Ashtamudi Estuary

An Integrated Management Plan

Wetlands INTERNATIONAL

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Wetlands International South Asia is the South Asia Programme of Wetlands International, a global organization dedicated to conservation and wise use of wetlands. The organization's mission is to sustain and restore wetlands, their resources and biodiversity. Wetlands International South Asia provides scientific and technical support to national governments, wetland authorities, non government organizations, and the private sector for wetland management planning and implementation in South Asia region. It is registered as a non government organization under the Societies Registration Act and steered by eminent conservation planners and wetland experts.

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Wetlands International South Asia ♦ Centre for Water Resources Development and Management

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Back Cover: A Houseboat inside Estuary;
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Abbreviations

ADAK	Agency for Development of Aquaculture, Kerala
AKSZ	Achen-Kovil Shear Zone
amsl	Above Mean Sea Level
APHA	American Public Health Association
AWA	Ashtamudi Wetland Authority
AWC	Asian Waterbird Census
BMC	Biodiversity Management Committee
BOD	Biochemical Oxygen Demand
CBD	Convention on Biological Diversity
CDA	Chilika Development Authority
CGWB	Central Ground Water Board
CMFRI	Central Marine Fisheries Research Institute
COD	Chemical Oxygen Demand
CRZ	Coastal Regulation Zone
CWRDM	Centre for Water Resources Development and Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
DO	Dissolved Oxygen
DoT	Department of Tourism
DTPC	District Tourism Promotion Council
FIRMA	State Fisheries Resource Management Society
GIS	Geographic Information System
HH	Household
HTL	High Tide Line
ILEC	International Lake Environment Committee Foundation
IMD	India Meteorological Department
IUCN	International Union for Conservation of Nature
KFWFB	Kerala Fishermen's Welfare Fund Board
KIHMS	Kerala Institute of Hospital Management Studies
KILA	Kerala Institute of Local Administration
KITTS	Kerala Institute of Travel and Tourism Studies
KREWS	Kerala Rural Employment and Welfare Society
KSBB	Kerala State Biodiversity Board
KSPCB	Kerala State Pollution Control Board
KSSP	Kerala Sastra Sahitya Parishad
KTDC	Kerala Tourism Development Corporation
LANDSAT	Land Satellite
LDA	Loktak Development Authority
LOICZ	Land–Ocean Interactions in the Coastal Zone
LSGs	Local Self Governments
LTL	Low Tide Line
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment, Forest and Climate Change

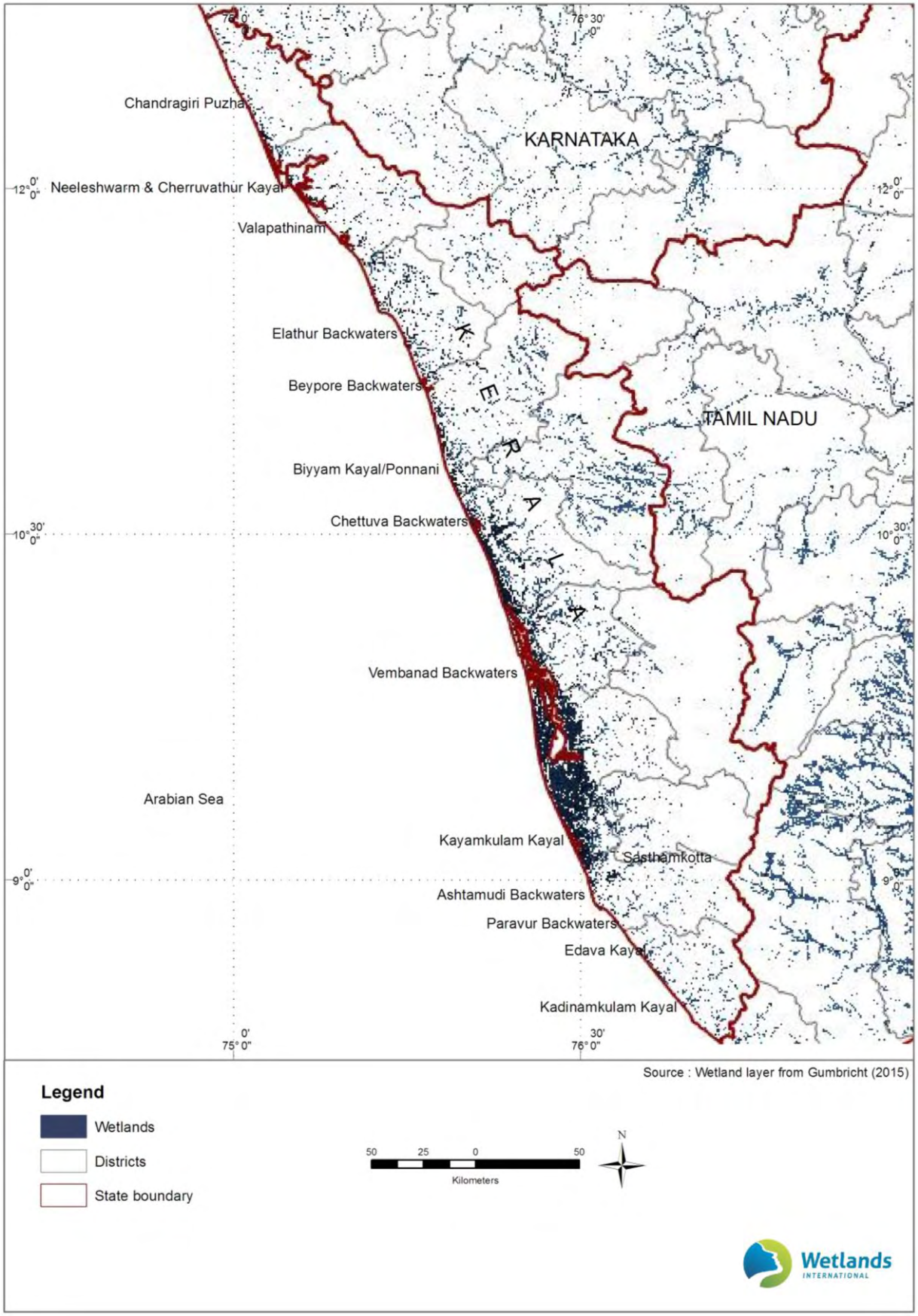
MPN	Most Probable Number
MSC	Marine Stewardship Council
MT	Metric Ton
MW	Megawatt
NCESS	National Centre for Earth Science Studies
NGOs	Non-Governmental Organizations
NDZ	No Development Zone
NPCA	National Plan for Conservation of Aquatic Ecosystems
PFCS	Primary Fisher Cooperative Society
OLI	Operational Land Imager
RCSE-SU	Research Center for Sustainability and Environment, Shiga University
SWAK	State Wetland Authority Kerala
WIAMS	Wetland Inventory, Assessment and Monitoring System
WISA	Wetlands International South Asia
ZSI	Zoological Survey of India

1. Introduction

1.1 Background

Wetlands form a conspicuous element of Kerala landscape, particularly within the state's lowland and midland regions (Map 1.1). Located within the Kollam District and spanning an area of 5700 ha, Ashtamudi kayal is one of the large estuaries of the Kerala (Map 1.2). A diverse and dynamic assemblage of fish, invertebrate and crustacean species provide the basis of rich fish and clam yields, with an annual harvest of over 25,000 MT of biomass and supporting livelihoods of nearly 5,000 inland fishers. The clam fisheries of the estuary are famed to be the first Marine Stewardship Council certified fishery in the country. This picturesque estuary serves as the gateway of Cochin backwaters, and is one of the prominent touristic destinations of the state. Its palm shaped eight-coned shape is deeply linked with the local culture and belief systems, with many sites of historical and cultural significance, such as Quilon port located along its shorelines. Atleast 70 plant and 370 animal species have been recorded here, with several species being of high conservation significance locally, nationally and globally. Ashtamudi was designated by the Ministry of Environment, Forest and Climate Change (MoEFCC) as a Wetland of International Importance under the Ramsar Convention in 2002.

Ashtamudi Estuary shoreline



Map 1.1 | Wetlands of Kerala

Map 1.2 | Location of Ashtamudi Estuary

The wide-ranging ecosystem services and biodiversity values for Ashtamudi exist within a densely populated and highly developed landscape. This ecologically fragile ecosystem has thus been subject to a range of anthropogenic pressures such as reclamation, shoreline alteration, reduced freshwater inflow and pollution. Nearly one-fifth of the estuary area has been reclaimed for settlements, industries and tourism infrastructure. Ashtamudi is a cesspool of waste brought in from over 3,500 point and non-point sources. The estuary is gradually shifting to a marine dominated stage on account of over 40 per cent reduction of freshwater inflows from Kallada River, weakening monsoon and increasing sea level. Recognizing these adverse trends, which limit the possibility of insuring wise-use of Ashtamudi as per commitments under the Ramsar Convention, the Department of Environment and Climate Change, Government of Kerala, initiated the formulation of an integrated management plan for the wetland. Wetlands International South Asia (WISA) and Centre for Water Resources Development and Management (CWRDM) were entrusted with the task of management plan formulation based on existing international and national guidelines and best practices, and in consultation with stakeholders.

This management plan is a response to the assigned tasks, and represents the commitment of Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India; Department of Environment and Climate Change Government of Kerala; CWRDM and Wetlands International South Asia, towards wise use of Ashtamudi Estuary.

1.2 Management planning purpose and objective

The overall purpose of wetland management planning is to put in place effective management arrangements for maintaining its full range of ecosystem services and biological diversity, now and into the future. The management planning process, by addressing the following specific objectives, sets the pathway for integrated management:

- Development of a baseline inventory of wetland features and governing factors
- Participatory appraisal with communities to reflect their views, rights and capacities to support integrated management
- Evaluation of sectoral plans and management practices, and identification of interlinkages and coordination needs for integrated management

- Development of management planning framework for conservation and wise use ensuring linkages with existing sectoral plans being implemented by various state government agencies and private sector
- Estimation of financial resources required for integrated management
- Recommending an effective institutional mechanism for management plan implementation
- Designing an effective monitoring and evaluation framework

1.3 Approach and Method

Estuarine ecosystems are driven by links and feedbacks between physicochemical attributes, habitats and the community structural and functional attributes which operate in an environment which is under anthropogenic and natural modifications. An integrated understanding of hydrological and biological processes within the entire basin from the headwaters through the catchment and estuary and, down to the coastal zone is required for holistic management. Management also needs to build on the natural features of the estuary using a combination of physical and biological interventions to increase resilience and its ability to cope with human-induced adverse change (Wolanski et al., 2012). Ensuring appropriate balance between freshwater processes and marine sources is critical to ecological integrity of estuaries (Adams, 2012). Ecohydrology by providing a framework for assessing interactions between water, sediment and nutrient fluxes and their relationship with biota provide appropriate management design principles for estuaries (Wolanski et al., 2004).

Management planning for Ashtamudi is based on the 'wise use' approach of Ramsar Convention. This approach is globally recognized as the central tenet of wetland management, and recognizes that restricting wetland loss and degradation requires incorporation of linkages between people and wetlands (Finlayson et al., 2011). By emphasizing that human use of wetlands on sustainable basis is compatible with conservation, the wise use approach aligns well with the fact that a certain level of natural variation and disturbance is important to maintain resilience within wetland ecosystems.

Wise use is defined with the text of Ramsar Convention as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development".

Seen in totality, wise use is about maintaining wetland values and functions in order to ensure maintenance of flow of benefits from wetlands (their ecosystem services)

from inter-generational equity point of view. Ecosystems approach requires consideration of the complex relationship between various ecosystem elements and promotion of integrated management of land, water and living resources. Wise use, through emphasis on sustainable development, calls for resource use patterns which can ensure that human dependence on wetlands can be maintained not only in the present, but also in the future.

Conservation and management actions for Ashtamudi have largely been driven by touristic and fisheries values of the estuary. Yet, there are eminent developmental threats on account of rapid urbanization and touristic pressure within the shorelines. Located on the peri-urban interface, the wetland is highly exposed to pollution threats, as well as reclamation for alternate usages. Management of Ashtamudi therefore needs to be closely embedded in the developmental planning of the region, and led by the Village Panchayat as the primary stakeholder.

Such an approach forms the crux of the New Guidelines for Wetland Management Planning adopted at the Eight Conference of Contracting Parties of the Convention (Ramsar Convention Secretariat, 2010). The need to integrate site management plans into public developmental planning system at local, regional and national levels is emphasized in these guidelines. Further, in order to safeguard sites and their features, the guidelines recommend adoption of an adaptable management process which allows wetland managers to respond to the legitimate interest of others, adapt to an ever-changing political climate, accommodate uncertain and variable resources, and survive the vagaries of the natural resources.

Integrated management planning is aimed at providing a programmatic framework for achieving wise use of wetlands through restoration of ecological character in a 'healthy state' and embedded within the environmental and socio-economic sustainability objectives pursued through the on-going developmental programming in the State of Kerala. The importance of securing appropriate governance structures to underpin such management is apparent.

Governance improvement, particularly within the basin and coastal zone scale forms a critical part of development and implementation of management plans for wetlands. Such an approach underpins Integrated Lake Basin Management framework which calls for achieving 'sustainable management of lakes through gradual, continuous and holistic improvement of basin governance, including sustained efforts for integration of institutional responsibilities, policy directions, stakeholder participation, scientific and traditional knowledge, technological possibilities, and funding prospects and

constraints (RCSE and ILEC, 2014). Achieving close relationship between planning and governance is critical considering multiple stakeholder and sectoral interests which underlie and to a large extent structure wetland biodiversity and ecosystem service values, and the need to secure people's involvement and participation in basin scale management for considerably long periods of time.

Management planning for Ashtamudi also draws upon the six governance pillars for Integrated Lake Basin Management (RCSE and ILEC, 2014), namely:

- Institutions: development of effective organizations and governance frameworks
- Policies: setting broad directions and specific rules
- Participation: expanding circle of involvement
- Technology: possibilities and limitations
- Information: pursuing sources of knowledge and wisdom, and
- Finance: seeking for sustainable sources at appropriate level

The approach is also in line with the National Environment Policy (2006) of Government of India which recommends integration of conservation and wise use of wetlands into river basin management involving all relevant stakeholders, in particular local communities. The policy further recommends integration of wetland conservation into sectoral development plans for poverty alleviation and livelihood improvement, and link efforts for conservation and sustainable use of wetlands with all on-going rural infrastructure development and employment generation programmes. Guidelines of MoEFCC's (Ministry of Environment, Forests and Climate Change) flagship programme for wetlands, NPCA (National Programme for Conservation of Aquatic Ecosystems) also recommend integration of wetland conservation in developmental programming by emphasizing convergence opportunities, stakeholder engagement and diagnostic evaluation approaches. The National Water Policy (2012) also espouse river basin scale planning, and integrated approaches in water resources management.

Conservation and sustainable use of wetlands adopting a basin approach, while systematically addressing the drivers of degradation, namely pollution and unsustainable water harvest is listed as priority area within Kerala State Environment Policy 2009. The management planning approach is also well-aligned with the Kerala Water Policy (2007) which calls for multidisciplinary and holistic approach for management considering water as part of ecosystem for the benefit of all and not for the profit of few. Kerala is also a front runner in putting in place a regulatory

mechanism for wetlands in the form of Kerala Conservation of Paddy Land and Wetland Act (2008) which restrict conversion and reclamation of wetlands. The management plan also responds to the requirements of Wetlands (Conservation and Management) Rules, 2010, notified by the Ministry of Environment, Forest and Climate Change under the Environment (Protection) Act, 1986. These rules require specification of wetland boundary and a zone of influence and enforcing a range of prohibition and regulation of developmental activities. At the time of writing this report, a revision of these Rules was under consideration of the Ministry.

The management plan for Ashtamudi has been developed using a diagnostic approach (Fig 1.1). Status and trends in hydrological, ecological and socio-economic features have been assessed to determine key factors limiting integrated management. An evaluation of institutional arrangements (including sectoral programmes, policy and regulatory frameworks and stakeholder arrangements) has been carried out to identify coordination opportunities. A community led and hierarchical assessment, monitoring and evaluation system has been recommended to enable adaptive management. These analyses form the basis of an action plan, with well-defined objectives and outcomes, to achieve wise use.

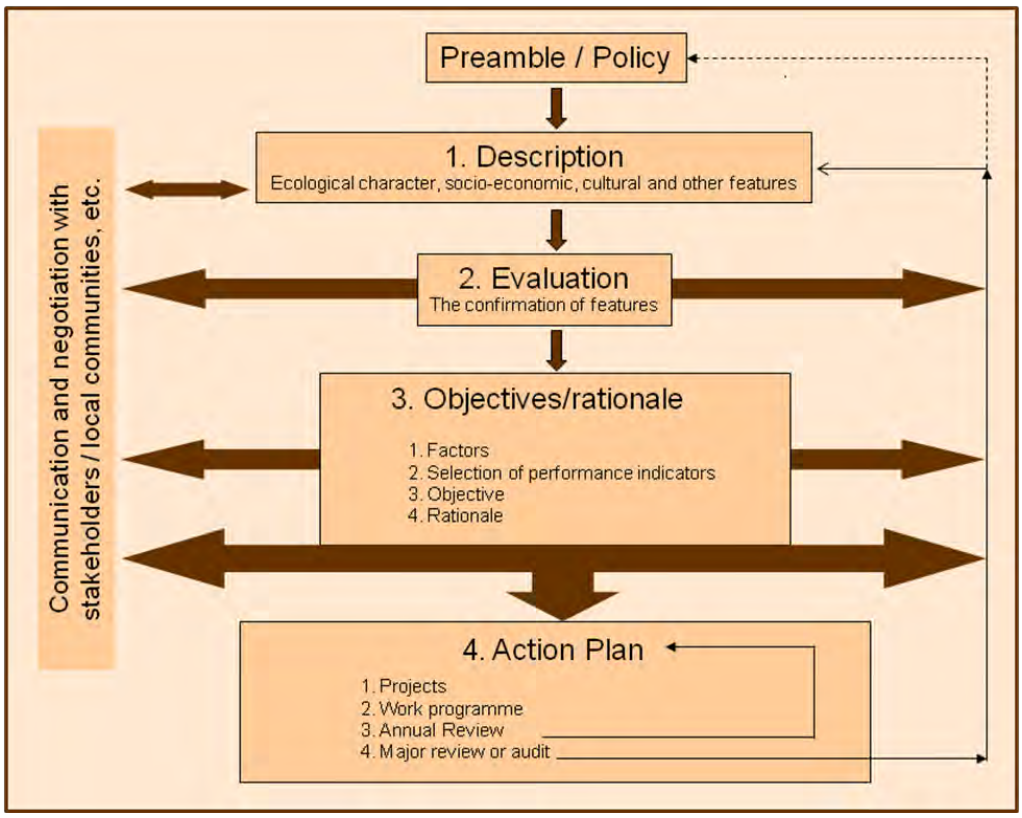


Fig. 1.1 | Management Planning Framework for Wetlands *(Source : Ramsar Convention Secretariat 2010)*

The management plan has been prepared by a team of experts of Wetlands International South Asia and Center for Water Resources Development and Management drawn from disciplines of hydrology, ecology, watershed management, sociology, and economics. Field surveys were conducted during 2015 and 2016 to assess various wetland features, and conduct stakeholder consultations. Data on hydrological and ecological aspects was collected from various state government departments, agencies and research institutes. Detailed socio-economic surveys and assessments were conducted in villages located around the lake and its command areas to determine wetland livelihood interlinkages. Secondary literature was also collated to establish status and trends in wetland features. To the extent possible, all available data has been presented in the form of thematic maps.

1.4 Report structure

The management plan is presented in six chapters. The first chapter sets out the background, approach and method used for management planning. An evaluation of the ecological, hydrological, socioeconomic and institutional features of the wetland are contained in Chapter 2. This information forms the basis for description of ecological character and assessment of risk of adverse change, which is discussed in Chapter 3. Institutional arrangements for wetland management are discussed in Chapter 4. A monitoring framework is outlined in Chapter 5. Chapter 6 contains a detailed action plan, budget and implementation arrangements for conservation and wise use of Ashtamudi.

2. Evaluation of wetland features

2.1 Wetland extent

Ashtamudi Estuary spans between $8^0 53'24'' - 9^0 01'12''$ N latitudes and $76^0 32' - 76^0 40'$ E longitudes. River Kallada debauches into the estuary at Koivilai, located to the west of Munroe Island. Moving from east, Thevally, Kureepuzha, Kandachira, Thekkumbhagam, Peruman, Kanjirottu, Kallada, and Kumbaluthu form the eight cones of the estuary, thus the name Ashtamudi. Munroturuttu, Thekkumbhagam, Trikkaruva and Trikakkadavur are four major islands within the estuary. Munroturuttu (also known as Munroe Island) is a complex of eight smaller islands formed by various distributaries of Kallada River as it merged into the Estuary. The mouth of Ashtamudi has been developed into a harbour, Neendakara, which is used by over 3000 marine fishing boats and trawlers. Breakwaters, 610 m seaward and 380 m leeward, provide a sheltered basin and navigable approach for these boats and trawlers.

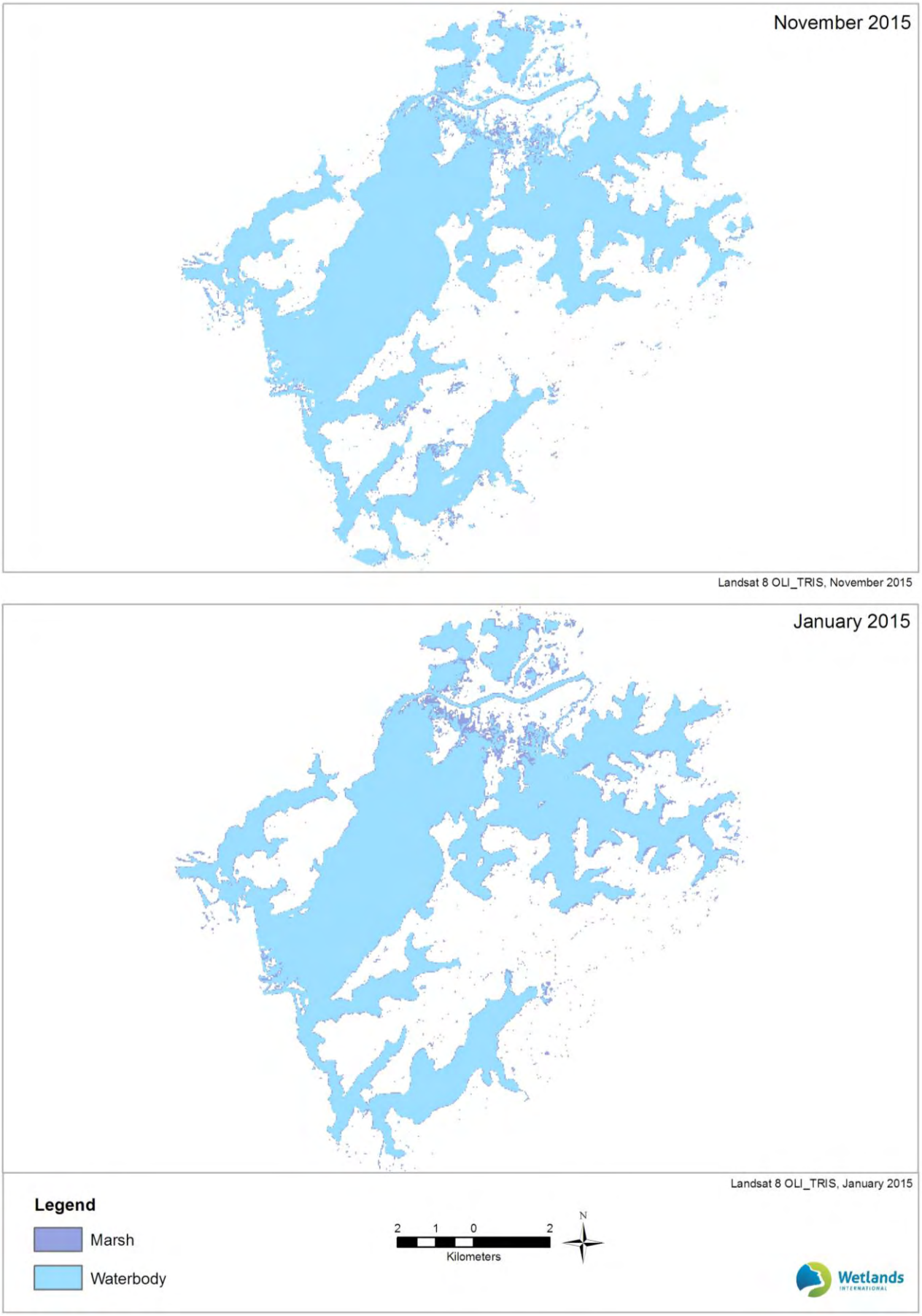
Estuaries are known to have a diffused boundary owing to the gradual transition between river, estuary, coastal embayment and open coast (Wolanski et al., 2012). There are several approaches to define an estuary using freshwater characteristics, salinity, presence of euryhaline biological species, connection with the sea and others (refer Wolanski and Elliot, 2016 for review of these approaches). We adopt a morphological approach in the case of Ashtamudi, marking the head as the coalesce of river channel into the waterbody. This approach also underpins delineation of wetland extent for designation as a Ramsar Site.

Neendakara fishing harbour

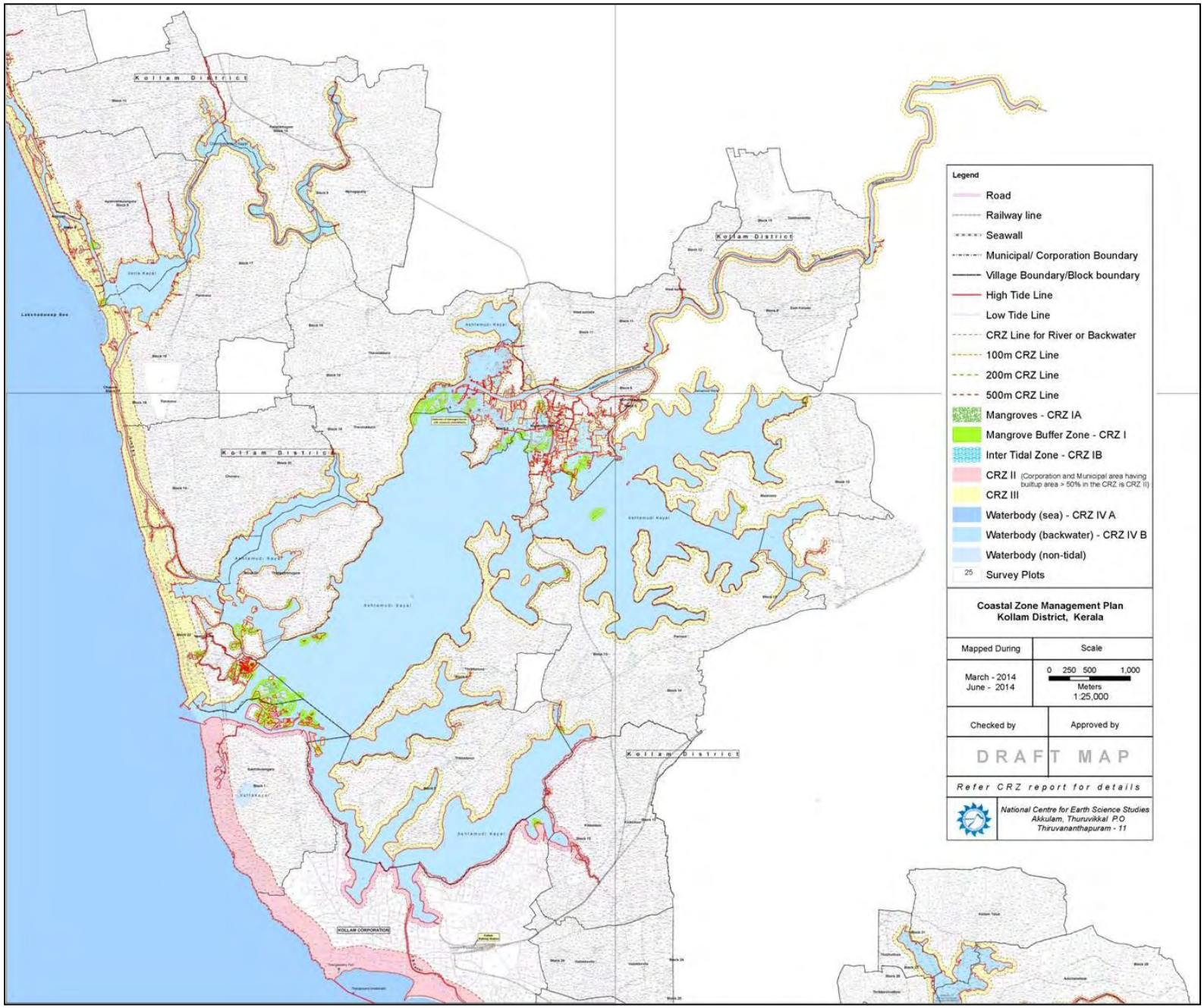
Ashtamudi Estuary is a maze of open waterbody encircled by marshes. During peak monsoon, the inundation reaches 5700 ha, with a maximum length of 10.6 km and width of 8 km. As interpreted from remote sensing images of January 2015 and November 2015, the open water area during the two periods increased from 5472 ha to 5695 ha. The area under marshes and mudflats consequently declined from 671 ha to 448 ha (Map 2.1). This seasonal transition marks an important aspect of ecological character of the wetland, particularly influencing its ecological productivity.

A delineation of coastal zone for Kollam District carried out for implementation of Coastal Regulation Zone (CRZ) Notification, includes demarcation of Ashtamudi Estuary boundary (NCESS, 2014). Within the estuary, a boundary has been defined using the high tide line, the line on the land upon which the highest waterline reached during the spring tide. Further, 100 m setback line is drawn landward of high tide line along the estuary for implementation of various regulatory provisions of CRZ Notification. On the upstream reaches, the extent of tidal influence which also defines the CRZ boundary, has been identified based on salinity concentration (5 ppt or more during the driest month). Map 2.2 indicates boundary of the Ashtamudi Estuary delineated for implementation of CRZ rules (NCESS, 2014). The area of estuary derived from the High Tide Line boundary (and excluding the river channel) come upto 5697 ha.

Being located in an immensely populated zone of Kerala, (with population density as high as 2,500 persons per square kilometre) with a range of developmental activities, the land use around Ashtamudi has a distinct anthropogenic imprint. The earliest inference on the extent of Ashtamudi Estuary can be drawn from Survey of India Toposheet of 1955, which is based on surveys done during 1920 - 1935. The map indicates an area of the estuary and adjoining marshes to be atleast 7534 ha (Map 2.3 and 2.4). Since then much of the shoreline has been reclaimed for settlements and industrial use, natural mouth converted into an engineered harbour and mangroves cut down to create Neendakara port and other infrastructure around the estuary.

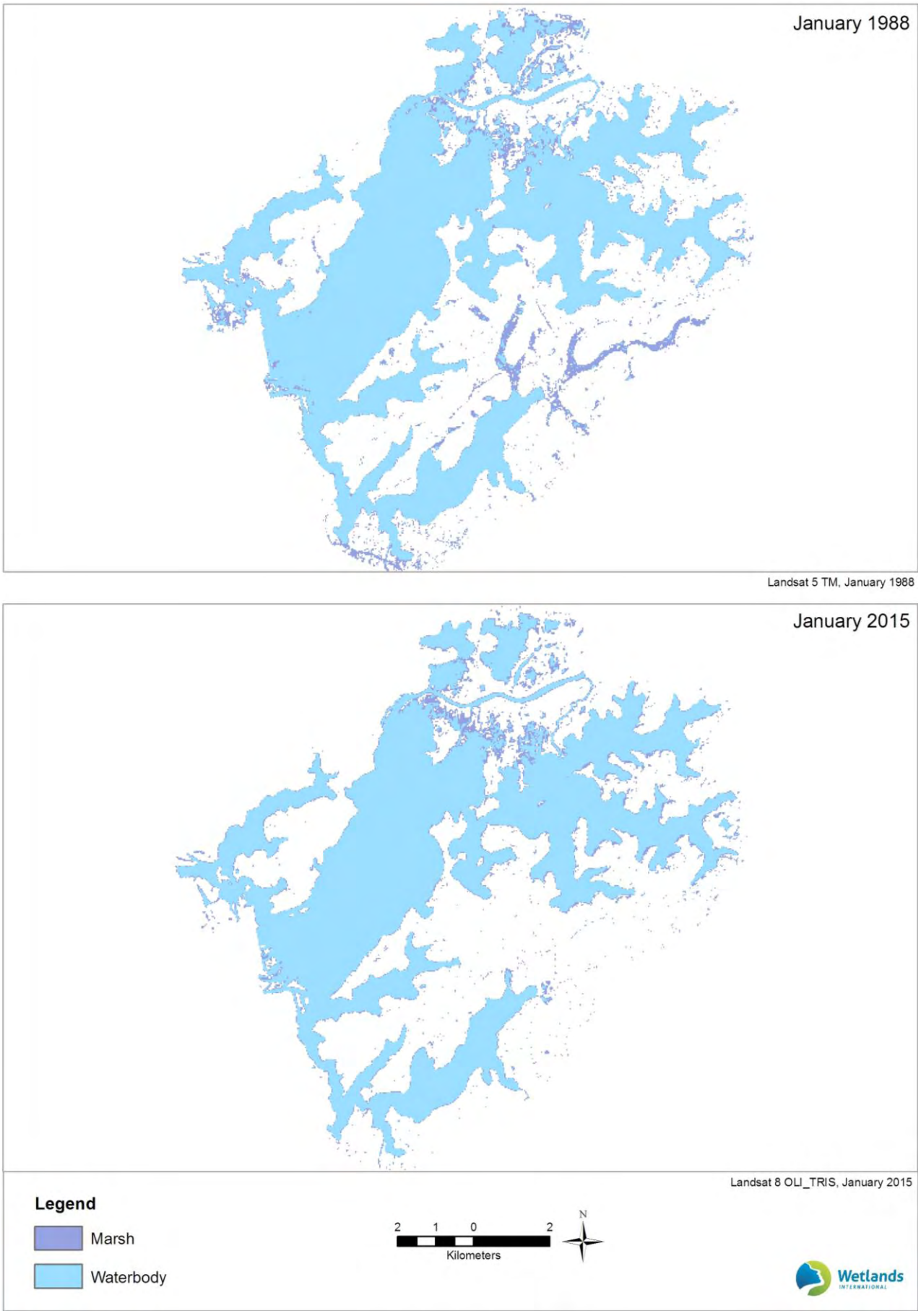


Map 2.1 | Seasonal transition in Ashtamudi inundation and adjoining marshes



Map 2.2 | The Coastal Regulation Zone around Ashtamudi Estuary

Map 2.3 | Ashtamudi Estuary (circa, 1940)



Map 2.4 | Transition in Ashtamudi inundation and adjoining marshes from 1988 - 2015

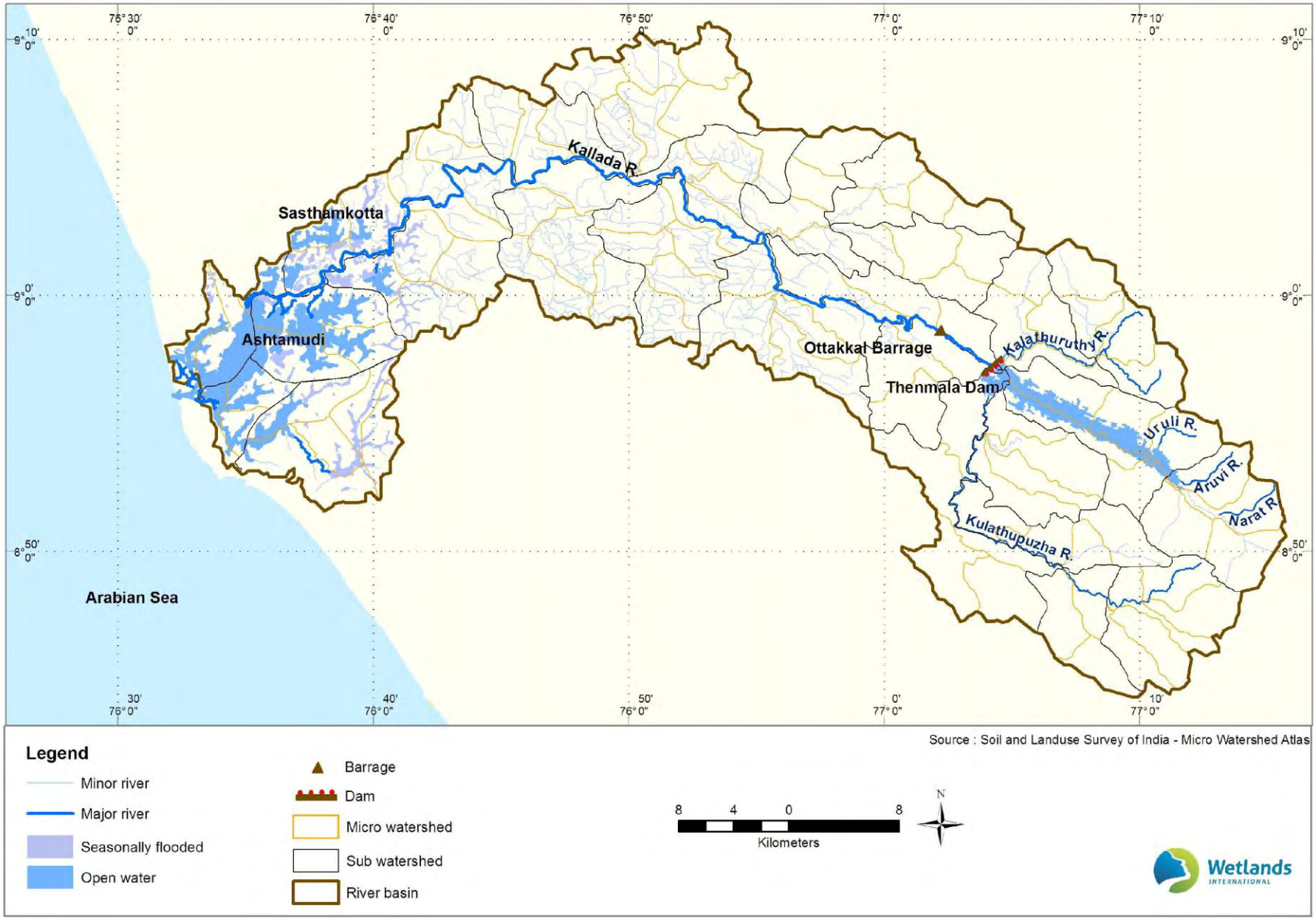
2.2 Catchment

Ashtamudi Estuary forms a part of extensive wetland regime formed on the alluvial deposits of River Kallada. Developmental planning, particularly land and water use changes within the basin of Kallada have a significant bearing on the status of estuary. This management plan section presents a description of the catchment area that drains freshwater into the estuary, and land use and land cover changes therein. The analysis is primarily based on remote sensing images supplemented with secondary information derived from published reports.

Kallada River Basin

Kallada, a perennial river arising from the Western Ghats is the primary source freshwater inflow into Ashtamudi Estuary. River Kallada originates as the Chendurni River in Papanasam range of the Western Ghats, at an altitude of 900 m amsl. Just after the source, Chendurni is joined on its right bank by three major seasonal streams, namely the Aruvi, Uruli and Narat. At Parappar, before which the river channel is joined by Kalathuruthy on right bank and Kulathupuzha on the left bank, a 335 m dam has been constructed (completed in 1986), leading to formation of reservoir with gross storage capacity of 504.92 Mm^3. Five kilometre further downstream of the dam, a pick-up weir has been constructed at Ottakkal with a capacity of 17 Mm^3, wherein the right and the left branch canals take off for irrigating a cultivable command area of 53,514 ha. Water from the reservoir is also used for generating 15 MW hydropower with the tailrace being reconnected to irrigation channels. The drainage pattern of River Kallada Basin is presented in Map 2.5.

View of Kallada River from National Highway 22 at Kadapuzha



Map 2.5 | Watersheds of Kallada River Basin

River Kallada exhibits a dendritic drainage over terrain with uniform rock structure. The river has an average gradient of 12.6 m/km, exhibiting high sinuosity, particularly in its middle and lower reaches, forming several incised meander loops flowing over tertiary and quaternary sediments (CGWB, 2013). The river is vertical eroding river and at places the channel bed lies as low as 8 m from the adjoining river banks, a characteristic observed in rivers in their upstream regions. For most part of its course the river bed is rocky with low sediment loads.

Before its confluence with the Ashtamudi Estuary at Koivila (located west of Munroe Island), the Kallada flows for a length of 121 km, drains 1,598 km^2 is joined by 47 tributaries. Majority of the basin area (84%) lies within Kollam District and the rest within Pathanamthitta and Trivandrum Districts. The basin has been delineated 26 sub-watersheds which have been further sub divided in to 107 micro-watersheds (SLUSI, 2017).

Climate

The basin is located within the warm humid tropical climatic zone, characterized by hot and wet summers and mild dry winters. Annual rainfall ranges between 2,225 mm and 4,038 mm, with peaks exceeding 3,000 mm especially at the head of the basin. Rainfall data from IMD station at Kollam indicate that during 1905- 2015, the estuary and its surrounding received an average annual rainfall of 2215.57 mm (maximum being 4160.2 mm in 1952 and minimum being 692.2 mm in 1969). Over half (53 %) of the rainfall is received during southwest monsoon period (June – September). Another 27 % rainfall occurs during the retreating northeast monsoon (October – December). The period between January-March remains more or less dry, however, summer rains are received during the months of April-May. The normal daily mean temperature varies between 26.1°C and 29.1°C. The wind speed ranges from 1.3 – 2.1 Km/hr with the maximum during the months of March to June and minimum during the months of September to December. The evaporation rate ranges from 2.87 – 6.67 mm/day. The rate is minimum during July and maximum in January to March. Sunshine ranges from 4.3 – 9.7 hours/day. Maximum sunshine is during the month of February. The months of June to August record minimum sunshine due to cloudy sky. The relative humidity is higher during the monsoon season as compared to the rest of the year.

Physiography

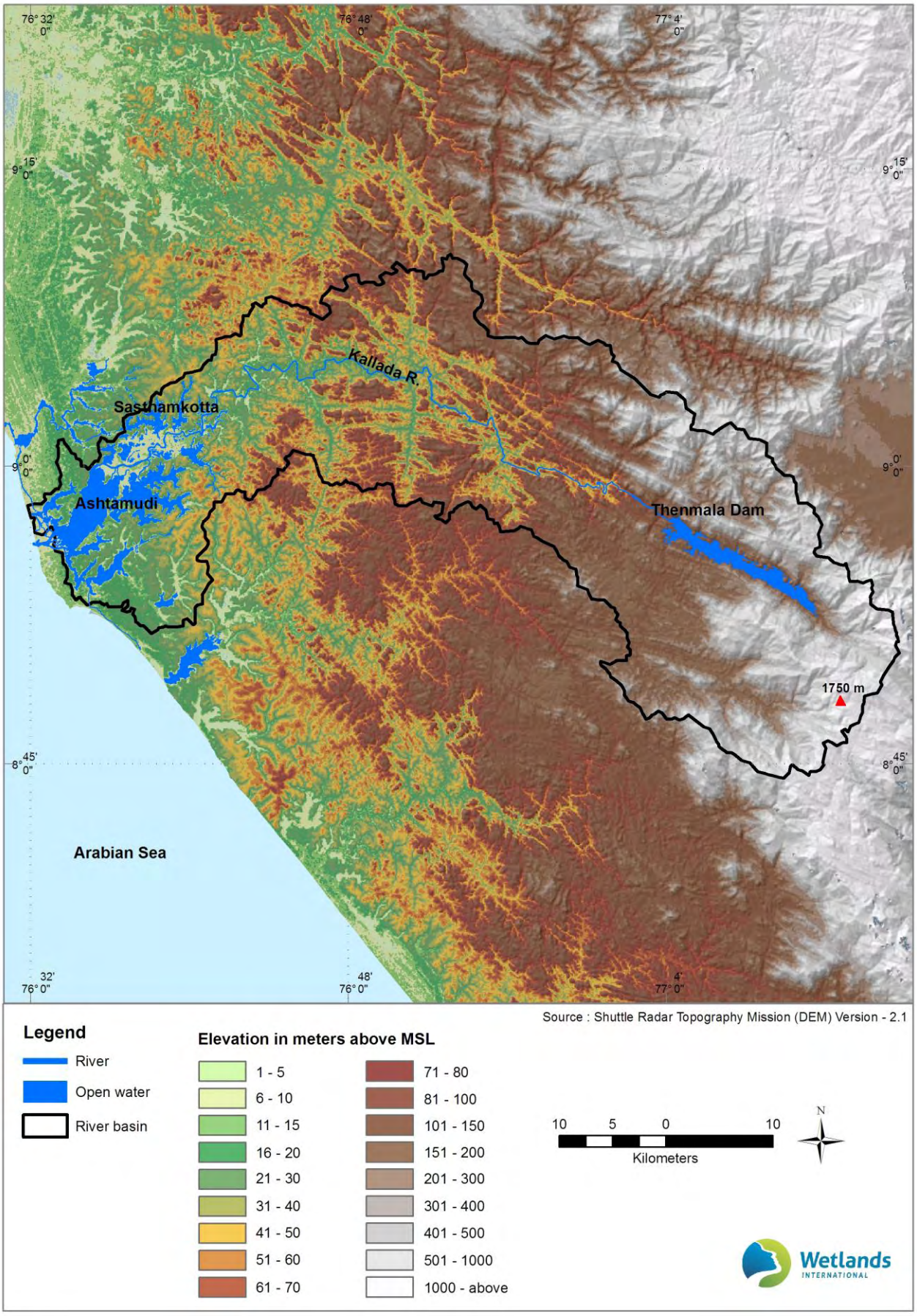
In a west to east progression, the basin of River Kallada can be divided into three distinct units viz. the coastal plains, the midlands and the highland regions. The coastal plains with an elevation ranging between 0-6 m amsl occur as narrow belt parallel to the coast. The midland region has altitudes ranging between 6-100 m amsl, and is mostly characterized by undulating topography formed by small laterite hills separated by valleys. The upper reaches of the Kallada Basin catchments lie in the Western Ghats, and have elevations between 100 – 1,763 m amsl, the highest point being Karimalaikodkal (Map 2.6). Large parts of the highlands form a part of the Papanasam Reserve Forests, the Courtallam slopes Reserve Forests and the Chendurni Wildlife sanctuary. Table 2.1 and Map 2.7 includes details of slope categories for the Kallada Basin.

Geology and Geomorphology

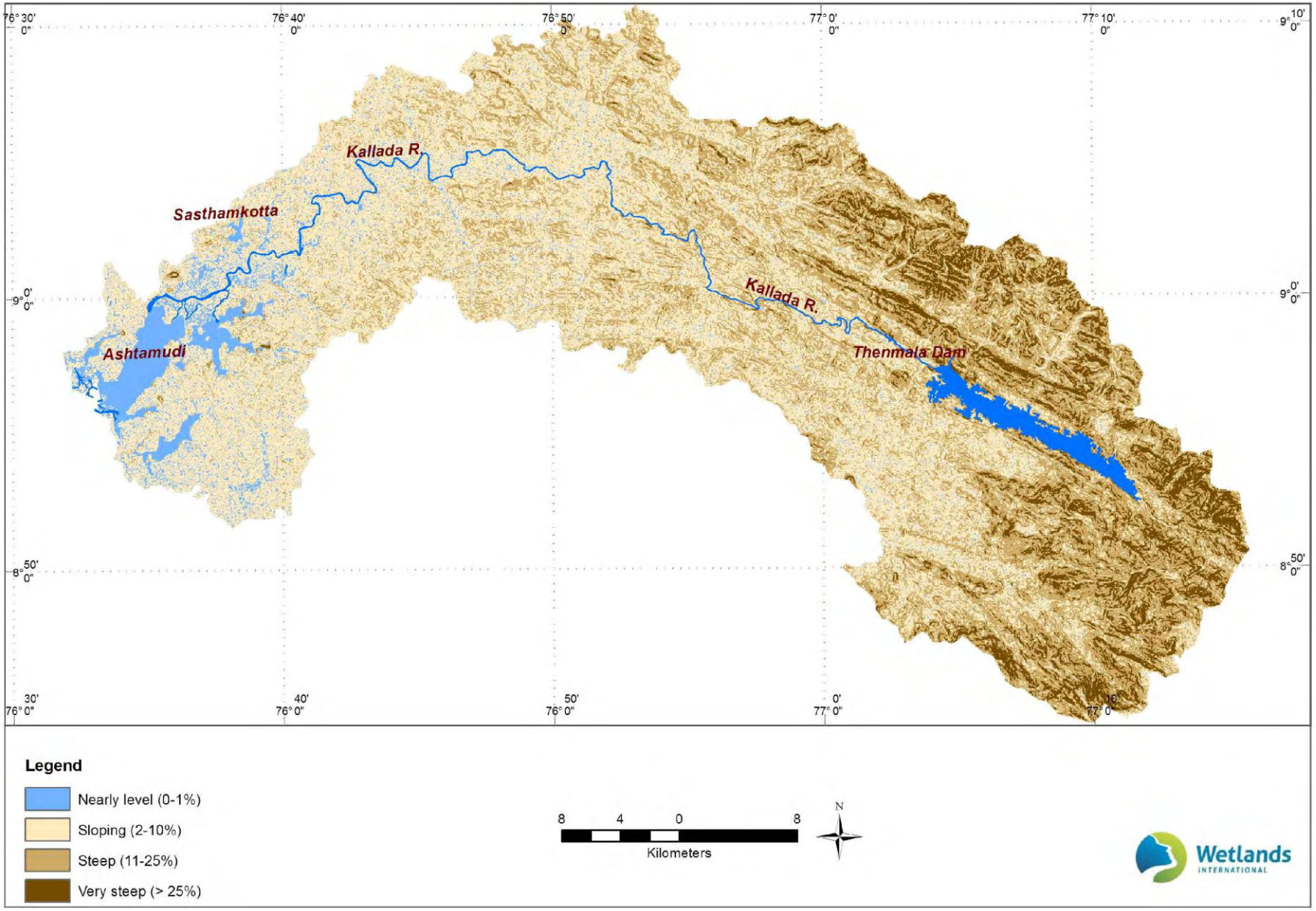
The Kallada Basin is made up of the Archaean crystalline basement, with overlying tertiary and quaternary sedimentary sequences. The rocks of Archaean age are exposed in the Western Ghats. The crystalline formations that occur here are khondalites, charnockites, granite gneisses and intrusives. For a good part of its initial course, Kallada River flows aligned to the Achen-Kovil Shear Zone (AKSZ), a major ductile shear zone separating two contrasting geological domains that separate the Southern Kerala Khondalite Block from the Northern Madurai Granulite Block. The AKSZ trends NW–SE with a width of ~ 15 km and extends for more than 120 km strike length (Rajesh and Chetty, 2006).

Table 2.1 | Slope characteristics of Kallada Basin

Slope categories	Area (km^2)	% of total
Nearly level (0-1%)	121	8
Gently sloping (2-10%)	797	50
Steep (11-25%)	539	34
Very steep (> 25%)	141	9
Total Basin Area	1598	100



Map 2.6 | Elevation profile of Kallada River Basin



Map 2.7 | Slopes in Kallada River Basin

The Southern Kerala Sedimentary Basin was formed by crustal thinning (Qureshy, 1982), during Late Oligocene or Early Miocene. The basin has a sediment fill of approximately 700 m thickness with 600m of the sediments of early to middle Miocene and the remaining 100 m of quaternary age (Nair et al., 2010). The Cenozoic sedimentary succession in the onshore part of the Kallada Basin is dominated by siliciclastic sediments with interbedded lignite seams (Reuter et al., 2010). The sources for siliciclastics are the Western Ghats sediments deposited by the rivers in marginal lagoons.

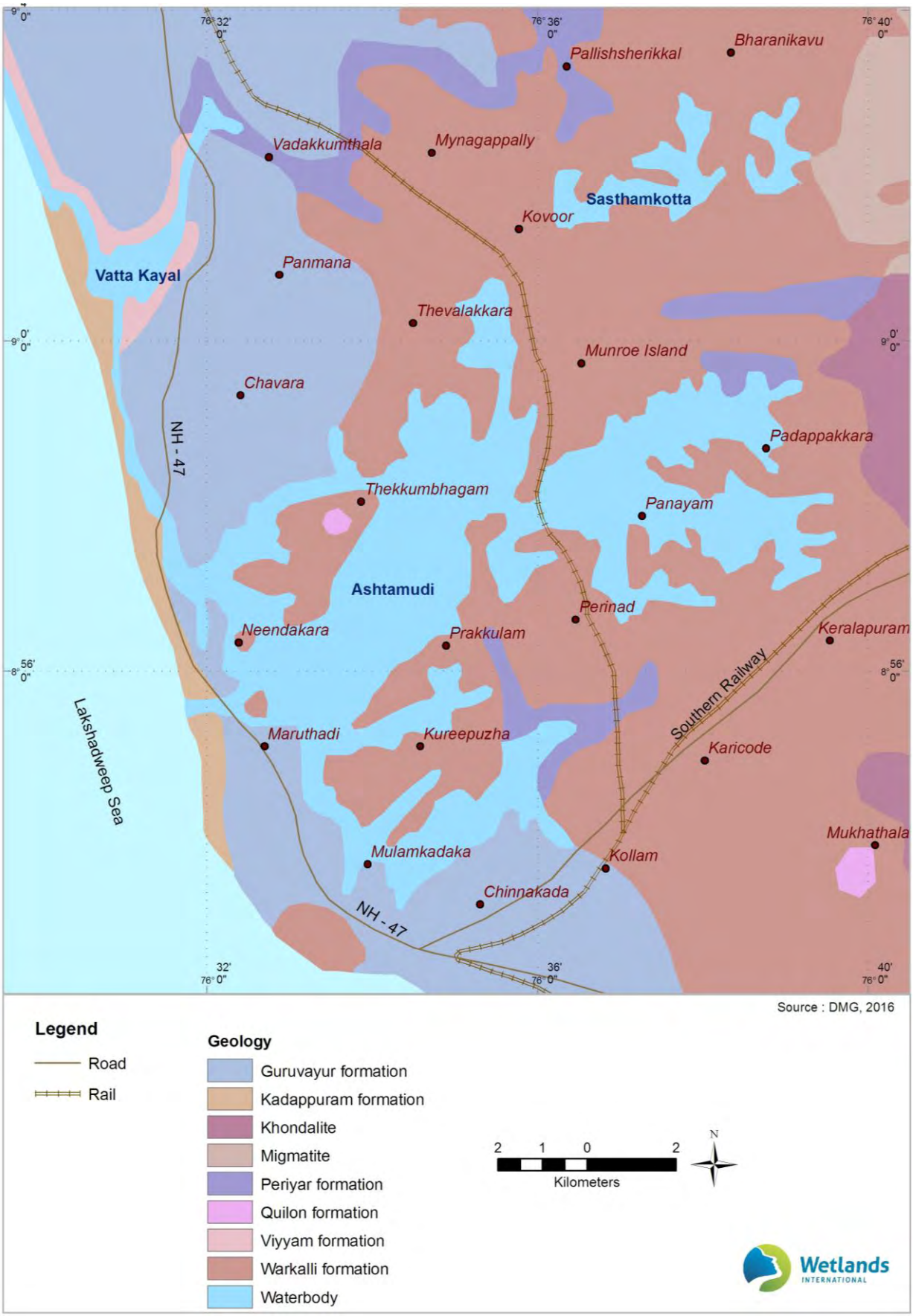
The tertiary Warkalli Formation and Quilon Formation are exposed on most of the region around Ashtamudi Estuary. Warkalli Formation is represented by sandstone and clay with lignite intercalations, over fossiliferous limestone and calcareous clay of the Quilon Formation. The sand latter formation is extensively exploited. Kollam District produces 36 % of crude clay and 43.5 % of processed clay in the state which accounts for 9.08% of the country's total China Clay production. Coastal side of the basin exposes Guruvayur Formation of the quaternary period; this is made of sand-silt-clay admixture and has marine origin (Map 2.8).

In most regions of Kerala, bauxite is associated with laterite and occurs as cappings over the crystalline and tertiary sedimentary rocks and forms lateritic plateau rising from 50 to 150 m above the msl. At Chattannur and Kundara in Kollam District, a zone of about 2 m thick bauxite is recognised at the contact between the crystallines and the overlying sedimentary rocks. The bauxite at the base of the sedimentaries indicates an earlier pre-Warkalli spell of lateratisation.

Soils

The National Survey of Soil Survey and Land Use Planning, Nagpur has identified mainly seven types of soils from the Kallada Basin. These are spread along a longitudinal north-south alignment and represent the geological sequence of formation of these soils from the Western Ghats to the coast. Textural analysis of soil samples indicates that the soil belongs to clay, sandy clay and sandy clay loam class.

Low lying coastal areas around the Ashtamudi Estuary mouth have very deep imperfectly drained clayey soils with shallow water table (Fine, Mixed Typic Dystropepts along with Fine, mixed Aeric Tropaquepts) which are on level lands with valleys with slight erosion.



Map 2.8 | Geological profile of region around Ashtamudi Estuary

Small patches of well drained to imperfectly drained, clayey soils with moderately shallow water table - Typic Dystropepts and Typic Tropaquepts (hydromorphic alluvial soils) are found in narrow valleys and level lands to the west of Sasthamkotta and along Kallada River. These alluvial hydromorphic soils have been formed as a result of transportation and sedimentation of material from adjacent hill slopes and also through deposition by rivers. The development of the soil profiles has occurred under impeded drainage conditions. These soils, therefore, exhibit characteristic hydromorphic features like grey horizons, mottling streaks, hard pans, organic matter depositions, iron and manganese concretion, etc. (Map 2.9).

Heavy rainfall and high temperature in south Kerala are conducive for laterisation. Extensive laterite soils poor in available Nitrogen and Phosphorus with high clay content and low Cation Exchange Capacity are found in Kallada basin over coastal laterites and lateritic mounds in midlands and hilly areas. Very deep, well drained, gravelly clay soils occur on coastal laterites. Kaolinitic clays in coastal stretches west of Sasthamkotta belong to these categories. These kaolinitic, skeletal, clayey soils belong to the type Typic Kandiustults along with Typic Kanhaplustults. A major part of middle basin of the Kallada River beginning from mid of Sasthamkotta till Punalur is characterized by very deep, well drained, gravelly clay soils with moderate surface gravelliness formed on gently sloping midland laterites.

Very deep, well drained gravelly clay soil with moderate surface gravelliness are found on moderately sloping laterite mounds and on gentle slopes around Sasthamkotta and the middle and upper reaches of the basin. It is found around Bharanikavu, spreading to Pattazhy, Maloor and Edamon that is situated in the foothills of Western Ghats. These comprise clayey, kaolinitic, Ustic Kanhaplohumults and clayey, kaolinitic, Typic Kandiustults soil types.

Forest loams are restricted to upper catchments of the basin. These are the products of weathering of crystalline rocks under forest cover, and have immature profiles with shallow soils, followed by gneissic parent material in various stages of weathering. Very deep, well drained gravelly loam soils (Ustic Humitropepts) are found on steeply sloping medium hills with thick vegetation in the basin of Kalathuruthy R., areas north of the Thenmala reservoir and along the Kulathupuzha River. These soils found around Ayiranalloor are subject to moderate erosion. They are also associated with well drained clayey soils on slopes (Ustic Palehumults).

Map 2.9 | Soil profile of region around Ashtamudi Estuary

Land use land cover change

The highlands of Kallada Basin form part of biodiversity rich Western Ghats (one of the 18 global biodiversity hotspots). The upper catchments form part of the core area of Agasthathyamalai Biosphere Reserve, which is famous for the endangered Lion Tailed Macaque (*Macaca silenus*) amongst other noteworthy flora and fauna. These areas are mostly forested, comprising the Chendurni Wildlife Sanctuary, the Thenmala Forests in the North of the Parappar Reservoir, Kulathupuzha Reserve Forests in the south, the Courtallam Reserve Forests of Tamil Nadu Forests in the East and Yeroor Reserve Forests of Punalur Forest Division and Achenkovil Reserve Forests in the West. Chendurni Wildlife Sanctuary established in 1984, covers an area of 171 km^2 on either side of the Parappar Reservoir. Biodiversity within the sanctuary is noted for high level of endemism.

The ridges and valleys of the basin, within 800 m to 1200 m amsl elevation are mostly forest. Southern hilltop evergreen forest constitutes the major forest type. The higher slopes are covered by dense multi-storeyed tropical evergreen vegetation with abundant lianas and epiphytes. The semi-evergreen forests occur at lower elevations and in areas with lesser rainfall. The Chendurni Sanctuary is believed to be named after a tree species found in these forests, the *Glutatra vancorica* locally called *Shenkurinji*.

The lower slopes of the hills below 600 m are covered by moist mixed deciduous forests. Myristica swamps which have a characteristic edaphic formation occur in the valley bottoms in areas subjected to inundation almost throughout the year. Grasslands and reed and cane breaks are also found in valleys and along streams and rivers.

Myristica swamps are characterized by the presence of the primitive angiosperm family Myristicaceae or nutmeg family. Three major genera are found within the Western Ghats of India, namely Gymnacranthera (1 species), Myristica (4 species) and Knema (1 species*). Myristica magnifica, Gymnacranthera canarica, Myristica malabarica, Myristica canarica, Knema attenuata.*

Important trees of being found in these forests are *Knema attenuata, Dipterocarpus indicus, Strombosia ceylanica, Canthium pergracile, Hopea racophloea, Vateria indica, Aglaia lawii, Calophyllum poIyanthum, Syzygium* sp., *Terminalia bellirica, Alstonia scholaris, Cullenia exarillata, Palaquium ellipticum, Dysoxylum malabaricum, Bischofia javanica, Humboldtia decurrens, Litsea oleoides,*

Holigarna grahamii, Antidesma menasu, Messua ferrea, Semecarpus auriculata etc.

Grasslands are observed bordering the semi evergreen and deciduous forests, wherever there are open spaces. These are created as result of degradation pressures caused by fires and grazing. Tall coarse grasslands comprising *Imperata cylindrica, Andropogan sp*. is interspersed with sporadic tree growth of *Emblica officinalis, Careya arborea, Pterocarpus marsupium* among others.

Forest plantations of teak, *Acacia auriculiformes, Acacia mangium* and other species occupy an area of approximately 135 km^2 in the Thenmala, Punalur and Achenkovil Forest divisions in the catchment (Kerala Forest Department, 2010). In the midlands, extensive rubber and eucalyptus plantations mark the landscape of hills tops and sides. The hill slopes are fairly thickly vegetated mostly with mixed crops and plantations.

The valley areas between the lateritic hills are rich in soil nutrients. These low-lying floodplains are used for paddy cultivation and multi–tier cropping of coconut and other crops with a ground tier of paddy. These areas are densely populated. Cultural diversity within the upper reaches of the basin is marked by the presence of atleast eight tribes (the Mala Pandram, Malayadiar, Malavedan, Kochuvelan, Malaluravar, Knaikkar, Ulladan, and Uraly). Remarkably, remnants belonging to Mesolithic period of the Stone Agewas excavated from a large cave situated at the north-western part of the Chendurni River.

Multi-tier cropping cultivation near Kuzhiyan

Within the direct catchment, plantations form the major land use accounting for 66% of the area. These plantations constitute mostly of coconut based homestead agro-forestry system, intermixed with mango (*Mangifera indica*), cashew (*Anarcardium occidentale*) and jackfruit (*Artocarpus heterophyllus*). Major crops grown in the area include cashew, coconut, tapioca, jackfruit and arecanut, with yields below state average. The vegetation is mostly stunted, possibly due to laterization.

The Kallada Basin has undergone a reduction in forest cover, with extensive patches converted for agriculture and plantation.[1] Coffee plantations were raised in Kulathupuzha and Chendurni valleys as early as the first decades of the 19th century, and later converted to tea or abandoned. Large moist deciduous and semi evergreen forests have been converted, even under state sponsorship, to raise eucalyptus plantations in Kulathupuzha and Anchal. In 1972-73, rubber plantations were raised in over 2,000 ha of clear forests in Kulathupuzha and Ayiranallur so as to enable resettling of 0.6 million repatriates from Sri Lanka. Construction of railway and roads have been also indicated for degradation of extensive forest tracts of the Kulathapuzha, Aryankavu, Nedumangad and Thenmala region.

An analysis of land use land cover change within the basin for the period 1988-2015, derived from remote sensing imagery indicates a decline in dense and open forest, and with almost a commensurate increase in plantation. The area under agriculture did not show any significant change, whereas marshes have declined. The area under settlements has increased significantly (Fig. 2.1 and Map 2.10).

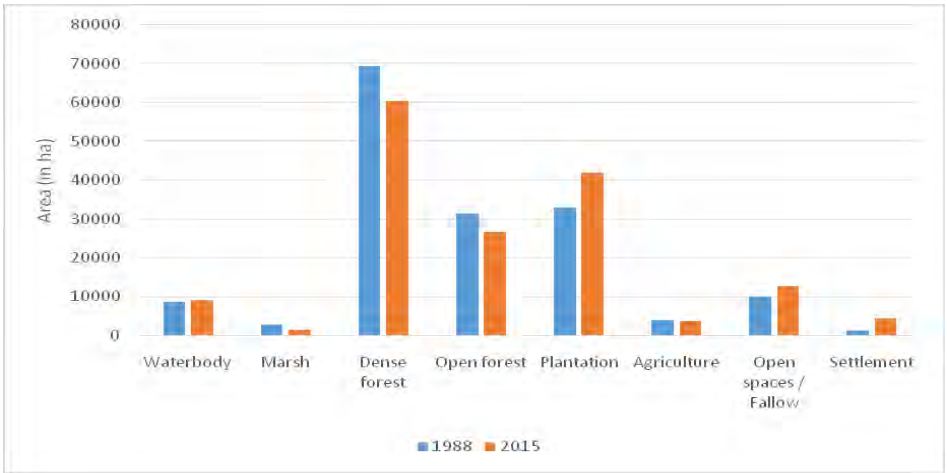
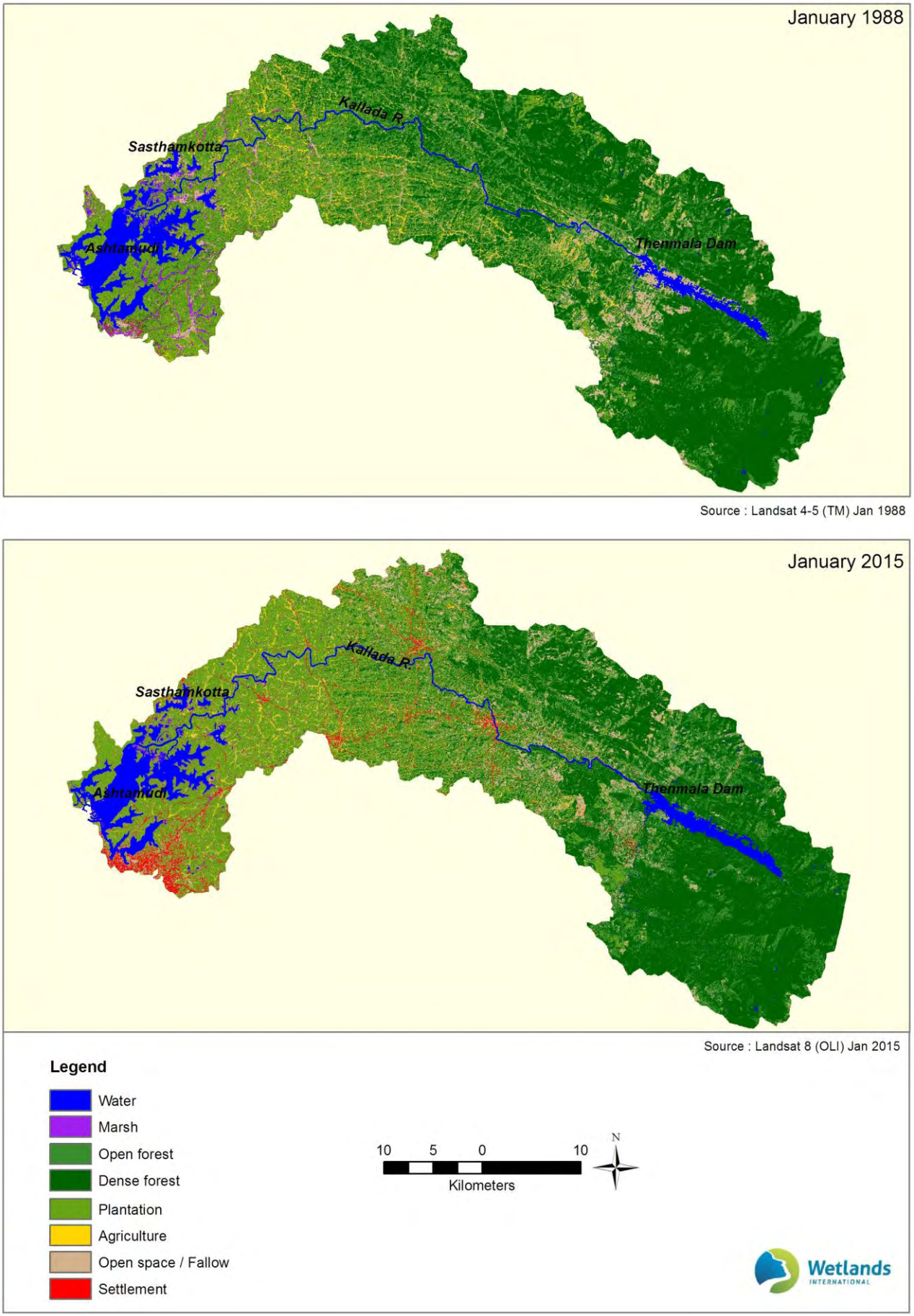


Fig. 2.1 | Land use land cover change within Kallada River basin

[1] Bourdillon's plot, named after then Conservator of Forests of Travancore, is the world's first stump planted plantation of teak which is located near the Palaruvi water falls in Aryankavu forest range.



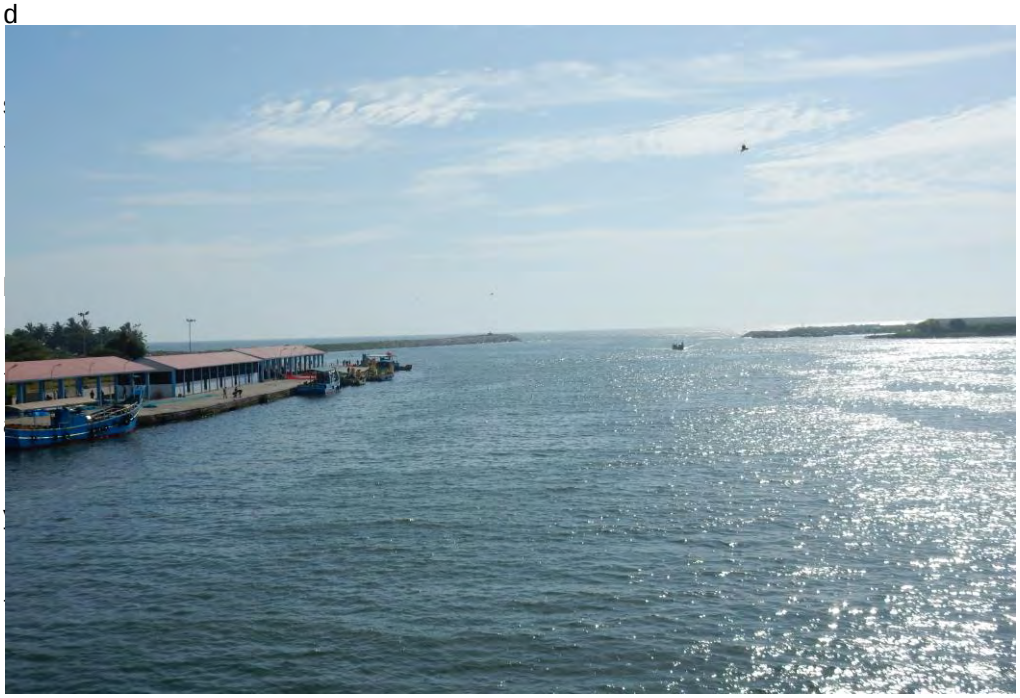
Map 2.10 | Land use land cover change in Kallada River Basin

2.3 Hydrological regimes

An estuary is a zone of transition with gradients in salinity, sediment characteristics, chemical composition and in diversity and productivity of species of animals and plants (Wolanski et al., 2012). Altered freshwater inflow into the estuary leads to changes in coastal ecosystem hydrology, downstream transport of nutrients and sediments, salinity regimes and ultimately impacting species habitats and ecosystem service values (Montagna et al., 2013). Maintaining hydrological regime and natural variability of an estuary is necessary to maintain its ecological character. Given the influence of freshwater inflows on coastal ecosystems, it is important to assess the effects of altered freshwater inflows and to create effective management strategies for water resources development and coastal zone management. This section of the management plan presents an overview of the hydrological regimes of Ashtamudi Estuary based on a synthesis of available data on river discharge, bathymetry, coastal processes, and water and sediment quality. The section concludes with a description of the key hydrological regime related issues that need to be factored in management planning.

Water Inflow and Outflow

Runoff from the basin of River Kallada and direct precipitation are the two major sources of freshwater inflow into the Ashtamudi Estuary. Kallada, after flowing for a 120 km length, coalesces into Ashtamudi through channels encircling Munroe Islands. The main channel flows into the estuary north of Island at Koivila, whereas a d



A view of mouth of Ashtamudi Estuary from Neendakara Bridge

lows along the eastern margins of the Island. The average annual inflow from the river (estimated from the daily gauge data for 2002-11 for Enathu discharge station) is 943.98 Mm^3. Seventy-eight per cent of this inflow is received during the south-west and northeast monsoon.

The River Kallada Basin, located at the gateway of Indian monsoon (a reference to Kerala as it is the first state in the country to receive monsoon rainfall) experiences two distinct monsoon seasons - the South-west monsoon (June-August) and the North-east monsoon (September-December). During 1905- 2015, the wetland and its surrounding received an average annual rainfall of 2215.57 mm (maximum being 4160.2 mm in 1952 and minimum being 692.2mm in 1969). The two monsoon seasons contribute 81% of the total rainfall with the rest during the summer months. Of the two, South-west monsoon is predominant contributing 49% of the total rainfall (Fig 2.2). Annually, on an average, the estuary receives 129 Mm^3 in the form of direct precipitation on the surface, of which 115 Mm^3 is lost due to evaporation (data from IMD Kollam Station for 2009-10).

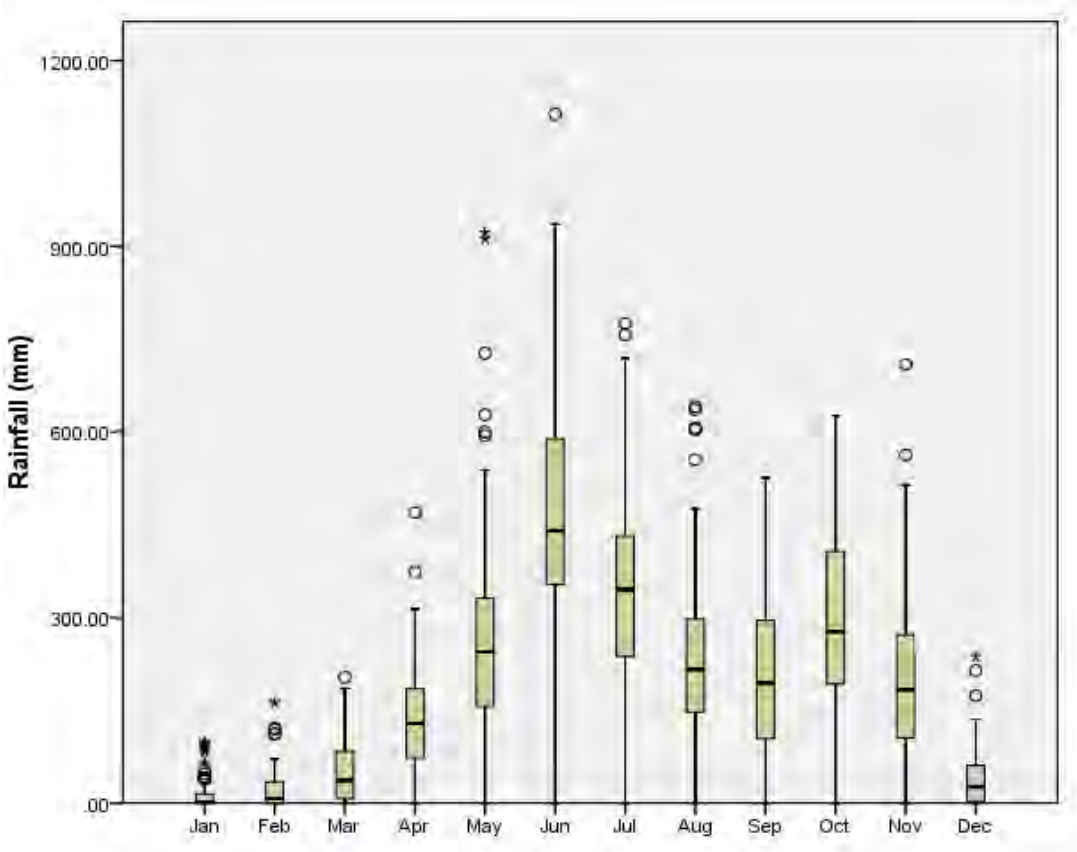


Fig 2.2 | Monthly rainfall for Kollam District (1905-2015)

An assessment of annual flux of water between the river, estuary and the sea is presented in Fig 2.3. Data on the tidal exchange is from the computation used in Zachariah and Johny (2008), based on LOICZ model. Net discharge into the estuary has been arrived at by reducing evaporation losses from river inflows and precipitation. The water balance analysis presented as above, despite being at a coarse resolution, indicates the relative predominance of the tidal exchange over the freshwater inputs from various sources. There is a need to compute water balance at least on a monthly basis to assess the relative significance of various input and output sources, in relationship with water quality and biota.

Sedimentation

Sedimentation in an estuary is a balance between the riverine and marine processes. While an estuary is a recipient of sediments from marine as well inland basins, flushing along with high river flow pulses during monsoon ensures a balance in deposition pattern. A reduction in the inland basin flows may lead to the marine processes dominating the flux, dumping sediments within the waterbody, and a gradual reduction in its water holding capacity.

Available information on water holding a capacity of the estuary is through a bathymetry survey carried out in 2014 (Mohan et al., 2016). As per the assessment (Map 2.11), the estuary has depth up to 6 meters in the region where River Kallada debauches in the waterbody, and around 2 meters closer to the Neendakara port side. The eastern margins also exhibit a few funnel-shaped depressions on the eastern margins. At a peak inundation area of 56.9 km^2, the water holding capacity of the estuary has been assessed to be 90.8 Mm^3 (Fig 2.4).

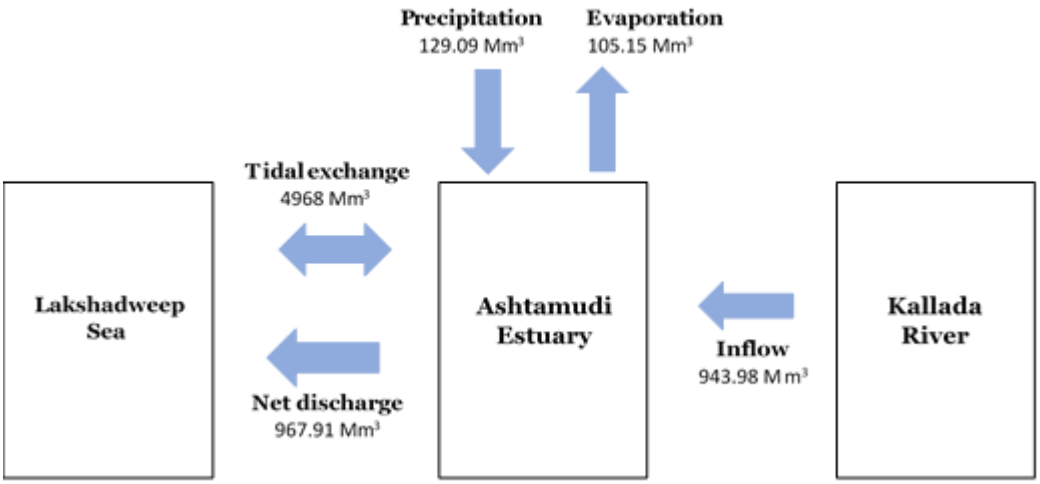
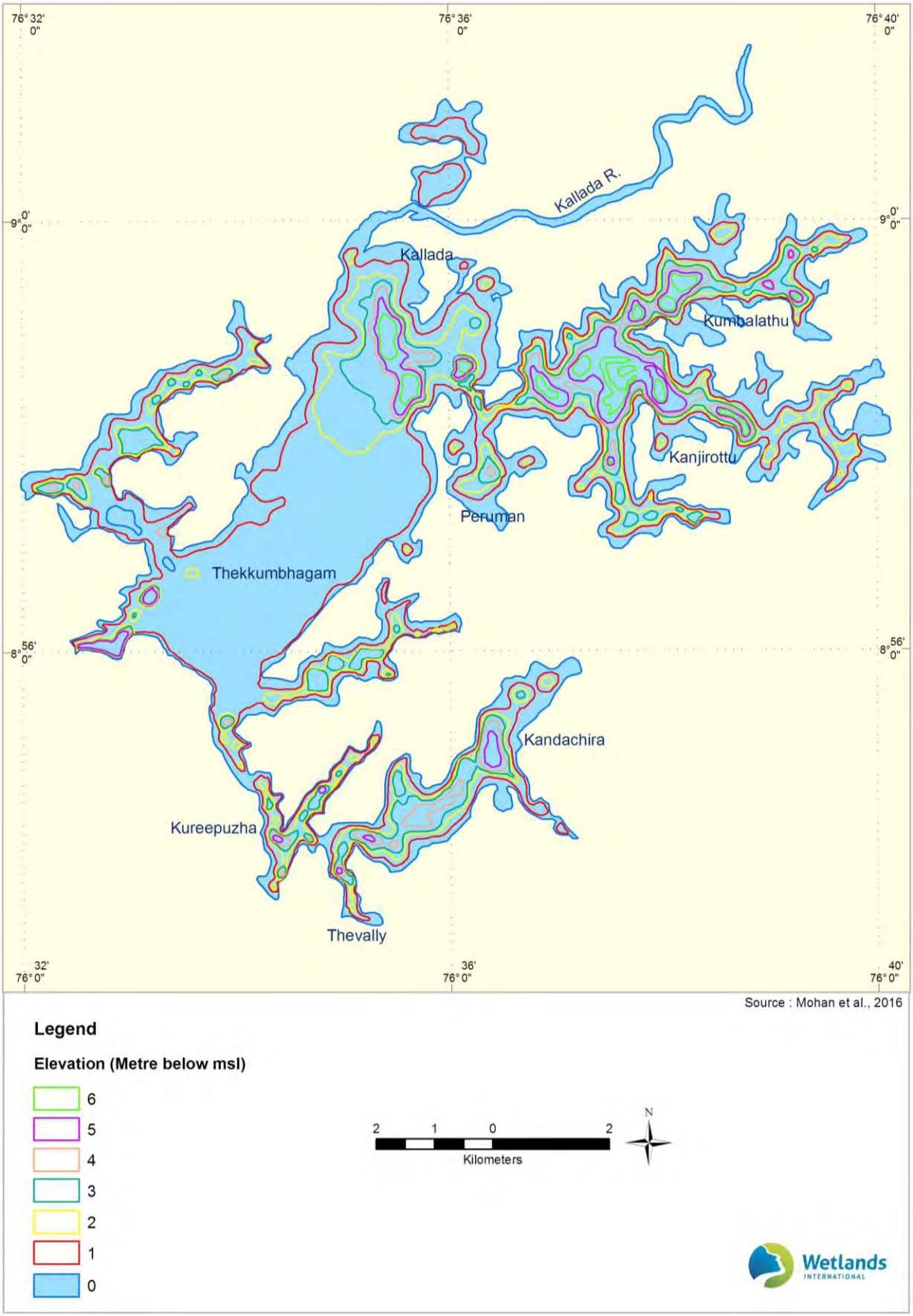


Fig 2.3 | Annual water balance for Ashtamudi Estuary



Map 2.11 | Bathymetric Profile of Ashtamudi Estuary

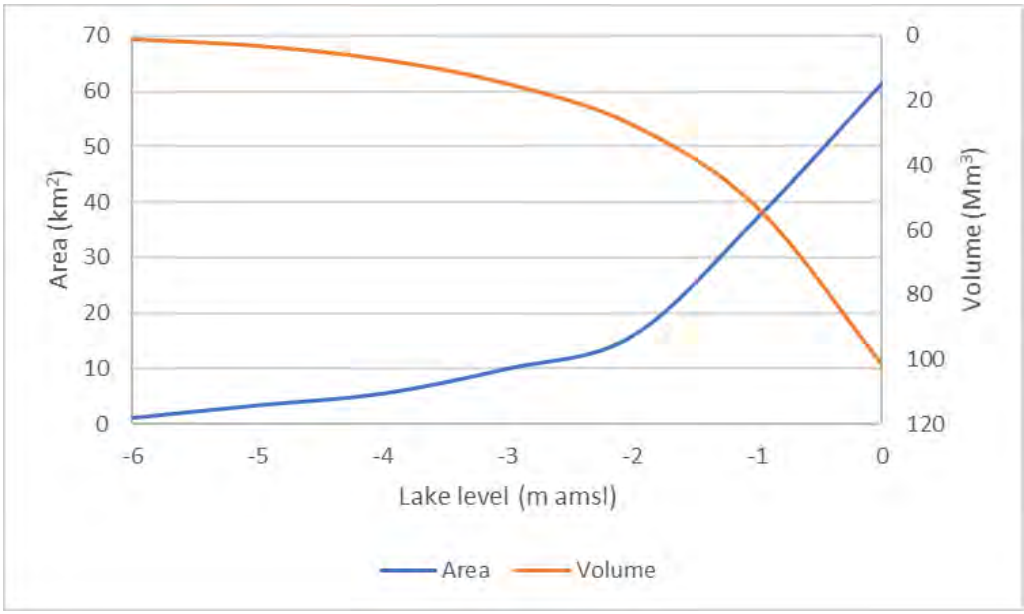


Fig 2.4 | Area capacity curve for Ashtamudi Estuary

The submerged sand banks and the development of flood tidal islands on the landward side of the estuarine entrance at Neendakara are indicative of high input of sediments from the littoral and nearshore regions. The estuary has started getting filled up from the west by flood tide inputs. In addition, the filling up of the estuarine basin has also taken place at the eastern end by the Kallada River. Palynological and isotopic research indicate that early Holocene witnessed rapid sedimentation in the fluvial end because of high rainfall events during that period. The high freshwater influx was also recorded near the mouth of the river. But, middle and late Holocene showed excessive inputs of sediments of finer sizes by transportation from the nearshore areas (Mohan et al., 2016). Apparently, the reduction of freshwater inflow from Kallada has tilted the balance towards a predominance of coastal processes and infilling of sediments in the estuary.

A direct consequence of reduced sediment input into Ashtamudi is on the stability of island located on the eastern shorelines. Land subsidence is being recorded at Monroe Island, which is inhabited by 2,400 households and also has culture fisheries operations in 412 ha. Assessments on the cause of subsidence have indicated replacement of coarse grain sand deposits from the river with that of fine grain deposits from the sea as one of the key contributing factors. These changes have been further aggravated by sand mining in the upstream stretches, thus inducing piping (fine soil being carried away by subsurface runoff) and erosion, and ultimately leading to high subsidence (Jha et al., 2016).

A damaged building due to land subsidence at Munroe Island

Coastal Processes

Littoral drift (movement of sediments in near-shore zones by waves and current) plays an important role in shaping and orienting the coastal landforms and the evolution of the coast. The Neendakara inlet acts as a confluence zone of the sea with the estuary. The tidal amplitude here is a maximum of 1.12 m, with an average of 0.5 m (tide-forecast.com). Net annual sediment transport rate at an open beach in Kollam for the period 1990-91 was assessed to be 3.83 x 10^6 m^3 (Sajeev et al., 1997). During pre-monsoon and post-monsoon months, the monthly drifts show a northerly trend while during monsoon it is southerly. The maximum value of sediment drift was 3.91 x 10^5 m^3 in June. The magnitude of drift shows a decreasing trend till September after which it shifts the direction. The gross annual transport is 8.05 x 10^5 m^3. Such high drift in a natural condition is likely to create shoal and bar formation at the mouth of the estuary, to be cut open by high-velocity river flows. With the reduction in inflows from Kallada, the mouth requires periodic dredging to be kept open, more to enable sufficient depth for port operations.

Construction of Tangasseri breakwaters in 1990 has also altered the sediment accretion and deposition patterns on the shoreline of the estuary (Sajeev and Subramanian, 2003). Analysis of shoreline changes for the period 1967-1997 have indicated an erosion in areas north of the Neendakara inlet, and between Neendakara

inlet to Tangasseri breakwater zone. The region south of Tangasseri breakwater has experienced accretion till 1990, and recession thereafter (ibid).

The sea level rise along the Kochi coast, for the period 1939 - 2007 is reported to be around 1.81 mm/yr. The rates have been higher (up to 3.7 mm/yr) for the period 1992 - 2007. The sea level rise future exposes the estuary to the risk of high salinization (Unnikrishnan et al., 2015). The long term sea-level rise rates (1939-2007) along Kerala coast is the higher that Vizag (0.93 mm / year) and Mumbai (1.08 mm / year) but considerably lower than the Bay of Bengal (4.99 mm/year).

Water Quality

Ashtamudi estuary is located in a highly developed landscape, with a population density exceeding 2,500 persons per km^2, several industrial units along the shoreline, with almost non-existent waste treatment facility. Degradation of water quality of the estuary is apparent.

Analysis of physicochemical properties of water of the estuary has been reported by several authors since 1975. Available data has therefore been grouped in batches of three years, wherever possible, in order to discern trends. However, as there is little information available on actual sampling stations and methods, the analysis is at best indicative in nature.

Water quality in Ashtamudi estuary is generally alkaline, mixosaline to eusaline, with pockets of depleted oxygen.

Surface water temperature varies between 26°C to 33°C throughout the year, with the maximum during the summer and minimum during the monsoons. Surface and bottom waters tend to be alkaline, expect in creeks wherein there is an influence of industrial pollution and discharge of untreated effluents.

Salinity, which is one of the key determinants of ecological productivity, ranged between 13-33.5 ppt for the period 2012-2015. Samples taken from the mouth region had higher salinity owing to the influence of Lakshadweep Sea. The influx of seawater and low discharge of fresh water during pre-monsoon period shifts the lake towards eusaline conditions (Sujatha et al., 2009). The gradual predominance of coastal processes is evident in increased salinity in upstream stretches, with mixosaline conditions noted in river stretch adjoining Sasthamkotta up to the Njankadavu bridge where salinity above 5 ppt is observed during the driest months (February to April) in 2014 (NCESS, 2014). Increasing population of *Paphia malabarica* (a clam which is

generally found in mixosaline and eusaline conditions) in all part of the estuary is also an indicator of such a change (Ampili and Shiny, 2016).

The quantity of the nutrients like Nitrogen and Phosphorus play an important role in the growth of an aquatic ecosystem. The concentration of nitrate and phosphate ranged from 4.1 to 11.3 mg/l and 0.1 to 4.1 mg/l respectively in the Kandachira kayal (a southernmost arm of the estuary), with higher values during the monsoon period with a decline during the post monsoon. This may be due to the sediment in the runoff from the upstream as well as fertilisers from the agricultural field (Sachin et al., 2013). Nitrate and Phosphate concentrations in the estuary have progressively increased most likely due to the dumping of untreated waste. The estuary received efflux of a number of drains from adjoining households and tourist resorts. Kollam canal is a major drain carrying sewage through Kollam City located in the south of the estuary, thus leading to severe depletion of oxygen in these stretches. BOD along the Thekkumbhagam island was found out to range from 0.8-14 mg/l (BOD>10 mg/l is considered polluted). This could be due to the sewage as well as solid waste being dumped at Kureepuzha which is along the banks of Ashtamudi estuary (Rajan, 2015). As per the data from the Kerala State Pollution Control Board (KSPCB), 2014 the coliforms level exceeds beyond the permissible limits with maximum total coliform of 1500 MPN/100ml and faecal coliform of 600 MPN/100ml.

Ashtamudi is also surrounded by clay mines as well as clay refining industries. A part of these effluents from the refining industries is discharged into the estuary. Water sample at the Kanjiracode area show the high quantity of iron, sulphate and calcium

A slaughter house near Thevally

content ranging 39.23 to 47.89 mg/l, 464.86 to 886.52 mg/l and 256.34 to 562.67 mg/l respectively which are way beyond the desirable limit. The COD value is also very high ranging from 51.2 to 256 mg/l.

Coconut coir retting and associated operations, though small scale, are extensively distributed along the coastal stretches and contribute heavily to the organic pollution load of the open water bodies. Large quantities of polyphenols along with hydrogen sulphide are released from the coconut husks during the retting process, creating anoxic conditions. Untreated retting effluents which contain high concentrations of biodegradable organic matter along with sulphides, nitrate and phosphates exert heavy BOD and COD stress on the surrounding aquatic environment. Such stressors are evident along the northern shorelines of the estuary, wherein much of retting activity takes place. These stretches also have high levels of dissolved methane (Zachariah and Johny, 2008). A 2004 assessment of water to air flux from 27 stations indicated that the estuary emitted 270 x 10^6 g of methane and that the flux to the coast as a result of tidal mixing and water flow is nearly 15% of the fluxes from the estuary to the atmosphere (Zachariah and Johny, 2008) (Table 2.2 and Map 2.12).

Neendakara port region has high instances of leaching of oil, grease and other lubricants from the boats using the port. Fish, especially edible fish like *Etroplus suratensis* has routinely been found to bear the smell of kerosene. The fish-processing unit, which has come up by reclaiming waterbody at Neendakara, is also discharging pollutants. Waste management operations in the 50 odd houseboats which operate within the estuary are also not appropriate. The wash of adjoining slaughterhouse is also released into the estuary (Sajeev and Subramanian, 2003). The Needakara harbour and Kandacheera region have emerged as amongst the most polluted parts of the estuary, requiring immediate attention.

Table 2.2 | Variation of water quality of Ashtamudi Estuary

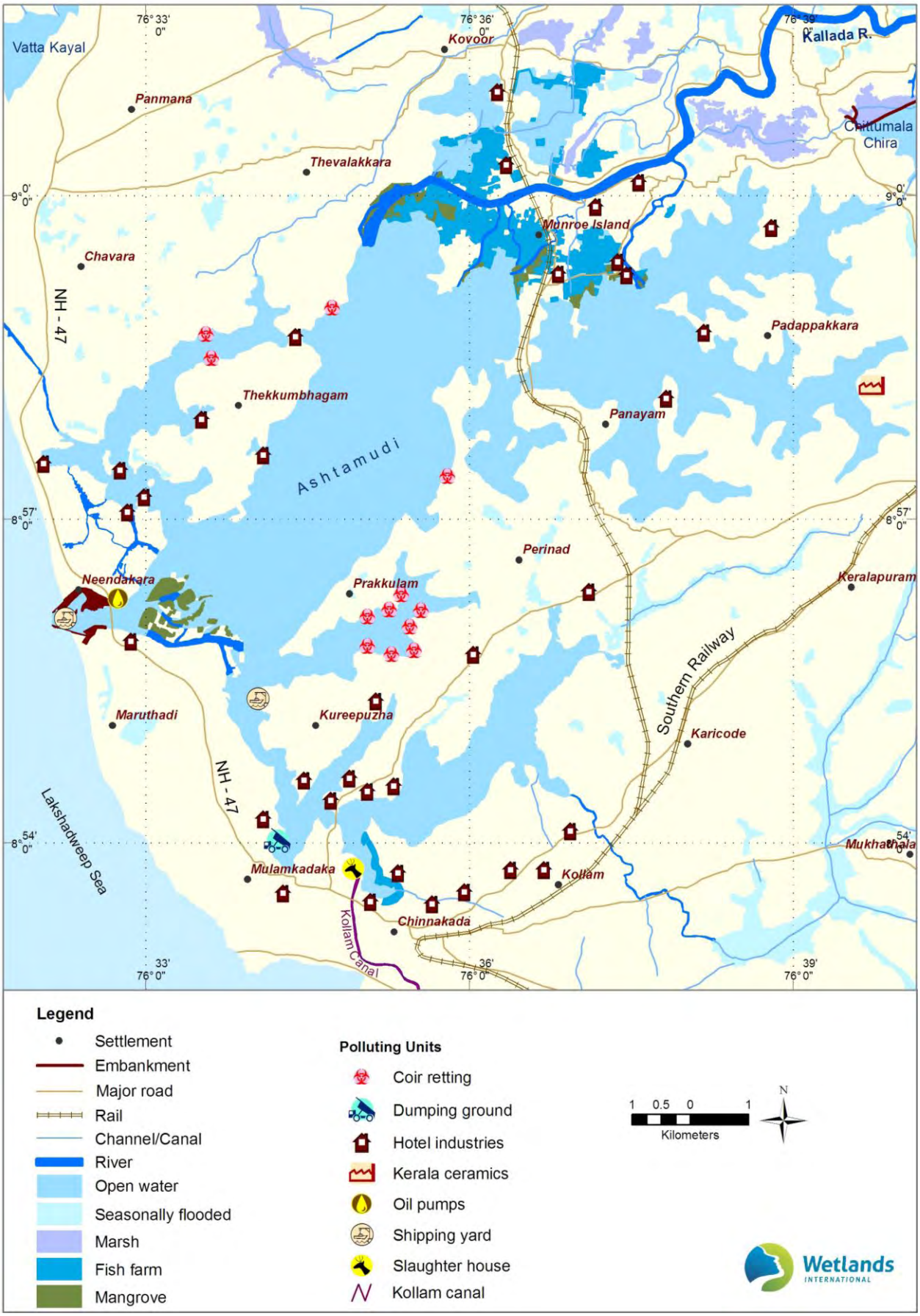
Parameters	1977-1980[1]	1996[2]	2007-2010[3]	2012-2015[4]
Temperature (°C)	26.5-33.75	-	25.5-32.5	26.60-31.4
pH	7.4-8.3	-	6.8-8.86	6.8-8.3
Acidity (mg/l)	-	-	20-28	-

[1] Mathew and Nair, 1980; Divakaran et al., 1981; Nair et al., 1984
[2] Appukuttan et al., 2002
[3] Antony and Ignatius, 2013; Sujatha et al., 2009; Sachin et al., 2013; Suma et al., 2012; Rajan, 2015
[4] Chinnadurai et al., 2016; Seethal et al., 2015; KSPCB, 2014

Parameters	1977-1980[1]	1996[2]	2007-2010[3]	2012-2015[4]
Alkalinity (mg/l)	-	-	82.5-120	-
Salinity (ppt)	0.39-34.87	5-33.1	6-36.68	13-33.5
Total Hardness (mg/l)	-	-	135-144	-
Conductivity (μS/cm)	-	-	-	8122-68000
Phosphate (mg/l)	0.03-0.16	-	0.1-4.1	-
Nitrite (mg/l)	-	-	0.3-5.1	-
Nitrate (mg/l)	1.47-10.5	-	4.1-41	-
Sulphate (mg/l)	-	-	78.6-886.52	-
Silicate (mg/l)	-	-	12.1-45	-
Chloride (mg/l)	-	-	32.5-46	-
Free CO2 (mg/l)	-	-	1.01-11	-
Dissolved CO2 (ppm)	-	-	1.14-1.842	-
Total solids (mg/l)	-	-	1668-3630	-
Total dissolved solids (mg/l)	-	-	72-3627.88	-
Total suspended solids (mg/l)	-	-	1.105-3.28	-
DO (mg/l)	2.55-7.29	1.17-2.79	2.5-6.3	4.1-6.3
BOD (mg/l)	-	-	0.8-14	1.8-2.8
COD (mg/l)	-	-	51.2-256	-
Calcium (mg/l)	-	-	256.34-562.67	-
Iron (mg/l)	-	-	39.23-47.89	-
Total Coliform (TC/100 ml)	-	-	-	180-1500
Faecal Coliform (FC/100 ml)	-	-	-	60-600

Sediment Quality

The composition of sediments within the estuary vary inter-annually on account of various physiographic features as water current and flow of tides. Sand is the highest constituent in the area around Neendakara (68%), followed by silt (17%) and clay (14%). In the rest, sand is more predominant (82%), followed by silt (11%) and clay (7%) (Muhamed et al.,2016). When compared with texture data of 1996, the Needakara region has seen a decline in clay content in texture (Appukuttan et al., 2002). There is an in-general decline in clay content in the estuary.



Map 2.12 | Major polluting sources around Ashtamudi Estuary

Nair et al. (1983) and Damodaran and Sajan (1983) reported relatively higher clay content in the creeks (5-26%) as compared with the present assessments.

Organic Carbon in 2014 assessments was estimated to be 1.77% near the mouth of the estuary, and 0.9% in the rest of the estuary (Mohamed et al., 2016). The concentrations reported in assessments of 1981 are lower in the Neendakara area and much higher in the river confluence zones. This transition correlates with reduced freshwater influence on the estuary. The 1981 assessment also indicated that despite high levels of organic carbon, the biogenic activity in the river confluence areas was lower, due to various factors including high water depth, salinity fluctuation and prevalence of reducing environment (Damodaran and Sajan, 1983). More recent assessments of biogenic activity are required to highlight the material flux within the estuary and the role of benthic organisms therein.

Key Issues

The hydrological regimes of Ashtamudi have been severely altered due to construction of upstream storage structures, increasing water abstraction and alternation of natural shoreline. The salinity gradient from freshwater to mixosaline conditions have been replaced by a mixosaline condition throughout the estuary. Altered sediment flux puts the estuary at risk of shrinkage unless interventions are made to periodically remove the sediments. Following issues emerge from the analysis:

Reduced freshwater inflow and increasing salinity

Freshwater inflows into the Ashtamudi have declined due to reduced inflow from the Kallada Basin and declining rainfall. The Thenmala Dam (also known as Kallada dam) with a reservoir of 524 Mm^3 capacity was constructed in 1986 near Thenmala for the purpose of hydroelectricity generation and irrigation in the neighbouring area. Water from the reservoir is also withdrawn for the water supply to the adjoining areas. Post construction of the dam, there has been a drastic reduction in the inflows into Ashtamudi. Annual discharge at Enathu during 1972-78 was 1646 Mm^3 (CWRDM, 1995), which was 174% higher that the discharge during the 2002-2011 period (Fig 2.5 a, b and c).

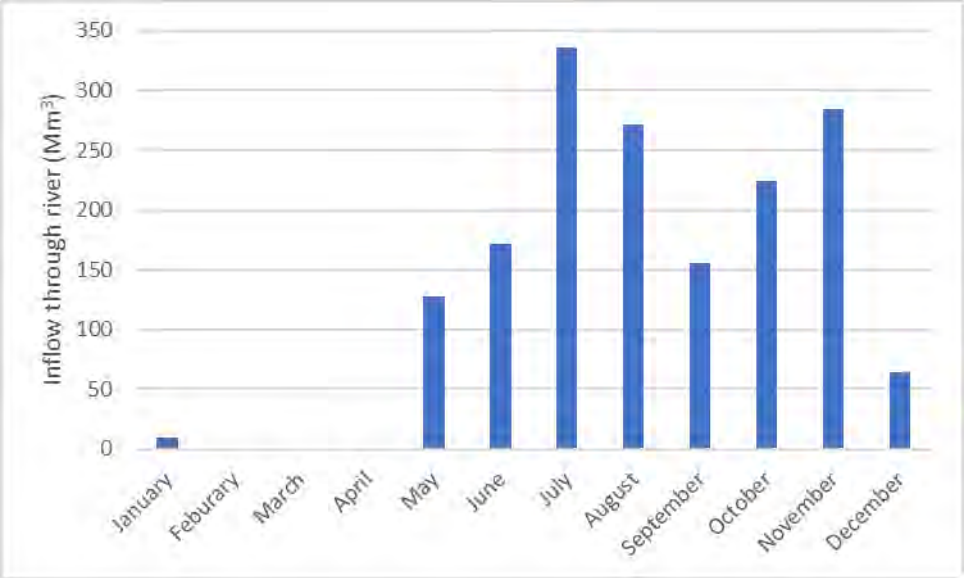


Fig 2.5 a | Monthly discharge of Kallada River at Enathu Gauge Station (1972-1978)

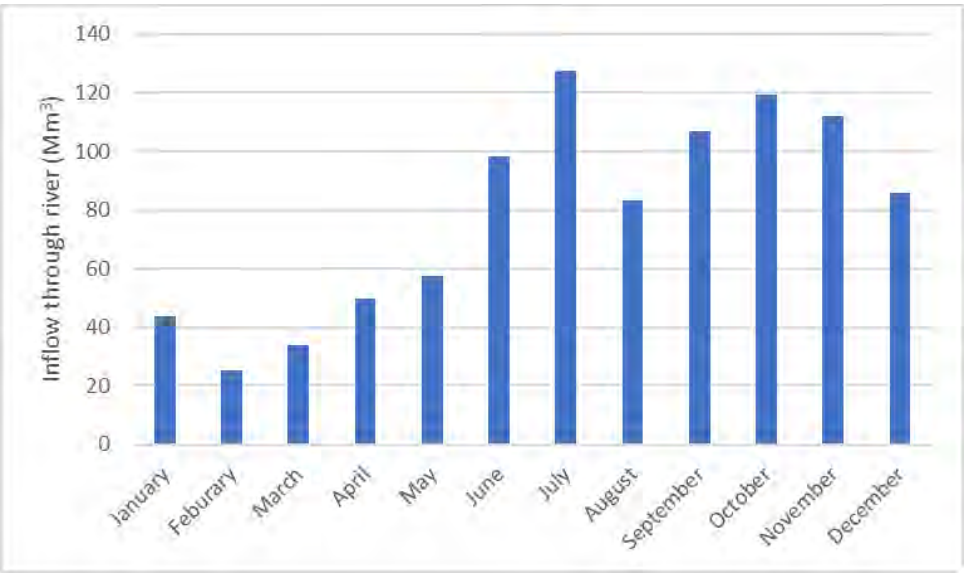


Fig 2.5 b | Monthly discharge of Kallada River at Enathu Gauge Station (2002-2011)

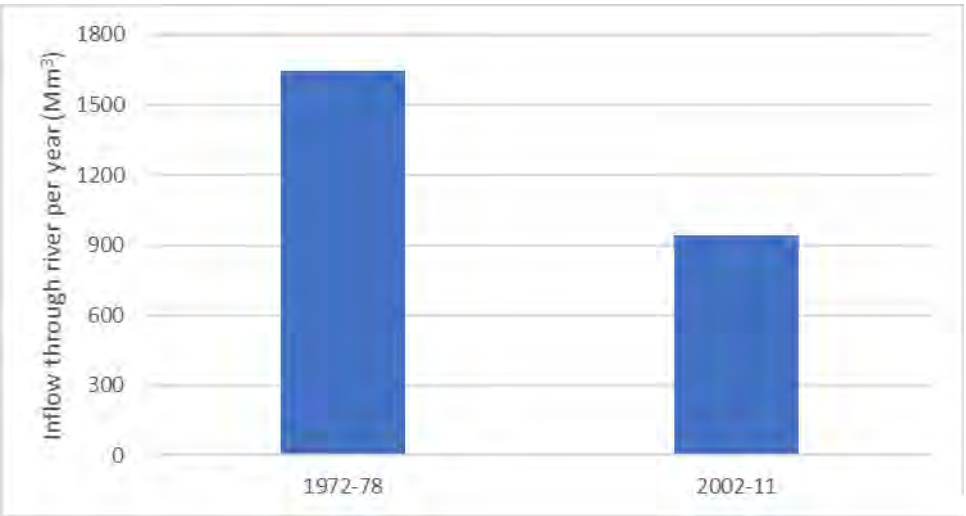


Fig 2.5 c | Trends in inflows from Kallada River into Ashtamudi Estuary

The analysis of 100-year rainfall for IMD Kollam Station distinctly indicates a gradually declining rainfall during the south-west monsoon and as a result total rainfall (Fig 2.6). Krishnakumar et al., 2009 confirm a similar trend for the Kerala State. As the estuary becomes more saline, adverse impacts on groundwater quality are also highly likely. Such trends need to be continuously monitored through a systematic monitoring programme, details of which are presented in Chapter 5.

An immediate consequence of reduced freshwater inflow is on salinity regimes (Fig 2.7 a and b. The overall salinity of the estuary has been increasing, and the gradient reduced (. Such shift has adverse consequence for species habitats and ecological productivity (further detailed in sections 2.4 and 2.5). With reduced flow of freshwater, riverine sediments have also reduced, rendering the islands unstable. Munroe, which is home to around 10,000 people, is gradually sinking. Removal of mangroves from the natural shorelines, unmanaged sand mining in the upstream areas has further aggravated erosion rates.

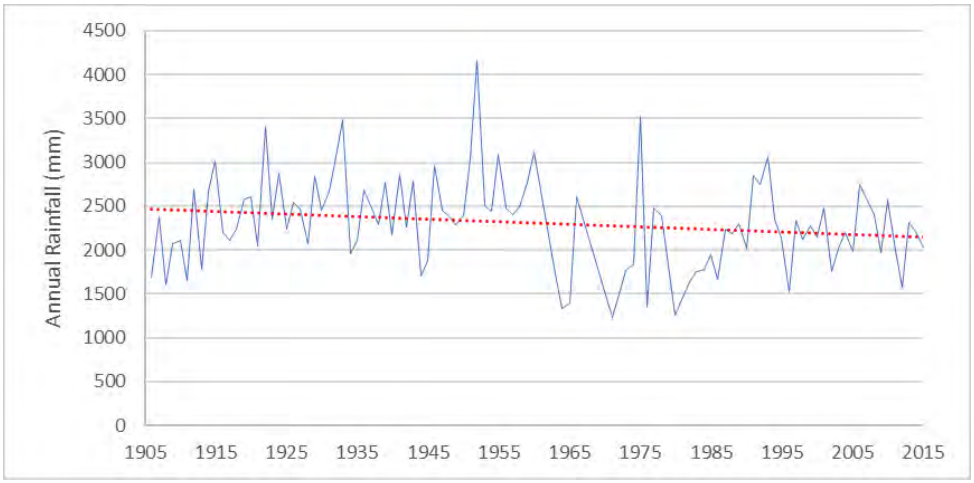


Fig 2.6 | Trend in rainfall in Kollam District (1905-2015)

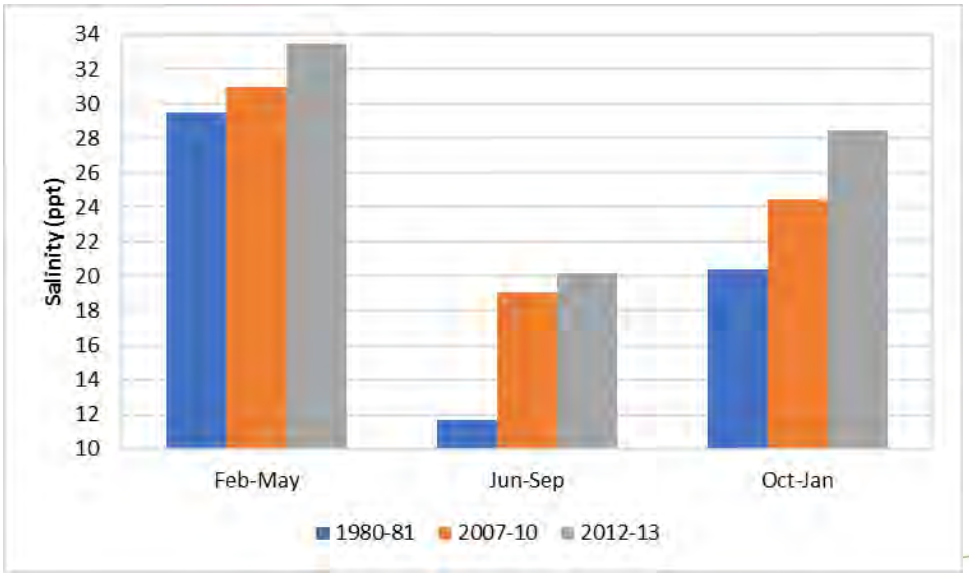


Fig 2.7 a | Change in salinity at Neendakara

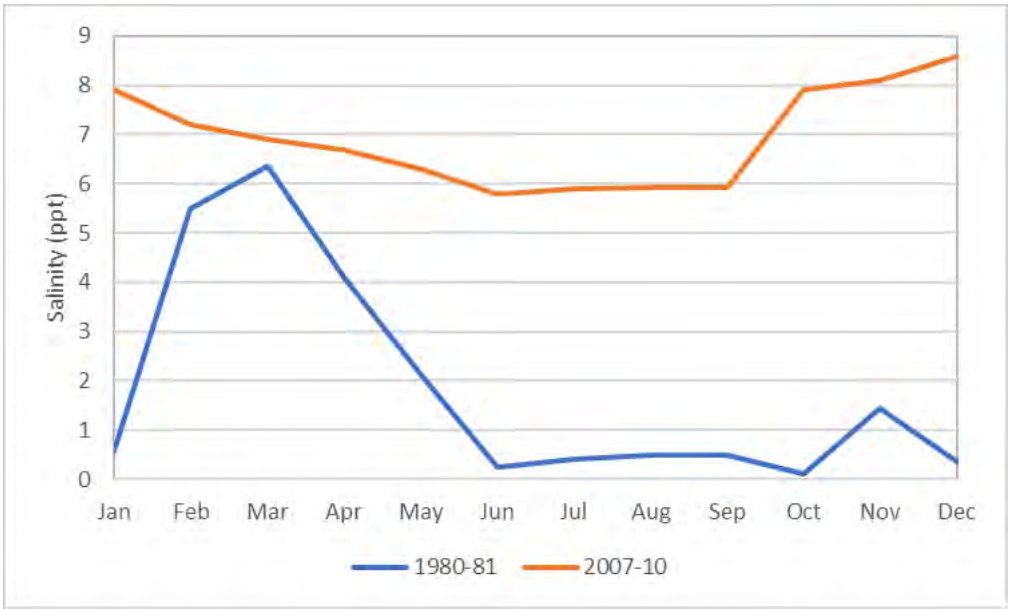


Fig 2.7 b | Change in salinity at Kadapuzha

Pollution

Ashtamudi has become a cesspool of waste due to direct discharge of untreated sewage and wastes from the Kollam City, adjoining industrial units, boats which use the Neendakara harbour and tourist houseboats. In near term, pollution is likely to become a serious health hazard by moving through food chains.

Kollam canal carrying sewage from Kollam City to Ashtamudi

2.4 Biodiversity

Estuaries are transitional environments influenced by freshwater as well as marine aquatic realms. Variable salinity regime and high turbidity have significant influence on the diversity and habitats of species within these ecosystems. Turbidity reduces the depth of photic zones thus limiting photosynthesis and primary production and eventually making estuaries heterotrophic systems where more energy is consumed rather than produced. Varying salinity creates an adaptation challenge for several species. Estuaries are majorly inhabited by species which can withstand a high degree of variability of environmental factors. High productivity and natural connectedness between marine and inland environments also render estuaries as hotspots of developmental activities, often adversely impacting ecosystem processes and functions.

Ashtamudi has been designated as a Ramsar Site under criterion 1 (representative, rare, or unique example of a natural or near-natural wetland type), criterion 2 (supports vulnerable, endangered, or critically endangered species or threatened ecological communities), criterion 3 (supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region) and criterion 8 (important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend). Maintenance of biodiversity values underpinning these criteria is critical to achieve wetland wise use.

Cormorants flocking on Chinese dip nets

Systematic attempts to characterize the biodiversity of Ashtamudi are yet to be made, though several sporadic and disparate studies on specific species groups have been carried out. Much of the available literature emanates through the work carried out by the Central Marine Fisheries Research Institute (CMFRI) and Zoological Survey of India (ZSI). This section of management plan presents a synthesis of available information on biodiversity values of Ashtamudi Estuary and major threats thereof.

An overview of available information on floristic and faunistic species recorded from Ashtamudi is presented in Table 2.3. Conservation status of these species is assessed through reference to IUCN Red List of Threatened Species (version 2016-3), Fish Base (version 02/2017) and World Register of Marine Species (http://www.marinespecies.org/aphia.php?p=search).

Table 2.3 | Conservation status of flora and fauna in Ashtamudi Estuary

Biodiversity	Group	No. of Species	Data Source	Status						
				CR	EN	VU	NT	LC	DD	NE
Flora	Phytoplankton	52	Mathew and Nair, 1980							52
	Mangrove	11	Sumesh et al., 2014 and Vidyasagaran and Madhusoodanan, 2014					10		1
	Mangrove Associates	7	Sumesh et al., 2014 and Vidyasagaran and Madhusoodanan, 2014	1				2		4
Fauna	Zooplankton	70	Divakaran et al., 1981; Divakaran et al., 1982; Nair et al., 1984; Raghunathan, 2007 and Nagendra et al., 2011							70
	Molluscs	16	Divakaran et al., 1981; Nair et al., 1984, Raghunathan, 2007 and Mohamed et al., 2013					1		15
	Pisces	151	Nair et al., 1983; Raghunathan, 2007 and Raj et al., 2014			2	4	62	9	74
	Crabs	5	Raghunathan, 2007 and Raj et al., 2014							5
	Shrimps and Prawns	12	Raghunathan, 2007 and Raj et al., 2014					1		11
	Amphibians	1	Raghunathan, 2007					1		
	Aves	116	AWC, 1992-2014 and Raghunathan, 2007				9	107		

CR-Critically Endangered; EN-Endangered; VU-Vulnerable; NT-Near Threatened; DD-Data Deficient; LC- Least Concern; NE-Not Evaluated

Flora

Information on the floristic species of Ashtamudi is limited to the distribution of phytoplankton and mangroves.

Mathew and Nair (1980) indicate presence of 52 species of phytoplankton of 35 families and 10 classes within the estuary (Annex 1). Among them, the dominant classes were represented by Bacillariophyceae (35%), Cyanophyceae (19%), Mediophyceae (10%) and Ulvophyceae (10%). Their abundance was high during the monsoon months which have low salinity and high nutrient enrichment from south west monsoon. The study attributes low abundance of phytoplankton during pre-monsoon and post monsoon periods due to pollution from coir retting grounds and effluents brought by the Kallada River.

Ecology of seagrass bed of *Halophila ovalis* in Ashtamudi Estuary was assessed by Nair et al. (1983) based on sampling at Kanjirakode. The average standing stock of *H. ovalis* varied from 3.6 to 4.8 g^2 (dry) during June to January. These bed areas have been heavily disturbed due to pollution and conversion of shorelines.

Mangroves form a conspicuous feature of Ashtamudi Estuary and a total of 12 true mangrove species and 6 associate species have been recorded here (Annex 2) (Sumesh et al., 2014 and Vidyasagaran and Madhusoodanan, 2014). These species were collected from Asramam, Neendakara, Thekkumbhagam and Kadapuzha areas of the wetland. Among them, *Rhizophora apiculata* is the pioneer species which inhabits the fringes. Asramam, which is one of the most famous mangrove sites in Kollam

Mangroves at Munroe Island

District, had undergone severe destruction due to land reclamation, conversion and real estate activities. *Syzygium travancoricum* which is a critically endangered species is found here in very few numbers. Similarly, *Lumnitzera racemosa*, one of the rare mangrove species in Kerala, has shown its restricted distribution in Asramam area. *Ceriops tagal*, believed to be extinct in Kerala coast was being rediscovered from Vincent Island of Kollam district (Vidyasagaran and Madhusoodanan, 2014).

The overall area of mangroves within Ashtamudi has rapidly declined. Mangroves have declined from 1.46 km^2 (Sajeev and Subramanian, 2003) in 1967 to 0.95 km^2 in 2016. They are restricted to three patches near Asramam, Munroe Islands and Kumbalam. Their regeneration has been affected owing to diverse range of anthropogenic pressures as loss of habitat, cattle grazing, coconut husk retting, and harvest for medicine, timber and pollution.

Fauna

A comprehensive study of the faunal diversity of Ashtamudi has been undertaken by Zoological Survey of India during 1988 to 1991 (Raghunathan, 2007). The study resulted with the identification of 12 species of polychaeta, 6 species of amphipoda, 3 species of isopoda, 13 species of copepoda, 7 species of cladocera, 9 species of prawns, 10 species of timber borers, 3 species of chaetognatha, 2 species of pelecypods, 125 species of fish and 92 species of birds in the wetland area (Raghunathan, 2007). Besides, several other studies as distribution and seasonal variation of benthic fauna (Divakaran et al., 1981), seasonal variation of zooplankton (Divakaran et al., 1982), fishery resources (Nair et al., 1983), distribution of benthic macrofauna (Nair et al., 1984), benthic foraminiferal assemblage (Nagendra et al., 2011), aquatic bio-resources of Ashtamudi were also carried out to assess the faunal diversity of the estuary.

Zooplankton

Zooplankton community of Ashtamudi have been assessed in various studies (Divakaran et al., 1981; Divakaran et al., 1982; Nair et al., 1984; Raghunathan, 2007 and Nagendra et al., 2011). Compiling the list indicates presence of atleast 70 species belonging to 7 classes representing 47 families of freshwater, brackish and marine origin in the last three decades (Annex 3). Among these, the most dominant class were Polychaeta (31%), Malacostraca (27%), Hexanauplia (20%) and Branchiopoda (14%). A preliminary study on the benthic foraminiferal assemblage of the estuary

was also conducted during 2000 which resulted in a total of 29 benthic and 3 planktic foraminiferal species (Nagendra et al., 2011).

Molluscs

Assessments carried out since 1981 indicate presence of atleast 16 species of molluscs in the estuary (Annex 4) (Divakaran et al., 1981; Nair et al., 1984 and Raghunathan, 2007 and Mohamed et al., 2013). These species majorly belong to two classes bivalvia (15 species) and gastropoda (1 species) comprising of 8 families. Among the bivalves exploited in Ashtamudi, clams are the most widespread and abundant. The important species of clams are *Paphia malabarica*, *Villorita cyprinoides*, *Marcia opima* and *Meretrix casta*. Of these, *Paphia malabarica* (Short neck or yellow foot clam) is widely distributed and continuously exploited clam for local consumption as well as export. The abundance of molluscan species has been influenced by changes in salinity regimes since the mid 80s. *M. opima* once abundant in the Neendakara region has been nearly completely replaced by *P. malabarica*, a species with high salinity tolerance.

Fish

A preliminary survey of fishery resources of Ashtamudi was conducted by Nair et al. 1983. The survey resulted in 97 species of fish belonging to 39 families. Of the total, about 50% of the species (42 species) were found to be true marine, 3 were brackish and 11 were freshwater species. The remaining 41 species were transient forms i.e.

Chinese dip nets in Ashtamudi

they were estuarine-riverine, marine-estuarine, and marine-estuarine-riverine species. Assessment of faunal diversity of Ashtamudi conducted by Raghunathan, 2007 along with the earlier investigation of Nair et al. 1983 yielded a total of 125 species of fish from the estuary. Raj et al. 2014 also conducted a study to assess the aquatic bio-resources of Ashtamudi during 2009-2011 where a total of 91 species of aquatic fauna belonging to 39 families have been recorded from the estuary. Of the 91 species, 68 were finfish, 5 were crabs and 9 species each were of prawns and molluscs. Among the finfish, 24 were true marine, 9 were true freshwater and 4 were true estuarine species. The remaining species were transient forms inhabiting estuarine-riverine (8 species), marine-estuarine (19 species) and marine-estuarine-riverine (4 species).

Consolidating the available studies indicate that the estuary, in the last three decades, has been a habitat to atleast 151 species belonging to 55 families (Annex 5). Gobiidae, Carangidae, Clupeidae and Leiognathidae are the dominant families.

Discussions with researchers during management planning revealed that at present the estuary might be inhabited by only 87 fish species. 29 species recorded in the estuary in the 80s (Nair et al., 1983) are no longer found. An additional 19 species of marine and transient forms have inhabited the estuary in the intervening period. A major proportion of decline in species richness is the account of reduction in freshwater species (*Rasbora daniconius, Danio aequipinnatus, Puntius filamentosus, Puntius amphibious, Puntius sarana, Puntius vittatus, Callichrous* sp.*, Xenentodon cancila, Channa punctata, Channa striata, Anabas testudineus* and *Puntius mahecola*). This is a very significant observation and nearly correlates with changes being observed in other groups such as clams and needs to be affirmed with comprehensive biodiversity assessments.

Bird

Ashtamudi estuary has been part of the Asian Waterbird Census (a volunteer based mid-winter waterbird census programme initiated in 1987) since 1992 and so far the site has been surveyed 15 times. The population of birds averaged at 2165 individuals during the census period of 1992-2015 with a peak count of 5291 in 2002 while the number of species ranged between a minimum of 16 to a maximum of 51 species (Fig. 2.8). There are 11 major bird congregation areas in and around the estuary (Map 2.13). These are mostly the shoreline areas of the estuary where the water is shallow and the availability of food is relatively higher.

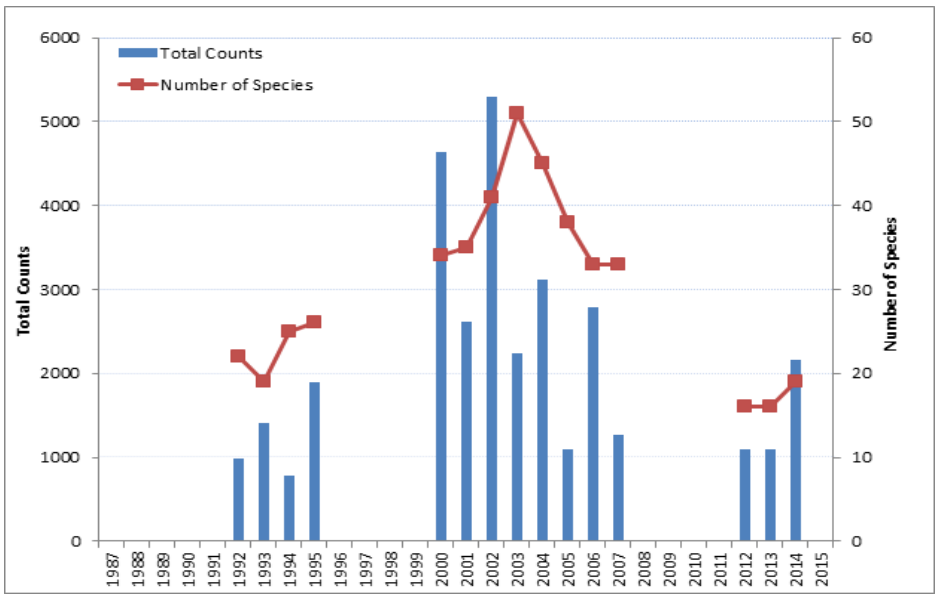


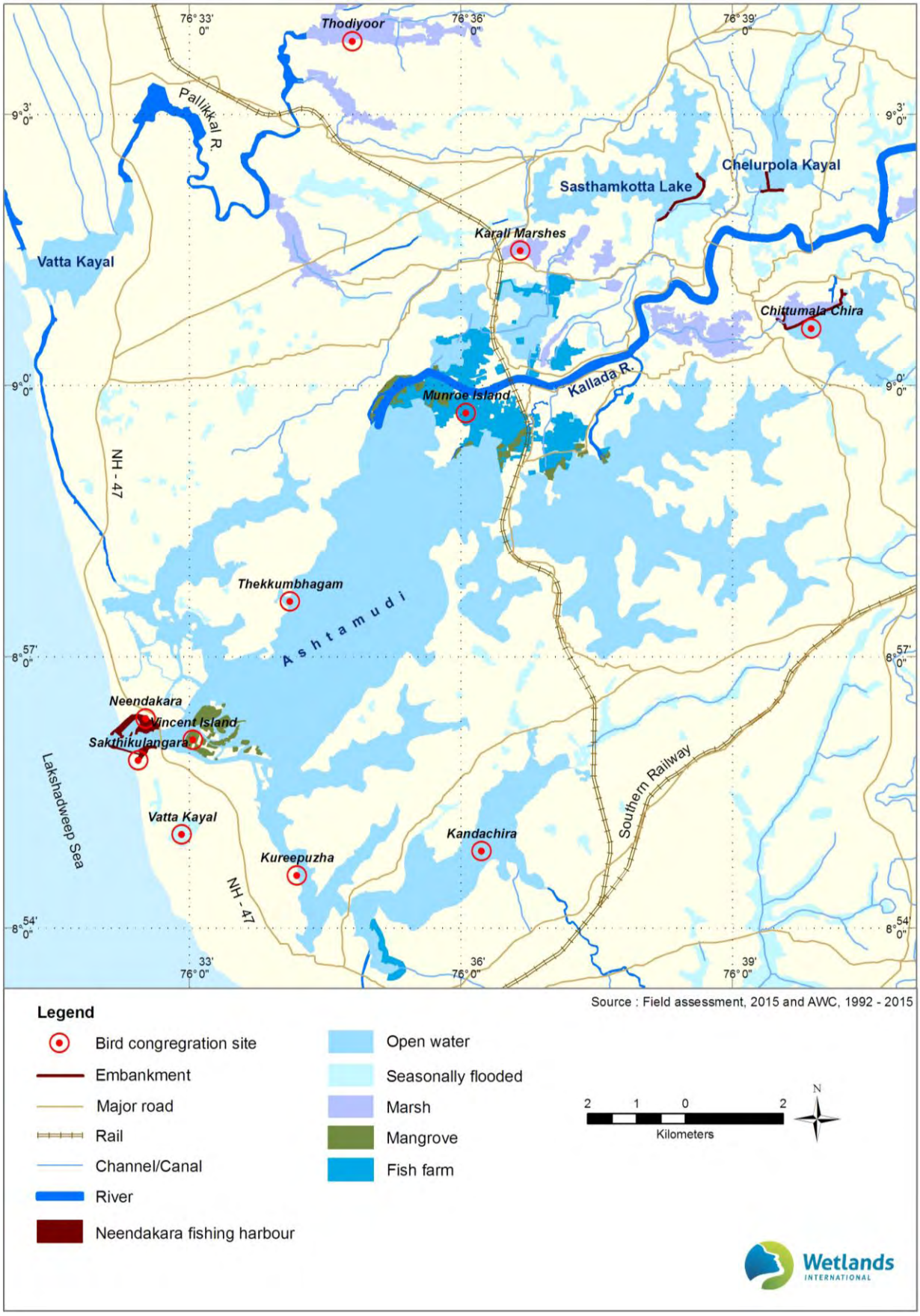
Fig. 2.8 |. Trends in bird species and their counts (AWC 1987-2015)

The counts over the years show great variation and such fluctuations are largely due to varying coverage in different years. The list of birds compiled from the census records yield 69 exclusive species. However, the analysis of Raghunathan, 2007 lists a total of 92 bird species in the estuary. Consolidating the two datasets gives a list of 116 birds belonging to 39 families (Annex 6). Among them, Scolopacidae, Laridae and Ardeidae were the dominant.

Of these 116 bird species, 71 are waterbirds and 86% (61 species) of these waterbirds are winter migrants (as per BirdLife International Database). A total of 9 waterbird species are classed as Near Threatened species according to the IUCN Red List of Threatened Species (version 2016-3). Apart from Ashtamudi Estuary, waterbirds are also known to inhabit the adjoining wetlands as Chittumala, Karali Marshes, Monroe Island, Vattakayal and also Sasthamkotta Lake highlighting the role of Ashtamudi and its adjoining marshes as a complex in sustaining these habitats.

Key Issues

The most extensive and most singular form of pollution in the backwaters of the country's south west coast including Ashtamudi is the retting of coconut husk for production of coir. This organic pollution leads to the depletion of the faunal diversity of the backwaters especially during the pre-monsoon period (peak retting period). Studies have shown that there is massive depletion in the plankton, benthic fauna and fish diversity in the retting zones as compared to the non-retting areas thus adversely affecting the primary production of the backwater.



Map 2.13 | Bird congregation sites in Ashtamudi

The overall salinity of the estuary is on the rise owing mainly to the rise in temperature, decrease in rainfall and the reduced inflow from Kallada River due to the construction of Kallada Dam. Due to this, there is a shift in the species composition of Ashtamudi showing more preference to salt tolerant varieties. This is evident from the fact that the once present freshwater fish species are no longer present in the estuary.

Mangrove cover plays a dominant role in shaping the biodiversity of the estuary. Apart from the mangrove species, this ecosystem is also known to harbour a diversity of fauna as fish, prawns and crabs. There is a sharp decline in the mangrove area of the estuary due to change in the land use such as reclamation for real estate activity. This has directly affected the flora and fauna of the estuary as many of the fish, prawns and crabs use this habitat in a variety of ways (spawning, nesting and breeding grounds) at different stages of their life cycle. Also, many of the mangrove species found in Ashtamudi are good soil binders and help protect the shoreline of the estuary. But, the rapid depletion of mangroves has caused shoreline erosion of the estuary and disfigurement of other islands in the backwater.

With regards to the assemblage of birds, the estuary and its adjoining marshes are under tremendous threats from various anthropogenic pressures. The Kandachira part of the estuary where a large congregation of Black-tailed Godwits could be seen has now been reduced to a few numbers. Karali Marshes which was once a haven for birds (especially known for the huge congregation of Purple Swamphen), have now been reduced to just a few due to extensive sand mining in the area.

2.5 Socioeconomics

Livelihoods of communities living around a wetland ecosystem have a direct bearing on its ecological character. The current section includes an analysis of livelihood systems and their interrelation with wetland functioning. The analysis is based on socioeconomic survey of 196 households (drawn from 17 wards) conducted during July to October 2015. The survey covered 10 Panchayat located along the estuary shorelines (Thekkumbhagam, Munroe Island, Perinad, Thevalakkara, Thrikadavur, East Kallada, Perayam, Thrikkaruva, Neendakara, and Chavara). Selection of household was done using stratified random sampling, using primary occupation as a selection variable. Focal Group Discussions were also conducted to understand communities' views, rights and capacities to engage in integrated management of Ashtamudi.

Developmental settings

Ashtamudi is fringed by the Kollam City, famed as the 'cashew capital of India' given the high concentration of trade in this commodity. Developmental planning of the Kollam City has a significant bearing on the status of Ashtamudi Estuary, its prime natural asset.

Kollam (historically referred to as Quilon), evolved as a port town, with extensive sea-trade relationships with Western India as well as countries as far as China. Merchant Sulaiman of Siraf in Persia, who visited in Malabar in the 9th century, found Quilon to be the only Indian port with high amounts of Chinese goods (Menon, 1964). Neendakara served as a small port for the Portuguese traders in the 16th century, and subsequently by the Dutch invaders till the 18th century (circa 1795) (Menon, 1878).

A view of Kollam Municipal Corporation

The Dutch Naval Commander General D' Lanoy is believed to have ordered reclamation of part of Ashtamudi marshes on the southern flanks (Dalawapuram) for plantation of coconut and other fruit trees (ibid). During the nineteenth century, the British furthered the expanse of Quilon by locating army garrison and extending markets. Railway links with Thirunelveli were established in 1904, and with Trivandrum in 1918 (Menon, 1964). Establishment of roads and railway link between Kollam to Ernakulam via Munroe Island in 1958 eventually fragmented Asthtamudi estuary in two, especially isolating Karali marshes.

Kollam City was accorded the status of a Municipal Corporation in 2000 by the Department of Town and Country Planning of the Government of Kerala. As per census records, the population of the city has grown 3.8 times between 1961-2011 (increasing from a population of 0.09 million to 0.35 million. While the growth itself is similar to that experienced in other parts of the state, the population density has become significantly high. Of the five sub-district that constitute Kollam Distrcit, the Kollam taluk had a population density of 2,565 persons per square kilometre in 2011 (computed from Census Records).

Much of fisheries infrastructure development around Ashtamudi has taken place after establishment of an intermediate fishing port at Neendakara. Its development started with identification under the Indo- Norwegian Foundation in 1952 for the establishment of Fishing- cum- Community Development Programme in India. During 1963-67, based on the recommendation of the Intermediate Port Development Committee of the Government of India, two breakwaters of length 610 m (seaward) and 380 m (leeward) were constructed in order to provide a sheltered basin and a navigable approach. A recommendation to establish a harbor at the location was finally realized in the 1980s, with funds provided by the Government of India as well as with state resources, and major parts of work completed in 1988. Further modernization and repair of the harbor were completed in 2010.

The highly densely populated shoreline of Ashtamudi has 12 Gram Panchayat of 3 taluk, namely Karungapally, Kollam and Kunnathur (Map. 2.14). These 12 panchayat, as per 2011 census, have a total population of 0.27 million, and include wards of five urban centers, which are adjoining to the estuary (Annex 7). The population estimate includes the Munroe Island, inhabited by 2,407 households (GoI, 2012).

Data from household surveys indicated that 10% of the households had direct dependence on Ashtamudi for livelihoods. Of these, a majority (93%) engage in fishing, including clam collection, while the rest derive sustenance from tourism and

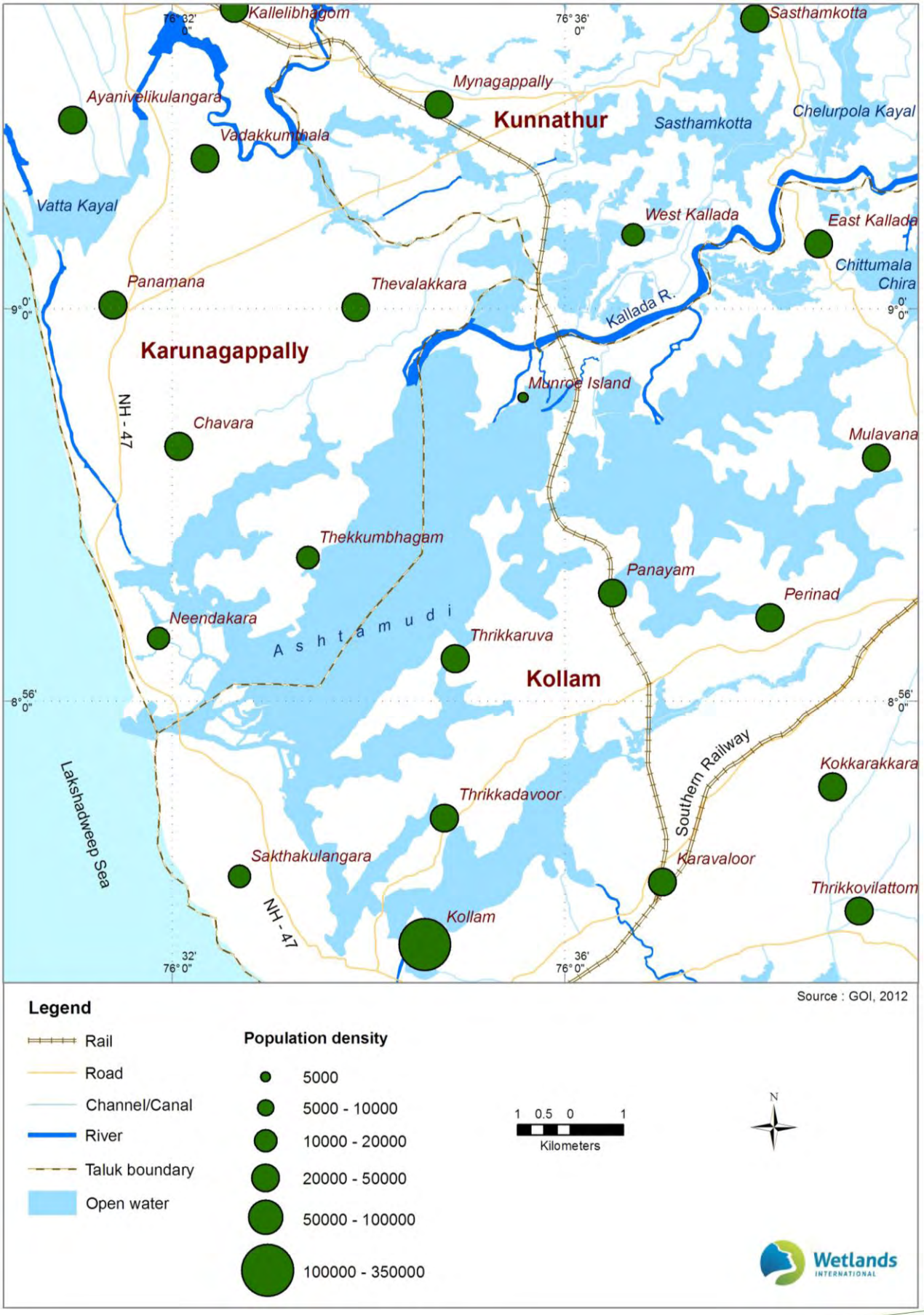
coir processing. The remaining households engage in small businesses, livestock farming or migrate to gulf region for livelihoods. A profile of primary and secondary occupation categories is depicted in Table 2.4. Map 2.15 presents abroad spatial distribution around Ashtamudi Estuary.

Kerala, in general, is economically and socially well-endowed, and such trends reflect in the socioeconomic indicators (Table 2.5). The households are nearly all literate. Nearly all household own houses, and 61% have concrete structures. Nearly all houses have toilets, though only half of these toilets have septic tanks. Drinking water, either though individual connections or community connections is available to nearly 53% of the households, and the rest source water from shallow wells. Water is invariably boiled before use, which limits instances of water-borne diseases, despite living in a region of high coliform and pathogen contamination. All households use clean energy source for cooking (Liquefied Petroleum Gas). With an average annual income of Rs. 200,426, the households living adjoining have much better economic condition that in other Ramsar Sites. However, in comparative terms, coir retters, capture fishers and laborers form the bottom of the rung, and significantly lesser incomes that the rest. Their asset indicators also rank lower than the rest (Fig. 2.9).

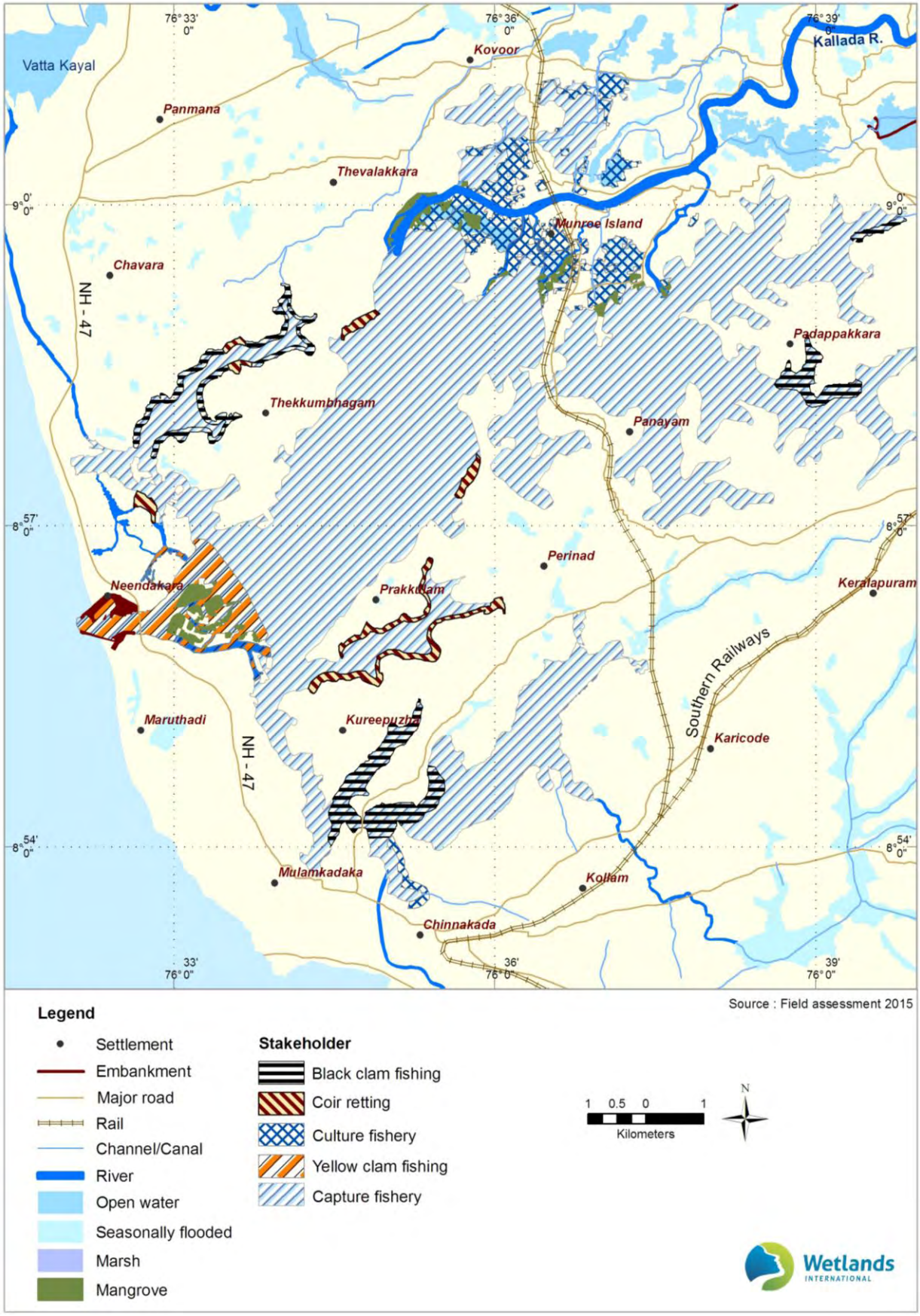
Table 2.4| Occupation profile of communities living around Ashtamudi Estuary

	Secondary Occupation categories										
	% of total HH	Capture fishing	Culture fishing	Marine fishing	Clam Collection	Coir processing	Small business	Service	Labour	Migrant	Agriculture & Horticulture
Capture fishing	7%	**100%**	0%	0%	7%	0%	14%	0%	14%	0%	0%
Culture fishing	1%	0%	**100%**	0%	0%	0%	0%	0%	0%	0%	0%
Marine fishing	15%	0%	0%	**100%**	0%	0%	17%	0%	8%	3%	0%
Clam Collection	1%	0%	0%	0%	**100%**	0%	0%	0%	0%	0%	0%
Coir processing	1%	0%	0%	0%	0%	**100%**	0%	0%	40%	20%	0%
Small business	13%	0%	0%	0%	0%	0%	**100%**	0%	26%	25%	11%
Service	27%	2%	0%	0%	0%	0%	38%	**100%**	2%	4%	0%
Labour	23%	9%	0%	0%	0%	0%	0%	0%	**100%**	0%	0%
Migrant	12%	0%	0%	0%	0%	0%	0%	0%	0%	**100%**	9%

(Primary occupation categories are expressed as % of total number of households surveyed, and are to be read along columns. Secondary occupations are expressed as a percentage of primary occupation categories, and are to be read along rows)



Map 2.14 |Population centres around Ashtamudi Estuary



Map 2.15 | Location of major stakeholders

Table 2.5 | Socioeconomic indicators

Livelihood assets			Unit	Total	Capture fishing	Culture fishing	Marine fishing	Clam Collection	Coir processing	Small business	Service	Labour	Migrant
Education													
	Adult literacy		% of Adult in household	99%	100%	100%	99%	100%	100%	100%	99%	100%	99%
		Male	% adult male in household	98%	100%	100%	97%	100%	100%	97%	99%	100%	97%
		Female	% adult female in household	99%	100%	100%	94%	100%	100%	100%	100%	100%	97%
Quality of housing													
	Owned		% Household	96%	93%	100%	100%	100%	100%	93%	94%	100%	92%
		Concreate house	% Household	61%	36%	100%	47%	50%	100%	63%	6%	60%	71%
		Semi Concreate house	% Household	23%	14%	0%	40%	50%	0%	15%	66%	27%	21%
		Earthen house	% Household	16%	50%	0%	13%	0%	0%	22%	19%	13%	8%
	Electricity	> 8 hrs	% Household	100%	100%	100%	13%	100%	100%	100%	100%	100%	100%
	Drinking water	House piped water supply	% Household	28%	15%	100%	73%	100%	0%	39%	6%	18%	18%
		Well	% Household	38%	62%	0%	7%	0%	100%	32%	58%	24%	45%
		Public piped water supply	% Household	25%	15%	0%	17%	0%	0%	21%	2%	50%	32%
	Energy for cooking	LPG	% Household	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Kerosene	% Household	36%	0%	0%	0%	0%	0%	100%	0%	100%	0%
	Toilets		% Household	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Single Pit	% Household	29%	43%	20%	22%	0%	50%	22%	39%	37%	14%
		Double Pit	% Household	29%	43%	30%	67%	50%	0%	30%	18%	14%	18%
		Septic tank	% Household	42%	14%	50%	11%	50%	50%	48%	43%	49%	68%
Mode of transport													
	Cycle		% Household	6%	7%	5%	7%	0%	50%	7%	6%	9%	4%
	Motorcycle		% Household	33%	36%	50%	30%	50%	0%	33%	0%	27%	29%
	Car/Jeep		% Household	11%	0%	1%	7%	0%	0%	7%	40%	2%	21%
Productive assets													
	Agriculture land	Own Agricultu re land	% Household	2%	0%	0%	0%	0%	0%	0%	1%	0%	4%
		Landholding (acre)	Average	0.35	0	0	0	0	0	0	0.35	0%	0.3

	Livestock	Own Livestock	% Household	8%	0%	0%	10%	0%	0%	4%	2%	4%	8%
		Own Poultry	% Household	0%	0%	100%	3%	0%	0%	0%	0%	0%	0%
	Fishing implements	Boats	% Household	10%	37%	50%	10%	0%	0%	0%	0%	0%	0%
		Nets	% Household	13%	80%	100%	13%	0%	0%	0%	0%	0%	0%
Membership to community organization													
	Village panchayat		% Household	1%	0%	0%	0%	0%	0%	0%	2%	0%	0%
	Panchayat committees		% Household	2%	0%	0%	0%	0%	0%	4%	2%	0%	4%
	NGO/Conservation group/Youth club		% Household	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Agricultural cooperatives		% Household	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Fish cooperatives		% Household	7%	43%	0%	0%	0%	0%	4%	0%	7%	0%
	Water user associations/Cultivator association		% Household	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Coir federation		% Household	2%	0%	0%	0%	0%	100%	0%	0%	0%	0%
	Kudumbashree		% Household	55%	57%	100%	53%	0%	0%	33%	60%	67%	54%
Annual Income													
			Average	200,426	172,308	200,000	283,333	225,000	75,000	231,154	197,843	110,930	242,609
			Standard Deviation	107,185	90,476	12,000	84,418	50,000	12,000	122,125	87,460	60,388	101,722
Annual Expenditure													
			Average	93,201	89,286	90,000	92,333	90,000	50,000	100,370	96,800	84,070	105,417
			Standard Deviation	42,269	31,977	10,000	44,232	45,000	20,000	46,944	45,420	29,726	52,169
Indebted													
			% Household	9%	29%	0%	0%	0%	20%	11%	11%	9%	4%
			Average Amount	226,429	101,667	0	0	0	200,000	225,000	438,333	100,000	150,000

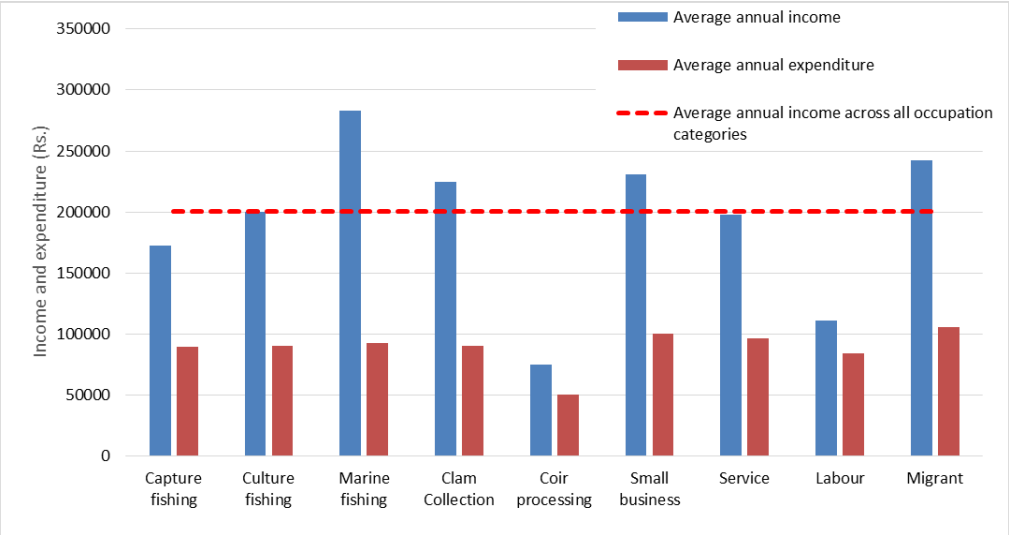


Fig 2.9 | Annual Income and Expenditure across various occupation categories

(Data Source: Household Survey)

Ecosystem Services

Communities living around Asthamudi, and the broader population are linked to the estuary in a number of direct and indirect ways. A useful frame for defining these interrelationships is through the lens of ecosystem services which define the benefits people receive from the ecosystems. Maintaining ecosystem services is an essential component of wetland wise use. The ecosystem services described in this section are classified under three broad groups, namely provisioning, regulating, cultural and supporting services.

Provisioning Services

Fisheries

The estuary is a rich source of fish, prawn, crab and clam resources. Commercial fisheries are reported to comprise 57 fish, 6 shrimp, 1 prawn, 5 crab and 6 bivalve species (Kurup and Thomas, 2001, List at Annex 8 and 9). These include a range of true estuarine, marine migrant and resident species.

Ashtamudi yields an annual landing of 28,611 MT of biomass (Mohamed et al., 2016) based on 5 years catch assessments done at five sites), having an estimated market value of 970 million (Mohamed et al., 2016, based on market price data of 2014). The catch is dominated by clams which constitute 83% of the total, the rest comprised by fish (7%), crab (6%) and prawn (4%) (Fig. 2.10). In market value terms, the catch in 2014 was worth Rs. 985 million, the major share of which was contributed by clam

(51%), followed by crab (19%), fish (18%) and prawn (12%) (Mohamed et al., 2016). Trends in landing of fish, prawn, crab and clams over the years is presented in fig. 2.11. Mullets, pearl spot, cat fishes, estuarine sprat, gerrieds, goby (*Glossogobius giuris*), ambassids, *Chanos chanos* and *Caranx* sp. constituted larger group of finfish whereas *Fenneropeanaeus indicus*, *Metapenaeus dobsoni, Macrobachium rosenbergi, Scylla tranquibarica, S. serrata* and *Portunus pelagicus* in shellfish dominant species in fish landing (Harikishnan, 2015). There are three major types of fisheries practiced in the estuary, namely capture, culture and clam fishing. Each of these is discussed in the following sections.

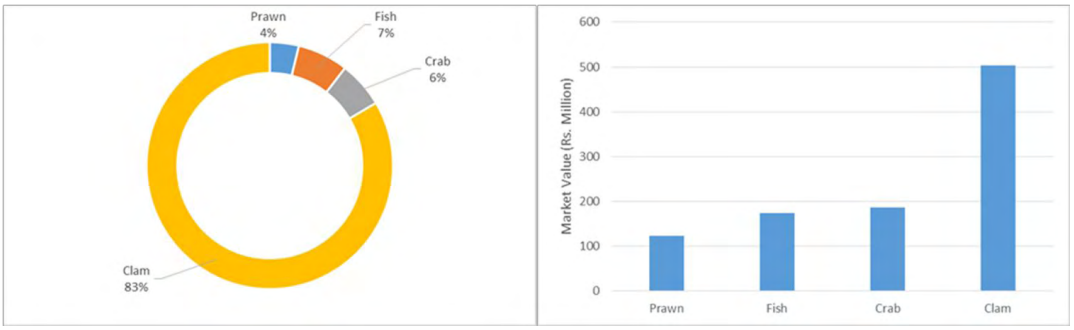


Fig 2.10 Total Fish,Prawn and Clam landing (2014) in terms of biomass and market value

(Data Source: Mohamed et al., 2016)

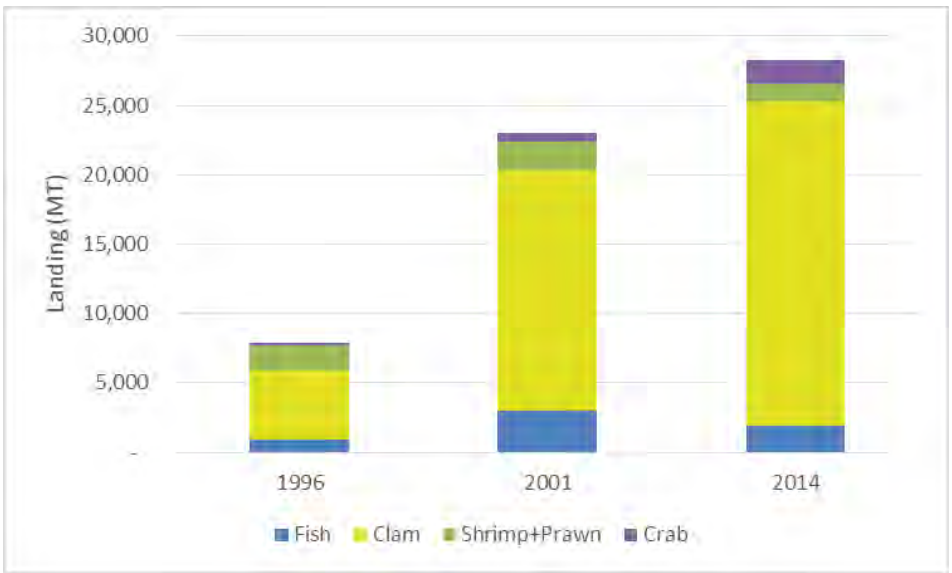


Fig 2.11 Trends in commercial landings *(Data Source: Sukumaran and Unnithan (2006)[1], Kurup and Thomas (2001) cited in Harikrishnan (2015), Mohamed et al. (2016)*

[1] Estimation of total landing for 1996 has been done by imputing a clam landing of 5,000 MT, as specific data for the year was not accessible)

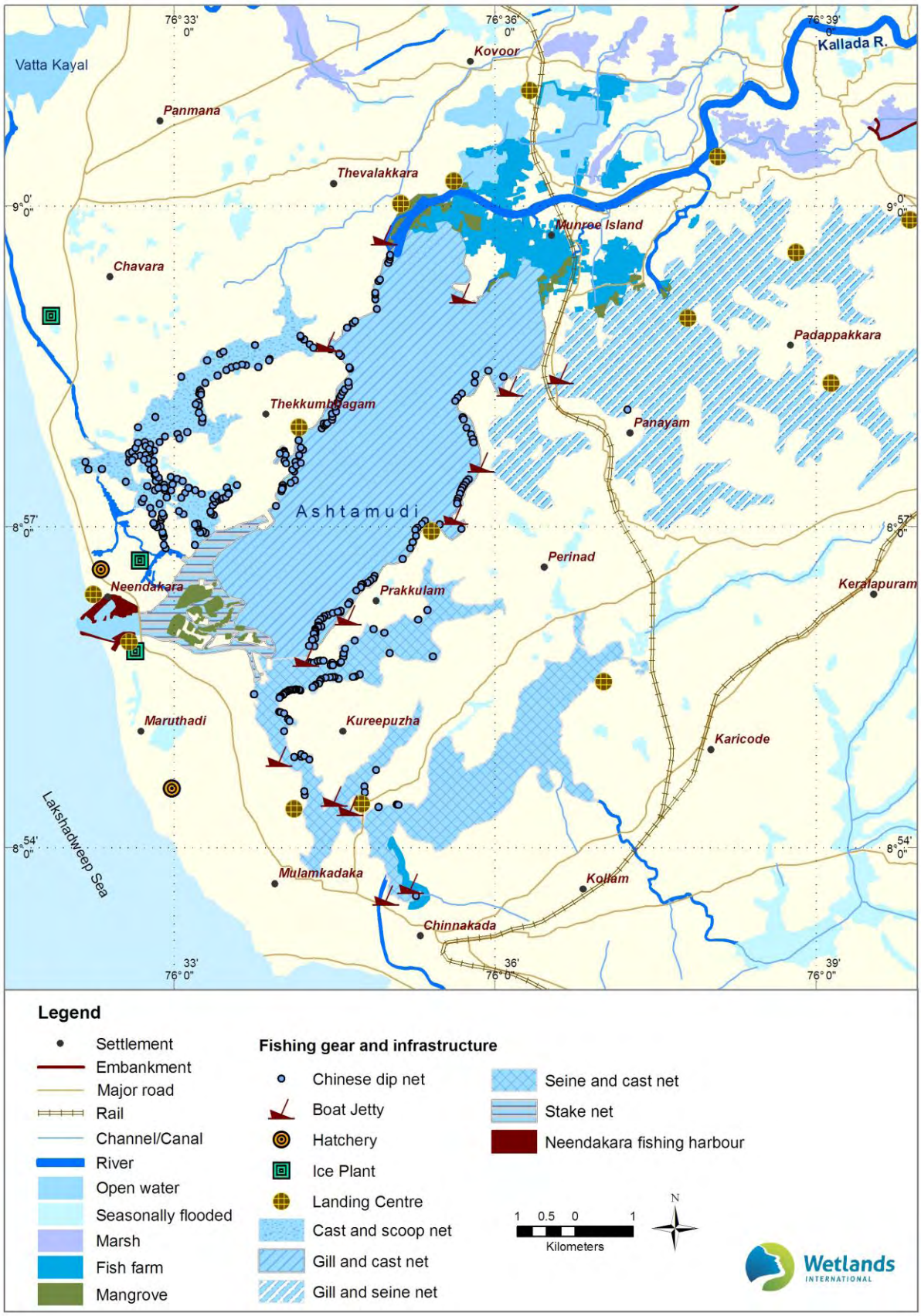
Capture fisheries: Capture fisheries in Ashtamudi forms the base of livelihoods of nearly 5,200 households, mostly of Latin Catholic and Araya communities. Fishing is done round the year, barring the period between June 15 to end July. Kollam, Kottarakara, Punalur, Pathanamthitta, Ranni, Kozhencherry and Parakode are major fish markets wherein the fish catch is traded. A fisher household on an average does fishing for 272 days in a year.

Total annual finfish, crab and shrimp/prawn landing at present is estimated to be 4,877 MT. This is lower than the 2001 estimates of 5,700 MT. In the intervening period, there has been a near threefold increase in crab landings, which dampens the decline in fish and prawn landings. The landing data, however, are not based on a uniform data collection protocol, and there is a high likelihood that a quite a significant proportion of changes would be attributed to methodological issues. Community surveys and focal group discussions, however, unanimously indicated a decline in fish and prawn landings.

Fishing is done using a range of nets, which include cast, gill, dip, siene, dredge and stake nets. An overall estimate of numbers of crafts used for capture fishing purposes, derived from a survey of fisher households conducted as a part of management planning is presented in Table 2.6. Apart from dredge net, which is near exclusively used from clam collection, rest are all used for fishers to capture fin and shell fish and prawn. When contrasted with estimates of fishing gears published in 2004, no major changes can be discerned, except in the number of dip nets. Map 2.16 indicates the areas wherein different types of nets are used at present.

Table 2.6 Fishing crafts and gears used in Ashtamudi

Fishing Crafts and Gears	2015	2004
Cast net	600	455
Gill net	1200	952
Chinese dip net	350	144
Seine net	400	317
Dredge	800	
Stake net	200	250
Boat	1900	



Map 2.16 | Use of fishing crafts, gears and infrastructure in Ashtamudi

Chinese dip-nets are one of the characteristic features of backwater fisheries in the state. Believed to have been in use for over 500 years, these nets are fixed in tidal regions of inshore areas, with sinkers floats and stakes and operated upto a depth of 5 m (Pillai et al., 2016). Lever system mounted on a wooden platform enable operation of the gear, which is lifted at periodic intervals (mostly using motors), based on availability of catch, which is mostly linked to the duration of tides. Assessment of hauls of dip nets in Vypin , a nearly estuary for a period of two years (January 2013 to December 2014) indicated that Mugil cephalus dominates (34%) the catch during most of the months followed by Megalops cyprinoides 12%, Johnius glaucus 8.8%, Stolephorus indicus 8%, Scatophagus argus 8%, Arius caelatus 5% and Gerres filamentosus 4%. The number of Chinese dip nets has increased from about 50 reported in late sixties (Menon, 1964) to nearly 150 reported at close of 2000, and 350 at present.

There has been no significant change in population of fishers fishing in Ashtamudi. The present population of 5,200 households is only 1.4 times the number reported in the 1960s (Menon, 1964).

Estuarine fisheries is organized through inland fisher cooperative societies (Ulnadan Matasya Thozhilal). These societies are registered with the Department of Fisheries, and are the key institutions for providing the members with access to subsidies for nets and boats, housing (upto two lakh), education and electricity. The members of the cooperatives sell the catch at prices determined by matsyafed and fish merchant associations. The role of fisher cooperatives has been an issue of concern, while their enrolment has been extensive, their impact in terms of securing benefits to their members has been fairly limited. Such issues have been reviewed and brought to the notice of Fisheries Department at a number of instances. The situation of cooperatives as described in the 1980s (Kurien, 1980) does not seem to be much different from the present.

Key fisheries infrastructure around Ashtamudi include 22 ice-plants (established capacity of 941 KW capacity), 20 landing centers and 5 fish hatcheries (2 owned by Matsyafed, 1 by FFDA, 1 by BFFDA and 1 under private ownership).

Several nets, especially stakenets, use very small mesh sizes thus harvesting juveniles, and thereby leading to decline in overall stock (Jyothilal et al., 2015). Ashtamudi was once famed for juvenile fishing, locally termed as padal fishing. The method involved construction of artificial reefs of twigs and leaves of trees in the shallow areas wherein juveniles and sub-adults of major commercially important fish as pearlspot, mullet

and shrimp tend to cluster. In 2001, atleast 400 such units were operational (Thomas and Kurup, 2004), leading to an annual biomass decline of atleast 600 MT (Kurup and Thomas, 2001). The instance of padal fishing has come down significantly, while stake nets continue to be a stress on the estuary's fisheries.

Clam fisheries: Ashtamudi is a source of a diverse range of clams, which are harvested for meat, as well as for industrial use. The estuary contributes as much as 90% of the overall clam meat export trade of India. Short neck clam, *Paphia malabarica*, dominate the high salinity areas adjoining Neendakara, whereas the freshwater inflow zones, such as creek areas of Thekkumbhagam, Kureepuzha and Padapakkara have beds of back clams (*Villorita cyprinoides*).

Currently, about 23,800 MT of clams are harvested from the estuary annually. As per assessments of CMFRI, the total clam biomass in the estuary is 24,191 MT in an estimated bed area of 173.3 ha. *P. malabarica* constitutes 87.4% of the total biomass and the rest by *M.casta* (Mohamed et al., 2013). The estuary used to be an important source of baby clam (*M. opima*) till the 80s, however, its production has rapidly declined and beds replaced by *P. malabarica*, most plausibly due to increase in average salinity in the mouth area of the estuary. Notably, in 1983, 698 MT of clams, primarily *M. opima* were harvested from Ashtamudi and the meat exported to Japan and Germany (Appukuttan et al., 1988).

P. malabarica landing from Ashtamudi Estuary

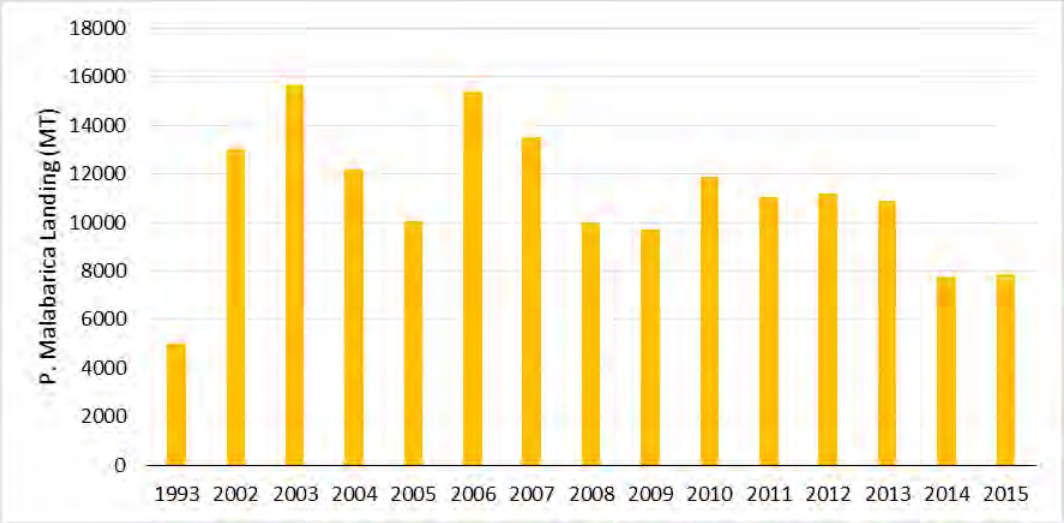


Fig.2 12| Trends in landing of *P. malabarica* (Data Source: Mohamed et al., 2013 and Mohamed et al., 2016).

Clam fishery provides a base of livelihoods to about 1,500 fishers, most of which are settled around the estuary near Needakara port. The clams are exploited by a range of methods including traditional scooping, hand picking and dredging. During periods of low tide, the buried clams are picked up after removing sand, and collected in net bags tied around the waste. Within a 4-5 hours operation, a fisher can collect upto 50-150 kg of clams. In deeper areas clams are also collected by canoes, with upto two divers collecting upto 200-300 kg of clams in a day. About 60% of the fishers are engaged in clam collecting, 17.5% each in clam processing and buying, and the rest engage as clam agents (2%). Clam fishery and processing provides upto employment of 18 days in a month, contributing an average income of Rs. 14,700 (Mohamed et al, 2016).

Culture Fisheries: The creeks and the islands present conducive environment for culture fisheries in Ashtamudi Estuary. Munroe Island remains a hub, wherein nearly 400 ha of the 1,337 ha area is used for such fishing practices. *Etroplus* is the major farmed species here, followed by brackishwater prawns. Aquaculture is also carried out at relatively small scale in islands adjoining Vincent Island. The CMFRI and the Fisheries Department have made several attempts to promote culture of mussel, sea bass and oysters in the estuary. Recent attempts for cage culture of *Etroplus* has met with low degree of success (Baiju et al., 2012).

Coir retting

The saline waters of the estuary provide an easy and accessible avenue for retting coir. To produce coir, coconut husks are first treated in saline water (retting), and the

Aquaculture farm in Munroe Island

fibrous mass removed by semi-hard shell (ripping). To soak the husk in estuarine waters, a circular net of coir is stretched across the water surface and stacked with husks, with the stack covered with coconut leaves to prevent drying. The husk mass remains in water for a period ranging between six to eight months. Tannin is wasted away due to flushing, also enabling bacterial action that decompose fiber binding pectin. Salinity lends strength to the fiber. The process also leads to generation of a large quantity of fiber dust or pith, which have more recently been used for indoor gardening, or even baled into bricks. During surveys conducted in 2015, atleast 25 retting units were operational around Ashtamudi. Much of the retting operations are concentrated around Trikkaruva, Thekkumbhagam and Chavara. Coir thus retted forms an important input to the cottage to upto medium scale industries producing ropes, mats, baskets, wall hangings. Much of the employment in coir processing is of womenfolk.

The retting process is also a stressor for the estuary as a large quantity of polyphenols are liberated in the process, leading to toxic conditions for biological community and polluting the aquatic environment. There have been repeated calls for use of environmentally safe technologies for the retting process.

Coir retting in Kuripuzha

Inland navigation

Ashtamudi forms a part of the national waterway network 3, connecting Kollam to Kottapuram for a distance of 168 km. Of the 7 terminals located along the waterway, Ashtamudi and Kollam are located along the estuary. Regular boat services to Muthiraparamb, Guhanandapuram, Ayiramthengu, Munroe Island and Alappuzha can be availed from Kollam jetty.

Regulating services

Estuaries are known to play an important role as sink of nutrients, regulators of climate and buffer for natural hazards. No assessment has been done to assess these ecosystem services. Developmental activities, such as modification of shorelines and removal of mangroves have limited the role of Ashtamudi in preventing shoreline erosion. The pollution loading is also way beyond its natural renewal capacity, tending the wasters to be a health hazard.

Cultural services

Ashtamudi is famed as the gateway of Kerala backwaters. As per information provided by the District Tourism Promotion Council (DTPC), over 50 houseboats

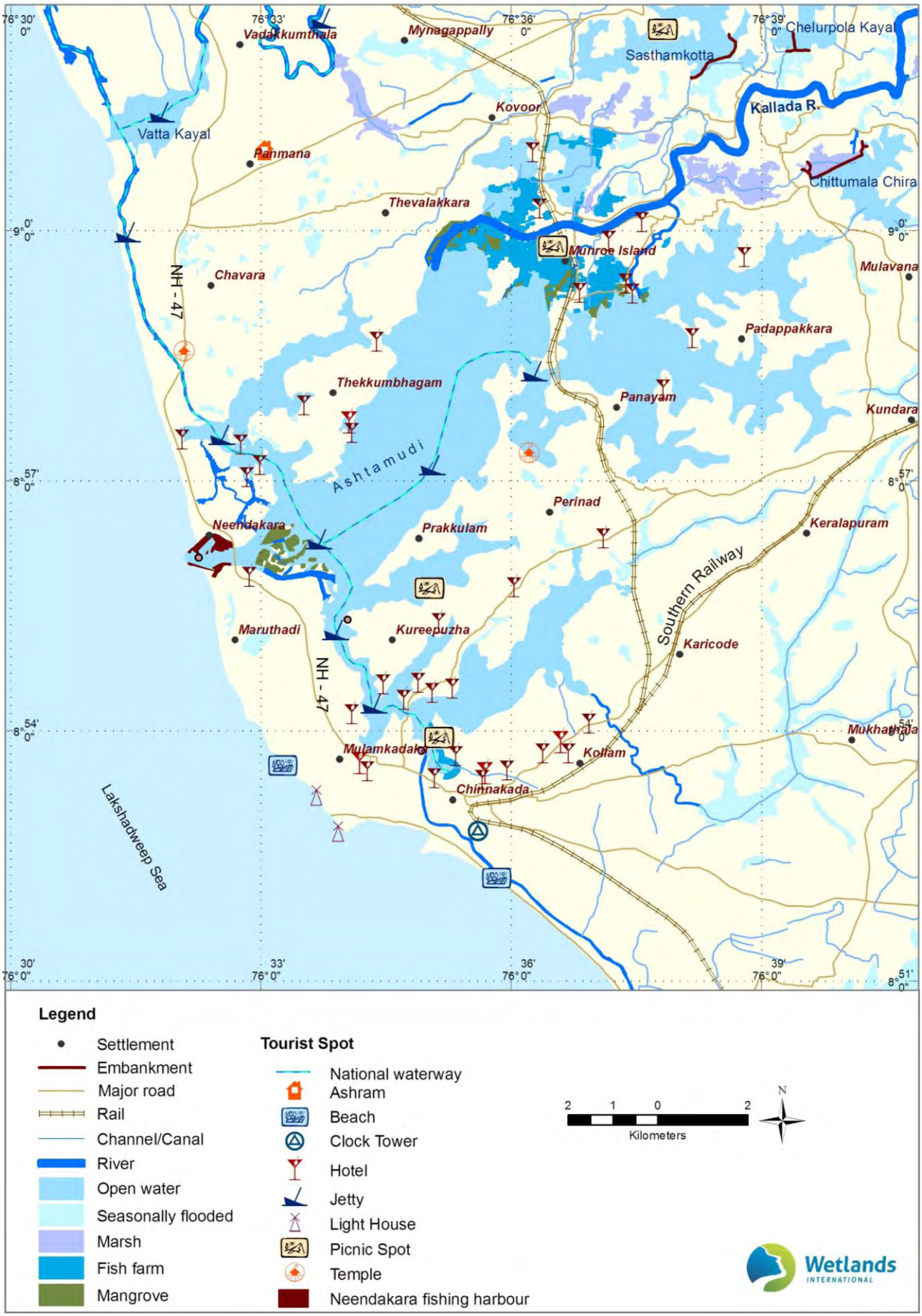
operate in the estuary. Houseboat and associated tourism support livelihood of more than hundreds of household of estuary shore community.

There are a range of tourism packages on offer, even connecting all backwater cities of Kerala namely Kollam, Alappuzha, Kumarakam, Kottayam and Kochi. Houseboat follow a specific navigation path started beginning from Kollam KSWTD boat jetty via National waterway 3 to Munroe Island (Map 2.17). Presently, nearly 25,000 tourists are estimated to visit the estuary each year. The prestigious President Trophy Boat Race (Valam kali), which is held in November 1 each year in the Estuary, marking the day Kerala State was created, is a center of attraction.

Community perceptions on management needs

The values of Ashtamudi as a source of fish, recreation and aesthetics are ranked higher by the communities. The role of the estuary in buffering floods is also recognized as an important ecosystem service (Fig. 2.12). There is in general lower preference for biodiversity values, which is largely due to lack of awareness. Random discussions with the houseboat owners indicates them to be largely unaware of the status of estuary as a Ramsar Site, and the associated roles and responsibilities as a tourist.

A houseboat in Ashtamudi Estuary



Map 2.17 | Tourist spots around Ashtamudi

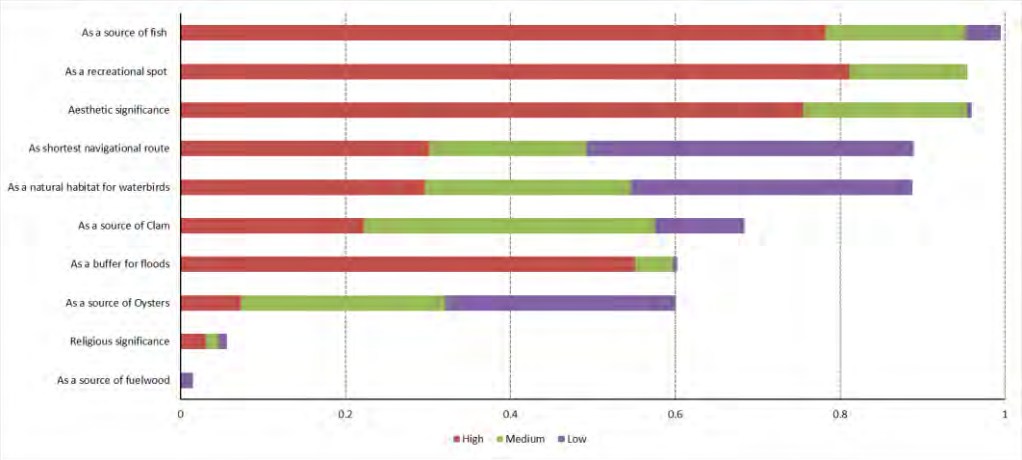


Fig 2.13 | Ranking of various ecosystem services of Ashtamudi by communities

Most of the respondents are in favour of management arrangements which secure biodiversity as well as livelihood values simultaneously, rather than preferring one over the other. Pollution, encroachment, unsustainable fishing practice and change in salinity gradient were identified as key drivers of wetland degradation. Much of these responses are in line with assessments presented in Chapter 2 of the management plan. The communities place higher emphasis on sustainable fishery development, ecotourism, communication and awareness programme, and demarcation of wetland boundary as intervention for management of the estuary. Creation of a separate institutional arrangement for Ashtamudi has also been accorded high priority.

Vulnerability contexts

Degradation of estuarine environs induces direct and indirect vulnerability to all stakeholders. For communities residing around the estuary, and having livelihoods dependent on resources, the impacts are higher. In addition, the following elements serve to enhance vulnerability of livelihood systems linked with the estuary:

Weak fisher cooperatives

The fisher cooperatives are not able to provide adequate infrastructure to their members. They have largely become an instrument for access to various welfare schemes of the government, with function high degree of political interference. Their role in overall fisheries resources management remains marginal.

Insufficient WASH infrastructure

While the region has good sanitation coverage, over 50% of the toilets have single pit with high degree of leaching into groundwater. Sanitation facilities in areas around Neendakara harbor (only 2 toilets per 1,000 fishers) are highly inadequate. There are several hanging toilets around the shorelines, which discharge waste directly into the waterbody. Insufficient WASH infrastructure adds to the pollution stress in the estuary.

Destructive fishing methods

The *P. malabarica* harvest in estuary is very close to its estimated maximum sustainable yield. The clam fisheries regulation has been in vogue since 90s, but its enforcement remains weak. Most of the respondent during survey reported that the mesh size regulations are not being adhered to strictly and there are instances of large-scale dredging of the clam beds with bag nets of small mesh sizes. Use of low mesh sizes and increased clustering of stake nets at the estuary mouth area remains a stressor to migrating fish and prawn species.

Unsustainable tourism

The houseboats are an important feature of backwater tourism. However, there are limited wastewater management facilities in these boats. The tourists are not offered any information on the ecological and socioeconomic values of the wetlands. There are no signage on the shoreline proclaiming the estuary to be a Ramsar Site.

Destructive fishing practices (Stake net) near Vincent Island

3. Ecological Character Description and Evaluation

Designation of Ashtamudi Estuary as a Wetland of International Importance (Ramsar Site) commits the Government of India and the State Government of Kerala to wise use of the wetland. As indicated in Chapter 1 of the management plan, wise use of wetlands entails 'maintenance of their ecological character achieved through implementation of ecosystem approaches, within the context of sustainable development'. Assessment and reporting on ecological character and ecological character change provide the basis of understanding the state of wetlands, thereby informing policy development and priority setting within the Convention, as well as within the national jurisdictions of Convention's Contracting Parties. An important function of site management planning is to outline an approach for maintenance of ecological character, and in doing so, retain those essential ecological functions which underpin delivery of ecosystem services and maintenance of biodiversity. Delivery of wise use commitments is therefore predicated to the extent to which wetland managers are able to define the site's ecological character, and use the analysis to design and implement management.

As defined by Ramsar Convention, ecological character is 'the combination of the ecosystem components, processes and benefits / services that characterize the wetland at any given point in time' (Ramsar Convention Secretariat, 2005a). The definition reflects wetland ecosystem complexity and dynamic nature by encompassing in a single frame, constituent biotic and abiotic components, processes which structure communities and thereby underpin ecosystem functioning, and the way in which human societies benefit from these ecosystems. For the purpose of implementation of the Article 3.2 of the Ramsar Convention, the obligation for 'maintenance' of ecological character pertains to human induced adverse change (Ramsar Convention Secretariat, 1996), while recognizing that wetland restoration is one of the options to induce a positive change in ecological character. Natural variability in features, discerned from monitoring, is envisaged to lead to a 'limit of acceptable change' to serve as a guide (Ramsar Convention Secretariat, 1996). The guidelines further emphasize on actual as well as likely change in ecological character, thereby affirming significance of adaptive management, and use of precautionary approaches in defining site management objectives.

Estuarine ecosystems are open, variable systems dominated as well as subsidized by physical processes, resulting in large exchanges of biotic and non-biotic material, including water, sediment, salts, nutrients, sediments and organisms with the connected freshwater as well as marine environments. Geologically, most of the world's estuaries were formed about 10 – 15,000 years ago when sea level rose after the last glaciation, and have since been progressively infilled and will continue to be (Day et al., 2013). Thus, present estuaries will, for the most part, cease to exist because they will fill up with sediment or because of sea level changes. The physical, chemical and biological environment is continually shaped by water sources and movements, and hydrodynamic components of coastal ecosystems. These biotic and abiotic ecosystem components operate under a high degree of human impact that characteristic of coastal areas. Ecological character description needs to be therefore focus on three key natural forces: a) climate (causing variability in freshwater runoff, evaporation regimes and sea level rise patterns), b) continental geology (causing variability in elevation, drainage patterns, landscapes and seascapes, and c) tidal regime (causing differences in the degree of mixing of freshwater and seawater), operating within the context of regional developmental policies and programming.

This chapter of management plan is aimed at description and evaluation of ecological character of Ashtamudi Estuary, with a purpose of identifying key features that need to be the focus of management, and their underlying ecosystem components and processes, maintaining which should be objective of management planning. The framework for ecological character description and evaluation used here is as per the Guidelines of Ramsar Convention (Ramsar Convention Secretariat, 2005b), and existing national frameworks (eg. DEWHA, 2008 of Government of Australia).

3.1 Status and trends

Ashtamudi is a part of wetland formations within the Southern Kerala Sedimentary Basin, the current form of which is attributed to evolutionary processes dated over 11,700 years ago (Mohan et al., 2016). The drying and cooling of the basin created conducive conditions for establishment of extensive riparian floodplains and swamps forests. Floods, experienced 8,500 – 5,500 years ago led to submergence of these forests with bank sediments derived from the nearby lateritic hills, leading to creation of swamps, marshes and lakes. As sea levels receded about 4,000 years ago, sediments were deposited at the head of the river mouths, forming the Kerala Bay Head Delta, the seaward propagation of which filled up half of the Ashtamudi, giving it a distinct identity from upstream floodplains. River meandering and migration

together with rapid sedimentation was responsible for cut off of many broad, scoured valleys into freshwater bodies like Sasthamkotta Lake, Chelurpola Lake, Chittumala Lake, and other inland wetlands.

Hydrological and ecological regimes of the Ashtamudi are defined by the salinity gradient created by intermixing of freshwater brought into the estuary from the basin of River Kallada and seawater from the Arabian Sea. Till early 19th century, the intertidal estuarine areas were fringed with extensive mangrove swamps, which were subsequently cleared for development of harbour and other infrastructure along the estuary shoreline. The natural shorelines have all been converted for settlements and industrial development within the last 50 years. The expansion of railways and road network has disconnected the marshes located in the upstream. Commissioning of the Kallada Dam has led to substantive decrease of freshwater inflow, which in conjunction with decreasing rainfall and sea level rise has led to reduction in salinity regimes. Water quality of the estuary has declined owing to continuous discharge of untreated waste from Kollam City, tourist resorts, industrial units, slaughterhouses, and houseboats.

Even in a highly modified regime, Ashtamudi Estuary has the following prominent ecological character elements which underpin the need for scientific management:

As a representative ecosystem of coastal wetlands
Rich source of fish, prawn and clam, yielding over 25,000 MT of biomass supporting livelihoods of over 5,000 households.

Important habitat for waterbirds in the Central Asian Flyway region. Over 60 species of migratory waterbirds are known to use Ashtamudi as a habitat.

Biological diversity habitat. Recorded diversity within the wetland complex includes over 70 plant and 370 animal species. These include 1 critically endangered, 2 vulnerable and 13 near threatened species.

Mode of inland navigation. The Kollam-Kottapuram stretch of West Coast canal system is National Waterway presently used by over 50 passenger boats and 50 houseboats for navigation.

Cultural and recreational values. Ashtamudi is famed as an entry to the Kerala backwaters, visited by nearly 20,000 tourists annually and providing source of incomes to nearly 50 houseboat-owners and employees.

Maintaining these ecological character elements provide a range of benefits related to food, biodiversity, development and climate security of the region, and therefore provide a useful basis for prioritization of ecosystem components, processes and services for management planning. However, several of these have emerged as a result of shifting developmental planning priorities (key being wetland tourism) and have induced adverse changes in ecosystem services and biodiversity (for example impact on hydrological regimes due to intensification of upstream water demands, or increasing pollution due to wetland tourism). Hence, in addition to the above, three criterions, namely ecological significance, social significance and administrative and regulatory requirements have been used. Ecological significance of the elements has been evaluated in terms of criticality in supporting an important ecosystem component, process and service; ability to be an integrative indicator of ecosystem state; species conservation status (for biotic components) or keystone species). Social significance refers to importance for local livelihoods. Administration or regulatory requirements refer to the provisions under relevant international (Ramsar Convention), national (eg. Wetland (Conservation and Management) Rules, 2010, Wildlife Protection Act, 1972), and state level regulatory frameworks (eg. Kerala Conservation of Paddy Land and Wetland Act, 2008). Status and trends in these key ecological character elements is summarized in Table 3.1.

Table 3.1 Status and trends in components, processes and services of Ashtamudi Estuary

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
Ecosystem Components				
1. Area, boundary and dimensions				
1.1 Area	Wetland regime extends to 5700 ha.	2015: LANDSAT 8 OLI Satellite Data NCESS, 2014	The wetland area has reduced from 7500 ha in 1950 to 5700 ha at present.	1988: LANDSAT 5 TM Satellite Data 2015: LANDSAT 8 OLI Satellite Data
1.2 Depth	Ashtamudi Estuary is shallow with an average depth of 1.8 m and a maximum depth of 9 m. The centre of the estuary has depth of around 1-2 m with deep funnel shape depression in its eastern margins.	2014: Mohan et al., 2016	Assessments to discern trends not available. However, there is a high likelihood of decrease in depth due to sediment transport from the Kallada river and tidal effect from the Arabian Sea.	
1.3 Shape	The wetland is in the shape of	2015: LANDSAT 8	Several creeks are being	

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
	a palm with 8 fingers waterbody.	OLI Satellite Data	narrowed down due to reclamation.	
2. Occurrence of wetland types within the site	The estuary presents 5472 ha of area under open water with the rest 671.31 ha under marshes.	2015: LANDSAT 8 OLI Satellite Data	Intertidal areas, especially mangrove marshes have been converted.	1988: LANDSAT 5 TM Satellite Data 2015: LANDSAT 8 OLI Satellite Data 1967-97: Sajeev and Subramanian, 2003
3. Biological components				
3.1 Flora				
3.1.1 Phytoplankton	52 species of Phytoplankton have been recorded from the estuary belonging 35 families and 10 classes.	1977: Mathew and Nair, 1980	Lack of data to discern trends.	1977: Mathew and Nair, 1980
3.1.2 Mangroves	11 species of true mangroves and 7 species of mangrove associates were recorded around the estuary. Out of these *Rhizophora apiculata* was the dominant species.	2014: Sumesh et al., 2014; 2010-12: Vidyasagaran and Madhusoodanan, 2014	There has been a decline in mangrove area of Ashtamudi from 1.46 km^2 to 0.95 km^2 from 1967 to 2016 due to diverse range of anthropogenic pressures as loss of habitat, cattle grazing, coconut husk retting and pollution from effluents through industries, oil spill and pesticides. Asramam, a famous mangrove site in Kollam District, had undergone severe destruction due to land reclamation, conversion and real estate activities.	2014: Sumesh et al., 2014; 2010-12: Vidyasagaran and Madhusoodanan, 2014 1967: Sajeev and Subramanian, 2003
3.2 Fauna				
3.2.1 Zooplanktons	70 species of zooplanktons have been recorded in the estuary belonging to 47 families and 7 classes.	1977: Divakaran et al., 1981; 1980-81: Nair et al., 1984; 2000: Nagendra et al., 2011; 1988-91: Raghunathan, 2007	No temporal assessments available to discern trends.	1977: Divakaran et al., 1982
3.2.2 Molluscs	16 species of molluscs have been recorded in the estuary representing 8 families from 2 classes, bivalvia (15 species) and gastropoda (1 species).	2011: Mohamed et al., 2013; 1977: Divakaran et al., 1981; 1980-81: Nair et al., 1984; 1988-91:	Habitats of *M. opima* have been replaced by high salinity tolerant *P. malabarica*.	

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
		Raghunathan, 2007		
3.2.3 Fish	151 fish species belonging to 55 families have been identified from the estuary. Among them, the most dominant families were Gobiidae, Carangidae, Clupeidae and Leiognathidae.	1980-1981: Nair et al., 1983; 1988-91: Raghunathan, 2007; 2009-11: Raj et al., 2014	Availability of freshwater species is on a decline.	2015: Field Assessment
3.2.4 Birds	116 birds have been identified from 11 bird congregation site in and around the estuary. 71 species are recognized as waterbirds of which 61 species are winter migrants.	1992-2014: AWC; 1988-91: Raghunathan, 2007	No trend	
4. Physical components				
4.1 Climate	The estuary and its drainage basin are situated in a warm humid tropical climate. The average annual rainfall is 2251.57 mm, majorly received in two spells of south-west and north-east monsoon. Rainfall during the south-west monsoon is the predominant component accounting for 48% of the total rainfall. Temperature ranges between 22-33 ^{o}C. The evaporation rate is highest (207 mm) during January and minimum in July (89 mm). Relative humidity ranges from 63% in January to 87% in June-July. The wind speed ranges from 1.3 to 2.1 km/hour. The wind speed is high during March - June and less during the months of September to December.	1905-2015: IMD; 2009-2010: CWRDM, 2010; 2013: CGWB, 2013	An analysis of 100-year rainfall for IMD's Kollam Station indicates a decline in rainfall during south-west monsoon. This trend also underlies a decline in total rainfall. These are similar to state-wide trends.	1905-2015: IMD 1900-2010: Krishnakumar et al., 2009
4.2 Water regime				
4.2.1 Water sources	Ashtamudi Estuary recieves inflow from River Kallada and rainfall. 88% inflow is contributed by River Kallada and the rest 12% is through rainfall. There is a net tidal exchange 4968 Mm^3 annually.	1905-2015: IMD; 2002-2011: Enathu Discharge Data, CWRDM 2004: Zachariah and Johny, 2008	The inflow from the Kallada river has reduced drastically since the construction of Thenmala Dam in 1980. The yearly inflow has reduced from 1646 Mm^3 in 1972-78 to 943.98 Mm^3 in 2002-11	1972-1978: Enathu Discharge Data, CWRDM; 2002-2011: Enathu Discharge Data, CWRDM
4.2.2 Water Balance	Based on the water balance studies, sources of inflow to the estuary are majorly inflows from the catchment contributing 88% and the rest	1905-2015: IMD; 2002-2011: Enathu Discharge Data, CWRDM	The inflow from the Kallada river has reduced drastically since the construction of Thenmala dam in 1980. The yearly inflow has reduced from	1972-1978: Enathu Discharge Data, CWRDM; 2002-2011: Enathu

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
	is direct rainfall contributing 12%. Outflows are through discharges into the sea and evaporation contributing 91% and 9% respectively. The tidal exchange from the sea is 4968 Mm^3, thus the gross discharge annually is 5935.91 Mm^3.		1646 Mm^3 in 1972-78 to 943.98 Mm^3 in 2002-11	Discharge Data, CWRDM
4.2.3 Connectivity to surface waters	Kallada River drains into Ashtamudi estuary on its eastern margins near the Munroe Island. The estuary is connected to the Arabian sea with an inlet on its western side near Neendakara.	2015: Field Survey	The interaction between the Kallada River and the estuary has decreased since the construction of Thenmala Dam in the upstream. With rise in sea level, the interaction of sea has increased with fine sand from the sea found in the eastern margins of the estuary along with increase in salinity	2016: Jha et al., 2016
4.3 Sediment regime	No detailed studies of estuary sedimentation are available. Hydrological investigation within the estuary indicate high input of sediments from the littoral end. Sedimentation is also taking place from the eastern end by the Kallada River.	2014: Mohan et al., 2016	The rate of sedimentation from the Kallada River has reduced since the construction of Thenmala Dam which has reduced the supply of deposits. Sand mining in the river has also led to reduction in sediments. There is an apparently piping effect in Munroe Islands leading to sinking.	2016: Jha et al., 2016
4.4 Water salinity	Ashtamudi is a brackish system thus salinity values are high. It ranges between 13 – 33.5 ppt	2013-2014: Seethal et al., 2015; 2012-2013: Chinnadurai et al., 2016	Overall salinity gradient is on a decline. The creek areas which used to remain fresh during monsoon and post monsoon period are brackish round the year,	1977: Mathew and Nair, 1980; 1977: Divakaran et al., 1981; 2008: Sujatha et al., 2009; 1996: Appukuttan et al., 2002; 2007-2009: Antony and Ignatius, 2016; 2008: Sujatha et al., 2009; 2009-2010: Sachin et al., 2013; 2013-2014: Seethal et al., 2015; 2012-2013: Chinnadurai et al., 2016
4.5 Dissolved	The estuary is well oxygenated with DO level ranging between	2014-15: KSPBC; 2013-2014:	Pockets of creeks which receive direct untreated effluents from	1977: Divakaran et al., 1981;

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
gases in water	4.1 – 6.3 mg/l.	Seethal et al., 2015	industrial units and settlements have lower dissolved oxygen levels.	1980-81: Nair et al., 1984; 2014-15: KSPBC; 2013-2014: Seethal et al., 2015
4.6 Dissolved or suspended nutrients in water	Available information for the period 2008-2009 indicates the concentration of nitrate ranging from 4 -41 mg/l, phosphate ranging from 0.1 – 4.1 mg/l and silicate ranging from 12.1 – 45 mg/l.	2007-2009: Antony and Ignatius, 2016; 2008: Sujatha et al., 2009; 2009-2010: Sachin et al., 2013	Gradual increase in nitrate and phosphate concentrations have been recorded within the estuary since 1977. It could be due to the addition of raw sewage and fertilizers.	1977: Mathew and Nair, 1980; 2007-2009: Antony and Ignatius, 2016; 2008: Sujatha et al., 2009; 2009-2010: Sachin et al., 2013
4.7 Coliforms	Total and fecal coliform ranges between 180-1500 MPN/100 ml and 60-600 MPN/100 ml near the confluence of Kollam Canal and Ashtamudi.	2014-15: KSPBC	No temporal assessments available to discern trends.	
4.8 Other effluents	Concentration of heavy metals like iron and calcium is very high ranging between 39.23-47.89 mg/l, and 256.34-562.67 mg/l respectively. The concentration of chloride and sulphate also ranges between 32.5-46 mg/l and 78.6-886.52 mg/l respectively. These values are high due to the effluent discharged from ceramic industry.	2009-2010: Suma et al., 2012	No temporal assessments available to discern trends.	
4.9 Sea level change	There is no sea level measurement for Kollam, but data from nearby Kochi region reports rise in sea level by around 3.7mm /year	1992-2007: Unnikrishnan et al., 2015	Comparing the long term average of 1939-2007 with present data (1992-2007) there has been an increase in sea level rise from 1.81 mm/ year to 3.7 mm/year.	1939-2007: Unnikrishnan et al., 2015
4.10 Features of surrounding area	As per land use land cover analysis for 2015, 55% of the drainage basin area is under forest, 26% under plantation, 6% under waterbody, 3% under settlement, 2% under agriculture and the rest under marshes and open area.	2015: LANDSAT 8 OLI Satellite Data	There has been a gradual intensification of land use within the direct drainage basin. Area under settlements and plantation have increased with decline in forest and marshes.	2015: LANDSAT 8 OLI Satellite Data 1988: LANDSAT 5 TM Satellite Data
Ecological processes				
5. Primary production	Recent studies are not available. Study conducted between 1988-91 revealed that gross productivity in Ashtamudi ranged from 18.99	1988-91: Raghunathan 2007	No assessment	

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
	to 341.82 mgC/m^3/hr in the surface water and 18.99 to 398.78 mgC/m^3/hr at the bottom. The net productivity in the Ashtamudi estuary ranged from 4.8 to 284.85 mgC/m^3/hr in the surface and from 31.30 to 225.86 mgC/m^3/hr in the bottom water.			
6. Nutrient cycling	The nutrient concentration in the estuary varies seasonally, with high concentration during the monsoon and low during the pre- and post-monsoon. However, no specific assessment have been carried.	2009-10: Sachin et al., 2013	No assessments.	
7. Sedimentation	The submerged sand banks and the development of flood tidal islands on the landward side of the estuarine entrance at Neendakara are indicative of high input of sediments from the littoral and nearshore regions. The estuary has started getting filled up from the west by flood tide inputs. In addition, the filling up of the estuarine basin has also taken place at the eastern end by the Kallada River.		Assessments to discern trends not available. However, there is a high likelihood of decrease in depth due to sediment transport from the Kallada river and tidal effect from the Arabian Sea.	
8. Species Migration	Nearly 80% of fish species comprising economic catch are migratory in nature.		Component of freshwater fish in landing has declined.	
Ecosystem services				
9. Fisheries	Ashtamudi yields an annual landing of 28,611 MT of biomass based on 5 years catch assessments done at five sites), having an estimated market value of 970 million The catch is dominated by clams which constitute 83% of the total, the rest comprised by fish (7%), crab (6%) and prawn (4%). In market value terms, the catch in 2014 was worth Rs. 985 million.	2011-15: Mohamed et al., 2016	There has been a sharp decline in the fish catch from 5,700 MT in 2001 to 2212 MT in 2015. During this period, there has been a 60% decline in shellfish.	2001: Kurup and Thomas, 2001; 2015: Field survey
	Ashtamudi accounts for over 90% clam fish export of India. Currently, about 23,800 MT of clams are harvested from the	2011: Mohamed et al., 2013	*P.malabarica* landing is very close to its maximum sustainable yield. Landing of	1982-93: Appukuttan et al., 2002; 2011: Mohamed

Ecological character element	Status	Assessment Year and Data Source	Trends	Assessment Year and Data Source
	estuary annually. P. malabarica constitutes 87.4% of the total biomass.		*M.opima* has declined.	et al., 2013
10. Inland navigation	The National Waterway (NW-3) which lies between Kollam and Kottapuram passes through Ashtamudi kayal. This inland navigation provides cheaper cargo transportation. There are a lot of mechanised luxury boats operating from the boat jetty all seasons to enjoy the beautiful backwaters. The water transport department operates regular boat services to West Kallada, Munroe Island and Alappuzha.	2006: Sitaram, 2014; 2015: Field Survey	No assessments.	
11. Recreational and Tourism	Ashtamudi backwaters are one of the major tourist destination. International tourists visiting Kerala has been estimated 0.97 million during 2015. There are around 12.46 million domestic tourists visiting Kerala during 2015. Of the people who visit Kerala around 9% people main attraction is backwaters. DTPC reported around 50 houseboats in Ashtamudi estuary. It was estimated that annual tourist inflow about 18,250 generate benefit around Rs.1.50 million from recreation	2015: DoT, 2015 2015: Field survey	The foreign tourists visit in Kerala has increased from 0.34 million in 2003 to 0.97 million in 2015.	2015: DoT, 2015
12. Important knowledge systems, and importance for research	Recent assessments on the estuary's ecological character are meagre. As Ashtamudi stands within the network of wetlands of international importance, it is pertinent that research, monitoring and inventory-making becomes a continuous task within lake management.		Studies on Ashtamudi Estuary have been sporadic.	

An overview of Table 3.1 indicates that several of the ecological character elements bear an adverse trend. In particular, connectivity of surface waters, tidal and inundation regimes, and circulation and mixing patterns has been adversely affected by hydrological regime regulation and fragmentation. The physico-chemical characteristics of surface waters are indicative of high degree of pollution. Efforts made to intensity tourism has negatively impacted several of the ecological components and processes. Indicators of ecosystem service provision, namely production of fin and shell fish indicate a declining trend.

3.2 Risk of adverse change

To assess the risk of adverse change in ecological character, we map the key threats (derived from adverse trends) with pressure, stressor, and potential impact. We define pressure as anthropogenic factors inducing environmental change. The stressors refer to ecosystem components and processes that transfer the impact of pressures on the state of the wetland. The potential impacts of the stressors on the estuary has also been mapped to inform management. The analysis is presented in Table 3.2.

Table 3.2 | Analysis of risk of change in ecological character of Ashtamudi Estuary

Threat	Pressure	Stressor	Potential impact
Pollution Ashtamudi Estuary has pockets of low dissolved oxygen, high nutrient concentrations and pH. high quantity of iron, sulphate and calcium content and high levels of dissolved methane.	Insufficient waste treatment infrastructure for Kollam City. Environmentally degrading coir retting practices. Inadequate waste treatment facility within the houseboats. Inadequate waste treatment and management facilities in industrial units. Unsafe sanitation technologies in use for over half of the settlements around the estuary.	Elevated nutrient levels. Increased concentration of organic and inorganic pollutants. Increased concentration of pathogenic organisms.	Reduction in fisheries and aquaculture yields, Fish kills, Reduction in habitat and biodiversity. Reduced amenity value, Adverse impact on health of communities living in the immediate vicinity of the estuary.

Reduced freshwater inflow into Estuary from Kallada Basin Annual discharge of Kallada River into Ashtamudi Estuary during 2002-11 was only 57% of the discharge recorded during 1972-78 period.	Increased freshwater storage within the basin.	Altered hydrodynamics, leading to increased siltation from the sea Changed tidal limits and reduced salinity gradients.	Changes in community structure – predominance of brackish and marine forms. Reduced fisheries and aquaculture productivity. Altered sedimentation patterns.
Conversion of intertidal habitats The natural shorelines of the estuary, consisting mangrove marshes and mudflats, have been extensively concretized. Area under mangroves has reduced from 146 ha to 950 ha during 1967-2016.	Reclamation and land use changes around intertidal habitats.	Intertidal habitat removal.	Reduced fisheries and aquaculture productivity. Altered sediment deposition pattern. Increased pressure on habitats. Reduced biodiversity.
Reduced freshwater species Within fish and clam, there is a gradual reduction in freshwater dependant species, which have been replaced by high salinity tolerant species.	Reduced freshwater inflows.	Increased salinity regimes.	Reduced ecological integrity. Reduced biodiversity. Reduced ecosystem productivity.
Unsustainable clam harvesting The current annual production of clam *Paphia malabarica* is very close (96.7 %) of the estimated maximum sustainable yield level of this species in the estuary.	Increased harvest for livelihoods. Weak enforcement of regulation.	Reduced stock.	Reduced harvest. Adverse impacts on livelihood systems dependant on clam resources.
Use of destructive fishing practices There is rampant use of nets of low mesh sizes, and obstruction of migratory routes.	Increased competition over limited resources. Weak enforcement of regulation.	Reduced biomass. Lower sizes of fish.	Reduced harvest. Adverse impacts on livelihood systems dependant on clam resources.

Reduced rainfall and increased rate of sea level rise The analysis of 100-year rainfall for IMD Kollam Station indicates a gradually declining rainfall during the south-west monsoon and as a result total rainfall. Comparing the long term average sea leevl rise during 1939-2007 with present data from the period 1992-2007, there has been an increase in sea level rise from 1.81 mm/ year to 3.7 mm/year.	Altered climate patterns.	Altered hydrodynamics, leading to increased siltation from the sea Changed tidal limits and reduced salinity gradients.	Changes in community structure – predominance of brackish and marine forms. Altered sedimentation patterns.

3.3 Knowledge gaps

In absence of a well-designed wetland inventory, assessment and monitoring programme for Ashtamudi Estuary, there are several knowledge gaps in understanding of ecological character. The following need to be addressed on priority:

a) Complete characterization of biodiversity change in response to reduced freshwater inflow conditions and pollution stresses.
b) Recruitment and migration patterns for key fish and prawn species.
c) Freshwater inflow requirement for maintenance of ecological integrity.
d) Risk of species invasion.
e) Management adaptation needs in response to changing climate.

4. Institutional arrangements

Institutions mediate the linkages human societies have with wetlands, thus having an important bearing on the overall ecosystem health. Institutions encompass all formal and informal interactions among stakeholders and social structures that determine decision making, power relationships and sharing of responsibilities. Various collections of institutions come together to form governance systems, that include interactions between different centres of power in the society at different scales. Most importantly, institutions and governance influence the direct and indirect drivers of change in a wetland ecosystem. The degree of fit of institutions and governance systems with functioning of Ashtamudi Estuary is one of the key determinants of wise use.

This section of the management plan contains an analysis of institutional arrangements in the context of integrated management of Ashtamudi. Existing institutional and governance settings are discussed in the first section. An evaluation of these settings is discussed next, with an aim of identifying gaps. The section concludes with recommendations for setting up of an effective institutional and governance arrangement which would enable wise use of Ashtamudi Estuary.

4.1 Managing wetlands: institutional prerequisites

Wetlands are open systems and subject to influence of a range of developmental planning and resources management decisions being implemented within their river basins and coastal zones. An important institutional pre-requisite is to ensure arrangements for cross sectoral coordination, so that various programmes pursued by different government as well as private agencies do not work for cross-purposes. Institutions also need to be adaptable, so as to be able to accommodate new information and perspectives on wetlands, needs of diverse stakeholder groups, and an uncertain political environment. Since communities living around a wetland have a direct bearing on the ecological state, and often have nuanced management systems based on traditional knowledge, institutional arrangements need to have adequate representation of such communities and knowledge systems. The institutions also need an adequate regulatory backing so as to effectively enforce measures for conservation and sustainable management.

Institutional arrangements and governance systems for wetlands in India have their roots in protected area management (for an overview of national policy development,

refer Kumar et al. (2017). National scale efforts for wetland conservation in India started taking shape since the 80s coinciding with India's ratification of Ramsar Convention in September 1982. A dedicated scheme for financing wetland restoration was initiated by the MoEF in 1987 to provide financial assistance to the states for implementation of site management plans. An important building block of the scheme was a guidance to the State Government to constitute State Level institutions for enabling cross-sectoral coordination and management. Responding to these guidelines, several states have constituted specific institutions for management of wetlands.

Given the need to bring in multiple departments and stakeholders together to implement management plans, the different state governments have considered constitution of dedicated wetland authorities. The Loktak Development Authority (LDA) constituted in 1986 was one of the first wetland development authorities set up in the country. In 1992, the Government of Odisha constituted the Chilika Development Authority to address the pressures on Chilika Lake, the largest brackishwater lagoon on the east coast threatened by increasing silt load, declining fisheries and expansion of shrimp aquaculture. In 1997, the Government of Jammu and Kashmir constituted the Lakes and Waterways Development Authority under the Aegis of the Housing and Urban Development Department for restoration of Dal and Nigeen Lakes. Within the decade of 2000, separate wetland authorities were created for waterbodies of Madhya Pradesh, lakes within Bengaluru City, and East Kolkata Wetland. The Lake Conservation Authority of Madhya Pradesh initially focused on Bhoj Wetlands but was entrusted the mandate for conservation of all waterbodies of the state in 2004. The State of Odisha constituted a distinct wetland authority for the entire state in 2012. The constitution of state wetland authorities was given a renewed push through a specific advisory to the State Governments in 2013. As on the date of writing this management plan, eight states had constituted such institutions.

The example of CDA indicates the value of wetland authorities in ensuring integrated management, particularly with the required degree of political ownership. At the same time, the authorities are also constrained by lack of adequate human and financial resources, limited powers of enforcement of regulatory regimes, and the ability to convene all sectors and stakeholders together. The case of Bhoj Wetlands clearly indicates that when not supported by adequate policy mandate and capacity, wetland authorities tend to lose their relevance. Ensuring fit between the ways wetlands function and the capability of wetland institutions remains a critical element of institutional design.

4.2 Existing institutions and governance settings

Policy frameworks

There is a wide gamut of policy and regulatory framework at the federal as well as state level to support conservation and wise use of Ashtamudi. The framework drawn strength from the Constitution of India, which in its Article 51-A (g) stipulates that "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures". Article 48A, part of the Directive Principles of State Policy obligates the State to protect and improve the environment.

The overarching policy framework for wetland conservation in India are set by the MoEFCC. The National Environment Policy (2005) identifies wetlands as 'freshwater resources'. Recommended policy actions include integration in developmental planning, management based on prudent use strategies, promotion of ecotourism, and implementation of a regulatory framework. Integration of wetlands in river basin management is also identified as a strategy for management of river systems.

The National Plan for Conservation of Aquatic Ecosystems (NPCA) is the Ministry's flagship scheme for conservation of wetlands. The scheme amplifies Government of India's commitment to Ramsar Convention's wise use principle for conservation and sustainable management of all wetlands. NPCA also contributes to the commitments to the Convention on Biological Diversity (CBD).

At state level, the **Kerala State Environment Policy** (2009) enlists conservation and sustainable use of wetlands for water and food security and economic benefit of people as a strategic area. Actions envisaged under the policy include prohibiting reclamation of wetlands, regulating unsustainable tourism and promoting sustainable utilization without compromising biodiversity values. The **Kerala Water Policy** (2008) identifies ecosystem integrity as well as the physical, social and environmental background of the state while deciding on water allocation priorities. In 2015, the **Kerala State Action Plan on Climate Change** was approved for implementation by the Ministry. The plan includes wetland management as an action under the water management sector.

Regulatory framework

The regulatory framework for wetlands in the country are defined by the Wetlands (Conservation and Management) Rules, 2010 notified under the Environment Protection Act, 1986. As per the decisions of Supreme Court of India dated 8 February

2017, Section 4 of these rules are applicable on all wetlands with area of 2.5 ha and above and identified within the National Wetlands Atlas. By the said decision, the following activities are therefore prohibited within Ashtamudi:

a) reclamation of wetlands;
b) setting up of new industries or expansion of existing industries;
c) manufacture, handling, storage or disposal of hazardous substances;
d) solid waste dumping (the existing practices if any before commencement of the rules are to be phased out within six months);
e) discharge of untreated wastes and effluents from industries, cities and towns and other human settlements (the existing practices if any before commencement of the rules are to be phased out within six months);
f) any construction of permanent nature except for boat jetties within fifty meters from the mean high flood level observed in the past ten years from date of commencement of rules;
g) any other activity likely to have an adverse impact on the ecosystem of wetland.

At the time of drafting this management plan, the Ministry had placed a revision of the Wetlands Rules for public consultation. Within the revised rules, the list of regulated and prohibited activities needs to be referenced to site's ecological character. The rules also require constitution of a State Wetland Authority as the nodal agency for policy making, regulation and management of wetlands of the state. **The Indian Fisheries Act, 1987; The Indian Forest Act, 1927; The Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Environment (Protection) Act, 1986**; and **The Biological Diversity Act, 2002** contain specific regulatory provisions having relevance for management of Ashtamudi. For example, Water (Prevention and Control of Pollution) Act, 1974 prohibits direct or indirect discharge of any poisonous, noxious or polluting matters in any waterbody and empowers the State Pollution Control Board to issue directions to ensure compliance of the same.

The Government of Kerala has also enacted the Kerala Conservation of Paddy Land and Wetland Act, 2008 to conserve paddy lands and wetland ecosystems and restrict their conversion or reclamation. The act completely prohibits the reclamation of wetlands in the state. The reclamation of paddy land is restricted to ten cents in a

Panchayat or five cents in a Municipality/Corporation. Any activity or construction in a paddy land in contravention to the provisions of the act is illegal[1].

The State Government has also notified The Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001) to protect river banks and river beds from large scale dredging of river sand and to protect their biophysical environment. In 2015, the provisions of the act and corresponding rules were used by the State Government to ban sand mining in six rivers of the state, including Kallada.

In order to ensure the livelihood security to the fisheries communities and other local communities living in the coastal area and the conserve and protect the coastal stretches and its unique environment, the Central Government has declared the coastal area of the country and water area up to the territorial limit as the coastal regulation zone (CRZ). The CRZ applies to the land area from High Tide Line (HTL) to 500mts on the landward side along the sea front. CRZ also applies to land area between HTL to 100m or the width of the creek whichever is less on the landward along the tidal influenced waterbody up to the distance where salinity concentration of 5 ppt is measured during the driest period of the month.

The CRZ have been classified under different zones as follows and each zone has different restriction as mentioned below:

CRZ I: These include ecological sensitive areas which play a role in maintaining the integrity of the coast like Mangroves (if area is above 1000 m2, 50m buffer around is required), coral reefs, mudflats, reserve forest, national parks, nesting grounds, salt marshes and area of archeological importance and area between Low Tide Line (LTL) and HTL. No new construction is permitted in the area except project relating to Department of Atomic energy, installation of weather radar, construction of trans harbor without effecting the tidal flow of water.

[1] The act stops local authorities to grant license or permit (under Kerala Panchayat Raj Act, 1994 (13 of 1994) or in the Kerala Municipality Act, 1994 (20 of 1994) for carrying out any activity or construction in a paddy land or a wetland converted or reclaimed in contravention of the provisions of this Act. As per the provisions of the act, a local level monitoring committee has to be constituted at Panchayat or Municipality level to prepare detailed guidelines for the protection of the paddy lands/wetlands under its jurisdiction and monitor compliance to the provisions of the act.

Any conversion in violation of the act invites penalties to the tune of imprisonment for two years and fine of one lakh rupees. This applies to person and companies as well. Authorised officers of Revenue Department have the powers to stop any such violation under the provisions of the Code of Criminal Procedure, 1973 (Central Act 2 of 1974) relating to search and seizure.

CRZ II: These include the area that have been developed close to the shoreline having Corporation and Municipal having built-up area more than 50% in the CRZ. Construction activities are only permitted on the landward side of the existing roads or existing authorized structure. Structures can be reconstructed subject with existing Floor space index or Floor area ratio norms. Only desalination plants and facilities for generating power with non-conventional sources are permitted.

CRZ III: These include areas that are relatively undisturbed and those not belonging to either CRZ I or II which include coastal zone in rural area. Area upto 200m in case of seafront and 100m in case of tidal influenced waterbody is a No Development Zone (NDZ). No construction is permitted in NDZ except repair work of existing structure. However, activities like agriculture, salt manufacturing, mining of rare minerals, storage of petroleum products, weather radars, construction of units for sewage treatment, disposal (with approval from Pollution Control Board) and facilities for local fishing communities like fish curing facilities, boat building yards are permitted. In area between 200m to 500m certain activities like construction of Hotels in vacant plots, public rain shelters, community toilets are permitted along with those permitted in NDZ.

CRZ IV: These include the water area from the LTL to 12 nautical miles on the seaward side and waterbody from the mouth at the sea up to the tidal influence in the waterbody. In this area no untreated sewage, ship washes, solid waste shall be let off or dumped. A comprehensive plan for treatment of sewage from costal town and nearby communities needs to be formulated within a year and implemented. There is no restriction on traditional fishing and allied activities undertaken by the local communities.

In view of a unique costal system of backwater and backwater islands in Kerala, special consideration has been given for Kerala. All islands in the backwater are covered under the CRZ notification. The CRZ area is 50m from the HTL on the islands. No new construction is permitted however repair of existing structures are permitted. The construction of dwelling units beyond 50m also needs permission from the Gram Panchayat. However, foreshore activities like fish processing, boat repair and fishing jetty are permitted in the area. A CRZ map for Kollam District has been prepared and is enclosed as Map 1.2.

The Kerala Tourism (Conservation and Preservation of Areas) Act 2005 passed by Government of Kerala envisaging conservation, preservation and integrated development of special tourist zones. Special tourist zones are notified in government

gazette, and the act prohibits developmental activities within the notified areas. Till date, Kovalam, Munnar, Kumarakom and Fort Kochi have been brought under the purview of this Act.

Ownership and management arrangements

The Department of Environment and Climate Change is the designated state level institution for conservation and management of wetlands in the state. A key role of the Department is to ensure coordination of various sectoral programmes on matters related to environment, including wetlands.

The department has constituted the State Wetland Authority Kerala (SWAK) vide Kerala gazette notification No. 49, dated 15 December 2015 (Annex 10). The Authority is registered as a society under the Travancore-Kochi Literary Science Charitable Society Registration Act, 1955.

SWAK is the designated regulatory authority for identified activities for management and wise use of wetlands. SWAK has been entrusted the role of policy development, enforcement of regulatory framework, and integrated management, implementation of action plans, research, awareness creation and mobilization of funds for wetland management. The Authority comprises a 11-member panel, chaired by the Environment Minister, with the Principal Secretary (Environment) as the Convener and officials from the Department of Water Resources, Science and Technology, Local Self Government, Agriculture as ex-officio members and four sector experts on limnology, hydrology, ecology and biodiversity.

Relevant sectoral programmes of Government agencies and departments

A number of state government agencies and departments have programmes with bearing on the status of Ashtamudi.

Kerala Coastal Zone Management Authority

The Kerala Coastal Zone Management Authority is the nodal agency for enforcement and enactment of the Coastal Regulation Zone Notification, 2011 and its amendments. The office functions at the Directorate of Environment and Climate Change, Thiruvannanthpuram. The Authority has prepared CRZ maps for enforcement of various provisions of the CRZ rules.

Kerala State Pollution Control Board

The Authority is the nodal agency for implementing provisions of a gamut of laws and rules on environment, *inter alia*:

a) Water (Prevention and Control of Pollution) Act and the Cess Act,

b) Environment (Protection) Act,

c) Hazardous Wastes (Management, Handling and Transboundary Movement) Rules,

d) Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Micro-organisms, Genetically Engineered Organisms or Cells,

e) Biomedical Waste (Management and Handling) Rules,

f) Municipal Solid Wastes (Management and Handling) Rules, and

g) Environmental Impact Assessment Notification.

Kerala State Biodiversity Board

Kerala State Biodiversity Board (KSBB) was constituted in 2004 under the provisions of the Biological Diversity Act 2002, Rules 2004 and Kerala State Biological Diversity Rules 2008. The KSBB is dedicated to conservation and protection of the agro, plant and fish diversity of the State. The major function of the State Biodiversity Board is to advise the State Government on any guidelines issued by the Central Government on matters relating to the conservation of biodiversity. The Board is headed by a Chairman, a Member Secretary and followed by a team of expert government officials.

Biodiversity Management Committee have been constituted in all Local Self Government Departments including village Panchayats, Municipalities, and Corporations during 2011-2012 for the successful implementation of the Biological Diversity Act 2002. The Kerala State Biodiversity Board (KSBB) has published a biodiversity register for wetland ecosystem covering the catchment area of Ashtamudi. The register is the result of a year-long mapping exercise carried out in association with a joint BMC comprising representatives of the Ashtamudi, East Kallada, and Mainagapally gram panchayats.

Forest and Wildlife Department

Management of mangroves in the state, including those within the intertidal areas of Ashtamudi Estuary has been placed under the mandate of Kerala Forest and Wildlife Department.

Tourism Department

Ashtamudi attracts many tourists because of its scenic beauty and religious significance. Kerala tourism department is the nodal agency managing tourist inflow

in Kerala. Tourism department works with line departments, institutions and organization such as Kerala Tourism Development Corporation (KTDC), Tourist Resorts (Kerala) Ltd., District Tourism Promotion Council, Kerala Institute of Travel and Tourism Studies (KITTS) and Kerala Institute of Hospital Management Studies (KIHMS). Tourism department provides support to District Tourism Promotion Councils (DTPCs) in all districts of Kerala.

Fisheries

The Department of Fisheries is the nodal agency for all affairs related to fisheries, including increasing production, conservation and sustainable exploitation of fisheries wealth, promoting cultivation of fish and prawns, development of fishing harbours and facilities for landing and marketing of fish, and for the upliftment and welfare of the fisher folk. The Department its allied agencies viz. Matsyafed, ADAK, KFWFB, FIRMA, FEDA, and BFDA implements the Government's visions and schemes in this sector.

As per the Draft Fisheries Policy of the State, all construction activities of the Harbour Engineering Department will be limited to the harbour areas, with the rest activities being coordinated by the Fisheries Department.

Local self-government

The decentralization initiated by the 73rd and 74th amendment Acts of the Indian Constitution has given greater responsibility and powers to the local bodies for local planning, effective implementation and monitoring of various social and economic development programmes. Kerala state government took to decentralized planning in 1996 and declared that 35 to 40 percent of the state plan fund would be utilized in the form of grant -in-aid to the Local Self Governments (LSGs) for formulating and implementing Local Development Plans. Over the years, the Gram Panchayat has appeared to put in more efforts to integrate sponsored programme into their Local Development Plans.

LSG connects with a number of institutions for implementation work of Local Development Plans such as the Rural Development Commissionerate, Panchayat Directorate, Urban Affairs Directorate, Town and Country Planning Department, Kerala Institute of Local Administration (KILA), Information Kerala Mission, Kudumbashree, The Kerala Rural Employment and Welfare Society (KREWS) and State institute of Rural Development.

Mining and industries

Sand and laterite mining are major issues in the estuary catchments. Department of Mining and Geology is the statutory body for mineral exploration, prospecting, and administration in Kerala. The Department carries out short-term investigations/studies and being a scientific organization, also undertakes geosciences projects sponsored by agencies like Kerala State Council for Science, Technology and Environment.

Laterite, sand and clay fall under the category of minor minerals. In exercise of the powers conferred by sub-section (1) of section 15 of the Mines and Minerals (Development and Regulation) Act, 1957), the Government of Kerala has made the Kerala Minor Mineral Concession Rules, 2015 that replaces similar rules of 1967 to regulate the extraction of minor minerals in the state. Quarrying, is not permitted within a distance of 50 metres from any reservoir, tanks, canals, rivers, forest lands or village roads among others except with the previous permission of the authorities concerned or the Government or the competent authority. As per the provisions of the Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001) sand mining is guided by the recommendations of a District Committee. Notably, the State Government has banned all sand mining in River Kallada.

Ports

Management and maintenance of Neendakara Port is placed within the mandate of Department of Ports. The Department has made investments in upgradation of port and harbor infrastructure at Neendakara.

Research and development

Research and development needs for wetland management are met through the Kerala State Council for Science, Technology and Environment, and a number of autonomous research and development centres as Centre for Water Resources Development and Management (CWRDM), National Centre for Earth Sciences Studies (NCESS), and number of academic institutions.

Engagement of civil society

Kerala has an active civil society which has played an active role in voicing environmental concerns. Kerala Sastra Sahitya Parishad (KSSP) maintains an active engagement in wetland issues, including that of Ashtamudi. In 2013, the Purogamana Kala Sahithya Sanghom (Pukasa) initiated a campaign to highlight the need for

protecting and conserving the Ashtamudi. WWF-India is working with CMFRI to support MSC Certification of clam fisheries of the estuary.

4.3 Evaluation

Being an open system, the status of Ashtamudi Estuary is linked with a range of developmental activities being implemented within Kallada River Basin and linked coastal zone. Unless aligned with the ecosystem components and processes, these activities can severely limit the possibility of wise use through alteration of natural water regimes, habitat connectivity and other pathways. Institutional arrangements for management of Ashtamudi Estuary must be appropriate to prevent any adverse change in ecological character as well as secure biodiversity and ecosystem services on long term.

Meta-analysis of governance systems related to common pool resources indicate that the presence of rights related to access (right to enter to defined property), withdrawal (right to harvest resource products), management (right to regulate and improve resource use), exclusion (right to determine who will have access to resource) and alienation (right to lease any of the aforementioned rights) as important constituents of governance systems that are able to manage a resource on the long term. Institutions crafted to govern common property resources are known to share common design principles, which when adhered to enhance management success. The institutions and governance setting pertaining to Ashtamudi Estuary are examined below with reference to these design principles to identify gaps.

Table 4.1. Evaluation of institutional arrangements for managing Ashtamudi Estuary

Enabling institutional conditions and implication for management	Status of current institutional arrangements	Key gaps
Clearly defined user and resource boundaries Presence of well-defined boundaries around Ashtamudi Wetland Complex is required to ensure that management zones and actions are defined in spatial terms and linked with user access rights, adverse land and water use change is prevented, and communities have incentives for protecting the wetland.	A boundary to meet the regulatory requirements under the Coastal Regulation Zone, 2011 notification has been delineated.	The CRZ boundary needs to be harmonized with the boundary of the Ramsar Site, as required to be set under the Wetlands (Conservation and Management) Rules, 2010. In addition, a zone of influence also needs to be defined wherein developmental activities have or are likely to impact wetland functioning. There is a pressing need to define such boundaries given the rapid and unorganized increase in construction activities all around

Enabling institutional conditions and implication for management	Status of current institutional arrangements	Key gaps
		the estuary, which have a bearing on water use and waste generation.
Congruence Rules for management of Ashtamudi confirm to functioning of biophysical and social systems. The rules also balance the cost of enforcement of management with the benefit derived from wetland ecosystem services and biodiversity.	Through application of section 4 of the Wetlands (Conservation and Management) Rules, 2010, a number of activities, primarily conversion of wetlands to non-wetland usages, construction within 50 meters of the peak inundation area and dumping of sewage have been prohibited.	There is limited influence on developmental planning, especially those related to water management within the Kallada Basin. Freshwater needs for maintenance of estuary ecosystem components, processes and services are yet to be defined and enforced.
Collective-choice arrangement Provision is made for those being affected by wetland management to participate in setting up of the management conditions and rules.	State Wetland Authority of Kerala has been set up to provide such an collaborative management framework.	The SWAK is mandated for all wetlands of the state. Given the complexity of institutional arrangements, there is a need for a dedicated management institution for Ashtamudi Estuary.
Monitoring system A monitoring system to assess changes in ecosystem components, processes and services is available, and used to inform and adapt wetland management.	There is no well-defined system to monitor Ashtamudi at present.	In absence of a well-defined monitoring system to enable communities to assess the status and trends in the wetland, and in particular, the impact of developmental activities, there is limited understanding of the risk of adverse change in wetland ecological character.
Graduated sanctions Sanctions for violation of management rules and conditions are graduated, and related to seriousness and context of violation.	Sanctions are defined under the extant regulatory framework such as Wetlands (Conservation and Management) Rules, 2010; Coastal Regulation Zone notification and rules associated with Kerala Wetlands and Paddy Land Act.	Enforcement mechanism for Wetlands (Conservation and Management) Rules, 2010 is yet to be clarified for Ashtamudi.
Conflict resolution mechanism A low cost and effective conflict resolution mechanism is available for supporting implementation of wetland management.	Conflict resolution mechanism in the form of appeal to the relevant bench of National Green Tribunal is provided within the Wetlands (Conservation	Available conflict resolution mechanisms, though effective, are not low cost. Local level conflict resolution mechanism is yet to develop in absence of clarity on roles and responsibilities of

Enabling institutional conditions and implication for management	Status of current institutional arrangements	Key gaps
	and Management) Rules, 2010. At community level, the Panchayat provides a forum for conflict resolution on matters related to management of common property.	various institutions vis-à-vis management of wetlands.
Minimal recognition of rights to organize Rights of stakeholders to define management objectives for Ashtamudi are not counter to existing government rules and regulations.	There no institutional arrangement at present for several stakeholder groups, such as fishery associations or houseboat owners associations to engage in management, and define management objectives.	Rights of communities and stakeholders in terms of wetland management are not defined.
Nested enterprises Institutional arrangements for management of Ashtamudi are linked with wider developmental planning within the River Kallada Basin, and coastal zone.	The role of linking management of Ashtamudi with river basin and coastal zone management is proposed to be delivered through SWAK.	Management of Ashtamudi is not linked with the basin or coastal zone scale developmental planning.

4.4 Proposed institutional arrangement for managing Ashtamudi

SWAK, if effective, will provide an institutional arrangement for achieving required level of coordinated action and enforcement of regulatory arrangements for conservation and wise use of wetlands of the state. However, it is important to ensure that various sectoral programmes being taken up within the catchment of Ashtamudi are coordinated, with due consideration of the impact of such programmes on the Ramsar Site. It is therefore proposed to constitute Ashtamudi Wetland Authority (AWA), under the aegis of the SWAK, as the nodal agency for integrated management of Ashtamudi.

The AWA is proposed to have the following functions:

- Coordinate implementation of the integrated wetland management plan through respective line departments
- Periodically review the wetland monitoring outcomes, and recommend necessary course correction measures to the respective departments
- Monitor enforcement of regulatory regimes related to wetlands (such as Wetlands (Conservation and Management) Rules, 2010; Kerala Conservation of Paddy Land and Wetland Act, 2008; The Coastal Regulation Zone Notification, 2011,

Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001), and report any omissions to the respective enforcement agencies

- Ensure consideration and integration of full range of ecosystem services and biodiversity values of Ashtamudi Estuary in developmental programming within river basin and coastal zone
- Engage with stakeholders, at different scales, to promote integrated management
- Commission specific studies to address knowledge gaps
- Promote awareness and outreach on biodiversity and ecosystem services values of Ashtamudi

The following are proposed to be members of the AWA:

- Member Secretary, State Wetland Authority Kerala (Chairman)
- Director, Department of Environment and Climate Change
- Director, Kerala State Biodiversity Board
- Chief Engineer, Water Resource Department
- Commissioner, Commissionerate of Land Revenue
- Chairman, Kerala State Pollution Control Board
- Director, Local Self Government Department
- Director, Fisheries Department
- Director, Department of Agriculture Development and Farmers Welfare
- Director, Kerala State Council for Science, Technology and Environment
- Director, Tourism Department/ District Tourism Promotion Council
- Director, Centre for Water Resource Development and Management
- Represetantive, Kollam Municipal Council
- Representative, Neendakara Port
- Representative, Primary Fisher Cooperatives
- Representative, Houseboat Associations
- Subject matter Experts
- Civil Society representatives

The Constitution of the Authority should be through a government order, and have regulatory backing through the provisions under Wetlands (Conservation and Management) Rules, 2010. The Authority should meet atleast initially once every quarter for the first year, and subsequently once every four months to review progress of implementation of management plan. Provisions for a permanent office space, human resources and infrastructure have been made within the management plan.

5. Monitoring Plan

Having a system to describe, monitor and detect changes in ecological character is critical to support decision making for wise use of the Ashtamudi Estuary. Equally important is to be able to assess effectiveness of management in terms of ability to develop and implement an integrated planning, management and evaluation system to secure wise use of the wetland.

The present system for monitoring Ashtamudi is highly fragmented and disjointed. A few government agencies and departments (for example the state government departments of water resources, agriculture, fisheries and animal resources, tourism; and agencies as Pollution Control Board) collect information on specific parameters of interest. There is no system at present for systematic collection of data on various wetland features and collating the same to support management. This severely limits the possibility of objectively defining the status and trends of various wetland features, and identification of related drivers and pressures. In absence of institutional arrangements for integrated management of Ashtamudi, each sectoral programme is monitored independently and consolidated at the level of department or agency. The monitoring is largely based on physical and financial targets, and are rarely linked with specific results. There are no mechanisms in place to assess the cumulative impacts of sectoral programmes on the status of the wetland or various wetland features.

The current section of the management plan describes a monitoring framework for Ashtamudi Estuary to support integrated management for wetland wise use. The section detail monitoring purpose and strategy and associated resource requirement. The monitoring plan is proposed to be applied both at the scale of wetland ecosystem, as well as institutional arrangements supporting management. Thus, a section outlining strategy and framework for assessing management effectiveness is also included. The cost implications of the monitoring plan are factored in the Chapter 6 (management planning framework).

5.1 Monitoring Objective

Developing a monitoring plan for Ashtamudi Estuary requires addressing the following inter-related requirements of wetland inventory and wetland assessment. It is imperative therefore to put in place an integrated Wetland Inventory, Assessment and Monitoring System (WIAMS) to address the overall information needs for wetland management, and to provide a robust decision support system for the same.

The ambit of monitoring is also envisaged to include assessment of management effectiveness.

The follow are the specific objectives for establishing WIAMS:

- Developing up-to-date and scientifically valid information on status and trends of wetland features and influencing factors
- Establishing a baseline for measuring change in ecosystem components, processes and services
- Informing decision makers and stakeholders on the status and trends in biodiversity, ecological functioning and ecosystem services of the wetland
- Supporting compliance to national and state legal requirements and regulatory regimes
- Determining impacts of developmental projects on ecosystem components, processes and services
- Identifying risks to ecological character and support development of response strategies
- Assessing effectiveness of wetland management

5.2 Monitoring Strategy

Monitoring strategy responds to the following information needs for effectively managing Ashtamudi Estuary, considering the developmental activities within the river basin and coastal zones, as well as its role in wider developmental planning:

- inventory - to establish the ecological character baseline
- assessment – to establish status, trends and threats to wetland using inventory information
- monitoring – to assess changes in status and trends, including reduction in existing threats or appearance of new threats, or even changes in management effectiveness

As these information pertain to various spatial scales, the overall information requirements can be classified at three hierarchical levels:

- Ashtamudi Estuary
- Ashtamudi and associated wetlands (linking Sasthamkotta, Karali marshes and other inland wetlands)
- Kallada River Basin and Coastal Zone

A hierarchical classification of inventory, assessment and monitoring needs for Ashtamudi Estuary is presented in Table 5.1. The information needs for inventory are derived from the core datasets needed to establish a baseline on ecological character[1] for Ashtamudi Estuary, and contain all the essential ecosystem components, processes and services, as well as management related parameters that characterize the site. At the basin scale, the information requirement is related to geo-morphological and climatological setup, as well as basin and coastal zone wide management arrangements, particularly those related to land and water resources. At the site scale, the information requirements pertain to important ecosystem component, processes and services, which are applicable to the site condition. At all levels, information on institutional arrangements and management practices is included so as to enable creation of a baseline on sectoral programmes, and the linked stakeholders, which are likely / have an impact on the wetland state.

Information needs related to assessment are aimed at deriving the status, trends and existing or likely threats to wetland system. At the site scale, the focus is on deriving ecological character change and ecosystem services valuations and tradeoffs. Specific assessments related to fish migration and waterbird habitats have also been identified based on the review of wetland features contained in previous chapters. The focus is on deriving the environmental flows which influence the vulnerability of ecological character change, based on deriving limits of acceptable change for the ecological character feature of interest, thereby maintaining the ecological integrity of the reservoir, maintenance of biodiversity and ecosystem services. At the Kallada River basin, the assessments are aimed at determining the climate induced risks to ecological character, ultimately aimed at developing a suitable response strategy for risk reduction and management. While not explicitly mentioned, strategic environmental assessments can be commissioned for any developmental project that has / likely to have negative impact on the wetlands.

Information needs for monitoring Ashtamudi have been derived from assessment of ecological character carried out for development of the management plan. Four cluster of needs have been identified: a) land use and land cover change, to assess the dynamics of land use within the catchment; b) hydrological regimes, to assess the flux

[1] Derived from the core inventory fields required for ecological character description as per Ramsar Convention Resolution X.15: Describing the ecological character of wetlands, and data needs and formats for core inventory: harmonized scientific and technical guidance. These fields have been further integrated into guidance related to information requirement for describing Ramsar site at the time of designation and subsequent updates (Ramsar Convention Resolution XI.8 and XI.8 annex 1)

of water, sediments and nutrients; c) ecological components and processes, to assess the biodiversity, habitat quality and resource productivity; and d) socioeconomics and livelihoods to assess the trends in ecosystem services – livelihoods interlinkages.

These monitoring information adequately address the needs of Wetland (Conservation and Management) Rules, 2010 of the Ministry of Environment, Forest and Climate Change which are applicable as Ashtamudi is a Ramsar Site. A list of wetland features, indicators and corresponding methodology and data collection frequency is provided as Table 5.2.

The monitoring and assessment needs are envisaged to be addressed by a dedicated monitoring programme and specific research and assessment projects. Inventory, being based on collated information on identified wetland features and management practices, will be developed based on the monitoring and assessment information, as well as secondary sources.

Inventory, assessment and monitoring form an integral part of wetland management, and thereby core activity of the nodal agency entrusted with the task of ensuring conservation and wise use of Ashtamudi. The management plan proposes establishment of Ashtamudi Wetland Authority under the aegis of the Kerala State Wetland Authority which, amongst other functions, will also be responsible for putting in place management to respond to any adverse change in ecological character. For the authority to be able to discharge these functions appropriately, a wetland monitoring unit is proposed be constituted within the Department of Water Resources with adequate human and technical resources. Given the established expertise and infrastructure within Center for Water Resources Development and Management, it is proposed to establish a sub-center of CWRDM to discharge the monitoring functions.

Linkages also need to be developed so that data from the existing monitoring networks of different agencies (for example, river flow and flood extent information from Central Water Commission and Department of Water Resources; groundwater quality and quantity from Central Ground Water Board; select surface water quality parameters from Kerala State Pollution Control Board; coastal processes from National Centre for Earth Sciences Studies and fisheries from Central Marine Fisheries Research Institute) can be accessed and shared. Similarly, provision for participation of NGOs and civil society in monitoring programme should also be built, especially for socioeconomics and livelihoods aspects and biodiversity monitoring (for

example, waterbird census being implemented by NGOs under the aegis of Asian Waterbird Census and Important Bird Area Programmes).

Table 5.1 | Inventory, assessment and monitoring needs for managing Ashtamudi Estuary

	Information Purpose		
Information Scale	Inventory	Assessment	Monitoring
Kallada River Basin and coastal zone	**Geology and Geomorphology** (Soils, elevation, slope, drainage pattern) **Climate** (Precipitation, Temperature) **Land use and land cover** **Water regimes** (river flows, upstream abstraction) **Coastal Zone** (littoral drift, tidal exchange)	**Climate risk and vulnerability** (changes in river flows, sea level rise and implications for estuary)	River basin management planning (water regulating structures and water allocation/discharge plans along the river basin) Coastal zone management planning
Ashtamudi and associated wetlands	**Climate** (Precipitation, temperature, wind, humidity, evaporation) Land use, land cover and management practices **Physical setting** (area, boundary, connectivity) **Water regime** (riverine and tidal flows, inflow -outflow balance, surface-groundwater interactions, inundation regimes, quality, regulation, abstraction) **Sediment regime** (inflow, outflow, balance, distribution and transport) **Sectoral programmes and institutional arrangements** for management of land and water resources and biodiversity conservation	**Ecological character risk and vulnerability** (limits of acceptable change for critical ecosystem components, processes and services; sensitivity and adaptive capacity of critical components; risks of adverse change in ecological character)	Land use and land cover change and impacts on estuary hydrodynamics (water availability and allocation amongst sectors)
Ashtamudi	**Physical setting** (area, boundary, topography, shape, bathymetry, habitat type and connectivity) **Climate** (precipitation, wind, temperature, humidity) **Water regime** (inflow, outflow, balance, surface-groundwater interactions, inundation regimes,	**Ecological character change** (change in ecosystem components, processes and services – can also be derived based on assessment of indicators related to ecosystems, habitat, species and / or	**Response of freshwater flow alteration** to salinity gradient and linked estuarine ecosystem processes

	quality) **Sediment regime** (inflow, outflow, balance, distribution and transport) **Biota** (plant and animal communities, conservation status) **Energy and nutrient dynamics** (primary productivity, nutrient cycling, carbon cycling, decomposition, oxidation-reduction) **Species interaction** (invasion, competition, predation, succession, herbivory) **Processes that maintain animal and plant population** (recruitment, migration) **Ecosystem services, stakeholders and trade-offs** (Provisioning –fisheries, clams, navigation; Regulating – Flood moderation, pollution abatement; Cultural – tourism and recreational values) **Institutional arrangements** (governance, formal and informal rights and ownership, application of acts and regulations)	management) Land use land cover change in intertidal areas Ecological status of fish breeding grounds and migration pathways Waterbird habitat assessment	

Table 5.2 Monitoring and assessment parameters and indicators

Parameter	Indicator	Priority	Monitoring Method	Monitoring Frequency
Land Use and Land Cover				
Land use and land cover change within Ashtamudi catchment	% area under various land use and cover classes (agriculture, forest cover, settlements, wetlands)	High	GIS and Remote Sensing Radar sensed data	Once in 5 years
Hydrological regime				
Water and sediment flux	Water inflow (River inflow, precipitation, local runoff)	High	Monitoring at gauging stations	Daily
	Water outflow (to the sea, evapotranspiration losses)	High		Daily
	Sediment inflow (from the sea and the river)	High		Daily
	Sediment outflow (to the river)	High		Daily
	Tidal exchange	High		Daily
Water holding capacity	Bathymetry	High	Bathymetric surveys	Once in 5 years
Inundation Regime	Seasonal fluctuation in waterspread area	High	Remote sensing	Once in 5 years
Surface Water quality	Temperature	Medium	Standard procedures of APHA	Twice in a month
	pH	High		
	Dissolved Oxygen	High		
	Specific Conductance	High		
	Nutrients and Nutrient Cycling (Nitrate, Phosphate, Silicate)	High		
	Cations and Anions (Calcium, Magnesium, Sulphate, Chloride, Fluoride, Sulphite)	High		
	Chemical Oxygen Demand	High		
	Transparency	Medium		

	Heavy metals (Arsenic, Mercury)	High		
	Biological oxygen demand	High	Standard procedures of APHA	
	Total Coliform	Medium		
	Faecal coliform	Medium		
Sediment quality	Texture	Low	Standard procedures of APHA	Once in six months
	pH	High		
	Organic carbon	High		
	Available nitrogen	High		
	Available phosphorus	High		
	Available calcium carbonate	Medium		
Ground water quality (in te peripheral regions of estuary)	Water level	Medium	Methodology approved by Groundwater Estimation Committee (1997)	Monthly
	Conductivity	Medium		Monthly
	Total hardness	Medium		Monthly
	Chloride	Medium		Monthly
	Fluoride	Medium		Monthly
	Arsenic	Medium		Monthly
	Iron	Medium		Monthly
Ecosystem Processes and Biodiversity				
Flora	Phytoplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Periphyton	Medium		Seasonal
	Mangroves and associates (diversity and abundance	High		Seasonal
	Species invasion	High	Habitat Sampling and Remote sensing (using high resolution data)	Once in 2 years
	Primary production	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal

Fauna	Zooplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic macro-invertebrates	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic Insects	Low	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Fish diversity	High	Taxonomic studies	Once in 5 years
	Amphibians	High	Taxonomic studies	Once in 5 years
	Reptiles	High	Taxonomic studies	Once in 5 years
	Fish catch and effort (number of fishing days, boats and types of gears)	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Monthly
	Recruitment (no. of juveniles)	High	Sampling and Taxonomic studies as per Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Fish breeding, spawning and migration pattern	High	Specific assessments and tagging experiments	Once in 5 years
	Water Bird population and diversity	High	Census and Taxonomic studies	Annual
	Water Bird migration pattern	High	Species specific ringing and banding studies	Once in 5 years
	Avian disease	Medium	Surveillance	Annual

		Habitat quality of bird congregation sites: Number of nests or egg Type of vegetation Water level Abundance of macro benthos	Medium	Assessment of bird habitat quality and Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10 (for macro benthos)	Annual
Socioeconomics and livelihoods					
	Community dependence on wetland ecosystem services	Fish catch	High	Socioeconomic survey	Monthly
		Performance of PFCS (Capitalization, infrastructure, catch processed, membership)	High		Annual
		% contribution of fisheries and tourism to income and employment	High		Bi-annual
		Number of tourists visiting wetland and direct and indirect spending	High		
	Livelihood status of wetland dependent communities	Physical capital, financial capital, social capital, human capital indicators of livelihood systems	Medium		
		Number of reported instances of conflicts	Medium		

5.3 Assessing management effectiveness

For wise use of Ashtamudi Estuary to be ensured, it is pertinent that periodic management effectiveness assessments are conducted. Such an assessment should enable evaluation of the degree to which institutional arrangements result in reduced risk of adverse change in ecological character, timely recognition of new risks, and mainstreaming full range of wetland values in wider developmental programming. The assessment should include, *inter alia*, following elements:

- Degree of (formal or informal) protection to the site
- Enforcement of existing regulation
- Clarity of management objectives
- Boundary delineation
- Availability and acceptance of management plan, including stakeholder endorsement
- Degree of management interface in research programmes
- Maintenance of integrated wetland inventory, assessment and monitoring systems
- Allocation of human resources to management
- Implementation and effectiveness of communication, education and awareness programmes
- Integration of landscape (eg. river basin and coastal zone) considerations in wetland management
- Inter-agency and intersectoral cooperation in implementation of management plans
- Stakeholder involvement, particularly local communities, in management

It is recommended that the aforementioned aspects are firmed-up and included in a management effectiveness assessment evaluation system. Evaluation should be carried out annually, and reported to the Ashtamudi Wetland Authority for their information and action as may be required for enhancing management effectiveness.

5.4 Infrastructure and human resources requirements

Implementing the monitoring strategy as outlined in the previous sections requires the following physical and human infrastructure support:

- Remote Sensing and GIS unit with advanced capabilities of remote sensing image processing, preparation of maps and development and maintenance of spatial datasets
- Ecological monitoring laboratory with capabilities for analysis of chemical, physical and biological properties of water and soil
- Database system for storing and retrieving monitoring and assessment data. The monitoring data would be stored along with metadata, as per the quality control procedures suggested in the following sections.
- Network of hydro-meteorological and water quality stations for hydro-biological monitoring (Map 5.1)

Need based training programmes should be conducted to upgrade skills of the concerned state government departments and agencies.

5.5 Reporting

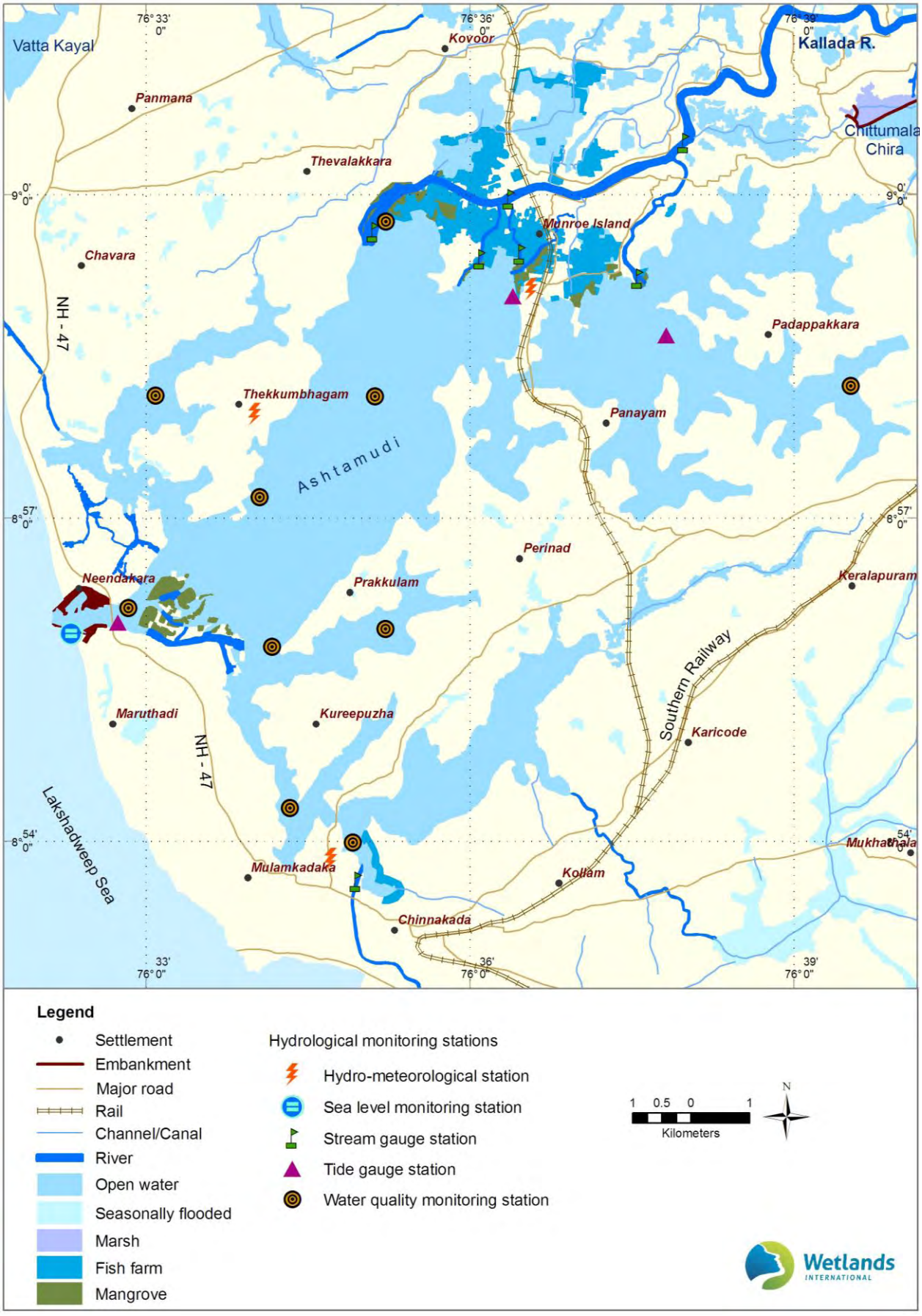
Reporting constitutes an important element of wetland monitoring programme. The intended user group, format, style and peer review requirement need to be set in the initial phases of set up of the monitoring programme.

It is proposed to develop an 'Ecosystem Health Report Card' system for the Estuary. The Health Report Card system has been initiated for Lake Chilika, and has been a popular means for conveying information on ecological state of the wetland to the stakeholders. The report card is based on evaluation of indicators against their respective threshold values for critical ecosystem components, processes and services. The outcomes are placed within ranks indicating minimum deviation from threshold to maximum deviation. Use of visualization tools and graphics enhances user interface.

Periodic reports, for example as a part of the annual report of the Ashtamudi Wetland Authority should aim to provide a summary overview of the outcomes of monitoring.

Special publications, for example wetland atlases constituting thematic maps on various parameters are intended to inform stakeholders on wetland status and trends.

Outcomes of specific assessments, for example ecological character status and trends, economic valuation, environmental flows etc. could be made available in the form of technical report series, with an extended summary for general readership. As the monitoring programs get sophisticated over a period of time, real time monitoring



Map 5.1 | Hydro-meteorological and water quality stations proposed at Ashtamudi Estuary

options through use of satellite based data communication techniques can be explored.

Quality control in monitoring systems is required to ensure the scientific validity of sampling, laboratory analysis, data analysis and reporting. They also play a critical role in preventing introduction of random and systematic errors in data collection, analysis and reporting.

It is recommended that a Quality Management and Assurance Plan is developed for the monitoring programme. The plan should determine, *inter alia*:

- Specification of objectives for sampling programme
- Data quality objectives: maximum amount of uncertainty that can be tolerated to ensure that the data is fit for intended use
- Sampling programme design: Statistical robustness of sampling frame; means to ensure that samples are representative of environment; sample recording; procedures for minimizing environmental impact
- Documentation: Procedures for field sample record keeping and methods documentation
- Sample processing validity (especially for water quality and biological components)
- Data quality control methods: processes for quality control samples, duplicates and replicates,
- Performance audit procedures, including data and systems audit

5.6 Review and adaptation

A periodic review of the monitoring programme is required to determine the extent to which the objectives, particularly support to management is achieved, and monitoring system remains relevant for the wetland state (particularly in the light of new and emerging threats). The review process should also aim at increasing the sophistication of the monitoring system to be able to assess complex landscape scale processes affecting the ecological character of wetland and related management.

Review process should include documentation on the way wetland inventory, assessment and monitoring information is being used to support management planning and policy goals. Review should also include identification of appropriate mechanisms to ensure that wetland monitoring is continued in the event of a funding shortfall.

6. Management Plan

6.1 Goal and Purpose

Integrated management of Ashtamudi Estuary requires strategies that can ensure provisioning of societal benefits while ensuring maintenance of its natural functioning and biodiversity values. Such a management needs to be based on an integrated understanding of hydrological, biological and social processes within the entire Kallada Basin from the headwaters through the catchment and estuary and down to the coastal zone. Management also needs to build on natural features of the estuary using a combination of physical, biological and social interventions which increase ecosystem resilience, particularly, ability to prevent human-induced adverse change to wetland ecological character.

The goal of integrated management of Ashtamudi Estuary is to secure ecological integrity of the wetland ecosystem, while providing ecological, economic and cultural benefits to the society on a sustainable basis.

The purpose is to put in place effective institutional and governance arrangements for stakeholder led management of Ashtamudi Estuary at Kallada River Basin and coastal zone scale.

6.2 Strategy

The management plan is proposed to be structured around following core strategies:

Creating an institutional setup for integrated management

Integrated management of Ashtamudi Estuary requires a dedicated institutional platform to secure consideration of full range of wetland values and functions in developmental programming, while seeking engagement of stakeholders at multiple levels. It is envisaged to constitute Ashtamudi Wetland Authority (AWA) under the aegis of State Wetland Authority of Kerala to provide such an institutional arrangement. The AWA shall be responsible for coordinating implementation of management plan by engaging various line department agencies of the government, research agencies and civil society organizations. AWC shall also maintain an overview of ecosystem health through a dedicated inventory, assessment and monitoring programme, and undertake mid-term corrections in management plan implementation, as may be required.

Integrated wetland monitoring and assessment system to guide management

As a dynamic ecosystem, Ashtamudi Estuary is prone to changes in response to a number of anthropogenic as well as natural drivers. Having a system to detect such changes, in particular, human induced adverse change in ecological character, is critical for success of management. Equally important is the need to periodically assess the effectiveness of management in terms of ability to achieve wise use with broad stakeholder participation. An integrated wetland inventory assessment and monitoring system is therefore proposed to be put in place to address the diverse information needs for managing Ashtamudi Estuary. A research strategy to address the gaps in existing knowledgebase and assess future risks will form an integral part of the system. It is proposed that CWRDM is mandated to manage the monitoring system with systematic reporting to AWA.

Ensuring ecosystem water requirements

Ashtamudi Estuary is gradually transitioning to a marine dominated environment due to reduced freshwater inflow from the Kallada River and declining rainfall. Such a transition is highly likely to impact ecological integrity of the Estuary due to reduced diversity of species and productivity. Management of water resources within the Kallada River Basin addresses only human demands of water, at the expense of reduced water availability for ecosystem functioning. Management of Ashtamudi Estuary will seek to assess freshwater requirements, and build the same into water resources planning for the river basin. Such allocation will also take into account scenarios of declining rainfall and increasing sea level rise.

Pollution abatement

In absence of appropriate waste management infrastructure within Kochi City and industrial operations around Ashtamudi, the Estuary has ended being a cesspool of untreated effluents. Management plan will seek improvement of water quality by enforcing the provisions of no untreated effluent discharge contained within the Wetlands (Conservation and Management) Rules, 2010, the Coastal Regulation Zone Notification, 2011, and the Water (Prevention and Control of Pollution) Act, 1974. Provisions will be made for proper sewage treatment and solid waste management within Kollam City. Alternate technologies for coir retting, which prevent discharge of toxins into estuary will be implemented. Safe water, sanitation and hygiene infrastructure will be created for shoreline households and houseboats.

Regulating fisheries and clam harvest within maximum sustainable yield levels

Ashtamudi accounts for over 90% of clam meat export of the country, providing livelihoods for nearly 1,500 households. The harvest of key species as P. Malabarica is hovering dangerously close to currently known maximum sustainable yield levels. Harvest of other fish and prawn species is on a decline. Management plan envisages to put in place resource management arrangements which would reduce harvest levels, as well as increase per unit value added. Investments will be made to strengthen fisher cooperatives, in terms of infrastructure as well as management capacities, so that these community organizations act as local resource stewards and promote use of code of conduct for responsible fisheries.

Transforming backwater tourism to ecotourism

Current backwater tourism practices in vogue in Ashtamudi are designed to delivered recreational value without consideration of values and functions of wetland ecosystem. Despite being a sizeable industry bearing direct linkages with ecosystem health of the estuary, no efforts are made to educate the tourists on wetland values, or enforce does and donts. Within the management plan, it is proposed to link current tourism with intensive communication and outreach on wetlands at multiple levels, using a targeted communications strategy.

6.3 Management Components and Objectives

The management plan for Ashtamudi Estuary is proposed to be organized in five components, namely a) institutional development; b) water management; c) biodiversity conservation; d) sustainable fisheries; and, e) sustainable livelihoods. Specific objectives intended to be achieved within each of these components are as under:

Component 1: Institutional development

- An effective arrangement for cross sectoral coordination and multi-stakeholder engagement in wetland management established and operationalized
- Systematic wetland inventory, assessment and monitoring system established to support decision making and management
- Capacity of concerned state government departments and agencies, civil society organizations and local communities for integrated wetland management enhanced

- Existing regulatory frameworks implemented for improvement of wetland ecosystem health
- Stakeholders, particularly local communities are aware of status and trends in Ashtamudi Estuary, management strategies and actions
- Management periodically updated based on effectiveness assessment and analysis of ecological, hydrological and social outcomes

Component 2: Water management

- Water and sediment requirements for maintaining ecological integrity of Ashtamudi Estuary assessed and integrated within river basin scale water allocation planning
- Salinity gradient ranging from freshwater environment in the creeks during monsoon and post monsoon re-established
- Pollution from anthropogenic sources within estuary abated through enforcement of existing regulations and through use of improved waste management technologies

Component 3: Biodiversity conservation

- Habitat conditions for migratory waterbirds are enhanced
- Pathways for migratory fish species maintained
- Mangroves and other intertidal habitats restored

Component 4: Fisheries management

- Code of Conduct for responsible fisheries implemented
- Clam, fish and other biomass harvest regulated within maximum sustainable yield levels
- Alternate clam processing options implemented for enhanced value realization to fishers
- Fisher Cooperatives strengthened for improved well-being of fishers and enhanced role in wetland management
- Fisheries infrastructure improved for enhanced access to safe catch storage, handling and marketing facilities

Components 5: Sustainable livelihoods

- Pressure on estuarine resources reduced and communities incentivized for resource stewardship through alternate livelihoods
- Responsible nature tourism developed within the backwaters

- Risk of pathogenic contamination reduced through improved access to water, sanitation and hygiene infrastructure

6.4 Action Plan

Component 1: Institutions and governance

1.1 Establishment of Ashtamudi Wetland Authority

Ashtamudi Wetland Authority is proposed to be established as a nodal agency mandated for coordinating integrated management of Ashtamudi. The Authority may be registered as a government non-profit organization (under the Travancore-Kochi Literary Science Charitable Society Registration Act, 1955) to enable flexibility in raising financial resources from public and private sources.

As per the provisions of the Societies Registration Act, a Memorandum of Association defining the jurisdiction, aims and objectives and governance structure will need to be submitted to the Registrar of Authorities. Rules and Regulations detailing the membership, powers and functions of governing and executive bodies, accounting and audit procedures, and management of property of the authority will also need to be formulated and submitted to the Registrar.

A three-tier governance structure is proposed with the Governing Body at the apex, an Executive Committee, and an office of the Chief Executive to implement the programmes. Meeting atleast once in year, The Governing Body will approve the overall management framework, and ensure intersectoral coordination between line departments and agencies. The Executive Committee shall meet regularly to approve annual plans and projects. The Office of the Chief Executive shall be responsible for implementing the decisions of the Executive Committee, and report to the Committee on the overall ecosystem health.

Following specific activities are to be undertaken:

- Government approval of constitution of AWA and the governance structure
- Finalization of Memorandum of Association
- Registration under Societies Registration Act
- Staffing and work allocation as per the structure suggested in Section 3.3.
- Conducting business as per the Terms of Reference outlined in Section 3.3

1.2 Integrated wetland inventory, assessment and monitoring system

An integrated wetland inventory, assessment and monitoring system is proposed to be set up to address the overall information needs of wetland management and to provide robust decision support system for the same. Specific objectives and a detailed framework have been outlined in Chapter 5 of the management plan. The following activities are proposed:

1.2.1 Establishment of wetland monitoring and research centre

A state of the art wetland monitoring and centre is proposed to be established within the DTPC Complex premises for monitoring the ecological, hydrological and socio-economic features of Ashtamudi. The centre would function under the aegis of CWRDM which would coordinate all inventory, assessment and monitoring programmes. A list of necessary equipment to be procured for the centre is in Annex 11

1.2.2 Development of database management system

A database system for storing, retrieving and analysing the WIAMS is proposed to be set up in a GIS environment. This system would serve as a template for the CWRDM for the inventory, assessment and monitoring system.

Specific activities to be take up under this activity include:

a) Development of data quality management and assurance plan including specification of data collection objectives, data quality objectives, sampling programme design, data and metadata documentation procedure, data quality control methods and performance audit procedures;
b) development of GIS based database management system;
c) managing the database as per approved plan, alongwith periodic updation and reporting.

1.2.3 Wetland monitoring and evaluation

Wetland monitoring and inventory protocols at the Ashtamudi Estuary, associated wetlands and Kallada Basin and coastal zone level as detailed in Section 5.2 of the management plan will be implemented. Implementation would include following additional activities:]

1.2.4 Ecosystem Health Report Card

It is proposed to assess and publish an Ecosystem Health Report Card, every two years, to assess and communicate wetland monitoring information to decision-makers and stakeholders.

The health report card summarizes indicators along major indices (e.g. key water and sediment quality parameters; parameters indicating health of coastal zone; fish, prawn, crab and clam landings; waterbird counts; biodiversity status) which represent various elements of ecological character of Ashtamudi Estuary, evaluated against respective thresholds set in line with management goals. Such a report card is being biennially published for Lake Chilika and has been found to be highly effective in communicating complex ecological, hydrological and socio-economic information in simple terms to decision-makers and stakeholders

1.3 Capacity development

Capacity building of Ashtamudi Wetland Authority, concerned State Government departments, agencies and local communities is proposed to be undertaken through professional training in following:

- Integrated wetland management
- Wetlands and water management
- Wetlands and livelihoods
- Conserving wetlands biodiversity

Other needs based training, as recommended by training needs assessment

Implementation of this component would be guided by a detailed capacity assessment of all management plan implementing agencies and departments, which will be conducted during the first year of management plan implementation. During the first two years, two training programmes for all concerned institutions on integrated wetland management and wetlands and water management are proposed. In addition, provision for exposure visits to Chilika and other sites wherein management has been relatively successful has also been made. Interventions of infrastructure enhancement has been made within the monitoring and evaluation section of the action plan.

1.4 Monitoring compliance with existing laws and regulations

Compliance with the provision of following rules and laws will be comprehensively monitored, and violations reported to concerned authority for ensuring remedial action:

- Provisions of Wetlands (Conservation and Management) Rules, 2010 – prohibiting conversion of wetlands into non-wetland usages, discharge of untreated sewage, soil waste dumping and activities likely to adversely affect wetland ecosystem health.
- Provisions of the Coastal Regulation Zone Notification, 2011 – prohibiting discharge of untreated effluent within regulated zones, setting up and expansion of new industries (with exceptions), land reclamation and a range of construction activities.
- Provisions of the Kerala Conservation of Paddy Land and Wetland Act, 2008 barring reclamation of wetlands.
- Provisions of The Kerala Protection of River Banks and Regulation of Removal of Sand Act (2001) under which mining is banned in Kallada River.

1.5 Communication and outreach

Stakeholder engagement in wetland management will be promoted through creating awareness on values and functions of Ashtamudi, management strategies adopted and opportunities for participation. Specific activities to be undertaken include:

Signage

Signage proclaiming Ashtamudi as a Ramsar Site is proposed to be placed at all major entry points of the estuary, namely DTPC Kollam, Thoppikadavu, Kadavur, Thekumbhagam and Monruthuruthu. The AWA may work out arrangements with all major resort owners to prominently display the wetland's Ramsar Site status within their properties. Recommended format for signage is provided Annex 12.

Webpage

It is proposed to create a dedicated webpage for Ashtamudi, as an electronic interface for stakeholders to connect with wetland managers. The page may be linked with the webpage of Department of Environment, and include information on various aspects of the Estuary, management plan implementation, outcomes of monitoring programme, research and development, news and career opportunities. The page will also host resources for wetland managers.

Resource material

Brochures, fact sheets and awareness material on Ashtamudi Estuary are proposed to be published in English and Malayalam for public distribution. A coffee table book is also proposed to be published for serious nature lovers.

Newsletter

A newsletter highlighting progress made in management plan implementation and key emerging issues related to Ashtamudi is proposed to be published annually in English and Malayalam, and disseminated to all stakeholders.

Workshops and public events

Public events are proposed to be organized on the eve of World Wetlands Day (Feb 2), World Environment Day (June 5) and International Day for Biological Diversity (May 22) as a means of reaching out to public on the issues of wetland conservation and wise use. Public events on specific issues, as water management and pollution abatement are also proposed to be organized, in cooperation with developmental programmes as Swacch Bharat Mission, as a means of engaging with stakeholders.

Ashtamudi Rangers' Camp

Camps, atleast once a year, are proposed to be organized for school and college students to make them aware of the significance of the lake. Students can be given an honorary Ashtamudi Rangers' badge on completion of the camp.

1.6 Management plan review

A mid-term and end-term review of management plan implementation is proposed to assess the extent to which stipulated objectives have been achieved with a high degree of resource efficiency and in participation with stakeholders. Evaluation would include assessment of management effectiveness. External agencies would be engaged for the purpose, who would report to AWA.

Component 2: Water management

2.1 Allocating water for ecosystem functioning

A reduction of freshwater inflows into Ashtamudi has led to predominance of marine environments, inducing threats to its ecological integrity and resource productivity. An important element of management plan is to assess and implement environmental water requirements for the Estuary. Methods for

assessment of environmental requirements can be broadly classed as follows (Adams, 2012):

- Conditions based which are set to maintain specific physical and habitat conditions in order to protect the estuarine ecosystem.
- Inflows-based deriving conditions for maintenance of freshwater inflows into the estuary based on hydrological analyses and modelling (such as required percentage of stream flows required for estuary ecological components and processes)
- Resource-based focused on species and communities of economic importance (such as fisheries)
- Holistic methods considering the entire ecosystem and using a range of multi-disciplinary approaches

Steps to be taken are as follows:

- Establishing a decision-making framework (constitution of a committee with major stakeholders, empowered to review assessment outcomes and influence implementation)
- Scoping a terms of reference for environmental water requirements
- Assessing trends in human demands of water at basin scale
- Assessing ecosystem water requirements (quantity and quality)and linked sediment fluxes
- Identifying tradeoffs and possible options
- Recommending possible Kallada Barrage operation rules to address environmental water requirements needs
- Setting up a monitoring system to evaluate performance against agreed upon indicators
- Implement environmental water requirement
- Review and adaptation

The assessment of environmental water requirements in proposed to be done by an enteral agency, working in collaboration with Kerala government research agencies as NCESS and CWRDM.

2.2. Water Quality Improvement

2.2.1 Waste management system for Kollam City

The absence of waste management infrastructure within Kollam City makes it one of the key pollution sources for Ashtamudi Estuary. As per the City Development Plan for Kollam, the projected sewage generation for the year 2031 and 2041 is 77 and 87 MLD respectively. For immediate requirement, STP (two units) of a cumulative capacity of 66 MLD and 305 km of branch sewers are required to be put in place. Provisions have already been made for this activity under the Atal Mission for Rejuvenation of Urban Transformation (AMRUT) of the Ministry of Urban Development.

The solid waste dumping site for Kollam City is located in Kureepuzha on the boundary of Ashtamudi estuary. The dump addresses only one-fourth of the waste generation, the rest invariably finding way into the estuary. In absence of treatment, leachate from the solid dump also becomes a source of pollution into the Estuary.

It is therefore proposed to treat the existing waste dump, and phase out these operations by locating an alternate site. Interventions for proper waste segregation at the household level, collection, and recycling through technologies as biomethanation and energy production need to be implemented, in collaboration with Kollam Municipal Corporation.

2.2.2 Management of Salughterhouse Effluent

The slaughter house located on the bank of Ashtamudi Estuary does not have adequate waste management facility and directly discharges waste into the Kollam Canal, and ultimately into the estuary. It is proposed to put in place effluent treatment facility in the slaughterhouse.

2.2.3 Alternate Technology for Coir Retting

It is proposed to establish closed coir retting facilities in all 25 retting units around Trikkaruva, Trikkadavur and Thekkumbhagam can be placed.

Closed coir retting technology has a biological leaching bed, which provides removal of bioextractables from coconut husk and thereby achieves anaerobic degradation of the bonding between the fibres and matrices. The pollutant is pumped to USAB high rate reactor leads to the formation of biogas which can be used as fuel. This is a quick process and takes around

30 days as compared with 10 months in the current practice. The coir pith produced in the process can be used as soil conditioner.

Implementation of this activity would involve engagement with the retting units on the adverse environmental as well as human health impacts of currently used retting practices. The unit owners would be trained in use of the alternate technology, and provided subsidies for adoption.

2.2.4 Houseboat waste

All houseboats would need to be fitted with a wastewater storage tank which can be emptied into a waste treatment facility located on the shorelines. Management plan implementation with also work with the Kerala Tourism Department to sensitize the boatowners on the implication of pollution on recreational values of the backwaters, and the extant regulatory measures in place prohibiting waste discharge in the waterbodies. Provisions are made within management plan to support adequate refurbishment of houseboats.

2.3 Research studies

Following specific research studies are proposed to be commissioned to address the knowledge gaps in assessing status and trends in ecological character:

- Sediment flux in the estuary – to assess the degree and source of siltation, and implication for water holding capacity.
- Climate risk and vulnerability to assess perception of climate risks based on sensitivity and adaptive capacity of critical ecological character elements; climate scenarios with respect to ecological character; and risk management options.

These studies are proposed to be conducted by AWA by engaging external agencies, The outcomes would be taken on board while evaluation management effectiveness, and undertaking mid-term course correction.

Component 3: Biodiversity conservation

3.1 Restoration of mangrove areas

The management envisages to restore mangroves within the intertidal areas of the Estuary. Given that much of the shoreline is under private ownership, it is proposed to undertake restoration using an incentive based bio-rights framework.

Under this framework, the participating household is provided a grant for livelihood activities, subject to a condition that the restored mangroves achieve a certain height and density over a period of time, and is maintained in that condition for a period not less than eight years. In case the height and density of mangrove does not reach the stipulated conditions, the grant is converted into a loan, and is reclaimed with a stipulated rate of interest. Wetlands International has implemented mangrove restoration programmes using similar approach in Indonesia and several West African countries, with considerable success over cash for work based approaches, wherein communities are paid for labour. During field surveys, restoration appeared to be feasible in areas around Asramam, Islands near Sakthikulangara and Munroe Islands.

Steps to be taken include:

- Survey and mapping of areas wherein mangrove restoration in feasible. The feasibility can be assessed on the basis of existence of mangrove patches within near past, availability of required salinity regime, physical features of the landform and tidal regime.
- Identification of target communities, collaboratively with Panchayat.
- Conducting sensitization workshops with the concerned Panchayat on the values of mangroves within the context of estuarine ecosystem, and restoration method.
- Formulating biorights contracts, with clear specification of restoration targets and linked conditionality, and monitoring mechanisms.
- Restoration within the identified sites.
- Monitoring of regeneration, technical support and contract enforcement.

3.2 Mid-winter census

Waterbird census conducted within the framework of Asian Waterbird Census provides a useful information base for assessing species-wise regional and global population. Ashtamudi Estuary is a habitat of over 60 of the known 216 species of migrating waterbirds recorded in India. While the census has been carried out for various years, the information remains patchy and disjointed.

It is proposed to conduct comprehensive mid-winter counts each year, in Ashtamudi Estuary and adjoining wetlands. The census can be led by the existing team at Kerala Agriculture University which has been conducting comprehensive census for Vembanad Kol wetlands since over a decade. Waterbird census also

provides an opportunity to promote awareness of wetlands, and therefore it is recommended to involve interested Panchayat members and volunteers in this operation. Action to be taken are as follows:

a) Training on bird identification and counting

It is proposed to train interested village community members and volunteers on identification and counting of birds so as to enable them being enumerators of census programme.

To support capacity development, it is proposed to publish a bird identification guide of Ashtamudi Estuary region in English and Malyalam.

b) Census

The census would be conducted as per the guidelines laid by the Asian Waterbird Census Programme and reported in standardized formats to State Coordinator for validation and onward compilation at national level.

3.3 Breeding waterbirds investigation

An assessment of distribution and breeding concentrations of all waterbird species in Ashtamudi Estuary and adjoining wetlands (Sasthamcotta Lake, Karali marshes, Chittumala, Veliyapadam marshes and Chellurpola kayal) is proposed to be undertaken to determine the current baseline population of breeding birds. Studies of the habitat preferences, precise requirements, ecology of key waterbird species and determination of current threats is proposed to enable planning and execution of measures to manage and improve existing habitats, to identify potential breeding areas and restore degraded areas to increase breeding habitats and address increased prey requirements. The services of Bombay Natural History Society or Salim Ali Center for Ornithology may be sought for implementing this study.

3.4 Animal disease surveillance

Knowledge of health of resident and migratory waterbird species is critical for assessing the risk and potential threat of avifaunal diseases. Knowledge of the health of these species that inhabit the wetland is critical to understand the risk and potential threat of transmission of avifauna diseases. It is proposed to train the Ashtamudi Wetland Authority in general identification of traits of common diseases as well as avian influenza. The authority will also be networked with

surveillance teams of State Animal Husbandry Department to enable timely response.

3.5 Biodiversity Register for Ashtamudi

It is proposed to develop a Biodiversity Register for Ashtamudi Estuary and associated wetland habitats. This register would be compiled by the Biodiversity Management Committees constituted within the Panchayat surrounding the estuary. Implementation of this activity may be supported by Kerala Biodiversity Board, Zoological Survey of India, Kerala Forest Research Institute, and Central Marine Fisheries Research Institute.

3.6 Ecotourism development

3.6.1 Master Plan Development

A community managed ecotourism master plan for Ashtamudi would be drawn up by engaging experts. The plan would establish the tourism potential by:

- Carrying capacity assessment of estuary for tourism. The assessment should inter alea establish the optimal number of houseboats that can be permitted with due consideration of the ecological character of the wetland.
- Identifying areas and features of ecotourism potential
- Identifying infrastructure development needs (eg. interpretation centre, boardwalk and nature trails and others)
- Analysis of regulatory environment in the context of ecotourism
- Institutional development needs
- Strength, Weakness, Opportunities and Threat analysis for ecotourism development
- Development of Regional Ecotourism Plan

3.6.2 Interpretation Center

It is proposed to establish an Ashtamudi Interpretation Center at KRTC, which is one of the significant entrypoints to the estuary. The Center is proposed to be a two storeyed 2,000 square feet construction with following facilities:

Viewing gallery – the gallery would display panels on the ecological, socio-economic and cultural significance of Ashtamudi Estuary;

Exhibits – life-size models estuary hydrology, fish migration, and waterbirds and their habitat;

Auditorium – as an audiovisual platform for screening of documentaries, holding talks, and workshops;

Monitoring laboratory – with equipment for ecological monitoring and GIS;

Conference hall – as a designated place for holding meetings, trainings and workshops.

Information kiosk – for public information through pamphlets, posters, maps and other references on key features of the wetland.

3.6.3 Capacity development programme for houseboat operators

A designated capacity development programme is proposed to be conducted for houseboat owners to train them in conducting tourists within an ecologically fragile area. Training would include introduction to various ecological features of the estuary, key biodiversity habitats and management needs and dos and donts for the operators as well as tourists. The training is proposed to be conducted at least once every year to take into account staff turnover.

Components 4: Fisheries management

4.1 Code of conduct for responsible fisheries

The Food and Agriculture Organization's Code of Conduct for Responsible Fisheries provides a validated reference framework for long-term conservation and sustainable use of fisheries resources. This voluntary framework emerged from a call from the International Conference on Responsible Fishing (1992) to strengthen the international legal framework for more effective conservation, management and sustainable exploitation and production of living aquatic resources, and was adopted by the FAO in 1995. After two decades since its adoption, the Code continues to be a reference framework for national and international efforts, including in the formulation of policies and other legal and institutional frameworks and instruments, to ensure sustainable fishing and production of aquatic living resources in harmony with the environment.

The management plan aims to create awareness on the needs of sustainable fishing, and mobilize local collective action by disseminating the code of conduct amongst the Ashtamudi Estuary fishers. The code will be translated into

Malayalam, and would be disseminated to all member fishers through outreach workshops. An important outcome to be targeted through the Code is regulation of use of small mesh sizes, and removing barriers to migratory routes.

4.2 Value addition in clam fisheries

Clams are traded in two forms: a) whole clam (fresh frozen or boiled frozen) and b) as clam meat (frozen blocks). Analysis of certified clam fisheries by CMFRI (reported in Muhamed et al, 2016) indicates that higher revenues can be generated if the trade is targeted at European markets, which have a preference for whole clams. The management plan aims to support this transition by promoting an alternate means of whole clam processing (rather than shucking clam meat) by depuration, prototypes for which are available with CMFRI.

Following steps are proposed:

- Conducting technology dissemination workshop with clam fisheries
- Establishing a demonstration project on whole clam processing
- Upscaling based on evaluation of outcomes of demonstration project

4.3 Maintenance of Marine Stewardship Council standard for certified clam fishery

Ashtamudi clam fisheries are famed to be the first Marine Stewardship Council certified fisheries of the country. The certification enables clam fishers to generate higher revenues and access new export markets. However, maintenance of certification requires meeting conditionality such as wilful forfeiture of clam catch due to enforcement of ban, cost of re-auditing (after 5 years), and cost of experts involved in auditing process.

Management plan entails efforts for maintenance of MSC certification through covering the cost of experts, providing alternate livelihoods for ban period, and training and outreach to the clam fisher community on sustainable clam fisheries.

4.4 Improving landing center infrastructure

It is proposed to provide landing platforms, storage area, weighing units, toilets and drinking water supply at all 20 landing center locations around the Estuary. These infrastructure would be managed by fisher cooperatives.

4.5 Cage culture of Pearl-spot

In convergence with Department of Fisheries' initiative "Matsyasamrudhi", a project for cage culture of state fish Karimeen (Etroplus Suretensis) is proposed to be undertaken with technical support of the Regional Agriculture Research Station, Kumarakom. The project would involve two sites, with two groups of beneficiaries (20 fishers each), and would be replicated based on the evaluation of outcomes. Specific activities are as follows:

- Site and beneficiary selection: Site selection require specific consideration of water level fluctuation; adequate water circulation; availability of sheltered, weed free, shallow bays; and operational accessibility.
- Training: The target fisher will be trained in use of cage culture technology, harvest & post-harvest management, and fish marketing. Training on the cage installation, species selection, stock maintenance and feeding operation and harvest will be imparted to the beneficiaries.
- Cage preparation and installation: Standard cages of 1 m^3 (1m x 1m x 1m) are proposed to be installed in a battery of six cages per unit.
- Productivity from cages would be monitored for four fishing cycles, and based on outcomes further dissemination would be done.

4.6 Monitoring and research

Following monitoring and research activities are proposed to support management of Ashtamudi Estuary Fisheries:

a) Stock and yield assessment

A systematic yield assessment protocol would be designed in consultation with CMFRI, and would be implemented to assess stocks and establish maximum sustainable yields for different fisheries. Provisions will be made for implementation of the assessment protocol and dissemination of outcomes.

b) Mapping migration pathways

Tagging experiment on commercially important fish species to assess migratory pathway, distribution and growth rates.

Component 5: Sustainable livelihoods

5.1 Improved sanitation services

Nearly half of the toilets around the shoreline have single pits and have inadequate sealing of faecal matter. It is prosed to replace nearly 20,000 such toilets with double pits to prevent water contamination with faecal matter.

5.2 Additional / alternate livelihoods

Additional / alternate livelihood options listed below would be provided to communities having direct livelihood dependence on Ashtamudi Estuary with an objective of reducing resource use pressure as well as incentivize resource stewardship.

- Dry fish unit for 6 fisher groups near Koduvila, Thekkumbhagam and Panayam with support of Fisheries Department. The dried and processed products can be market under the brand name "Drish Kerala" by Kerala State Coastal Area Development Corporation (KSCADC) in Sakthikulangara
- Vermi composting unit for 50 groups, using poultry waste and household waste. Arrangements would be made with Panchayat for sale of compost through Kudumbasree units.
- Coir based handicrafts for 5 self-help groups with support of Kerala State Coir Corporation Limited to promote ropes, mats, baskets, wall hangings etc. in national and international market
- Promote culture of ornamental fish species (such as the clownfish Amphiprion chrysogaster, A. percula, A. frenatus, A. ocellaris and one spot damselfish Chrysiptera unimaculata, Dascyllus aruanus and D. trimaculatus) for 5 fisher group with support of CMFRI

6.5 Budget

The management plan implementation for five years entails a budget of Rs. 175.53 crores. Of this, the component of water management is allocated 71%. Next highest allocation is for livelihoods at 15%. Components on institutions and governance, biodiversity conservation and sustainable fisheries have been allocated 6%, 5% and 3% of the budget respectively. A component-wise overview of the budget is in Table 6.1, and a detailed activity level budget in Table 6.2.

Table 6.1 | Component-wise budget required for implementation of management plan (in Rs. Lakh)

	Component	Total	Year 1	Year 2	Year 3	Year 4	Year 5
1	Institutions and Governance	1,045.25	375.25	378.25	188.75	52.25	50.75
2	Water Management	12,442.20	4,394.00	3,912.50	3,990.90	92.40	52.40
3	Biodiversity Conservation	876.50	22.50	567.50	255.50	20.50	10.50
4	Sustainable fisheries	572.50	11.50	228.50	242.50	80.00	10.00
5	Livelihoods	2,617.50	20.00	685.50	959.50	949.50	3.00
	Grand Total	**17,553.95**	**4,823.25**	**5,772.25**	**5,637.15**	**1,194.65**	**126.65**

6.6 Prioritization and Phasing

Management plan implementation during the first year would be focused on putting in place institutional and governance mechanisms, as well as integrated inventory, assessment, and monitoring system. During the second year, implementation will focus on ensuring water quality improvement as well as enhancement of fish resources. Interventions for livelihoods are proposed to be taken up post initiation of the interventions of pollution abatement. Year four will aim at closure of major works, with evaluation of management plan implementation scheduled in year 5. An activity-wise phasing of management plan is presented in Annex 13.

6.7 Implementation arrangements

Implementation of management plan is to be coordinated by the AWA, under the aegis of Department of Environment, Government of Kerala. Specific works would be carried out by line departments. Lead agencies for each of the components is specified in the following table:

Component	Lead agency
1) Institutions and governance	
Establishment of Ashtamudi Wetland Authority (AWA)	Department of Environment
Capacity development	AWA
Monitoring compliance with existing laws and regulations	AWA
Communication and outreach	AWA

2) Water Management	
Environmental water requirements	AWA
Improvement of waste management in Kollam City	Kollam Municipal Corporation
Management of slaughterhouse effluent	Kollam Municipal Corporation
Waste management of houseboats	Tourism Department
Alternate coir retting technology	AWA with Kerala State Coir Corporation
3. Biodiversity Conservation	Kerala State Biodiversity Board
4. Sustainable Fisheries Development	Fisheries Department with support of Department of Local Self Government and CMFRI
5. Livelihood Improvement	Department of Local Self Government with technology partners

6.8 Financing

The management plan budgeting has been done on convergence financing basis. As per details provided in table below, a major share of investment for waste management can be sourced through AMRUT, and has already been earmarked into planning. Of the total budget requirement of Rs. 173.53 cr, nearly 144.91 cr can be raised in the form convergence financing. The rest can be proposed for financial support to the MoEFCC's National Plan for Conservation of Aquatic Ecosystems Scheme. The Scheme operates on a 60:40 sharing basis. Thus, of the total budget, 40% would need to be secured by the state government in the form of internal resources.

Table 6.2 |Convergence financing opportunities for management of Ashtamudi Estuary

Management Plan Components		Budget		Convergence Scheme	Concerned Department/ Agency/ Organization	Convergence Budget
1	Institutions and Governance		1,045.25			
1.1	Establishment of Ashtamudi Management Authority	125.00				
1.2	Integrated wetland inventory, assessment & monitoring system	688.00				

Management Plan Components			Budget		Convergence Scheme	Concerned Department/ Agency/ Organization	Convergence Budget
	1.3	Capacity development	99.50				
	1.4	Monitoring compliance with existing laws & regulation	10.00			DoE	10.00
	1.5	Communication & outreach	87.75				
	1.6	Management Plan Review	35.00				
2	Water Management			12,242.20			
	2.1	Environmental water requirement	51.00				
	2.2	Enhancement of water quality					
		Improvement of sewage management in Kollam city	9,319.20		AMRUT	KSUDP	9,319.20
		Improvement of solid waste management	2,572.00		AMRUT	KSUDP	2,572.00
		Management of slaughterhouse effluent			AMRUT		
		Alternate coir retting method	75.00				
		Upgradation of houseboats in Ashtamudi	125.00				
	2.3	Research studies	100.00				
3	Biodiversity Conservation			876.50			
	3.1	Mangrove restoration	429.00				
	3.2	Annual water birds census	27.50				
	3.3	Water bird disease surveillance	10.00				
	3.4	Breeding waterbirds investigation	25.00				
	3.5	Biodiversity Register	35.00				
	3.6	Eco-Tourism Development	350.00				
4	Sustainable fisheries			572.50			

Management Plan Components		Budget		Convergence Scheme	Concerned Department/ Agency/ Organization	Convergence Budget
4.1	Code of Conduct for sustainable fisheries	15.00				
4.2	Value added in clam fisheries	317.50				
4.3	Marine Stewardship Council Standard Maintenance	30.00				
4.4	Improving landing center infrastructure	100.00				
4.5	Cage culture	50.00		NFDB	DoF	50.00
4.6	Monitoring and Research	60.00				
5	Livelihoods		2,617.50			
5.1	Safe sanitation	2,500.00		Suchitwa Mission		2,500.00
5.2	Additional Livelihoods	117.50		Matsya Samridhi Project	DoF	40.00
			17,353.95	-	-	14,491.20

6.9 Review and Adaptation

An outcomes based monitoring system would be adopted for review of management plan. Performance indicators and benchmarks would be established at the beginning of management plan implementation. A mid-term review would be carried out at the end of 2.5 years, by engaging an external agency. Review would include the degree of change in adverse trends on ecological character, as well as management effectiveness achieved. The outcomes would be used to revise management, as appropriate, in consultation with the State Wetland Authority Kerala. An end term review would be done at the end of five years, the outcomes of which would be used to assess the degree to which the intended outcomes have been achieved, and course of actions for the next five years.

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Phytoplankton recorded in Ashtamudi

(Source: Mathew and Nair, 1980)

Bacillariophyceae

Achnanthaceae

1. *Achnanthes* sp.

Bacillariaceae

2. *Bacillaria paradoxa* J.F.Gmelin, nom. illeg.
3. *Nitzschia sigma* (Kützing) W.Smith
4. *Nitzschia* sp.

Catenulaceae

5. *Amphora normanii Rabenhorst*
6. *Amphora* sp.

Cymbellaceae

7. *Cymbella marina* Castracane

Diploneidaceae

8. *Diploneis smithii* (Brébisson) Cleve

Fragilariaceae

9. *Fragilaria oceanica Cleve*
10. *Fragilaria* sp.

Naviculaceae

11. *Navicula gracilis* Ehrenberg
12. *Navicula* sp.

Pleurosigmataceae

13. *Pleurosigma aestuarii* (Brébisson ex Kützing) W.Smith
14. *Pleurosigma angulatum* (J.T.Quekett) W.Smith
15. *Pleurosigma directum* Grunow
16. *Pleurosigma elongatum* W.Smith

Surirellaceae

17. *Surirella* sp.

Tabellariaceae

18. *Asterionella japonica* Cleve

Chlorophyceae

Hydrodictyaceae

19. *Pediastrum duplex* Meyen

Oedogoniaceae

20. *Oedogonium* sp.

Conjugatophyceae

Desmidiaceae

21. *Desmidium* sp.

Zygnemataceae

22. *Spirogyra* sp.

Coscinodiscophyceae

Coscinodiscaceae

23. *Coscinodiscus excentricus* Ehrenberg
24. *Coscinodiscus gigas* Ehrenberg
25. *Coscinodiscus sublineatus* Grunow

Melosiraceae

26. *Melosira sulcata* (Ehrenberg) Kützing

Cyanophyceae

Merismopediaceae

27. *Synechocystis* sp.

Microcoleaceae

28. *Trichodesmium thiebautii Gomont ex Gomont*

Microcystaceae

29. *Microcystis aeruginosa* (Kützing) Kützing

Nostocaceae

30. *Anabaena* sp.

Oscillatoriaceae

31. *Lyngbya aestuarii* Liebman ex Gomont
32. *Lyngbya confervoides* C.Agardh ex Gomont
33. *Oscillatoria limosa* C.Agardh ex Gomont
34. *Oscillatoria margaritifera* Kützing ex Gomont
35. *Oscillatoria* sp.

Rivulariaceae

36. *Calothrix scopulorum* C.Agardh ex Born et & Flahault

Dinophyceae

Ceratiaceae

37. *Ceratium furca* (Ehrenberg) Claparède & Lachmann
38. *Ceratium tripos* (O.F.Müller) Nitzsch

Peridiniaceae

39. *Peridinium* sp.

Euglenophyceae

Euglenaceae

40. *Euglena* sp.

41. *Trachelomonas* sp.

Florideophyceae

Ceramiaceae

42. *Ceramium* sp.

Mediophyceae

Biddulphiaceae

43. *Biddulphia mobiliensis* (J.W.Bailey) Grunow

Climacospheniaceae

44. *Climacosphenia moniligera* Ehrenberg

Hemiaulaceae

45. *Cerataulina bergonii* (H.Peragallo) F.Schütt

Isthmiaceae

46. *Isthmia* sp.

Stephanodiscaceae

47. *Cyclotella meneghiniana* Kützing

Ulvophyceae

Cladophoraceae

48. *Rhizoclonium* sp.

Pithophoraceae

49. *Pithophora* sp.

Ulotrichaceae

50. *Ulothrix flacca* (Dillwyn) Thuret

Ulvaceae

51. *Enteromorpha intestinalis* (Linnaeus) Nees

52. *Enteromorpha* sp.

Mangroves and mangrove associates recorded in Ashtamudi

(Source: Sumesh et al., 2014 and Vidyasagaran and Madhusoodanan, 2014)

True Mangrove Species

Acanthaceae

1. *Acanthus ilicifolius* L.

Avicenniaceae

2. *Avicennia marina* (Forsk.) Vierh.
3. *Avicennia officinalis* L.

Combretaceae

4. *Lumnitzera racemosa* Willd.

Euphorbiaceae

5. *Excoecaria agallocha* L.

Fabaceae

6. *Derris trifoliata* Lour.

Lythraceae

7. *Sonneratia caseolaris* (L.) Engl.

Pteridaceae

8. *Acrostichum aureum* L.

Rhizophoraceae

9. *Bruguiera gymnorhiza* (L.) Lam.
10. *Ceriops tagal* (Perr) CB.Rob.
11. *Rhizophora apiculata* Blume

Associate Mangrove Species

Apocynaceae

1. *Alstonia scholaris* (L.) R.Br.
2. *Cerbera odollam* Gaertn.

Guttiferae

3. *Calophyllum inophyllum* L.

Malvaceae

4. *Hibiscus tiliaceus* L.
5. *Thespesia populnea* (L.) Soland. ex Correa

Myrtaceae

6. *Syzygium travancoricum* Gamble

Pandanaceae

7. *Pandanus fascicularis* Lam.

Zooplankton recorded in Ashtamudi

(Source: Divakaran et al., 1981; Divakaran et al., 1982; Nair et al., 1984; Raghunathan, 2007 and Nagendra et al., 2011)

Appendicularia

Oikopleuridae

1. *Oikopleura* sp.

Branchiopoda

Bosminidae

2. *Bosminopsis deitersi* Richard, 1895

Chydoridae

3. *Chydorus barroisi* (Richard, 1894)
4. *Leydigia* sp.

Daphniidae

5. *Ceriodaphnia cornuta* G.O. Sars, 1885

Moinidae

6. *Moina micrura* Kurz, 1874

Podonidae

7. *Evadne* sp.
8. *Evadne tergestina* Claus, 1864

Sididae

9. *Diaphanosoma sarsi* Richard, 1894
10. *Diaphanosoma* sp.
11. *Penilia avirostris* Dana, 1849

Hexanauplia

Acartiidae

12. *Acartia* sp.

Calanidae

13. *Undinula* sp.

Centropagidae

14. *Centropages* sp.

Cyclopidae

15. *Cyclops* sp.
16. *Mesocyclops* sp.

Diaptomidae

17. *Diaptomus* sp.
18. *Paradiaptomus* sp.
19. *Phyllodiaptomus* sp.

Euchaetidae

20. *Euchaeta* sp.

Oithonidae

21. *Oithona* sp.

Paracalanidae

22. *Acrocalanus* sp.
23. *Paracalanus* sp.

Pseudodiaptomidae

24. *Pseudodiaptomus* sp.

Tachidiidae

25. *Euterpina* sp.

Malacostraca

Ampeliscidae

26. *Ampelisca scabripes* Walker, 1904

Anthuridae

27. *Indanthura carinata* Pillai & Eapen, 1966

Apseudidae

28. *Apseudes chilkensis* Chilton, 1924

Cirolanidae

29. *Cirolana fluviatilis* Stebbing, 1902
30. *Cirolana willeyi* Stebbing, 1904

Corallanidae

31. *Corallana nodosa* Schioedte & Meinert, 1879

Corophiidae

32. *Corophium triaenonyx* Stebbing, 1904

Eriopisidae

33. *Eriopisa chilkensis* (Chilton, 1921)

Hyssuridae

34. *Xenanthura linearis* Pillai, 1954

Maeridae

35. *Quadrivisio bengalensis* Stebbing, 1907

Melitidae

36. *Melita zeylanica* Stebbing, 1904

Mysidae

37. *Mesopodopsis* sp.
38. *Mesopodopsis zeylanica* Nouvel, 1954

Paranthuridae

39. *Paranthura plumosa* Pillai, 1966

Photidae

40. *Photis digitata* K.H. Barnard, 1955
41. *Photis geniculate*

Sphaeromatidae

42. *Sphaeroma terebrans* Bate, 1866

Tanaididae

43. *Tanais estuarius* Pillai, 1954
44. *Tanais* sp.

Polychaeta

Goniadidae

45. *Goniada* sp.

Glyceridae

46. *Glycera* sp.

Hesionidae

47. *Ophiodromus* sp.

Lumbrineridae

48. *Lumbrinereis* sp.

Nephtyidae

49. *Nephthys* sp.

Nereididae

50. *Dendronereis* sp.
51. *Namalycastis indica* (Southern, 1921)
52. *Nereis* sp.
53. *Perinereis* sp.
54. *Platynereis* sp.

Onuphidae

55. *Diopatra neapolitana* Delle Chiaje, 1841
56. *Diopatra* sp.

Pilargidae

57. *Ancistrosyllis constricta* Southern, 1921
58. *Ancistrosyllis* sp.

Sabellidae

59. *Sabella* sp.

Serpulidae

60. *Mercierella enigmatica* Fauvel, 1923

Sigalionidae

61. *Sthenelais* sp.

Spionidae

62. *Nerine cirratulus* (Delle Chiaje, 1831)
63. *Polydora ciliata* (Johnston, 1838)
64. *Polydora* sp.
65. *Prionospio* sp.

Syllidae

66. *Opisthosyllis* sp.

Sagittoidea

Sagittidae

67. *Sagitta bipunctata* Quoy & Gaimard, 1827
68. *Sagitta enflata* Grassi, 1881
69. *Sagitta pulchra* Doncaster, 1903

Scyphozoa

Ulmaridae

70. *Aurelia* sp.

Molluscs recorded in Ashtamudi

(Source: Divakaran et al., 1981; Nair et al., 1984; Raghunathan, 2007 and Mohamed et al., 2013)

Bivalvia

Arcidae

1. *Tegillarca granosa* (Linnaeus, 1758)

Cyrenidae

2. *Villorita cyprinoides* (Gray, 1825)

Donacidae

3. *Donax* sp.

Mytilidae

4. *Modiolus plumicens*
5. *Musculista arcuatuta*
6. *Musculista senhousia* (Benson, 1842)
7. *Perna viridis* (Linnaeus, 1758)

Ostreidae

8. *Crassostrea bilineata* (Röding, 1798)
9. *Saccostrea cucullata* (Born, 1778)

Solenidae

10. *Solen* sp.

Veneridae

11. *Marcia opima* (Gmelin, 1791)
12. *Meretrix casta* (Gmelin, 1791)
13. *Meretrix meretrix* (Linnaeus, 1758)
14. *Paphia malabarica* (Dillwyn, 1817)
15. *Protapes gallus* (Gmelin, 1791)

Gastropoda

Potamididae

16. *Cerithidea fluviatilis* (Potiez & Michaud, 1838)

Fish Species recorded in Ashtamudi

(Source: Nair et al., 1983; Raghunathan, 2007 and Raj et al., 2014)

Acanthuridae

1. *Acanthurus mata* (Cuvier, 1829)
2. *Ctenochaetus strigosus* (Bennett, 1828)

Ambassidae

3. *Chanda commersonii* (Cuvier, 1828)*
4. *Chanda gymnocephalus* (Lacepède, 1802)*

Anabantidae

5. *Anabas testudineus* (Bloch, 1792)*

Aplocheilidae

6. *Panchax lineatus* (non Valenciennes, 1846)

Apogonidae

7. *Apogon thermalis* Cuvier, 1829

Ariidae

8. *Arius dussumieri* Valenciennes, 1840
9. *Arius maculatus* (Thunberg, 1792)*
10. *Arius subrostratus* Valenciennes, 1840*
11. *Arius thalassinus* (non Rüppell, 1837)

Atherinidae

12. *Pranesus duodecimalis* (Valenciennes, 1835)*

Bagridae

13. *Horabagrus brachysoma* (Günther, 1864)
14. *Mystus gulio* (Hamilton, 1822)

Belonidae

15. *Tylosurus crocodilus* (Péron & Lesueur, 1821)
16. *Tylosurus strongylurus* (Van Hasselt, 1823)*
17. *Xenentodon cancila* (Hamilton, 1822)*

Carangidae

18. *Alepes djedaba* (Forsskål, 1775)
19. *Alepes para* (Cuvier, 1833)
20. *Atule mate* (Cuvier, 1833)*
21. *Carangoides praeustus* (Anonymous [Bennett], 1830)*
22. *Caranx carangus* (Bloch 1793)
23. *Caranx ignobilis* (Forsskål, 1775)*
24. *Caranx sexfasciatus* Quoy & Gaimard, 1825
25. *Chorinemus* sp.*
26. *Scomberoides* sp.
27. *Trachinotus blochii* (Lacepède, 1801)

Chanidae

28. *Chanos chanos* (Forsskål, 1775)

Channidae

29. *Channa punctata* (Bloch, 1793)*
30. *Channa striata* (Bloch, 1793)*

Cichlidae

31. *Etroplus maculatus* (Bloch, 1795)*
32. *Etroplus suratensis* (Bloch, 1790)*
33. *Oreochromis mossambicus* (Peters, 1852)

Clupeidae

34. *Anadontostoma chacunda* (Hamilton, 1822)*
35. *Ehirava fluviatilis* Deraniyagala, 1929
36. *Escualosa thoracata* (Valenciennes, 1847)
37. *Nematalosa nasus* (Bloch, 1795)
38. *Sardinella albella* (Valenciennes, 1847)
39. *Sardinella fimbriata* (Valenciennes, 1847)*
40. *Sardinella longiceps* Valenciennes, 1847
41. *Sardinella* sp.*

Cynoglossidae

42. *Cynoglossus bilineatus* (Lacepède, 1802)
43. *Cynoglossus lida* (Bleeker, 1851)*
44. *Cynoglossus lingua* Hamilton, 1822*
45. *Cynoglossus macrostomus* Norman, 1928
46. *Cynoglossus puncticeps* (Richardson, 1846)
47. *Paraplagusia bilineata* (Bloch, 1787)

Cyprinidae

48. *Danio aequipinnatus* (non McClelland, 1839)
49. *Puntius amphibius* (Valenciennes, 1842)*
50. *Puntius filamentosus* (Valenciennes, 1844)*
51. *Puntius mahecola* (Valenciennes, 1844)

52. *Puntius sarana* (Hamilton, 1822)*
53. *Puntius vittatus* Day, 1865
54. *Rasbora daniconius* (Hamilton, 1822)*

Drepaneidae

55. *Drepane punctata* (Linnaeus, 1758)

Dussumieriidae

56. *Dussumieria acuta* Valenciennes, 1847*

Eleotridae

57. *Butis butis* (Hamilton, 1822)
58. *Eleotris fusca* (Forster, 1801)

Elopidae

59. *Elops machnata* (Forsskål, 1775)

Engraulidae

60. *Stolephorus commersonii* (non Lacepède, 1803)*
61. *Stolephorus indicus* (Van Hasselt, 1823)*
62. *Thryssa hamiltonii* Gray, 1835*
63. *Thryssa malabarica* (Bloch, 1795)*
64. *Thryssa mystax* (Bloch & Schneider, 1801)*
65. *Thryssa purava* (Hamilton, 1822)
66. *Thryssa setirostris* (Broussonet, 1782)

Epinephelidae

67. *Epinephelus diacanthus* (Valencienne s, 1828)
68. *Epinephelus malabaricus* (Bloch & Schneider, 1801)
69. *Epinepheles* sp.*
70. *Epinephelus tauvina* (Forsskål 1775)*

Gerreidae

71. *Gerreomorpha setifer* (Hamilton, 1822)*
72. *Gerres abbreviatus* Bleeker, 1850*
73. *Gerres oblongus* Cuvier, 1830*
74. *Gerres oyena* (Forsskål, 1775)*
75. *Pertica filamentosa* (Cuvier, 1829)*

Gobiidae

76. *Acentrogobius caninus* (Valenciennes, 1837)
77. *Acentrogobius chlorostigmatoides* (Bleeker, 1849)
78. *Acentrogobius cyanomos* (Bleeker, 1849)
79. *Acentrogobius reichei* (Bleeker, 1854)
80. *Acentrogobius* sp.
81. *Bathygobius fuscus* (Rüppell, 1830)
82. *Brachyamblyopus* sp.
83. *Brachyamblyopus urolepis* (Bleeker, 1852)
84. *Glossogobius biocellatus* (Valenciennes, 1837)
85. *Glossogobius giuris* (Hamilton, 1822)*
86. *Odontamblyopus rubicundus* (Hamilton, 1822)
87. *Oligolepis acutipennis* (Valenciennes, 1837)
88. *Oxyurichthys formosanus* Nichols, 19 58
89. *Oxyurichthys microlepis* (Bleeker, 1849)
90. *Oxyurichthys tentacularis* (Valenciennes 1837)
91. *Trypauchen vagina* (Bloch & Schneider, 1801)

Haemulidae

92. *Pomadasys hasta* (Bloch, 1790)*

Hemiramphidae

93. *Hyporhamphus limbatus* (Valenciennes, 1847)*
94. *Hyporhamphus xanthopterus* (Valenciennes, 1847)*
95. *Zenarchopterus buffonis* (Valenciennes, 1847)*
96. *Zenarchopterus dispar* (Valenciennes, 1847)*

Leiognathidae

97. *Gazza minuta* (Bloch, 1795)
98. *Leiognathus bindus* (Valenciennes, 1835)
99. *Leiognathus blochii* (Valenciennes, 1835)
100. *Leiognathus equulus* (Forsskål, 1775)*
101. *Leiognathus lineolatus* (non Valenciennes, 1835)*
102. *Leiognathus splendens* (Cuvier, 1829)*
103. *Secutor insidiator* (Bloch, 1787)*
104. *Secutor ruconius* (Hamilton, 1822)*

Lethrinidae

105. *Lethrinus nebulosus* (Forsskål , 1775)
106. *Lethrinus* sp.*

Lutjanidae

107. *Lutjanus argentimaculatus* (Forsskål, 1775)*

108. *Lutjanus fulviflamma* (Forsskål, 1775)*
109. *Lutjanus johni* (Bloch, 1792)*
110. *Lutjanus russelli* (Bleeker, 1849)*

Megalopidae

111. *Megalops cyprinoides* (Broussonet, 1782)*

Monodactylidae

112. *Monodactylus argenteus* (Linnaeus, 1758)

Mugilidae

113. *Liza macrolepis* (Smith, 1894)*
114. *Liza parsia* (non Hamilton, 1822)*
115. *Liza tade* (Forsskål, 1775)
116. *Mugil cephalus* Linnaeus, 1758*
117. *Osteomugil cunnesius* (Valenciennes, 1836)*
118. *Valamugil buchanani* (Bleeker, 1853)*
119. *Valamugil seheli* (non Forsskål, 1775)*

Mullidae

120. *Parupeneus indicus* (Shaw, 1803)

Muraenesocidae

121. *Muraenosox cinereus* (Forsskål, 1775)

Ophichthidae

122. *Ophichthus microcephalus* (Day, 1878)

Ostraciidae

123. *Ostracion lentiginosus* Bloch & Schneider, 1801

Paralichthyidae

124. *Pseudorhombus triocellatus* (Bloch & Schneider, 1801)*

Platycephalidae

125. *Platycephalus cantori* Bleeker, 1879
126. *Platycephalus indicus* (Linnaeus, 1758)*

Plotosidae

127. *Plotosus lineatus* (Thunberg, 1787)

Pomacanthidae

128. *Pomacanthus annularis* (Bloch, 1787)

Pomacentridae

129. *Pomacentrus cyanomos* Bleeker, 1856

Pristigasteridae

130. *Ilisha melastoma* (Bloch & Schneider, 1801)

Scatophagidae

131. *Scatophagus argus* (Linnaeus, 1766)

Sciaenidae

132. *Daysciaena albida* (Cuvier, 1830)

Serranidae

133. *Cephalopholis pachycentron* (Valenciennes, 1828)

Siganidae

134. *Siganus canaliculatus* (Park, 1797)
135. *Siganus javus* (Linnaeus, 1766)

Sillaginidae

136. *Sillago sihama* (Forsskål, 1775)*

Siluridae

137. *Callichrous* sp.

Soleidae

138. *Brachirus orientalis* (Bloch & Schneider, 1801)*
139. *Synaptura commersonii* (Lacepède, 1802)*

Sparidae

140. *Acanthopagrus berda* (Forsskål, 1775)

Sphyraenidae

141. *Sphyraena jello* Cuvier, 1829*

Syngnathidae

142. *Doryichthys cuncalus* (Hamilton, 1822)

Terapontidae

143. *Autisthes puta* (Cuvier, 1829)
144. *Pelates quadrilineatus* (Bloch, 1790)
145. *Therapon jarbua* (Forsskål, 1775)*
146. *Terapon theraps* Cuvier, 1829

Tetraodontidae

147. *Arothron hispidus* (Linnaeus, 1758)
148. *Chelonodon patoca* (Hamilton, 1822)
149. *Tetrodon fluviatilis* Hamilton, 1822
150. *Tetraodon immaculatus* Bloch & Schneider, 1801

Triacanthidae

151. *Triacanthus brevirostris* Temminck & Schlegel, 1850

* Commercially important fish species

Birds recorded at Ashtamudi

(Source: AWC, 1992-2014 and Raghunathan, 2007)

Sl. No.	Common Name	Scientific Name	Family	IUCN Status
1	Ashy Prinia	*Prinia socialis* Sykes, 1832	Cisticolidae	LC
2	Ashy Woodswallow	*Artamus fuscus* Vieillot, 1817	Artamidae	LC
3	Asian Green Bee-eater	*Merops orientalis* Latham, 1802	Meropidae	LC
4	Asian Openbill*	*Anastomus oscitans* (Boddaert, 1783)	Ciconiidae	LC
5	Baillon's Crake*	*Porzana pusilla* (Pallas, 1776)	Rallidae	LC
6	Barn Swallow	*Hirundo rustica* Linnaeus, 1758	Hirundinidae	LC
7	Bar-tailed Godwit*	*Limosa lapponica* (Linnaeus, 1758)	Scolopacidae	NT
8	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)	Ploceidae	LC
9	Black Bittern*	*Ixobrychus flavicollis* (Latham, 1790)	Ardeidae	LC
10	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817	Dicruridae	LC
11	Black Kite	*Milvus migrans* (Boddaert, 1783)	Accipitridae	LC
12	Black-capped Kingfisher	*Halcyon pileata* (Boddaert, 1783)	Alcedinidae	LC
13	Black-crowned Night-heron*	*Nycticorax nycticorax* (Linnaeus, 1758)	Ardeidae	LC
14	Black-headed Cuckooshrike	*Lalage melanoptera* (Rüppell, 1839)	Campephagidae	LC
15	Black-headed Gull*	*Larus ridibundus* Linnaeus, 1766	Laridae	LC
16	Black-headed Ibis*	*Threskiornis melanocephalus* (Latham, 1790)	Threskiornithidae	NT
17	Black-rumped Flameback	*Dinopium benghalense* (Linnaeus, 1758)	Picidae	LC
18	Black-tailed Godwit*	*Limosa limosa* (Linnaeus, 1758)	Scolopacidae	NT
19	Black-winged Stilt*	*Himantopus himantopus* (Linnaeus, 1758)	Recurvirostridae	LC
20	Blue-tailed Bee-eater	*Merops philippinus* Linnaeus, 1766	Meropidae	LC
21	Brahminy Kite	*Haliastur indus* (Boddaert, 1783)	Accipitridae	LC
22	Broad-billed Sandpiper*	*Limicola falcinellus* (Pontoppidan, 1763)	Scolopacidae	LC
23	Bronzed Drongo	*Dicrurus aeneus* Vieillot, 1817	Dicruridae	LC
24	Bronze-winged Jacana*	*Metopidius indicus* (Latham, 1790)	Jacanidae	LC
25	Brown-headed Gull*	*Larus brunnicephalus* Jerdon, 1840	Laridae	LC
26	Caspian Tern*	*Sterna caspia* Pallas, 1770	Laridae	LC
27	Cattle Egret*	*Bubulcus ibis* (Linnaeus, 1758)	Ardeidae	LC
28	Chestnut-shouldered Petronia	*Petronia xanthocollis* (Burton, 1838)	Passeridae	LC
29	Cinnamon Bittern*	*Ixobrychus cinnamomeus* (Gmelin, 1789)	Ardeidae	LC
30	Clamorous Reed-warbler	*Acrocephalus stentoreus* (Ehrenberg, 1833)	Acrocephalidae	LC
31	Collared Kingfisher	*Todiramphus chloris* (Boddaert, 1783)	Alcedinidae	LC
32	Common Coot*	*Fulica atra* Linnaeus, 1758	Rallidae	LC
33	Common Greenshank*	*Tringa nebularia* (Gunnerus, 1767)	Scolopacidae	LC
34	Common Kestrel	*Falco tinnunculus* Linnaeus, 1758	Falconidae	LC
35	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	Alcedinidae	LC
36	Common Moorhen*	*Gallinula chloropus* (Linnaeus, 1758)	Rallidae	LC

Sl. No.	Common Name	Scientific Name	Family	IUCN Status
37	Common Redshank*	*Tringa totanus* (Linnaeus, 1758)	Scolopacidae	LC
38	Common Sandpiper*	*Actitis hypoleucos* Linnaeus, 1758	Scolopacidae	LC
39	Common Snipe*	*Gallinago gallinago* (Linnaeus, 1758)	Scolopacidae	LC
40	Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)	Cisticolidae	LC
41	Common Teal*	*Anas crecca* Linnaeus, 1758	Anatidae	LC
42	Common Tern*	*Sterna hirundo* Linnaeus, 1758	Laridae	LC
43	Cotton Pygmy-goose*	*Nettapus coromandelianus* (Gmelin, 1789)	Anatidae	LC
44	Curlew Sandpiper*	*Calidris ferruginea* (Pontoppidan 1763)	Scolopacidae	NT
45	Drongo Cuckoo	*Surniculus lugubris* (Horsfield, 1821)	Cuculidae	LC
46	Eastern Short-toed Lark	*Calandrella dukhunensis* (Sykes, 1832)	Alaudidae	LC
47	Eurasian Curlew*	*Numenius arquata* (Linnaeus, 1758)	Scolopacidae	NT
48	Eurasian Oystercatcher*	*Haematopus ostralegus* Linnaeus, 1758	Haematopodidae	NT
49	Ferruginous Duck*	*Aythya nyroca* (Güldenstädt, 1770)	Anatidae	NT
50	Garganey*	*Anas querquedula* Linnaeus, 1758	Anatidae	LC
51	Great Cormorant*	*Phalacrocorax carbo* (Linnaeus, 1758)	Phalacrocoracidae	LC
52	Great Crested Tern*	*Sterna bergii* Lichtenstein, 1823	Laridae	LC
53	Great Egret*	*Ardea alba* Linnaeus, 1758	Ardeidae	LC
54	Greater Sandplover*	*Charadrius leschenaultii* Lesson, 1826	Charadriidae	LC
55	Green Sandpiper*	*Tringa ochropus* Linnaeus, 1758	Scolopacidae	LC
56	Grey Heron*	*Ardea cinerea* Linnaeus, 1758	Ardeidae	LC
57	Grey Plover*	*Pluvialis squatarola* (Linnaeus, 1758)	Charadriidae	LC
58	Grey Wagtail	*Motacilla cinerea* Tunstall, 1771	Motacillidae	LC
59	Gull-billed Tern*	*Gelochelidon nilotica* (Gmelin, 1789)	Laridae	LC
60	Herring Gull*	*Larus argentatus* Pontoppidan, 1763	Laridae	LC
61	House Crow	*Corvus splendens* Vieillot, 1817	Corvidae	LC
62	Indian Cormorant*	*Phalacrocorax fuscicollis* Stephens, 1826	Phalacrocoracidae	LC
63	Indian Paradise Flycatcher	*Terpsiphone paradisi* (Linnaeus, 1758)	Monarchidae	LC
64	Indian Pond-heron*	*Ardeola grayii* (Sykes, 1832)	Ardeidae	LC
65	Indian Spot-billed Duck*	*Anas poecilorhyncha* Forster, 1781	Anatidae	LC
66	Intermediate Egret*	*Ardea intermedia* Wagler, 1829	Ardeidae	LC
67	Kentish Plover*	*Charadrius alexandrinus* Linnaeus, 1758	Charadriidae	LC
68	Large Cuckooshrike	*Coracina macei* (Lesson, 1831)	Campephagidae	LC
69	Lesser Crested Tern*	*Sterna bengalensis* Lesson, 1831	Laridae	LC
70	Lesser Frigatebird	*Fregata ariel* (Gray, 1845)	Fregatidae	LC
71	Lesser Sandplover*	*Charadrius mongolus* Pallas, 1776	Charadriidae	LC
72	Lesser Whistling-duck*	*Dendrocygna javanica* (Horsfield, 1821)	Anatidae	LC
73	Little Cormorant*	*Phalacrocorax niger* (Vieillot, 1817)	Phalacrocoracidae	LC
74	Little Egret*	*Egretta garzetta* (Linnaeus, 1766)	Ardeidae	LC
75	Little Grebe*	*Tachybaptus ruficollis* (Pallas, 1764)	Podicipedidae	LC
76	Little Ringed Plover*	*Charadrius dubius* Scopoli, 1786	Charadriidae	LC
77	Little Stint*	*Calidris minuta* (Leisler, 1812)	Scolopacidae	LC

Sl. No.	Common Name	Scientific Name	Family	IUCN Status
78	Little Tern*	*Sterna albifrons* Pallas, 1764	Laridae	LC
79	Marsh Sandpiper*	*Tringa stagnatilis* (Bechstein, 1803)	Scolopacidae	LC
80	Mottled Wood-owl	*Strix ocellata* (Lesson, 1839)	Strigidae	LC
81	Northern Pintail*	*Anas acuta* Linnaeus, 1758	Anatidae	LC
82	Oriental Darter*	*Anhinga melanogaster* Pennant, 1769	Anhingidae	NT
83	Oriental Magpie-robin	*Copsychus saularis* (Linnaeus, 1758)	Muscicapidae	LC
84	Oriental Skylark	*Alauda gulgula* Franklin, 1831	Alaudidae	LC
85	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	Pandionidae	LC
86	Pacific Golden Plover*	*Pluvialis fulva* (Gmelin, 1789)	Charadriidae	LC
87	Pallas's Gull*	*Larus ichthyaetus* Pallas, 1773	Laridae	LC
88	Peregrine Falcon	*Falco peregrinus* Tunstall, 1771	Falconidae	LC
89	Pheasant-tailed Jacana*	*Hydrophasianus chirurgus* (Scopoli, 1786)	Jacanidae	LC
90	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	Alcedinidae	LC
91	Pintail Snipe*	*Gallinago stenura* (Bonaparte, 1830)	Scolopacidae	LC
92	Plum-headed Parakeet	*Psittacula cyanocephala* (Linnaeus, 1766)	Psittacidae	LC
93	Purple Heron*	*Ardea purpurea* Linnaeus, 1766	Ardeidae	LC
94	Purple Swamphen*	*Porphyrio porphyrio* (Linnaeus, 1758)	Rallidae	LC
95	Red-wattled Lapwing*	*Vanellus indicus* (Boddaert, 1783)	Charadriidae	LC
96	Richard's Pipit	*Anthus richardi* Vieillot, 1818	Motacillidae	LC
97	Rose-ringed Parakeet	*Psittacula krameri* (Scopoli, 1769)	Psittacidae	LC
98	Small Minivet	*Pericrocotus cinnamomeus* (Linnaeus, 1766)	Campephagidae	LC
99	Spot-billed Pelican*	*Pelecanus philippensis* Gmelin, 1789	Pelecanidae	NT
100	Stork-billed Kingfisher	*Pelargopsis capensis* (Linnaeus, 1766)	Alcedinidae	LC
101	Streaked Weaver	*Ploceus manyar* (Horsfield, 1821)	Ploceidae	LC
102	Striated Heron*	*Butorides striata* (Linnaeus, 1758)	Ardeidae	LC
103	Vernal Hanging-parrot	*Loriculus vernalis* (Sparrman, 1787)	Psittacidae	LC
104	Watercock*	*Gallicrex cinerea* (Gmelin, 1789)	Rallidae	LC
105	Western Marsh-harrier	*Circus aeruginosus* (Linnaeus, 1758)	Accipitridae	LC
106	Western Reef-egret*	*Egretta gularis* (Bosc, 1792)	Ardeidae	LC
107	Whimbrel*	*Numenius phaeopus* (Linnaeus, 1758)	Scolopacidae	LC
108	Whiskered Tern*	*Chlidonias hybrida* (Pallas, 1811)	Laridae	LC
109	White-bellied Sea-eagle	*Haliaeetus leucogaster* (Gmelin, 1788)	Accipitridae	LC
110	White-breasted Waterhen*	*Amaurornis phoenicurus* (Pennant, 1769)	Rallidae	LC
111	White-browed Fantail	*Rhipidura aureola* Lesson, 1830	Rhipiduridae	LC
112	White-browed Wagtail	*Motacilla maderaspatensis* Gmelin, 1789	Motacillidae	LC
113	White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	Alcedinidae	LC
114	Wood Sandpiper*	*Tringa glareola* Linnaeus, 1758	Scolopacidae	LC
115	Yellow Bittern*	*Ixobrychus sinensis* (Gmelin, 1789)	Ardeidae	LC
116	Yellow Wagtail	*Motacilla flava* Linnaeus, 1758	Motacillidae	LC

* Waterbird species

Population in and around Ashtamudi

S.No	Settlement	Name	HH	Population
1	Rural	Thevalakkara	10473	42977
2	Rural	Thekkumbhagom	4388	16937
3	Urban	Neendakara	4087	16976
4	Rural	Mundrothuruth	2407	9054
5	Rural	Kizhakkekallada	5603	21820
6	Rural	Mulavana	9289	35887
7	Urban	Thrikkaruva	6307	25432
8	Urban	Panayam	6415	25607
9	Urban	Perinad	8719	35173
10	Urban	Thrikkadavoor	9845	39285
11	Rural	Chavara	1689	6857
12	Rural	West Kallada	310	1167
Total			**69532**	**277172**

Shrimps and Prawns recorded in Ashtamudi

(Source: Ragunathan, 2007 and Raj et al., 2014)

Palaemonidae

1. *Macrobrachium rosenbergii* (De Man, 1879)

Penaeidae

2. *Fenneropenaeus indicus* (H. Milne Edwards, 1837)
3. *Marsupenaeus japonicus* (Bate, 1888)
4. *Metapenaeus affinis* (H. Milne Edwards, 1837)
5. *Metapenaeus dobsoni* (Miers, 1878)
6. *Metapenaeus monoceros* (Fabricius, 1798)
7. *Parapenaeopsis stylifera* (H. Milne Edwards, 1837)
8. *Penaeus canaliculatus* (Olivier, 1811)
9. *Penaeus indicus* H. Milne Edwards, 1837
10. *Penaeus latisulcatus* Kishinouye, 1896
11. *Penaeus monodon* Fabricius, 1798
12. *Penaeus semisulcatus* de Haan, 1844

Crabs recorded in Ashtamudi

(Source: Raghunathan, 2007 and Raj et al., 2014)

Portunidae

1. *Charybdis (Charybdis) feriata* (Linnaeus, 1758)
2. *Portunus (Portunus) pelagicus* (Linnaeus, 1758)
3. *Portunus (Portunus) sanguinolentus* (Herbst, 1783)
4. *Scylla serrata* (Forskål, 1775)
5. *Scylla tranquebarica* (Fabricius, 1798)

Notification for constitution of State Wetland Authority Kerala

Kerala Gazette No. 49 dated 15th December 2015.
PART I

GOVERNMENT OF KERALA

Abstract

ENVIRONMENT DEPARTMENT—INTEGRATED MANAGEMENT OF WETLANDS IN KERALA—THE WETLAND (CONSERVATION & MANAGEMENT) RULES, 2010—STATE WETLAND AUTHORITY KERALA (SWAK) CONSTITUTED—ORDERS ISSUED

ENVIRONMENT (A) DEPARTMENT

G. O. (P) No. 157/2015/Envt. Dated, Thiruvananthapuram, 13th November 2015.

Read:—(1) D. O. No. J-22012/68/2003-CS(W)-Pt.V dated 23-12-2013, 14-3-2014 and 19-9-2014 from the Additional Secretary, Ministry of Environment and Forests, Government of India.

(2) D. O. No. J-22012/31/2013-C(W)-dated 10-1-2014 from the Additional Secretary, Ministry of Environment and Forests, Government of India.

(3) G. O. (Ms.) No. 08/2015/Envt. dated 25-5-2015.

ORDER

In exercise of the powers conferred by sub-sections (3) of section 3 of the Environment Protection Act, 1986 and in pursuance of the Rule 8(2) of the Wetlands (Conservation and Management) Rules, 2010 published as the notification of the Government of India in the Ministry of Environment and Forest, No. G. S. R. 951 (E) dated 4th December 2010, the Government of Kerala hereby constitute the State Wetland Authority Kerala (SWAK) comprising of the following members, namely:—

(i)	Hon'ble Minister (Environment)	— Chairman (Ex-officio)
(ii)	Principal Secretary (Environment)	— Convener (Ex-officio)
(iii)	Principal Secretary (Water Resources)	— Member (Ex-officio)
(iv)	Principal Secretary (Science and Technology)	— Member (Ex-officio)
(v)	Principal Secretary (LSGD)	— Member (Ex-officio)
(vi)	Secretary (Agriculture)	— Member (Ex-officio)
(vii)	Smt. B. G. Sreedevi, Director, National Transportation Planning and Research Centre, Thiruvananthapuram (NATPAC)	— Expert Member (Pollution Control)
(viii)	Dr. Beena, K., Head of the Department, Department of Zoology, Devaswam Board College, Sasthamkotta.	— Expert Member (Limnology)
(ix)	Shri S. Jain Mithra, Scientist, State Remote Sensing and Environment Centre, Thiruvananthapuram	— Expert Member (Hydrology)
(x)	Dr. Rajesh, R., Regional Director, Kerala Social Security Mission	— Expert Member (Ecology)

(2) The State Authority shall be the regulatory authority designated for the identified activities for management and wise use of Wetlands situated as described under Rule 7 and as defined as Rule 2 (g) of the Central Rules.

(3) The non-official member of the State Authority shall hold office for a term of 3 years from the date of issue of this order.

(4) An expert member in Biodiversity shall be nominated later.

(5) In pursuance of the G. O. (Ms.) No. 08/2015/Envt. dated 25-5-2015 the State Authority shall be registered as a Government owned society under the Travancore-Cochin Literary, Scientific and Charitable Societies Act, 1955.

By order of the Governor,

P. MARA PANDIYAN,
Principal Secretary to Government.

To

The Secretary, Ministry of Environment and Forests, Government of India (with C/L)
All Members of the State Wetland Authority, Kerala
Dr. Chidambara Iyer., J, Under Secretary, Environment Department
Director of Environment and Climate Change, Thiruvananthapuram
Finance Department
Law Department (vide Ref. No. 2824/Leg.F2/2015/Law)
The Principal Accountant General (A&E/Audit) Kerala, Thiruvananthapuram
Environment (B) Department
Information and Public Relations Department (Web and New Media)
Stock File/Office Copy.

List of equipment for wetland monitoring

Hydrological Equipment and Material

- Automatic Weather Station
- Sunshine recorder
- Automatic water level recorder
- AA Current meters
- Stream gauge
- Piezometer
- Staff gauge on permanent piers
- Wireless Station
- Thermo-hydrograph
- Digital depth- temperature analysers
- Ecosounders
- Tied gauge
- Fibreglass boat with outboard motor
- Poles fixed for float observations
- Wading rods and cable and drum (cranes) for lowering current meters

Fisheries Equipment

- Fishing gears
- Plankton nets
- Buoys
- GPS
- Fisheries Assessment Softwares (ELEFAN, CEDA, etc)
- Fish base Application – Fish identification
- Fibreglass boat with outboard motor

Research Equipment

- DR 4000 Spectrophotometer
- UV spectrophotometer
- Digital pH and conductivity meters
- Multiparameter Water quality meter
- Water quality multi parameter probes
- Paqua Lab with bacteriological assembly
- Colorimeter
- Distillation unit
- Kjeldahl assembly
- Incubators
- Autoclave
- COD digester
- BOD Incubator
- Burette
- Automatic pippettes
- Digital Flame photometers
- Electronic Balance
- Centrifuge machines
- Cold centrifuge machine
- Grinders
- Automatic sieves
- Hot air oven
- Magnetic stirrers
- Burners & heaters
- Ekmans Grab and potable dredgers
- Plankton samplers
- Glassware and Chemicals

GIS Equipment

- GIS softwares (Erdas, ArcGis, QGis, etc)
- GIS workstation
- Plotters
- A0 size scanner
- GPS

Computing and Networking Equipment

- Desktop (I 7)
- Laptop
- Laser printer Colour A3
- Online UPS 2KVA
- Broadband Internet connection
- MS Office software and other software

Documentation and Display equipment

- Photocopier
- LED Projector
- LED Panel
- DSLR Camera with tripod
- Binoculars

Facilities

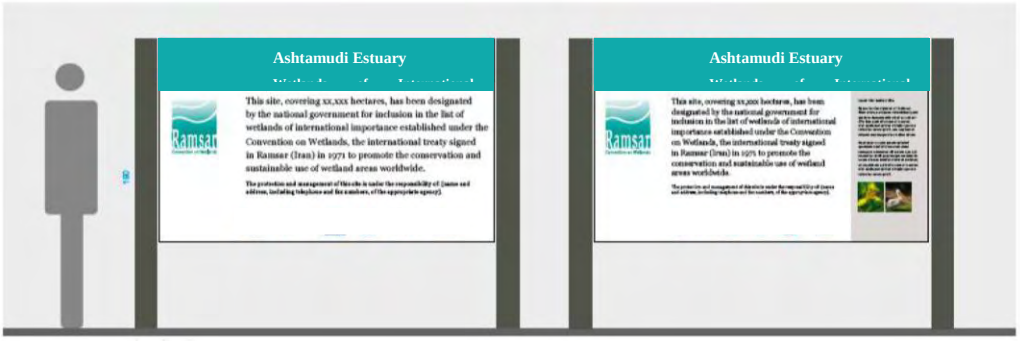
- Furnishing and accessories
- Vehicle
- Silent Generator 15 KVA

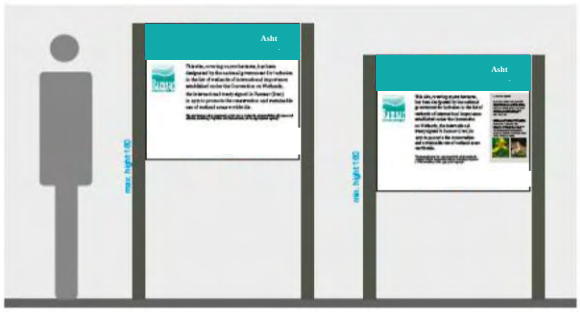
Guidance on signs for Ramsar Sites

Guidance on signs for Ramsar Sites

11 January 1997

At the 19th meeting of the Ramsar Standing Committee, 29 October-1 November 1996, the members adopted a decision that defines recommended wording for signs at all Ramsar Sites, when translated into the local languages of the sites.





The decision reads as follows:

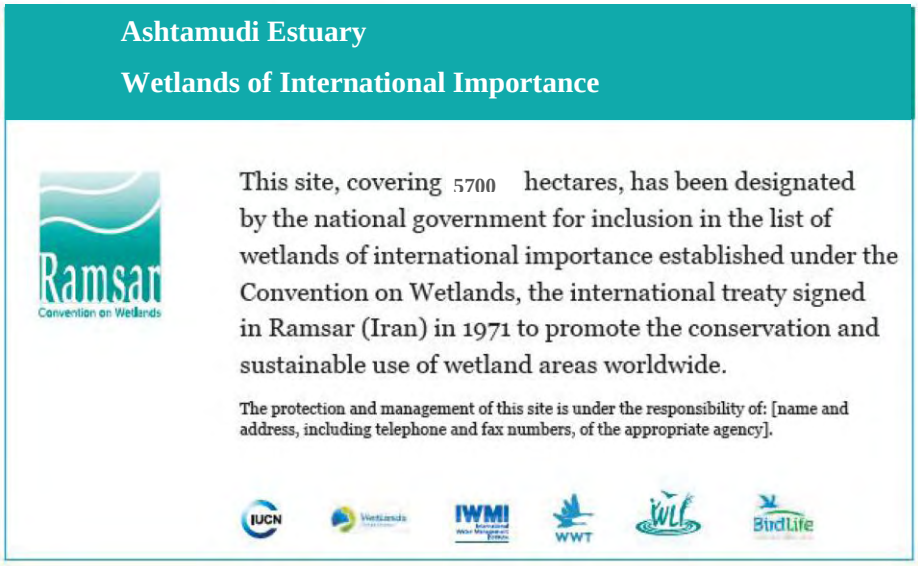
Decision 19.18: The Contracting Parties should endeavor to place descriptive signs at all Ramsar Sites, and these signs should include the Ramsar logo, as well as the following suggested text as amended to meet particular circumstances:

THIS SITE, COVERING 5700 HECTARES, HAS BEEN DESIGNATED BY THE NATIONAL GOVERNMENT FOR INCLUSION IN THE LIST OF WETLANDS OF INTERNATIONAL IMPORTANCE ESTABLISHED UNDER THE CONVENTION ON WETLANDS, THE INTERNATIONAL TREATY SIGNED IN RAMSAR (IRAN) IN 1971 TO PROMOTE THE CONSERVATION AND SUSTAINABLE USE OF WETLAND AREAS WORLDWIDE.

The protection and management of this site is under the responsibility of: [name and address, including telephone and fax numbers, of the appropriate agency].

Variation for countries with a federal system:

ON THE PROPOSAL OF [NAME OF THE STATE/PROVINCIAL GOVERNMENT], THIS SITE, COVERING 5700 HECTARES, HAS BEEN DESIGNATED BY THE NATIONAL GOVERNMENT .... [continues as above]



Activity wise budget (in Lakhs)

Components and Activities	Rate (Rs..)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
			Physical (2017 - 21)	Financial (2017 - 21) (Rs.. Lakhs)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
1 Institutions and Governance				**1,045.25**		**375.25**		**378.25**		**188.75**		**52.25**		**50.75**
1.1 Establishment of Ashtamudi Management Authority				125.00		51.00		56.00		6.00		6.00		6.00
1.1.1 Official notification				-										
1.1.2 Registration				-										
1.1.3 Governing Body meetings				5.00		1.00		1.00		1.00		1.00		1.00
1.1.4 Office Infrastructure				100.00		50.00		50.00						
1.1.5 Office Running Expenses				20.00				5.00		5.00		5.00		5.00
1.2 Integrated wetland inventory, assessment & monitoring system				688.00		270.00		276.50		115.00		16.50		10.00
1.2.1 Establishment of wetland monitoring and research centre				500.00		200.00		200.00		100.00				
1.2.2 Development of database management system				50.00		25.00		25						
1.2.3 Wetland monitoring and evaluation	7,50,000	per year		50.00		10.00		10		10.00		10		10.00
1.2.4 Ecosystem health Report Card				-										
a) Analysis				5.00				2.50				2.50		
b) Publication				3.00				1.50				1.50		
c) Stakeholder workshop				5.00				2.50				2.50		
1.2.5 Research studies														
a) Sediment flux assessment	40,00,000	per study		40.00		25.00		15.00						
b) Climate vulnerability assessment	35,00,000	per study		35.00		10.00		20.00		5.00				
1.3 Capacity development				99.50		32.50		31.00		21.00		15.00		-
1.3.1 Training needs assessment														
a) Consultant engagement				10.00		10.00								
b) Dissemination workshop				1.50		1.50								
1.3.2 Training				-										
Integrated wetland management	8,00,000	per training	1	8.00	1	8.00								
Wetlands and water management	8,00,000	per training	1	8.00	1	8.00								
Wetlands and livelihoods	8,00,000	per training	1	8.00			1	8.00						
Conserving wetlands biodiversity	8,00,000	per training	1	8.00			1	8.00						
Other needs based	8,00,000	per training	2	16.00					2	16.00				
1.3.3 Exposure visit				-										
National	5,00,000	per visit	2	10.00	1	5.00			1	5.00				
International	15,00,000	per visit	2	30.00			1	15.00			1	15.00		
1.4 Monitoring compliance with existing laws & regulation				10.00		2.00		2.00		2.00		2.00		2.00
a) Surveys	Lump sum			7.50		1.50		1.50		1.50		1.50		1.50
b) Reporting	Lump sum			2.50		0.50		0.50		0.50		0.50		0.50
1.5 Communication & outreach				87.75		19.75		12.75		29.75		12.75		12.75
1.5.1 Signage	2,00,000	per sign	4	8.00	4	8.00								
1.5.2 Webpage				-										
a) Creation				2.00		2.00								
b) Maintenance				2.00				0.50		0.50		0.50		0.50
1.5.3 Resource material				25.00		5.00		5.00		5.00		5.00		5.00
a) Brochure and Pamphlet	2,00,000	per set	2	4.00	1	2.00			1	2.00				
b) Coffee table book	8,00,000	per publication	1	8.00					1	8.00				
c) Popular reading book	5,00,000	per publication	1	5.00					1	5.00				
1.5.4 Newsletter	75,000	per annum	5	3.75		0.75		0.75		0.75		0.75		0.75
1.5.5 Workshops & public event	2,00,000	per event	10	20.00	1	2.00	2	4.00	3	6.00	2	4.00	2	4.00
1.5.6 Ashtamudi Rangers camp	2,50,000	per camp	4	10.00			1	2.50	1	2.50	1	2.50	1	2.50
1.6 Management Plan Review				35.00		-		-		15.00		-		20.00
1.6.1 Mid-term review				15.00						15.00				

Components and Activities	Rate (Rs..)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
			Physical (2017 - 21)	Financial (2017 - 21) (Rs. Lakhs)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
1.6.2 Final Review				20.00										20.00
2 Water Management				**12,242.20**		**4,394.00**		**3,812.50**		**3,890.90**		**92.40**		**52.40**
2.1 Environmental water requirement				**51.00**		**22.00**		**23.00**		**2.00**		**2.00**		**2.00**
2.1.1 Assessment				40.00		20.00		20.00						
2.1.2 Stakeholder consultations				5.00		2.00		3.00						
2.1.3 Monitoring and Review				6.00						2.00		2.00		2.00
2.2 Enhancement of water quality				**12,091.20**		**4,372.00**		**3,739.50**		**3,838.90**		**90.40**		**50.40**
2.2.1 Improvement of sewage management in Kollam city														
a) Civil works	1,40,00,000	per MLD		9,240.00		2,772.00		2,772.00		3,696.00				
b) Operation & Maintenance	4,00,000	per MLD		79.20					66.00	26.40	66.00	26.40	66.00	26.40
				-										
2.2.2 Improvement of solid waste management				-										
Construction				2,500.00		1,600.00		900.00						
Operation & Maintenance	3,00,000	per MT		72.00					80.00	24.00	80.00	24.00	80.00	24.00
				-										
2.2.3 Management of slaughterhouse effluent	to be covered under 2.2.1			-										
				-										
2.2.4 Alternate coir retting method	3,00,000	per unit	25	75.00			10.00	30.00	10.00	30.00	5.00	15.00		
				-										
2.2.5 Upgradation of houseboats in Ashtamudi	2,50,000	per unit	50	125.00		-	15.00	37.50	25.00	62.50	10.00	25.00		
2.3 Research studies				100.00				50.00		50.00				
2.3.1 Sediment flux assessment	50,00,000	per study		50.00				25.00		25.00				
2.3.2 Climate risk and vulnerability assessment	50,00,000	per study		50.00				25.00		25.00				
3 Biodiversity Conservation				**876.50**		**22.50**		**567.50**		**255.50**		**20.50**		**10.50**
3.1 Mangrove restoration				429.00		10.00		410.00		3.00		3.00		3.00
3.1.1 Survey				20.00		10.00		10.00						
3.1.2 Bio rights contract	2,50,000	per group		250.00			10.00	250.00						
3.1.3 Restoration	1,50,000	per group		150.00			10.00	150.00						
3.1.4 Mentoring				9.00						3.00		3.00		3.00
3.2 Annual water birds census				27.50		5.50		5.50		5.50		5.50		5.50
3.2.1 Pre-census workshops				5.00		1.00		1.00		1.00		1.00		1.00
3.2.2 Census				12.50		2.50		2.50		2.50		2.50		2.50
3.2.3 Results synthesis and publication				10.00		2.00		2.00		2.00		2.00		2.00
3.3 Water bird disease surveillance				10.00		2.00		2.00		2.00		2.00		2.00
3.3.1 Surveillance				10.00		2.00		2.00		2.00		2.00		2.00
3.3.2 Reporting				-										
3.4 Breeding waterbirds investigation				25.00		-		10.00		15.00		-		-
3.3.1 Assessment				20.00				10.00		10.00				
3.3.2 Dissemination workshop				5.00						5.00				
3.5 Biodiversity Register				35.00		5.00		15.00		10.00		5.00		-
3.2.1 BMC Workshops				10.00		5.00		5.00						
3.2.2 Register creation				20.00				10.00		10.00				
3.2.3 Publication				5.00								5.00		
3.5 Eco-Tourism Development				350.00		-		125.00		220.00		5.00		-
3.5.1 Master plan				40.00				20.00		20.00				
3.5.2 Interpretation center	15,000.00	per sft		300.00				100.00		200.00				
3.5.3 Capacity development programmes				10.00				5.00				5.00		
4 Sustainable fisheries				**572.50**		**11.50**		**228.50**		**242.50**		**80.00**		**10.00**
4.1 Code of Conduct for sustainable fisheries				15.00		6.00		4.00		5.00		-		-

Components and Activities	Rate (Rs..)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
			Physical (2017 - 21)	Financial (2017 - 21) (Rs.. Lakhs)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
4.2.1 Dissemination workshops	1,00,000.00	per workshop	10.00	10.00	3.00	3.00	4.00	4.00	3.00	3.00				
4.2.2 Outreach material				5.00		3.00				2.00				
4.2 Value added in clam fisheries				317.50		1.50		147.50		134.50		29.50		4.50
4.2.1 Technology orientation workshop	1,00,000	per workshop	2.00	2.00	1.00	1.00	1.00	1.00						
4.2.2 SHG Formation	50,000.00	LS		1.00		0.50		0.50						
4.2.3 Depuration Unit	25,00,000.00	per unit	2.00	50.00			1.00	25.00	1.00	25.00				
4.2.4 Monitoring and Evaluation				4.50						1.50		1.50		1.50
4.3 Marine Stewardship Council Standard Maintenance				30.00		-		2.50		27.50		-		-
4.2.1 Expert Input	15,00,000	per input	1.00	15.00					1.00	15.00				
4.2.2 Workshops	2,50,000.00	per workshop	2.00	5.00			1.00	2.50	1.00	2.50				
4.2.3 Audit				10.00						10.00				
4.4 Improving landing center infrastructure	5,00,000	per center	20.00	100.00			5.00	25.00	10.00	50.00	5.00	25.00		
4.5 Cage culture				50.00		-		45.50		1.50		1.50		1.50
Site and beneficiary selection				1.00				1.00						
Training				4.50				4.50						
Cage installation	20,00,000.00	per unit	2.00	40.00				40.00						
Monitoring				4.50						1.50		1.50		1.50
4.6 Monitoring and Research				60.00		4.00		4.00		24.00		24.00		4.00
4.6.1 Stock and yield assessment				20.00		4.00		4.00		4.00		4.00		4.00
4.6.2 Migration assessment				40.00						20.00		20.00		
5 Livelihoods				**2,617.50**		**20.00**		**685.50**		**959.50**		**949.50**		**3.00**
5.1 Safe sanitation	12,500.00	per unit	20,000.00	2,500.00			5,000.00	625.00	7,500.00	937.50	7,500.00	937.50		
5.2 Additional Livelihoods				117.50		20.00		60.50		22.00		12.00		3.00
5.3.1 Dry Fish Unit	5,00,000	per group	6.00											
a) SHG Formation				1.00		1.00								
b) Training				4.00		4.00								
c) Financing support				18.00				18.00						
d) Marketing linkages				5.00						5.00				
e) Evaluation				2.00								1.00		1.00
5.3.1 Ornamental Fish Unit	10,00,000	per group	2.00											
a) SHG Formation				1.00		1.00								
b) Training				4.00		4.00								
c) Financing support				12.00				12.00						
d) Marketing linkages				2.00						2.00				
e) Evaluation				1.00								1.00		
5.3.2 Coir Based Handicraft Unit	7,50,000.00	per group	5.00											
a) SHG Formation				1.00		1.00								
b) Training				4.00		4.00								
c) Financing support				25.50				25.50						
d) Marketing linkages				5.00						5.00				
e) Evaluation				2.00								1.00		1.00
5.3.3 Vermicomposting	60,000.00	per group	50.00											
a) SHG Formation				5.00		5.00								
b) Training				5.00				5.00						
c) Equipment support				19.00						10.00		9.00		
d) Evaluation				1.00										1.00
Grand Total				**17,353.95**		**4,823.25**		**5,672.25**		**5,537.15**		**1,194.65**		**126.65**

Stay in touch

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