International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1419-1428 www.ijaem.net ISSN: 2395-5252

Recommendations for Management of Estuary Mouth – a case of Ashtamudi Lake Kollam

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Submitted: 10-08-2022 Revised: 22-08-2022 Accepted: 24-08-2022

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.

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 urbanisation, 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.

KEYWORDS: Estuary, Estuary Mouth Management, Pollution

I. INTRODUCTION

Figure 1 Origin of Ashtamudi Lake

[1]. Ashtamudi Lake has been designated as Ramsar Site in November 2002. It supports many endangered species according to the Red Data Book of Indian Plants, such as Syzygiumtravencoricum. It supports around 43 marshy and mangrove species, 57 species of birds, 97 species of fishes and many unique copepod species.It is the deepest among all the estuaries of Kerala with a maximum depth of 6.4 m at confluence zone.

These peculiar characteristic and threat faced by the estuary makes it a biodiversity hotspot and a centre where many activities confluence. The increasing influence of anthropogenic activities had led to the deterioration of lake and estuary health. Though Ashtamudi Lake Management Plan is being prepared to address pollution, mangrove conservation, prevent estuary reclamation, fishing, control of motorboat effluents etc.The imminent need for estuary health restoration at the local level is not addressed. Hence the estuarine portion of the backwater extend which covers 6km upstream from the bar mouth and its riparian influence is considered.

Figure 2 Estuary Mouth at Neeendakara

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[2].Astamudi lake is also one of the most contaminated lakes with water quality declining with each passing year and the biodiversity of aquatic flora and fauna is also beingthreatened which calls for immediate lake management Plans.

A local level intervention would bring in a more practical perspective to the conservation and restoration of lake habitats. The integration of locally adopted management practices into the local areaplans would involve communities and stakeholders to be actively involved in the practices.

II. NEED FOR STUDY

[3].Ashtamudi estuary is the second largest estuarine system in Kerala covering an area of 61 Sq.km. The Ashtamudi estuary is the deepest estuary with a depth of 6.4 m at the confluence zone. Neendakara Harbour situated at the estuary mouth is one of the largest in the state. Thousands of fishermen depend directly on the estuary for their livelihood.

Astamudi Lake Management Plan is being prepared to address pollution, mangrove conservation, prevent estuary reclamation, fishing, control of motorboat effluents etc.[3]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.Ashtamudi is also included in the RAMSAR sites and is included in the ALMP zones and includes bioreserve zone, mangrove conservation and rehabilitation zone.

[3].Ashtamudi Lake in Kerala contributes approximately 80% of the overall clam export trade in India, providing livelihood for at least 3,000 local people.

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. There seems to be several planning endeavours to be undertaken by urban and local bodies for the economic upliftment of estuary dependent communities which calls for estuarine protection to maintain and restore the riparian health, estuarine heath and thus by indirectly impactingthe communitiesand ecosystem services.

AIM

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

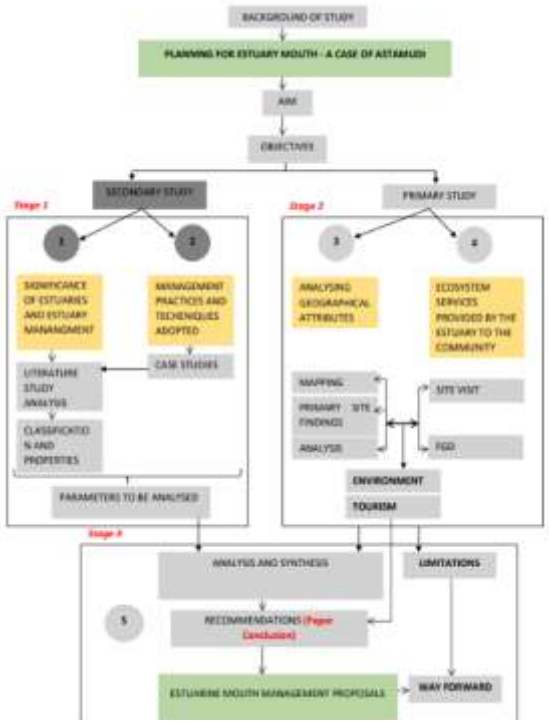
OBJECTIVES

- To understand the significance of Estuaries in an ecosystem.
- To analyse Geographical attributes by mapping city level information.
- To understand 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 suggestfeasible recommendations to integrate into anestuary mouth management plan for study area.

LIMITATION

Study limited to the Coastal and Riprarian wards Islands and communities in the Neendakara Grama Panchayath,Shakthikulangara, Thekkumbhagom Islands, Thrikadavoor and Thrikkaruva.

III. METHODOLOGY



A framework is followed for the research which enables background study focus group discussions understanding the contextual relevance and issues through case studies etc. The study proceeds in three stages which initially involves background study and secondary study to understand the significance of estuary management. The primary study involves focus

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group discussions and citizen involvement surveys to understand the context of study.

IV. LITERATURE

[4] "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." (National Estuary Programme, EPA, US)

"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. It is thus strongly affected by tidal action and within its sea water is mixed or diluted with freshwater from land drainage"(Pritchard, 1967).

[5] Estuaries provide us with several resources, benefits, and services. Estuaries provide places for recreational activities, scientific study, and aesthetic enjoyment.(Y. Buitenhuis and C. Dieperink, 2019)and provide ecological, economic, and cultural values to the location.

- Estuaries are unique environments to which plants and animals have specially adapted.
- Transition from land to sea and fresh water to salt water
- Estuaries are protected from ocean forces by reefs, barrier islands, headlands, and deltas.
- Estuaries transport and trap nutrients and sediment through the combined action of freshwater flow, wind, waves, and tidal action

Estuaries are classified into different types based on various criterions (Pritchard 1967)Geomorphology-Five types,Water circulation and stratification: Four types, Systems energetic/ ecosystem energetic: Five types, Freshwater discharge: Three types.Ashtamudi Estuary comes under the geomorphological type and is a bar-built estuary categorised as negative estuary as it is a back water.

Figure 3 Typical Estuarine Character

[6] 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 (M. P. Weinstein, 2007)

[6] Techniques for estuary protection are programs to Reduce Stormwater run-off directly into estuaries

- Deep-well injection
- Evaporation ponds
- Dischargeinto surface water/municipal sewer
- Estuary Zonation Maps
- Inventory of Zones

Accidental or long-term contaminant spills

- Contingency Plans
- Oil spill drills
- Primary Response Contractors (PRCs)
- Geographic Response Plans (GRPs)
- Incident Command System (ICS)
- Trajectory Analysis Planner (TAP)

Protection Recovery

- Marine and estuarine shorelines and intertidal protection
- Estuarine reserves
- Regulations for protecting biological integrity
- Programs for shoreline adoption, clean up, habitat enhancement and monitoring by citizen groups.
- Marine Spatial Planning

Estuary Management practices adopted are protection of biodiversity and sense of place, co-operative and effective governance, restoration of estuary health, research, and monitoring, increasing public awareness, promoting eco-tourism, enhancing local livelihood. (M. P Weinstein,2007)

V. STUDY AREA

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 was 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

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estuarine area which comes in waterfront are specifically taken up to understand the issues.

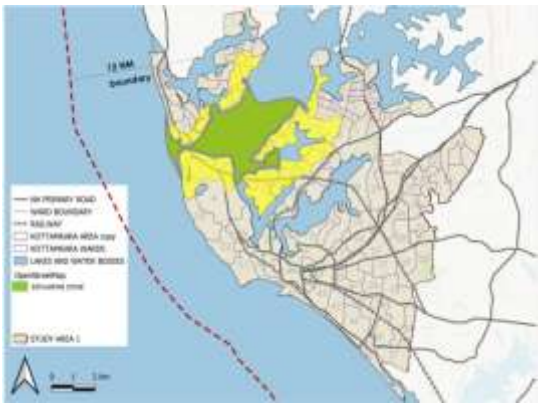

Figure 4 Estuarine extend of Ashtamudi Lake 6Km upstream from the upstream

The estuarine extend of Ashtamudi lake is 6 Km upstream from the estuary mouth. The riparian wards which line the estuarine extend is considered as the study area (R. Sathyadhas,2010).

Table 1 Details of the study extend

Local Body Name	Wards	Area	Population	Male	Female	Sex Ratio	Literacy	Physically Disabled
Neendakara GP	15	10.19	15424	7727	7697	1033	93.12	1514
Thrikadavoor GP	22	14.85	35859	17992	18167	991	91.69	2413
Thekkumbhagom GP	13	20.26	15815	7789	8024	1030	91.91	781
Thrikaruva GP	16	18.39	23122	11358	11764	996	89.95	1257

The population of Kollam City is 361,440 and is likely to grow to up to 400,000 by 2031. (Census,2011) The rapid growth of Kollam City due to establishment of new Government offices and Industrial projects (Neendakara Port and Titanium Complex projects) have increased the pollution load on the Ashtamudi Lake. The Lake plays a vital role in the socio-economic and cultural history of the district.

It can be inferred from the map that Kollam Corporation has the most population Concentration with Thrikadavoor coming next. Neendakaragrapanachayath 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.

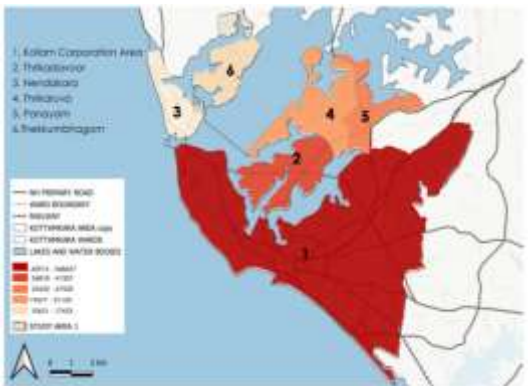

Figure 5 Population Concentration

The waterfront wards which form the riparian areas as the buffer zone, and the eighteen wards are given below from ShakthikulangaraNorth (including the islands), NeendakaraGramapanchayath, ThekkumbhagomGramapanchayath, ThrikkaruvaGramapanchayath, ThrikadavoorGramapanchayath.

Figure 6 Delineated Study Area

CRZ Extend on the seaside is 300 m from the HTL and 120-200 m on the lakefront, half the width of the creek-on-creek areas and 50m from hight tide line for the islands.

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Figure 7 CRZ mudflats and most encroachments

The most vulnerable areas are the San- Thome Islands and Thrikkaruva islands and some parts of the Thrikadavoor and Maruthadi areas which are more prone to floods and with 33% CRZ violations.

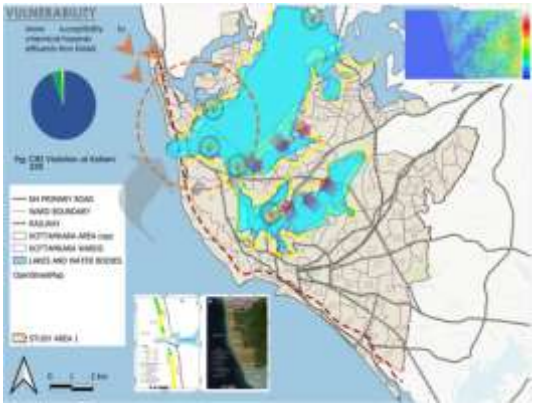

Figure 8 Ecological Vulnerabilities

Figure 9 Presence of Mangroves, Boat Maintenance in study area

Transportation

Nearest Airport - Thiruvananthapuram International Airport (65Kms). Nearest Railway station- Kollam Junction railway station. The map shows locations of boat jetty's, parking availability and availability of pedestrian areas the national waterway and the harbour in the mouth area along with increasing tourism spots and economic activities the requirement for parking and pedestrian paths are increasing.

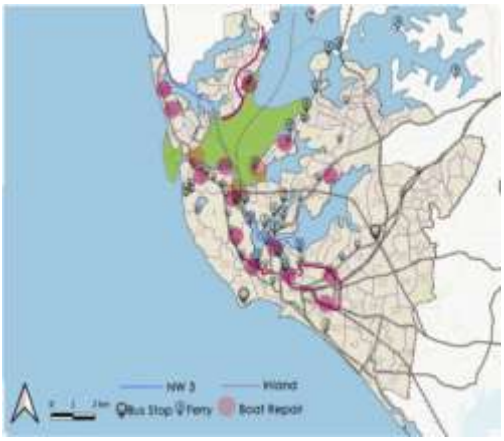

Figure 10 Transportation, Pedestrian, and parking

Tourism

Kollam district acts as a transit zone for tourists on their journey from Thiruvananthapuram to Kochi.Major circuits include Alappuzha - Kayamkulam -Kollam, Thiruvananthapuram-Kulanjathupuzha - Thenmala
Thiruvananthapuram - Kottarakkara - Thenmala - Kottayam -Kottarakkara - Paalaruvi–Thenmala.
[7] Increase in Domestic tourist - 4.14 %, increase in international tourist - 1.1 % (though there is increase in domestic tourist foreign tourist arrival shows negative trend) (Kerala Tourism Statistics,2021)
Though there is considerable presence of infrastructure in the backwater tourism segment Kollam is still developing and is far away from establishing an upper hand in tourism Industry especially in case of coastal tourism and heritage tourism.
The various sites of tourism potential are still under exploration and there's is need in infrastructure support in many areas.

Figure 11 Tourism Map

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The Ashtamudi creeks are left unexplored and not utilized. There seems to be need for more resorts and infrastructure for lodging.But the tourism industry always has a negative impact on estuarine environments which so eco-friendly practices need to be sought on to reduce tourist impact and plastic accumulation.
Connectivity to the inner creeks should be improved and made accessible by adding them to the existing regional circuits. Due importance to be provided for protection of Islands and controlled regulations to promote tourism and development and preservation of ecosystems.

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.

VI. DRIVERS FOR ANALYSIS

Figure 12 Drivers for analysis derived from Case Studies and literature

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.

VII. ANALYSIS

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 13 Oil spill and debris accumulation impacting water quality

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.

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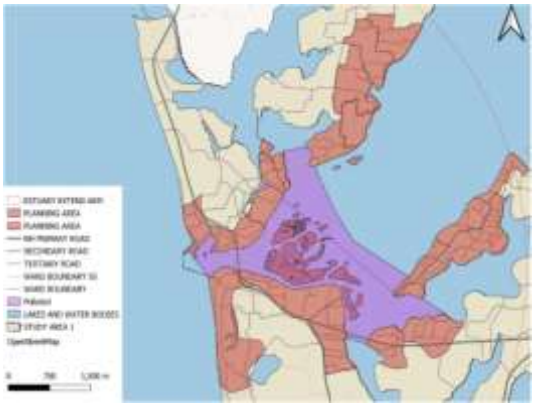

Figure 14 Water Quality Affected area

Figure 15 Shoreline Nature

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.

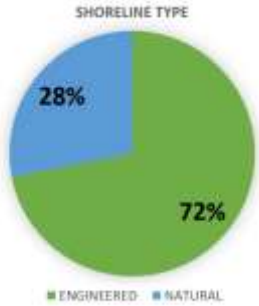

Figure 16 Riparian Area integrity

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

Figure 17[8] a. AponogetonAppendiculatus b. Flagellaria indica c. BruguieraGymnorhiza d. Villorita e. CalophyllumInophyllum 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. EtroplusSuratensis n. Crane Bird

The above given species are the predominantly available species of flora and fauna which is vulnerable. Bruguieragymnorhiza is a mangrove type in the Ashtamudi Ramsar site that is critically endangered. Excoecriaagallicha 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.

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Figure 18 Accessibility

Most of the waterfront are semi-public or Private owned, Public open spaces are not ample and those which are not used to the full potential.

A fair share of population does depend on the inland and coastal fishing livelihoods.Shakthikulangara area shoes a prominence in Ice plants and export factories while Neendakara has a population depending on hatcheries 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.

Figure 19 Fisheries Resource distribution and Fish pedalling units

Figure 20 Chinese Nets for fishing in islands

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 21 Vulnerable Areas

FINDINGS

Water Quality

- The presence of mudflats and its organisms which helps restore the water health. Clam Shells Naturally filter water, improves water quality.
- Presence of Harbour.NW3 passing through Inland Navigation.
- Natural flow when uninterrupted cleans the debris.
- Coastal erosion, erosion of riparian boundaries

Riparian Health

- Presence of natural shoreline, mangroves, and mudflats.
- Increasing encroachments, erosion of the shore.
- Diverse habitat, scenic beauty, Improved Water Health.
- Invasive species, industrial Leeching.

Accessibility

- Many unexplored places of scenic beauty. Scope for tourism.
- Connectivity from the city. Not Marketed to the potential.
- Public Spaces Clubbed with marketplaces could be brought along.
- Prevalence of Antisocial activities. Floods

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Citizen Involvement

- Presence of Lake dependent communities.Traditional Knowledge.
- Lack of empowerment.Lack of awareness.
- Could be involved in tourism activities.Volunteering for lake front development.
- Conflict among local groups. Political power plays

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

- Remove debris in environmentally sensitive areas if environmentally valuable and feasible.
-Adopt best management practices for handling, storage efficient use of water
-Review environmental protection measures on upland commercial and industrial units and manage to prevent impacts.
-Work with the responsible agencies to investigate and mitigate the impacts of leachates from the landfill on fish and plants.

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

- Halt the reduction of riparian habitat and restore if possible. Explore Development Permit as a tool
-Develop infrastructure maintenance practices with ecological benefits
-Ensure the reeds around the lagoons are not disturbed during bird breeding season
-Restore vegetation on degraded mudflat areas in phases
-Work with agencies to protect the riparian vegetation.

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

- Designate environmentally sensitive areas where public recreation is not encouraged
- Develop an interpretive and education plan for the estuary
-Develop a public recreational system with support facilities and amenities.
- Increase the accessibility to the waterfront by roads and pedestrian paths
- Increase Surveillance

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

- Develop public education information regarding the sensitivity of the resources in these areas and the importance of staying on 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 involvemente.g., Clean Ashtamudi initiative

VIII. PROPOSALS

Figure 22 Proposed land use Plan

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 restorationof the habitat.

Figure 23 Proposed Integrated Methods

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.

IX. 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, Globalwarming, and unbalanced salinity levels the ecosystem is at huge risk leading to disruption in the natural balance of the waterbodies and riparianenvironment.Moreover, a huge number of populations is dependent on Ashtamudi estuary for their livelihood. The disruption of estuary health impact several varied factors.

Thus, it becomes imperative to propose and adopt Estuary managementtechniquescateringto the unique characteristics of the Estuary and its riparian areas alone.

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