PLANNING FOR MANAGEMENT OF ESTUARY MOUTH - A CASE OF ASHTAMUDI KOLLAM

THESIS REPORT

Submitted by

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MUP (2020 - 2022) BATCH

to

the APJ Abdul Kalam Technological University in partial fulfillment

of the requirements for the award of the

Post Graduate Degree of M. Planning in

Urban Planning

URBAN PLANNING

DEPARTMENT OF ARCHITECTURE

THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING

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DEPARTMENT OF ARCHITECTURE

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ENGINEERING

CERTIFICATE

Certified that the Project entitled "**Planning for management of Estuary Mouth - A Case of Ashtamudi Kollam"** submitted by **Roshni Ann Johnson (TKM20MUP013)** of MUP (2020-22) BATCH, in partial fulfillment of the requirements for the award of Post-Graduate Degree in Urban Planning, under the APJ Abdul Kalam Technological University is a bonafide work carried out by her under our guidance and supervision.

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INTERNAL EXAMINER

EXTERNAL EXAMINER

DECLARATION

I hereby declare that the project entitled **"Planning for management of Estuary Mouth - A Case of Ashtamudi Kollam"** is a bona-fide record of the study done as part of thesis work done under the supervision of Ar. Shahina Muthu S during the **Fourth Semester M.Plan (2022)** Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College Of Engineering, Kollam. I declare that, to the best of my knowledge, the work reported herein does not form part of any other project report or dissertation based on which a degree or award was conferred on an earlier occasion to any other candidate.

Place: Kollam

Date: 12/09/2022

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ABSTRACT

Estuaries are home to a diverse habitat and is often where the environmental and economic interest collide. Most water bodies in India from many estuarine environments which are under threat from various marine and inland water-based activities. It is high time that regional level estuary management plans be brought into action for the protection of fragmented habitats of the threatened estuaries. Thus, it becomes imperative to introduce local level estuary mouth management plans to maintain estuarine health and to restore the habitat.

The study explores the contextual study of the Ashtamudi Estuary extend 6km upstream rooting down to the riparian wards of the extend from four local bodies. An onsite investigation and survey was conducted in the riparian wards to understand and analyze the varied effects of shore on the estuary and lake health. From the investigation and literature studies, contextually relevant parameters are sought for which the issues are identified for which recommendations are provided.

Ashtamudi Lake's estuary mouth is home to variety of habitats which include avi-faunal and aqua-faunal species. The paper discusses various impacts generated by intensities of riparian habitat and land-use pattern including urbanization, tourism activities and industrial development over estuarine water resources. The study investigates the impact of various marine and inland water activities on the study area to recommend various methods which can be adopted at the spatial planning level to manage the health of estuary mouth.

Key Words: Estuary, Estuary Mouth Management, Pollution

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List of Abbreviations

EPA – Environmental protection Agency

ALMP – Ashtamudi Lake Management Plan

EFL – Ecologically fragile land

EZM – Estuary Zonation Map

CRZ – Coastal Regulation Zone

DO – Dissolved oxygen

ERM – Effective range Medium

ERL – Effective range low

PHC – Polysaturated hydrocarbons

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND STUDY

The integration of spatial and environmental concerns, such as water resources, are critical drivers for sustainability. The importance of place-based approaches in planning contribute better to protect the ecological values and environmental quality. (Rodrigues, 2021)

The role of spatial planning to protect environmental values, by preventing the fragmentation of habitats and by fostering the implementation of nature-based solutions and green and blue infrastructures, is underlined, especially in environmentally sensitive areas. (Rodrigues, 2021)

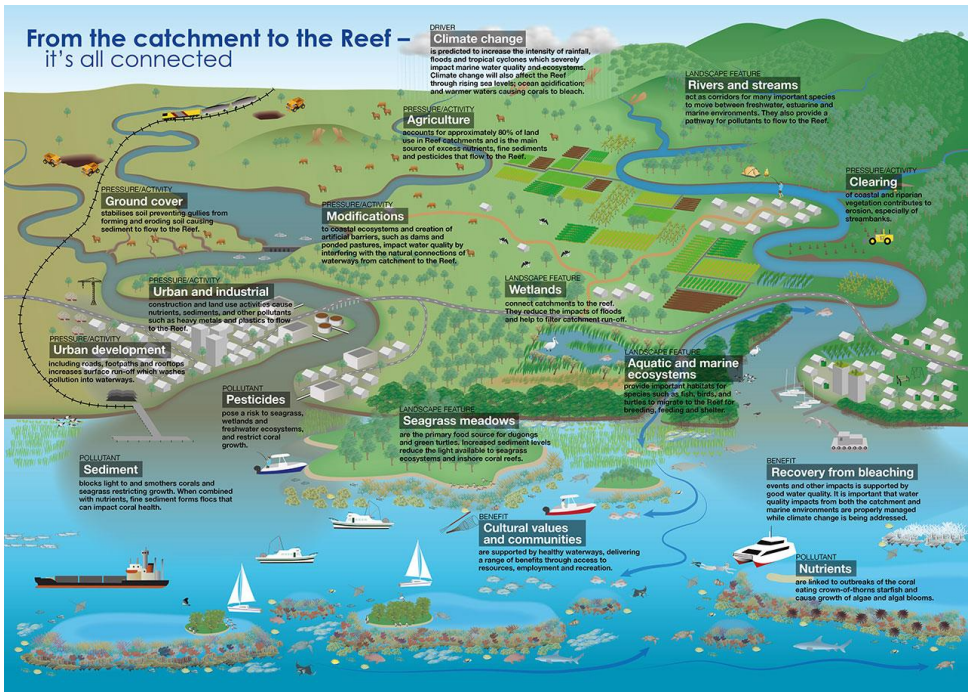


Figure 1 An Estuarine System

Source: Retrieved from https://www.reefplan.qld.gov.au/__data/assets/pdf_file/0019/48511/gbr-connected-ecosystem-diagram.pdf

Sensitive habitats like estuaries where various activities which generate income collide spatial planning becomes a major factor which controls the socio economic and environmental health of the area. The adoption of developmental controls through land use regulations and control to co-ordinate and manage multi-faceted planning aspects like tourism, industrialization and urbanization impacts on the estuary environment can be mitigated and controlled efficiently.

1.2 NEED AND FEASIBILITY OF STUDY

The Ashtamudi estuary is the second largest estuarine system in Kerala with an area of 61 sq.km. This is the second largest wetland in Kerala and one of the deepest estuaries among all the other estuaries. (Ministry of Environment, 2015)

The Neendakara Harbour is one of the largest fishery harbours in the State, situated at the mouth of the wetland. Thousands of fishermen depend directly on the estuary for their livelihood. Ashtamudi Lake in Kerala (southwest coast of India) contributes approximately 80% of the overall clam export trade in India, providing livelihood for at least 3,000 local people. (Kerala, status of Wetlands in Kollam District) Estuaries are 25 times more efficient at converting sunlight and nutrients to plant biomass than open ocean environments, and 2.5 to 8 times more efficient than terrestrial agriculture.

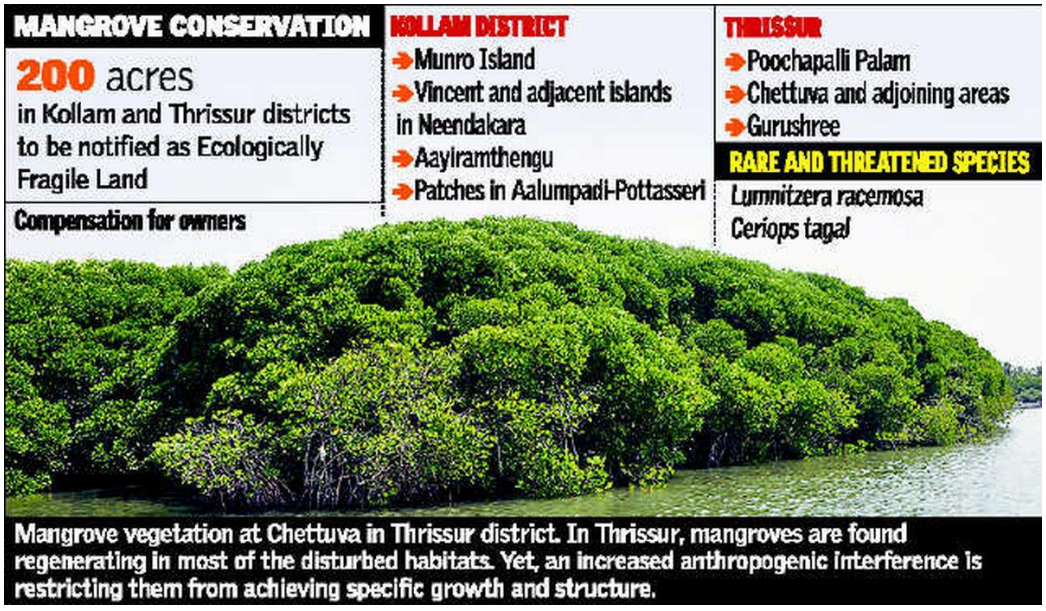


Figure 2 News for being listed under Ecologically Fragile Land

Source: Retrieved from https://www.thehindu.com/news/cities/Kochi/select-mangrove-swathes-to-become-efl/article7060273.ece

Astamudi Lake Management Plan is being prepared to address pollution, mangrove conservation, prevent estuary reclamation, fishing, control of motorboat effluents etc.

ALMP ZONES

1. Marine Bio Reserve Zone

2. Bird and Animal Habitat in bio reserve zone

3. Mangrove Conservation and Rehab Zone

Ashtamudi Lake has been designated **as a Ramsar Site** in November 2002, ((Grace K Mikhaye, 2019)

It supports many endangered species according to the Red Data Book of Indian Plants, such as Syzygium travencoricum (Bureau, 2021)

It supports around 43 marshy and mangrove species, 57 species of birds, 97 species of fishes and many unique copepod species (Paul, 2021)

It is the deepest among all the estuaries of Kerala with a maximum depth of 6.4 m at confluence zone.

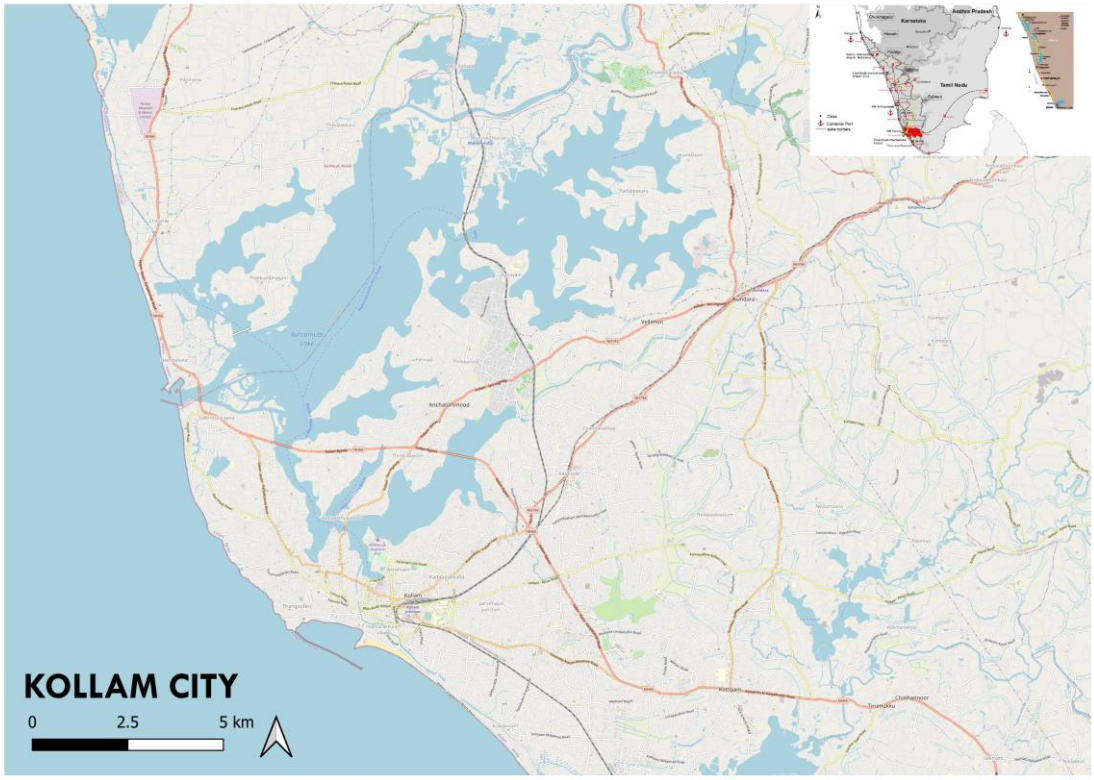


Figure 3 Map showing Needakara Estuary and Astamudi Lake, Kollam
Source: Author Generated

The Fisheries department together with Integrated Rural Technology Centre (IRTC), Town Planning Department and respective local bodies may take up the preparation of settlement plans for fishing villages which could be implemented by KSCADC through local bodies. (Fisheries, 2019)

1.3 AIM

To formulate planning recommendations and proposals for conservation and management of estuary mouth of Ashtamudi wetland systems.

1.4 OBJECTIVE

- To study the significance of Estuaries in an ecosystem.
- To understand the Geographical attributes by mapping local body level information.
- To analyse the services provided by the estuary to the study area and the communities.
- To understand and adopt feasible management techniques and practices for protecting and preserving the estuarine environment.
- To suggest feasible recommendations and proposals to integrate into an estuary mouth management plan for study area.

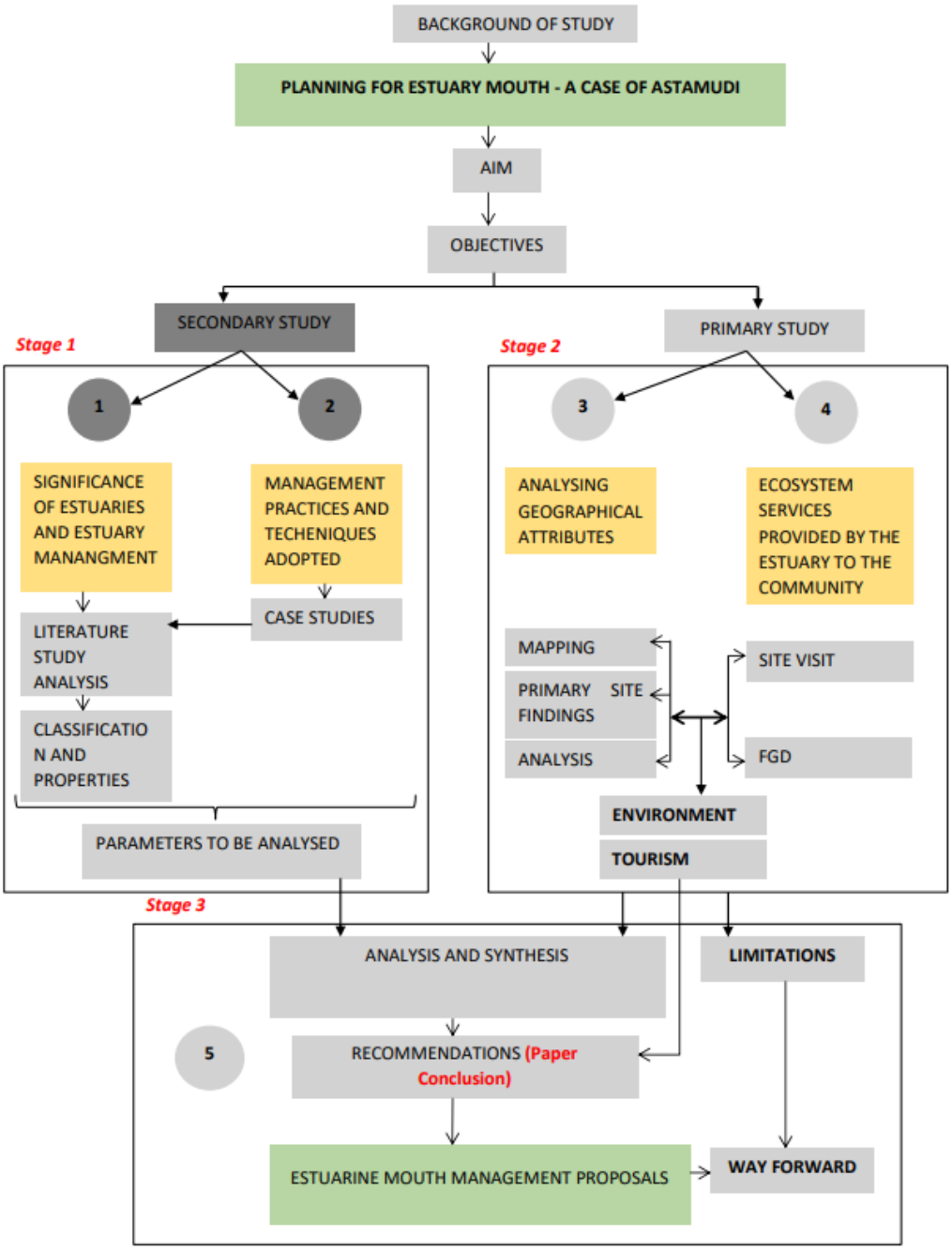
1.5 SCOPE AND LIMITATIONS

To understand and apply various management techniques to involve estuarine communities in protection of estuarine environments to restore and conserve biodiversity and ecosystem cultural and economic services offered by the estuarine environment of Neendakara.

Study limited to the Coastal and Riparian wards Islands and communities in the Neendakara Grama Panchayath and Shakthikulangara.

1.6 METHODOLOGY

A simple framework is followed for the research which enables background study focus group discussions understanding the contextual relevance and issues through case studies etc.



CHAPTER 2 LITERATURE REVIEW

2.1 DEFENITIONS

The word estuary originated from Latin where ‘aestus’ means ‘tide’.

An estuary is a semi-enclosed (partially enclosed) coastal body of water (with one or more rivers or streams flowing into it) which has a free connection to the open sea. (Hossain, 2019) It is thus strongly affected by tidal action and within its sea water is mixed or diluted with freshwater from land drainage (Pritchard, 1967)

“An estuary is a partially enclosed, coastal water body where freshwater from rivers and streams mixes with salt water from the ocean. Estuaries, and their surrounding lands, are places of transition from land to sea.” (Agency, EPA)

“An estuary is an area where a freshwater river or stream meets the ocean. When freshwater and seawater combine, the water becomes brackish, or slightly salty.” (Geography, 2005)

“An estuary is a partially enclosed body of water formed where fresh water from land meets and mixes with salt water from the ocean” (Research, 2007)

Estuaries provide us with several resources, benefits, and services. Estuaries provide places for recreational activities, scientific study, and aesthetic enjoyment. Estuaries are an irreplaceable natural resource that must be managed carefully for the mutual benefit of all who enjoy and depend on them. (Agency, EPA)

- The unique environment of estuaries allows plants to adapt specifically to the estuarine conditions.
- Transition from land to sea and fresh water to salt water
- Reefs, headlands, barrier islands and deltas protect the estuary from tidal force of the ocean.
- The uniqueness of sediment quality of the estuaries can be attributed to the combination of sea breeze, land breeze, freshwater flow, waves and tidal action.

Figure 4 An Estuarian Habitat

Source: Retrieved from Journal of Environmental Planning and Management, Y. Buitenhuis and C. Dieperink

2.2 Types of Estuaries

Estuaries are classified into different types based on various criterions. (Pritchard, 1967)

1. Geomorphology-Five types
2. Water circulation and stratification: Four types
3. Systems energetic/ ecosystem energetic: Five types

4. Freshwater discharge: Three types

2.2.1 Geomorphological Estuaries

Coastal Plain Estuaries/Drowned River valleys

Formed by rising sea levels in already existing river basins. Drowned river valleys are most extensively developed along coastlines with relatively low and wide coastal plains.

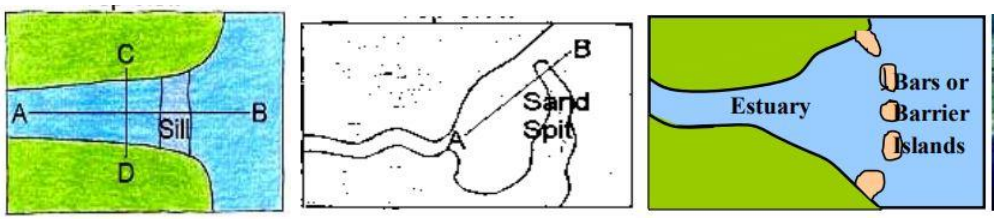


Figure 5 Fjords & Rias & Bar built Estuaries
Source: (Geography, 2005)

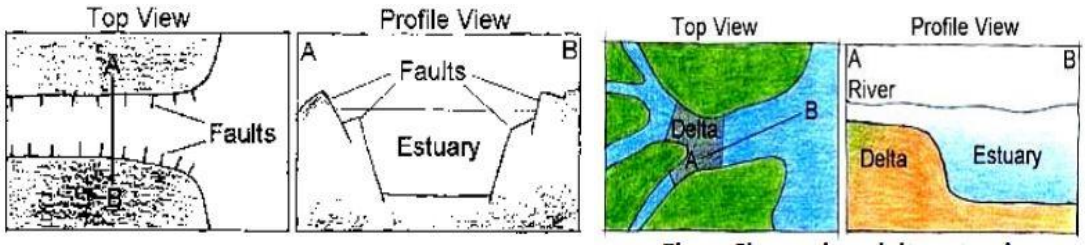


Figure 6 Tectonic Estuaries & River Delta Estuaries
Source: (Geography, 2005)

2.2.2 Water circulation and stratification

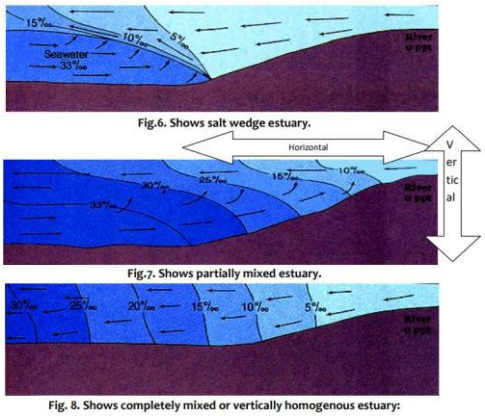


Figure 7 Types based on circulation
Source: (Geogrpahy, 2019)

2.2.3 Based on Freshwater discharge

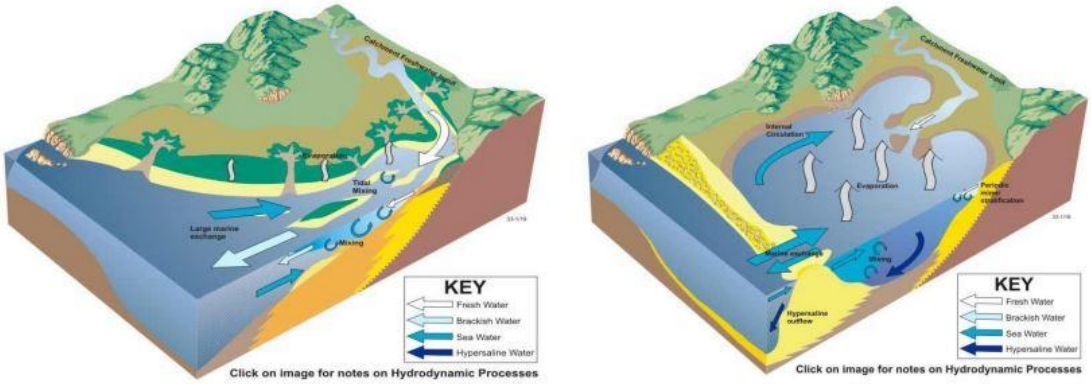


Figure 8 Positive (left) Negative (right) Estuaries
Source: (Geogrpahy, 2019)

2.2.4 Based on Systems / Ecosystem Energy

- Physically stressed systems of wide latitudinal range
- Natural arctic ecosystems with ice stress
- Natural temperate coastal ecosystems with seasonal programming
- Natural tropical coastal ecosystems of high diversity

2.3 Characteristics of an Estuary

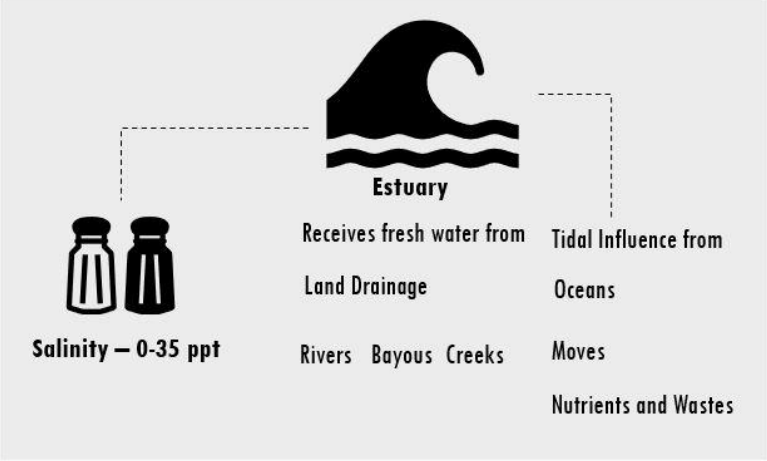


Figure 9 Estuarine Characteristics
Source: Author

The estuarine species are called euraline biota as they must tolerate ranges of salinity range spontaneously. The tidal ranges naturally flush off the waste products, impurities and even prevent pollution, this also maintains the salinity levels and add nutrients to the estuary and maintains PH. Wind direction is generally from the landward side to the seaward side which dries off the usually wet areas. ("Lessons on the Lake - The Magic of the Estuary - USGS")

2.4 Estuarine Ecosystem

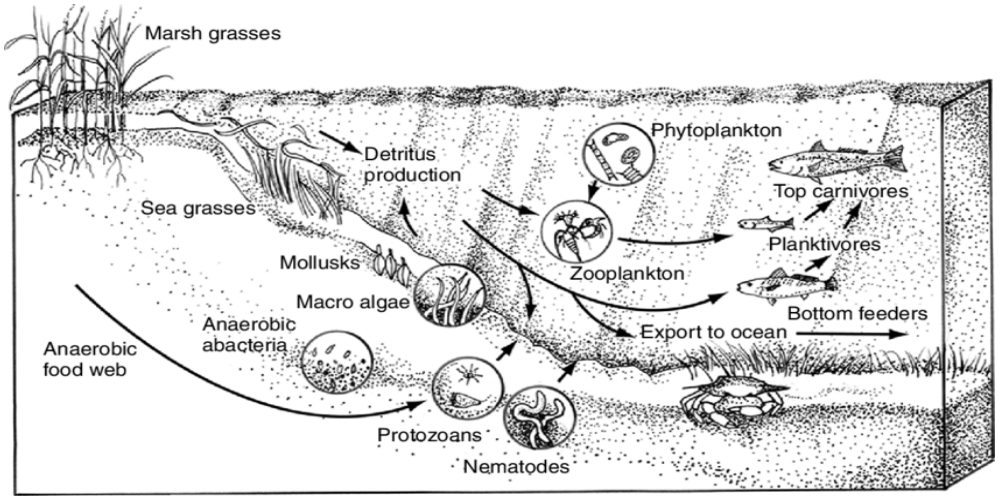


Figure 10 Food web diagram for a typical estuarine ecosystem
Source: (John W. Day, 1997)

Many plant and animal species thrive in estuaries. Presence of clam in estuaries enable the concentration of shell fish, small fish, migrating birds and shore animals. (Geography, 2005) The waters are rich in nutrients such as plankton and bacteria. Detritus which is the food matter for the benthic species is the decomposed plant matter which settles in. (John W. Day, 1997)

2.5 Estuaries – Services and Values

2.5.1 Ecological Values

Maintain water quality through natural filtration . uch of the sediments and pollutants are filtered out . Wetland soils and plants like mangroves, sea grasses and reeds also act as a natural buffer between the land and ocean, absorbing floodwaters from land and storm surges from the ocean. (John W. Day, 1997)They help maintain biodiversity by

providing a diverse range of unique habitats that are critical for the survival of many species. Estuaries provide breeding spaces for varied species of fishe, shellfish and act as nursuries which allow juveniles to thrive. (Latifa Pelage, 2019)

2.5.2 Economic Vlaues

They are tourist attractions.Used for transport and industry. They have ecological importance to commercial fisheries. Natural buffer between the land and ocean, absorbing floodwaters and storm surges. (John W. Day, 1997)They help maintain biodiversity by providing a diverse range of unique habitats that are critical for the survival of many species. (Latifa Pelage, 2019)

2.5.3 Cultural Values

Estuaries provide cultural importance as it allows recreation, education in fisheries and botany, aesthetics and traditional practices. The recreational values include fishing, swimming, boating, and bird watching etc. are some of the estuarine recreational activities which people enjoy. They offer benefits and services which greatly improve our lifestyle. Estuaries should be protected and managed with efficiency for benefit of the environment and the community to enjoy and derive ecosystem services provided. (Latifa Pelage, 2019)

2.6 Estuarine Communities

- Estuaries are excellent sites for community living. They provide freshwater for drinking and hygiene. Being the contact point of rivers and oceans aids in the development of trade and communication.
- Jakarta, Indonesia, New York City, New York; and Tokyo, Japan are examples of estuary based developed cities.
- These urban areas have undergone rapid change, through land reclamation, pollution, and overfishing.
- Communities have filled in the edges of estuaries for housing and industry since the times of Ur. This process is called land reclamation.

- Estuaries act as a natural barrier against the shoreline erosion by reducing the intensity of the coastal waves and thus allow the development of coast and communities. (Weinstein, 2009)

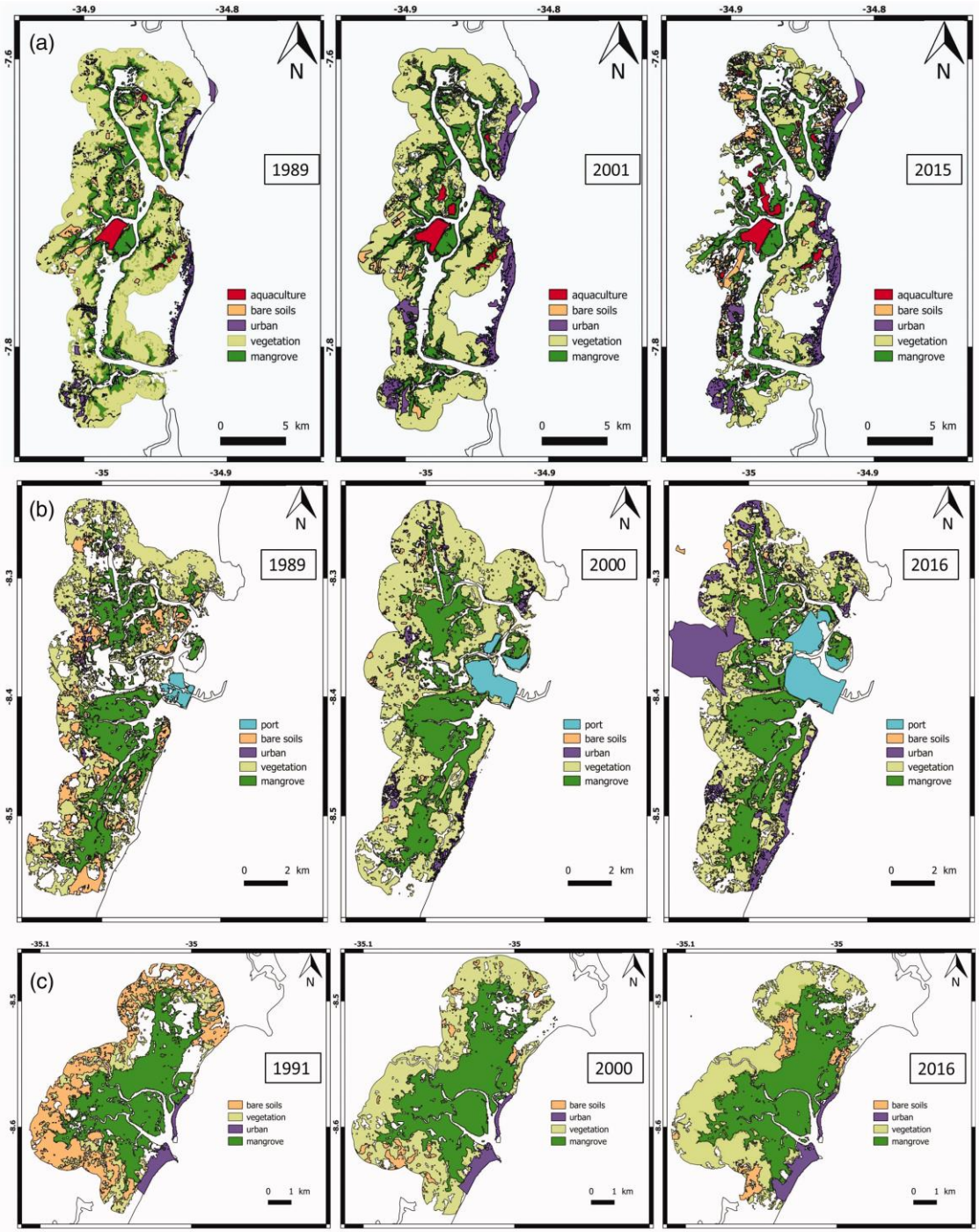


Figure 11 Evolution of mangrove areas and anthropic activities spatial occupation over the past three decades in (a) the Santa Cruz Channel, (b) Suape, and (c) Sirinhaém

Source: Coastal Land Use in Northeast Brazil: Mangrove Coverage Evolution Over Three Decades

2.7 Threats faced by Estuaries

The threats faced by Estuaries include excess silt flowing in from land clearance, Pollution from sewage, industrial wastes, and agricultural run-off, Oil spills / oil spillage, Invasion by introduced species, Reclamation for marinas, Extraction of sand and gravel, Construction of harbours and channels, Construction of embankments and roads, Solid wastes and garbage disposal, Natural disasters (e.g., cyclone, earthquake), Conversion to mining, Conversion to aquaculture, Conversion to agriculture, Conversion to salt pans, Conversion to urban development, Over exploitation by traditional users, Different pests and diseases, Other hazardous chemicals, Lack of sustainable mangrove management etc. (John W. Day, 1997) (Research, 2007)

2.8 Zonation Characteristics

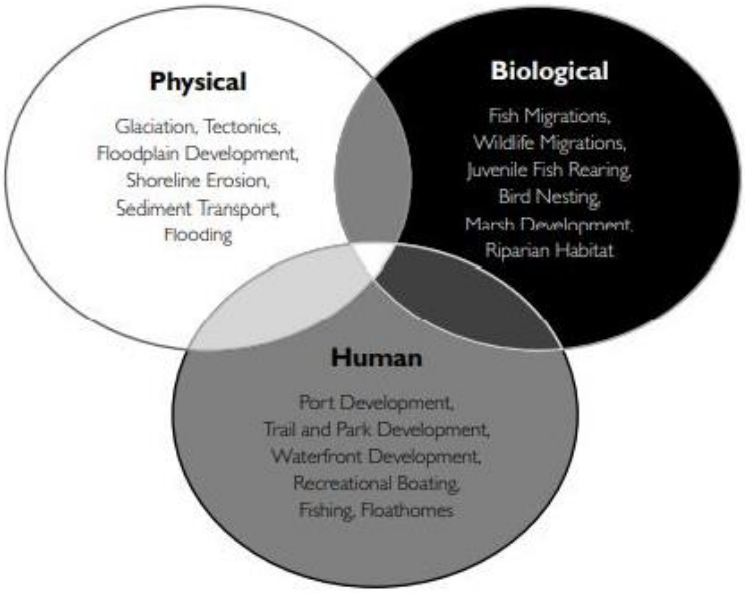


Figure 12 Zonation Characteristics on different levels

The human dimensions of sustainability and restoration science must become an integral part of the ecological restoration process. Natural components include Tidal marshes, beaches and other natural features, shoreline categorization- sensitivity map, estuary categorization. Human Components include Human Components – Population density, area, dredged channels, Reclaimed Land. (Geogrpahy, 2019)

2.9 Techniques Adopted

Programs to Reduce Stormwater Run-off Directly into Estuaries

1. Deep-well injection
2. Evaporation ponds
3. Discharge into surface water/municipal sewer

Estuary Zonation Maps

Inventory of Zones

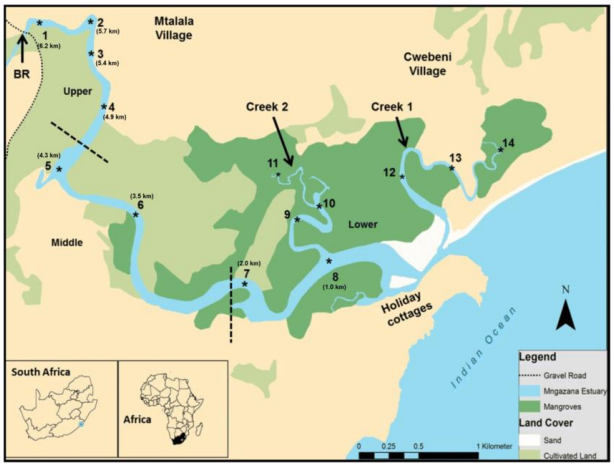


Figure 13 Estuary Zonation Map

Source: British Ecological Society, Journal of Applied Ecology, M. P. Weinstein, 2007

Accidental or Long-term Contaminant Spills

1. Contingency Plans
2. Oil spill drills
3. Primary Response Contractors (PRCs)
4. Geographic Response Plans (GRPs)
5. Incident Command System (ICS)
6. Trajectory Analysis Planner (TAP)

Protection recovery

1. Marine and estuarine shorelines and intertidal protection

2. Estuarine reserves
3. Regulations for protecting biological integrity
4. Programs for shoreline adoption, clean up, habitat enhancement and monitoring by citizen groups.
5. Marine Spatial Planning

2.10 Estuary Management Practices adopted in Studies

Table 1 Estuary Management Practices Which are adopted in Studies

Protection of biodiversity and sense of Place	Establish a marine protected area
	Integrate into IDP/SDF
	Zonation Plan
	RAMSAR Status
	CWBCR Core area
Co-operative and effective governance	Appointment Estuary Management Forum
	Define Co-operative governance arrangement
	Secure Financing
	Provide resources and Capacity
Restoration of Estuary Health	Secure freshwater input
	Clear Invasive species
	Eliminate illegal fishing
Research and monitoring	Promote Scientific Research
	Monitor Estuary Health
	Monitor Human Use
Increasing public awareness	Create Mechanisms to communicate with stake holders
	Education and awareness programmes
Promoting ecotourism	Establish and manage visitor facilities
	Responsible Marketing
Enhancing Local Livelihood	Sustainable use of estuarine resources
	Provide alternate livelihoods
	Empower local communities
	Favour Local communities

CHAPTER 3 SITE DELENIATION

3.1 Estuarine Extend

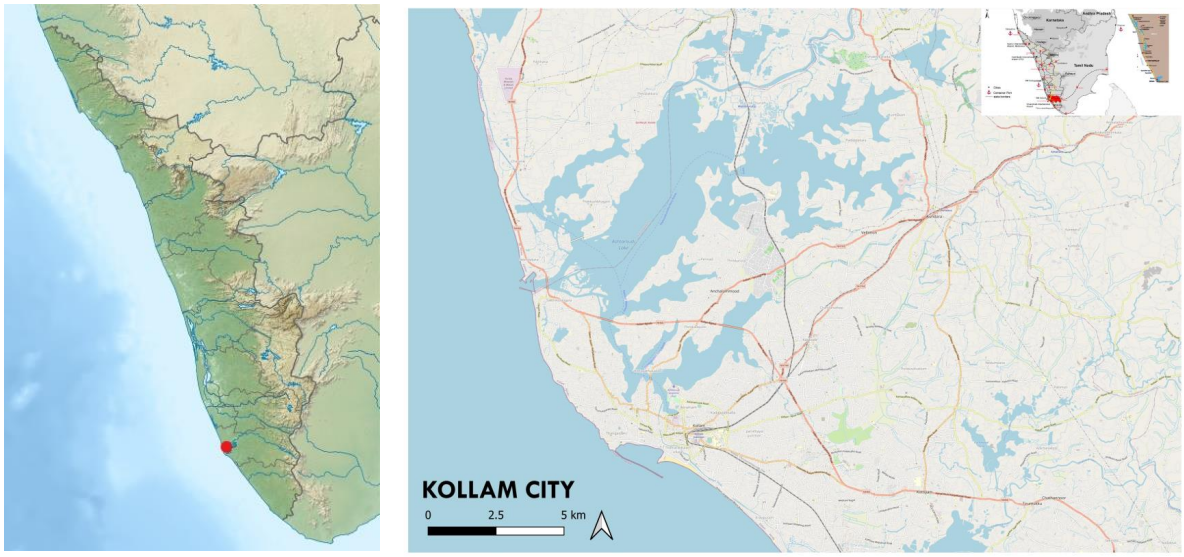


Figure 14 Location, Kollam Neendakara
Source: Author Generated

The beautiful Ashtamudi lake in Kollam district is one of the largest wetlands system in Kerala and also the deepest among the others. Thousands of populations of the Kollam District live by the shores of Ashtamudi. (Sitaram, 2014)

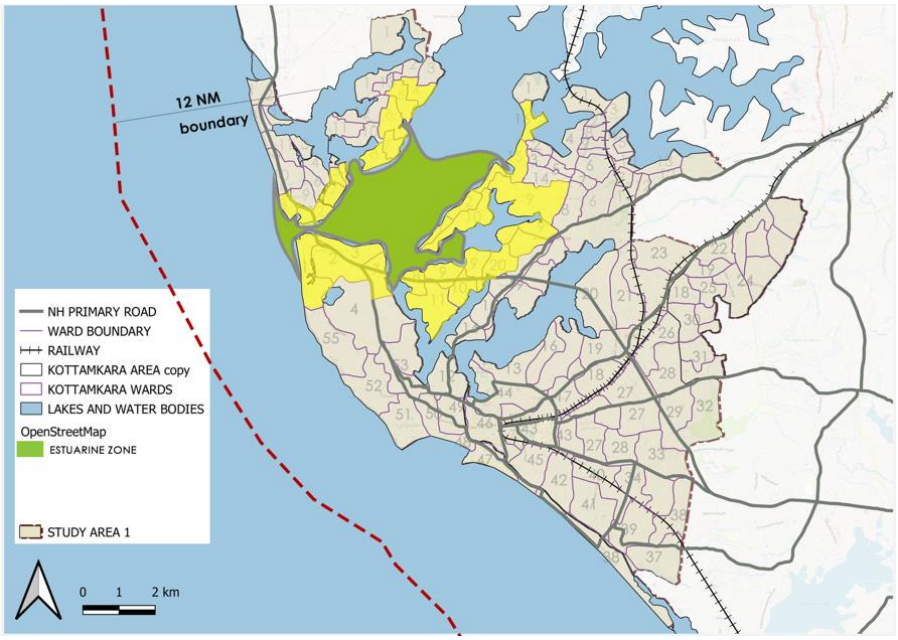


Figure 15 Estuarine Zone in Ashtamudi Lake
Source: Author Generated Referred from Socio Economic Scenario of Marine Fisheries in Kerala - Status and Scope for Improvement

Table 2 Details of Riparian Local Bodies

Local Body Name	Wards	Area	Population	Male	Female	Sex Ratio	Literacy	Physically Disabled
Neendakara GP	13	10.19	15424	7727	7697	1033	93.12	1514
Thrikadavoor GP	22	14.85	35859	17692	18167	1061	91.69	2415
Thekkumbhagom GP	13	20.26	15813	7789	8024	1030	91.91	781
Thrikkaruva GP	16	18.39	23122	11358	11764	996	89.95	1257

Source: Census 2011

Study area - Consist of the Kollam Municipal Corporation and four grama panchayats namely - Neendakara, Thekkumbagom (Islands), Thrikadavoor GP (now working as zonal office), and Thrikkaruva. The area is delineated based on the Extend of estuarine extend and fishing species extend which is particular to the estuarine confluence zone. Wards which are present along the estuarine area which comes in waterfront are specifically taken up to understand the issues.

Ashtamudi is listed under Ramsar Site and there is declining biodiversity in the lake. Silting, Leaching and disposal of effluents is leading to degradation of Lake. The harbour and estuary are a source of Livelihood for several people dependent on the area. Astamudi Lake is gaining track as a major tourist destination which calls out for immediate planning efforts for proper and efficient management of resources and prevent environmental degradation. (Bureau, 2021)

The population of Kollam City is 361,440 and is likely to grow to up to 400,000 by 2031. The incongruent and spontaneous development of kollam city due to industrial and government establishments (Neendakara Port and Titanium Complex projects) Has

increased the contamination in the lake (.Krishnakumara, 2021) The Lake plays a vital role in the socioeconomic and cultural history of the district. (Sitaram, 2014)

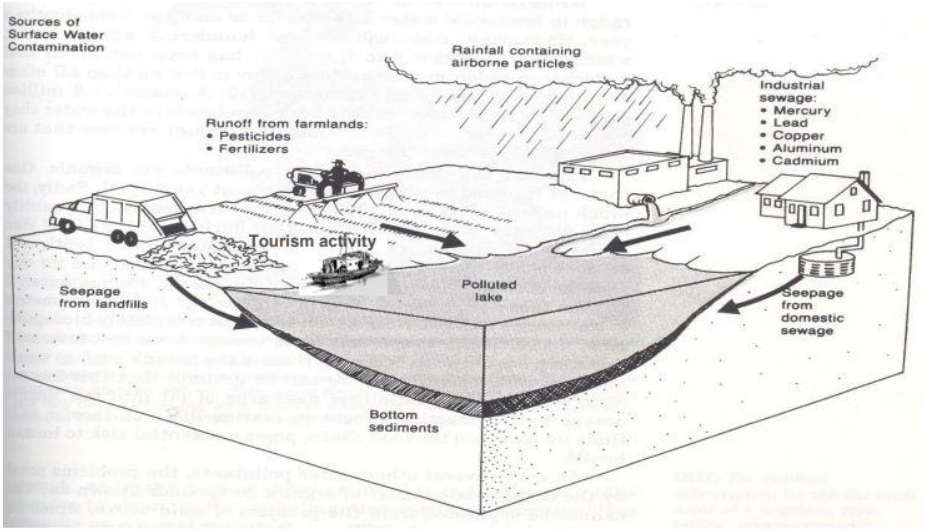


Figure 16 Causes of Degradation of Astamudi lake

Source: Retreiced from https://academic.hep.com.cn/fesci/article/2017/2095-0195/2095-0195-11-4-670.shtml

Fishing is the major activity in the Ashtamudi Lake. Aquaculture activities like prawn culture, mussel culture etc. are also common. Legal and illegal sand mining is on the rise in estuary as well as the river channel. Ashtamudi Lake in Kerala (southwest coast of India) contributes approximately 80% of the overall clam export trade in India, providing livelihood for at least 3,000 local people. (K. S. Mohamed, 2013)

The economic services which are delivered by the Ashtamudi lake, and the gross and net productivity are found to be much higher than that of the other estuaries present in India. (Jayakumar, 2011)The Ashtamudi estuary is an ideal habitat for fin fishes, prawns, crabs, and clams and provides livelihood to thousands of people. The water quality of Ashtamudi lake is deteriorating with each passing year due to the impacts of socio-economic activities which is happening along the shore. (Sitaram, 2014)The dissolved oxygen (DO), which is one of the indicators for availability of oxygen in water body, is found to be decreasing over the years. (Kurup, 2004)

The major attributes of the Ashtamudi Wetland System:

(i) serve as a source, sink and transformer

(ii) provide an ideal habitat for diverse flora and fauna

(iii) serve fishery activities

(iv) make available congenial ground for coconut husk processing

(v) help in water management

(vi) house for the fisheries harbor

(vii) Offer potential tourism opportunities.

3.2 Population Pattern and Functional Characteristics

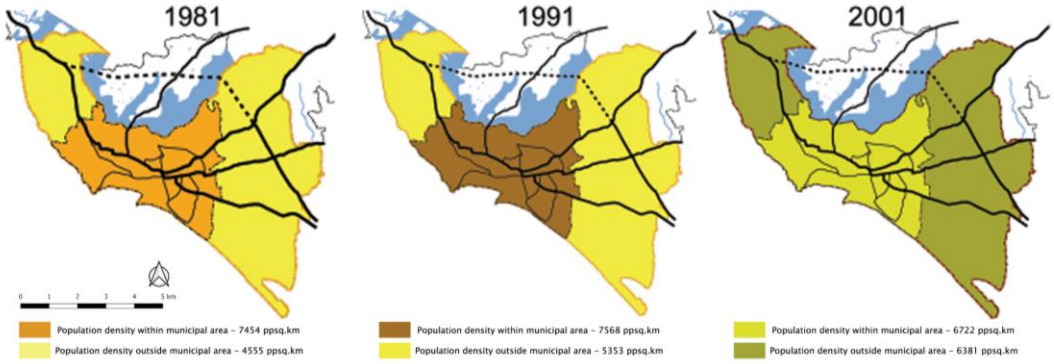


Figure 17 Fig:Growth of Kollam

Source: Author Generated

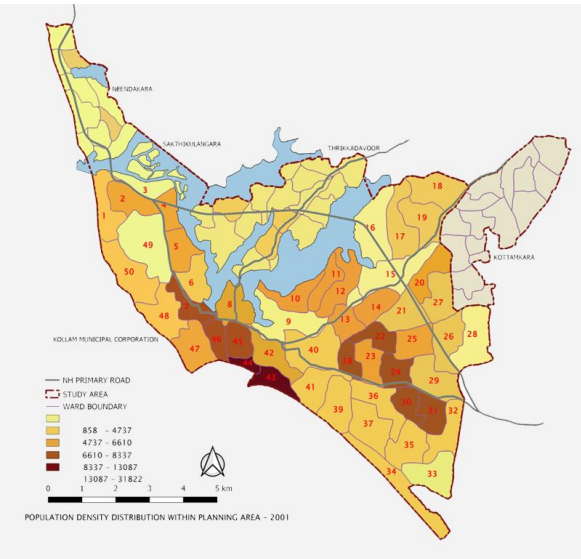


Figure 18 Population Density Distribution

Sourcre: Author Generated

The growth index in Kollam district increased from 100 to 7,561 during 1901-2011. The percentage share of urban population in Kollam during 2011 was 7.45% as compared to the total population of the state, whereas the share to the total population of the district was 45.11%. Kollam ranked 7th among the districts about percentage of urban population.

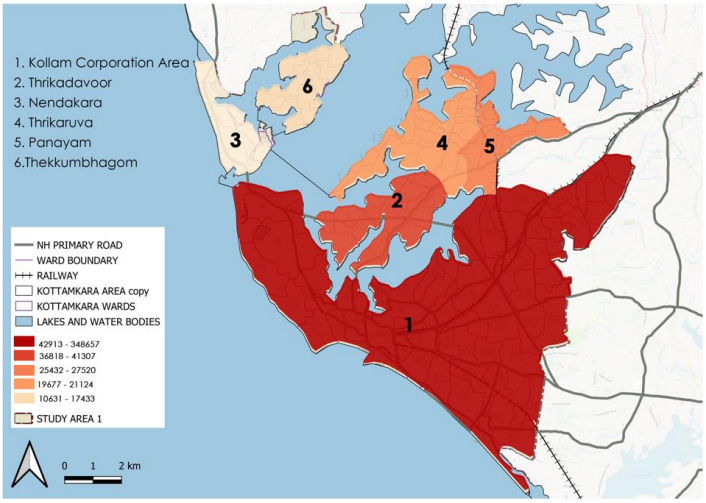


Figure 19 Population Concentration

Source: Author Generated Retrieved from Census 2011

It can be inferred from the map that Kollam Corporation has the most population Concentration with Thrikadavoor coming next. Neendakara grama panchayat is the least populated. The point of estuary mouth seems to be the point where there is most population concentration. The population concentration may change with the future extension of the corporation limit to Neendakara.

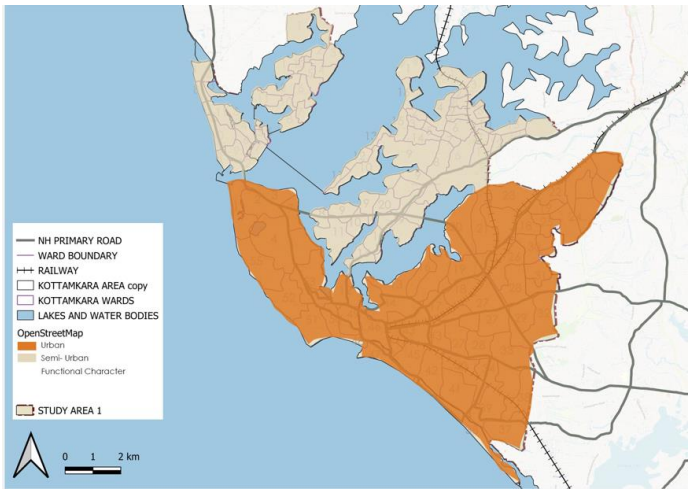


Figure 20 Functional Character of the Local Bodies Under Area

Source: Author Generated Retrieved from Census 2011

It is observed that Kollam corporation is the only body exhibiting rural character whereas the other four grama panchayats exhibit Semi- Urban nature. The study area of estuarine extend would be dealing with the peripheral ward of Maruthadi and Shakthikulangara of the Kollam Corporation. There is a contrast of urban and rural character along the estuarine zone.

3.3 Hierarchy of Settlements

Kollam Corporation shows characteristic of a first order settlement while Neendakara grama panchayath and Thrikadavoor show characteristics of second order settlements while the rest of the panchayaths show the nature of third order settlements.

Since the estuary area is an activity and employment generating zone the potential for development of services to satisfy demand is high. Growth of urban Character is Happenign along the NH 47 towards the Trivandrum direction.

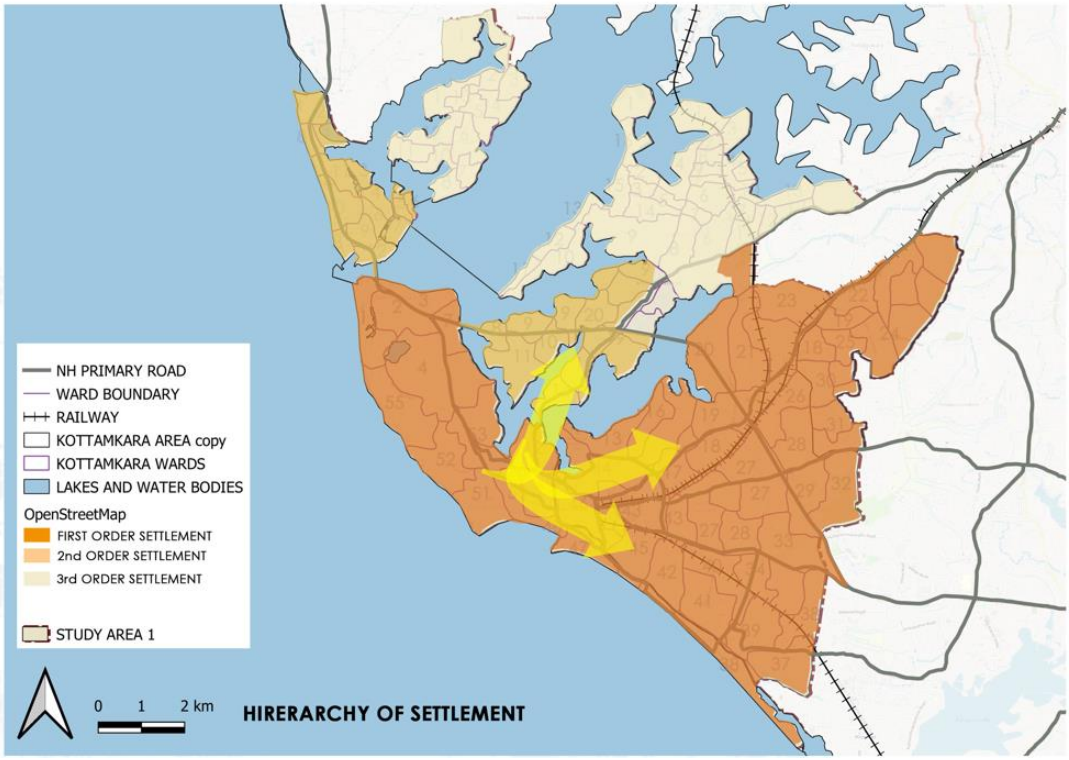


Figure 21 Hirearchy of Settlements

Source: Author Generated Retrieved from Census 2011

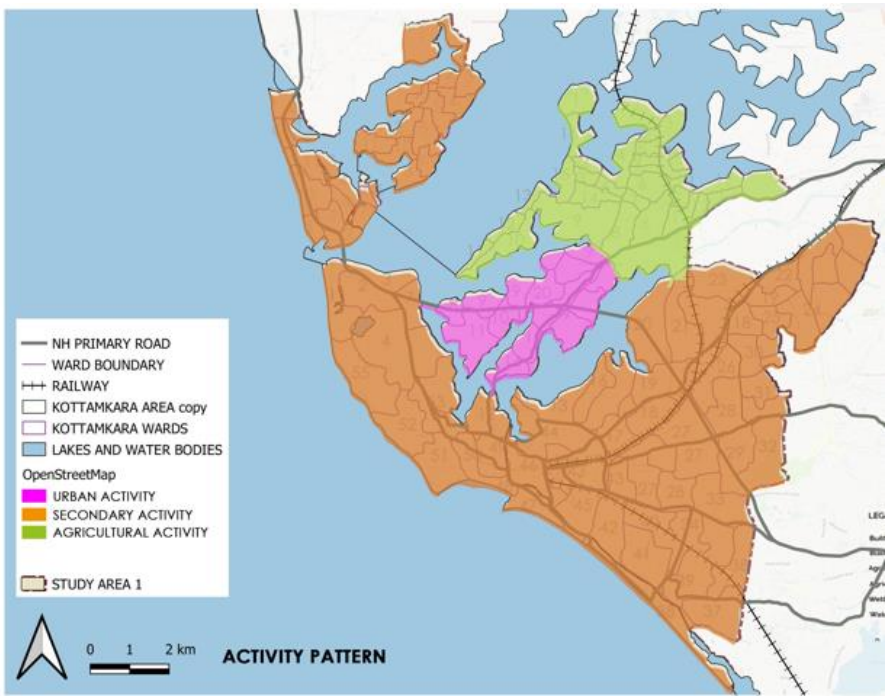


Figure 22 Activity Pattern

Source: Author Generated Retrieved from Census 2011

The Kollam Municipal Corporation, Neendakara grama panchayat and Thekkumbhagom grama panchayat show urban activity whereas Thrikadavoor shows secondary activity and Thrikkaruva shows Agricultural activity.

3.4 **Land use Evolution**

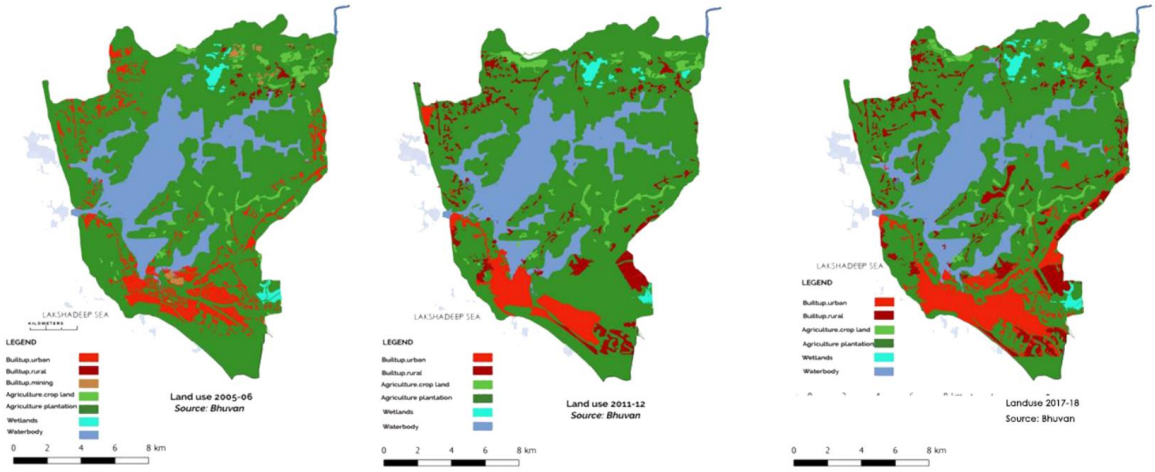


Figure 23 Lnaduse Evolution from 2015-2018

Source: Bhuvan

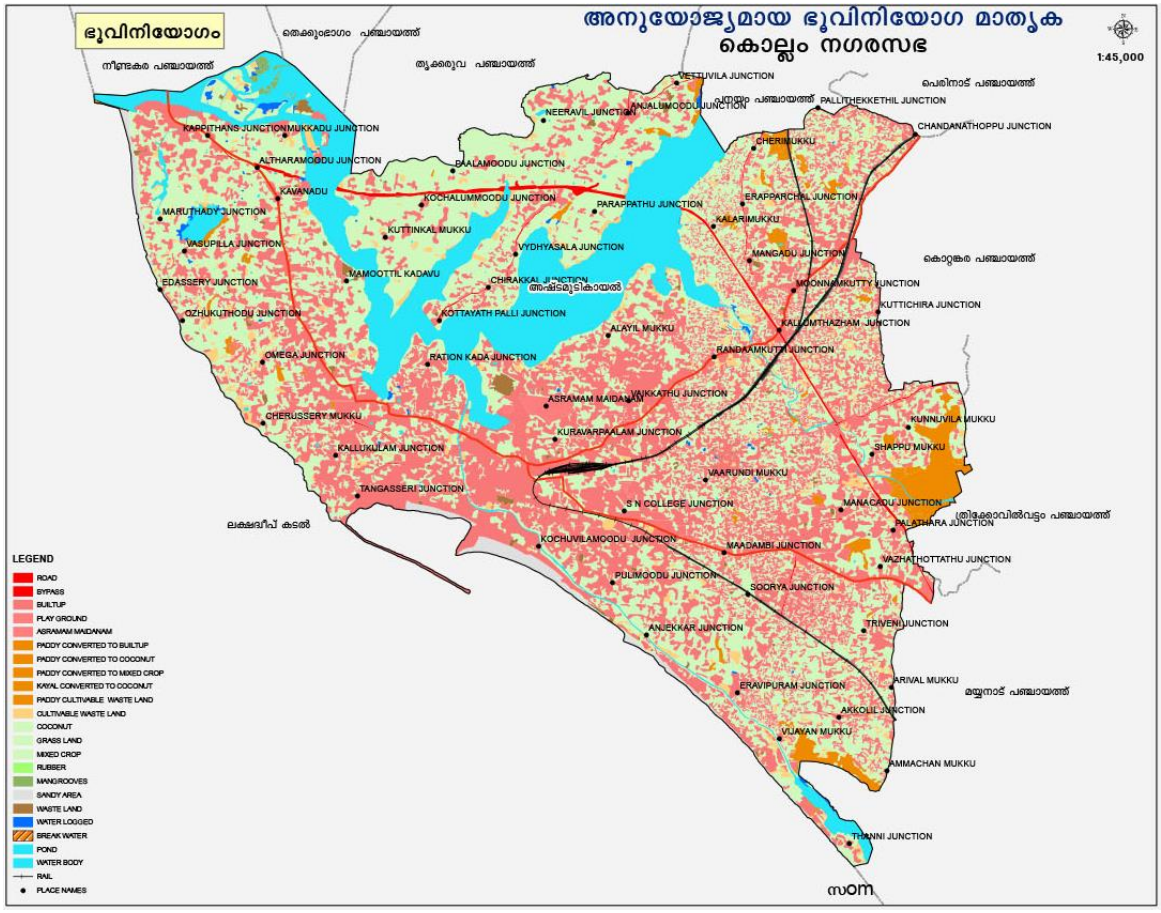


Figure 24 Existing Landuse Map

Source: Prepared by Kollam Municipal Corporation

Table 3 Land use Distribution

SERIAL NUMBER	CATEGORY	LAND USE 2011		PROPOSED LAND USE 2011 DPI		URDPFI
		Area km2	Percent	Area km2	Percent	
1	Residential	42	72.84	39	89	35 - 40%
2	Commercial	1	2.13	1	1.46	4 - 5%
3	Industrial	1	1.81	2	3.75	10 - 12%
4	Public and semi public	3	5.5	1	3.25	12 - 14%
5	Park and open space	2	3.07	1	1.95	18 - 20%
6	Transportation	3	5.58	1	1.05	12 - 14%
7	Water bodies	3	5.75	3	6.32	
8	Paddy land	1	1.24	1	0.68	
9	Dry agriculture	1	2.08	0	0	

Source: Data Collected from Office visit to Kollam Municipal Corporation

The land use suggest that Kollam is a service-oriented city with not much developmental changes. Area under public semipublic use - 5.5%. Agricultural Area 3%. Growth trends happening along the NH and roads.

3.4.1 Demography

Population growth in Kerala is 4.9% and that of Kollam is 0.91%

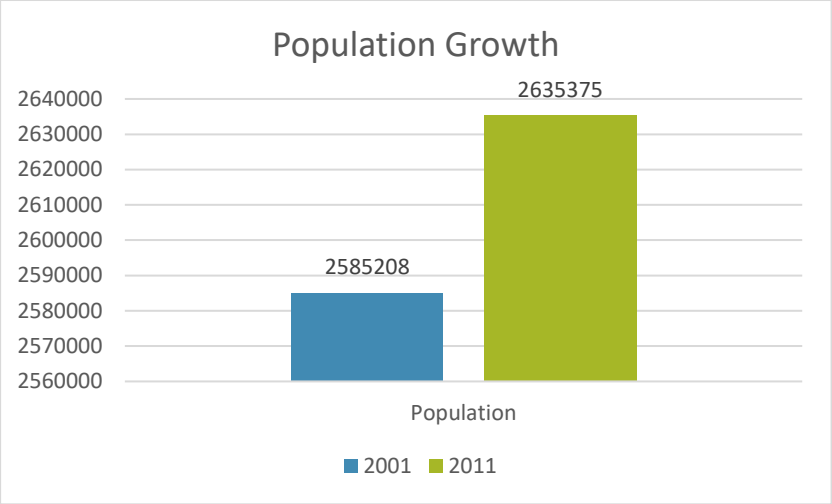


Figure 25 District Population Growth

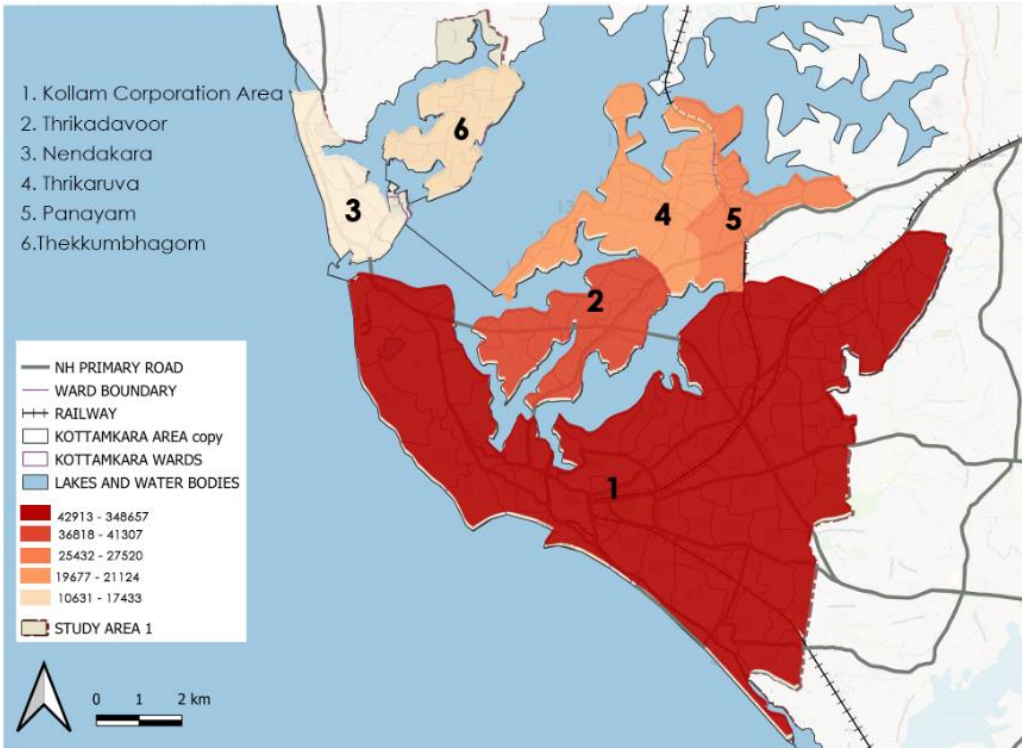


Figure 26 Population Concentration in Site

Source: Author generated retrieved from Census 2011

We can infer from the map that Kollam municipal corporation has the most population concentration followed by Thrikkadavur grama panchayath Thrikkaruva and Panayam.

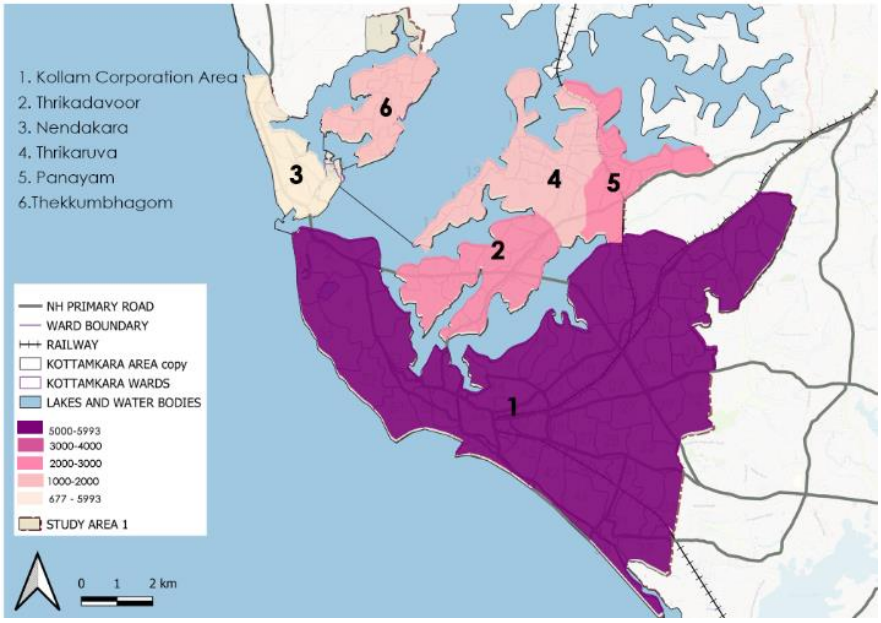


Figure 27 Population density
Source: Author generated retrieved from Census 2011

It is inferred from the map that population density is the most in the Kollam municipal followed by Thrikadavoor and Thrikkaruva.

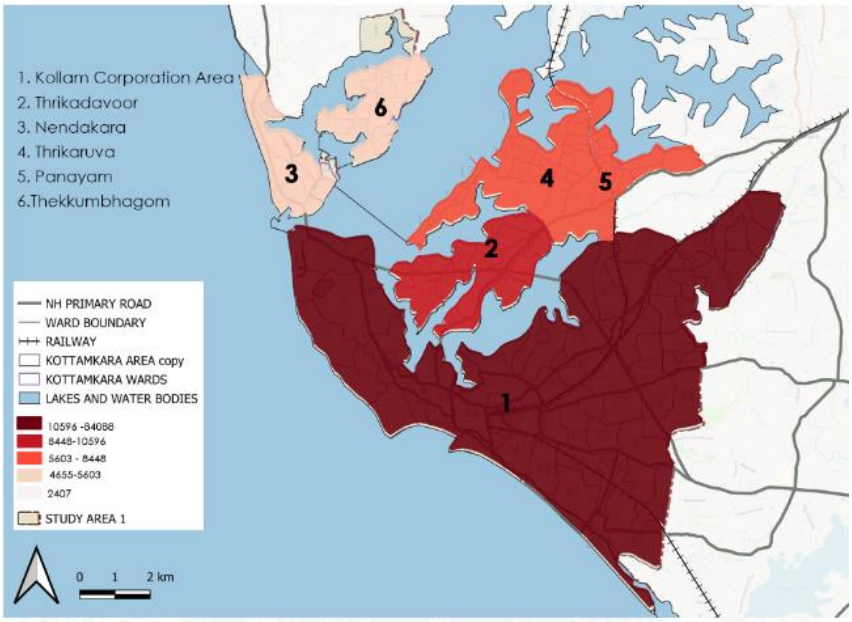


Figure 28 Household concentration in the study area
Source: Author generated from Census 2011

Household concentration is more in the Kollam Municipal corporation then in Thrikadavoor followed by Panayam and Thrikkaruva the household concentration in Needakara and Thekkumbhagom is considerably less than the other local bodies in the study area.

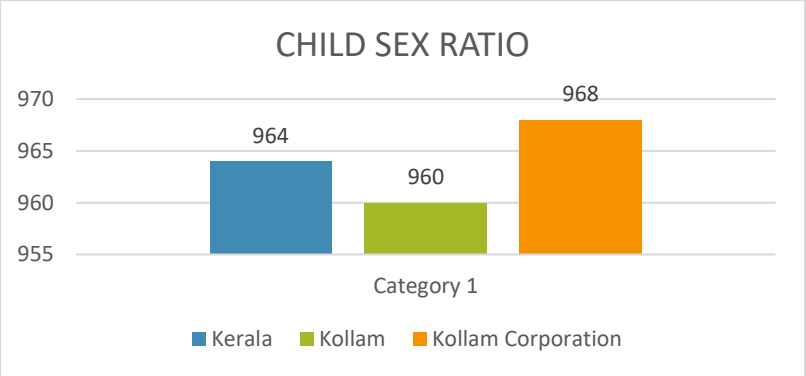


Figure 29 Child Sex Ratio
Source: Author Generated from Census 2011

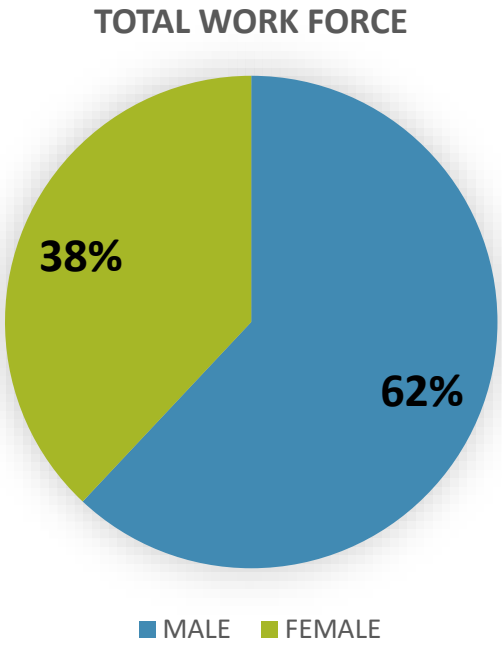


Figure 30 Total Work Force
Source: Author Generated from Census 2011

The total workforce in the study area constitutes of thirty eight percent females and sixty-two percentage of male therefore the need to integrate more woman into the workforce should be done. Woman empowerment and enabling woman to begin small scale

innovations or household industries can be promoted or even in estuary dependent activities.

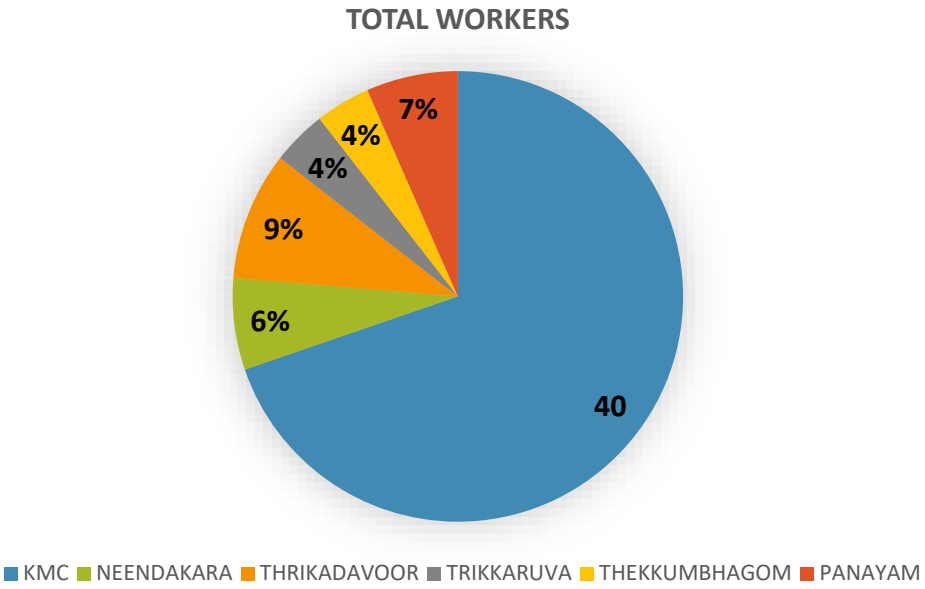


Figure 31 Total Workers
Source: Author Generated from Census 2011

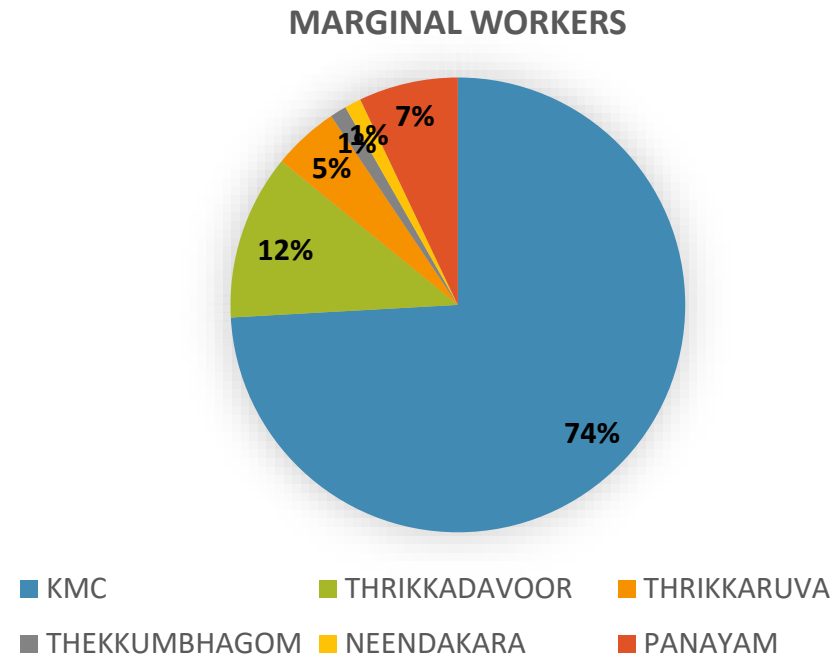


Figure 32 Marginal Workers
Source: Author Generated from Census 2011

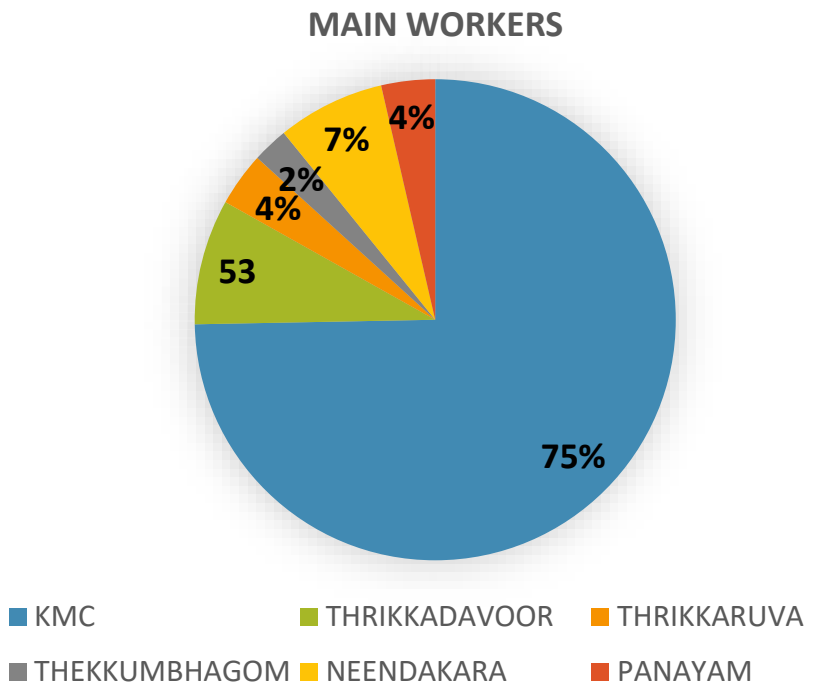


Figure 33 Main Workers
Source: Author Generated from Census 2011

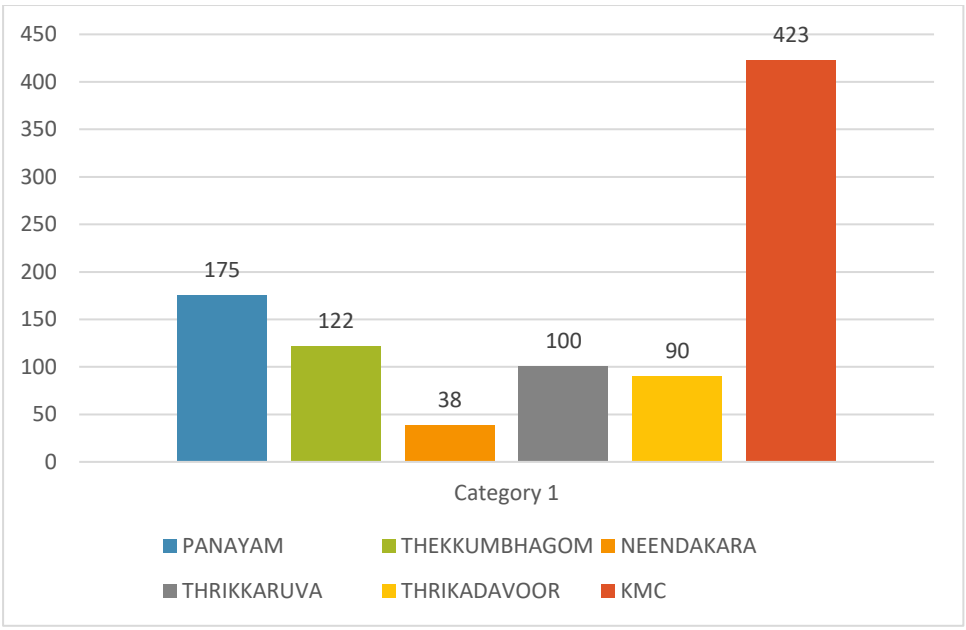


Figure 34 Number of Cultivators in the Study Area
Source: Author Generated from Census 2011

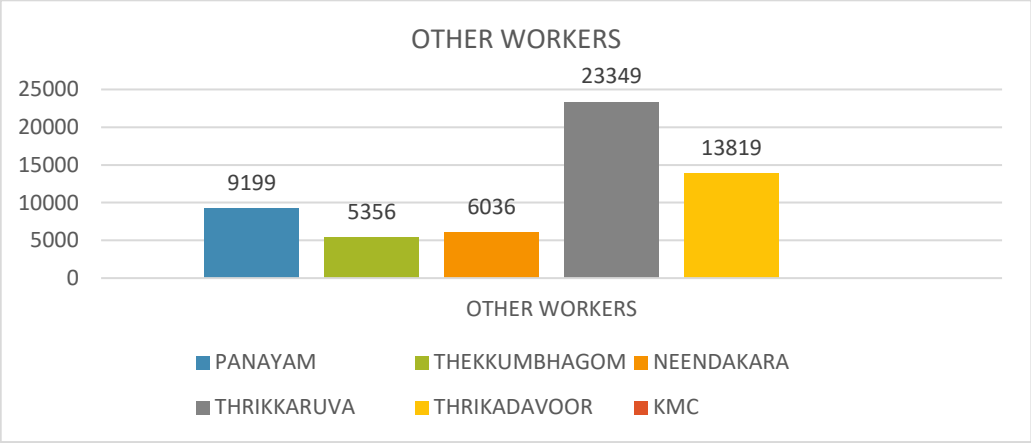


Figure 35 Other Workers in the study area
Source: Author Generated from Census 2011

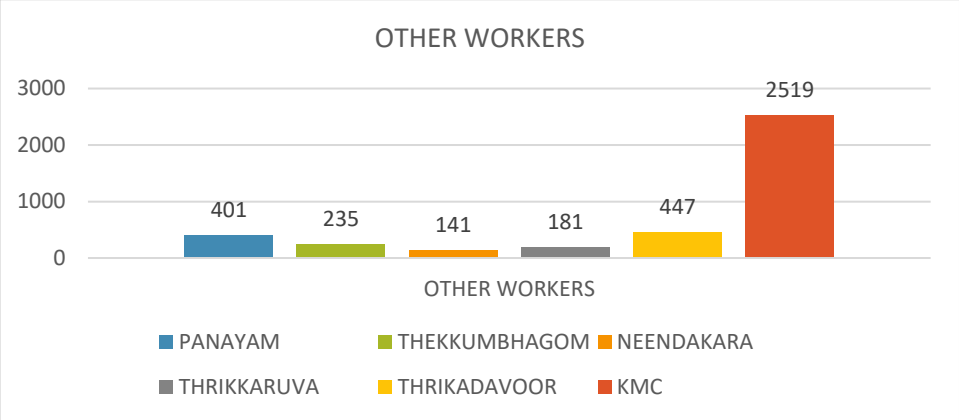


Figure 36 Other Workers in the Local bodies
Source: Author Generated from Census 2011

3.4.2 Transportation

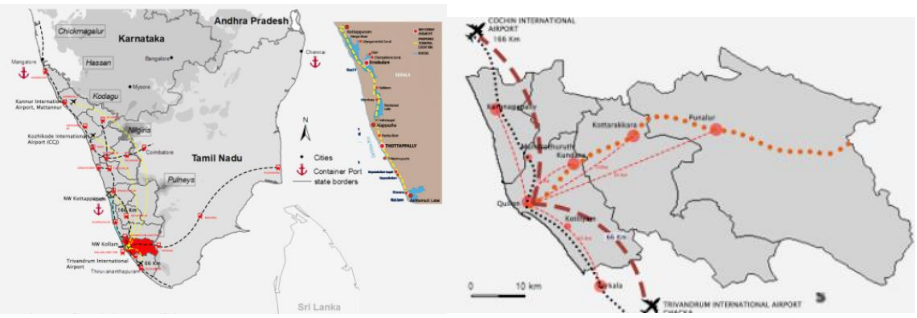


Figure 37 Regional Connectivity
Source- Author Generated

Kollam is well connected to the other regions through Roads, rails, water ways and Air. The two Islands in the study area is connected to the NH and Kollam Bypass Road.

Air: Nearest airport: Thiruvananthapuram (71 km), Rail: Kollam is an important railhead of the Southern Railways named Quilon, Road: KSRTC, Central Bus Station (3 Km from Railway station), Ferry services: The ferry station is adjacent to the Central Bus Station (3 km from the railway station), Kollam Port - 5 Kms from Railway Station.

Figure 38 Transportation Routes in the Study Area
Source- Author Generated

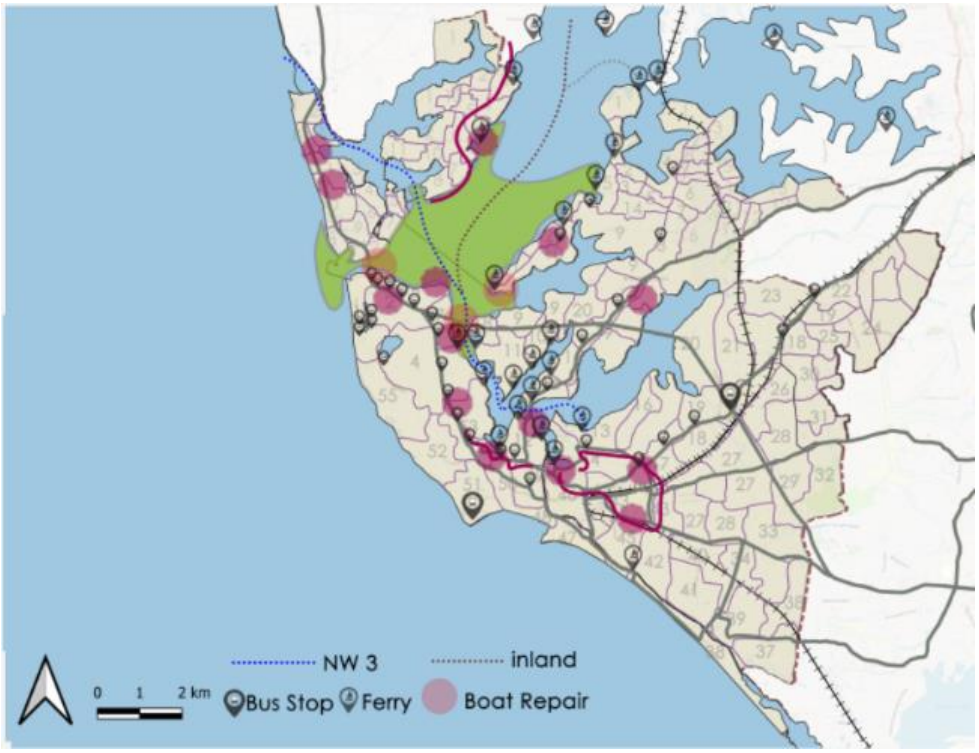


Figure 39 Map showing parking availability boat jetties and bus stop
Source- Author Generated

3.4.3 Citizen Involvement Survey

A Citizen involvement Survey was conducted in eighteen wards in Kollam which form waterfront wards. The wards which are the buffer Zones are Maruthadi, Meenathumchery, Kavanadu, Shakthikulangara North, Kureepuzha West, Kureepuzha, Vettuthara, Foundation, Anamkandam, Maryland, Pallikodi, Njarumoodu,Udayadityapuram, Thekkuvila, Tholukadavu, Sambranikodi, Madusseril, Friends and Prakkkulam. Survey was conducted on filed and through telephone covering 10-15 households from each of these wards.

It is observed that water runs off from most localities only to flood in shallow areas causing waterlogging conditions. Groundwater condition is also found to be deteriorating with time, those wells which had water which was fit for drinking has now rendered useless as the water either became hard due to increased urbanization or the encroachment of wetlands leading the people to resort more to municipal supply of water rather than underground water which is now deemed not useful.

More than 50% of the population depend on estuary related activities and more than 60% of the population practice nature-based techniques. More than 60% of the population is willing to participate in lake dependant activities. Occupational satisfaction is observed to be less among the residents and there is rising call for governance level interventions for conservation of lake among the citizens.

Figure 40 Citizen Involvement Survey
Source- Author Generated

3.4.4 Tourism

The tourism in Kollam district is peculiar for its representation as mini-Kerala model as it offers all the leisure activities as a prototype from coasts, midlands and the highlands and the picturesque backwaters and cliffs.

The percentage share of Kollam in tourism sector is exceptionally low compared to neighboring cities like Thiruvananthapuram, Alappey and Kottayam. About 1.2% of the total foreign tourists to Kerala visits Kollam and the share of domestic tourist is about 2.2%. Kollam is not a prominent destination in the tourist circuit mainly because of its location,

lack of branding, CRZ regulations prevents the development along the beach side, competition from other cities etc.

Figure 41 Regional Tourism
Source- Author Generated

The major tourism circuits are Kollam district acts as a transit zone for tourists on their journey from Thiruvananthapuram to Kochi.Major circuits- Alappuzha -Kayamkulam - Kollam Thiruvananthapuram- Kulanjathupuzha – Thenmala Thiruvananthapuram - Kottarakkara - Thenmala – Paalaruvi, Kottayam -Kottarakkara - Paalaruvi - Thenmala Nearest Airport - Thiruvananthapuram International Airport (65Kms), Nearest Railway station- Kollam Junction railway station, KSRTC Bus Stand - Taluk cutchery,kollam Private Bus stand - Andamukkam city bus stand, Downtown Kollam Thiruvananthapuram - Parippally – Kollam.

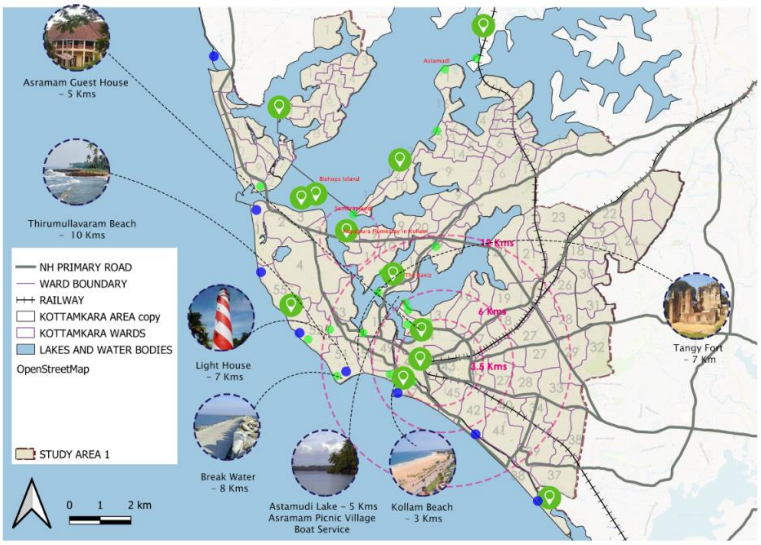


Figure 42 Tourism Map
Source- Author Generated

Figure 43 Images read left to right Thekkumbagom Islands, Shakthikulangara Harbor, Thrikkaruva, San-Thome Island
Source- Author Generated

3.4.5 Environment

Figure 44 Origin of Ashtamudi
Source- Author Generated

Ashtamudi Lake (Lat. 8°45'-9°28'N and Long. 76°28'-77°17'E) is the second largest Lake estuary of Kerala. It lies 145 km south of Kochi and has an area of 61.4 km2. (Jayakumar, 2011) It remains connected with the Arabian Sea throughout the year and the Kallada River which empties into the lake is the main source of fresh water.

The water body derives its name from the planimetric shape with eight branches radiating from near the central part. The lake looks like an octopus. Thebranches ofthe Ashtamudi Lake are known as creeks. It has eight creeks and islands are the peculiar features found in

the lake. The most important island is Munroe Island, Chavara and Thekkumbhagam.

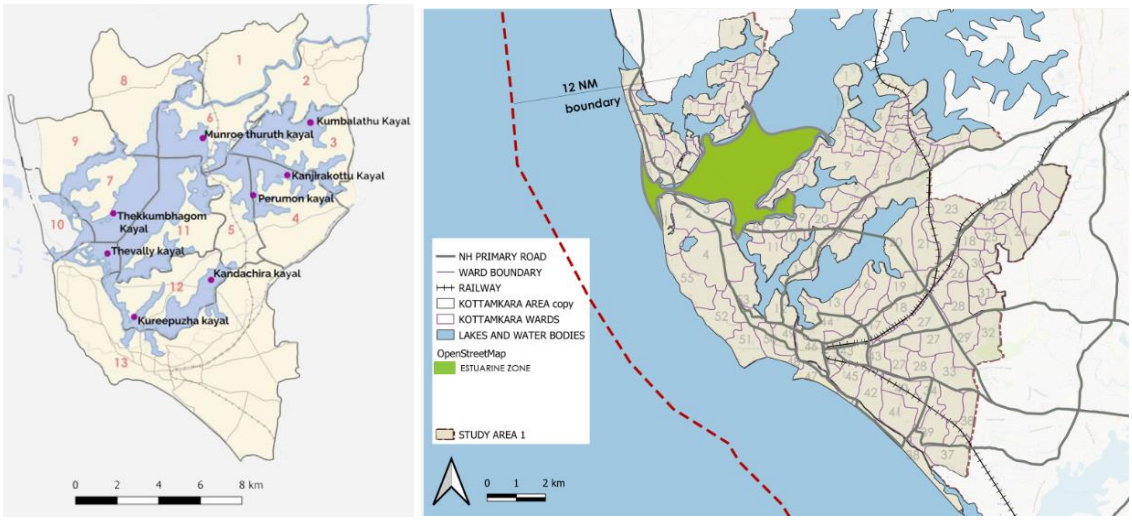


Figure 45 Ashtamudi Lake and the estuarine extend
Source- Author Generated

About 173 hectares (1.73 km2) of area near the bar mouthrrounded by Neendakara and Dalavapuram villages in the north, Sakthikulangara village in the south, Chavara Thekkumbhagom in the east and Sakthikulangara Bar-mouth in the west is the fishing area. The water depth of the fishing area varied from 1-3m, and the bottom was either muddy or a mixture of loose sand, gravel, and broken shells.

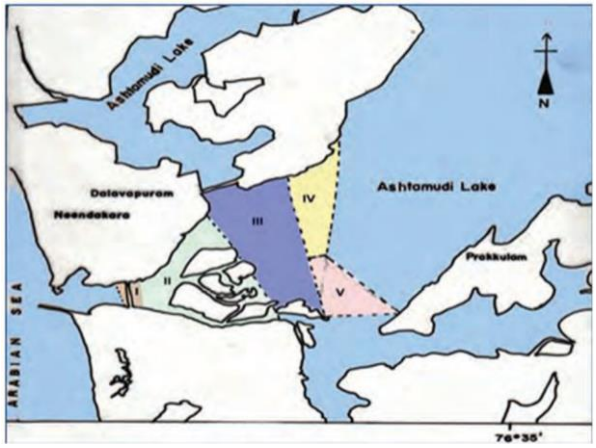


Figure 46 Clam Distrbution
Source- Retrieved from (K. S. Mohamed, 2013)

Zone I is located near the bar-mouth. The water spread area of this Zone is 15 ha with maximum depth of 3m. Zone II is located between Zone I and Zone III. The water spread area of this Zone is 60 ha with average depth of 1.5 m. Zone III is situated in adjacent to Zone II occupies an area of 50 ha with maximum depth of 2.5m. Zone IV is in adjacent

to Zone III and Zone V. The water spread area of this zone is 31.7 ha with maximum depth of 2.25m. Zone V is located adjacent to Zone IV. The water spread area of this zone is 16.6 ha with average depth of 1.25m.

Flora and Fauna

Avi-faunal Attractions in Ashtamudi Lake

Ashtamudi Estuary is home to fifty-seven avifaunal species, of which 6 are migratory and 51 residents. There are forty species of wetland-dependent birds, of which 45% are long distance migratory ones. Terns, plovers, cormorants, and herons are the most abundant of these.

Forty-five species of insects have been identified in the lake, out of which there are twenty-six species of Butterfly. Twenty-nine zooplankton species have been found, in addition to nine phytoplankton species in the lake's water body. *(Bureau, 2021)*

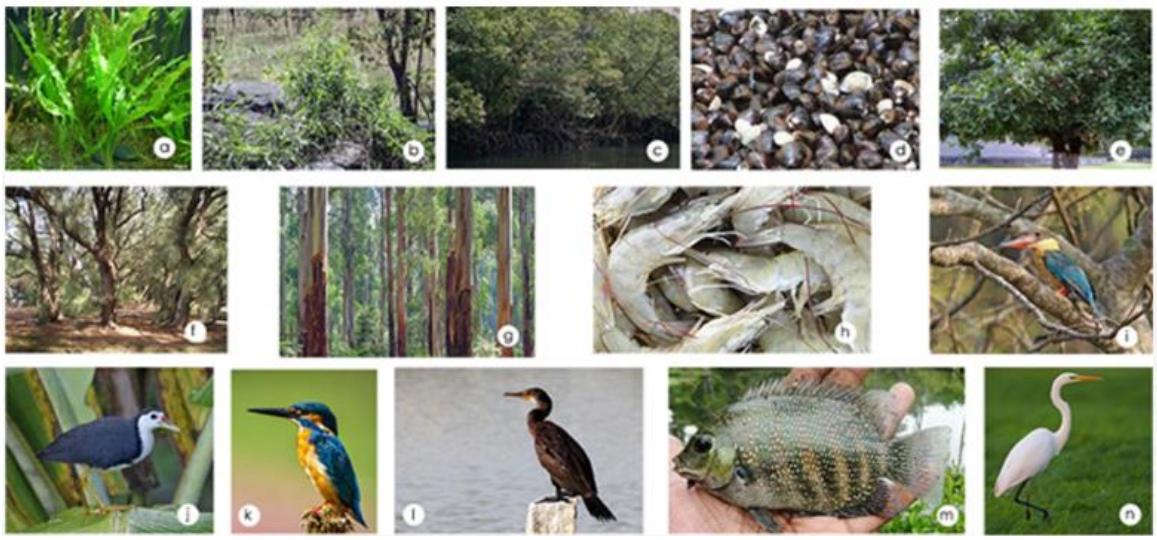


Figure 47 a. Aponogeton Appendiculatus b. Flagellaria indica c. Bruguiera Gymnorhiza d. Villorita e. Calophyllum Inophyllum f. Casuarina Equisetifolia g. Eucalyptus globulus h. Prawn i. Wood Sand Pipe j. Strok piled king fisher k. White breasted waterhen l. Common kingfisher m. Etroplus Suratensis n. Crane Bird

Source: Retrieved from https://images.newindianexpress.com/uploads/user/imagelibrary/2020/8/11/w900X450/Karimeen_EPS1234.jpg?w=640&dpr=1.3

Aqua-faunal Attractions in Ashtamudi Lake

97 species of aquatic animals have been reported to inhabit the lake, including marine, estuarine, estuarine riverine and estuarine marine ones. It is also home to unique species of copepod, all species of palaemonid prawns, edible crabs, black clams, and varied fish

species. (Bureau, 2021) Regulating Fishnet sieve pore dimensions, introduction of pedaled boating practices which are traditional is sought out to improve the pollution in the lake.

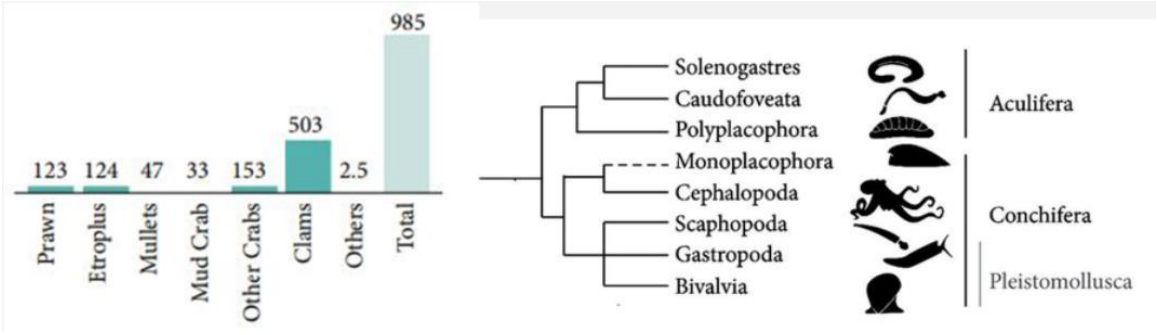


Figure 48 List of Mollusca type
Source: Retrieved from (Bureau, 2021)

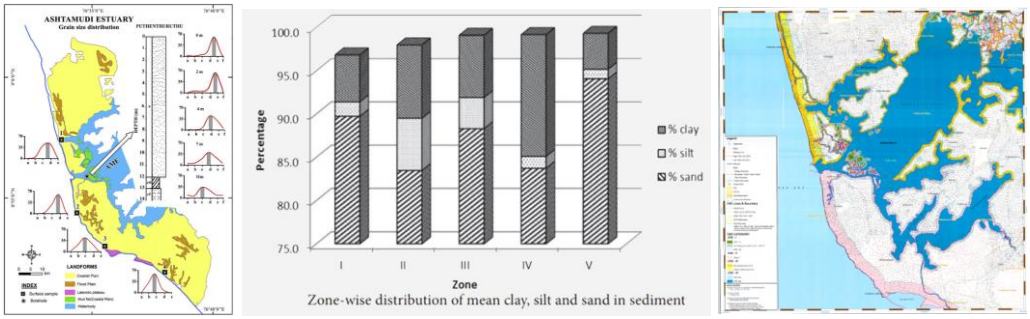


Figure 49 Sediment Nature and CRZ
Source: Retrieved from http://keralaczma.gov.in/assets/Maps/2011/CZMP%20Map/KL_10.pdf

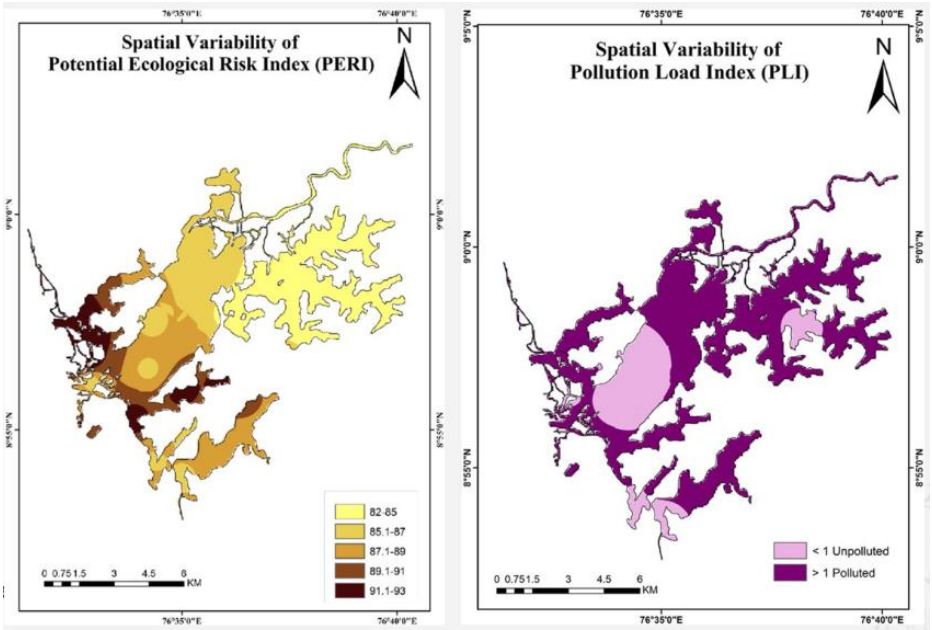


Figure 50 Ecological Risk Index and Pollution Load Index
Source: Retrieved from Holocene Records of Human Driven Geological Impacts in a Ramsar Wetland of India

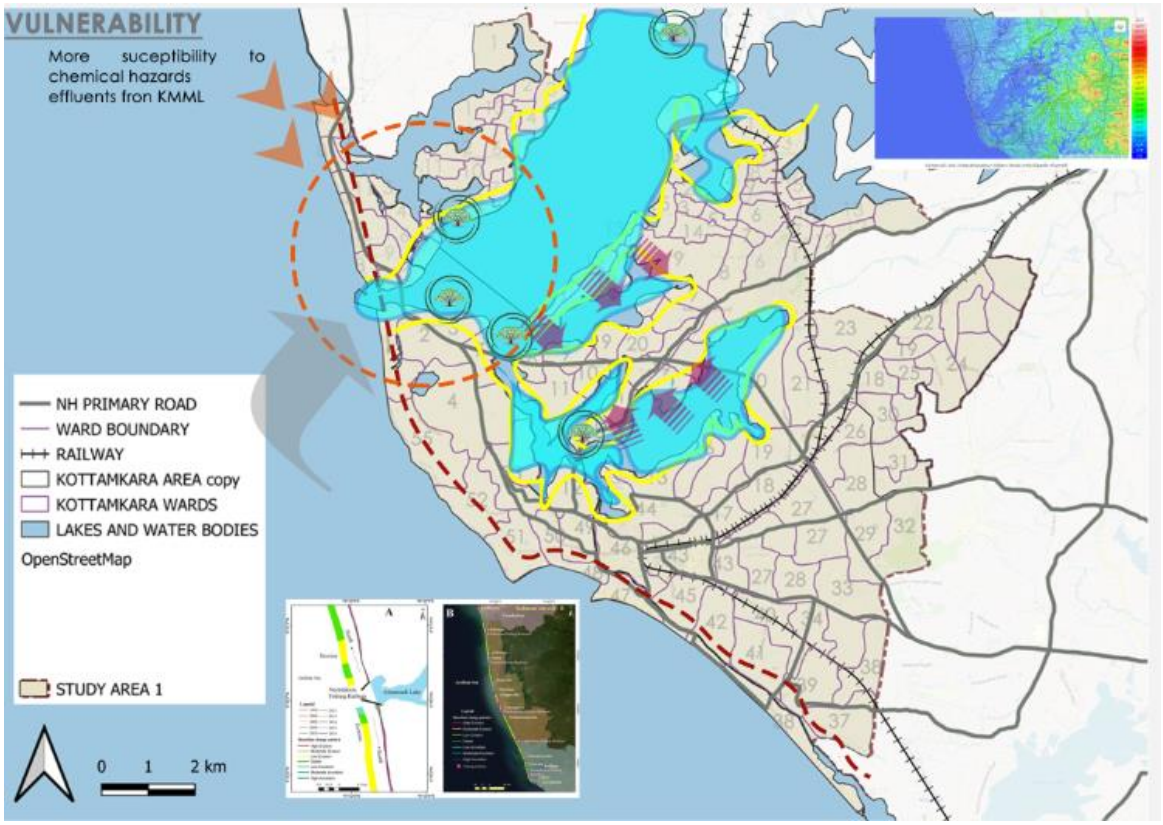


Figure 51 Flood map and environmentally stressed areas
Source: Author Generated

The increasing tourism and fishing activities and development of infrastructure has caused an enormous impact on the biodiversity in the estuary area. The changing land use with increase in buildings resorts, boating etc. has caused variation in the PH level rendering the habitat useful for the estuarine molluscs, clams and other flora and fauna.

Table 4 Reclamation with Years

YEAR	LAKE AREA (Km^2)	% AREA RECLAIMED
1999	64.24	-
2003	61.40	4.42
2006	57.34	10.74

Source: Retrieved from https://townplanning.kerala.gov.in/2018/12/03/kollam-district/

Deterioration and subsequent Restoration plans for Ashtamudi Lake. The Ashtamudi Lake has been a victim of fishing and trade activities which has become Indigenous in the area. The intense anthropogenic pressure, oil spills from fishing boats and industries, encroachments and development through conversion and destruction of natural habitats causing shrinking of fragile zones, untreated sewage with excess disposal of industrial waste and human excreta are the causes behind the substantial deterioration of lake's environment. Kanjiracode creek, one arm of the Ashtamudi Lake at its south-east has suffered severe extinction due to dumping of waste and clay into the lake by a state public sector unit. This destruction has affected the livelihood of local people and fishermen, dependent on species of fish that have disappeared.

With deteriorating water quality, leeching, coastal erosion, and release of untreated effluents etc. it becomes imperative to seek water body management techniques to monitor and regulate the activities upstream and downstream.

3.4.6 Survey

A survey was conducted on the 17 Riparian wards to understand the social and economic characteristics and environmental characteristics. The wards of 4 local bodies Kollam Municipal Corporation, Thekkumbhagom Gramapanchayath, Thrikkaruva Grama panchayath and Thrikadavoor zone are surveyed.The wards Maruthadi, Meenathumcherry, Kavanadu, Kureepuzha West, Kureepuzha, Vettuthara, Foundation, Anamkandam, Mary Land, Sambaranikodi, Friends, Prakkkulam, Pallikodi, Njarumoodu, Udayadityapuram, Thekkuvila and Tholukadavu are studies. Minimum 10 households from each ward are surveyed to arrive at the findings.

It is found that 15% of the households are with household size more than 6, majority of the families have a household size of 4 which forms about 60 %. The families are either nuclear or joint families. The sixty percentage of the population is female and the there is sheer concentration of middle-aged population in the study area. The least found age group are the preteens ranging from age seven to age twelve.

(All graphs' charts and information collected and analyzed by the author through site survey)

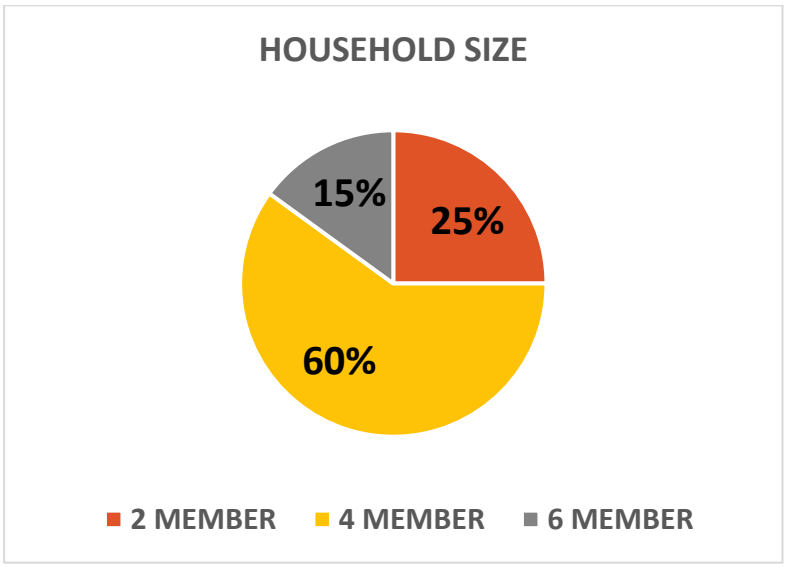


Figure 52 Household Size

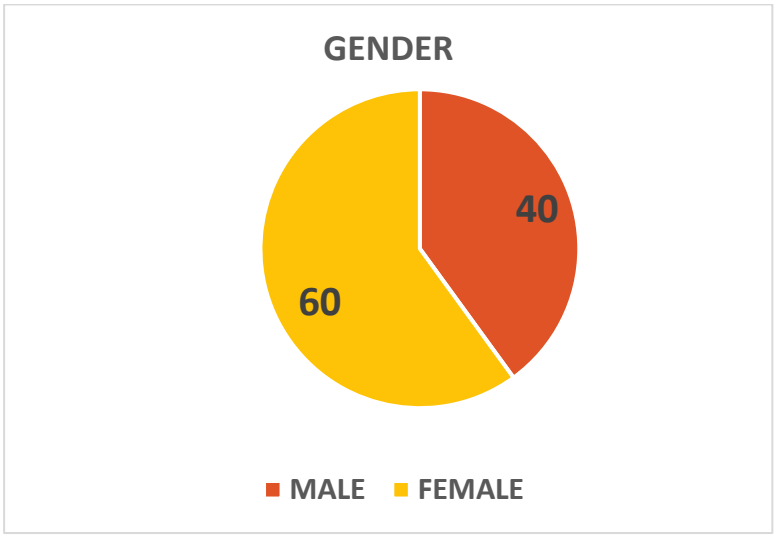


Figure 53 Gender

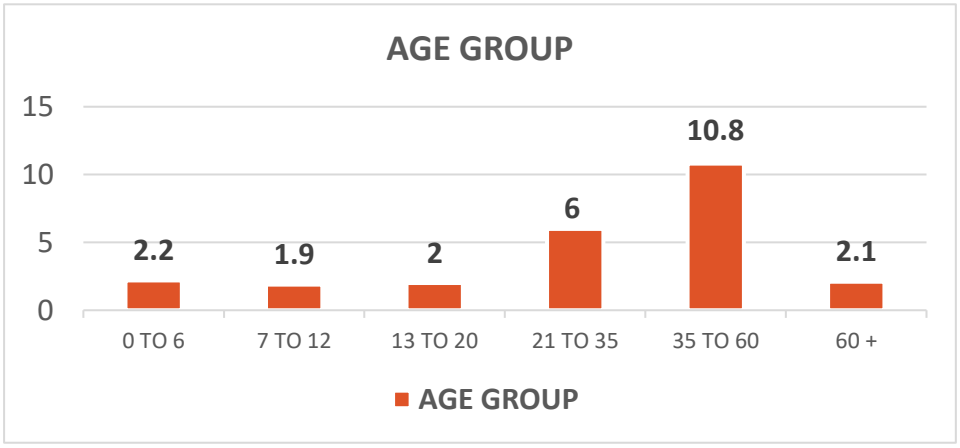


Figure 54 Age group division

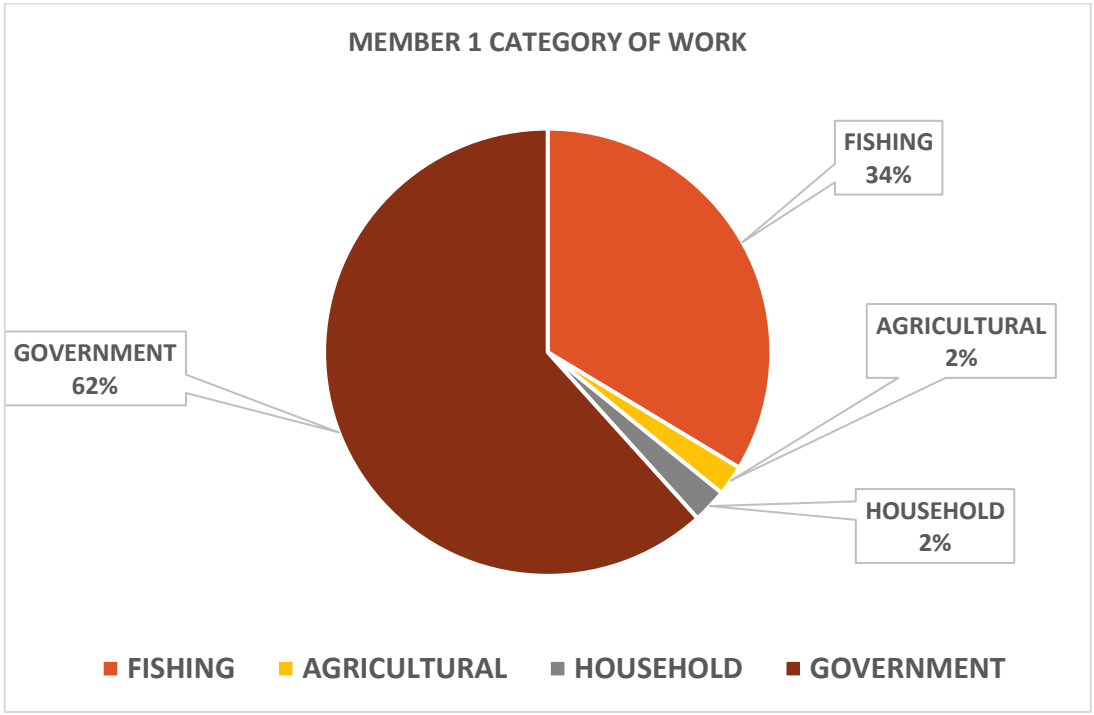


Figure 55 Member 1 Occupation Type

The major share of the population depends on government and other business jobs and the secondary occupation is fishing. Agricultural, cultivation and household workers are observed to be less. Majority of the lake dependent community commute by walking or cycling government servants use two wheelers, public transport and four wheelers.

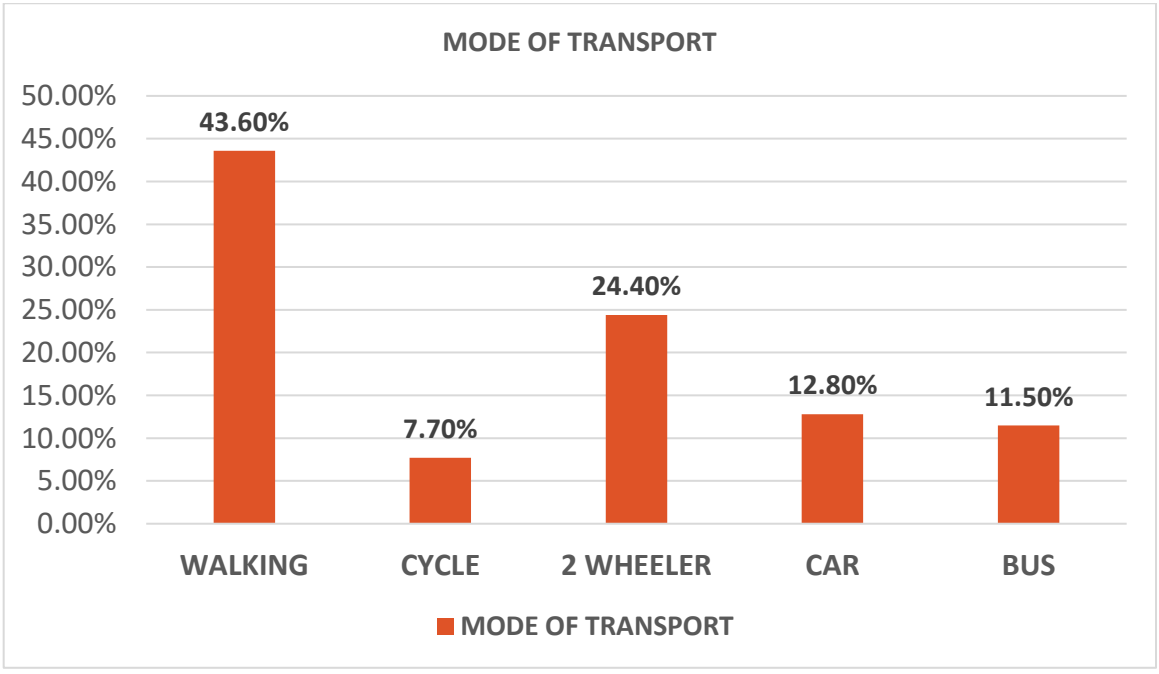


Figure 56 Mode of Commutation

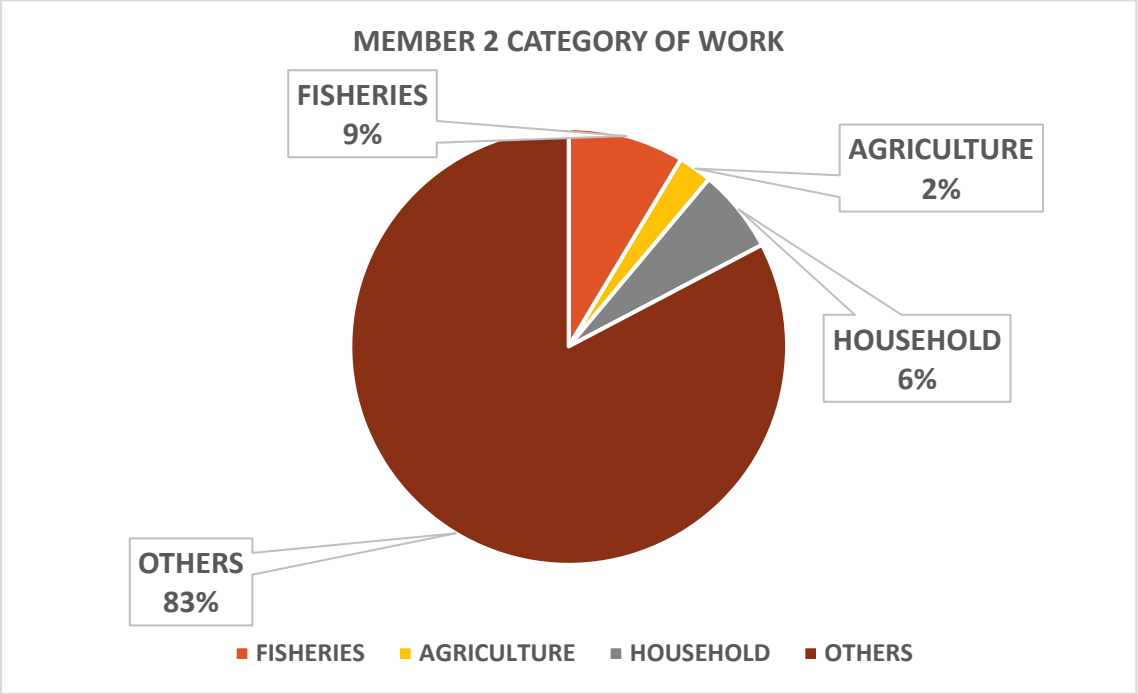


Figure 57 Member 2 Category of Work

Other members of the family are involved in either government or minor works, and fisheries comes next, six percentage depends on household business. Majority of the population has an annual income less than five lakhs.

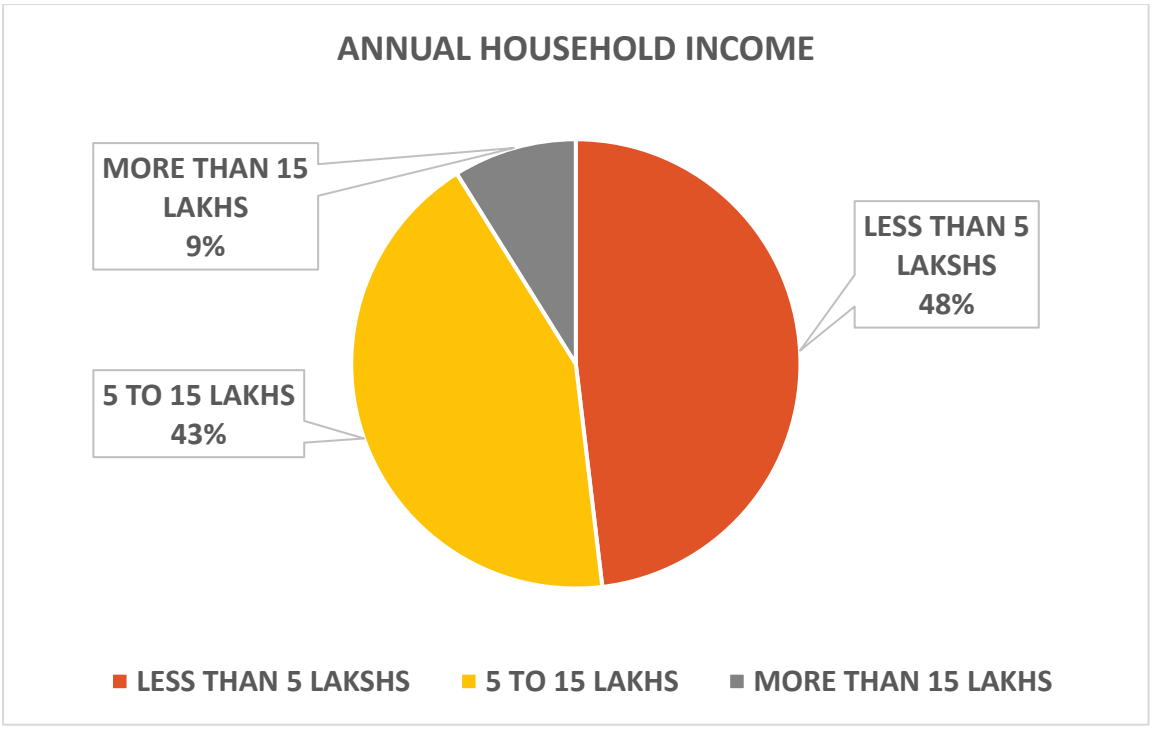


Figure 58 Annual Household Income

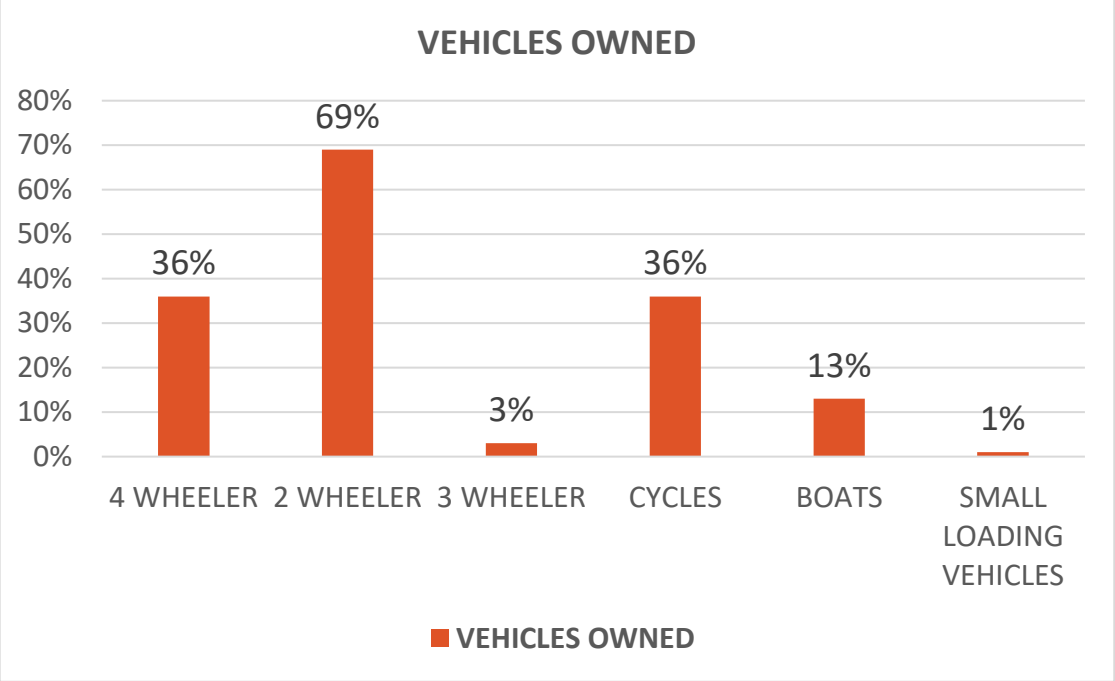


Figure 59 Vehicles Owned

Majority of the household's own two-wheeler vehicles and then cycles and four wheelers are used. Thirteen percentage of the population owns small boats or boats.

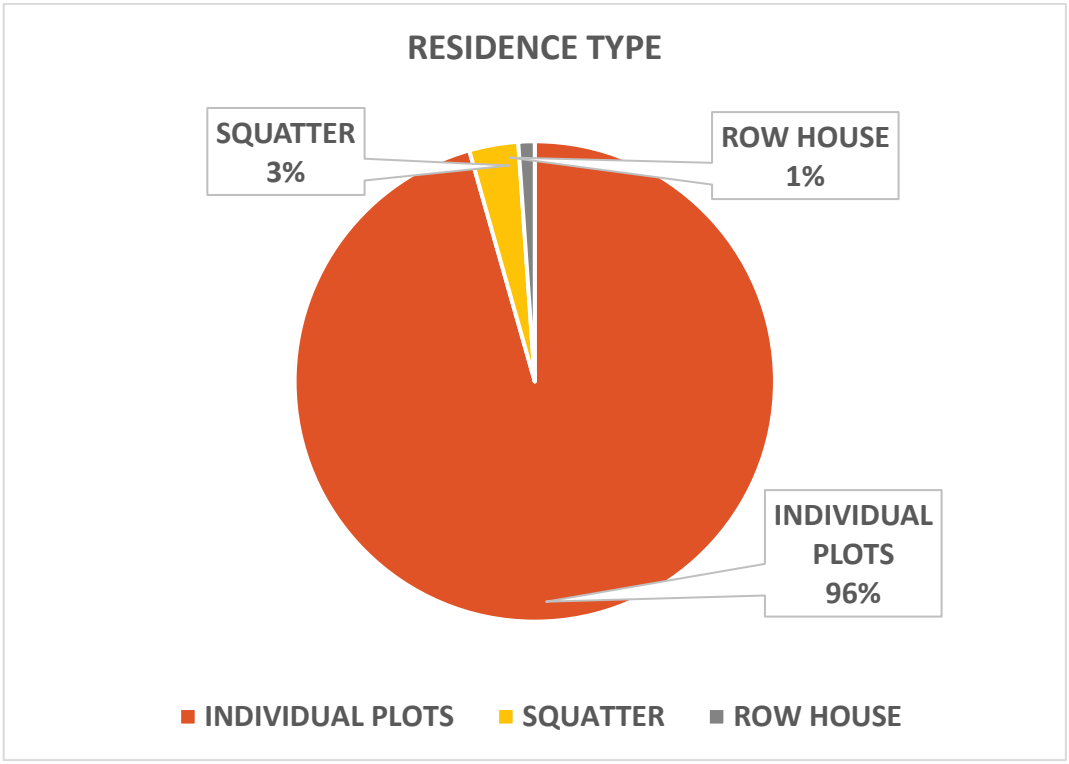


Figure 60 Residence Type

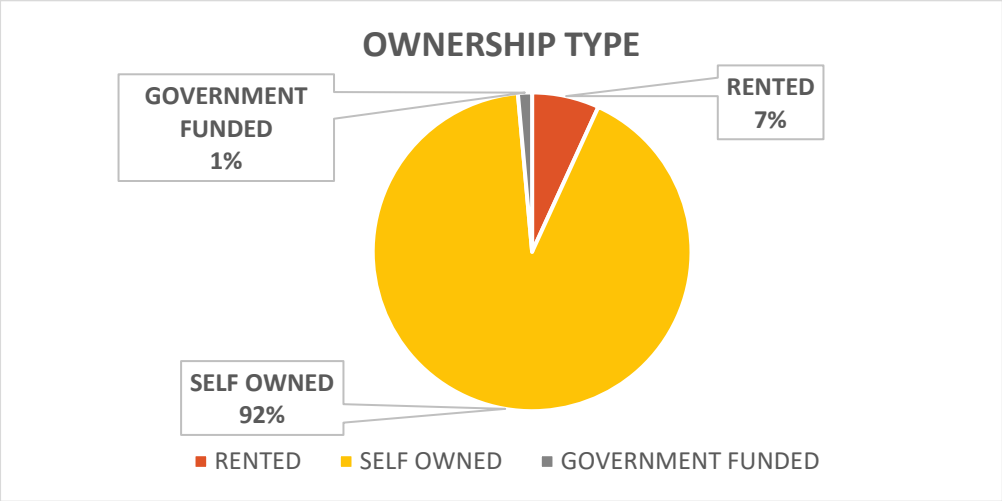


Figure 61 Ownership Type

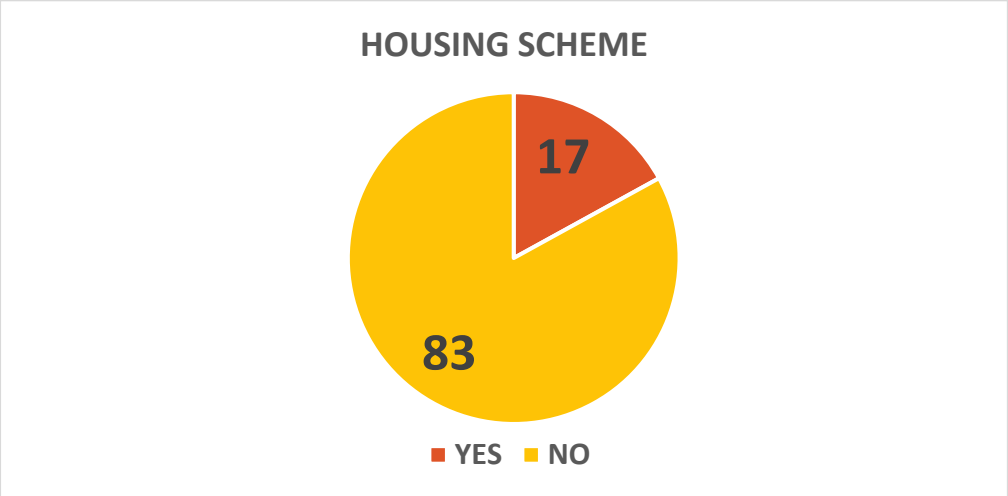
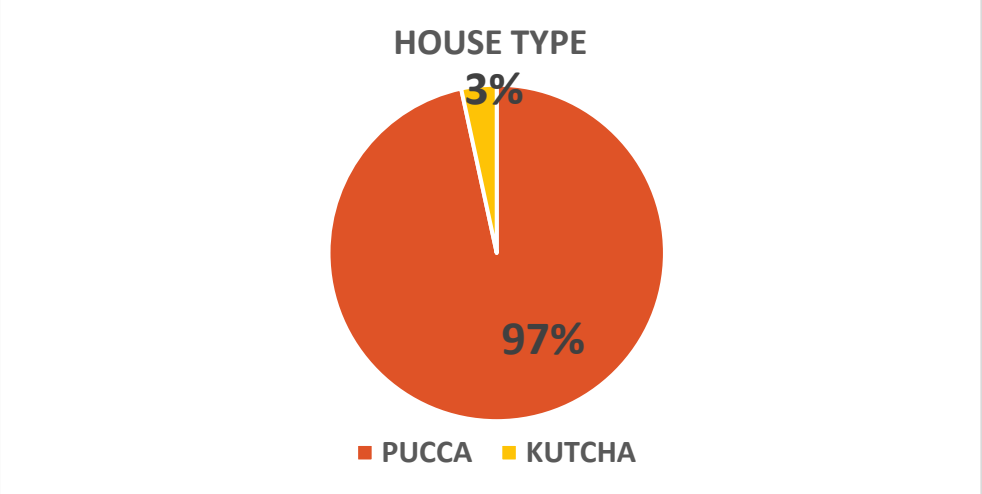


Figure 62 Schemes for building aid

Majority of the houses are self-owned build without any government aid and is also pucca in nature.



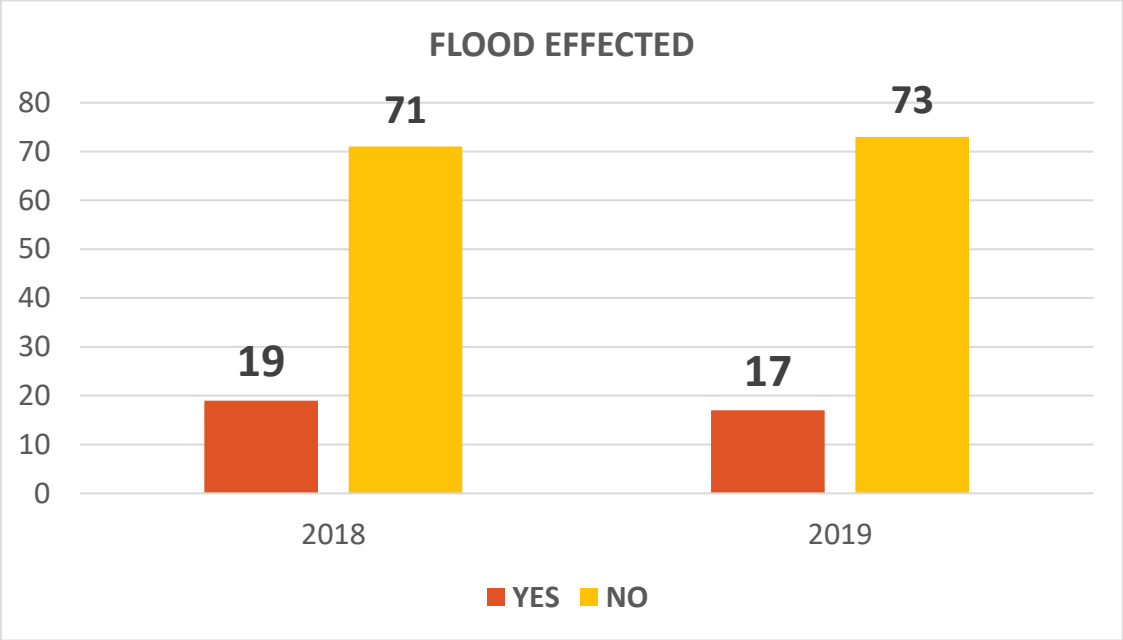


Figure 63 Flood Affected

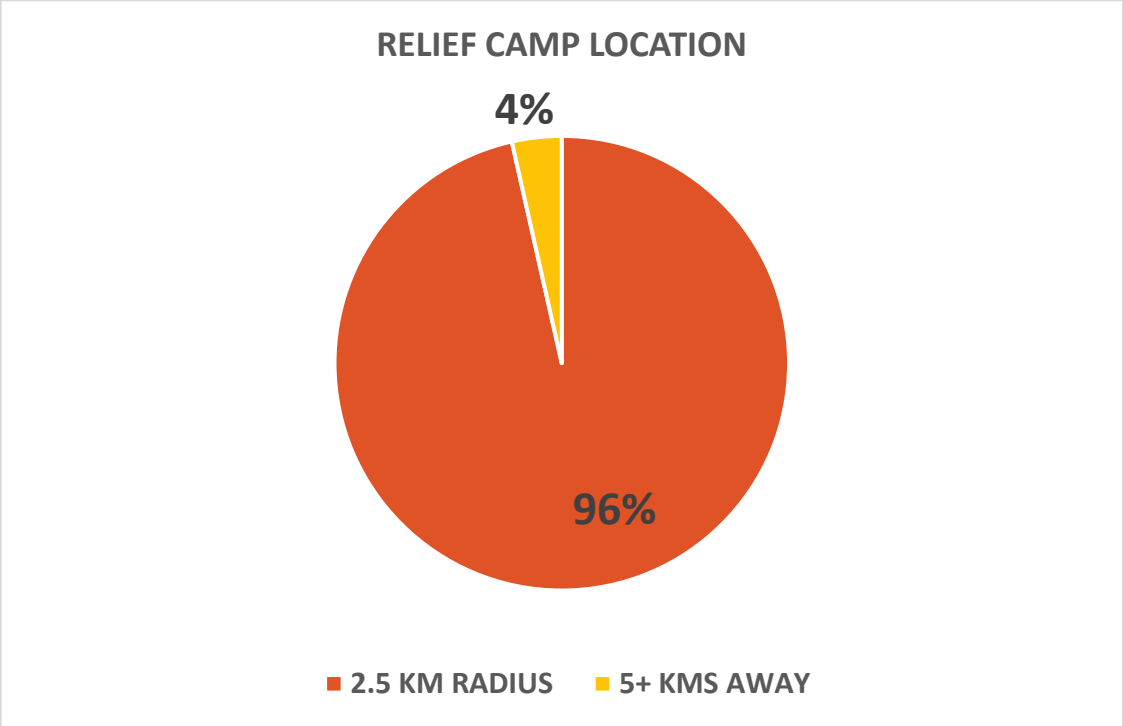


Figure 64 Relief camp Proximity

The riparian wards were affected more in the 2018 floods where 19 percent of the houses were affected by the 2018 floods rest were not affected. Most of the house members did not go to refugee camps.

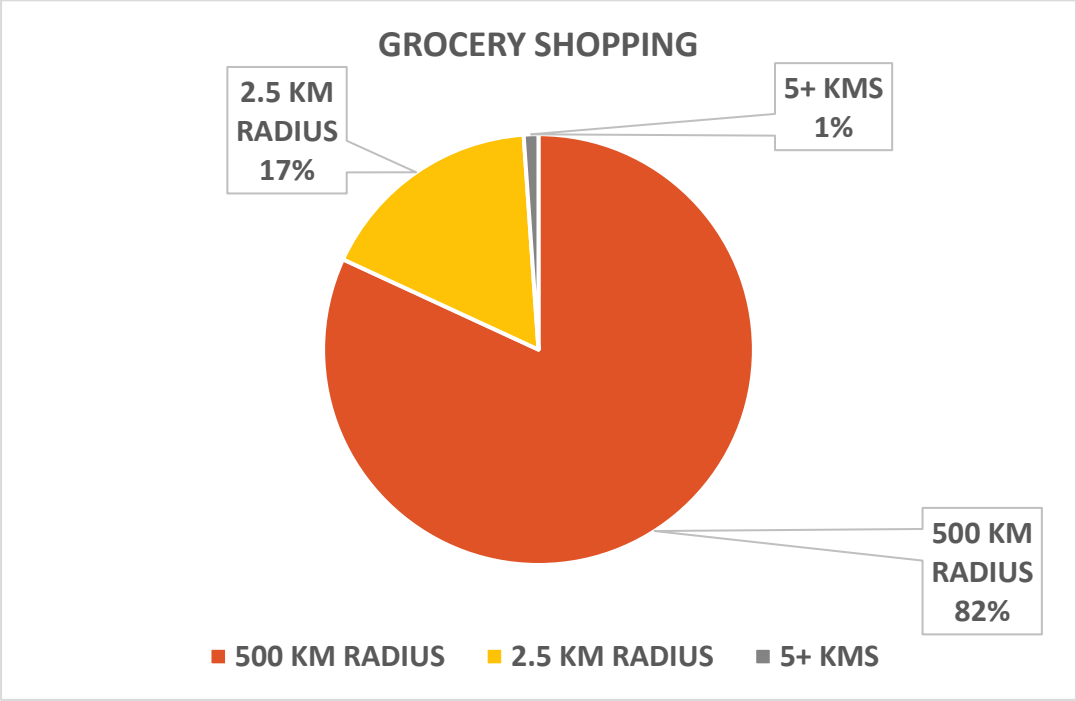


Figure 65 Grocery Shop Proximity

Grocery shopping is within 500 m radius of accessibility while 75% is within 2.5 Km radius. Fifty six percent of the houses have accessibility Transport stand and other stands are within 500m radius.

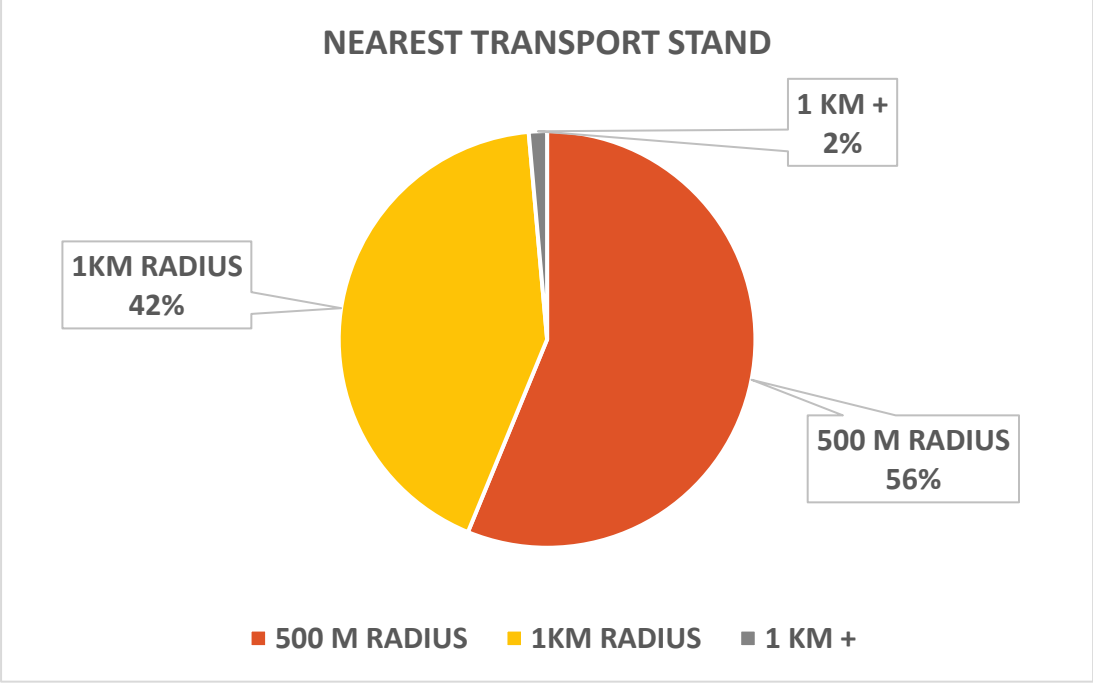


Figure 66 Transport Stop Proximity

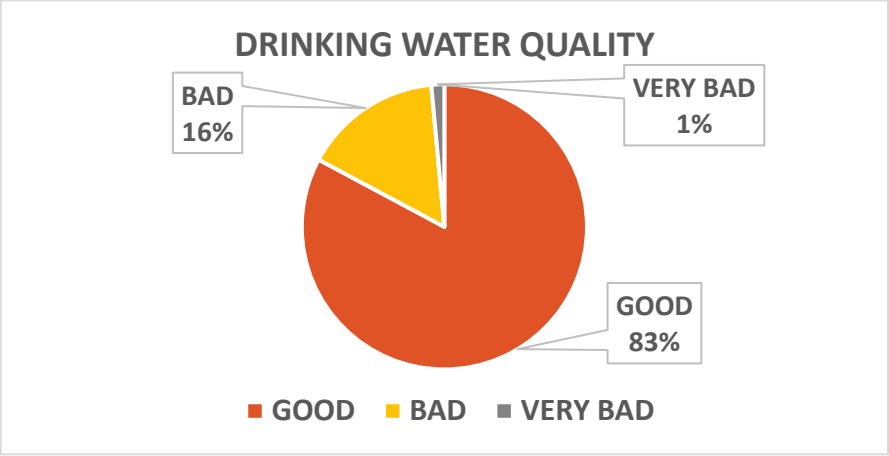


Figure 67 Drinking Water Quality

Drinking water quality is good mostly but is bad in certain panchayaths like Neendakara where all households receive municipal water supply. Majority of the household dispose waste in their own premises. In twenty-five percentage of houses plastic waste is collected through home collection by local bodies. Eighty six percent of the people dump into lake.

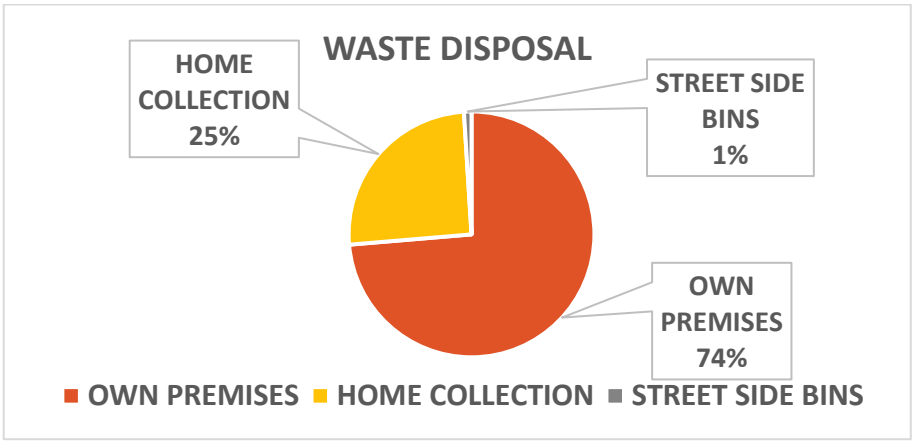


Figure 68 Waste Disposal

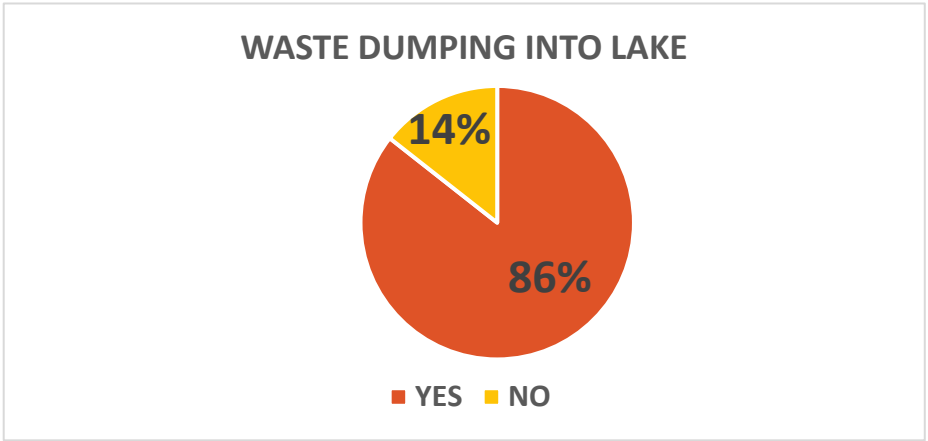


Figure 69 Dumping into Lake

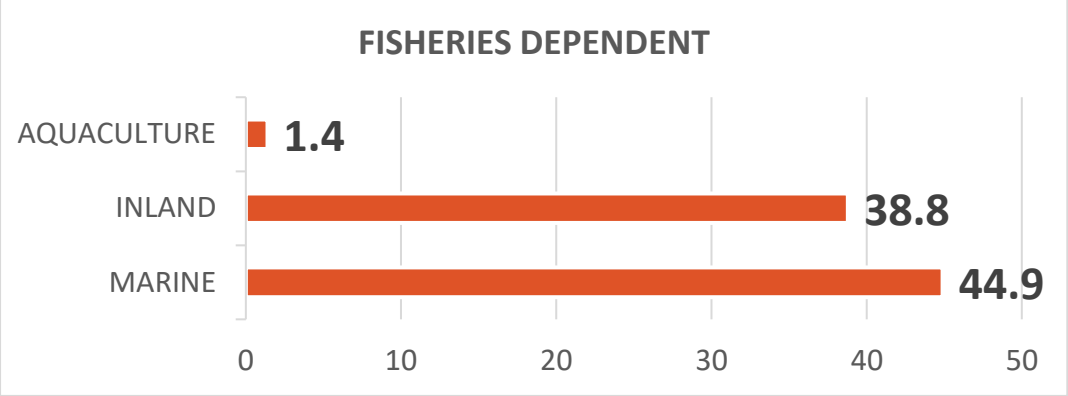


Figure 70 Dependency on Fisheries

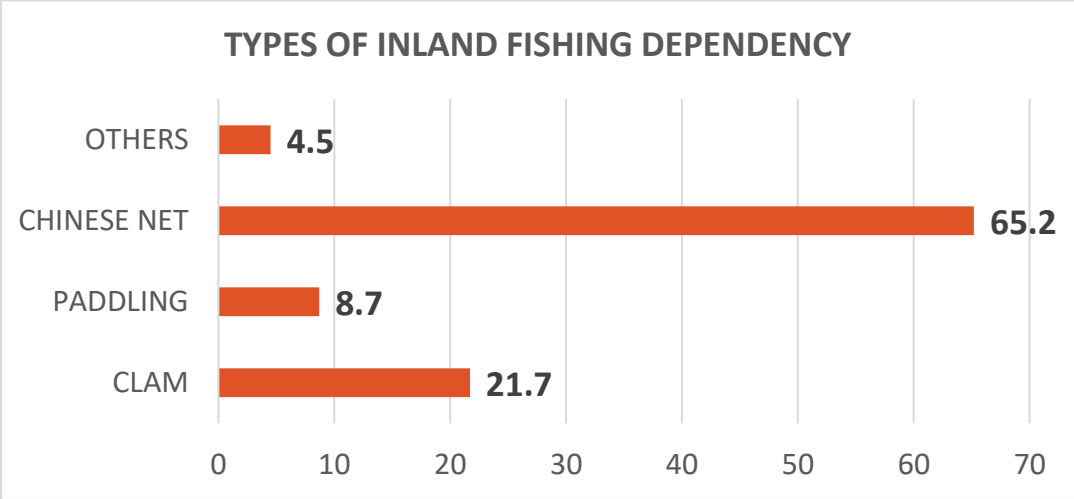


Figure 71 Inland Fisheries type

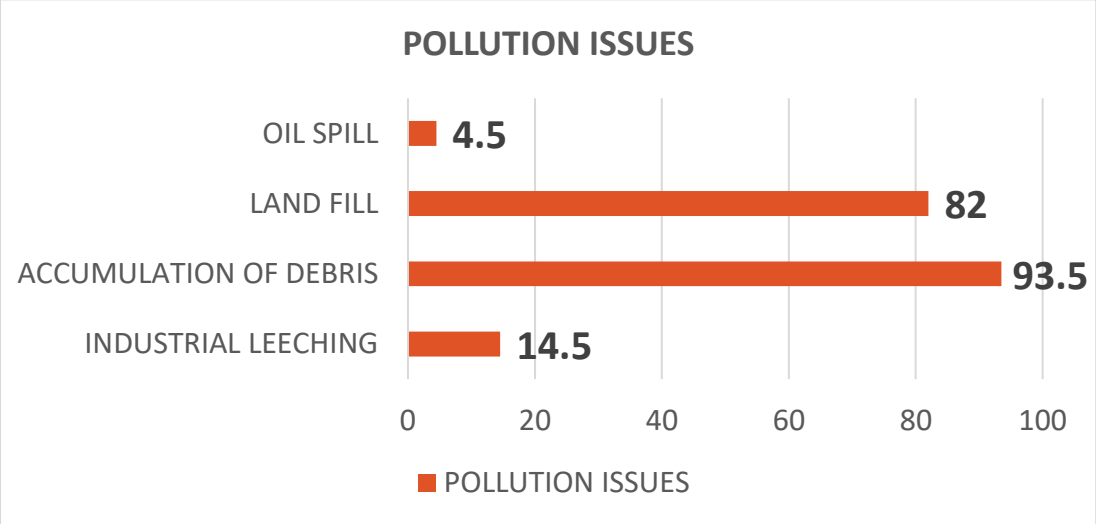


Figure 72 Pollution Issues

Majority depends on Marine fisheries, and in inland fishing majority depends on Chinese nets and clam cultivation. Pollution is majorly due to debris accumulation and landfill.

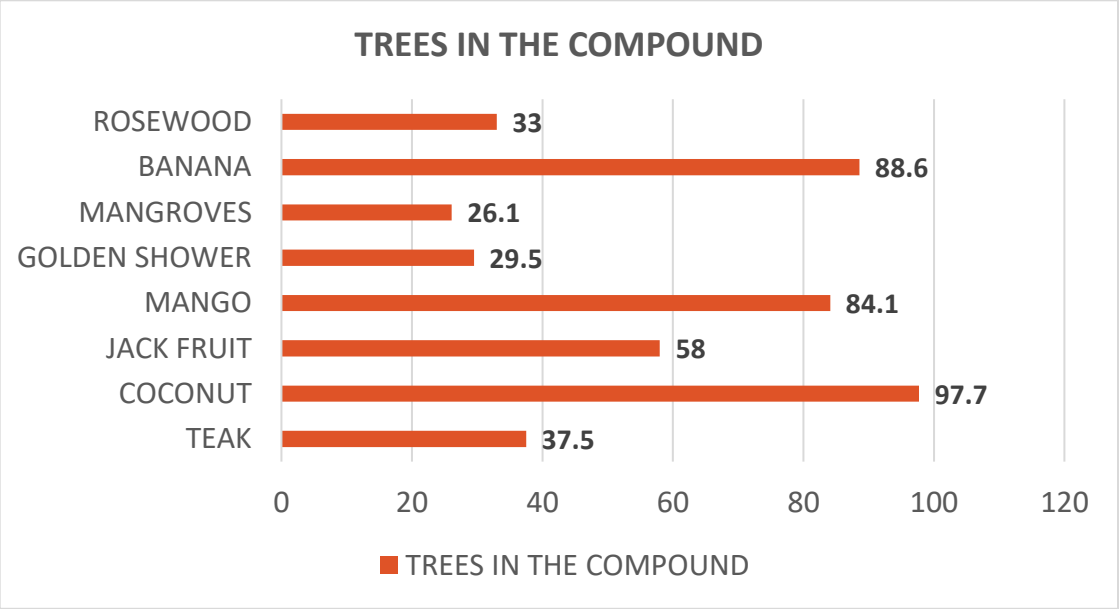


Figure 73 Type of Trees in the Study Area

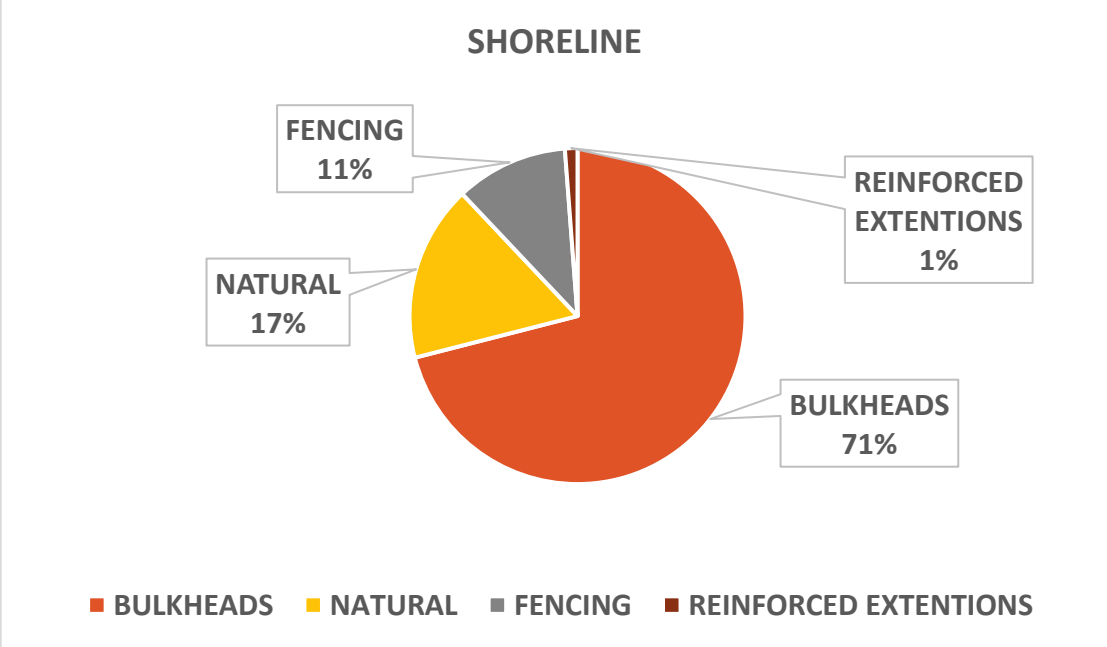


Figure 74 Shoreline Nature

The shore is predominated by coconut trees then banana, mango and jackfruit and mangroves are also predominant in islands. Tree felling is predominant in the riparian areas for housing and others uses.

Most of the shoreline is reinforced with either bulkheads or laterite built. Natural shoreline seen in seventeen percentage of the shoreline and fencing is provided in eleven percentage of the shore area.

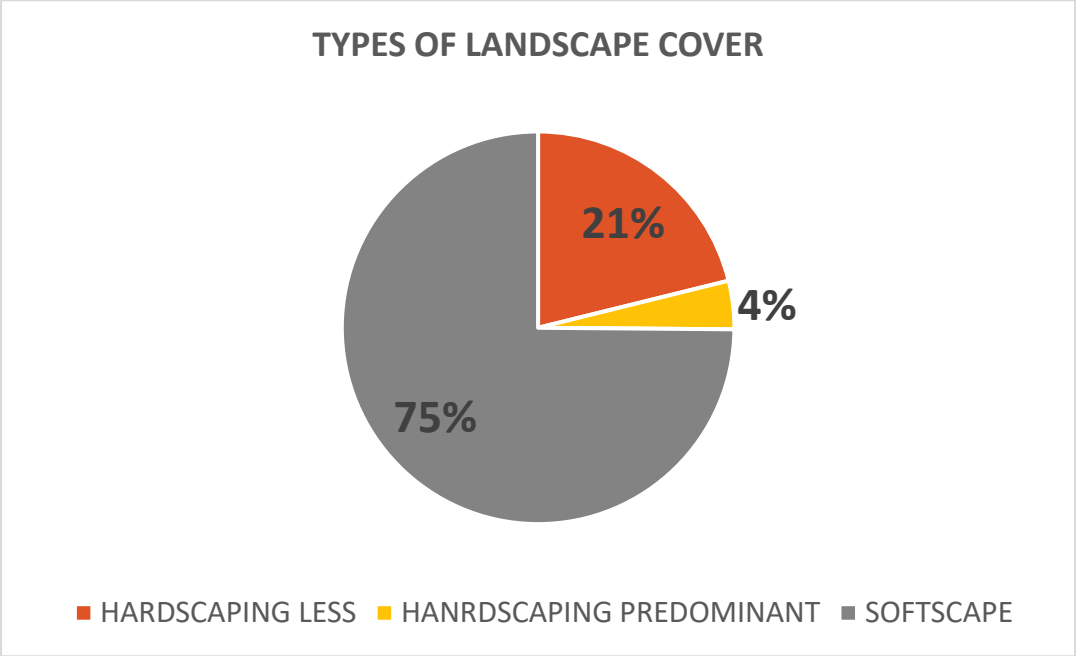


Figure 75 Landscape Cover

Seventy-five percentage of the houses have no hardcover and twenty-one percent of the population has partial hardscaping. There is a need for open public places among the population. Especially in Municipal Area and Neendakara Merryland Ward.

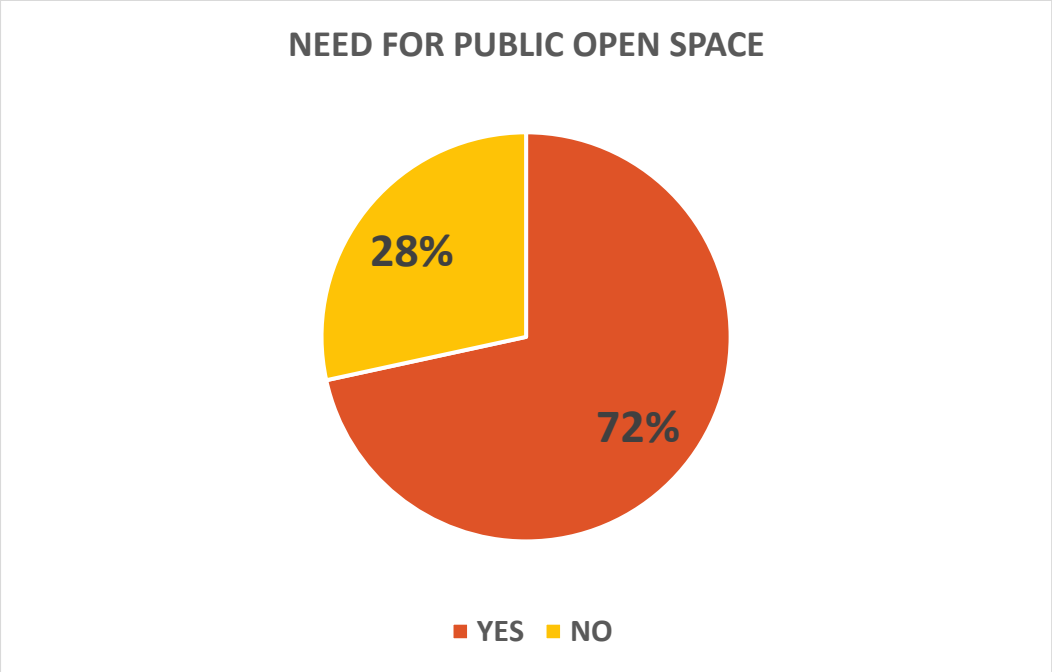


Figure 76 Need For public Open Space

CHAPTER 4 CASE STUDIES

4.1 Estuary management and community- New Jersey

The New York – New Jersey Harbor Estuary is the biggest public resource in the nation's largest and most densely developed metropolitan area. The tidal nature brings in nutrient rich sediments and nature which supports 12-mile squares of tidal wetlands, two hundred fish species and three hundred bird species. The estuary provides as a waterway, for recreation and economic point serving fourteen million people.

The New York – New Jersey Harbor & Estuary Program are the local bodies which help bring together stakeholders through citizen partnership, scientist, and policy makers to attain fishable and swimmable waters in the estuary for people and wildlife.

The funds are arranged under the EPA under the clean water Act and is managed by The Hudson River Foundation.

The management Plan is prepared by identifying the challenges and then formulating the action agenda with respect to the environment through the environmental monitoring plan.

4.1.1 Indicators Assessed

WATER QUALITY		
INDICATORS	LONG TERM TREND	SHORT TERM TREND
Dissolved Oxygen	↗	↗
Enterococcus	↗	≈
Nitrogen	↗	↗
Water Temperature	↘	≈
Debris Collected by Skimmers and Booms	●	↗
Debris Collected on Beaches	↗	↗
Microplastics	●	●
Chemical Contaminants of Emerging Concern	●	●

PORT AND MARITIME (Toxic Contamination)		
INDICATORS	LONG TERM TREND	SHORT TERM TREND
Metals in Sediments	≈	●
PAHs in Sediments	↗	●
Dioxin in Sediments	↗	≈
PCBs	↗	↗

PUBLIC ACCESS AND STEWARDSHIP		
INDICATORS	LONG TERM TREND	SHORT TERM TREND
Publicly Accessible	●	↗
On-Water Access	●	↗
On-Water Programs	●	↗

HABITAT AND ECOLOGICAL HEALTH		
INDICATORS	LONG TERM TREND	SHORT TERM TREND
Benthic Index of Biotic Integrity	≈	●
Estuarine and Diadromous Fish Abundance	↘	≈
Established Oyster Beds	●	●
Whale and Dolphin Abundance	●	●
Tributary Habitat Connectivity	●	●
Riparian Area Integrity	●	●
Stream Health Bioassessment	↗	●
Percent and Distribution of Natural Shorelines	●	●
Horseshoe Crab Abundance	●	↘
Submerged Aquatic Vegetation	●	↘
Area of Coastal Forest and Grassland	●	↘
Area of Wetlands	↘	↘
Nesting Pairs of Harbour Herons	≈	↘

TREND IDENTIFIERS	
↗	Indicates a trend that is improving in terms of environmental health
↘	Indicates a trend that is deteriorating in terms of environmental health
≈	Indicates that the data are not trending, are stable or variable
●	Indicates that there are insufficient data to determine a trend or that this type of analysis is not applicable

4.1.2 Water Quality

Aimed to reduce the sources of pollution so that the waters of the Harbor Estuary will meet the fishable/swimmable goal of the Clean Water Act.

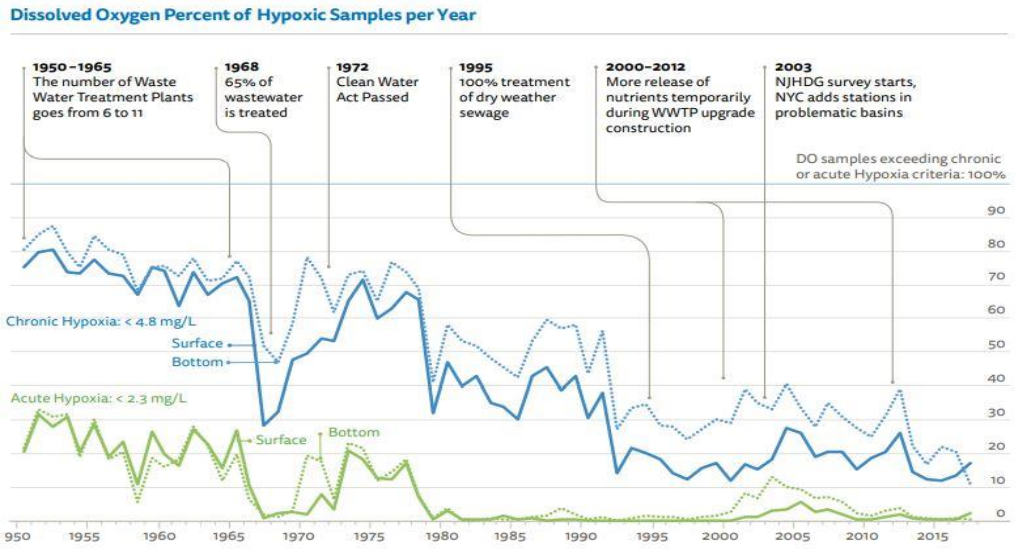


Figure 77 Dissolved Oxygen

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

With increase in water treatment plants the low dissolved oxygen content in has decreased significantly in the estuarine environment. The hypoxic conditions improved in New York City in New Jersey with the introduction of wastewater treatment plants in the highly contaminated areas and source points of discharge.

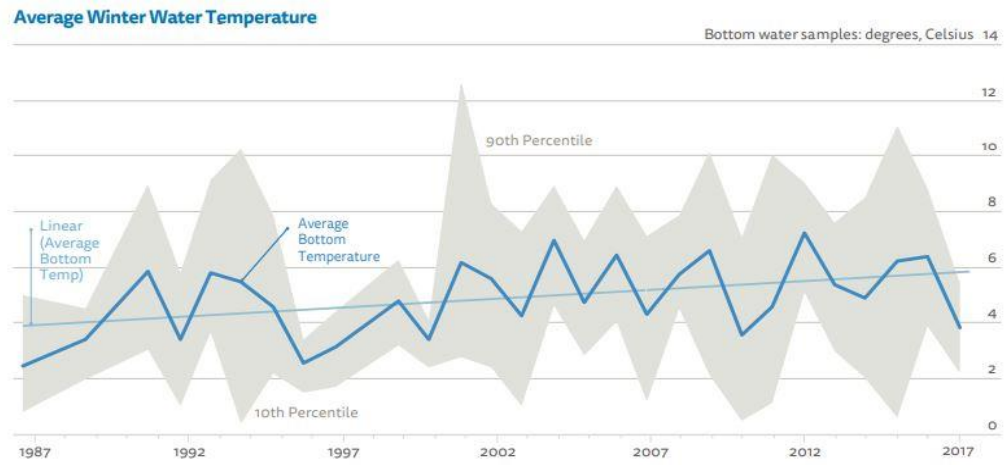


Figure 78 Climate and Temperature

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

Surface water temperature shows disparity to portray a trend while not changing significantly. During winters the average water temperatures are increasing with time which indicates a declining trend of ecological and estuarine health.

Pathogens

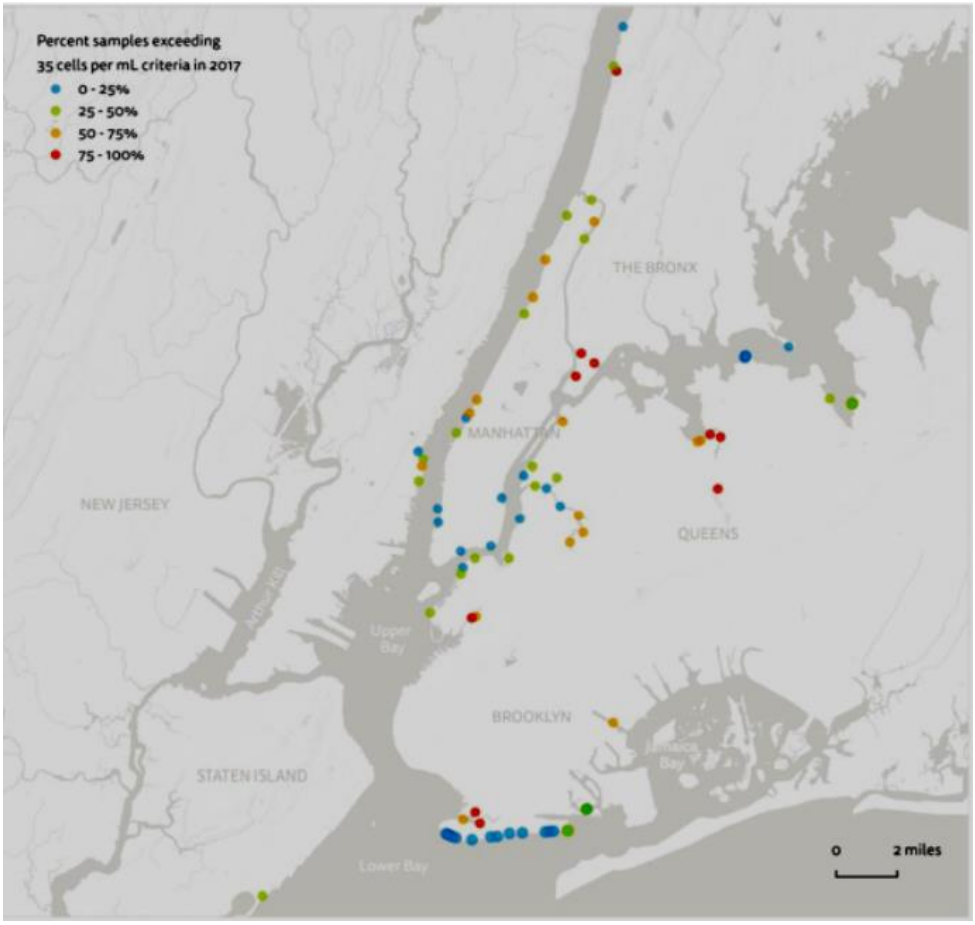


Figure 79 Pathogen Distribution

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

Local bodies and regional bodies are involved to enable citizen partnership in monitoring pathogens, Ph, Dissolved oxygen, and accessibility points. They were involved in paid continuous monitoring of pathogens in shore areas.

Microplastics

Different methodologies were adopted with fixed sample sizes and goals. In the study it was found that large amounts of plastic contents like nurdles or preproduction plastic pellets were deposited into the estuary zone through the industries into the

waterways. The studies showed an increased concentration of various plastic products in each amount of water.

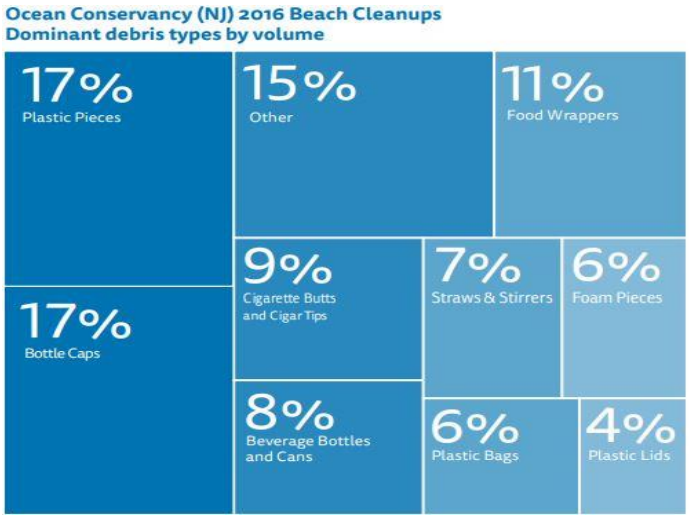
Table 5 Microplastic concentrations

MICROPLASTICS RESEARCH IN THE HARBOR ESTUARY		
Organization	**Dates of study**	**Average estimated abundance of particle per kilometre square**
Bay keeper (Marine)	March-August 2015	256000
Rutgers university bay keeper (freshwater)	May- August 2016 -2017	28,000- 30,00,000
Clear water, Inc.	August 2014-August 2015	30,00,000
Hudson River Park trust	June October 2016, 2017	1,00,000-1,89,000

Table 6 Pharmaceutical Contamination

STUDY OF PHARMACEUTICAL CONTAMINATION IN THE ESTUARY		
Month	**Percentage of sites where the compound is found**	**Detection frequency of 16 compounds across all sites**
May 2016	98%	55%
July 2016	92%	52%

Debris Accumulation



4.1.3 Habitat and Ecological Health

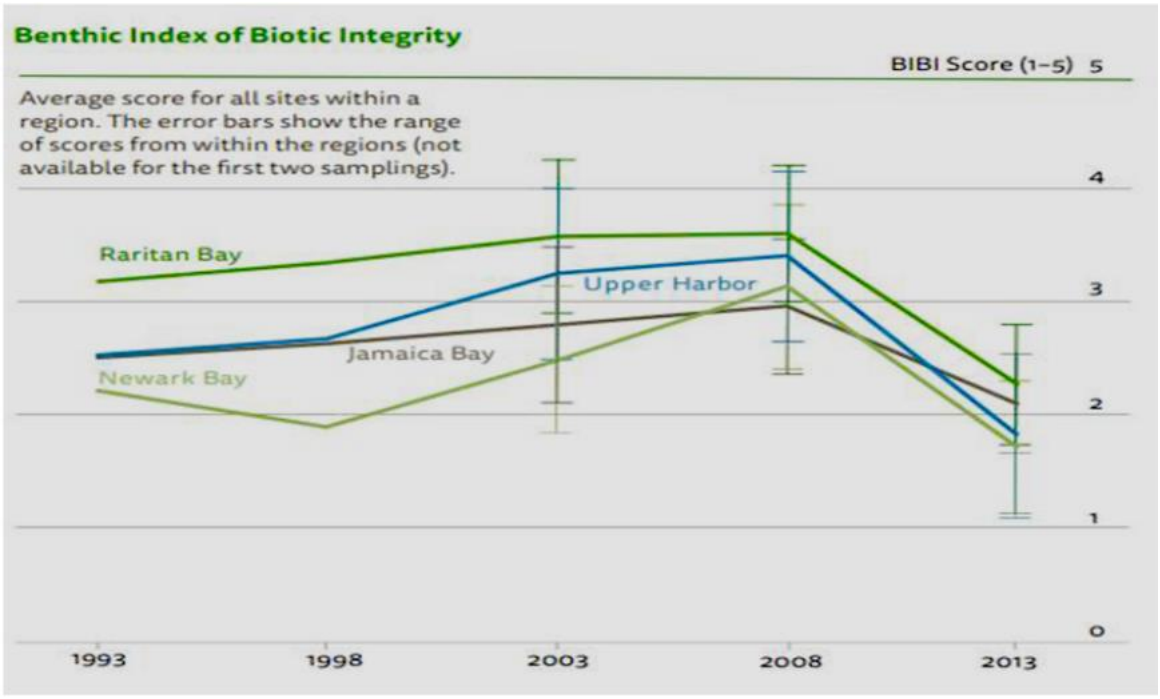


Figure 80 Benthic Index of Biotic Integrity
Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

The scoring is between 1–5, with 5 representing high ecological health and hence less pollution and 1 representing low ecological health.

Mapping Oyster Beds - Index of Biotic Integrity

The Harbour Estuary's oyster is not developed for culinary purposes but rather for the ecosystem services and benefits they provide. Oyster reef walls not only does provide three-dimensional habitat and filter water thus naturally cleansing but also attenuate the wave nature and thus helps in shoreline stabilisation and prevents erosion. (Loren D Coen, 2007)

The forests and grasslands along rivers and streams, including streambanks and floodplains, improve water quality by filtering out toxins and excess nutrients, keep waters cool, and provide food for aquatic organisms (USDA, 2018). The health and integrity of these riparian areas is directly correlated with aspects of stream health including flow regime and water quality (Snyder et al., 2003).

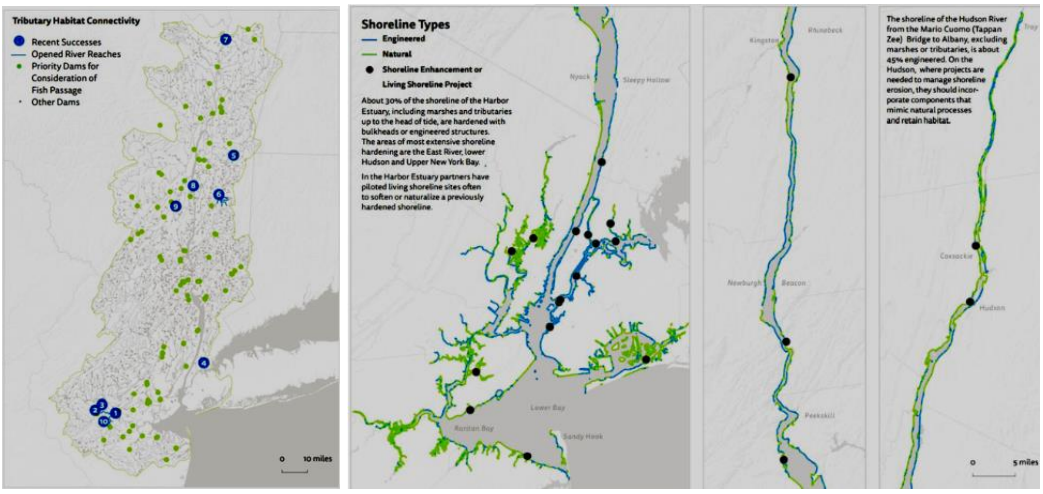


Figure 81 Tributary Habitat Connectivity and Shoreline Type

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

Three different agencies operate skimming and boom programs in the Harbour Estuary. Skimmer vessels are boats fitted with a front-mounted conveyer belt that skims the surface water down to a two to three feet depth and collects floating debris. Booms are floating nets that are usually placed across tributaries entering the harbour to collect trash flowing downstream.

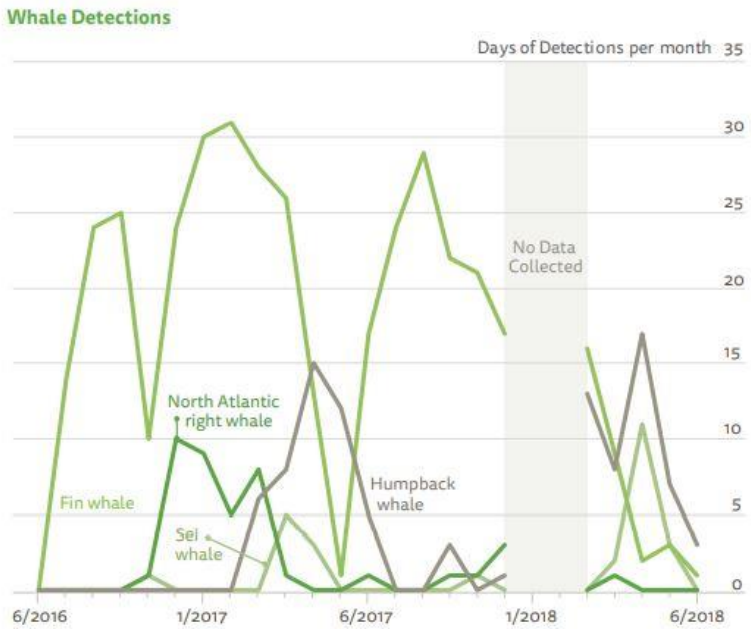


Figure 82 Fish Abundance and biodiversity

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

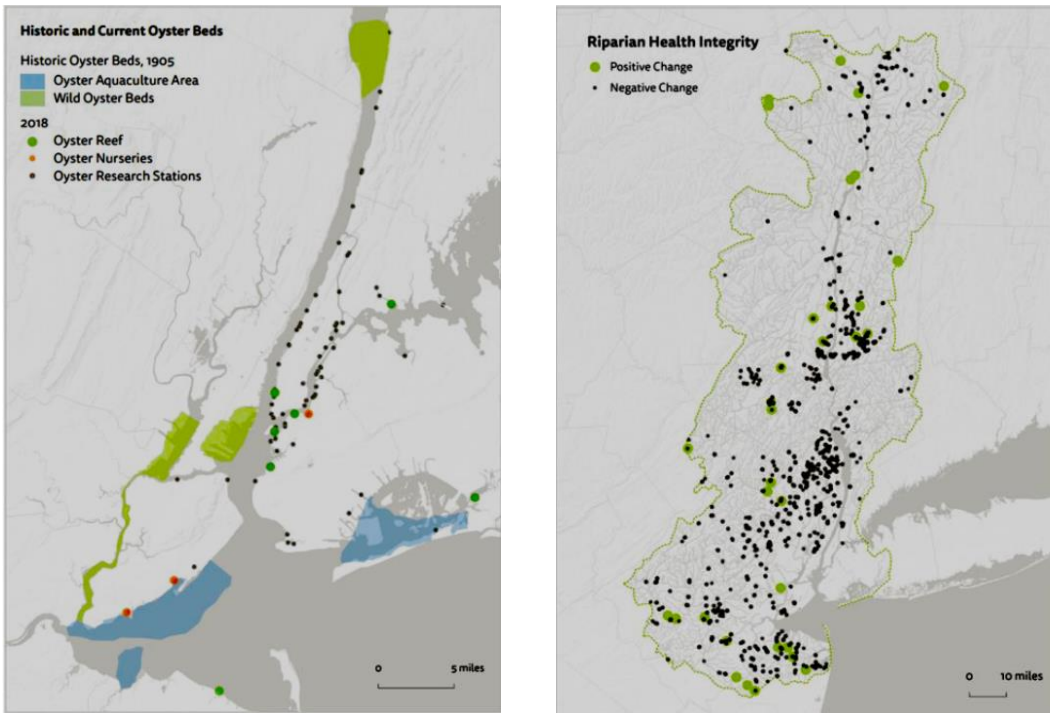


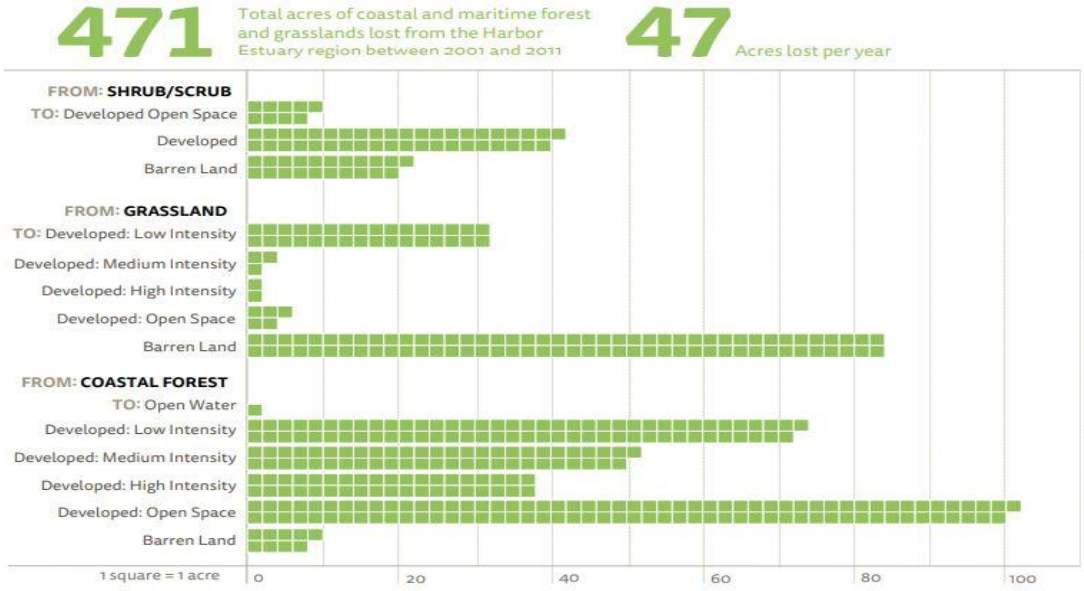
Figure 83 Oyster bed distribution and riparian area integrity
Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

Table 7 Chnge in Riparian Habitat

CHANGE IN A CAUSE OF NATURAL RIPARIAN HABITATS (FORESTED GRASSLAND WETLAND) FROM 2001 - 2011				
Developed land	Barren land	Pasteur	Cultivated crops	Open water
1212	25	4	7	81

Table 8 Change in Air

CHANGE IN AIR CAUSE OF DEVELOPED (HIGH MEDIUM LOW INTENSITY) OR BARREN LAND, PATURE, CROPLAND FROM 2001- 2011				
Forest	Wooded wetlands	Herbaceous wetlands	Grassland	Scrub or shrub
10	5	7	3	1



It should be noted that the riparian zones should have indigenous special and not prevalence of invasive species. When there is negative change, it shows that there is more introduced species than indigenous species and hence change.

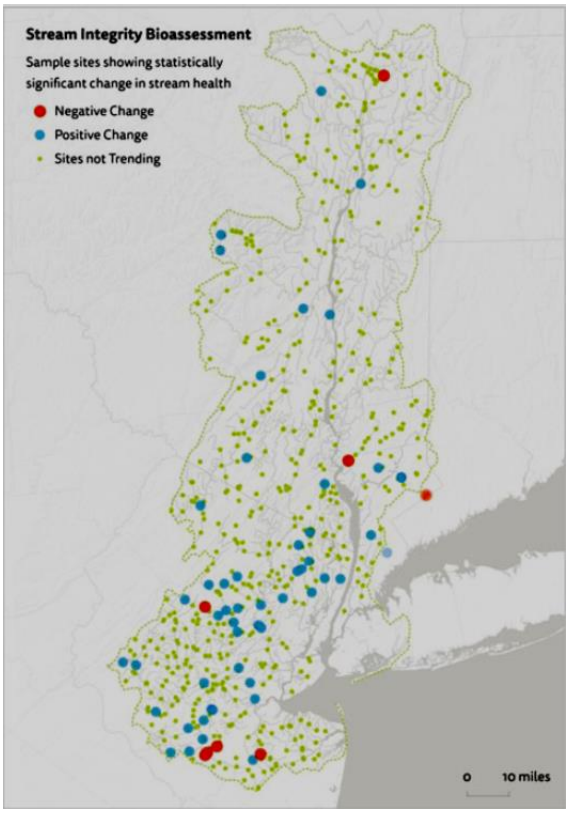


Figure 84 Stream Integrity Bio- Assessment Terrestrial

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State Of The Estuary 2018

4.1.4 Maritime Activities

ERM and ERL are the mathematical correlation of toxic material concentration to the biotic health of a system and represents the estuarine and shore health.

Effects Range Median (ERM) shows a higher risk due to concentration where visible deterioration of health happens, Effects Range Low (ERL) 10% of the organisms are adversely affected due to the concentration. Concentrations below the ERL are likely non-toxic for the given contaminant.

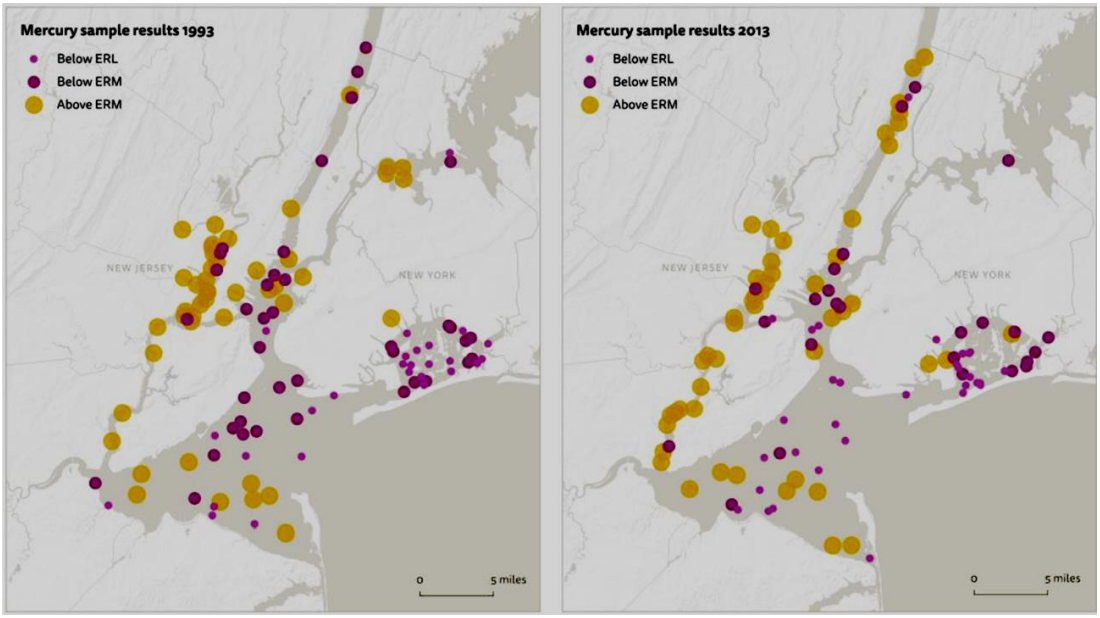


Figure 85 Mercury Concentration before and after the interventions

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State of The Estuary 2018

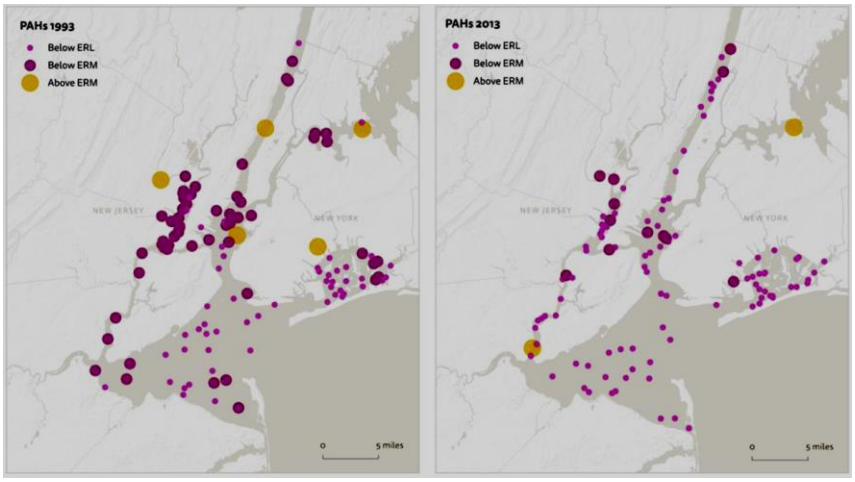


Figure 86 PAH Concentration

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State of The Estuary 2018

4.1.5 Community Involvement

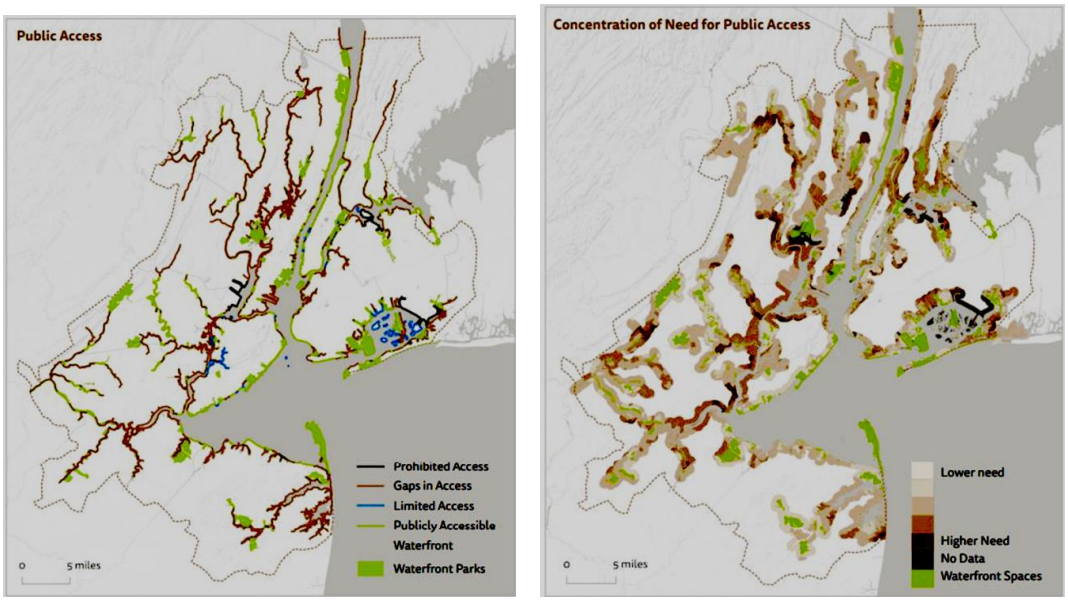


Figure 87 Accessibility and Need

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State of The Estuary 2018

Table 9 Community Participation

COMMUNITY PARTICIPATION					
	A day in the life of the Hudson and harbour		City of water day	Riverkeeper sweep	
Year	**Sites**	**Participants**	**Participants**	**Sites**	**Participants**
2003	14	341			
2004	16	1175			
2005	26	695-lots of rain			
2006	34	1329			
2007	49	2500			
2008	53	2800	7200		
2009	61	3000	11,000		
2010	54	3336	13,000		
2011	59	3487	25,000		
2012	67	3765	26,000	30	450
2013	60	3271	26,000	70	1400
2014	54	3220	25,000	82	1900
2015	80	5121	25,000	102	2000
2016	81	5297	26,000	109	2200
2017	90	5502	35,000	102	1790
2018			35,000	120	2300
Growth rate	**543%**	**1514%**	**393%**	**300%**	**411%**

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State of The Estuary 2018

It is observed that when accessibility to waterfront is increased more stakeholders were willing to participate in conservation activities and community involvement increased. Citizens were involved in surveys, restoration activities and trash collection etc

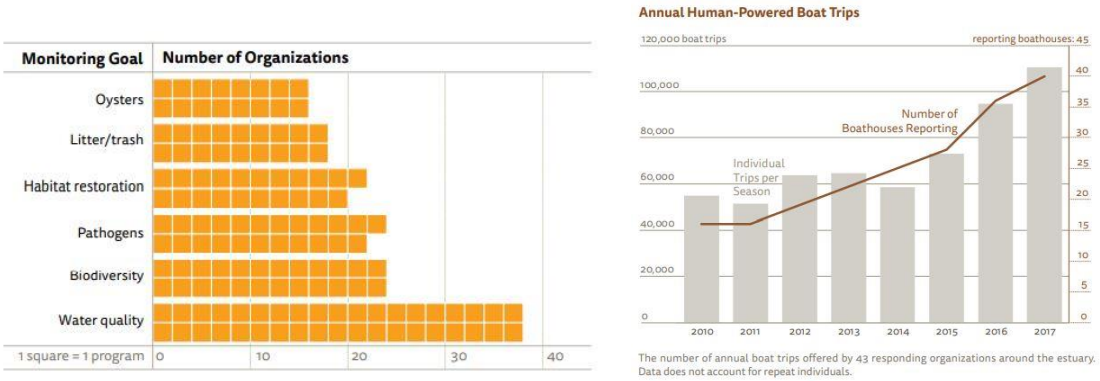


Figure 88 Boat Trips

Source: Environmental Health and Trends of The New York– New Jersey Harbour Estuary, The State of The Estuary 2018

Inference

The case study gives insight into the parameters to be sought to assess estuary health and zonation parameters and the improvement in ecological health of environment and aquatic biome with various aspects and influences.

4.2 Cape Estuary Program for Diep Estuary

The Diep River originates from the Riebeek Kasteel Mountains north-east of Malmesbury, running 65 kilometers south-west towards Cape Town, connecting the sea at Milnerton, 5 kms north of the Port of Cape Town.

For the formulation of the preparation the Estuary Management Plan, the estuary is delineated as the area from the estuary mouth to the Blaauwberg Bridge at Coastal & Environmental Consulting 5 the upper end of Rietvlei, with the lateral boundaries being the 5-meter mean sea level contour. These boundaries, as well as the 1:100-year flood line are delineated.

The Vision for the C.A.P.E. Estuaries programmed is: “Our estuaries are beautiful, rich in plants and animals, they attract visitors, sustain our Livelihoods, and uplift our spirits.”

Figure 89 Diepp estuary consisting of Reivetli and Milnerton Lagoon
Source: Report on the implementation of the Western Cape Estuary Management Programme 2020/21

4.2.1 Land use and Infrastructure Development

The Diep Estuary includes the river from the mouth to the bridge and is delineated with 5m contour points from the mean sea level. Most of this area falls under the natural reserves but this area also consists of already modified and developed banks. There are still some undeveloped or non-engineered shore which lays open as public open space which lies between the reserve and the 5m contour line and flood line.

The above said area along with the coast happening between the dolphin beach ponds and sunset beach should also be included to the strict reserve area to protect the estuarine and riparian environment.

Figure 90 Proposed New Boundary for Nature Reserve
Source: Report on the implementation of the Western Cape Estuary Management Program 2020/21

The wetland is delineated using the guidelines developed for South African wetlands.

1. No developments should be allowed within the reserve boundaries of the estuary (other than the already existing structures)

2. Facilities inside the reserve should allow and motivate the promotion of conservation objectives for effective management, education on the conservation, awareness and citizen awareness and non-dependent activities.

3. The boundary conditions of the interzones within the reserve and the reserve external connections should be well managed to segregate and allow adaptation with evolution of the flora and fauna.

4. Stringent environmental based recommendations and regulations are to be brought by the local bodies to approve for rezoning and further development of the reserve and the areas surrounding the reserve whose health has significant impact on the estuary. (eg. on water quality).

4.2.2 Water Quantity and Quality

The salinity regime should be such that it facilitates the rehabilitation of estuarine communities - such as Callianassa - in those areas which they previously occupied.

Figure 91 Flood prone areas around Diepp Estuary

Source: Report on the implementation of the Western Cape Estuary Management Program 2020/21

Conditions of a healthy estuarine environment should be reestablished at the estuary mouth. The mouth is supposed to naturally close during summer at least in some years segregating the brackish water from saline waters for best nature of estuaries. Flows of water and stratification within the system are not clearly understood. The nature of flows should be studies and interpreted to optimize the flow directions and thus to develop the condition of anoxic conditions.

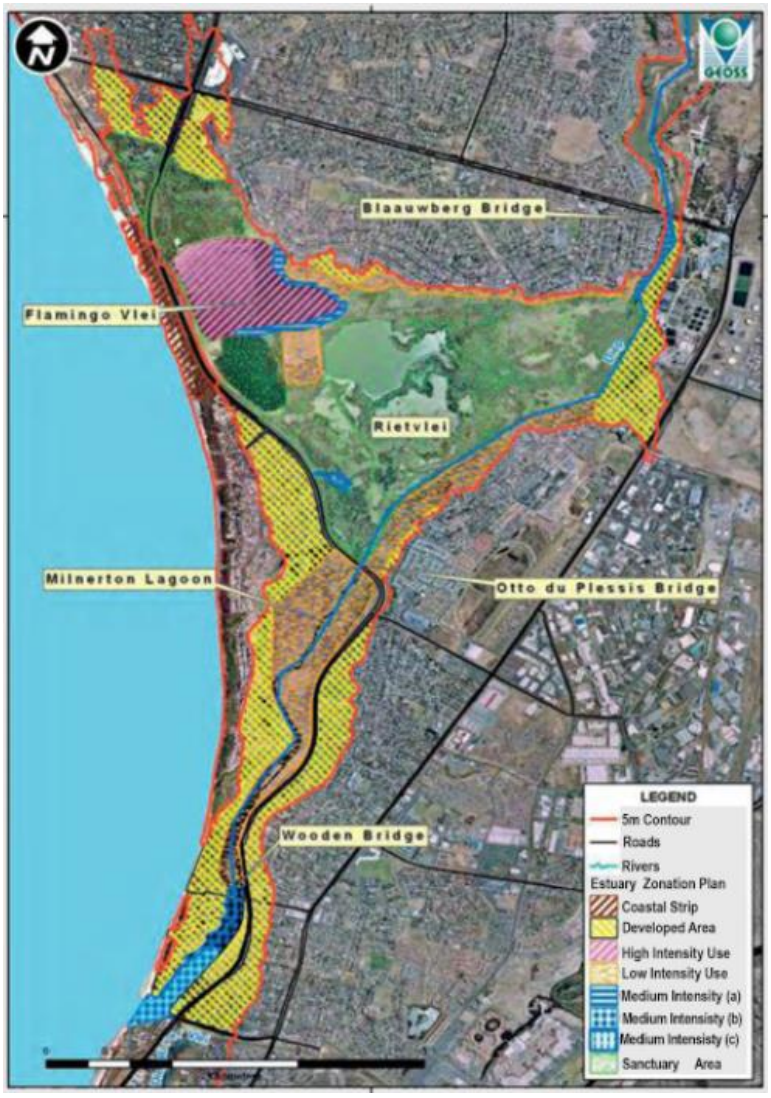


Figure 92 Visitor Use Plan

Source: Report on the implementation of the Western Cape Estuary Management Program 2020/21

Objectives proposed for improved sediment quality:

x The native sediment nature and condition should be restored as much as possible. (Eg. particle size distribution, organic content etc.).

x The bacteriological concentration of the estuarine environment is to be maintained at safe levels such that it does not pose a threat to the human health.

x The sediment quality should possess the integrity to sustain indigenous species and reestablishment of benthic invertebrates such as Calluanassa.

Management of water quantity and quality- Interim management measures, Reduction/manipulation of flows from Potsdam Flows from the catchment, Stormwater flows, Management of water levels, Dust problem

Flooding- Pollution Prevention/ minimization- Potsdam, Sewerage infrastructure in the Milnerton/ Blaauberg area, Sewerage blockages Pump stations |Reporting and response, Stormwater drains., Informal settlements and low-cost housing areas, Pollution sources in the river catchment, Monitoring.

Conservation, Planning and Sustainable Use

1. Legal status of the Reserve

2.Urban Development and Planning
Must ensure that any further rezoning for urban development in areas upstream and likely to impact on the estuary must be subject to stringent environmental conditions.

These should include:
(Lynn Jackson, 2011)

X the establishment of biodiversity corridors and buffer zones

X installation of stormwater drainage in line with the Policy on Minimizing the Impact of Stormwater from Urban Development on Receiving Waters

X retention of existing natural wetlands on the site and incorporation into the development

X restrictions on the construction of overhead transmission lines in the vicinity of the estuary

X establishment of Environmental Liaison Committees to monitor the environmental conditions of the approvals.

3. Conservation and ecotourism development

A conservation development framework needs to be developed Issues to be addressed include:

X The erection of fencing or construction of berm and channel boundaries around the entire reserve.

X Additional bird hides and other bird viewing facilities should be erected, and screened walkways for the existing ones constructed possibly using reeds

X Breeding features for birds established, particularly in and around the south lake (Bird Island in Peninsula tip)

X Walking Trails

X Plans to relocate the model aircraft site (a nearby attraction)

X A corridor between Vissershok and Atlantis needs to be provided for in the Catchment Management Strategy.

4. Biological research and monitoring

5. Rehabilitation and habitat restoration

A rehabilitation plan covering both aquatic and terrestrial areas needs to be developed.

- The re-introduction of primary producers (such as Zostera) and benthic invertebrates, such as sandprawns

CHAPTER 5 **ANALYSIS**

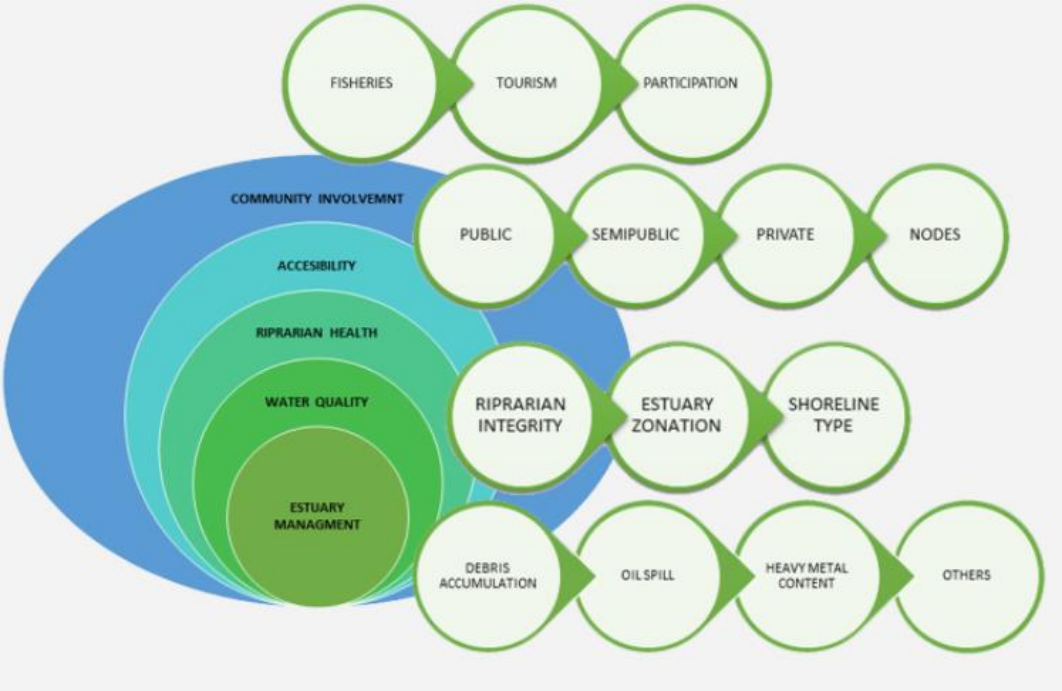


Figure 93 Indicators for Assessment
Source: Author Generated

Water Quality, Riparian Health, Accessibility, and Community involvement are the primary indicators derived from the case studies and literature studies with respect to the context.

The sub indicators analysed for research are Debris accumulation, Oil spill, Heavy metal concentration, Riparian Integrity, Estuary Zonation, Shoreline Type, Public- semi-public-private accessibility, nodes, fisheries, Tourism, and participation.

Figure 94 Riparian Wards
Source: Author Generated

The waterfront riparian wards are studies based on the techniques adopted from case studies, Corporation wards and wards from Neendakara, Thekkumbagom and Thrikkaruva which lines the waterfront are taken.

The presence of national waterway,Neendakara and Shakthikulangara Harbour, leeching of effluents from KMML and the debris deposit along the mangroves and islands is leading to deterioration in quality of water and more pollution of the estuary.

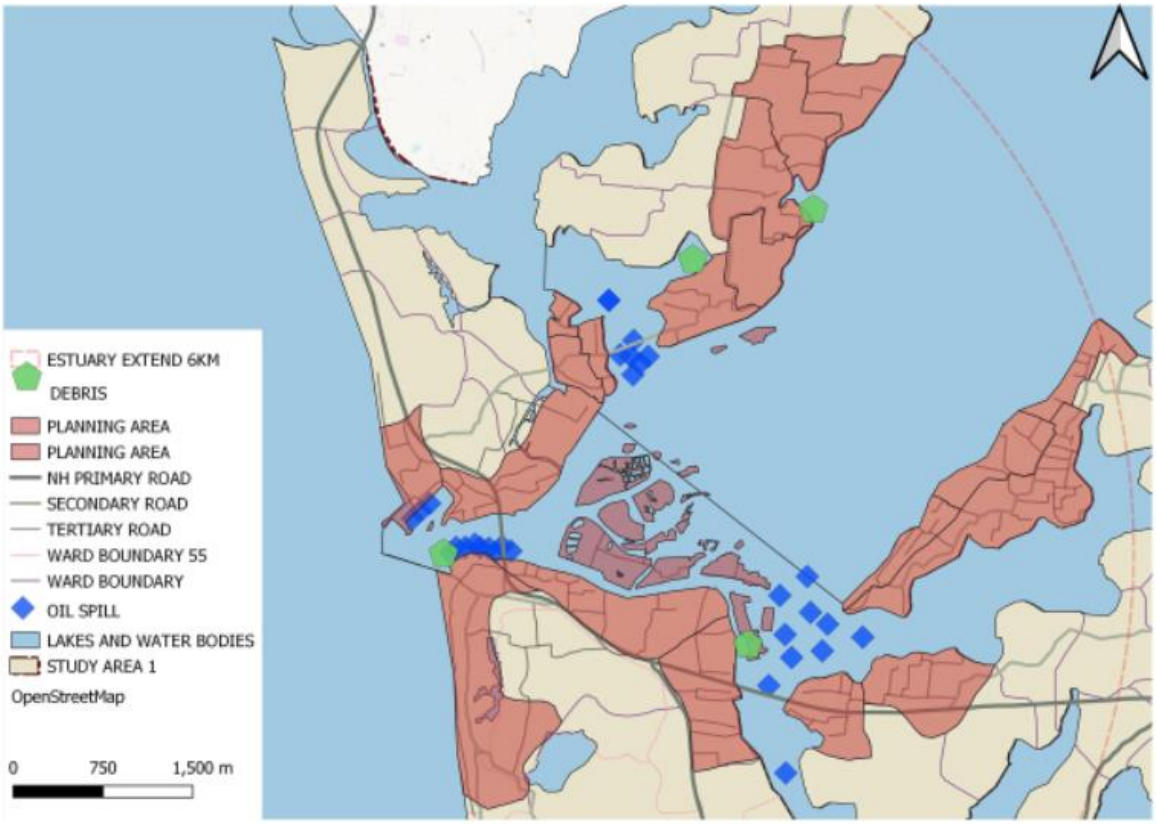


Figure 95 Water Quality Oil spills and debris Accumulation
Source: Author Generated

Along with it the Spatial Variability of the potential ecological risk index and pollution load index are found to be high in the mouth region and the eight creeks od Ashtamudi rendering the estuarine water quality to be less.

The presence of national waterway, Neendakara and Shakthikulangara Harbour, leeching of effluents from KMML and the debris deposit along the mangroves and islands is leading to deterioration in quality of water and more pollution of the estuary

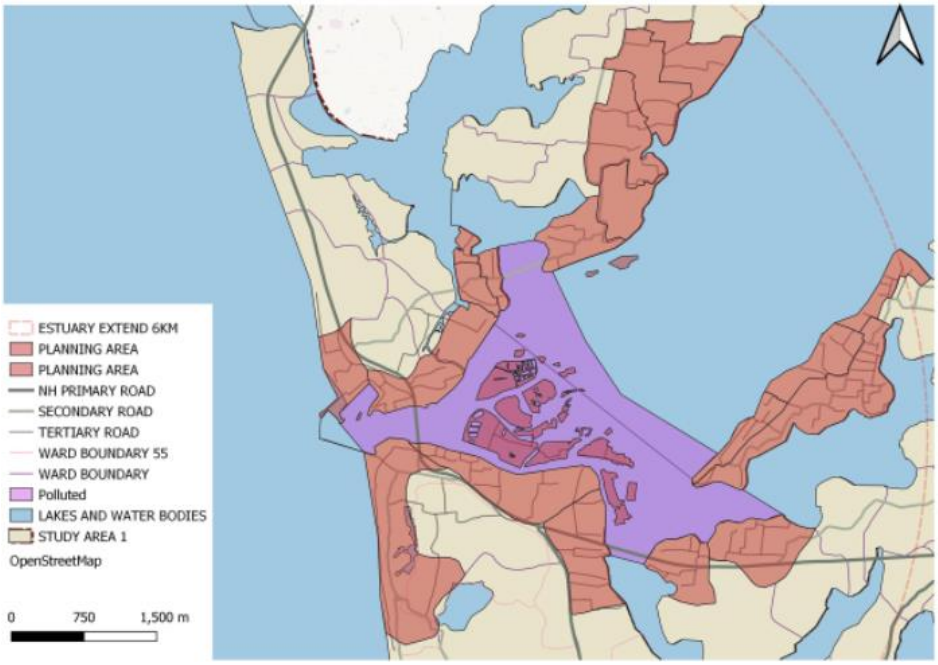


Figure 96 Area under huge ecological and pollution risk Index
Source: Author Generated

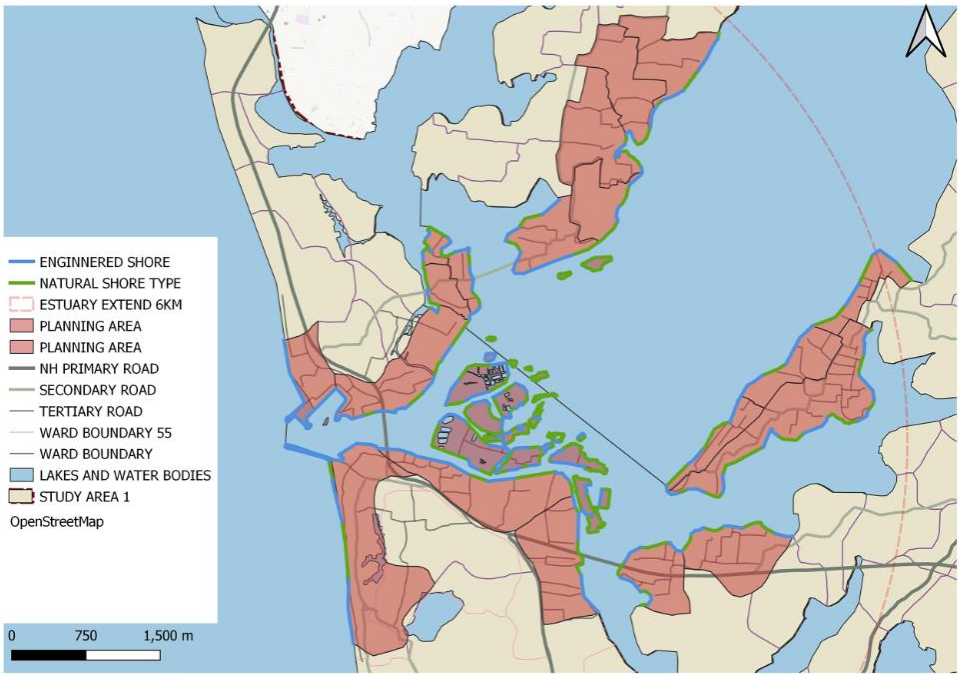
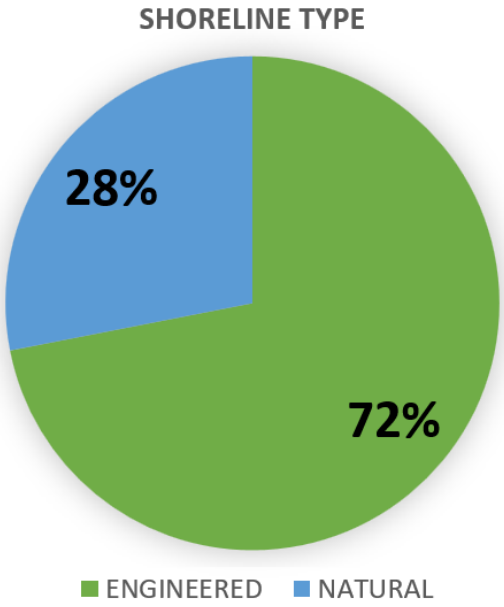


Figure 97 Engineered and Nonengineered shore
Source: Author Generated

Almost 72% of the shore is engineered either with soft structures like bulkheads or other hard engineering for retaining which makes the areas more vulnerable as non-engineered shores Are proven to improve estuarine health than engineered ones.



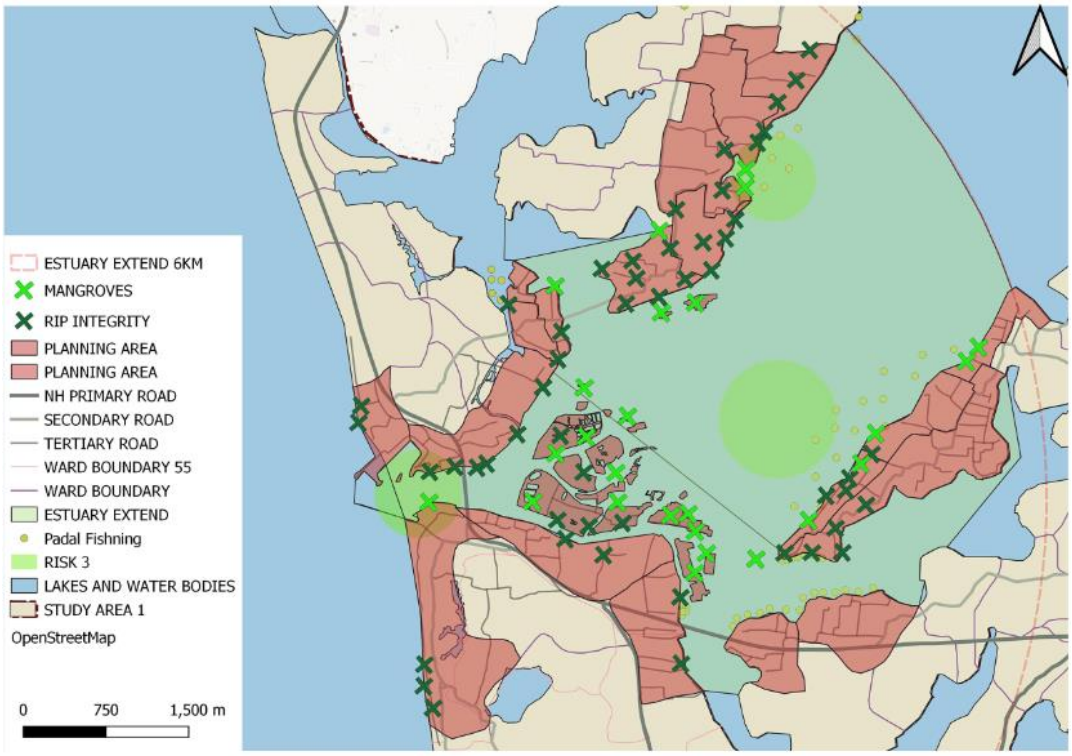


Figure 98 Riparian Area Integrity
Source: Author Generated

Trees found in and around Ashtamudi include the Teak, Rose Wood, White Pine, Coconut, Jackfruit, Mango, and the Golden Shower Tree. (Nayana, 2020)

Table 10 Endangered Mangroves

LIST OF MANGROVE PLANTS IN ASHTAMUDI ESTUARY AND THEIR STATUS		
Species	**Family**	**IUCN**
Acanthus ilicifolius	Acanthaceae	EN
Acrostichumaureum	Pteridacea	LR
Avicennia marina	Avicenniaceac	EN
Avicennia Officinalis	Avicenniaceac	EN
Bruguieragymnorrhiza	Rhizophoraceae	CR
Ceriopstagal	Rhizophoraceae	EN
Derris trifoliata	Leguminosae	EN
Exoecariaagallocha	Euphorbiaceae	VU
Lumnitzeraracemosa	Combretaceae	EN
Rhizophoraapiculata	Rhizophoracea	EN
Sonneratiacaseolaris	Sonneratiacea	EN
EN- Endangered, LR- Low Risk, CR- Critically Endangered, VU- Vulnerable		

The above given species are the predominantly available species of flora and fauna which is vulnerable. Bruguiera gymnorhiza is a mangrove type in the Ashtamudi Ramsar site that is critically endangered. Excoecria agallicha is a species of mangrove which is vulnerable and there are sets of mangrove species in the study area which comes under the category of endangered species.

With rise in prominence of Tourism in Sambranikodi Islands the surrounding neighbourhoods are seeing a pressure for building tourism infrastructure a result of which can be the rise of resorts in the area. This seems to be proportional and connected to the encroachments and locations at the verge of conversions.

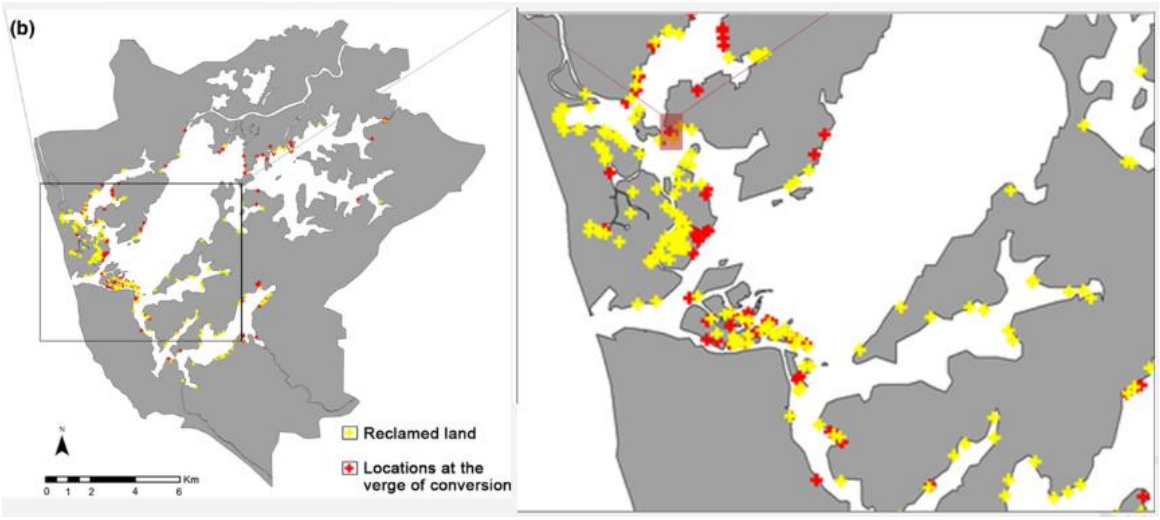


Figure 99 Land Reclamation and Conversion threats
Source: Author Generated

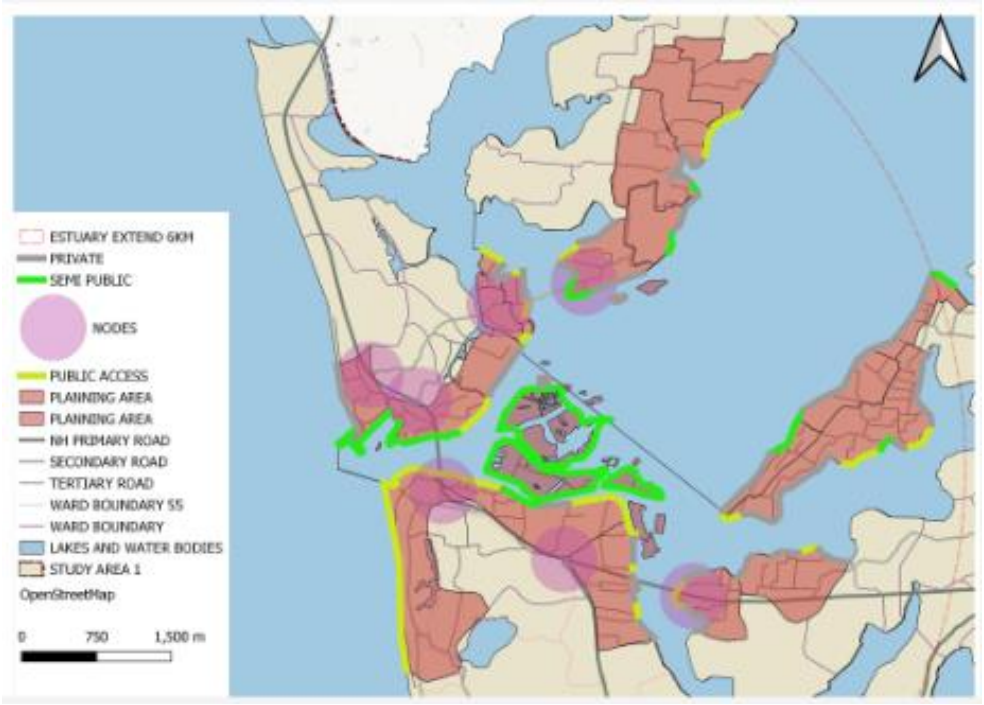


Figure 100 Ease of Access
Source: Author Generated

Most of the waterfront are semipublic or Private owned, Public open spaces are not ample annd those which are are not used to the full potential.

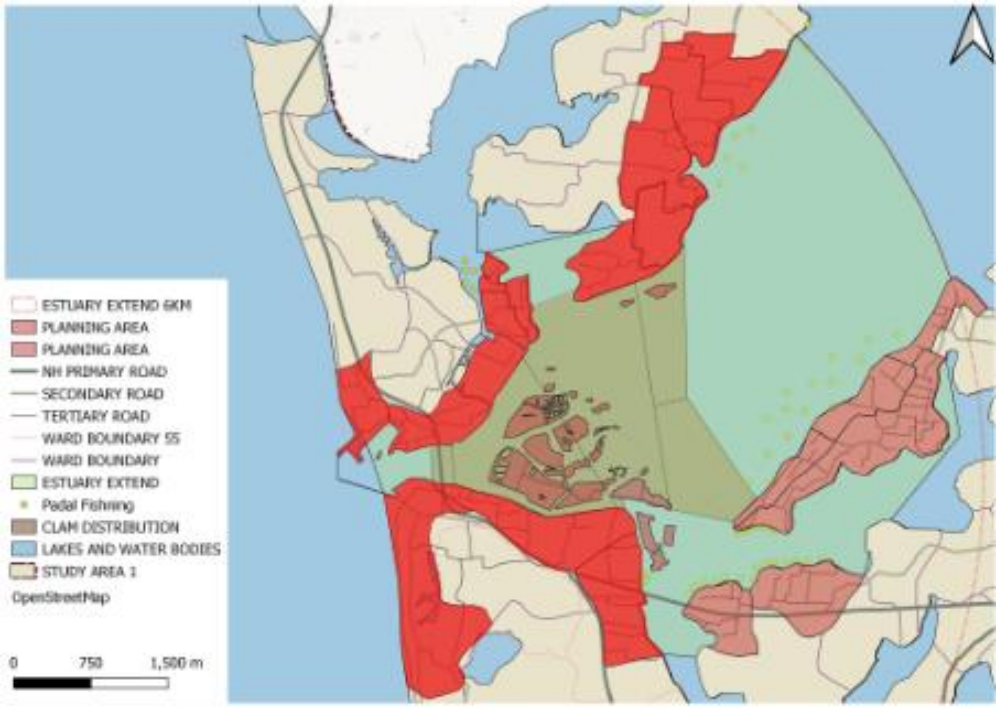


Figure 101 Fish Distribution Data
Source: Author Generated

Therefore, the most risk prone area is the Island Area (San-Thome Islands) where the mouth opens to and the proximity of Sambaranikodi Islands, release of KMML effluents and leeching into the water body, waster debris accumulation from Kureepuzha waste plant, National Waterway 3 is the most vulnerable zone impacted by the factors and has various mangroves which call in for preservation and restoration.

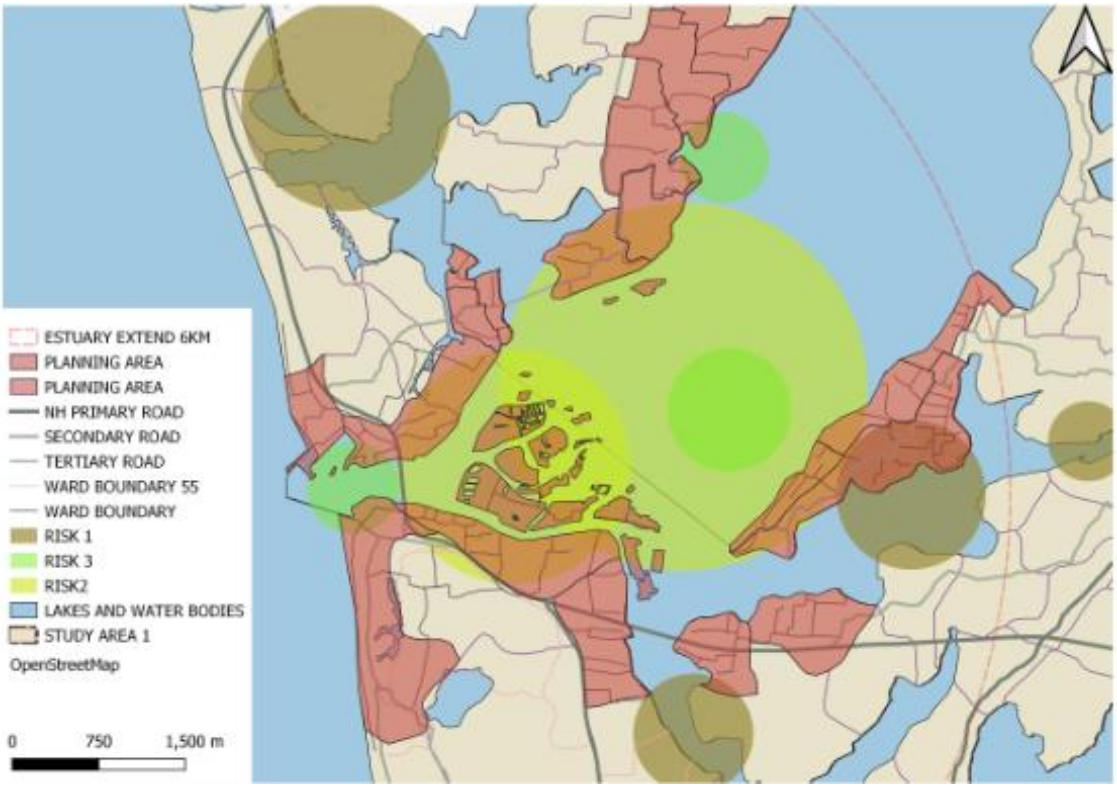


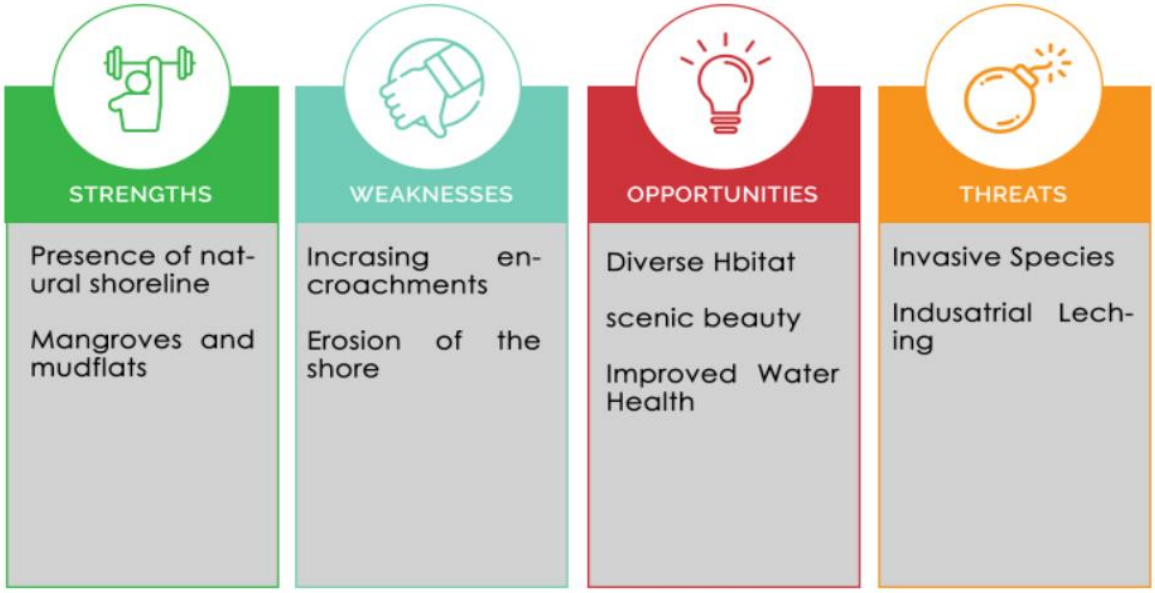
Figure 102 Vulnerabilities
Source: Author Generated

A fair share of population does depend on the inland and coastal fishing livelihoods. Shakthikulangara area shoes a prominence in Iceplants and export factories while Neendakara has apopulation depending on hatecheries and household fisheries and cleaning units. Thekkumbhagom Panchayath and other lake front wards use paddling which is a traditional and local method of fish capture.

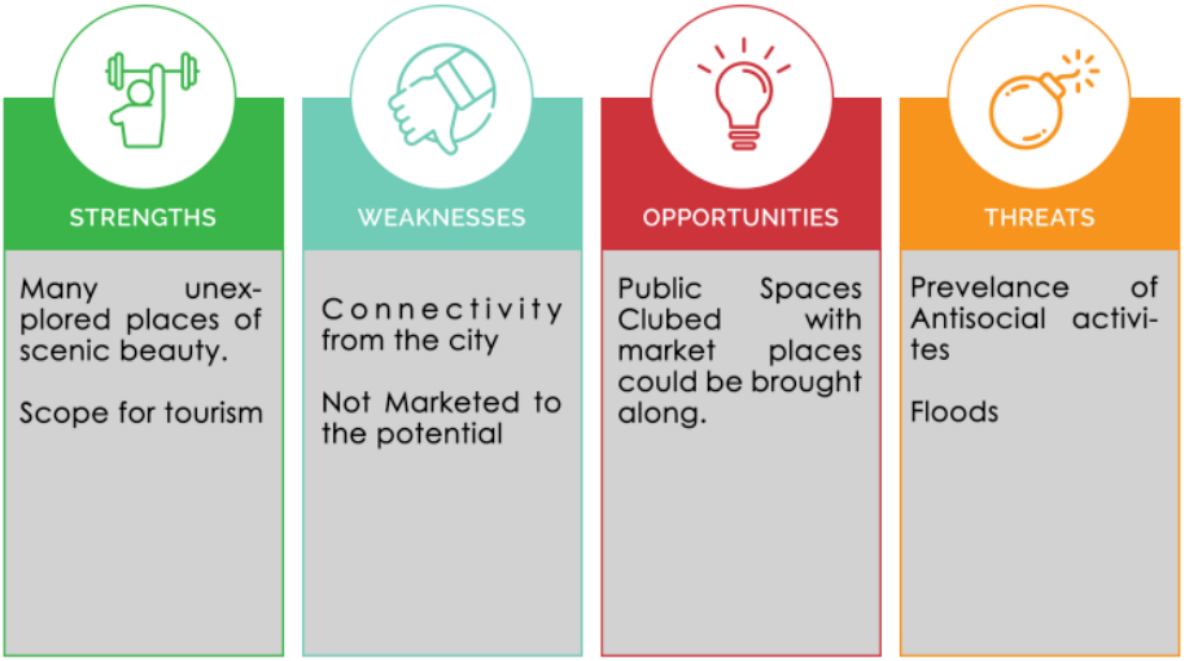
5.1 SWOT

Water Quality

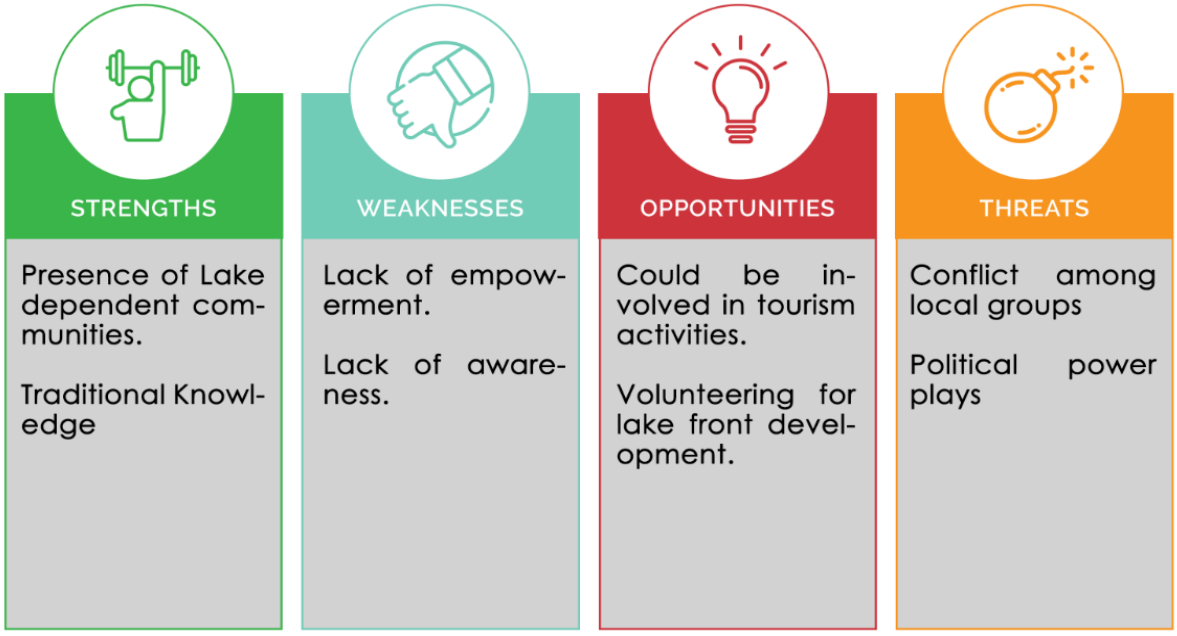
Riparian Health



Accessibility



Citizen Involvement



5.2 RECOMMENDATIONS

To improve Water Quality and re-establish the water characteristics for better estuarine health.

- Environmentally sensitive areas should be clean from external impurities and hence debris to be cleared.

- Adopt nature-based water conservation, storage, and filtering methods for restoration of ground water quality.

-The upstream estuarine activities should be reviewed and controlled with strict regulations as in the water contamination at the industrial portion of Kanjiracode creeks and Thrikadavoor creeks.

-Work in collaboration with industries and respective authorities to control and regulate and mitigate leeching from the landfill and industries on the flora and fauna.

To improve Riparian Health by regulating shore activities and lakefront activities.

- Reduce the felling of trees and deterioration of indigenous riparian habitats and restore if possible, exploring development permit as a tool.

-Adopt and maintain infrastructure and bank stabilization by use of ecofriendly methods and maintenance.

-Ensuring the habitat protection and maintenance for enabling habitats such as reeds and breeding of birds, fishes etc.

-Restore vegetation and innate characteristics in mudflat areas and prevent the effects of dredging.

-Work with local bodies to improve riparian health.

To improve Accessibility and hence improve citizen involvement and better surveillance.

- Segregate environmentally sensitive areas and control where public recreation or other activities are not encouraged.

- Interpretive visiting plan and education plan is to be developed for the estuary for citizen involvement.

- A public recreational plan to be formulated with infrastructure to support the natives and the tourist visiting.

- Increase the accessibility to the waterfront by roads and pedestrian paths to increase public engagement in monitoring and cleaning activities.

- Increase Surveillance to reduce antisocial activities which is prevalent in the water edges.

To increase Citizen Involvement to improve and practicalize local level mouth management.

- Public education need to be provided for the unemployed group to engage and to make them understand the sensitivity of the estuary and effect on their livelihoods and resources.

– Educating the importance of trails

- Public -Economy benefits to be educated to the communities

- Engaging the public and youth through volunteer points or job opportunities.

- Encourage social movements and youth involvement e.g., Clean Ashtamudi initiative

CHAPTER 6 **PROPOSALS**

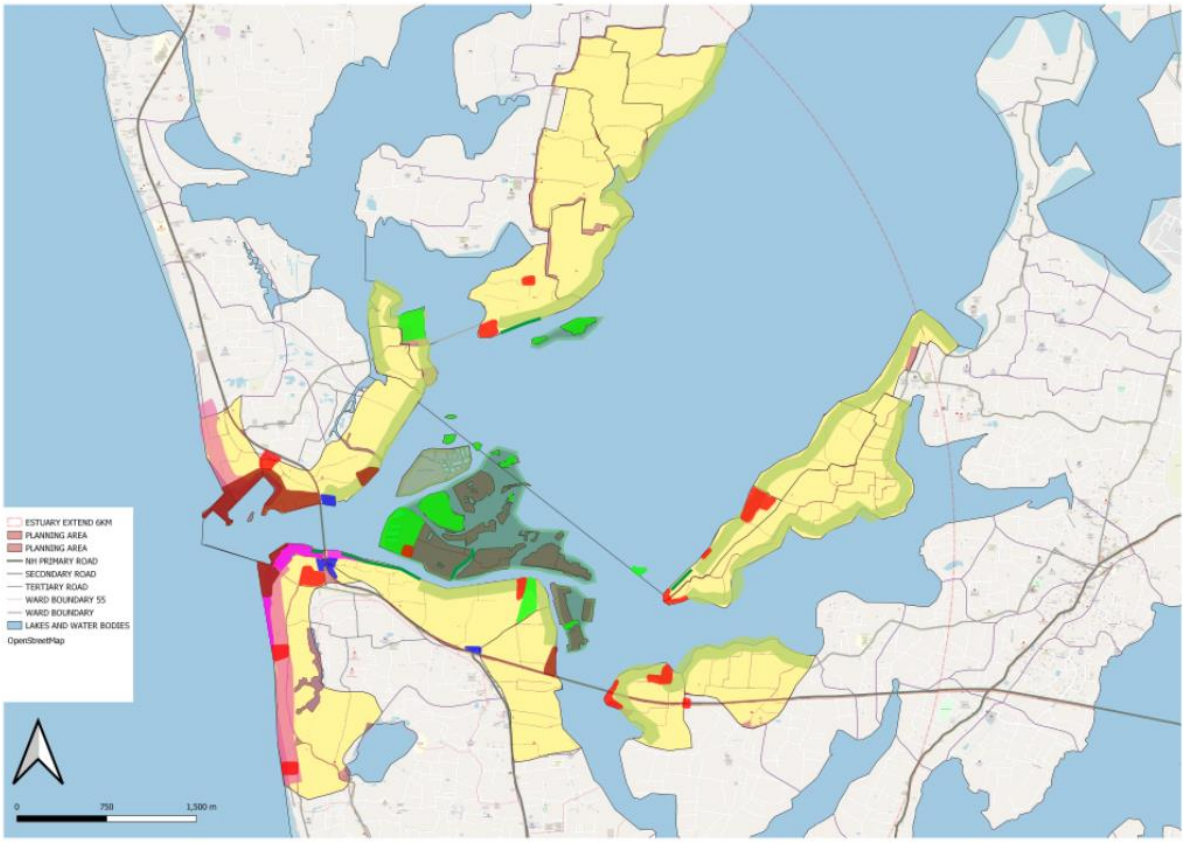


Figure 103 Proposed Land Use
Source: Author Generated

Land Use Plan proposed do not allow or consider the mudflats and mangrove regions in the San- Thome islands and Sambranikodi Islands. The proposed land use plan allows for private public collaboration to redeem benefits and to support eco restoration of the habitat.

1. Bio fencing for forestry Practices, vegetation planting and bank stabilization.
2. Eco trail Route – non- motorise boating, fishing, floating eateries
3. Sediment and water quality – IT integration for geofencing and immediate oil spill responses, Plastic interceptors for debris collection.
4. Recreation Planning – Visitor use maps, land use, market stroll, bird sanctuary and viewing point.

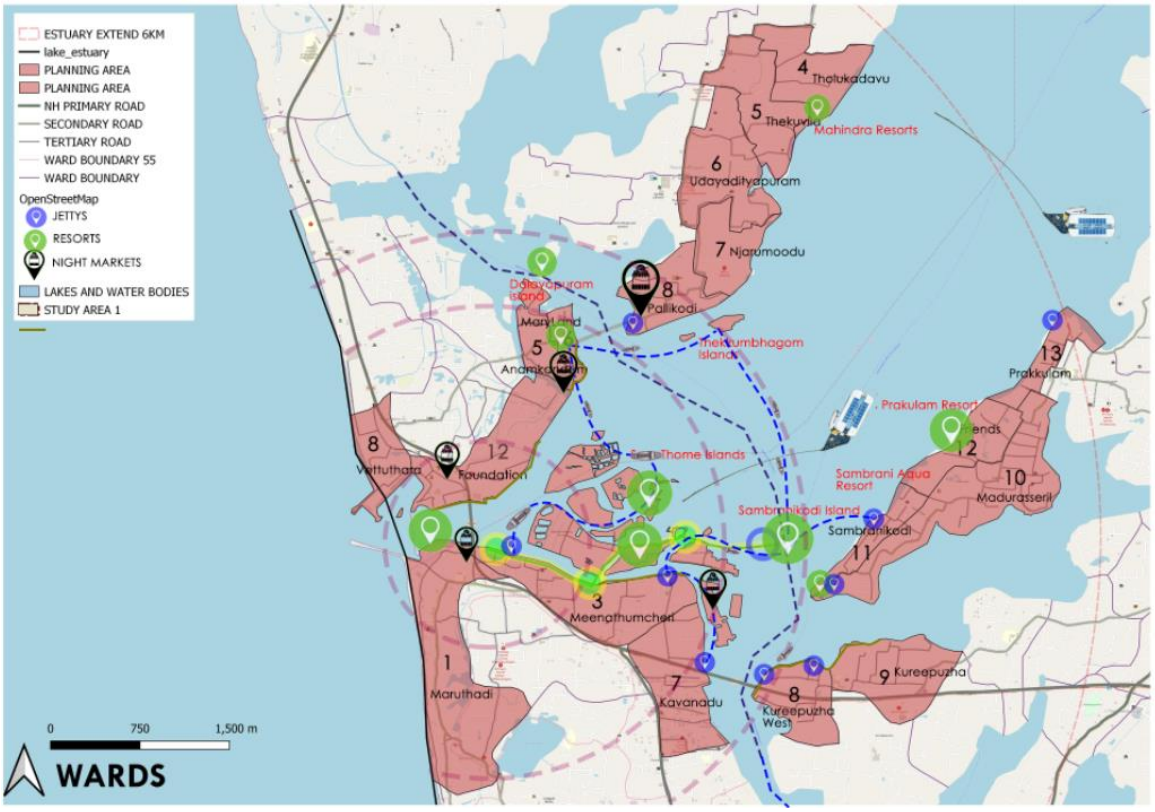


Figure 104 Integrated Plan
Source: Author Generated

Bio Fencing

Bio fencing of different methods can be adopted as external walls and retention walls using rhizome /legume root species and mangrove roots.

Modern adaptation could also be sought to avoid and filter seepage of Industrial and Waste leeching into the estuarine environment.

Figure 105 Bio fencing Techenique 1, Techenique 2 Retaining in coasts, Techenique 3 using legumnous mangroves.
Source: Retrieved from Living fence Ctherine Gilon,Jitendra Raj Bajracharya/ICIMOD, https://goemkarponn.com/wp-content/uploads/2021/05/IMG-20210521-WA0030.jpg

Eco- trail Circuits

Proposing an Eco- Trail connecting the tourist spots (San Thome Islands and proposing a visitor use plan with open acess and limited access).

Ecotrail to sambranikodi Islands with stop points in between and floating markets and hotels run by non motorised boats.

Fish pedaling units and mesh size to be regulated to prevent overexploitation in areas with more phytoplankton debris- Puthenthuruthu area.

Figure 106 Walkways and boating through mangroves with ecofriendly trails using bamboo reeds

Source: Retrieved from https://www.shutterstock.com/image-photo/bamboo-bridge-mangrove-600w-1128911807.jpg, https://images.newindianexpress.com/uploads/user/imagelibrary/2016/10/16/w600X300/TouristscannowtakeaboatridethroughthemangroveforestsinUllalinManga.jpg?w=640&dpr=1.3

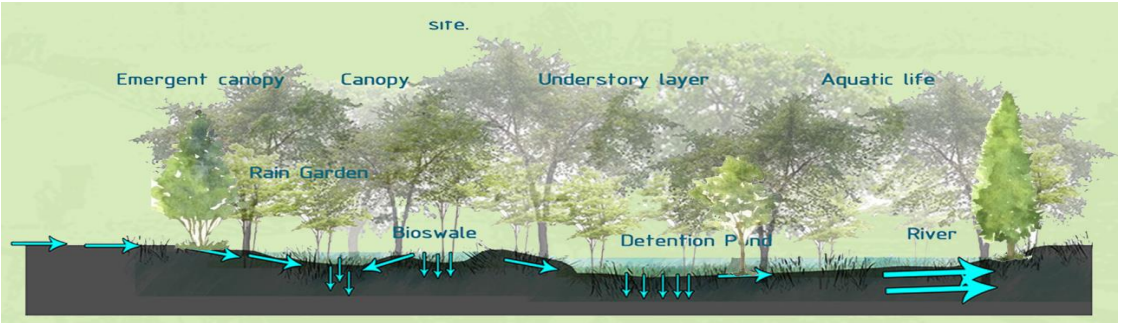


Figure 107 Bioswales to be constructed

Source: Retrieved from https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_004866.jpg

During heavy rains, excess water is channeled under the sidewalk grates and filter strip into the bioswale.

Bioswales catches the storm water runoff as it moves to the water body through shallow vegetated depressions which capture and treat the water of its impurities.

Recreation Planning

Four passenger pedaled boats used to reduce impact of oil spills and as a recreation activity. The travel between the islands can be through these boats.

Figure 108 Pedaled Boats, Floating restaurants
Source: Retrieved from https://kaiptrade.en.made-in-china.com/, https://www.marineinsight.com/recreation/10-amazing-floating-restaurants

Floating boats which provide freshly served food is in rising prevalence. The security of food should be taken into consideration and covered row boats should be provided.
The introduction of floating food courts and food kiosk can also be used under governments strict regulation.

Waterfront night markets near the Harbor and Bay area to be provided. Markets are proposed in Thekkkumbgom, Neendakara and the Islands in conjunction with the eco trails.

Sediment and Water Quality

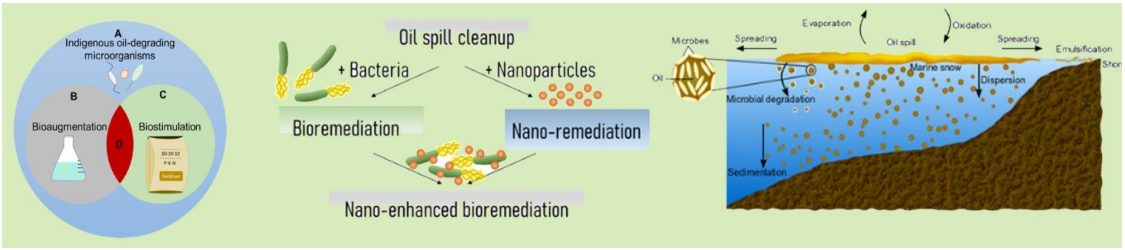


Figure 109 Types of Oilspill remediation
Source: Retrieved from https://pubs.acs.org/doi/10.1021/acsestengg.0c00217

Control of Oil spills- IT integrated response for oil spills by sensors placed at strategic positions which are coinciding places of oil spill pollution, and which does not hinder the passage of boats through water way are selected.

Emergency response transmitters are used to release the biomaterials to breakdown the oil particles and maintain the ph. of the environment.

a) Bioremediation uses microorganisms consume or break down various components of oil spilled in marine environments. (Pete, 2021)

b) Bioaugmentation uses cultured oil-degrading microbes. (Pete, 2021)

c)Bio stimulation use of growth limiting nutrients, nitrogen, and phosphorus, usually in the form of fertilizer. (Pete, 2021)

d) Overlap, the combination of both bioaugmentation and bio stimulation to enhance bioremediation of oil spills. (Pete, 2021)

Debris Removal- Use of plastic interceptors to collect waste especially plastic to transform it for reuse. The interceptor is placed against the flow of the waterbody.

The plastic interceptors collect the floating debris brought down by the flow of the lake using the flagella like interceptors and convey the same to the conveyor belt where it is crushed and send for reprocessing.

Figure 110 A Plastic Interceptor
Source: Retrieved from
http://www.oceansplasticleanup.com/Cleaning_Up_Operations/The_Ocean_Cleanup/2019

CHAPTER 7 **CONCLUSION**

The presence of Estuaries and one like Ashtamudi is a blessing to the economy and with concern to the ecosystem services it provides for the environment. With deteriorating biodiversity, Global warming, and unbalanced salinity levels the ecosystem is at huge risk leading to disruption in the natural balance of the waterbodies and riparian environment. Moreover, a vast number of populations is dependent on Ashtamudi estuary for their livelihood. The disruption of estuary health impact several varied factors.

The deteriorating health of the estuarine environment of the Lake is attributed mainly to the floating debris, change in shoreline and increasing encroachments due to rise in anthropogenic activities like building of resorts by reclaiming mangroves, dredging for the national water way 3, the ripple wave which effects the wave nature and significant increase in island reclamation and destruction of mangrove habitats.

The solution of land use control and development regulations discussed in the proposals allow the preservation of estuarine formations like mangroves, marshes and mudflats which enable the migratory birds and other benthic species to thrive and reestablish the ecosystem which is deteriorating with each year.

The integrated plan allows the various local level methods which can be adopted for bank stabilization and to prevent the leachates from reaching the waters and hence maintaining the water salinity and pH. The positive aspect and nature of rising prevalence of tourism activities and public involvement and accessibility to water edges are also integrated to develop and implement under the Ashtamudi Lake Management Plan to find solutions at a local level.

The estuarine health is sure effected by the upland activities but the local problems which need local solutions need to be integrated to decentralize the planning process. Successful local body level strategies unique to the context is to be developed owing to the peculiar nature of the estuary. Thus, it becomes imperative to propose and adopt Estuary management techniques catering to the unique characteristics of the Estuary and its riparian areas alone.

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