implied that one percent increase in amount of payment would reduce the probability of choosing community management by 0.18 per cent. At the same time this scenario induced people to shift to the other three alternatives (public management, private management and PPP) where in an equal 0.13 per cent was observed. The price sensitivity (both direct and cross price elasticity) of public management, private management and PPP were found low compared to that of community management. The result thus underlined the importance of public financial support for the management of mangroves.

Kerala being a coastal state, the ecological contributions of the mangroves are vital. An effective management strategy for mangroves is to be evolved in view of the rising pressure on land resources and conflicting interests among the stakeholder groups. The conservation development conflicts often work in favour of development alternatives causing damage to the natural resources. The study was conducted using four stakeholder groups selected (residents, fishermen, paddy farmers and general public).The study tried to evolve a management strategy which was socially acceptable and ecologically safe,employing stakeholder preferences through choice experiment.They preferred community management (41.6%) as it provided opportunity for the local community to participate in management decision process. At the same time, the importance of public funding for such activities was revealed in the analysis. The community management system through government support could be suggested as policy optionfor the institutional form of mangrove management in the state together with the efforts for awareness creation programmes.

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