Kochi Municipal Corporation

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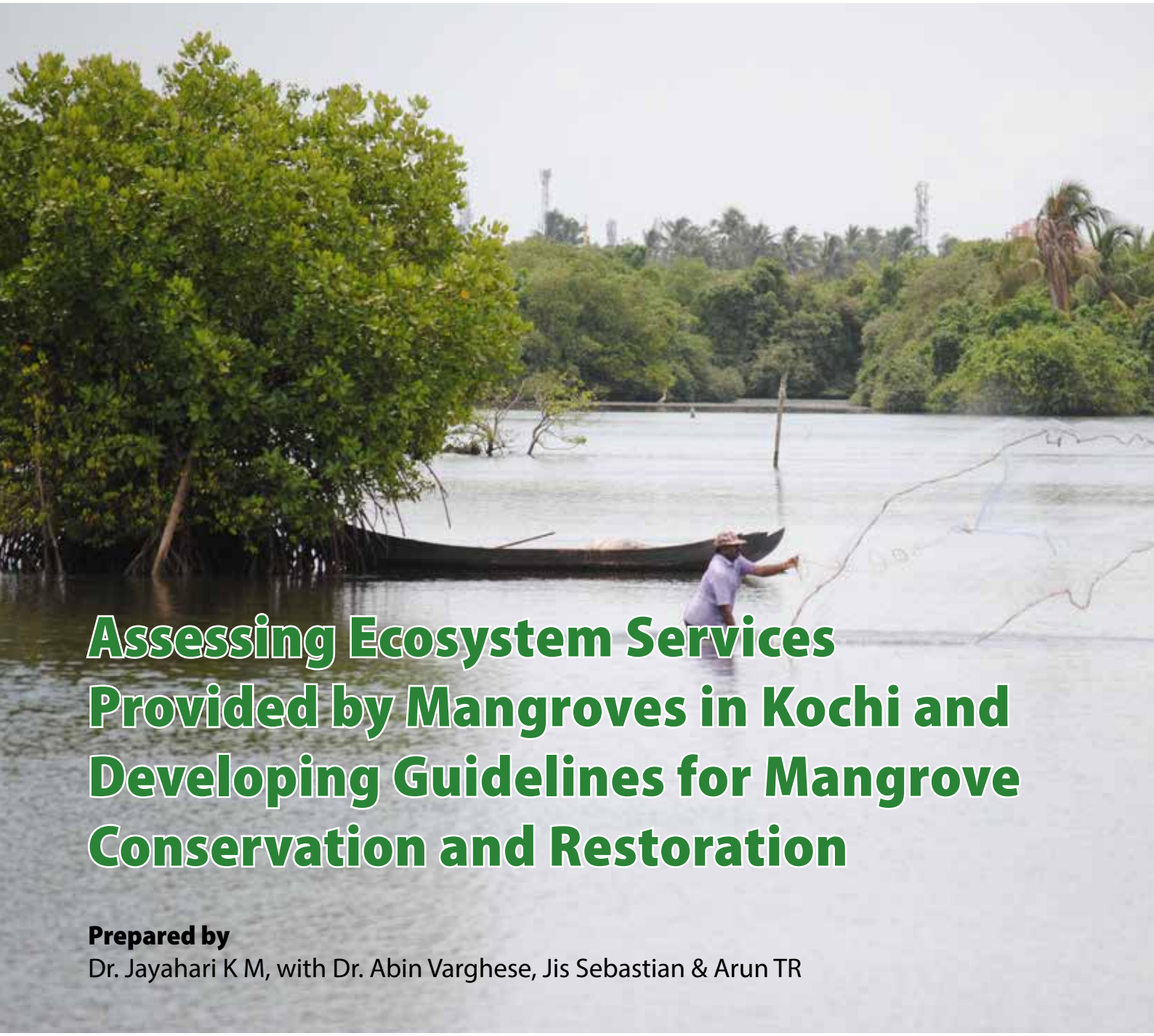

Assessing Ecosystem Services Provided by Mangroves in Kochi and Developing Guidelines for Mangrove Conservation and Restoration

Prepared by
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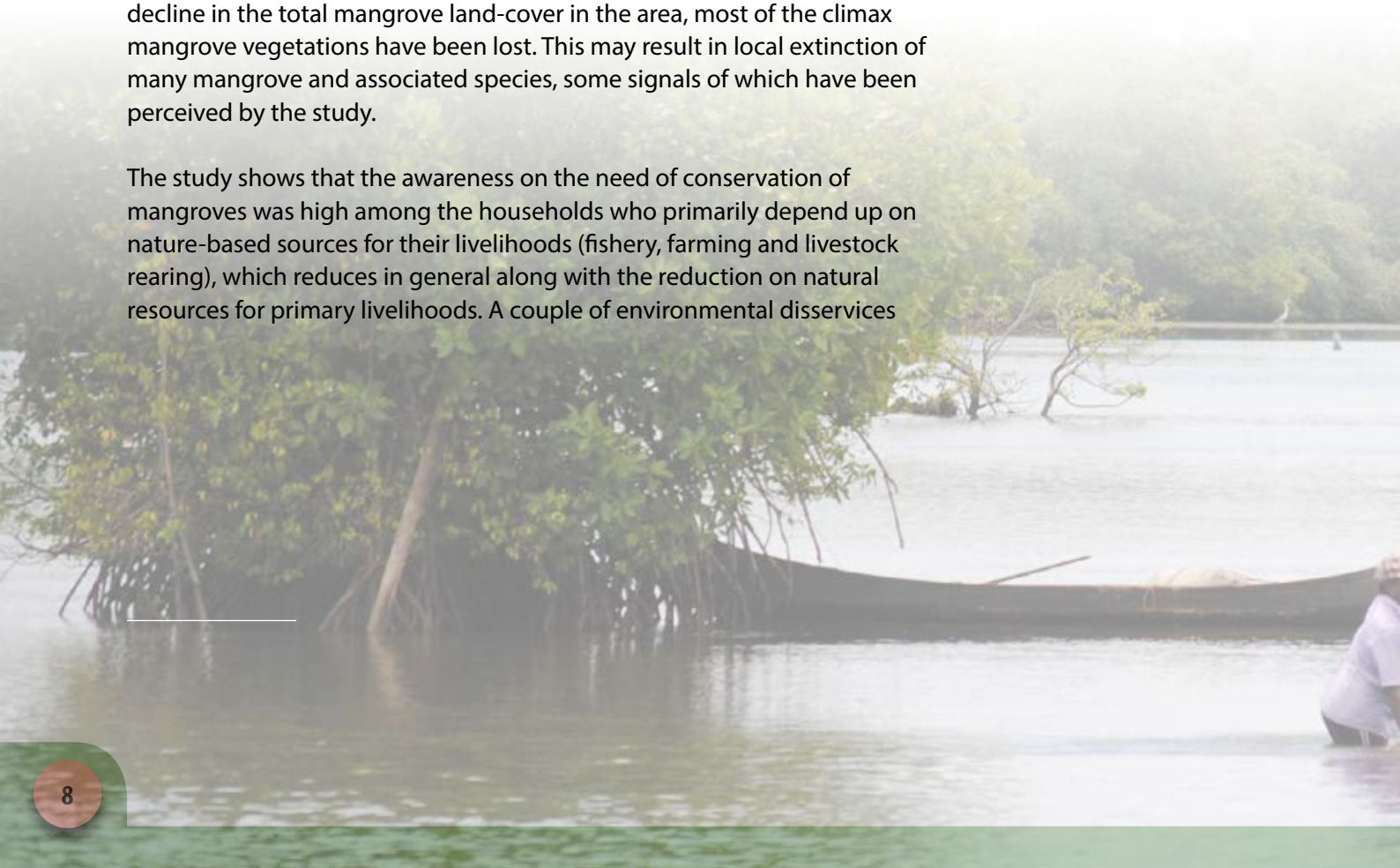
K. M. Jayahari

Executive Summary

The state of Kerala has marked the highest growth of urban population among the Indian states during the last decade. Urbanization tremendously changes the local land-use land-cover profile of the landscape. In a state like Kerala this land-use and land-cover change can be one of the significant drivers of biodiversity degradation and there is an urgent need to understand in detail and protect the urban biodiversity. This study is an attempt to understand the ecosystem service value of the mangrove ecosystems in Kochi Municipal Corporation and suggest investment strategies to protect the same.

The spatial analysis reveals that the mangrove area dynamics in Kochi Municipal Corporation and adjoining areas is complex. Within the area of Kochi Municipal Corporation and adjoining 7 local bodies, there was a decline of 24 percent mangrove areas in the study area between years 2000 and 2017 (11% decline between 2000-2017 and 14% decline between 2013 and 2017). A detailed analysis of the dynamics between the mangrove land-cover and non-mangrove land-uses shows that between 2000 and 2017, 3.58 km^2 of mangroves which translates to more than 78 percent of the total mangrove areas in the year 2000 has been converted to some other land uses. At the same time new mangrove areas which translates to 2.5 km^2 has been newly established in the study area. Even though altogether there is only a slight decline in the total mangrove land-cover in the area, most of the climax mangrove vegetations have been lost. This may result in local extinction of many mangrove and associated species, some signals of which have been perceived by the study.

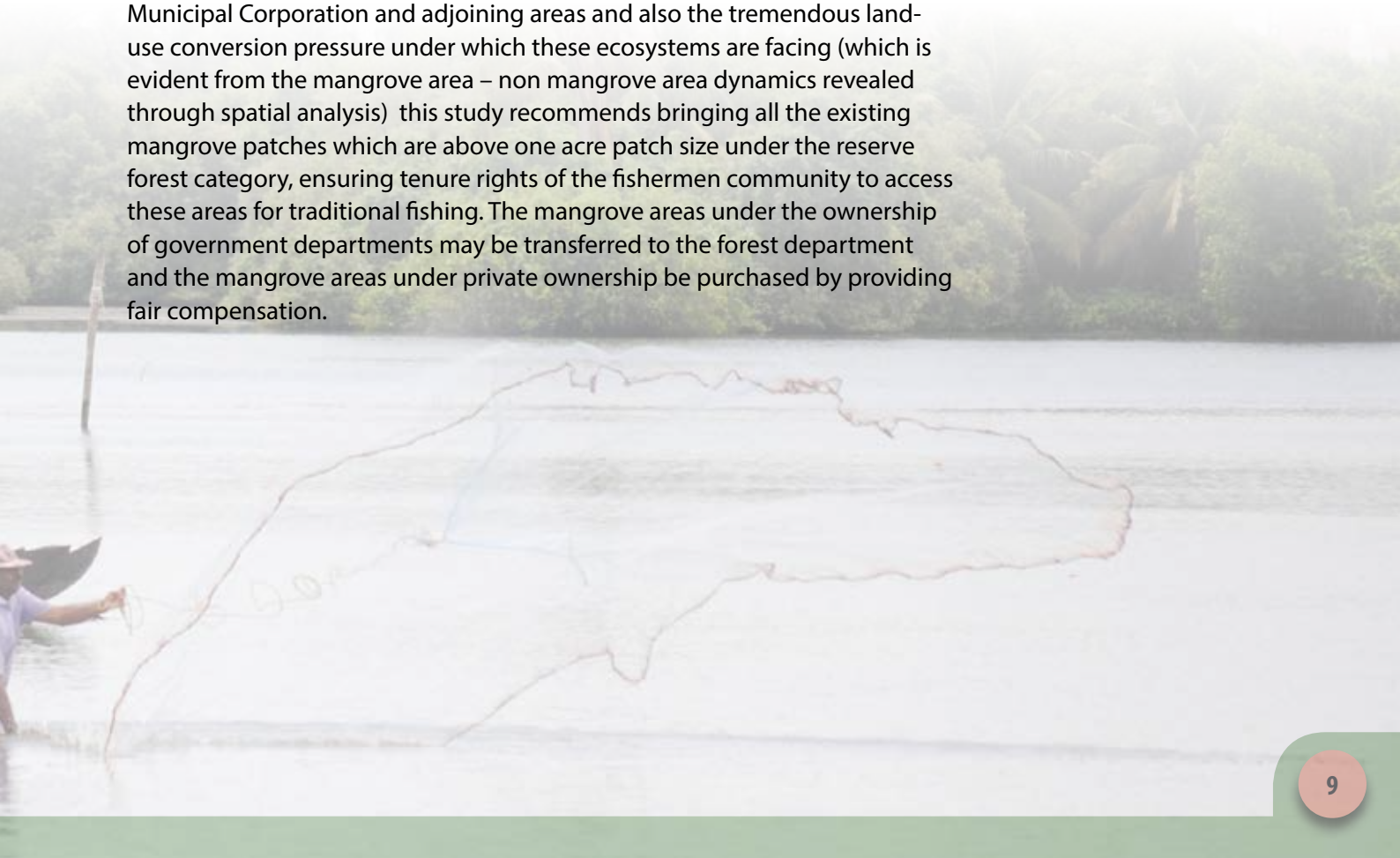
The study shows that the awareness on the need of conservation of mangroves was high among the households who primarily depend up on nature-based sources for their livelihoods (fishery, farming and livestock rearing), which reduces in general along with the reduction on natural resources for primary livelihoods. A couple of environmental disservices



also have been observed during the study, which impacts the conservation attitude of local communities towards mangroves. One significant result of the study is that the ecosystem functioning of mangroves and there by the availability of ecosystem services are seriously hampered by the factors like water pollution due to discharge of hazardous chemicals and deviation from traditional fishing practices. As the value and volume of the ecosystem services availed from the mangrove ecosystem is the significant factor in maintaining conservation attitude towards mangroves among the local communities, this reduction in the volume and value will have serious impacts. The report has suggested a few measures for improving the conservation attitude of the general public towards mangrove ecosystem in Kochi Municipal Corporation and adjoining areas.

Even though the study has attempted to quantify the value of different ecosystem services provided by mangrove ecosystems in Kochi Municipal Corporation and adjoining area, significant benefits have been recorded only from the inland fisheries activities. The study shows that the regular inland fishermen of the area receives an average benefit of ₹124,000 per annum from mangrove ecosystem. An over all estimation, using data from samples across the mangrove areas of 2.47 km^2 (247 hectares) within Kochi Municipal Corporation and adjacent areas results in total fisheries ecosystem services generation worth ₹1.7 million per annum per ha ($24,100/ha/yr). This shows that the ecosystem services provided by mangrove ecosystems in the area plays a significant role in maintaining the livelihood of economically marginalised fishermen community of the area, including those dependent on inland fishery partly, for their livelihood.

Considering the economic and ecological significance of mangroves in Kochi Municipal Corporation and adjoining areas and also the tremendous land-use conversion pressure under which these ecosystems are facing (which is evident from the mangrove area – non mangrove area dynamics revealed through spatial analysis) this study recommends bringing all the existing mangrove patches which are above one acre patch size under the reserve forest category, ensuring tenure rights of the fishermen community to access these areas for traditional fishing. The mangrove areas under the ownership of government departments may be transferred to the forest department and the mangrove areas under private ownership be purchased by providing fair compensation.



Background Note, Relevance of the Study and Objectives

By the year 2014, more than half of the world's population has been accounted to be living in the urban areas, which is a result of both urbanization – the process of expansion of urban areas[1] and human migration. The process which involves tremendous land use changes, mainly the conversion of different land uses into built-up areas has a very serious impact on both urban and non-urban ecosystems[2]. These urban ecosystems have been proved to be providing vital ecosystem services to the urban dwellers[3] and so the need of incorporating these urban ecosystems in urban planning is being recognised better during the recent years[4]. The pace of urbanisation is much higher in the developing countries than the developed ones[5]. India is one among them, which is well known among the economic world on behalf of its pace of economic growth. Within India, the state of Kerala stands second in terms of urban population with more than 47% of its population living in urban areas[6].

Situated at the southern tip of Western Ghats – one of the world's biodiversity hotspots, the state of Kerala is rich in biodiversity. Coupled with the high degree of biodiversity encompassed by the state, its high level of urbanisation results in more impacts on the ecosystems. The coastal city of Kochi is the economic capital of the state. This is located in the district of Ernakulam in the state of Kerala and is spread over an area of 107.13 sq. km. With a population of 601,574 as recorded in 2011 census, the city of Kochi has Kerala's highest population density with 5,620 people per sq. km. Rich with backwaters and estuaries the city also has a good coverage of mangroves, which one among recognized significant ecosystems.

Mangroves are unique ecosystems which are known for generation of vivid ecosystem services which can be broadly classified into commercial, recreational and subsistence fisheries, by serving as a breeding ground and nurseries for aquatic life etc[7]. Studies assessing the ecosystem services potentially influence the conservation action plan development - right from grassroot level programmes to policy formulation[8]. Many studies at global, regional and local scales have proved the biodiversity significance of mangroves and also the community dependency on mangroves for ecosystem services. Like any other ecosystem, the dependence of the community on ecosystem services provided by mangroves also are highly site specific. According to an estimate of Kerala Forest Research Institute, Ernakulum District in Kerala, encompasses the third largest mangrove areas of 260 hectares in the state, behind the districts of Kannur and Kozhikode[9].

Ecosystem services are activity, function, condition or process of natural ecosystems that benefit and sustain human life[10]. Even though mapping of the spatial pattern of ecosystem service generation and

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consumption is widely occurring in the conservation world, the outcomes are rarely considered during the policy and other decision making related to the land use[11]. The economic significance of mangrove ecosystems has been well established by scientific studies, with regard to the ecosystem services provided by the mangroves ranging from aesthetic values to disaster reduction. The spatial pattern of dependence on the mangrove ecosystems have been worked out in many parts of the world. In the state of Kerala as well, recent studies on the economic significance of mangroves have classified the dependence of the communities, broadly into direct and indirect[12] – fishermen and paddy cultivators are the significant direct dependant groups of communities[13]. Other dependencies for firewood collection, sand mining etc. have also been recorded.

Ecosystem services and their need can lead to degradation of the ecosystems, due to over extraction. Betterment of the ecosystems through participatory conservation by the stakeholders, understanding the value of the ecosystem services can also happen. Kerala has witnessed both these trends, rather the recent stories from the state shows the realization of ecosystem services generated by mangroves and their demand has increased level of participatory mangrove conservation efforts[14] and there by an increase in the net mangrove areas in the state[15]. The case does not need to be the same across the state. During the beginning of the century, the mangrove areas of the Kochi city have been converted into other landuses for various reasons[16]. There have been no recent studies focusing on urban and peri-urban areas of Kochi Municipal Corporation (KMC) to understand the changes in extent of mangrove areas and their connect with the ecosystem service generation and utilization pattern of mangrove patches.

The present study aims to understand the temporal changes in the mangrove areas in the urban and peri-urban areas of Kochi Municipal Corporation and its connect with the pattern of ecosystem service generation and consumption by communities in and around these patches and their awareness about the significance of ecosystem services provided by these patches. This will lead to the development of broad policy directives on the means of investing in improving the mangrove ecosystems along with the cost - benefit analysis.

11. Darvil, R. and Lindo, Z. (2015). Quantifying and mapping ecosystem service use across stakeholder groups: Implications for conservation with priorities for cultural values, *Ecosystem Services*: 13, 153–161
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Project Objectives

1. Map the temporal changes in the extent of mangrove patches in the urban and peri-urban areas of Kochi Municipal Corporation.

2. Estimate the economic values of the Supporting, Provisional, Regulatory and Cultural ecosystem services generated by the mangrove patches in the urban and peri-urban areas of Kochi Municipal Corporation.

3. Understand the relationship between the socioeconomic profile of consumers and nature of ecosystems generated and consumed with the conservation and degradation of mangrove patches.

4. Conduct a consultation workshop with the city Councillors, experts from the sectors of ecology, ecological, economics and community development to evaluate the outcomes of the studies and develop broad policy directives on investing on mangrove afforestation and reforestation programmes in the urban and peri-urban areas of Kochi Municipal Corporation.

Methodology

Proposed Methodology

The overarching methodology for the proposed project was a mixed method approach, involving both quantitative and qualitative tools. The methods include remote sensing – GIS based spatial mapping, questionnaire surveys, in-depth qualitative interviews and focus group discussions. The methods used for each objective are detailed below:

A. Expert Consultation

An inception workshop was carried out involving experts from the sectors of ecology, environmental economics, socio-economics and statistical and spatial modelling. An inception workshop was carried out at Kochi for fine-tuning the questionnaires and other tools, data analysis methodologies and modelling techniques etc. A technical working group was constituted, involving the participants of the workshop. This group played a crucial role in evaluating the workshop proceedings and preparing the final policy / strategy document with regard to the mangrove conservation in Kochi Municipal Corporation. The group met again towards the end of the programme to finalize the policy / strategy document, based on the findings of the study.

B. Temporal Changes in the Extent of Mangroves and Identification of Hotspots of Degradation and Improvement Strategies for the same.

Table 1: Details of the Datasets to be used

Sl. No.	Specifications	Year (2001)	Year (2018)
1	Satellite Series	Landsat-5	Resources at 1/2
2	Sensor	TM	LISS IV
3	Path / Row	144 / 053	
4	Data Acquired (Date)	27.12.2008	
5	Band Used	4, 3, 2	3, 4, 5
6	Spatial Resolutions	30 m	5.8 m

The present mangrove areas of the urban and peri-urban areas of Kochi Municipal Corporation were mapped using the remote sensing techniques. High resolution spatial data was subjected to supervised classification using the ground truthing data that was collected as part of the study.

A time-series analysis was carried out for identifying the temporal changes in the mangrove distribution in the area, using best available high resolution satellite image circa the year 2000. These analyses brought out the areas where the mangrove patches have disappeared and new mangrove patches have established during the last 20 years.

Analysis Performed

a. Pre-processing
The standard image processing techniques of Extraction, Layer stacking, Geometric Correction and Georeferencing were performed on two Landsat OLI and LISS IV images which were available for different years- 2001 and 2018. They served as the primary data for this study. Images were geometrically corrected to common Universal Mercator Co-ordinated system of 430 North zone. The entire satellite image was clipped using study area boundary.

b. Image classification
The satellite images were classified in to different land use classes. Supervised classification technique in the Erdas Imagine 2015 software or visual interpretation technique was followed based on the accuracy of the output map obtained after analysis. From the output raster/ vector data the mangrove area was extracted. The data collected during field trips (training sites /ground control points using GPS) and Google Earth imagery served as reference data.

c. Change analysis
The land use land cover layers of different years were overlaid by applying the UNION overlay analysis function. This analysis was very useful to understand the extent of changes that occurred during the period 2001 to 2018.

C. Estimate the Total Economic Values of the Supporting, Provisional, Regulatory and Cultural Ecosystem Service Generated by the Mangrove Patches in the Urban and Peri-Urban Areas of Kochi Municipal Corporation.

Detailed household level questionnaire survey was conducted with in the three zones of the existing mangrove areas (with in 0.5 km, 1 km and 2 km radius) to reveal the following information. Methodologies were used for the economic evaluation of the ecosystem services with regard to the profile of land use and socioeconomic profile of the individuals receiving these services.

Non-market valuation techniques such as revealed and expressed preference methods were used for valuating direct and direct use-values. Revealed preference method relies on existing market prices to derive economic values for non-traded goods. In expressed preference methods, people are asked to give their value estimates based on hypothetical scenarios of alternative states of the mangrove resource[17].

D. Spatially map the profile of ecosystem service generation, consumption and dependants from all the mangrove patches with the study area.

Relevant information for spatial mapping of ecosystem services was obtained from the questionnaire survey. The two profile considerations – variations in economic value of the ecosystem services across different consumer groups and value variations across the three zones were identified and spatially mapped. The consumer groups were created based on their socio-economic profile. This was measured to change the economic value of the ecosystem. Value change was also expected based on the distance from the ecosystem within the consumers belonging to specific groups. These changes were spatially captured and mapped.

E. Understand the Relationship between the Socio-Economic Profile of Consumers and Nature of Ecosystems Services Generated and Consumed with the Conservation and Degradation of Mangrove patches.

Data for this objective was generated during the questionnaire survey for the second objective. Data collection on the socio-economic profile of the communities was carried out not only in the existing mangrove patches, but also in those areas where the mangrove patches have disappeared during the last 20 years. Finally, the areas were classified into three categories

i. Areas where the mangrove patches have disappeared
ii. Areas where the new mangrove patches have established and the existing mangrove patch area has improved
iii. Areas where the mangrove patches have been maintained without degradation

F. Conduct a consultation workshop with the city Councillors, Technical Working Group Members and Representatives of Other Organizations involved in Ecological Restoration and Conservation Endeavours in the region to Evaluate the Outcomes of the Studies and Develop Broad Policy Directives on Investing on Mangrove Afforestation and Reforestation Programmes in the Urban and Peri-Urban areas of Kochi Municipal Corporation.

The information generated through the study was presented to the city Councillors, socio-economic and ecological experts and other organisations who are working on participatory conservation of ecosystems within the state. Detailed discussions were carried out on the following:

i) Fine tuning the data analysis
ii) Developing broad policy and strategy guidelines for conservation and improvement of mangrove ecosystems of within KMC, in the light of the study outcomes.

17. Lal, P. 2003. Economic valuation of mangroves and decision-making in the Pacific. Ocean & Coastal Management, 46 (9-10). 823-844

Revised Methodology

Methodological revisions have been carried out in consultation with the Technical Working Group. The methodology has been presented in front of the Technical Working Group after testing the same.

A. Study Area

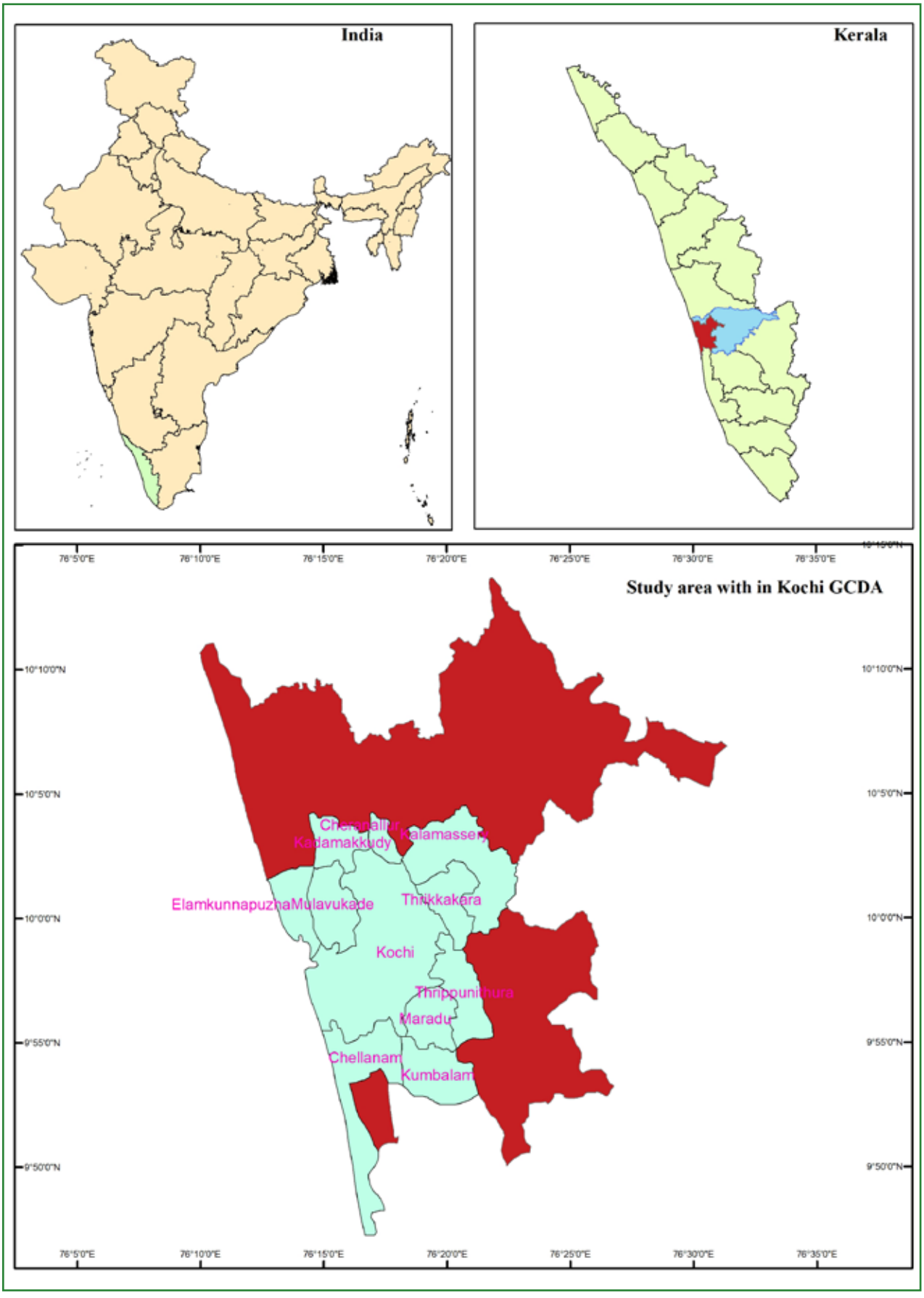
The study area which has been proposed was the area under Kochi Municipal Corporation only. The initial analysis has shown that the mangrove areas within Kochi Municipal Corporation are comparatively less. Pilot data collection which has been carried out for fine tuning the data collection tools have indicated the cross-border flow of ecosystem services of mangroves between Kochi Municipal Corporation and the neighbouring Panchayats. Considering this situation, the neighbouring Panchayats also have been included in the study area. The map of the study area is provided as Map1.

At present the study area includes Kochi Municipal Corporation and adjoining Panchayats – Chellanam Kumbalam Maradu, Thripunithura, Trhikkakkara, Kalamassery, Cheranallur, Kadamakkudy, Mulavukad and Elamkunnappuzha.

B. Socio Economic Data Collection

Detailed household level questionnaire survey had been planned to be conducted with in the three zones of the existing mangrove areas (with in 0.5 km, 1 km and 2 km radius). After spatially identifying the mangrove areas, the zonation has been attempted. Due to the spread of small patches of mangroves throughout the study area the zones around each patch were highly overlapping. The zonation has been carried out by also clustering the nearby mangrove patches were the results were again the same. Rather than colleting the data from different zones, it was decided to gather data from randomly selected mangrove patches falling in different size classes.

The ecosystem service dependence on mangroves has been discussed within the Technical Working Group. Considering the discussions and the initial survey, the community groups who depend on the mangrove patches for ecosystem services and dis-services have been grouped into Fishermen, Livestock Keepers, Rice Farmers and others. Separate questionnaires have been prepared for these stakeholders which has been fine-tuned by the TWG members. The questionnaires are available as Annexure 1. Three types of questionnaires have been designed for the household survey (Please see Annexure II for all the questionnaires) which include a general questionnaire for household details (demographic and socio economic details), separate questionnaire to gather data on the ecosystem services (for – fishermen (resident and migratory), bee keepers, private employees, livestock keepers, vacation residents / tourists, farmers (general farmers, rice farmers and rice and fish farmers), tour operators / homestay holders / farm tourism operators) and a questionnaire to gather the details on willingness to pay for ecosystem services.



Map 1: The Study Area

C. Detailed Methodology followed for Spatial Analysis

Mapping of the mangrove areas has been carried out for three years (2000, 2013 and 2017). The gain and loss of mangrove areas was also quantified for these three years. The land use classes which have been converted into mangroves and the land-use classes which have been converted from the mangroves were also identified during the mapping. The detailed results are as follows.

Step 1: Image selection

LISS IV images, appropriate for mapping the landuse were available for the area only from the year 2012 onwards. For mapping the mangrove patch status for the year 2000 a combination of Landsat VII ETM and PAN were used and for 2013 and 2017 status LIS IV were used. The details of the layers are available in Table 2. The images were selected based on the availability of the cloud free images for the area in the database.

Step 2: Layer stacking

Layer stacking is a process of combining multiple bands of a scene into a single image. Bands with same spatial resolution only used to perform layer stacking. In the present study the Green, Red and Near Infra Red Bands are used for the layer stacking process. The details of the satellite images used for the present research work are given below.

Table 2: Details of the Satellite Images used for Spatial Analysis

S. No.	Satellite	Sensor	Spatial Resolution	Date	Bands using
1	Landsat VII	ETM + PAN	30m / 15 m	26.10.2000	2, 3 & 4
2	Resourcesat 2	LISS IV	5.8 m	17.03.2013	1, 2 & 3
3	Resourcesat 2A	LISS IV	5.8 m	13.03.2017	1, 2 & 3

Step 3: Geometry correction

Image Geometry Correction is the process of digitally manipulating image data such that the image's projection precisely matches a specific projection surface or shape surface. In order to compare satellite image of different years needs to be geometrically corrected.

Standard image registration is carried out by tying together points on a target image and a reference image or map (known as Ground Control Points or GCPs). The transformation is a least squares solution of the form:

$$y = a_0 + a_1x^2 + ... + a_nx^n$$

This equation defines a **rubber sheet** surface used to overlay the image onto a map projection. The greater the number of points used to define the transformation, the more accurate the transformation is within the net of points. This is because the **rubber sheet** is tied more accurately to the map. (Note that parts of the image outside the net of points may be subject to wild errors). By selecting 3 - 4 points a linear transformation will be produced; 6 - 9 points a quadratic transformation; and 10 - 20 points a cubic transformation. The analyst carrying out the registration will aim to achieve RMS errors of less than +/- one pixel between the chosen target points and the predicted target points (as defined by the transformation itself).

Step 4: Pan Sharpening

"Pan Sharpening" is shorthand for "Panchromatic Sharpening". It means using a panchromatic (single band) image to "sharpen" a multispectral image. In this sense, to "sharpen" means to increase the spatial resolution of a multispectral image. Merging methods for utilising both the high resolution panchromatic and the multispectral images in a combined manner is one way of improving the methods for many remote sensing applications such as change detection, classification etc. The aim of the resolution merge is to achieve a maximal spatial detail augmentation and a minimal color distortion. In the present study Landsat image for the year 2000 was Pan Sharpened.

Step 5: Create subset image (clipping)

Clipping is the process by which a **subset** of the raster dataset is **created**. Clipping removes data outside the area of interest reducing the file size and improving the processing time for many operations. The image was subset using KMC boundary before the analysis.

Step 6: Visual image interpretation of the image

The image was visually interpreted based on visual interpretation elements and GPS points of the mangrove patches collected from the study area through ground truthing. During the digitizing process, features from the traced map or image are captured as coordinates as polygon format into four categories; Mangroves, Built up Areas, Water Body and other Mixed Landuses.

Step 7: Ground verification of the classification

All the mangrove patches which have been mapped were numbered and more than 40% of the patches were already verified on ground. Except in two locations the spatial data includes all the existing mangroves. The spatial analysis failed to map the mangrove areas where only *Avicennia officinalis* is present in small patches. All other mangrove patches have been covered in the map. The map can be confidently said as a conservative maping of the mangrove patches of the study area.

D. Ecosystem Service Evaluation

Ecosystem service evaluation of the mangrove patches was performed with the data collected from the field about the services which the local communities are availing from the mangrove patches. Separate questionnaire has been used for different user groups. In case of fisheries service the species of fishes in the catch of the local people has been listed out. Mangrove dependencies of the species has been identified from published documents. The proportion of benefit from the mangrove dependant species only has been considered for the estimation of ecosystem service value.

Technical Working Group

A Technical Working Group (TWG) has been constituted with 15 members in it. Professionals from International and National organizations, Scientists from Research and Development Institutions, Professors and Research Scholars from Universities and Other Academic Institutions, Legal Professionals practicing environment litigations and Environment Conservation Activists from the regions constitute the TWG. The members are selected from different age groups – with a vision to get guidance and continue the efforts initiated by the project across deferent ecosystems and regions. The list of the members is available in table 3.

Table 3: List of Technical Working Group Members

No.	Name	Designation	Organization
1	Dr. Dhanya Radhamani	Assistant. Professor	Malayalam University
2	Harish Vasudevan	Advocate	Self
3	Dr. John Samuel	Adviser	UNDP
4	Dr. Priyadarsanan Dharmarajan	Fellow	Ashoka Trust for Research in Ecology and Environment
5	Purushan Eloor	Activist	
6	Rashmi Mahajan	Ph.D. Scholar	Ashoka Trust for Research in Ecology and Environment
7	Dr. Shijo Joseph	Scientist	Kerala Forest Research Institute
8	Dr. T V Sajeev	Scientist	Kerala Forest Research Institute
9	Nachiket Kelkar	Ph.D. Scholar	Ashoka Trust for Research in Ecology and Environment
10	Dr. Soubadra Devy	Fellow	Ashoka Trust for Research in Ecology and Environment
11	Raj Bhagat	GIS Expert	WRI India
12	Dr.C M Joy	Retired Professor	Sacred Hearts College, Thevara
13	Ramith M	Manager	Wildlife Trust of India
14	Dr. Smitha Krishnan	Post-Doc Scholar	Ashoka Trust for Research in Ecology and Environment
15	Ashkar Khader	Advocate	Self Employed
16	Dr. C. Rajan	Director	Centre for Heritage, Environment and Development

The first meeting of the Technical Working Group was carried out on February 29th 2019 at Kochi. The detailed proceedings of the meeting are attached as Annexure 2.

Status and Temporal Changes of the Mangrove Patches in the Urban and Peri-Urban Areas of Kochi Municipal Corporation

The spatial analysis classified the study area into four land use classes. Mangroves, Water bodies, Built-up areas and Mixed Cropping with built-up areas. Bulit-up areas are the distinct buildings and the mixed cropping with built-up areas are the buildings mixed with vegetation. The study area included Kochi Municipal Corporation (KMC) and adjoining Panchayats – Chellanam Kumbalam Maradu, Thripunithura, Trhikkakkara, Kalamassery, Cheranallur, Kadamakkudy, Mulavukad and Elamkunnappuzha. Out of these administrative units no mangrove patches were found in the Panchayats of Kalamassery, Thrikkakara and Cheranallor.

Mangrove Distribution Across the Study area

As on 2017, total minimum area of 3.47 km^2 of mangroves has been identified in the study area with hundred percent confidence level. All the areas identified by the spatial analysis are mangrove patches and some very small mangrove patches would have missed out to be marked through the analysis, which will not be more than 10 percent of the total area identified. Mulavukadu Panchayat has the highest mangrove area (2,015 ha) and Kadamakudy Panchayat has the lowest mangrove area (28 ha). Kochi Municipal Corporation encompasses 57 ha of mangrove area.

These mangrove areas in the study area are spread across 702 individual patches. Majority of the patches range between an area of 0.1 – 0.5 ha (298 patches) and 273 patches are of less than 0.1 ha size. There are only nine patches in the study area which have more than 5 ha patch size. The number of patches which have sizes between 0.5 ha to 1 ha and 1 ha to 5 ha are more or less the same (60 and 62, respectively). The number of patches of mangroves in each panchayat and KMC along with the patch size are given in Table 4.

Table 4: Mangrove patches and patch size in the study area

Panchayat/Corporation	Mangrove patches - number and size					
	< 0.1 Ha	0.1 - 0.5 ha	0.5 - 1 ha	1 -5 ha	> 5 ha	Total
Chellanam	53	67	12	14	2	148
Elamkunnapuzha	54	42	16	22	3	137
Kadamakudy	16	11		1	0	28
Kochi Municipal Corporation	21	23	6	5	2	57
Kumbalam	10	22	4	4	0	40
Maradu	11	17	7	7	1	43
Mulavukadu	89	101	12	3	0	205
Thrippunithura	19	15	3	6	1	44
Total	**273**	**298**	**60**	**62**	**9**	**702**

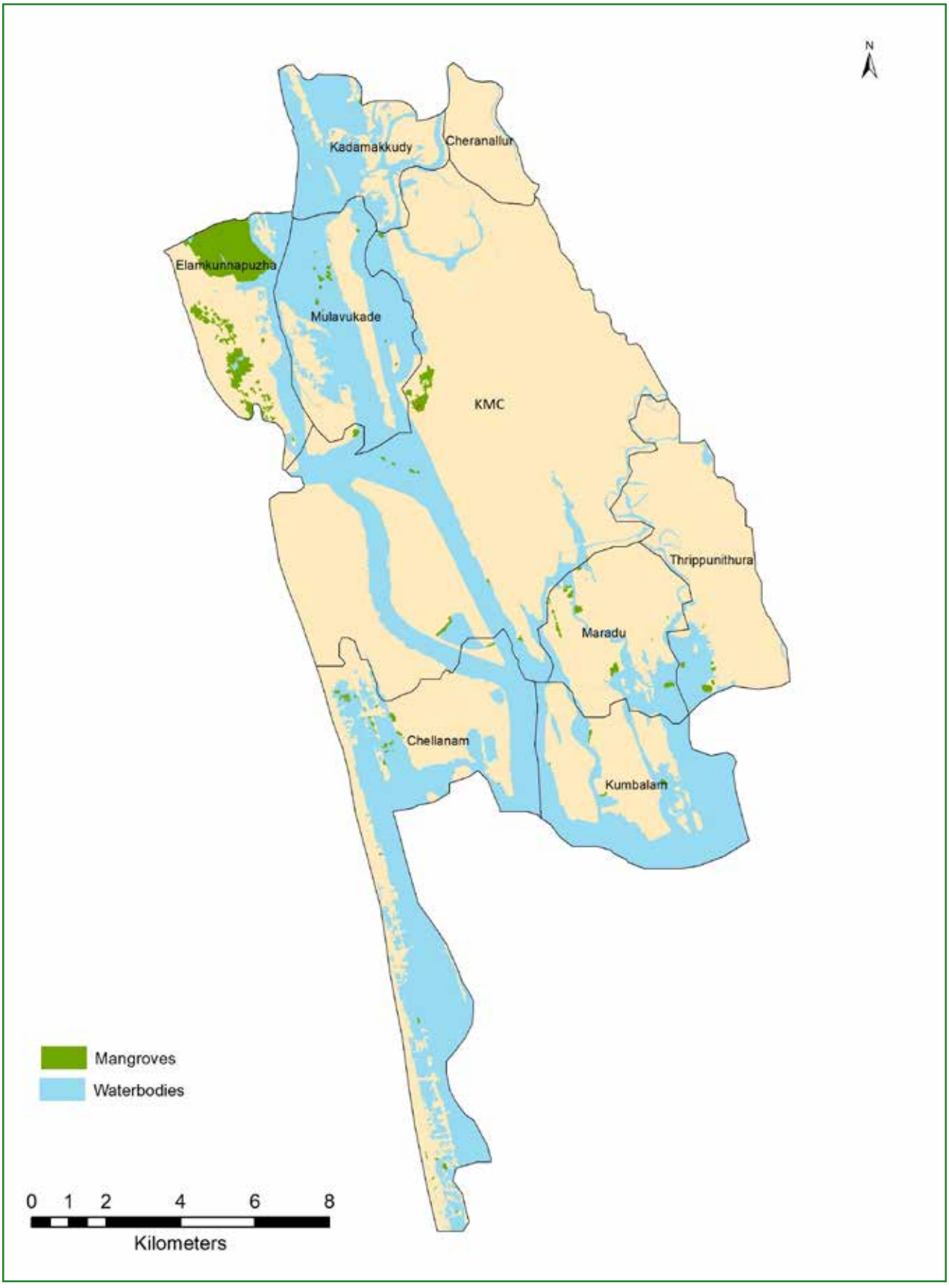
Temporal Changes in the Mangrove Areas

Mangrove distribution maps of the study area for the years 2000, 2013 and 2017 have been prepared. A total of 4.56 km^2 of mangrove areas have been identified in the study area during the year 2000, which has been subsequently reduced to 4.03 km^2 by 2013 and further reduced to 3.47 km^2 by 2017 (Table 5 and Map 2).

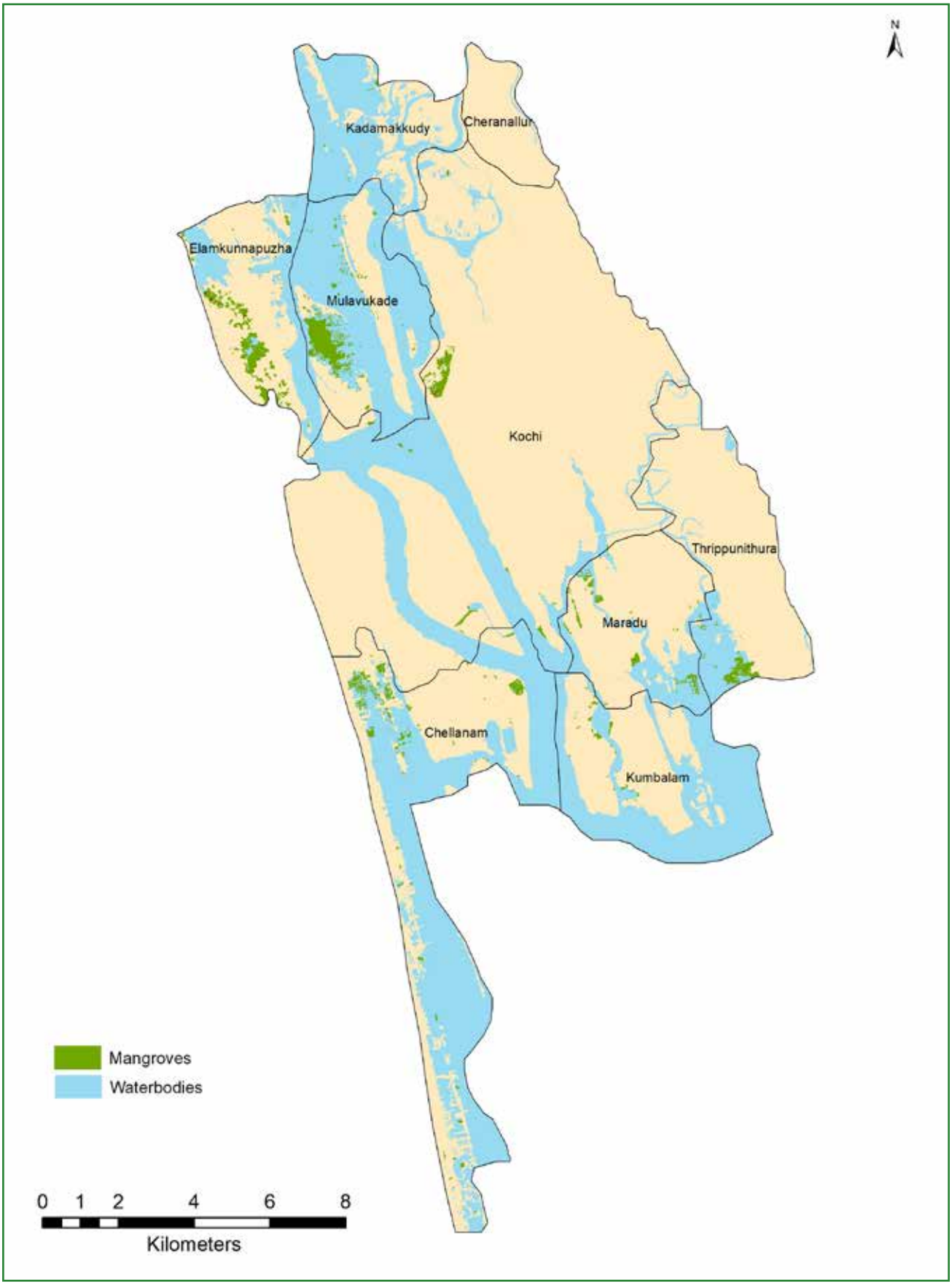
Table 5: Time series changes in the land-use classes of the study area

Sl. No.	Land use type	Area (km^2)		
		2000	2013	2017
1	Mangroves	4.56	4.03	3.47
2	Built-up area	0.005	0.02	0.02
3	Waterbodies	75.36	75.80	81.38
4	Mixed cropping with built-up	143.93	144	138.99
Total Area		**223.86**	**223.86**	**223.86**

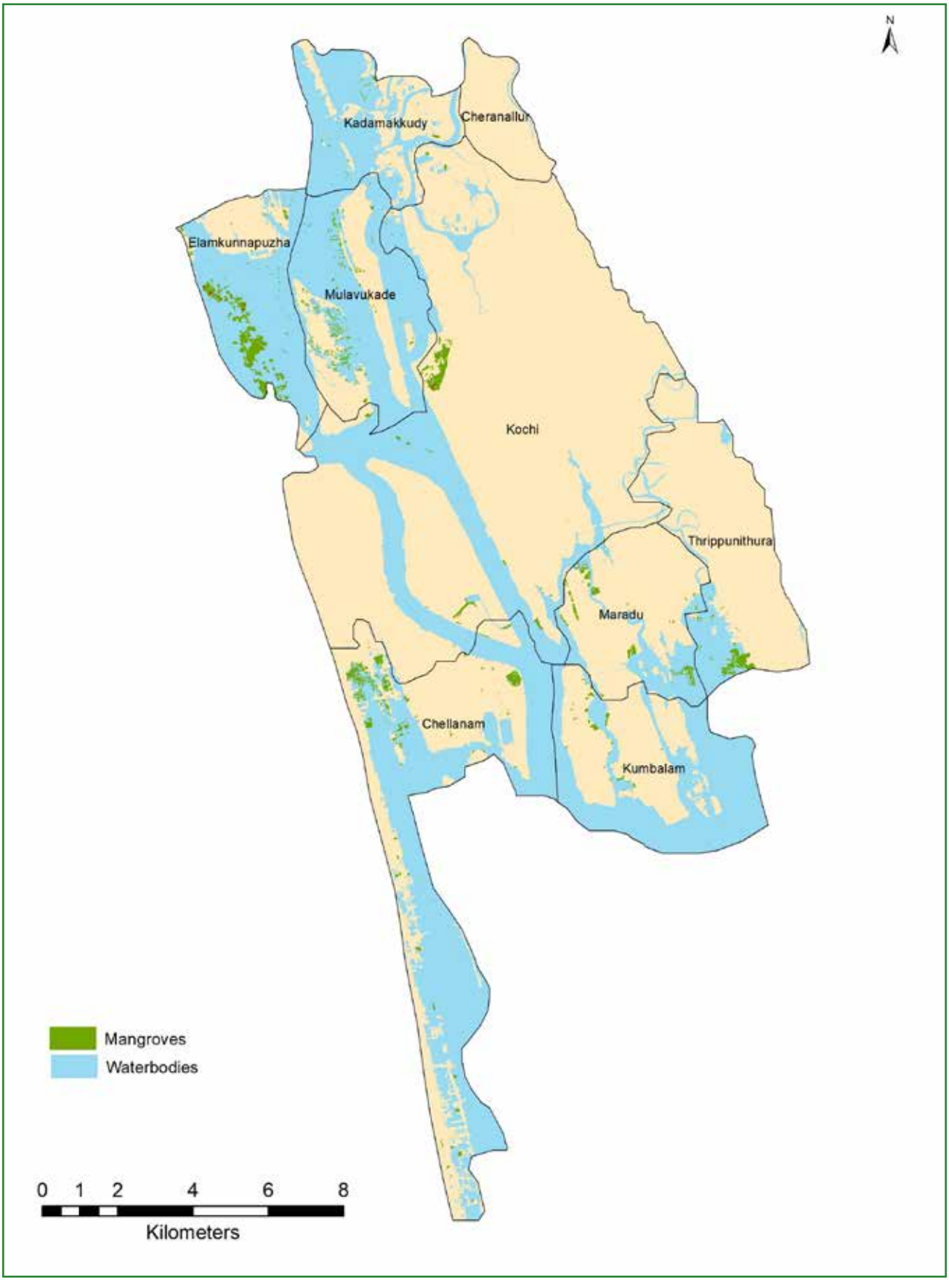
Overall, there was a decline of 24 percent mangrove areas in the study area between years 2000 and 2017 (11% decline between 2000-2017 and 14% decline between 2013 and 2017). This overall figure does not give the real picture of the change. A detailed analysis of the dynamics between these three land-use classes during these two-time gaps will reveal the severity of the issue (Table 6). Between 2000 and 2013, more than 2.8 km^2 of the mangrove areas have been converted to other land uses and slightly more than 2.3 km^2 of other land-uses were converted into mangroves. This shows the drastic loss of mangrove habitats in the study area and same time establishment of more mangrove areas as well. Between 2000 and 2017, 3.58 km^2 of mangroves which translates to more than 78 percent of the total mangrove areas of 2000 has been converted into some other land uses. At the same time new mangrove areas which translates to 2.5 km^2 has been newly established in the study area.



Map 2: Mangrove patches in year 2000



Map 3: Mangrove patches in year 2013



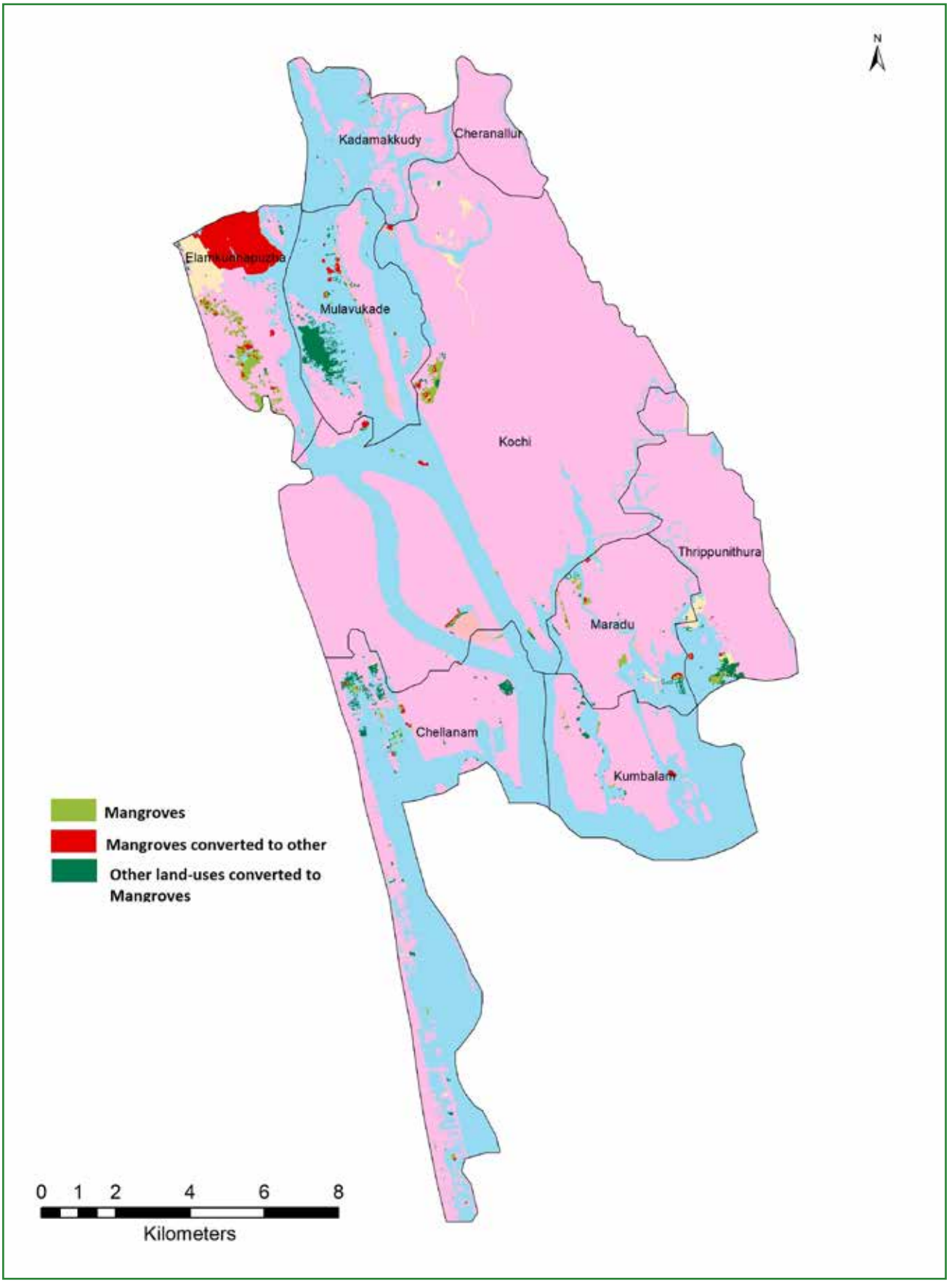
Map 4: Mangrove patches in year 2017

Table 6: Changes in the mangrove areas in Kochi Municipal Corporation

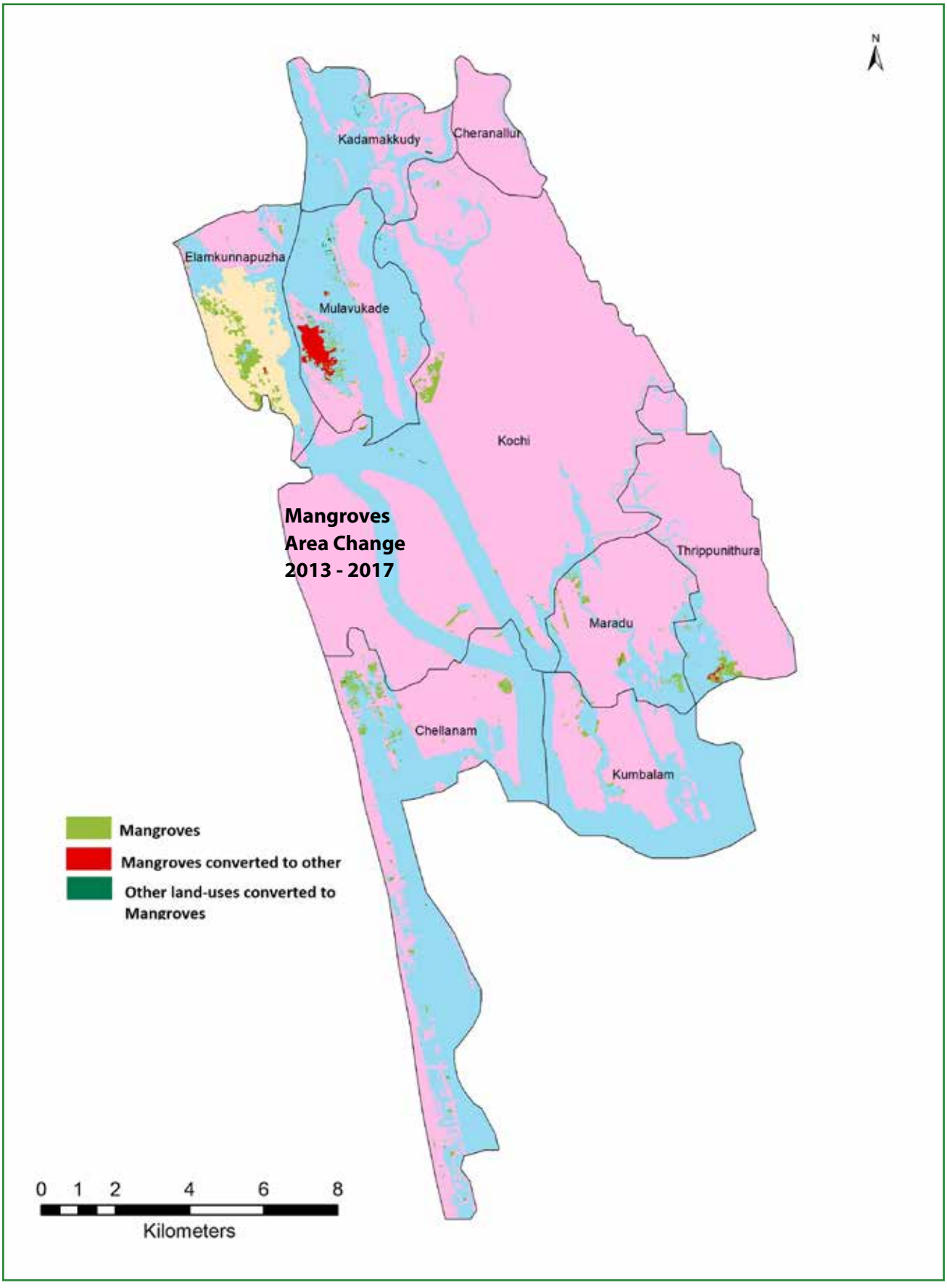
Type of change	Land Use/ Land Cover Change	Area (km^2)		
		2000 -2013	2013 -17	Total
Maintained	Mangroves	1.734	3.278	
Loss	Mangroves to Built-up areas	0.012	0	0.012
	Mangroves to Water Bodies	0.305	0.071	0.376
	Mangroves to Mixed land use	2.513	0.687	3.2
Gain	Water Bodies to Mangroves	0.821	0.097	0.918
	Mixed Land use to Mangroves	1.482	0.092	1.574

Majority of the mangrove conversion between the years 2000 and 2013 happened in Elamkunnappuzha Panchayat, whereas between the years 2013 and 2017 the converted areas were higher in Mulavukadu Panchayat. A good amount of the mangroves which got destroyed in Mulavukad Panchayat between the years 2013 and 2017 were the ones that had established between 2000 and 2013.

Most of the mangrove areas have been converted into mixed land uses which include built-up areas and other cultivation etc. Similarly, more than 1.5 km^2 of this land-use has been converted into mangroves. Near to 1 km^2 of the water bodies also got converted into mangroves during the years between 2000 and 2017.



Map 5: Areas of mangrove conversion in the study area (2000 - 2013)



Map 6: Areas of mangrove conversion in the study area (2013 - 2017)

Visible Ecological Impacts of Mangrove Land-use Changes

Serious long-term observations are required to identify the ecological impacts of the land-cover changes, especially the mangroves. The study could identify some ecological imbalances in the mangrove areas, which may be possible due to the large-scale destruction of mangrove areas together with the conversion of other land uses into mangroves.

IUCN Red List (2008) assessed the population of *Kandelia candal* L.Druce and *Rhizophora apiculata* as decreasing, with threats from residential and commercial development, agriculture and aquaculture, biological resource use and climate change and severe weather. However, the status of these species is 'Least Concern' as they are distributed from the Western Ghats to eastwards until Indonesia. According to IUCN experts, these species are common within the range, but becomes 'more rare' at the extremities of its range. For example In Sumatra, *Kandelia candal* is considered rare. In India, it was found in 36% of 100 sampling sites, and is considered to be rare in the Nicobar and Andaman Islands (Kathiresan, 2008). This species is common along the western coast and in Orissa and Sundarbans off the eastern coast (IUCN 2010 version 3.1).[18]

Kandelia candal (known as 'koorkkakandal' in Malayalam) is identified as a true mangrove which is confined to salty-marshy environment along backwaters[19]. Preethy *et al*, 2010[20] recorded the species as common in Valanthakkad. This has been also reported as frequent in Kannur and Kozhikode districts[21]. Mr. K.A. Itoop, a mangrove enthusiast has found this species also in Kumbalangi village in 2005[22]. An extensive survey of three months associated with this study could find only six trees in Valanthakkad, an island in Ernakulam district. The entire island is facing evacuation and mangrove conversion for real estate development. Every ecosystem has different successional stages of establishment during which different types of species gets established. In a situation where more than 78 percent of the mangrove areas have been converted into other landuses in the study area, the rarity in sightings of mangroves species like *Kandelia candal* can be an impact of such drastic landuse changes.

Figure 1: Pictures of Kandelia candal from Valanthakkad[23]

18. https://portals.iucn.org/library/node/10315
19. Surya S and Hari N. 2018. International Journal of advanced and Innovative Research (2278-7844)/7(6):1-15
20. Preethy CM, Varghese R and Nandan S.B. (2010). A baseline study on the distribution of mangroves in and around Ernakulam, Kerala. Lake 2010:Wetlands,Biodiversity and Climate change at Centre for Ecological Sciences, IISC
21. Vidyasagaran, K. and Madhusoodanan, V. K. (2014). Distribution and plant diversity of mangroves in the west coast of Kerala, India. Journal of Biodiversity and Environmental Sciences. 4: 38-45.
22. https://www.thehindu.com/2005/12/29/stories/2005122900960200.htm
23. Photos Jis Sebastian

Figure 2: A picture of Mangrove Patch Valanthakkadu[24]

24. Photo Jayahari KM

Relationship Between the Socio-Economic Profile of the Consumers of Ecosystem Service Disservices from Mangroves and the Conservation of Mangroves

The household survey included questions to gauge the understanding of the people from different socio-economic backgrounds on the significance of mangroves and also their approach towards mangrove conservation. The nature of primary livelihood of the households, educational status, gender of the respondents were considered as the parameters defining the social status of the respondents.

Awareness of Households with Different Primary Livelihood Source about the Ecosystem Service Significance of Mangroves

Primary livelihood of the households is provided in Table 7.

Table 7: The details of primary livelihood of the household surveyed in each Panchayats and KMC

Panchayats / Corporation	Fishing	Daily Wage Labour	Govt. / Private employee	Business	Farming & Livestock Keeping	Jobless / Not revealed	Total
Chellanam	24	23	3		7	5	62
Elamkunnapuzha	11	6	6			2	25
Kadamakudy	1	1	0		1	1	4
KMC	24	9	4	3	2	5	47
Kumbalam	9	4	9	1	2	4	29
Maradu	20	2	5	1		2	30
Mulavukadu	5	5	5		1	3	19
Thrippunithura	2	6	3		1	3	15
Cheranallur	5	7	5			1	18
Total	**101**	**63**	**40**	**5**	**14**	**26**	**249**

The employment categories of the respondents fell under six major classes – Fishing, Daily wage, Government / Private employees, Business, Farming, Livestock keepers and Jobless people. Highest number of households surveyed had fishing as their primary livelihood (41%) which was followed by daily wage labour (25%). Government and private employees constituted 16% of the sample and jobless or job not revealed class comprised of 10 %. Farming and livestock keepers were poorly represented in the data with 6% of the sample and self-employed or business people were the lowest representation with 2%. For the data analysis purpose these employment classes have been further reduced to three – Fishing, Farm/ Livestock keepers, Government or Private Employee and other categories.

The awareness of the community about the ecosystem service benefits of the mangroves was tested through a question whether they understand that the mangroves are beneficial to them through any ecosystem services. 60 to 86 percent of all categories of respondents said yes to the question. The highest percentage was from the group of farmers and livestock keepers (Table 8).

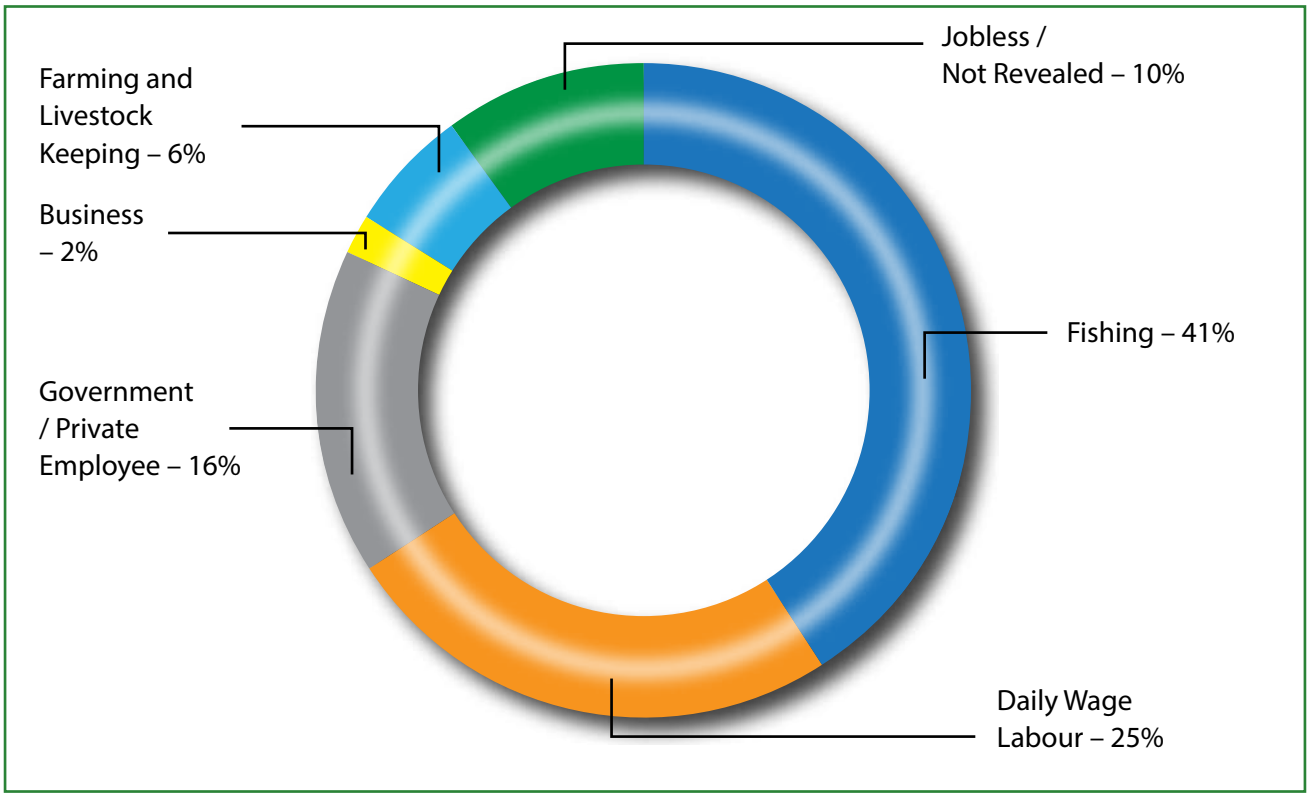
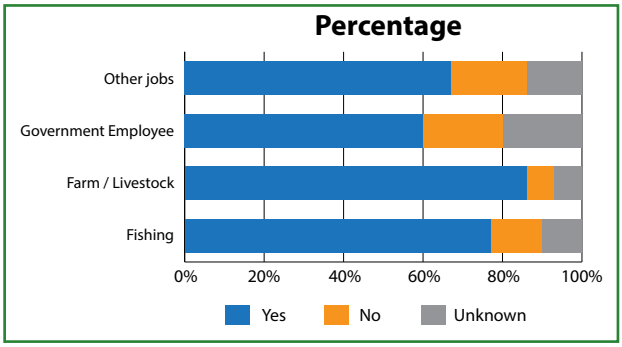


Chart 1: Primary livelihood of the households surveyed (percent)

Table 8: Awareness of households about the benefits of mangroves to human beings

Absolute Number			
Occupation	**Yes**	**No**	**Unknown**
Fishing	77	13	10
Farm / Livestock	86	7	7
Government Employee	60	20	20
Other jobs	67	19	14



The uncertainty and lack of awareness of the benefits of mangroves was comparatively higher among the group of people who are permanently employed in government of private sector. Among the households where the primary income sources are directly from the ecosystems (fishes, agriculture and livestock), the awareness among the benefits of mangroves was higher.

Households were probed with questions about specific ecosystem services from mangroves. The answers can be classified into five categories – aware and benefitted, aware but not benefitted, not aware about the benefits, believes no benefits available and not responded to the question. The responses of the households against the questions regarding different ecosystem services are as provided in Tables 9 – 14 and charts 2 – 7. For an easy representation these categories are coded as follows in the charts and tables: aware and benefitted (A&B), aware but not benefitted (A&nB), not aware about the benefits (NA), believes no benefits available (NB) and not responded to the question (Nil).

Awareness about Fisheries Benefits from Mangroves

Table 9: Number of people in different livelihood class and their level of awareness on fisheries benefits from mangrove

Primary livelihood	A&B	A&nB	NA	NB	Nil
Fishing	68	11	12	11	4
Farm/Livestock	7	2	0	3	2
Government Employee	1	4	3	1	1
Other jobs	41	31	30	9	8

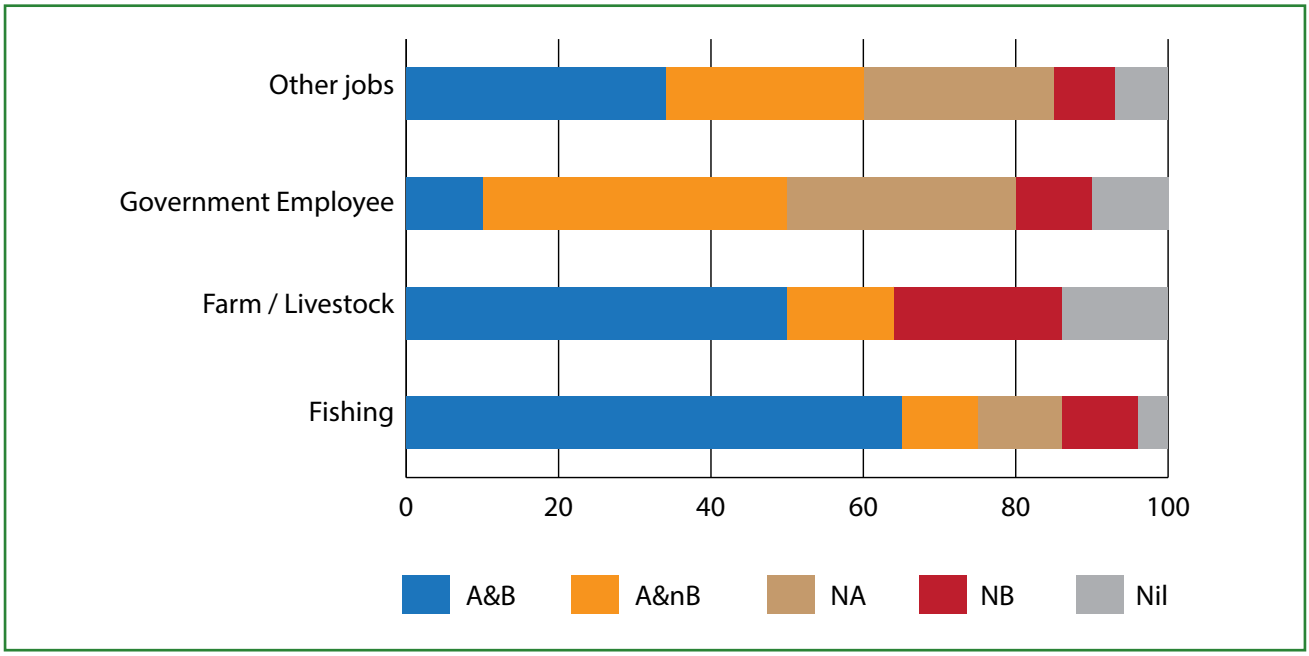


Chart 2: Percentage of people in different livelihood class and their level of awareness on fisheries benefits from mangrove

Awareness about Reducing Climate Change Risks Benefits from Mangroves

Table 10: Number of people in different livelihood class and their level of awareness about reducing climate change risks

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	52	4	27	4	19
Farm/Livestock	7	0	3	2	2
Government Employee	4	1	4	0	1
Other jobs	61	1	35	0	22

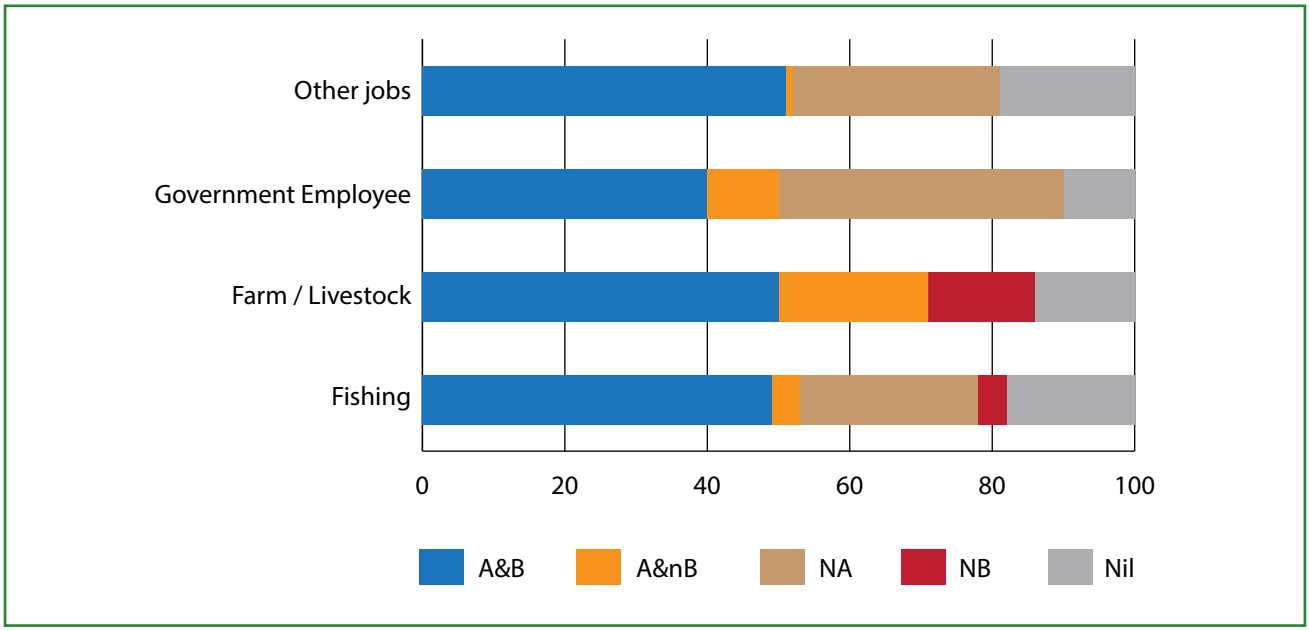


Chart 3: Percentage of people in different livelihood class and their level of awareness of reducing climate change risks

Awareness about Regulation of Wind Speed by Mangroves

Table 11: Number of people in different livelihood class and their level of awareness about regulation of wind speed

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	81	9	9	3	4
Farm/Livestock	11	1	1	1	0
Government Employee	7	1	2	0	0
Other jobs	92	5	15	1	6

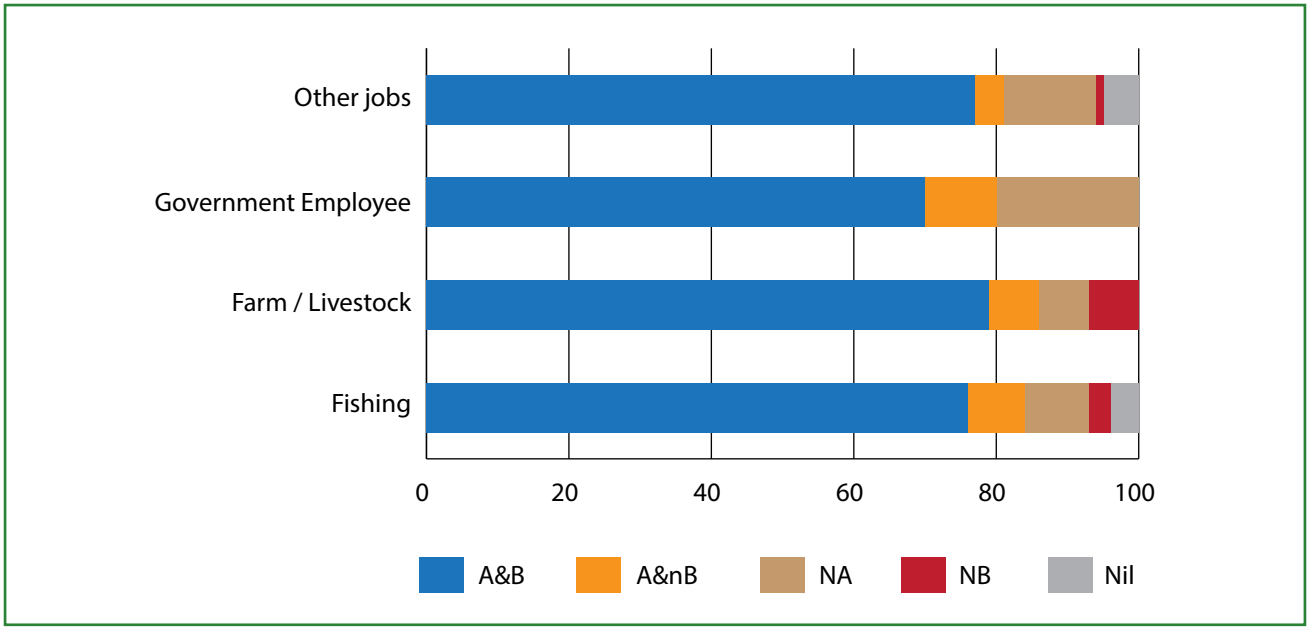


Chart 4: Percentage of people in different livelihood class and their level of awareness about regulation of wind speed

Awareness about Biodiversity Significance of Mangroves

Table 12: Number of people in different livelihood class and their level of awareness on biodiversity significance of mangroves

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	57	20	15	4	10
Farm/Livestock	8	3	0	2	1
Government Employee	2	4	4	0	0
Other jobs	67	17	22	4	9

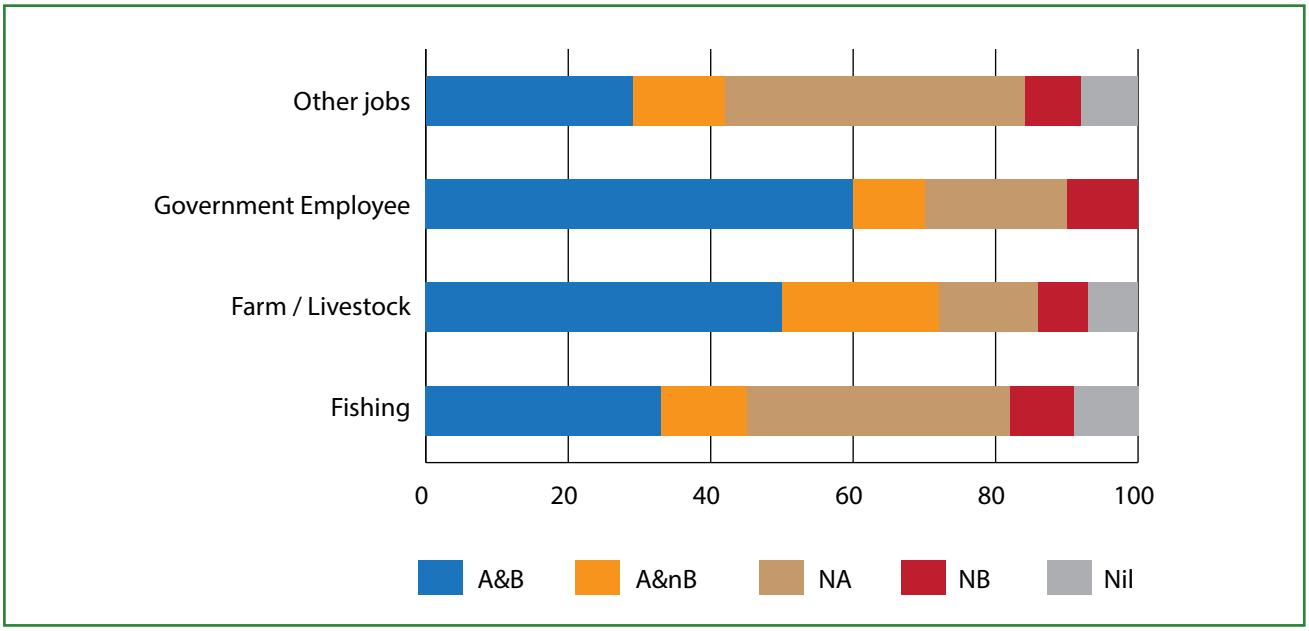


Chart 5: Percentage of people in different livelihood class and their level of awareness on biodiversity significance of mangroves

Awareness about Protection from Sea Level Rise (Tsunami and Strong Waves) from Mangroves

Table 13: Number of people in different livelihood class and their level of awareness of protection from sea level rise

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	15	2	70	4	15
Farm/Livestock	3	0	8	0	3
Government Employee	1	1	6	0	2
Other jobs	17	0	83	0	19

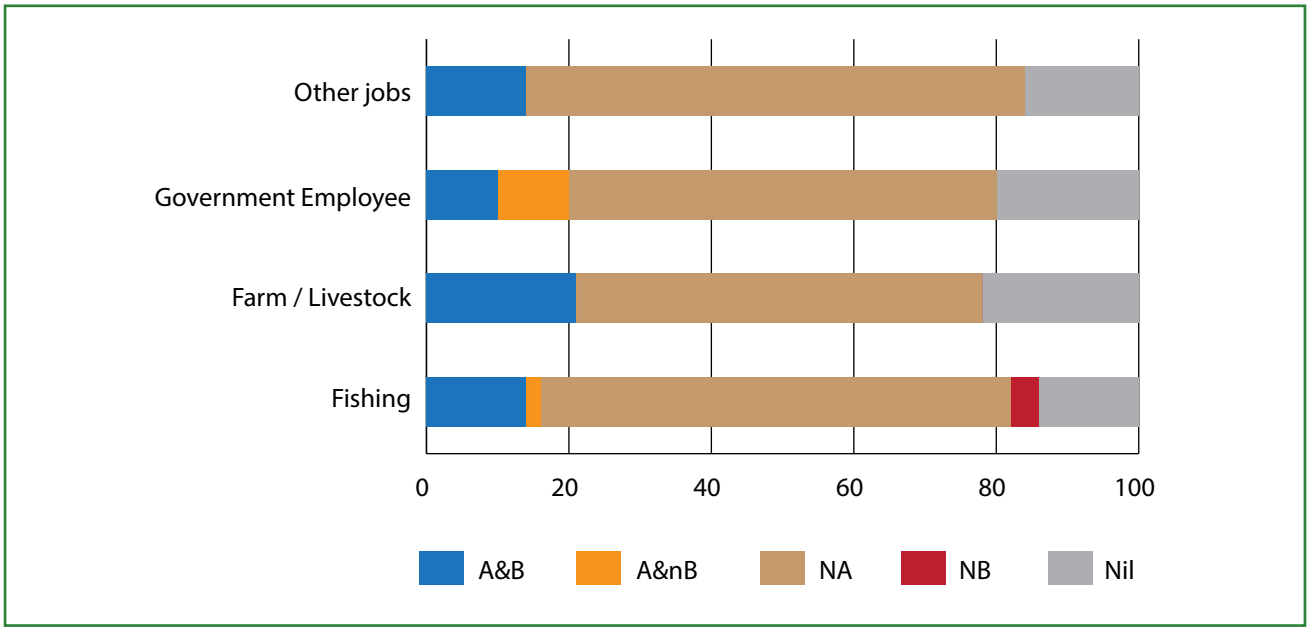


Chart 6: Percentage of people in different livelihood class and their level of awareness of protection from sea level rise

Awareness about Flood Control Benefits from Mangroves

Table 14: Number of people in different livelihood class and their level of awareness on flood control by mangroves

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	35	13	39	9	10
Farm/Livestock	7	3	2	1	1
Government Employee	6	1	2	1	0
Other jobs	34	16	50	10	9

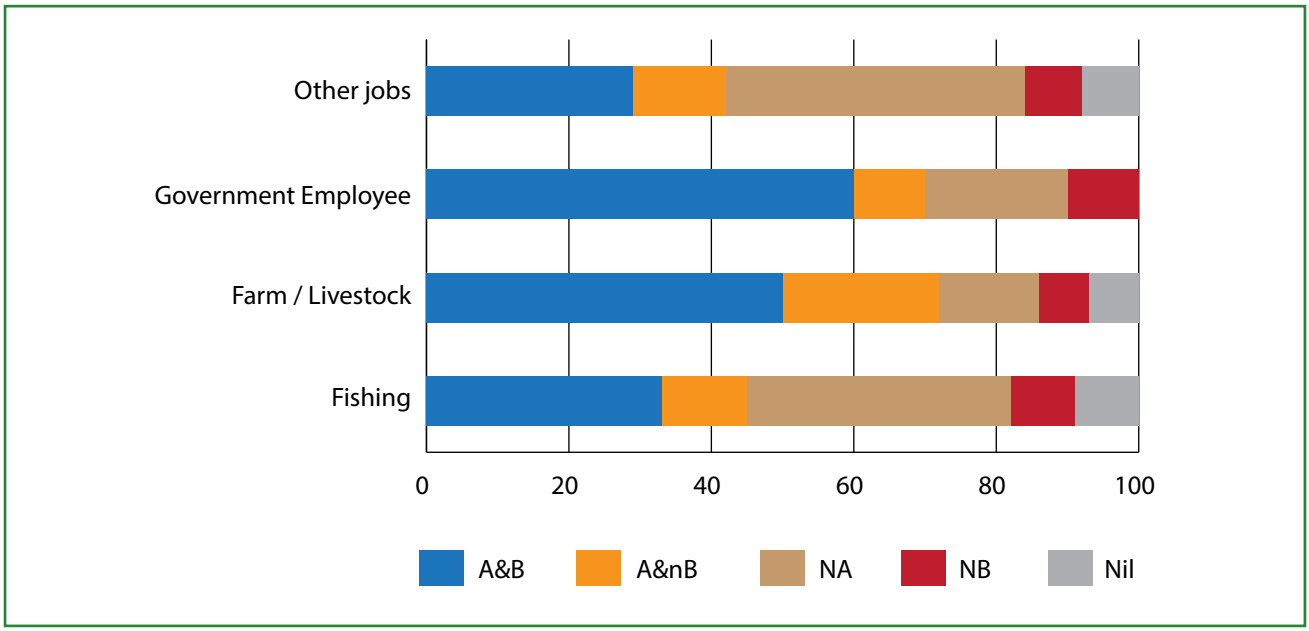


Chart 7: Percentage of people in different livelihood class and their level of awareness on flood control by mangroves

Awareness about Recreational / Tourism Benefits from Mangroves

Table 15: Number of people in different livelihood class and their level of awareness on tourism benefits from mangroves

Primary Livelihood	A&B	A&nB	NA	NB	Nil
Fishing	15	32	42	3	14
Farm/Livestock	4	5	4	0	1
Government Employee	1	3	6	0	0
Other jobs	13	36	54	2	14

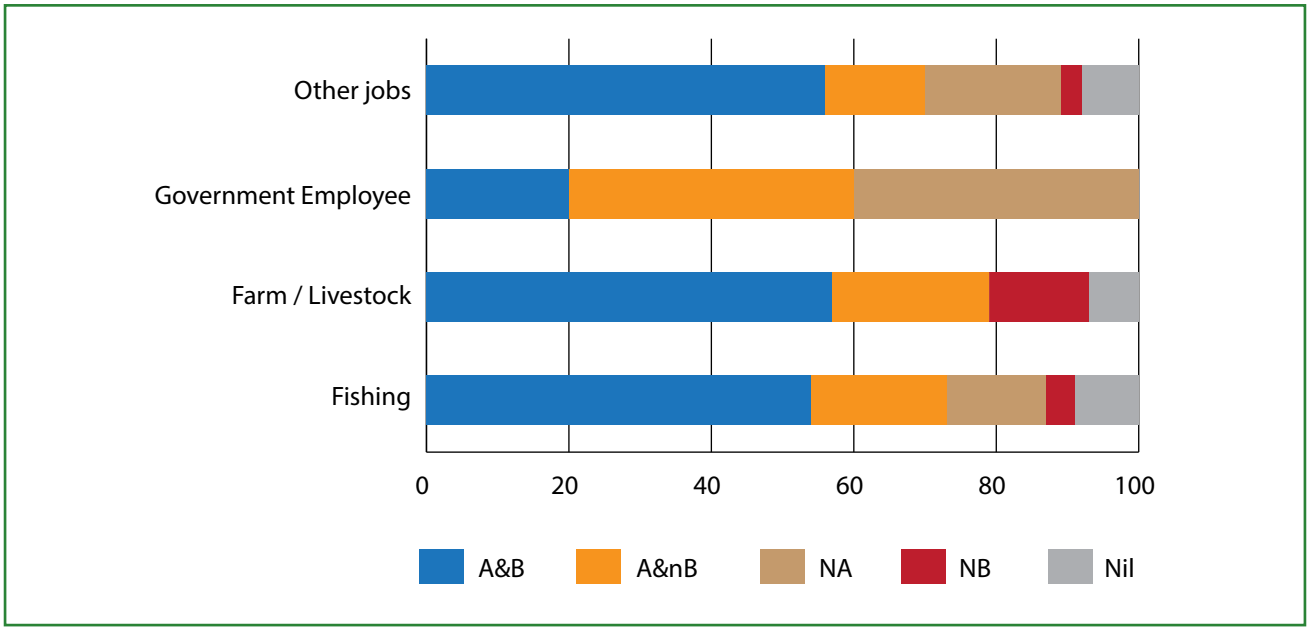


Chart 8: Percentage of people in different livelihood class and their level of awareness on tourism benefits from mangroves

Questions were asked to test the awareness level of seven ecosystem services specifically vis – fisheries, climate buffering, sea level rise regulation (tsunami and strong waves), flood control, regulation of wind speed, biodiversity and recreation or tourism benefits. Considering that the answers – aware and benefitted and aware and not benefitted as good understanding about the significance of the ecosystem services, a comparison of the awareness levels of each livelihood class is given in Tables 8 - 15.

The ecosystem service which is recognised by most of the respondent households across the different livelihood classes is wind speed regulation. The coastal areas experience strong wind which regulated by thick patches of mangroves. This service is known to minimum 80 percent of people across all the livelihood classes. Sea level rise regulation (protection from strong waves and tsunami) is the service which is least known among respondents across all the livelihoods.

Fishermen community perceives significance of mangroves in case of five ecosystem services out of the tested seven. Government and private employees have lowest percent of responses with good understanding about the ecosystem service significance of mangroves in case of five ecosystem services out of seven probed. The results are summarised in Table 16 and Chart 9.

Table 16: Percentage of responses with good understanding about the ecosystem service significance of mangroves.

Primary Livelihood	Fisheries	Climate Buffering	Sea Level Rise Regulation	Flood Control	Wind Speed Regulation	Biodiversity	Recreational Benefits
Fishing	75	53	16	45	84	73	44
Farm/Livestock	64	50	21	72	86	79	64
Government/ Private Employee	50	50	20	70	80	60	40
Other jobs	60	52	14	42	81	70	41

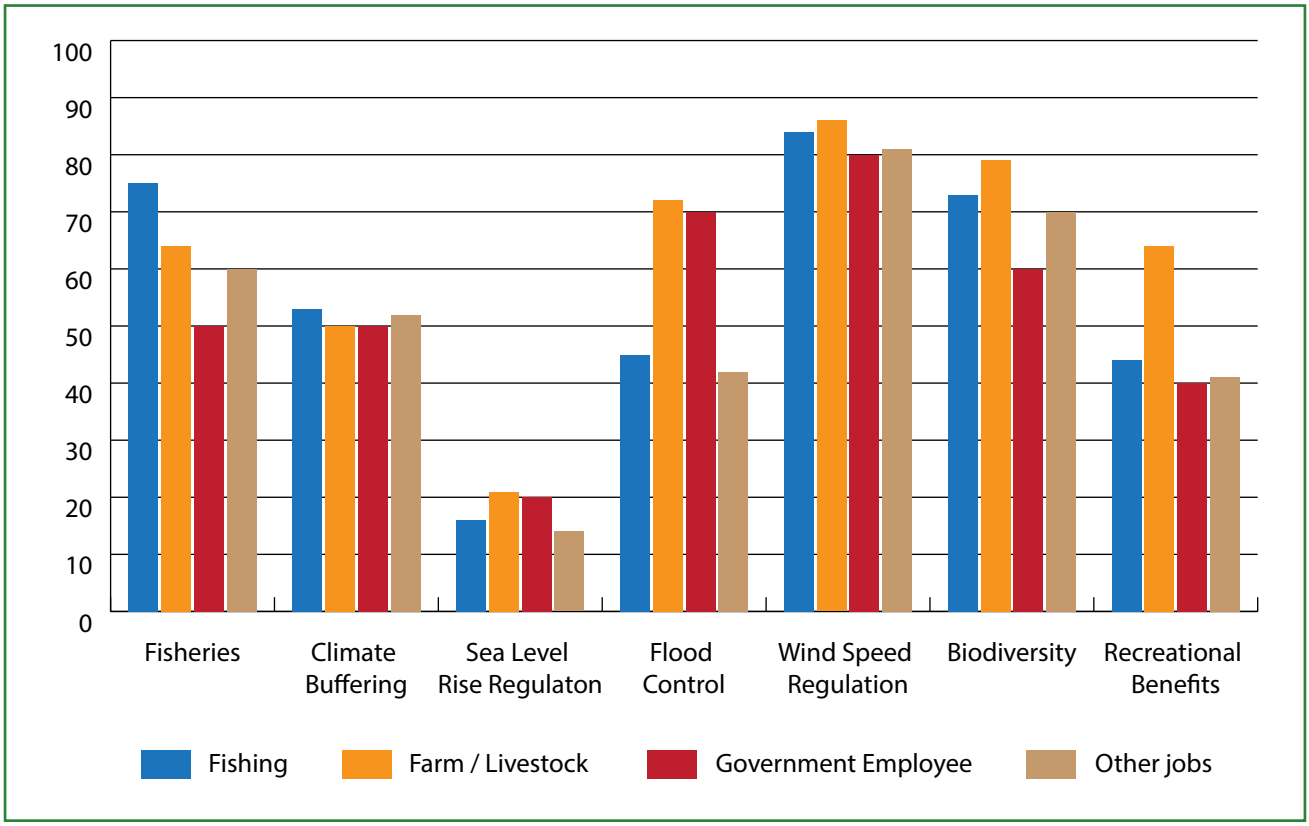


Chart 9: Percentage of responses with good understanding about the ecosystem service significance of mangroves

The Gender Angle with Regard to Awareness about the Ecosystem Service Significance of Mangroves

Similar to the case of households' classification based on the primary income source, awareness about the four ecosystem services provided by mangroves was analysed based on the gender of the respondents. The responses against the questions regarding different ecosystem services are as provided in Table 17 and Chart 10. For an easy representation these categories are coded as follows in the charts and tables. aware and benefitted (A&B), aware but not benefitted (A&nB), not aware about the benefits (NA), believes no benefits available (NB) and not responded to the question (Nil). Except in case of significance of mangroves for providing firewood, for all other ecosystem services, women showed less awareness than men.

Table 17: Number of responses with good understanding about the ecosystem service significance of mangroves among men and women

Gender	Fisheries	Sea level rise regulation	Fuel Wood	Wind speed regulation
Men	14	16	52	84
Women	10	11	45	80

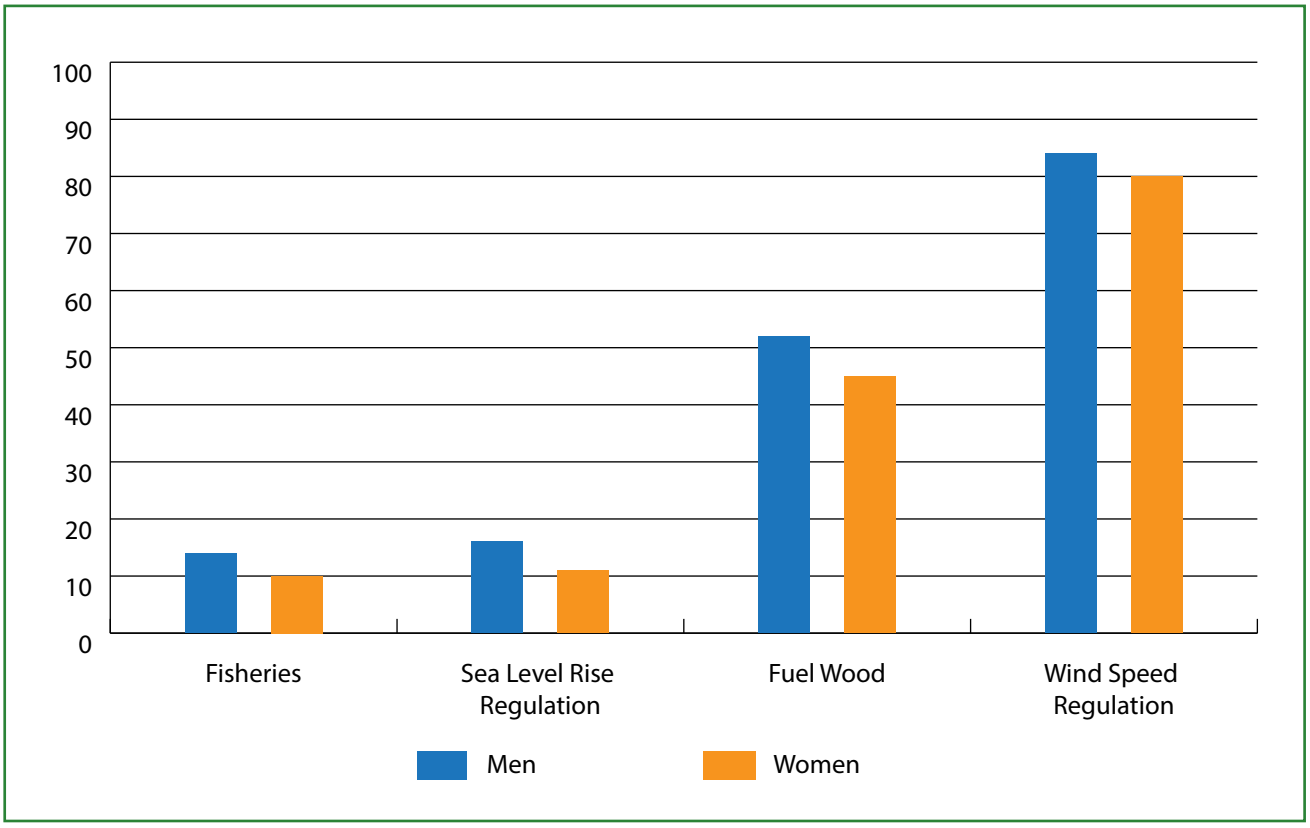


Chart 10: Percentage of responses with good understanding about the ecosystem service significance of mangroves among men and women

The Role of Education on Awareness about the Ecosystem Service Significance of Mangroves

Based on the education levels of the respondents, three parameters were comparatively tested – Willingness to conserve mangroves, Whether the loss of mangroves will have an impact on their day to day life, Reasons for conserving mangroves and readiness to move from the present settlement to anywhere for development. These questions were carefully selected in the backdrop of the developmental scenario in Kochi. Willingness to conserve mangroves tests the general approach towards mangroves and the reasons to conserve aim to identify how strong are the conservation drivers. In order to check the awareness of the community about the temporal changes in mangrove distribution in the area, a question was included about their perception of the temporal changes in the extent of mangroves.

Similarly, the willingness to move from the present settlement for development was used as an indicator to understand the intensity of their conservation interests.

Out of the 249 households surveyed, 61 percent of the respondents were educated till primary school level. Only 5 percent had educational qualification of graduation or above (Chart 11). A few people were not ready to reveal their education levels.

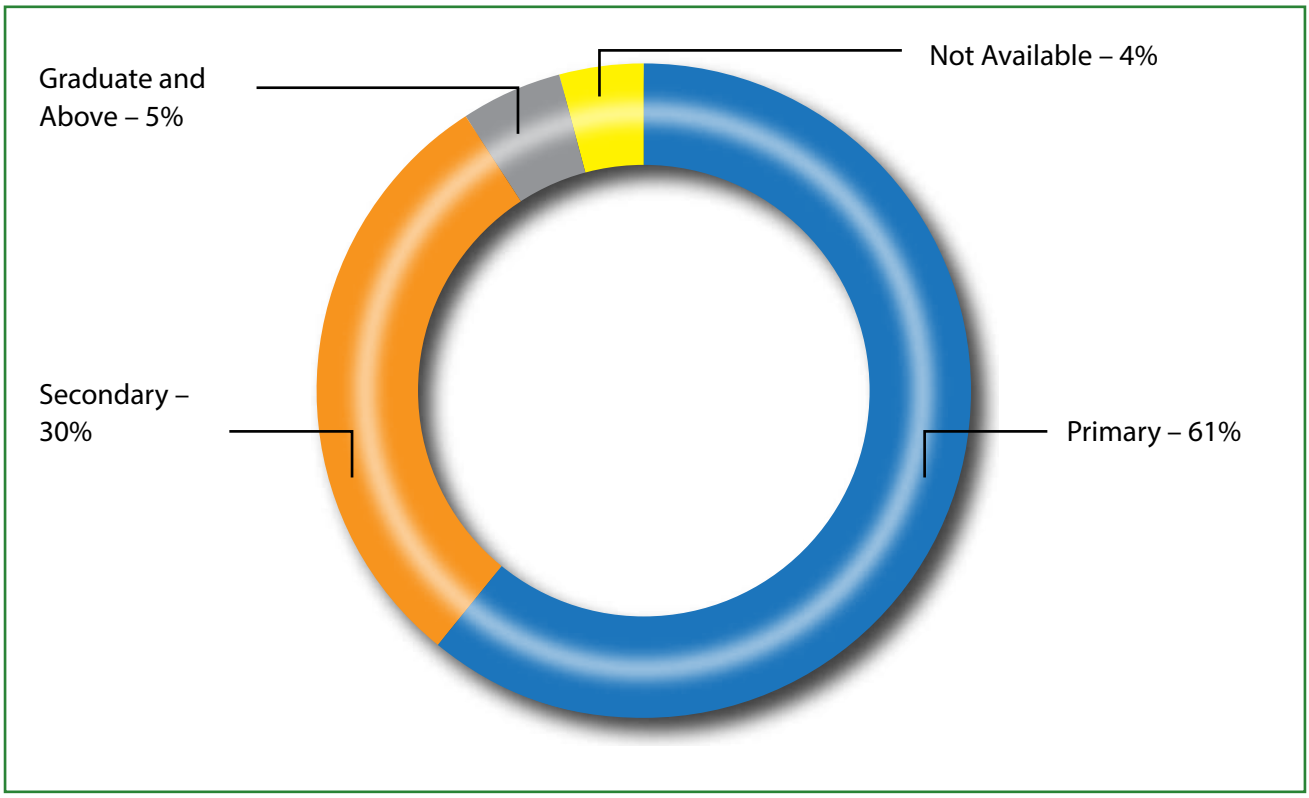


Chart 11: Education levels of the primary respondents of households surveyed

Surprisingly as shown in Table 18, lowest percent of responses for conservation of mangroves came from those respondents who were educated till graduation or above. Comparatively secondary school educated respondent group has shown higher percent of opinion in favour of mangrove conservation.

Table 18: Percent of responses towards the necessity for conservation of mangroves across respondents with different levels of educational background

Education Levels	Yes	No	No Opinion
Primary	68	29	3
Secondary	74	23	3
Graduate and above	50	50	0
Not available	60	40	0

The respondents were probed with questions regarding the priority reason for mangrove conservation. More or less equal number of responses were secured for livelihood security (N=29), climate resilience (N=24), prevention of soil erosion (N=29) and biodiversity conservation (N=24). Prevention of soil erosion and livelihood security were the reasons prioritised by the respondents. Respondents with primary education prioritised livelihood security and prevention of soil erosion, whereas respondents with secondary education prioritised livelihood security and climate change resilience. Graduate level respondents prioritised prevention of soil erosion. None of the respondents who are graduates or have higher educational qualifications have prioritised biodiversity conservation (Table 19).

Table 19: Prioritisation of reasons for mangrove conservation by respondents with different educational qualifications

Education Levels	Reasons for Conservation of Mangroves					
	Livelihood Security	Climate Change Resilience	Prevention of Soil Erosion	Biodiversity Conservation	Others	Don't Know / No Reason
Primary	12	9	12	11	4	52
Secondary	12	11	7	8	3	59
Graduate	7	7	29	0	0	57
Not available	10	10	20	10	10	40

When specifically asked about the most significant benefits from mangroves, most of the respondents across all educational classes highlighted fish availability (Table 20).

Table 20: Significant benefits from mangroves

Education Levels	Most Significant Benefit from Mangroves			
	Fish	Ecological Value	No Significant Benefits	Not Available
Primary	116	6	25	4
Secondary	58	6	7	3
Graduate	9	1	3	1
Not available	8	1	1	0

Most of the respondents from all educational classes were unwilling to move from the present settled places for developmental needs. At the lower education level class, there were high number of people who did not respond at all to this question. The uncertainty about such decision making is increasing with decrease in educational levels (Table 21).

Table 21: Willingness respondents towards requirement to move from the present settled locations for development

Education Levels	Willingness to Move for Development (in Percentage)		
	Yes	No	No Response
Primary	13	55	31
Secondary	13	41	46
Graduate	0	64	36
Not available	0	10	90

In order to further understand the intensity of conservation interest of the respondents, their willingness to pay for conservation of mangroves has been probed through questions in terms of the amount they are ready to pay per year, the preferred mode of payment and reasons for making the payment.

Most of the respondents across all the livelihood classes have showed their willingness to pay for mangrove conservation, irrespective of their conservation attitudes towards the ecosystem (Table 22). The amount which the respondents were willing to pay per annum ranged from ten rupees to thousand rupees per annum, though most of the respondents were not sure about the amount they would like to pay (Table 23).

Table 22: Willingness to pay for mangrove conservation

Primary Income Source	% Respondents		
	Yes	No	Don't Know
Fishing	74	23	3
Farm/Livestock	69	31	0
Government Employee	80	10	10
Other jobs	71	21	8

Table 23: Per annum contribution for mangrove conservation

Primary income sources	Amount (Rupees per annum)					
	10-15	51-100	101-250	251-500	501-1000	Not sure
Fishing	12	24	6	6	3	55
Farm/Livestock	2	2	2	0	0	7
Government Employee	1	3	0	0	0	6
Other jobs	16	30	4	11	5	52
Total	**31**	**59**	**12**	**17**	**8**	**120**

Environmental Disservices by Mangrove Ecosystem

The major environmental disservice generated by the mangrove ecosystem was Human Wildlife conflict in the study area. This has been recorded in different parts of the study area. Smooth-coated otter (*Lutrogale perspicillata*) has been recorded as the wildlife which conflicts with fish farming in some parts of the fish farms. The species inhabits mainly in the mangrove patches and comes to the nearby fish farms (especially

Figure 3: Otter burrow located in one of the mangrove patches in the study area[25]

25. Photo by Jayahari KM

cage fish farms) and feeds on the farm fish. This conflict is one of the major disservices from mangrove patches to some of the community members living around the mangrove patches. The conflict has not observed to be interfering with traditional fishery. Otter burrows (refer Figure 3) were photographed with the claw marks of otters from the mangrove patches near the households which have reported the human wildlife conflict.

Mangroves established in the wetlands are protected under the Kerala Conservation of Paddy Land and Wetland Act, 2008. The mangrove plants growing in the shrimp farms are acting as the perching places for the birds of prey and enables them to pick more prawns from the shrimp farms. These high levels of predation have also been recognised as human wildlife conflict in many locations within the study area.

Factors Affecting the Ecosystem Functioning

Along with the environmental disservice (human wildlife conflict), many factors were found to be impacting the functioning of mangrove ecosystem services and reducing the volume of ecosystem services generated. These factors are listed below.

Deviation from traditional practices of fishing is one of the significant factors contributing to reduction the functioning of mangrove ecosystems and thereby leading to reduction in the ecosystem services thus generated. The traditional practice of fishery has an in-built sustainability element in its practice. It has been handed over generations as values to be followed, beyond the economic gain from the practice. Crab capture is an example, in which, traditionally full-grown crabs only were captured from the mangrove patches and the captured sub adults and young ones are released back to the ecosystem. Though some people still follow this traditional practice, a number of people do not do the same. They capture crabs of all sizes, which has led to drastic reduction in the crab productivity from the ecosystem.

Deviations from traditional practices have been observed to be occurring when non-resident people start depending on the ecosystem services. Traditional fishermen, living within the ecosystem, allow the entry of flora, fauna and other micro-organisams into the mangrove ecosystem during high tide and carry out fishing using net during when the water flows back towards the sea, during the time of withdrawal of high tide. Incidents of fishermen from outside the ecosystem carrying out fishing when the water flows into the mangrove ecosystems through high tide waves have been observed during the field work. Even though the catch is the same in both the cases (fishing during the onset and fishing at the time of withdrawal of high tide) the ignorance of the immigrant fishermen ultimately inhibits ecosystem functioning, thereby reducing ecosystem services provided by the mangroves.

Another factor which has been recorded as detrimental to overall ecosystem functioning, not only of the mangroves, but the entire wetlands, is severe pollution existing in the area. The release of hazardous effluents from the factories in the industrial area near to the northern side of Vembanad Lake (which is locally called as *Poison Water*) disrupts the functioning of the entire ecosystem, leading to mass death of the fauna. This drastically impacts the functioning of the ecosystem, which in turn impacts the livelihood of the dependent communities. Repeating of this deleterious process several times over the year has led to drastic reduction in the ecosystem services provided by the mangroves and also negatively impacts the conservation interest of the stakeholders.

Opportunity Cost of Changing the Mangrove Land-use

The study aimed at documenting the ecosystem service benefits of mangrove patches for different kinds of stakeholder communities, which ultimately resulted in estimation overall Ecosystem Service values.

Even though there is a high level of dependence and an understanding among the community on the significance of the mangroves, conversion of mangroves to alternate industrial and infrastructure land use is a high temptation for the people who own the mangroves. Larger projects are being planned in the study area, which will lead to the destruction of considerable areas of mangrove ecosystems.

Many factors have been identified influencing the attitude of the community members towards the mangrove ecosystems, as individually and collectively. The attitude can be observed as changing in varying degrees from a conservative attitude through a conservation neutrality to a destructive attitude. The main factors influencing the community attitude are the volume of services and disservices available for the community from the mangrove ecosystems and the number of livelihood sources available for the community members and its nature (directly depending / not depending on the mangroves).

Legal Background of Mangrove Conservation in the Study Area[26]

Mangroves as it is, have not been identified as a protected species, even though as trees most of the mangrove species are protected by the Kerala Preservation of Trees Act, 1986. The nature of the land in which the mangroves exist also could provide some protection to the ecosystem as wetlands are protected by the Kerala Conservation of Paddy Land and Wetland Act, 2008 and the notified Costal Regulatory Zones (CRZ) 1 A are protected by Kerala CRZ rules (under the Environment Protection Act, 1986).

Even though many of these mangrove patches can fall under the category of forests, based on the definition of forest in the Forest Conservation Act, 1980, such efforts are not happening in the state of Kerala. These efforts are extremely important in the back drop of the drastic land-use changes to which the mangrove ecosystems are subjected in the study area, as revealed in earlier sections in this report.

Conclusions

The awareness on the need for conservation of mangroves was high among the households who primarily depend up on nature-based sources for their livelihoods (fishery, farming and livestock rearing). A considerable difference has been observed with regard to awareness about ecosystem services between the households which are dependent up on the nature-based livelihood sources and those which have dependence on salaried jobs. Daily wage employee groups also showed better awareness about the ecosystem services provided by the mangrove ecosystems, since nature-based livelihood (fishery, farming and livestock) for their secondary source of livelihood. No significant relation was found between education levels and the attitude to conserve mangroves, though it was noted that the highly educated respondents showed less interest in mangrove conservation.

Increased awareness about the flood regulation benefits of mangroves among all types of respondents was observed. This can be attributed to the recent floods which happened in Kerala during the last two years. Similarly, even though the benefits of mangroves in reducing the impacts of Tsunami and strong sea waves are well documented, absence of these natural disasters in the study area led to respondents not having significant awareness about the same. There thus is a strong correlation between the mangrove conservation interests of the local people and the benefits they are deriving from the same.

These inferences need to be observed in the backdrop of the environmental disservices and also the factors which led to reduction in the ecosystem functioning, thereby impacting the volume of ecosystem

26. Information from the consultation with Adv. Hareesh Vasudevan

services generated from the mangrove ecosystems. Human wildlife conflicts are not experienced by traditional nature-based livelihoods, whereas it is experienced by the fishermen practicing modern nature based techniques like cage fishery and shrimp farming.

Since the interest of the community in conserving mangroves is directly linked to the volume of ecosystem services the mangroves provide, any reduction in these benefits can lead to greater risk of reduction in community interest towards mangrove conservation.

It is also clear that the conservation interests are more among those classes which are generally less influential in socio-political systems (farmers and fishermen). As the higher educated and income level sections of the society are have less conservation interests in mangroves and the opportunity costs of changing the mangrove land-use is high in the study area, there are all the chances that the conservation interests of farmers and fishermen be side-lined during a political decision making about mangrove conservation.

The overall understanding about the relationship between the ecosystems and local people results in the need for the following conservation measures to be taken in the study area to avoid further mangrove land use changes.

a) Awareness generation among the local people about the significance of mangroves for maintaining the ecological balance and generating ecosystem services in the area
   i. Recognize and highlight those individuals who still use the mangrove ecosystems in a sustainable manner, facilitating its ecosystem functioning
   ii. Create awareness among the new generation fishermen folks on need for sustainable use of the ecosystem
   iii. Facilitate the civil society organizations in the area to initiate localised mangrove conservation programmes

b) Regulation of the activities which disbalance ecosystem functioning of mangroves in order to ensure that generation of ecosystem services is not hampered. The priority should be to regulate the non-traditional fishing practices in the mangrove areas and in the backwaters.

c) Undertaking measures to declare the mangrove patches which qualify under the definition of Forest Conservation Act, 1980 as forests. A financial mechanism should be developed to compensate the financial loss incurred by the owners of such mangrove patches in the private landholding areas.

d) Undertaking adequate measures to tap the recreational / tourism potential of mangrove patches in KMC and adjoining areas.

Supporting, Provisional, Regulatory and Cultural Ecosytem Services Generated by the Mangrove Patches in Urban and Peri-Urban Areas of Kochi Municipal Corporation

A total of 249 households have been surveyed during the study. The households were identified based on the methodology described above and the data was collected through detailed questionnaire surveys. Along with the household data collection, focus group discussion and expert consultations have also been carried out. As mentioned in the earlier section of the report more than seven ecosystem services from the mangrove ecosystem have been identified by the local people surveyed. While probing for data on economic evaluation of these ecosystem services, it has been identified that the respondents were not able to perceive the ecosystem services in economic terms, since all of them except the fisheries harvest were relatively occasionally avails and meagre. It was not possible to convert certain ecosystem services like regulation of wind speed into economic terms due to the small duration of the study. The economic evaluation of the ecosystem services from mangroves are thus mainly confined to benefits from fisheries for this study.

An Additional Note on the Methodology

Numerous methodologies are available for the economic estimation of fishery ecosystem services from mangroves. There are different means through which the mangrove ecosystem contributes to the fish fauna within the ecosystem as well as in downstream ecosystems[27]. They are as follows –

a) Primary productivity in mangrove ecosystem serves as the foundation of the fishery food web
b) The detrital pathway through which the mangrove primary productivity is moving to the downstream ecosystems
c) Mangrove provides nursery ground for the fishes and reduces predation risk

The evaluation methodologies depend up on the level of detailed data available on the contribution of mangroves to the availability of fish resources through the above three means. The economic evaluation of the fishery ecosystem service from the mangrove ecosystems in this study has been estimated with an assumption that the percentage of catch of species which have high dependence on mangrove ecosystem as a nursery or for any other survival purpose is the contribution of mangroves. A detailed ecosystem utilisation / habitat utilisation pattern of the species of fishes identified were also not available, in order to adopt highly precise methods available. As far as the market prices are concerned, the fishes which have higher mangrove dependency were of higher price and these species have higher share in the total catch in terms of quantity. Since in the study area, brackish water was surrounded by mangroves, most of the fishing occurs within 500 m to 1 km of mangroves. The maximum distance between two mangrove patches in the study area as slightly less than 4 km. In most cases mangrove patches were noticed to be very much closer to each other. Due to these two situations, the percentage of mangrove dependant species has been directly used as the percentage of the total income of the fishermen from mangrove ecosystem.

27. Hutchison, J., Spalding, M. and zu Ermgassen, P. (2014). The Role of Mangroves in Fisheries Enhancement. The Nature Conservancy and Wetlands International. P54

Fishing Ecosystem Services from Mangroves

Among the 249 households surveyed during the study, many highlighted fishing as the primary or secondary livelihood. Out of the total 773 individuals interviewed in these households to identify the quantity of the ecosystem services they receive from the mangrove ecosystems, 215 individuals were involved in fishing as either their primary or secondary livelihood option in the area.

23 species of fishes were found as the major species, which the respondents harvest from the backwaters (some of them were fishing also at the lake mouth and the sea adjoining to the lake). A list of the species is provided in Table 23. A detailed literature survey shows that 12 out of these 23 species are mangrove ecosystem dependent either for their breeding, survival or both. Out of these 12 species, survival of 9 species are in peril without the presence of the mangrove species (Table 24). The details of the species, the availability of which is influenced by the presence of the mangrove species are as follows.

Arius subrostratus (Valenciennes, 1840) is commonly known as Shovelnose sea catfish. *A. subrostratus* commonly occurs in estuaries, lagoons, tidal rivers, marine water and some mangrove area and is a benthic invertebrate feeder. It is distributed in the Indo- West Pacific regions including India, Pakistan, Indonesia, Thailand and Philippines. As such the species does not need the mangrove ecosystem for its survival as it is reported that "also found burrowed in the soft mud of the mangroves[28]". In case of Kochi area a Ph.D. thesis concentrating on the species[29] proves that the abundance of the species is mostly around the mangrove area. This is highly significant as far as the catch of the fish is concerned.

Metapenaeus monoceros (Fabricius, 1798) normally known as Speckled Shrimp is distributed through out the Indo-West Pacific, along the African coast to the Red Sea and around India to the Bay of Bengal[30]. In western coast, especially in Kochi backwaters, the species is highly associated with the mangrove ecosystem for their breeding[31, 32]. Recently a decline of 84 percent of the catch of the species have been reported from Kochi back waters compared to 1997[33]. There are no direct evidences to correlate this with the serious land-use changes the mangrove areas of the region has been undergone.

Secutor ruconius (Hamilton, 1822) which is normally called as deep pugnose ponyfish. The species is distributed across - tropical Indian Ocean and southeast Asia, north to Taiwan and China, south to northern Australia. Also reported from New Caledonia[34]. The species has included in the list of threatened mangrove fauna by Kathiresan et al (2015)[35]. Even though specific reports from Kochi about the breeding of the species in Mangrove ecosystem is not available, the species has been reported to be breeding mainly in the mangrove ecosystems[36].

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28. https://www.fishbase.se/summary/1295
29. Ambily, V. (2016). Phenology and life history traits of Arius subrostratus Valenciennes 1840 from Cochin estuary India, PhD Thesis, Mahatma Gandhi University, p 349.
30. http://www.faomedsudmed.org/html/species/Metapenaeus%20monoceros.html
31. Achuthankutty, C.T., M.J. George and Goswami S.C. (1977). Larvel ingression of prawns in the estuaries of Goa, P*roceedings of the symposium on warm water zooplanktons*, Special Publication, UNESCO/NIO, 412-424.
32. Goswamii, S.C, C.T. Achuthankutty and M.J. George. (1997). Occurrence of larvae of commercially important penaeid prawns along the central west coast of India, Mahasagar – Bulletin of National Institute of Oceanology, 10, 129 – 137.
33. Kripa, V. (2017). Changes in environment: Implications for fisheries in Indian waters. In: Winter School on Structure and Function of the Marine Ecosystem : Fisheries, 1-21 December 2017, Kochi.
34. Thollot, P., 1996. Les poissons de mangrove du lagon sud-ouest de Nouvelle-Calédonie. ORSTOM Éditions, Paris.
35. K. Kathiresan, N. Veerappan and R. Balasubramanian. (2015). Status of Fauna in Mangrove Ecosystems of India in Marine Faunal Diversity in India Editors: K. Venkataraman and C. Sivaperuman, 485 -487.
36. K. Krishnamurthy and M.J. Prince Heyaseelan. (1981). The early life history of fishes from Pichavaram Mangrove area in India, Rapp. P.-v. Réun. Cons. int. Explor. Mer, 178: 416-423.

Liza subviridis is another species which has a close association with mangrove habitats in the backwaters[37&38]. Even through the species is not breeding in the mangrove areas, their aggregation is higher in the mangrove areas[39].

Etroplus suratensis which is popularly called as Pearl Spot, is distributed in the coastal regions of peninsular India and Sri Lanka. In India, the wild populations have been recorded from the states of Kerala and Tamil Nadu. There are also populations in Goa, Andhra Pradesh, Orissa and West Bengal[40]. This is an essentially brackish water species, and which breeds in the backwater vegetation mainly mangroves[41].

Scatophagus argus (Linnaeus, 1766) which is commonly known as Spotted Butterfish, is another species which is closely associated with mangrove ecosystems. This species as well thrives in the mangrove ecosystem, but the the ecosystem is not necessary for its breeding or survival[42].

Table 24: Fish species identified as major harvest of the respondents to the survey

Sl. No.	Scientific Name	Common English name	Malayalam Name
1.	*Penaeus indicus*	White shrimp	Naran Chemeen
2.	*Arius subrostratus*	Cat Fish	Koori
3.	*Gibelion catla*	Indian Crap	Katla
4.	*Oreochromis niloticus*	Tilapaia	Tilapia
5.	*Metapenaeus monoceros*	Speckled prawn	Choodanchemmen
6.	*Secutor ruconius*	Pony fish	Mullan
7.	*Liza subviridis*	Mullet	Kanambu
8.	*Stolephorus idicus*	Indian anchovy	Kozhuva
9.	*Pseudetroplus maculatus*	Orange chromide	Pallathi
10.	*Labeo dussumieri*	White fish	Pullan
11.	*Etroplus suratensis*	Peral Spot	Karimeen
12.	*Scatophagus argus*	Spoted Scat	Nachkarimeen
13.	*Lutjanus argentimaculatus*	Red snapper	Chembaili
14.	*Nematalosa nasus*	Lizard shad	Thodi
15.	*Scylla serrata*	Mud crab	Kayal njandu
16.	*Acanthopagrus latus*	Yellow sea bream	Eeri
17.	*Carangoides malabaricus*	Yellow fin trevally	Vatta
18.	*Villorita cyprinoides*	Black clam	Karuthakakka
19.	*Gerres filamentosus*	Whip fin silver biddy	Prachi
20.	*Metapenaeus dobsoni*	Kadal shrimp	Theli

37. Samad, M. and Abbas, G. (1999). Population structure of the mullets Liza subviridis, L. carinata and Valamugil cunnesius (Family Mugilidae) from Sansdispit backwaters along Karachi coast (northern Arabian Sea), Indian Journal of Marine Sciences, 28, 312 -319.
38. FAO. (1994). Mangrove Forest Management Guidelines, FAO Forestry Paper 117, FAO, Rome, Italy, ISBN 95-5-103445-1
39. Bharadhirajan, P., Murugan, S., Gopalakershanan, A. and Murugesan, P. (2015). Finfish diversity in Coleroon estuary, south coast of India. Indian of Geo-Marine Science, 44(1), 104-109.
40. https://www.iucnredlist.org/species/172368/60612143#geographic-range
41. Antony, G. George J. P., Mathew, A., Giri, S., Chakravarty, G., Chakraborty, S.K. and Roy, D.S. (2005). Ichthyofauna of the Mangrove Ecosystem in Mangrove Ecosystem: A manual for assessing biodiversity, CMFRI Special Publication No 83, 83-115.
42. Sivan, G. and Radhakrishnan, C.K. (2011). Food, Feeding Habits and Biochemical Composition of Scatophagus argus, Turkish Journal of Fisheries and Aquatic Sciences (11), 603-608.

Sl. No.	Scientific Name	Common English name	Malayalam Name
21.	*Rastrelliger kanagurta*	Indian mackerel	Ayala
22.	*Sardinapilchardus*	Sardine	Chala
23.	*Glossogobius giuris*	Tank goby	Poolan

Lutjanus argentimaculatus is commonly known as Mangrove red snapper and the species is highly associated with the mangrove ecosystem, as the name indicates.

Nematalosa nasus (Bloch, 1795) is commonly known as Bloch's Gizzard Shad. The species is very common in the mangrove areas of southern India[43]. Mangrove forests are under pressure for their commercially important resources and as sites for shrimp aquaculture. However, due to the reported abundance of N. nasus within mangroves, this is not considered a major threat[44].

Scylla serrata (Forsskål, 1755) is a crab species found in the Mangrove areas in Indo-West Pacific region from East and South Africa to South East and East Asia (from SE of China and Sri Lanka), and North East Australia. This species is also found in Eastern Pacific, around the Marianas, Fiji and the Samoa Islands. The species is associated with mangroves in estuaries and sheltered coastal habitats, they are found in soft muddy bottoms where they dig deep burrows. Overall in the Kochi area,the catch is mainly from Mangrove areas only.

Table 25: Species of fishes and crabs caught from the study area and their survival dependency levels on Mangrove ecosystems

Sl. No.	Scientific Name	Mangrove Dependency for Breeding	Mangrove Dependency for Survival
1.	*Acanthopagrus latus*	High	High
2.	*Etroplussuratensis*	High	High
3.	*Gerres filamentosus*	High	Medium
4.	*Lutjanus argentimaculatus*	High	High
5.	*Metapenaeus dobsoni*	High	Low
6.	*Metapenaeus monoceros*	High	High
7.	*Nematalosa nasus*	High	High
8.	*Scylla serrata*	High	High
9.	*Secutor ruconius*	High	Medium
10.	*Carangoides malabaricus*	Low	Low
11.	*Liza subviridis*	Low	Low
12.	*Scatophagus argus*	Medium	Medium
13.	*Arius subrostratus*	No	Moderate
14.	*Gibelion catla*	No	No
15.	*Glossogobius giuris*	No	No
16.	*Oreochromis niloticus*	No	No
17.	*Penaeus indicus*	No	No

43. Kathiresan, K. and Rajendran, N. (2002). Fishery resources and economic gain in three mangrove areas on the south-east coast of India. Fisheries Management and Ecology 9(5): 277-283.
44. https://www.iucnredlist.org/species/154774/115233646#habitat-ecology

Sl. No.	Scientific Name	Mangrove Dependency for Breeding	Mangrove Dependency for Survival
18.	*Pseudetroplus maculatus*	No	No
19.	*Rastrelliger kanagurta*	No	No
20.	*Sardina pilchardus*	No	No
21.	*Stolephorus idicus*	No	No
22.	*Villorita cyprinoides*	No	No
23.	*Labeo dussumieri*	No	No

Acanthopagrus latus (Houttuyn, 1782) is commonly called as Yellowfin seabream. *A. latus* is known to be abundant in mangroves (dominated by *Avicennia marina*) and creeks and nearby rocky area[45]. In absence of the rocky areas abundant in the study area the species is very much dependant on mangroves ecosystem for breeding and survival.

Carangoides malabaricus is always mentioned as a fish species which is a part of the mangrove ecosystem, including the mangroves in Kerala[46 &47]. The relationship of the species and the ecosystem is largely unknown. At this point the study considered that the mangrove ecosystems has low significance in the survival and breeding of the species.

Gerres filamentosus (Cuvier, 1829) is commonly known as Whipfin Mojorra. Mangroves are one of the significant breeding grounds of the species[48]. Mangrove ecosystems are highly significant for the survival of the juveniles until they attain maturity and move out of the ecosystem[49].

Metapenaeus dobsoni (Miers, 1878) or Kadal shrimp is distributed through out the west coast of India to the Philippines and New Guinea[50]. Even though scientific information about the breeding behaviour of the species is not available for the study area, this prawn species is reported to be dependent on mangroves as juveniles and frequent coastal waters as adults. Mangrove ecosystems are significant for the breeding of the species[51].

Since most of the households who were approached carry out fishing in the backwaters, a the catch of 72 percent of the respondents included those species whose survival is dependant on the mangrove ecosystem.

Frequency of Fishing by the Respondent

Most of the respondents were occasional fishers. 32 respondents revealed that they are regular in fishing either daily or twice or thrice in a week. Since this is an income source many of the respondents were not ready to reveal the exact economics associated with the livelihood (Chart 12)

45. Platell, M.E., Ang, H.P., Hesp, S.A and Potter, I.C. (2007). Comparisons between the influences of habitat, body size and season on the dietary composition of the sparid Acanthopagrus latus in a large marine embayment, Estuarine, Coastal and Shelf Science (72), 626-634.
46. Rejna, K.P., Moideenkoya, R.V.K. and Shabna, V.C. (2015). Diversity of Fish Fauna in Kadalundi Estuary, Kozhikode, Kerala, International Journal for Species 12(36), 117-121.
47. Swapna, A., Kumar, R.R. and Sasidharan, V. (2016). Spatial temporal assemblage structure of fishery resources in relation with environmental variables along with mangrove creeks of Souther Andaman, International Journal of Recent Scientific Research, 7(2), 8789-8805
48. https://indiabiodiversity.org/species/show/232328
49. Sadovy, Y. and A.S. Cornish. (2000). Reef fishes of Hong Kong. Hong Kong University Press, Hong Kong. 321 p.
50. https://www.sealifebase.ca/summary/Metapenaeus-dobsoni.html
51. Silas, E.G. (1986). Management of Mangrove associated fisheries and aqua culture in the Sunderbans, India, in FAO Fisheries Report No.370 Suplement, 21-44.

It has been already documented by the state government agencies in Kerala that as of 2005 out of the inland fishermen population (total 68,741) in Ernakulam district only 13% (9396) are active fishermen[52]. Other practices fishing as a part time activity. This study results are also more or less aligned with this. The study area encompasses around 10% of the overall area of Ernakulam dstrict.

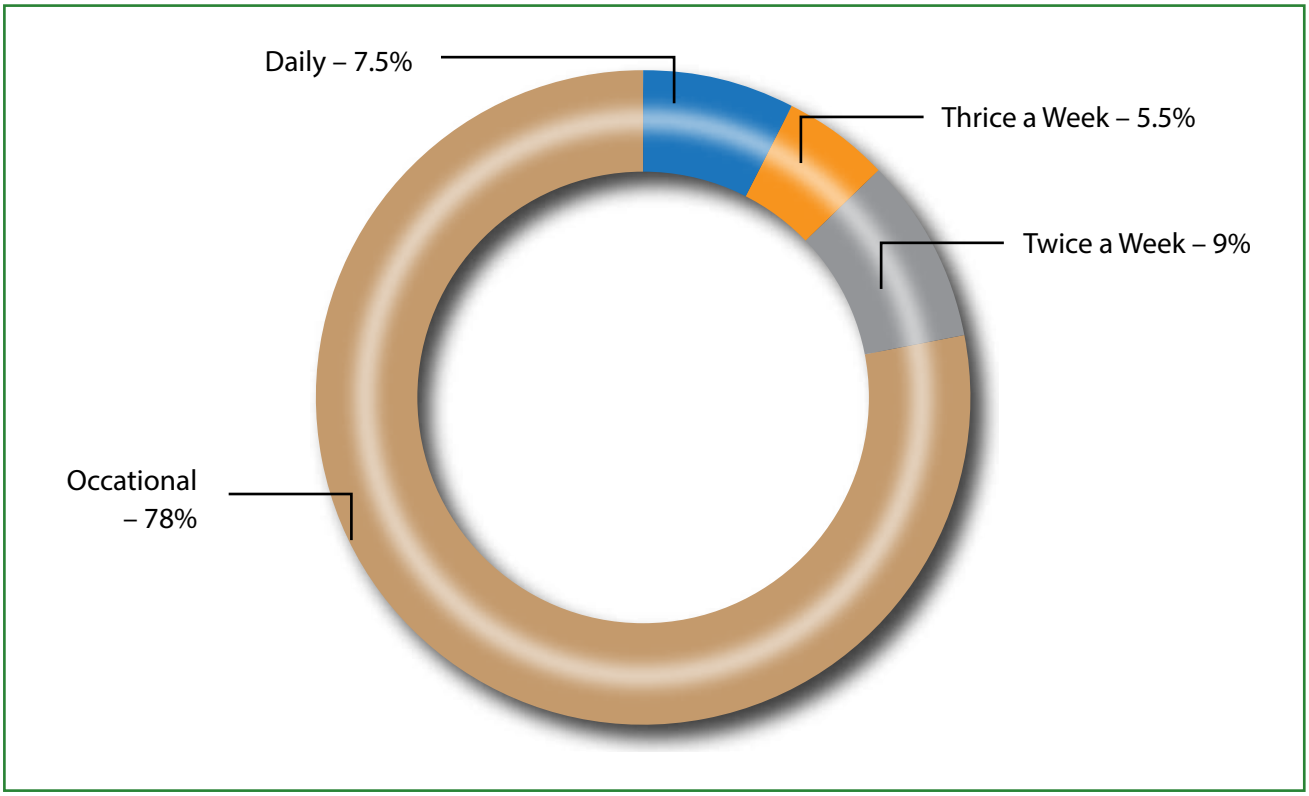

Chart 12: Percent of fishing frequencies of the respondents

Economic Benefits from Fishing and Ecosystem Fishing Service Contribution of Mangroves

Only 89 respondents have revealed their economic rewards from fishing. The economic rewards vary from ₹ 400 to ₹ 300,000 per annum. The average annual income of the 11 respondents who are regular fishermen (at least fishing three days in a week) was ₹178,000 per annum. As mentioned earlier, 70 percent of the fish catch involves the species which are highly dependent on mangroves for survival. A rough estimation of ₹124,000 per annum per fisherman is the economic benefit received by a regular fisherman from mangrove ecosystem.

The according to the Government of India estimates[53], total inland water area in Ernakulam District is 162km^2 and the total number of regular inland water fishermen are 9,396 as of the year 2005[54]. This results in an average of 58 active fishermen per km2 of inland water area in the district of Ernakulam to which the study area belongs. The study area has a total of 81 km^2 inland water area (Table 26). Proportionally the area should have 4,700 active fishermen, which results in a potential of minimum fishery ecosystem services worth ₹ 5,853 million per annum ($8.4 million/yr). The study area has a mangrove land-use of 2.47 km2 (247 hectares) which shows that the mangroves of the study area provides ₹1.7 million worth fishery ecosystem services per annum per ha ($24,100/ha/yr).

52. http://ifpkochi.gov.in/IFPS2.pdf
53. Shyam, A.T.S (2013). Groundwater booklet of Ernakulam District, Kerala State, Government of India, P 27.
54. http://ifpkochi.gov.in/IFPS2.pdf

Table 26: Areas of different land-use classes in the study area

Sl. No.	Land use type	Area in km^2
1	Mangroves	3.47
2	Built-up area	0.02
3	Waterbodies	81.38
4	Mixed built-up and other land-uses	138.99
	Total Area	**223.86**

A comparative analysis of per ha fishery ecosystem service contribution of mangrove ecosystems resulted in different studies across the world with the present study is provided in Table 26.

Estimation of fishery ecosystem services from Mangroves

Sl. No.	Location	Fishery Catch Type	Range ($/ha/year)
1	Global[55]	All	0 - 18,743
2	Gulf of California[56]	Offshore	25,000 - 50,000
3	Philippines[57]	Coastal and Offshore	2,002
4	Vanuatu 1[58]	Offshore	733 -1,106
5	Vanuatu 2	Offshore	1,301 – 2,192
	Present Study	**Coastal (All species)**	**24,100**

The study results are comparable to some of the international studies. This study results are worked out considering the income of active fishermen, who at least do fishing in three days a week around the seasons.

55. De Groot, R., L. Brander, S. van der Ploeg, R. Costanza, F. Bernard, L. Braat, M. Christie, N. Crossman, A. Ghermandi, L. Hein, S. Hussain, P. Kumar, A. McVittie, R. Portela, L. C. Rodriguez, P. ten Brink, and P. van Beukering (2012). Global estimates of the value of ecosystems and their services in monetary units, Ecosystem Services 1(1), 50–61
56. Aburto-Oropeza, O., Ezcurra, E., Danemann, G., Valdez, V., Murray, J. and Sala, E. (2008). Mangroves in the Gulf of California increase fishery yields. Proceedings of the National Academy of Sciences, 105(30): 10456–10459
57. Hutchison, J., Spalding, M. and zu Ermgassen, P. (2014). The Role of Mangroves in Fisheries Enhancement. The Nature Conservancy and Wetlands International. P54.
58. IUCN. (2014). Economic valuation of mangrove ecosystem services in Vanuatu, Summery Report, P 17 (Available at https://www.iucn.org/sites/dev/files/economic_valuation_of_mangrove_ecosystems_vanuatu_summary.pdf)

Suggested Investment Strategy

The present study conducted in and around Kochi Municipal Corporation area (study area has been elaborated in the previous chapters) shows that every hectare of mangroves is providing fishery ecosystem services of $24,100ha/Yr. At the same time the study shows that 78 percent of the original mangrove areas that existed in year 2000 have been converted into other land uses by year 2017. In addition, a little less than this area of new mangrove patches has also been established during this time span. These facts show that these ecosystems which are of high significance for the offshore fisheries in these areas are highly dynamic. Recent initiatives for protecting these patches by the state forest department has been helping in reducing the rate of conversion of mangroves, whereas the high developmental pressure demanding land in this area is existing as a constant threat to the mangroves.

In Kerala, the destruction of mangrove trees comes under the violation of law under the Kerala Preservation of Trees Act, 1986 and the State Forest Department books case against the person who carries out the logging. More than that, in general a legal framework is not existing in the state to protect Mangrove ecosystems. Considering the fact that there is a marginal decrease in the overall mangrove patches in the study area between years 2000 and 2017, it has to be inferred that the protection and conservation of the existing mangrove patches are tantamount as far as Kochi Municipal Corporation and adjoining areas are concerned, rather than establishing new mangrove areas.

Investment Strategy for Conservation and Protection of Mangrove Patches in Kochi Municipal Corporation Area

Recent mangrove protection efforts in Kerala have been seen as concentrating on securing the tenure and ownership of the mangrove patches. State Governments, Non-Government Organizations and individuals are taking part in this effort. A combined effort of Kerala Land and Revenue Department and Kerala Forest Department has identified and mapped 236 ha of mangrove areas which is under the ownership of government and local governments (*Panchayats*) in Kannur District which has been later accrued by forest department, declaring the area as a reserve forest. In another initiative started by individual conservation enthusiasts and Non-Governmental organisations like One Earth One Life have purchased more than 22 hectares of mangrove area in the same district for protection and conservation. Similar efforts of acquiring mangrove patches from private landowners by providing sufficient compensation and declaring those areas as Reserve Forest is ongoing in the state[59].

The present study also recommends these investments to transfer the ownership of the mangrove patches to the forest department as the most suitable initiative towards conserving the mangrove patches in Kochi Municipal Corporation. The present study shows heavy dependence of local community on the mangrove patches in the study area for inland fisheries.

Kochi Municipal Corporation has 22 patches of mangroves, which are measured to have more than 1 acre area. Altogether these patches amount to an area of 47.9 ha. Out of these mangrove areas 2.7 ha

59. https://timesofindia.indiatimes.com/city/thiruvananthapuram/forest-department-on-a-mission-to-acquire-and-conserve-mangroves/articleshow/69497895.cms

is a protected patch – Mangalavanam Bird Sanctuary, declared under the Wildlife Protection Act, 1972. Securing the ownership of these patches by the Kerala State Forest Department by acquiring them with sufficient compensation (for private owners) and declaring them as the Reserve Forest is recommended as the best investment for conservation of Mangroves in the study area. Considering the heavy dependence on the mangrove patches by local fishermen community, the tenure of the fishermen to use these ecosystems for their traditional fishing should also be ensured. This can be done under the provisions of The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The detailed steps of the investment strategy are described below.

Step 1: Mapping the mangrove patches within the Kochi Municipal Corporation: This has been already carried out under this study.

Step 2: Documentation of the ownership of the mangrove patches: Out of the 57 patches, 22 patches (which are of patch size more than 2000 m^2 area) are recommended to be considered for declaring as reserve forest. These patches can fall under private and public (State Government, Union Government and Kochi Municipal Corporation) ownerships. The ownership documentation needs to be carried out by extensive on- site verification.

Step 3: Ownership Transfer of the public mangrove patches: This process is comparatively simple since this involves only government agencies. The process followed in the case mentioned above (Kannur District) can be followed.

Step 4: Procurement of Private Mangrove Patches: Separate settlement process will need to be initiated for this process since the land price in Kochi Municipal Corporation is highly variable, based on the location. Different international and national funding agencies provide financial support for these kinds of efforts. As mentioned earlier, the State Government also have an ongoing scheme to support this initiative. Collaboration with the forest department is required for declaration of the areas as Reserve Forest.

Step 5: Ensuring the Tenure of Local Fishermen Community for Fishing in the Reserve Forest Patches: This can be done by issuing Community Forest Rights to the local fishermen of the area to carry out different fishing activities in the Mangrove Reserve Forest. This will require the enumeration of local fishermen who are dependent on the mangrove forest and providing them identification cards to carry out fishing in the mangrove patches. The process will have to be completed in a mission mode to ensure the livelihood security of the community and also the process not to impact the same.

Financial Framework

The total area of mangrove ecosystems recommended to be brought under the Reserve Forest Category in Kochi Municipal Corporation area is around 45 hectares (4,507,639 m^2) which comes around 45 million square meter area. The land price in Kochi Municipal Corporation is highly variable, based on the location. An average land price of Rs. 1,500 per square feet, estimates an investment of Rs. 161 million per ha in Kochi Municipal Corporation. An economic evaluation of per hectare fisheries ecosystem services is Rs. 1.7 Million per hectare per annum only. A holistic and detailed economic estimation of ecosystem services provided by mangrove ecosystems is not available from India. This would have helped to incorporate the values of other ecosystem service provided by mangroves in Kochi Municipal Corporation area. In such a scenario carrying out a financial viability analysis and developing a business model is not possible for this investment strategy.

Annexure1: Questionnaires Used for Data Collection

1. General Questionnaires

Household Survey

This study is conducted as a part of 'Assessing ecosystem services provided by mangroves in Kochi and developing guidelines for mangrove conservation and restoration project led by Jayahari KM, commissioned under the integrated sub-national action for biodiversity: Supporting implementation of National Biodiversity Strategy and Action Plans (NBSAP) through the mainstreaming of biodiversity objectives across City-Regions (INTERACT-Bio) Project. The information gathered will be used only for the research work.

I. HOUSEHOLD DETAILS

Preliminary Information (PRE)

PRE 1. Code for the household:	
PRE 2. Address of the house:	
PRE 3. Village:	
PRE 4. Ward; Gram Panchayat:	
PRE 5. Taluka/Tehsil:	
PRE 6. Ward; Municipality/Corporation:	
PRE 7. GPS way point number of household (GPS):	
PRE 8. Date of the interview:	Date:
PRE 9. Time of the interview	Start: End:
PRE 10. Contact No:	

A. Household Information

A1	Head of the household	Name: Gender: ☐ Male ☐ Female
A2	Main Breadwinner in the household	Name:
A3	Names of the people being interviewed	Head/Breadwinner Spouse: Other :
A4	Total no. of family members (living under the same roof and sharing same kitchen)	

A5	Caste of the family	☐ General ☐ OBC ☐ SC ☐ ST ☐ Other ☐ Don't know (prefer not to say)

Sl. No.	Name (including the head)	Relationship with the head	Gender (M/F)	Age (Yrs)	Education (Yrs of schooling)	Working status (W/NW)	Resident status (R/NR)	Primary occupation	Secondary Occupation (if any)	Income (INR)/Monthly

Relation with head: Wife= W; D = Daughter; S = Son; M = Mother; F = Father; B= brother; Si= Sister; DIL= Daughter-in-law; Oth = others; Male =M,
Female= F Working = W, Non-Working = NW

R= Resident, i.e. a person who resides a majority of a year (i.e. > 180 days) in the household. NR=non-resident, is a person who does not live in the household, but is part of the family.

B. Family Assets

Common for all Households

B1	Type of house by roof	☐ Tiled ☐ Thatched ☐ Concrete ☐ Sheets
B2	Type of house by floor	Burnt brick/Stone/Cement Mosaic/Floor/Tiles
B3	Does your house have the electricity connection?	☐ Yes ☐ No
B4	Which cooking medium do you use?	☐ Fuel wood ☐ LPG ☐ Biogas ☐ Other
B5	Modern household equipment	☐ Mixer ☐ Fridge ☐ Air Conditioner ☐ Washing Machine ☐ TV Ceiling fan/Table fan ☐ None
B6	Livestock and their no.	☐ Cows ☐ Goats ☐ Chicken /Duck ☐ Other ☐ None
B7	Does household own any land?	☐ Yes ☐ No ☐ Leased in ☐ Wetland ☐ Gardenland ☐ Mangrove area ☐ Residing in fragment
B8	Total area of the land owned by household?	…….. (/…….. in acres)
B9	Private source of water for household	☐ a. Dug-Well ☐ b. Bore-well ☐ c. Piped water connection ☐ d. Nothing Private
B10	Source of water for land/farm	N A ☐ 1. Private : ☐ a. Dug-Well ☐ b. Bore-well ☐ 2. Common: ☐ a. Dug well ☐ b. Bore-well ☐ c. River

B11	Modern Equipment for farming	☐ Kerosene/Diesel Pump ☐ Electricity Pump ☐ Tractor ☐ Thrasher ☐ Other ☐ Nothing
B12	Source of transportation	☐ Bicycle ☐ Two-wheeler, Three-wheeler ☐ Four-wheeler ☐ No source
B13	Does household has a ration- card?	☐ Yes ☐ No
B14	Type of ration-card	☐ Pink ☐ Blue ☐ White ☐ Yellow ☐ No ration-card
B15	Does your family have Mahatma Gandhi National Rural Employment Guarantee Act job card?	☐ Yes ☐ No
B16	If Yes, How many family members go for MGNREGA work?	
B17	Does Any member in the household have a bank/postal account?	☐ Yes ☐ No No of accounts:
B18	How long has it been since settled here?	
B19	Anything to add?	

C. Living Expenses

Particulars	**Household Expenditures (INR)**	
	Monthly	**Annual**
1.Agriculture		
2.Education related		
3.Ration and Stationaries		
4.Health and medicine		
5.Electricity bills		
6.Water bills		
7.Telephone/Internet bills		
8.Vehicle/Fuel/Transport		
9.Domestic animals/Pets		
10. Recreation/Excursion/Cinema		

II. ECOSYSTEM SERVICES

Knowledge and Awareness regarding ecosystem services and disservices

1. Are you getting any benefit from the mangrove area: ☐ Yes ☐ No ☐ Don't know

2. Ranking of goods/services provided by mangroves

Goods/services	Importance			
	Yes; benefitting	Aware; but not benefitting	Not aware	No use
Fuel wood				
Fodder and pasture				
Fisheries				
Medicine				
Food source				
Timber				
Mangrove charcoal				
Non timber produce (honey, materials for roof, mat, baskets, decorations)				
Agriculture				
Recreation and tourism				
Education and scientific value				
Habitat for biodiversity				
Flood control				
Ground water recharge				
Shoreline protection from erosion and instability				
Act against high tide				
Protection from wind/tsunami waves/cyclones				
Reducing extreme climate events				
Protection against sea level rise				
Art, Spiritual				
Carbon sequestration				
Nutrient sink				
Protection against UV-B radiation				
Pollination services				
Genetic resources				
Sedimentation and nutrient retention				

4. Are you experiencing any difficulties due to the presence of mangroves near your residence/business?

☐ Yes ☐ No

If Yes, Please list down

5. In your opinion whether the mangroves should be conserved or not? ☐ Yes ☐ No

If Yes, why?

If no, why?

6. Are you willing to move out of your current place of residence/business if any alternate developmental activities come up in the area?

☐ Yes ☐ No

6a. 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)	

6b. 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	
4	Others (if any specify)	

7. a. Have you ever planted mangroves in the area ? ☐ Yes ☐ No

b. If yes,

Month/Year of plantation	Species planted	No of plants	Area of plantation	Present status

8. Is there any destruction of mangroves in your area: Yes / No

8a.If yes, can you find any relation between the following?

Sl. No.	Particulars	Reasons
1	Destruction of mangrove areas	Developmental activities
		Tourism
		Land for house construction
		Collection for different purposes by people
		Changes in climate
2	*Status quo* position (regarding political or social affairs)	
3	Improves the status	Restoration activities
		Area expansion
		People recognize the importance of mangroves

9. Is there any climatic impact (changes in rainfall, temperature, humidity and wind) on mangroves over the years? ☐ Yes ☐ No

If yes, please explain

10. In your opinion why mangroves are significant?

☐ 1. Fisheries and allied production, ☐ 2. Ecological value,

☐ 3. Not significant, ☐ 4. Other uses (Please specify)

11. In your opinion, what is the current status of mangroves in your area?

☐ 1. Depleting, ☐ 2. No change, ☐ 3. Improving

11a. If answer is 1, what are the possible reasons?

11b.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	Natural regeneration with no external aid	
4	Any other reasons (please specify)	

12. Suppose if the mangroves are completely destroyed, do you think that it will affect you?

☐ Yes ☐ No

If yes, state how?

13. Are you doing any measures to conserve the mangroves? ☐ Yes ☐ No

If yes, please give details

13a. Are you interested in better conservation and management of mangroves in your area?

☐ 1. Interested ☐ 2. Concerned but don't want to involve ☐ 3. Not interested

☐ 4. Want it to be removed from specific sites

13b. If you are interested, how do you proceed?

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

13c. If you want it to be removed, why?

14. Is mangroves important to you in your culture or faith?

☐ Yes ☐ No

14a. If Yes, how?

15. List the species of mangroves and associates in your area?

16. If you are not a farmer/agricultural labourer now, have you ever been one?

☐ Yes ☐ No

If Yes,

16a.What did you do as a farmer/agricultural labourer?

16b. Why did you stop farming?

☐ 1.Change in landuse ☐ 2. Labour shortage ☐ 3.Lack of support and machinery

☐ 4. High cost and Loss/no benefit ☐ 5. Invasion of private groups ☐ 6. Increasing salinity

☐ 7. Non availability of seeds

2. Questionnaire for Fishermen

II. A. RESIDENTS

II. A. a. Fisher men

1. What kind of fishery do you practice? ☐ A) culture fishery ☐ B) capture fishery

2. Where do you carry out the practice?

☐ a) Freshwater ☐ b) Brackish water ☐ c) Marine

Sl. No.	Species of Fishes/ Crustaceans	Area		Fishing method used	Market where sold (Local/Co-Operative Society/Wholesalers)
		Own (ha)	Natural water bodies		
1					
2					
3					
4					

3. Fishing activity

Season/ Period	If associated with days (Ekadasi/ Ashtami etc.)	Hours/ day	Days/ week	Average catch/ week		Major species (*mangrove associated)	Market price
				Initial	Final (once dried)		
Jan-March (Makaram-Dhanu-Kumbham-Meenam)							

Season/ Period	If associated with days (Ekadasi/ Ashtami etc.)	Hours/ day	Days/ week	Average catch/ week		Major species (*mangrove associated)	Market price
				Initial	Final (once dried)		
April-June (Meenam-Medam-Edavam-Midhunam)							
July-Sept (Midhunam-Karkkidakam-Chingam-Kanni)							
Oct-Dec (Kanni-Thulam-Vrushchikam-Dhanu)							

4. Cost of fishing

a. Capital investment in fishing

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

b. Variable expenses

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

5. Gender in activity

Sl. No.	Activities	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Marine fishing							
2	Inland fishing							
3	Brackish water fishing							
4	Net weaving/ maintenance							
5	Boat maintenance							
6	Making and maintaining pond for culture							
7	Stocking							
8	Protection from predation							
9	Unloading/ sorting/Icing							
10	Curing/Drying/ Processing							
11	Marketing							
12	Homestead agriculture							

*Lead->50%, Assist-<50%; Hours – out of 24

6. Details of income

Particulars	Income	
	INR	Other forms
Fishing in marine		
Fishing in Inland		
Fishing in brackish water		
Allied business		
Total income/month		

7.Are you getting any assistance from institutional sources for fishing activities?

☐ Yes ☐ No

If yes, give details.

8. What is the importance of mangroves in fisheries?

9. Suppose the mangroves are cleared, what do you think would be the cost of fishery for you?

a. Capital investment in fishing

Sl. No.	Items	Notes (from fishermen)
1	Boat	
2	Net	
3	Others	

b. Variable expenses

Particulars	No.		Wages (`)	Notes (from fishermen)
	Owned	Hired		
Labour				
Materials				
1.				
2.				
Marketing cost				

10. Select one from the following:

a. Clear the mangroves for more land

b. Maintain mangroves as a source of fishery

c. Maintain the mangroves as a source of fishery and pay a nominal price for the same

3. Questionnaire for Bee Keepers

II.A.f. Bee keeper

1.How long have you been doing apiculture?

2. What are the food sources for bees in your area?

3. Are mangroves important for bees?

☐ Yes ☐ No

If Yes, how?

4. Total number of bee boxes you have?

5. Details - Cost and Income

Cost	INR	Income	INR/monthly
Purchase and establishment		Honey	
Bee keeper clothes and tools		Wax	
Labour cost		Other	
Marketing			

6. Do you receive any assistance from institutions?

☐ Yes ☐ No

If Yes, details.

7. Suppose mangroves are to be cleared, do you think your bee farming will be affected?

☐ Yes ☐ No

If Yes, how?

8. Have you planted mangroves for the purpose?

☐ Yes ☐ No

If Yes, give details?

9. Gender in activity

Sl. No.	Activities	Labour details in the effort (L-lead, A-assist/Hours)									
		Total No of labour	Nativity		Gender		Age group	Family itself			
			Local	Outsiders	F	M		Head	Spouse	Daughter	Son
1	Dividing colony										
2	Ensuring food and health										

3	Planting										
4	Harvesting										
5											

10. Select one from the following:

a. Clear the mangroves for more land

b. Maintain mangroves as a source of resource in bee keeping

c. maintain the mangroves as a source of resource in bee keeping and pay a nominal price for the same

4. Questionnaire for Government Private Employees

II.A.h. Government/Private Sector Workers/Entrepreneurs

1. Work sector:

2. Employment Nature: Permanent/Temporary

3. Do you do any activity involving mangroves of the area:

☐ Yes ☐ No

If yes, list

4. Are you willing to conserve mangroves of the area?

☐ Yes ☐ No

If Yes, how?

5. Do you think mangroves support the livelihood of people in your area?

☐ Yes ☐ No

6. Do you find the position of your land inconvenient for the purpose of education and employment?

☐ Yes ☐ No

If Yes, how?

7. Gender in activity

Sl. No.	Activities	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Cleaning of house							
2	Cleaning of clothes							
3	Cooking							
4	Tuition to kids							
5	Waste management							
6	Homestead agriculture							
7	House maintenance							
8	Running business							
9	Managing business accounts							
10								

*Lead->50%, Assist-<50%; Hours – out of 24

8. Suppose mangroves are to be cleared from the land, do you think the cost of living would increase for you?

☐ Yes ☐ No

If Yes, how?

9.Choose one from the following:

a. Clear the mangroves for more land

b. Maintain mangroves as a source of resource for homestead agriculture

c. maintain the mangroves as a source of resource for homestead agriculture and pay a nominal price for the same

5. Questionnaire for livestock Keepers

II.A. c. Livestock/Dairy Farmer

1. How long have you been growing livestock?

2. Types of livestock: Egg/Meat (Chicken/ Duck/ Pig/Buffalo), Dairy(Cow, Goat, Buffalo)

3. Details:

Sl. No.	Variety used (Local/hybrid)	Quantity	Market cost (INR)	Yield /month			Market value of yield (INR)
				Eggs	Meat	Milk	

4. Cost of livestock farming:

Sl. No.	Particulars	Monthly
1	Input cost (purchase+ enclosure)	
2	Feed	
3	Health maintenance	
4	Labour charges	
5	Harvesting charges	
6	Marketing charges	
7	Total cost	

5. Does your livestock feed in the mangrove areas:

☐ Yes ☐ No

6. Do you prepare any feed for livestock out of resources from the land?

☐ Yes ☐ No

If Yes,

Type of feed	Obtained from	Quantity/day	Market value (INR)

7. Do you think mangroves are important for maintaining healthy livestock?

☐ Yes ☐ No

7a. If Yes, why?

8. Do you collect fodder for livestock from mangroves?

☐ Yes ☐ No

8a. If yes, what are the species collected?

8b.Type of material collected?

☐ Leaves, ☐ Seeds, ☐ Flowers, ☐ Branches, ☐ Roots

8c.Preferable size/quantity per day?

9. Gender in Activity

Sl. No.	Livestock farming activities	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Shed making							
2	Cleaning of sheds							
3	Purchasing/preparing livestock feed							
4	Feeding livestock							
5	Milking							
	Homestead agriculture							
6	By-product sale/ storage							
7	Processing							

Sl. No.	Livestock farming activities	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
	Managing business accounts							
8	Marketing							
9	Waste management							
10	Homestead agriculture							

*Lead->50%, Assist-<50%; Hours – out of 24

10. Suppose mangroves are to be cleared, what do you think the cost of keeping livestock for you?

Sl. No.	Particulars	Monthly
1	Input cost (purchase+ enclosure)	
2	Feed	
3	Health maintenance	
4	Labour charges	
5	Harvesting charges	
6	Marketing charges	
7	Total cost	

11. Select one from the following:

a. Clear the mangroves for more land

b. Maintain mangroves as a resource

c. Maintain the mangroves as a resource and pay a nominal price for the same

6. Questionnaire for Outsiders/Vacation residents

II.A.i. Outsiders/Vacation residents

1. Native place:

2. Size of the family/group:

No	Individuals	Employment type	Education	Gender	Age

3. Purpose of stay:

a. Work related

b. Pleasure

4. If Work related,

Does your work relate to mangroves or wetlands?

☐ Yes ☐ No

If Yes, How?

Job:

5. Duration of stay:

6. Reason for selection of the place for stay:

7. Do you think mangroves increases the aesthetic/recreational value of this property?

☐ Yes ☐ No

8. Do you acknowledge aesthetic value towards the rent of the property?

☐ Yes ☐ No

If No, why?

9. What is the actual expense occurred to you for this recreational experience?

10. What do you think is the cost should be for this recreational experience?

11. Suppose mangroves are not present in the area, would you be still willing to pay the same amount for the experience?

☐ Yes ☐ No

If No why?

7. Questionnaire for Rice Farmers

II .A. b. Agriculture/farmers (Rice)

1. What method of rice farming are you following?

☐ a. Rice only ☐ b. Rice-fish system

2. How long have you been doing rice/rice-fish system farming?

☐ Less than 5 years

☐ 5-15 yrs

☐ 15-25 yrs

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

3. Details of the land under use

Sl. No.		Season	Area(ha)		Variety
			Total	Under cultivation	
1	Pokkali	Virippu (May-Oct)			
		Oorumundakan (Aug-Jan)			
2	Kaipppad	Mundakan (Sept-Jan)			
		Puncha (Dec-Apr)			

4. Has there been -a reduction in the area in which you are cultivating rice or- irregularities in farming?

☐ Yes ☐ No

If Yes, why? (Tick all that applies)

☐ a. High labour cost ☐ b. Less/ No yield ☐ c.Introduction of chemmeen kettu
☐ d. Lack of support/machinery ☐ e. economic unviability ☐ f. climate variations
☐ g. lack of suitable harvesters

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

6. Suppose mangroves are cleared, do you think the cost would increase for rice farming/rice fish system for you?

☐ Yes ☐ No

If Yes,

Sl. No.	Input used	Quantity applied	Rate (`)	Subsidies		Transportation cost (`) if any (`)	Other expenses
				Rate/unit	Total amount (`)		
	Seeds						
	Manures and fertilizers						
	Labour charges						
	Machine						
	Bund preparations						
	Harvesting						
	Marketing						

7. Select one from the following:

☐ a. Clear the mangroves for more land

☐ b. Maintain mangroves as a means for rice farming/rice fish system

☐ c. Maintain the mangroves as a a means for rice farming/ rice fish system and pay a nominal price for the same

1.Rice Only

1. Labour use pattern

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	Planting							
4	Intercultural operations							
5	Harvesting							
6	Post harvest operations							
	Total							

2. Gender in Activity

Sl. No.	Rice farming activities	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Land preparation							
2	Sowing							
3	Planting of young plants							
4	Weeding							
	Milking							
5	Fertilizer application							
	By-product sale/ storage							
6	Harvesting							
7	Steaming and drying							
8	By-product sale/ storage							
9	Processing							
10	Marketing							
11	Stocking of seeds							

*Lead->50%, Assist-<50%; Hours – out of 24

3. Details of Expenses for rice

Sl. No.	Input used	Quantity	Rate (`)	Subsidies		Transportation cost (`) if any (`)	Other expenses
				Rate/unit	Total amount (`)		
1	Kettu/Bund preparations						
2	Seeds						
3	Manures and Pesticides						
4	Labour charges						
5	Machine						
6							

4. Details of yield obtained

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

5. Cost of marketing

Particulars	Value (`)
Rice	
By products	
Total cost	

6. In your opinion are you getting any benefits out of mangroves for your rice farming?

☐ Yes ☐ No

6a. 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	High quality pokkali/other rice	
6	Any other please specify	

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

7a. If yes, is it due to mangroves? ☐ Yes ☐ No

7b. If yes, how much reduction in manure quantity?

7c. If yes, What are the reasons for the less use of manures?

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

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

If Yes, why?

9. Can mangroves be used for natural bunding in the rice fields?

☐ Yes ☐ No

2. for Rice-Fish System

1. How do you practice rice-fish system?

a. simultaneous farming b. Rotational farming

2. What is the method you follow for farming fish in the rice-fish system?

1a. Capture system -inflow of prawn seedlings from sea and the backwaters

1b. Culture system-Chemmen/meen kettu using seed stock

3. Do you think there is reduction in inflow of prawn seedlings in the recent years?

☐ Yes ☐ No

If Yes, why?

a.Siltation b. developmental activities c.Dams and bunds d.Unscientific practices e.Other

4. Is it more beneficial than farming rice alone?

☐ Yes ☐ No

If Yes, how?

5. Details of the rice-fish system

Farming	Season	Rice variety	Fish/ Crustacean	Yield		Market Price
				Rice (Kg)	Fish (Kg)	
Simultaneous	Virippu					
	Oorumundakan					
	Mundakan					
	Puncha					
Rotational	Virippu					
	Oorumundakan					
	Mundakan					
	Puncha					

6. Labour use pattern -Fish and Rice

Sl. No.	Particulars	Family labour		Hired labour		Prevailing wage rate/hrs of work (`)		
		Men	Woman	Men	Woman	Hours of work	Men	Woman
1	Installation of sluice gates							
2	Strengthening and renewal of bund							
3	Breed depositing							
4	Protection							
5	Guard of work shed							
6	Pumping out water and Harvest							
7	Post harvest operations							
8	Fish Marketing							

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	Planting							
4	Intercultural operations							
5	Harvesting							
6	Post harvest operations							
	Total							

7. Cost of fish culture and rice

Sl. No.	Particulars	INR
1	Cost of fish breed	
2	Fabrication and installation of sluice gates	
3	Strengthening and renewal of bund	
4	Breed depositing and protection	
5	Fuel	
6	Fabrication of work shed and shelter	
7	Guard of work shed	
8	Water filtration net	
9	Small wooden boat	
10	Harvesting	
11	Marketing	
12		

Sl. No.	Input used	Quantity	Rate (`)	Subsidies		Transportation cost (`) if any (`)	Other expenses
				Rate/unit	Total amount (`)		
1	Kettu/Bund preparations						
2	Seeds						
3	Manures and Pesticides						
4	Labour charges						
5	Machine						
6							

8. Gender in Activity- Fish and Rice

Sl. No.	Fish system	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Installation of sluice gates							
2	Strengthening and renewal of bund							
3	Breed depositing							
4	Protection							
5	Guard of work shed							
6	Pumping out water and Harvest							
7	Post harvest operations							
8	Fish Marketing							

Sl. No.	Rice system	Members contribution in the effort (L-lead, A-assist/Hours)						
		Head of the house	Spouse	Children		Others	Age	Remarks
				M	F			
1	Land,bund preparation							
2	Seed sowing							
3	Planting of young plants							
4	Weeding							
5	Fertilizer application							
6	Harvesting							
7	Steaming and drying							
8	By-product sale/ storage							
9	Processing							
10	Marketing							
11	Stocking of seeds							

*Lead->50%, Assist-<50%; Hours – out of 24

9. In your opinion are you getting any benefits out of mangroves for your rice farming?

☐ Yes ☐ No

9a. 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	High quality pokkali/other rice	
6	Any other please specify	

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

10a. If yes, is it due to mangroves? ☐ Yes ☐ No

10b. If yes, how much reduction in manure quantity?

10c. If yes, What are the reasons for the less use of manures?

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

11. Are you experiencing salt water intrusion in your paddy fields? ☐ Yes ☐ No

If Yes, why?

12. Can mangroves be used for natural bunding in the rice fields?

☐ Yes ☐ No

8. Questionnaires for Tourism operators/Homestays/Farm tourism

II.A.g. Tourism operators/Homestays/Farm tourism

1. Name of the resort/Homestay/House boat/Farm tourism:

2. Number of rooms you rent out:

3. Range of tariff:

4.Distance of mangrove area from your property:

5. Do you find mangrove as an attraction for tourists?

☐ Yes ☐ No

If yes, how?

6. Do you find Mangrove as an inconvenience to tourists or business?

☐ Yes ☐ No

If Yes, how?

7. Do you get any assistance from Institutions for the business?

☐ Yes ☐ No

If Yes, what?

8. If farm tourism, What are the major activities at the farm?

Farm Activities	Details	Tick (that applies)
Paddy cultivation	Sowing festival Harvesting festival	☐ ☐
Fishery	Prawn cultivation Fish cultivation Crab cultivation Fish and crab hunting Last fish hunting ceremony (/Kettu kalakku)	☐ ☐ ☐ ☐ ☐
Leisure activities	Country boat rowing Boat cruise in canals	☐ ☐
Educational tours	Learning about rice Learning about fishery Learning about ecosystem Learning about mangroves	☐ ☐ ☐ ☐

9. a) Details of Expenses

Particular	Cost/month	Cost/Year
1. Electricity		
2. Water		
3.Cooking Gas		
4.Tax		
5.Labour		
6.Maintenance and beautification		
7.Fuel expenses		
8.Advertising		
9.Cultivation expenses		

b) Factors contributing to Income

No	Particulars	Tick that applies	Income/ month during season (Sept-February)	Income/month during off-season (March-Aug)
1	Recreational value			
2	Aesthetic value			
3	Facilities			
4	Remoteness of the place			
5	Mangroves in particular			
6	Farm activities			

10. Do you spend money towards the raising, protection and management of mangroves?

☐ Yes ☐ No

If yes, how?

11. Do you think mangroves increases the aesthetic/recreational value of your property/business?

☐ Yes ☐ No

If yes, how

12. If farm tourism, what are the reasons behind promoting farm tourism?

Sl. No.	Particulars	Rank
1	Conservation of traditional rice/fishery practices	
2	Conservation of the unique ecosystem	
3	Conservation of mangroves	
4	To promote research and science	
5	To generate income for self and locals	
6	Others	

13. Gender in Activity

Sl. No.	Activities	Labour details in the effort (L-lead, A-assist/Hours)									
		Total No of labour	Nativity		Gender		Age group	Family itself			
			Local	Outsiders	F	M		Head	Spouse	Daughter	Son
1	Cleaning										
2	Cooking										
3	Caretaker										
4	Advertisement										
5	Security										
6	Waste management										
7	Homestead agriculture										
8	Farm-Rice cultivation										
9	Farm-Fishing										
10	Farm-boat cruise and other activities										

*Lead->50%, Assist-<50%; Hours – out of 24

14. Suppose mangroves are to be cleared, how do you think the cost would vary for you to run the business?

Particular	Cost/month	Cost/Year
1. Electricity		
2. Water		
3.Cooking Gas		
4.Tax		
5.Labour		
6.Maintenance and beautification		
7.Advertising		
8.Farm activities		
9.Fuel expense		

15. Select one from the following:

☐ a. Clear the mangroves for more land

☐ b. Maintain mangroves as a source of resource

☐ c. maintain the mangroves as a source of resource in tourism and pay a nominal price for the same

9. Willingness to Pay Questionnaire

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

☐ 1. direct payment ☐ 2. tax

1b. one time

Installments

1c. If installments

• Monthly/ Quarterly/Annually for 2 years

• Monthly/ Quarterly/Annually for 5 years

• Monthly/ Quarterly/Annually for 10 years

2. Are you willing to pay

☐ 10% or ☐ 1% of your monthly income ?

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

3. Reasons for willing to pay :

4. Reasons for not willing to pay :

5. Suppose there is a payment scheme for the service you benefit from mangroves. Would you still plant and protect mangroves?

Annexure 2: Evaluation of Ecosystem Services Provided by Mangrove Ecosystems and Developing Guidelines for Investment in Mangrove Restoration – Kochi

Date: February 23, 2019; 10:30 Am To 4:00 PM

Venue: Sarovaram, NH 47 Cochin Bypass, Maradu P O, Cochin. Kerala.

Participants

1	Dr. Monalisa Sen
2	Dr. C.M Joy
3	Dr. Dhanya Radhamani
4	Adv. Harish Vasudevan
5	Adv Ashkar
6	Dr.Smitha Krishnan
7	Dr. Shijo Joseph
8	Dr.T V Sajeev
9	Dr. Priyadarsanan Dharmarajan
10	Ms. Rashmi Mahajan
11	Mr. Nachiket Kelkar
12	Mr. Raj Bhagat
13	Mr. Ramith
14	Mr. Purushan Eloor
15	Mr. Dr. K.M Jayahari
16	Ms. Philomina joseph
17	Ms. Rani Varghese
18	Ms. C.M Preethy
19	Dr. Abin Joseph
20	Mr. Alex C.J.
21	Mr. Sony R.K.
22	Ms. Jiss Sebastian
23	Mr. Geo Joseph

The technical working group called to order at 10.25 am by Dr K.M. Jayahari. He welcomed the gathering and started his concept presentation. His presentation provided the concept of mangroves in Kerala. He pointed out the importance of identifying the drivers of ecosystem changes in urban ecosystem

mangroves. He explained the significance of evaluating the mangrove ecosystem, mangrove ecosystem services, social consciousness, policy frameworks and opportunity cost and power dynamism. The presentation gave an overall idea about spatial analysis, data collection and data analysis in the proposed study. He provided the work philosophy and work methodology. He ensured the willingness of project organizers on accepting the quality changes in the methodology of proposed work and readiness of publishing the final outcome of the project on the public domain.

After his presentation, he invited the gathering for discussion. Dr. Priyadarsanan Dharmarajan enquired about the time duration of the study. Dr. Monalisa Sen explained the international framework of present work and its city based model structure at the national level. Mr Nachiket Kelkar pointed out the quality of ecosystem services in mangroves. Dr. T. V. Sanjeev explained the impact of art forms especially cinema and documentary to common peoples regarding conservation and awareness of ecosystem by pointing Malayalam films like 'Kamattipadam' and 'Kumbalangi nights'. He reiterated that while assessing the ecosystem services of mangroves there should be space for documenting the struggles of society due to the ecosystem (IOC struggle in Puthuvypu). Dr Priyadarsanan Dharmarajan expressed the role of landholders in mangrove ecosystem conservation strategies. He conveyed the proposal for advocating the state government for buying the mangrove land areas. Incentives dispersal for private mangrove landowners and development pressure of government on government-owned mangrove ecosystems. Dr Smitha Krishnan emphasized the role of community involvement in the present study and advocated for grassroots level involvement of mangrove-associated indigenous communities. She had raised her apprehension on the quality of GIS mapping data on the study period. Mr. Ramith expressed the idea that a combination of awareness and involvement of communities associated with mangroves would give more results for the conservation. Ms Philomina Joseph expressed the ecotourism projects in mangrove areas where people are willing to plant mangroves and emphasized ecotourism in conservation strategies.

Dr. C. M. Joy provided the concept of integrated farming practices in mangrove ecosystems and thereby conservation strategies. Mr Purushan Eloor expressed the urgency of micro-level awareness on mangroves benefits to the society especially the indigenous community. He reiterated that the organizations and government bodies must work with an objective that the mangroves associated communities must feel the ecological services of mangroves. Adv. Ashkar pointed out the Bombay High court judgment regarding the protection of the mangrove ecosystem and it is a violation of the article 21st if mangroves are destroyed. Dr. Dhanya Radhamani enquired about the reforestation/afforestation plan of present study and pockets for mangrove cultivation.

After the scientific discussions, the gathering dispersed for tea at 11.15 am. At 11.35 am the gathering assembled for the presentation of methodology and tools of proposed study followed by discussion. Mr. Sony R. K. and Ms. Jis Sebastian presented the methodology of the proposed study. First, they had explained the objectives of the study followed by the detailed methodology of proposed work. Dr K.M Jayahari announced the discussion of methodology part after the presentation. Dr. C. M. Joy proposed that the present study must assess the ecosystem services done by mangroves in the study area. Dr. K. M. Jayahari replied for the above proposal with an explanation that the present study was more focused on the identification of benefits of the mangrove ecosystem in local communities. Dr. Smitha Krishnan enquired the impact of the recent flood in Kerala was going to be a part of methodology and the project coordinators explained those are not coming under the objectives of the study. Dr. T. V. Sanjeev proposed the present study could be presented in the international platforms especially the London Conference in 2020. Ecosytem services that are provisioning gain the local attention whereas carbon sequestration fetches the global attention, he pointed out. Dr. K. M. Jayahari replied to the proposal by stating the lacunas in the spatial scale of the present study and duration of the study. The filtered social survey may

lead to biases as per Mr. Nachiket. He therefore suggested apart from the data collected, an analysis on the secondary data (ie, from previous resources) may also be done.

Adv. Harish Vasudevan expressed the policy implementation strategies in the conservation of the mangrove ecosystem. He emphasized the importance of mangrove land acquisition from private landholders and implementation of Kerala government policy in the conservation of mangroves. He expressed these were the major tools for conservation: Policy, Instrument and financial assistance for protection. A discussion on legal mapping was followed. How provisions can be used in getting a policy documented lead to the thoughts on formation of separate draft for documenting policy under the leadership of Adv. Harish and Dr. Priyadarsanan. Dr. Priyadarsanan Dharmarajan expressed drawbacks of present government policies in the conservation strategies of mangroves. Mr Ramith provided a comprehensive view regarding the policy implementation of conservation in mangroves, based on Kannur district model. In Kannur effective cooperation of Revenue department, Kerala forest department and Kerala Biodiversity Board together framed the conservation policy and effectively conserving the ecosystem.

A discussion was held regarding the conflict between true mangroves and associates. Ms. C. M. Preethy discussed the contradicting taxonomical researches in the subject that presents very different figures of the mentioned groups. She mentioned places wherein people wrongly identify mangroves as associates. Dr. Jayahari mentioned about signature herbarium that is to tag species geologically into true and associates. He shared his concern about What is the criteria that people use to identify mangroves as tree mangroves could be of importance. Dr. C. M. Joy shared his view that mangroves are classified into true, semi and associates. Ramith suggested high importance given to *Rhizophora* might have played a role in getting people believe that *Rhizophora* is the only mangrove! He also stressed on the thought that entire ecosystem of mangroves including mudflats, paddy fields has to be emphasized rather than just trees. Mr. Purushan added that connecting people with mangroves could be the way ahead. He proposed Vallarpadam container terminal road as a potential zone for the development of enabling conditions. For example, he mentioned introducing tourism along with fishing.

After the fruitful discussions of the methodology of proposed research work, the gathering dispersed for lunch at 1.30 pm. The gathering reassembled at 2.20 pm followed by the presentation of Mr Nachiket Kelkar. He explained the tools in the methodology, giving more idea regarding the Classification and Regression Tree, General Linear Model and Path analysis. At 2.45 pm Dr. Abin Joseph presented GIS tools and Techniques. He explained the study area (277.526 Km2) of the proposed study, satellite focused (Landsat VII, Resourcesat 2, Resourcesat 2A), resolution, image classification and visual interpretation. He ensured the usage of good quality data with minimum atmospheric noises.

At 3.30 pm, the TWG concluded the scientific discussions by Chair Dr. K. M. Jayahari. He proposed the different approaches that are in consideration to carry out the work in the proposed duration. An open platform would be created for the entire team and TWG members wherein they could contribute, criticize or use data for publications and references. He invited the continuous assessment of the proposed study in future by TWG members. He ensured that the suggestions of TWG members would definitely be incorporated in the proposed study. He requested continuous support and cooperation of expertise in TWG members in the implementation of the proposed project. At 3.40 pm Dr. K. M. Jayahari invited Dr. Monalisa Sen for casting the official vote of thanks. Meeting adjourned at 3.45 pm.

Minutes prepared by: Mr. Geo Joseph, Research Scholar, Sacred Heart College Thevara, Mahatma Gandhi University, Kottayam, Kerala.

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