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# Wetlands of Kerala

(Research Project: KFRI 636/2012
KFRI component)

CESS, CWRDM & KFRI

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# Project Proposal

| | |
|---|---|
| Title: | **Inventory of wetlands of Kerala.** |
| Ref | DoECC/T2/540/2011 Dt 04/02/2012<br>KFRI RP-636/2012 Dt 24-02-2012 |
| Introduction | Remarkable steps have been taken by the state government to set up regulatory mechanism consistent with the Ramsar convention to maintain the ecological character of the identified wetlands and develop an inventory of such wetlands. As part of continuation of the activities, Government of India have now suggested that State Government take up coordinated and concerted efforts for conservation and preservation of wetlands and healthy environment. The Central Government has designated the Department of Environment and Climate change as the Nodal agency for regulating the management and wise use of wetlands in the state. |
| Team | KFRI Component: P.Vijayakumaran Nair |
| Funding agency | Through CESS, Thiruvanathapuram. |
| Objectives | Objectives of the present work are to prepare a brief document of the wetlands of Kerala under the wetlands (Conservation and Management) Rules 2010, by incorporating the items given under the guidelines given the Department of Environment and Climate change, Government of Kerala as shown below:<br>• Geographical delineation of wetlands<br>• Demarcate their zone of influence along with proper maps<br>• The size of the wetland, and<br>• Account of the pre-existing rights and privileges consistent or not consistent with the ecological health of the wetland |
| Methods | The methodology adopted here for delineating the stipulated wetland patches have been achieved by integrating the spatial distribution of wetlands in 1:50,000 Survey of India (SOI) topographical sheets with IRS P6 Satellite imagery of 5.8 m spatial resolution. The salient features of the methodology adopted are Generation of a standard spatial data frame work with WGS 84 Datum and UTM Zone 43 projection for seamless spatial data integration. Geo-referencing of satellite imagery with respect to the standard spatial data framework. Identification of wetlands with the content accuracy of 1:50,000 SOI maps. Onscreen digitization of wetland using Arc GIS software. Integration of base layers such as major roads, drainage, locations and administrative units from Natural Resources and Environmental Data Base (NREDB) of Kerala. District-wise wetland vector data merging and coding for the preparation of map layouts. Area statistics generation of wetlands based on wetland codes. Preparation of district-wise map layouts for all fourteen districts of Kerala. Preparation of layouts of each coded wetland in 1:50,000 scale for easy reference in A3 format' Printing of maps for the production of wetland atlas. The spatial data operations and analysis were carried out using ERDAS Imagine and ARC-GIS software |
| Duration | 3 months (March 2012-May2012) |
| Budget | Rs 2.47 Lakhs. (KFRI pmponent) |

## CONTENTS

## LIST OF TABLES

## LIST OF PLATES

| Plate No | LIST OF PLATES |
|---|---|
| 38 | Biyyam kayal and Puduponnani estuary |
| 39 | Kanjirapuzha reservoir, Siruvani reservoir |
| 40 | Malampuzha reservoir |
| 41 | Meenkara reservoir, Moolathara reservoir, Chulliyar reservoir |
| 42 | Pothundi reservoir, Mangalam reservoir |
| 43 | Peruvarippalam reservoir, Thunakkadavu reservoir, Parambikulam reservoir |
| 44 | Walayar reservoir |
| 45 | Viyyam Kayal |
| 46 | Chetwai kayal |
| 47 | Kodungallur kayal |
| 48 | Vazhani reservoir, Peechi reservoir |
| 49 | Chimoni reservoir |
| 50 | Peringalkuttu reservoir |
| 51 | Sholayar reservoir |
| 52 | Malankara reservoir |
| 53 | Mullaperiyar reservoir |
| 54 | Idukki reservoir, Irattayar reservoir |
| 55 | Ponmudi reservoir |
| 56 | Anayirangal reservoir |
| 57 | Chengulam reservoir, Kallarkutty reservoir |
| 58 | Kundala reservoir, Mattupetty reservoir |
| 59 | Gavi reservoir, Pamba reservoir |
| 60 | Kakki reservoir |
| 61 | Karingalil Chal, Pannivelichira |
| 62 | Vembanad Lake part |
| 63 | Vembanad Lake part |
| 64 | Vembanad Lake part |
| 65 | Vembanad Lake part |
| 66 | Idamalayar reservoir, Bhoothathankettu reservoir |
| 67 | Vembanad lake part |
| 68 | Vembanad Lake part |
| 69 | Vembanad Lake part |
| 70 | Vembanad lake part |
| 71 | Vembanad Lake part |
| 72 | Vembanad Lake part, Pudupandam kayal, Cherukara kayal, Vattakayal, Vattakayal west |
| 73 | Karingalichal, Valiyankarachira, Vallikunnathuchira, Changapadam, Pollonnilchal, Kuthiravattomchira, Poomalachal |
| 74 | Kayamkulam kayal part |

LIST OF PLATES

# 1. INTRODUCTION

Wetlands are places where the ground is generally saturated or flooded for extended periods during the growing season such that distinctive soils form and specialized vegetation grows under conditions in which oxygen is depleted or absent. Such environments include marshes, fens, bogs, and swamps. Wetlands occur at the confluence of unique terrestrial, hydrological and climatic conditions that give rise to some of the most biodiverse regions of the world. They play a vital role in the cycling and storage of key nutrients, materials and energy through the Earth's systems. Wetland components include water, soil, vegetation, and wildlife. The early establishment of human settlements and subsequent expansion were based on irrigated agriculture along major river floodplain valleys – Nile, Tigris–Euphrates, Niger, Indus, Mekong, etc. The first human hunter-gatherers camped by the side of these wetlands had utilized, modified, exploited or impacted it in various ways (Aber, et al., 2012). And some of the human civilizations perished due to modification or damage done to the wetlands. Wetlands continue to be essential for modern society. They represent the primary sources of fresh water for people in most places. Their ability to minimize flooding and storm damage, nourish fisheries, sustain irrigated agriculture, recharge ground water aquifers, provide navigational water-ways, supply hydro-power, timber, yield fossil fuels and provide many other resources are now widely acknowledged. These functions are clearly evident, as they influence the daily lives of people living in and deriving economic benefits from wetlands. In spite of local recognition of wetland functions and values, the regional and global significance of wetlands is yet to get proper attention.

Wetlands are significant sinks for carbon stored in their organic soil and sediment. They are likewise important sources for carbon dioxide ($CO_2$) and methane ($CH_4$), both greenhouse gases, released from the stored organic mass. Wetlands are critical components of the avian fauna which is the most obvious and perhaps important aspect of wetland conservation. In some American and African wetlands, for example, millions of waterfowl and shorebirds visit briefly or remain seasonally during annual migrations. Such dramatic concentrations of wildlife have attracted hunters since prehistoric times, and hunting continues to

be a major cause of concern. Wetlands are, in fact, among the most productive ecosystems in the world (Niering, 1985). Wetlands also harbor some of the greatest biodiversity found on the planet. Many aquatic animals are endemic to isolated wetlands, such as the hundreds of fish species found in the lakes of eastern Africa (Dugan, 2005). In other cases, wetlands represent the last refuges of animals forced out of other habitats by human development-the Bengal tiger in the Sundarbans of India and Bangladesh and the Jaguar in wetlands of South and Central America are examples. Endangered species, such as the whooping crane (*Grus americana*), are often foremost in the public eye as symbols for the need to preserve wetland habitats.

Costanza et al., (1997) attempted to estimate the economic value of ecosystem services for major biomes of the world. They identified 17 ecosystem services, many of which are connected to or interact with wetland environments, particularly those involving water, soil, gases, nutrients and climate. The value of these services was determined using market and non-market means, such as the willingness-to-pay method. They found that wetlands in general and estuaries, seagrass/ algae beds, coral reefs, tidal marsh/mangroves, and swamps/floodplains in particular have the highest values for providing a broad array of ecosystem services. Wetland values are considerably greater, in fact, than tropical forest or other biomes.

The total coverage of existing wetlands is estimated to range from at least 7 million $km^2$ to about 10 million $km^2$, or 5–8 percent of the land surface of the world, depending upon the definition for what is included (Mitsch and Gosselink, 2007). Bog, swamp, marsh, fen, muskeg, and similar habitats are represented in this total. The broader definition of Ramsar includes lakes, rivers, and coastal marine water bodies (up to 6 m deep), which pushes the wetland coverage to more than 12 million $km^2$. Peatland (mire) includes those types of wetlands that accumulate peat at least one foot (30 cm) in thickness which may happen in swamp, bog, muskeg, and fen environments. Peatlands cover approximately 4 million $km^2$ worldwide (Dugan 2005).

What is economically beneficial in upper portions of drainage basins such as irrigation, timber harvesting, hydroelectric power, recreation and other human uses- is often deleterious for down-stream inhabitants of wetlands in the coastal regions. Upstream manipulations and exploitation of wetland water resources have resulted in serious degradation or dramatic changes in lower drainage basins. In contrast, some interventions of wetlands actually benefit marine and aquatic life and provide them protection from predators. It is safe to say that major wetland systems of the world have not been changed in substantial ways by human activities. Some wetlands are situated at the transition zones between dry uplands and deep-water lakes and marine environments. Wetlands, thus may be viewed as the links that bind together all other habitats at the Earth's surface, and continue to play key roles in the overall environmental system through transfer and storage of materials and energy (Aber, et al., 2012). Negotiations between various countries and non-governmental agencies in the 1960s culminated with a treaty adopted in the Iranian city of Ramsar in 1971 to protect the wetlands. This treaty, which came into force in 1975, dealt with conserving wetland habitats necessary for migratory water-birds. The number of contracting parties (countries) has reached 165, representing all parts of the world, and nearly 1900 sites have been listed as wetlands of international importance covering more than 185 million ha as per the Ramsar records.

The Indian wetlands encompass diverse and heterogeneous assemblage of habitats ranging from glaciers, freshwater lakes to estuaries, flood plains, corals, mangroves and related ecosystems. They are areas where water is the primary factors controlling the environments and the associated plant and animal life. These occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. According to the Ministry of Environment and Forests (MoEF) wetlands must have one or more of the following attributes:-

1. At least periodically the land supports predominantly hydrophytes.
2. The substrate is predominantly undrained hydric soil
3. The substrate is non soil and is saturated with water or covered by shallow water some times during the growing season of each year.

As among the country's most productive environments wetlands provide tremendous economic benefits, for example; water supply (quantity and quality); fisheries, agriculture, maintenance of water table and nutrient retention in floodplains; wildlife resources, transport; and recreation and

tourism opportunities in the country. In addition, wetlands have special attributes as part of the cultural heritage of the society. These functions, values and attributes can only be maintained if the ecological processes of wetlands are allowed to function continuously. Unfortunately, in spite of important progress made in recent decades, wetlands continue to be among the country's most threatened ecosystems, owing to alarming rate of conversion, pollution and over exploitation of their resources.

The Kerala wetlands offer several substantive benefits to the state and its people. The role of wetlands in supporting biodiversity, and the values provided by many well functioning wetland systems to human welfare in the state would suggest that their role is extremely important for Keralites. Although difficult to estimate, the total life support function of wetlands may be significant, as wetland comprises diverse range of marine, coastal, estuarine and freshwater habitats in Kerala. The strong relationship between healthy functioning wetland ecosystems and human sustenance and health underlines the importance of appropriate management strategies that support both the health of the wetlands and that of the people.

Wetlands have assumed considerable attention in recent years in the state with growing interest in productive and retentive uses to which they could be best utilized. Such uses include supplementing human dietary requirements; ecological significance in terms of flood control, water purification, aquatic productivity and microclimatic regulation and as habitats for fish, birds and a variety of wild life. Different types of wetlands like reservoirs, ponds, tanks, marshes, swamps, open water bodies, mangroves, tidal marshes etc exist in the state. The state has lost some of its prime wetlands rapidly due to biotic and anthropogenic interferences. The importance of this ecosystem has been realized recently and hence steps have been initiated for their conservation and management and to educate the public on the need for their conservation as well as proper economic utility. Scientific and application oriented studies on their productivity have also become focused, of late. However, by understanding the need and importance in the society, Government has adopted several steps for the conservation, and wise use of wetlands. As part of this, The Central Government, in exercise of the powers conferred by sub-section (3) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986), constituted the Central Wetland Regulatory Authority. The National Environmental Policy, 2006 recognizes the numerous ecological services rendered by wetlands. The Central Government have framed the vital rules for conservation and management of

wetlands, namely, the Wetland (Conservation and Management) Rules, 2010 (WCMR) the provisions of which are being implemented by State governments in close collaboration with the Central Government.

## 2. WETLAND CLASSIFICATION

The Ministry of Environment and Forests (MoEF) adopted the final wetland classification system as shown in Table-1 below. Realizing the wetlands in India, MoEF has published a Directory of Wetlands in 1990. Later MoEF has sponsored another project for wetland mapping using remotely sensed data using IRS1A/1B satellite data. This has helped in inventorying and comparing both the inland and coastal wetlands using Survey of India topo-sheets and remotely sensed data to generate an information data base of the wetlands.

**Table-1. Wetland Classification System (MoEF, 1990)**

| | | |
|---|---|---|
| **INLAND WETLANDS** | | |
| 1. Natural | 1.1 | Lakes/Ponds |
| | 1.2 | Ox-bow lakes/Cut-off meanders |
| | 1.3 | Waterlogged (seasonal) |
| | 1.4 | Playas |
| | 1.5 | Swamp/marsh |
| 2. Man –made | 2.1 | Reservoirs |
| | 2.2 | Tanks |
| | 2.3 | Waterlogged |
| | 2.4 | Abandoned quarries |
| | 2.5 | Ash pond/Cooling pond |
| **COASTAL WETLANDS** | | |
| 3. Natural | 3.1 | Estuary |
| | 3.2 | Lagoon |
| | 3.3 | Creek |
| | 3.4 | Backwater (kayal) |
| | 3.5 | Bay |
| | 3.6 | Tidal flat/mud flat |
| | 3.7 | Sand/beach/spit/bar |
| | 3.8 | Coral reef |
| | 3.9 | Rocky coast |
| | 3.10 | Mangrove forest |
| | 3.11 | Salt marsh/marsh vegetation |
| | 3.12 | Other vegetation |
| 4. Man-made | 4.1 | Salt pans |
| | 4.2 | Aquaculture ponds |

## Wetlands in Kerala

Physiographically, the State is divided into highlands, midlands and the coastal plains which have various wetland types under extreme threat in Kerala, more than in any other State. It can be attributed to very high population density and close habitations. Studies carried out in recent years has pointed out the unfavorable changes taking place in the physico-chemical, biological and geological environment of the wetlands of Kerala. The wetlands of the state help in generating electricity, irrigation agriculture, controlling floods, providing habitat for diversity of living organisms, preventing salinity intrusion, assimilation of pollutants, serve as habitat for migratory birds and mangroves species. They are facing severe problems including loss of areal extent due to anthropogenic pressure, over exploitation of its resources and reduction of its carrying capacity. A classic example is the Vembanad wetlands which covered an area of 2033.02 km2 and its river basins spread over 6126.48 km2 area in the near past. Vembanad Lake during 1917, 1970 and 1990 were 290.85 km2, 227.23 km2 and 213.28 km2 respectively. A total of 63.62 km2 area was reclaimed from the lake during the period 1917-1970, primarily for formation of polders and to enlarge the extent of the Wellington Island and Cochin Port (Gopakumar and Takara, 2009). Kuttanad is another wetlands covering 400 km2 adjacent to Vembanad spread over Alappuzha, Pathanamthitta and Kottayam districts famous for punja cultivation of rice during October-March. Pokhali fields are areas put to rice (June-October) and shrimp farming adopted in Alappuzha, Ernakulam and Thrissur districts in an area of 85 km2. Kole lands are famous wetlands in Thrissur and Malappuram districts covering 130 km2 and cultivation of rice is mainly during November-August. In Kannur and Kozhikode districts, a rotational farming system is adopted in Kaipad wetlands during June-November in an area of 25 km2 (Jayan and Sathyanathan, 2010). The situation of the river system and paddy lands is all the more alarming.

The wetlands are famous water fowl habitats in the state. Loss of wetlands and decline in biodiversity due to dredging, reclamation and sediment accumulation, pollution due to municipal, agricultural, tourism and industrial activities; destruction of mangroves for urbanization, pollution problems due to coir retting, etc are some of the issues in wetland conservation. Time has reached, perhaps crossed to take immediate measures for conserving the remaining wetland ecosystems.

Lack of base-line information on various parameters that determines the health of these ecosystems is a major problem before the planners and decision makers for chalking out proper strategies for environmental management and conservation. Remarkable steps have been taken by the state government to set up regulatory mechanism consistent with the Ramsar convention to maintain the ecological character of the identified wetlands and develop an inventory of such wetlands. As part of continuation of the activities, Government of India have now suggested that State Government take up coordinated and concerted efforts for conservation and preservation of wetlands and healthy environment. The Central Government as per the Gazette Notification No. GSR 951 (F) dated 4th Dec 2010, recently notified the Wetland Conservation and Management) Rules 2010 to enhance the wetlands conservation and management efforts in the country. As per Rule 8 (2) of the Notification of the State Government, vide G.O. (Rt) No. 51/11/Envt. Dated 30/05/2011 designated the Department of Environment and Climate change as the Nodal agency for regulating the management and wise use of wetlands in the state.

## 3. OBJECTIVES OF THE PRESENT WORK

Objectives of the present work are to prepare a brief document of the wetlands of Kerala under the wetlands (Conservation and Management) Rules 2010, by incorporating the items given under the guidelines given the Department of Environment and Climate change, Government of Kerala as shown below:

Geographical delineation of wetlands

Demarcate their zone of influence along with proper maps

The size of the wetland, and

Account of the pre-existing rights and privileges consistent or not consistent with the ecological health of the wetland

The State of Kerala, situated between 8o 18′ to 12o45′ latitude and 74o52′ to 77o22′ longitude, forms the study area. Conventionally, Kerala can be divided into three physiographic regions, lowlands, midlands and highlands. Lowlands are the coastal plains, made up of estuaries, backwaters and the shores of Lakshadweep Sea. The midlands placed

between high mountains and the lowlands, are made up of undulating hills and valleys. The highlands form parts of the Western Ghats, which rise to an average height of 900 m, with a number of peaks over 1800 m. Forty-four rivers originate from the Western Ghats, out of which forty one are west flowing and the rest three are east flowing. These rivers cut across Kerala with their innumerable tributaries and branches. However, they are comparatively small and entirely monsoon fed. The coastal zone of the state forms attractive and economic valuable wetland features like lakes, estuaries, creeks, backwaters, beaches, spits, sand bars, mudflats, etc. Wetlands of Kerala constitute a productive ecosystem which supports unique aquatic flora and fauna including waterfowls, fish, shell fish and other wildlife. Besides supporting unique biota, the wetlands perform several ecological functions, which are not yet fully understood. These wetlands also serve as a source of livelihood for the people who inhabit adjacent to these areas.

## Review of work

Directory of wetlands of Kerala is a recent project funded by the Kerala State Biodiversity Board. The southern seven districts were covered by the Kerala Forest Research Institute, Peechi (KFRI), and the northern districts by Salim Ali Centre for Ornithology (SACON, 2004), Coimbatore. Similar work had already been completed for the rest of India. There have been several attempts to enumerate smaller wetlands in the past. CWRDM, Kozhikode lists a large number of ponds especially from northern districts. However the work is not supported with map of these water bodies. Another attempt has been under the Panfish scheme. Based on government instructions, all ponds were enumerated on a war footing. The list provides details such as location, ownership, type of use and area. This work also lacks map support. A report on wetlands prepared by CED contains very general treatment of the subject using low resolution satellite images.

The rivers of Kerala and their tributaries are well mapped and documented. Landuse Board of Kerala in their work on Atlas of wetlands traced out outlines of water sheds and named them in a hierarchical manner. These are used by the government departments in their planning and developmental activities. But unfortunately the Panchayath boundaries do not follow water shed boundaries and therefore any basin dependent planning is difficult. There have been many attempts to map

the tanks and ponds of Kerala. Almost all these have their short comings. Water atlases of Kerala prepared by CWRDM in 1995 do not deal with this aspect. Wetland atlas of landuse board contains only the water bodies present in topo sheets. Coverage of this aspect in tanks and ponds of Kerala prepared by CWRDM in 1989 is also incomplete and they lack Geo-referenced maps. There was remarkable attempt to compile the list of ponds and tanks in a short time for the PAN fish project of government of Kerala. The list though almost complete is plagued with measurement unit problems. Moreover there is no geo-reference given so that any re-confirmation is hardly possible. The land use map prepared by CESS and ISRO do show most of the large ponds and paddy fields. Here all ponds are included under the broad category of water bodies and since names of individual ponds are not given, there is much updating needed.

The review on various studies on wetlands conducted by Centre for Earth Science Studies (CESS), CWRDM, Kozhikode, KFRI, Thrissur and State remote sensing Centre in the last 20 years reveal that inventory level information on wetlands are available through the various multidisciplinary projects carried out over the years. However, it is desirable to update data and certain data gaps filled using the latest satellite imageries (IRS P6 LISS IV/ LISS III + PAN) so that the output envisaged in the specified criteria for the preparation of brief document could be achieved satisfactorily.

During 1989, the Department of Space sanctioned a project on mapping of coastal wetlands of Kerala in 1: 250,000 scale to CESS. This happened to be the first inventory mapping programme of the coastal wetlands in the country. The project was completed in 1991. The nationwide programme on Coastal Studies Project, sponsored by the Department of Ocean Development and Department of Space, Govt. of India followed this. CESS has undertaken studies related to coastal wetland/landform mapping on 1:50,000 scale. This study estimated each of the wetland categories in the coast.

As part of the project on nationwide Wetland Mapping, funded by the Ministry of Environment and Forests, Govt. of India, CESS was entrusted with the Wetland Mapping of Kerala, which was completed in 1998. The inventory mapping of the entire State was carried out using IRS 1A LISS I of 1988, 1989 and 1990. The detailed studies on two notified wetlands,

Ashtamudi Lake and Sasthamcotta Lake, were also carried out along with this project. The "Wetlands of India" brought out by the Department of Space, Govt. of India had incorporated the above work carried out by CESS.

State level distribution of wetlands

The wetlands of the State are classified into two broad categories namely inland and coastal wetlands. The total area is 12790.07 ha, out of which the inland wetland cover about 34199.57 ha and the coastal wetlands cover 93730.50 ha (Anon, 1999). These are either natural or man-made. The Table-2 provides details of these wetlands. Recent areal estimates by various agencies on wetland categories including water-spread, aquatic vegetation and turbidity show that there are 1762 wetlands. In addition, 2592 wetlands smaller than 2.25 ha have also been identified (Anon, 2010). Thus the total wetland area estimated is 160590 ha. The major wetland types are River/Stream (65162 ha), Lagoons (38442 ha), Reservoirs (26167 ha) and waterlogged (20305 ha) areas (Annon, 2010).

**Table- 2. Area under Wetlands in Kerala (Anon, 1999)**

| Wetlands | Area (ha) | % Area | Number |
|---|---|---|---|
| **INLAD WETLANDS** | | | |
| Natural | 2180.00 | 0.01 | 11 |
| Man-made | 32019.57 | 25.72 | 53 |
| Total | 34199.57 | | 64 |
| **COASTAL WETLANDS** | | | |
| Natural | 85671.50 | 67.97 | 86 |
| Man-made | 8059.00 | 6.30 | 7 |
| Total | 93730.50 | | 93 |
| **Grand Total** | **127930.07** | **100** | **157** |

The important wetland units in the State are estuaries, backwaters/kayals, aquaculture ponds, chemmeenkettu, pokkali fields, creeks, mudflats, abandoned quarries, waterlogged (both seasonal and man-made), sand/beach/spit, tanks, lakes, ponds and reservoirs. Being narrow and linear in most of the places the sand/beach category of the coastal wetlands is not accurately again delineated in the present work. The coastal wetlands have a larger extent in comparison to their counterpart. Except for reservoirs many of the inland wetlands are smaller in dimension to be mapped in 1: 50,000 scale. Since wetlands

with regular agricultural practices have not been included in the classification system paddy fields and many of the well known wetlands of Kerala such as Kuttanad and Trichur kole lands are not included in this mapping. The wetlands adjacent to the water bodies are also mapped as they are seasonally flooded during rainy seasons and/or put to agriculture/fishery activity. Table-3 gives the district wise distribution of wetlands prepared as part of a study conducted by CESS in 1998.

**Table-3. District-wise distribution of wetlands in Kerala**

| Wetland type (Category code) | Number(s) | Area (ha) |
|---|---|---|
| **Thiruvananthapuram** | | |
| Lakes/ponds (1.1) | 1 | 350 |
| Reservoir (2.1) | 3 | 1420.74 |
| Estuary (3.1) | 1 | 87 |
| Backwater/Kayal (3.4) | 3 | 1080 |
| Sand/beach (3.7) | 2 | 2570 |
| Rocky coast (3.9) | 2 | 657 |
| **Kollam** | | |
| Lakes/ponds (1.1) | 5 | 936 |
| Reservoir (2.1) | 1 | 1535 |
| Waterlogged (2.3) | 2 | 282 |
| Estuary (3.1) | 1 | 4970 |
| Backwater/Kayal (3.4) | 6 | 1768 |
| Beach (3.7) | 1 | 255 |
| Rocky coast (3.9) | 1 | 610 |
| **Alappuzha** | | |
| Lakes/ponds (1.1) | 3 | 687 |
| Waterlogged –seasonal (2.3) | 1 | 87 |
| Tank (2.2) | 1 | 90 |
| Abandoned quarries (2.4) | 4 | 1205 |
| Backwater/Kayal (3.4) | 1 | 1062 |
| Sand/Beach/Spit (3.7) | 11 | 7964 |
| Aquaculture pond (4.2) | 1 | 1861 |
| **Pathanamthitta** | | |
| Reservoir (2.1) | 4 | 1689.13 |
| **Kottayam** | | |
| Waterlogged (2.3) | 5 | 2704 |
| **Idukki** | | |
| Reservoir (2.1) | 7 | 10746 |
| Waterlogged (2.3) | 2 | 148 |
| **Ernakulam** | | |
| Reservoir (2.1) | 1 | 132 |
| Waterlogged (2.3) | 1 | 549 |

| Wetland type (Category code) | Number(s) | Area (ha) |
|---|---|---|
| Estuary (3.1) | 2 | 21284 |
| Sand/Beach (3.7) | 2 | 2654 |
| Aquaculture ponds (4.2) | 6 | 6198 |
| **Thrissur** | | |
| Reservoir (2.1) | 4 | 1504 |
| Waterlogged (2.3) | 1 | 75 |
| Abandoned quarries (2.4) | 5 | 2334 |
| Estuary (3.1) | 1 | 2855 |
| Backwater/kayal (3.4) | 1 | 821 |
| Sand/Beach (3.7) | 1 | 386 |
| **Palakkad** | | |
| Reservoir (2.1) | 7 | 3470.7 |
| **Malappuram** | | |
| Waterlogged (2.3) | 2 | 2020 |
| Estuary (3.1) | 2 | 2960 |
| Backwater/kayal (3.4) | 1 | 559 |
| Creek (3.3) | 1 | 201 |
| Sand/Beach | 2 | 4686 |
| **Kozhikode** | | |
| Waterlogged (seasonal) 1.3 | 1 | 12 |
| Reservoir (2.1) | 1 | 968 |
| Waterlogged (man-made) 2.3 | 1 | 223 |
| Estuary (3.1) | 1 | 469 |
| Backwater/Kayal (3.4) | 2 | 508 |
| Tidal mudflat (3.6) | 7 | 1247 |
| Sand/beach/bar/spit (3.7) | 3 | 4501 |
| Rocky coast (3.9) | 2 | 789 |
| **Kannur** | | |
| Reservoir (2.1) | 1 | 904 |
| Estuary (3.1) | 2 | 2261 |
| Backwater/Kayal (3.4) | 1 | 87.50 |
| Tidal mudflat (3.6) | 4 | 1315 |
| Sand/beach/bar/spit (3.7) | 1 | 89 |
| Rocky coast (3.9) | 1 | 143 |
| **Kasaragod** | | |
| Estuary (3.1) | 4 | 2092 |
| Creek (3.3) | 2 | 664 |
| Backwater (3.4) | 1 | 215 |
| Mudflat (3.6) | 2 | 2112 |
| Sand/beach (3.7) | 9 | 7503 |
| Rocky coast (3.9) | 2 | 773 |

CESS undertook the pioneering study on the Mangroves of Kerala. It has been estimated that there were about 700 km2 of mangroves in Kerala in the historic past, which has been reduced to less than 50km2 area which occur as isolated patches at present (Table-4). Today these are the remnants of an over exploited system, which need immediate conservation, restoration and sustainable management. CESS served as a coordinator to undertake mangrove afforestation programme in few estuaries of the State with the active participation of local stake holders.

**Table- 4. Mangrove locations in Kerala**

| Sl.No | Location | District |
|---|---|---|
| 1. | Chittari | Kasaragod |
| 2. | Dharmadom | Kannur |
| 3. | Nadakkavu | Kozhikode |
| 4. | Edakkad | Kannur |
| 5. | Valapattanam | Kannur |
| 6. | Pappinisseri | Kannur |
| 7. | Muzhapilangad | Kannur |
| 8. | Kunhimangalam | Kannur |
| 9. | Pazhayangadi | Kannur |
| 10. | Kavvai | Kannur |
| 11. | Thalassery | Kannur |
| 12. | Ezhimala | Kannur |
| 13. | Mahe | Pudusserry |
| 14. | Kotti | Kozhikode |
| 15. | Koduvalli | Kozhikode |
| 16. | Badagara | Kozhikode |
| 17. | Kallai | Kozhikode |
| 18. | Kadalundi | Kozhikode/Malappuram |
| 19. | Tirur | Malappuram |
| 20. | Chetwai | Thrissur |
| 21. | Edappalli | Ernakulam |
| 22. | Panangad | Ernakulam |
| 23. | Aroor | Alappuzha |
| 24. | Kannamali | Ernakulam |
| 25. | Puthuvypin | Ernakulam |
| 26. | Kumarakom | Kottayam |
| 27. | Asramam | Kollam |
| 28. | Veli | Thiruvananthapuram |

CESS has undertaken Mapping of the coasts suitable for aquaculture development (Table-5) and also prepared a Coastal Zone Management Plan for the State of Kerala in 1997 on 1:50,000 and 1:25,000 scales. The plan served as a forerunner of the Coastal Regulation Zone Act, introduced by the Ministry of Environment and Forests, Government of India. The details of fish farms in the state available from the Fisheries department publication, is reproduced as Table-6.

**Table-5. Details of areas suitable for aquaculture along Kerala coast**

| Sl.No | District | Coastal stretch | Mud/tidal flat including filtration ponds (ha) | Brackish water (ha) |
|---|---|---|---|---|
| 1. | Kasaragod | Manjeswaram-Kasargode | 138 | 286 |
| | | Chandragiri Nileswaram | 126 | 795 |
| 2. | Kannur | Payyannur-Ezhimala | 133 | 2783 |
| | | Taliparamba | 535 | 1095 |
| | | Mambaram | 97 | 54 |
| | | Valapattanam-Dharmadom | 789 | 2066 |
| | | Thalassery-Payyoli | 281 | 1016 |
| 3. | Kozhikode | Quilandy | 210 | 978 |
| | | Pudiyangadi | 197 | 689 |
| | | Kozhikode-Parappanangadi | 137 | 1598 |
| 4. | Malappuram | Tanur-Ponnani | 153 | 1268 |
| 5. | Thrissur | Veliyankode-Edakkazhiyur | - | 265 |
| | | Chavakkad | 88 | 1008 |
| | | Thripayar | 854 | 1142 |
| 6. | Ernakulam | Kodungallur-Njarakkal | 4248 | 3019 |
| | | Mala-Edappally | 1679 | 1157 |
| | | Kochi-Chellanam | 5540 | 10609 |
| 7. | Alappuzha | Cherthala-Punnamada | 442 | 3508 |
| | | Alapuzha-Harippad | 186 | - |
| | | Arattupuzha-Clappana | 653 | 1562 |
| | | Kayamkulam-Karunagapally | 519 | 543 |
| 8. | Kollam | Chavara-Edava | 690 | 6732 |
| 9. | Thiruvananthapuram | Varkala | 32 | 62 |
| | | Anjengo-Veli | 18 | 1177 |
| | | Sangumughom-Vizhinjam | - | 125 |
| | | Pulluvila-Poovar | - | 188 |

**Table-6. Brackish fish water fish/prawn farms of the Department of Fisheries**

| Sl.No | Name of farm | Area (ha) | District | Taluk |
|---|---|---|---|---|
| 1. | Ayiramthengu fish farm | 38.89 | Kollam | Karunagappally |
| 2. | Palaikari fish farm | 48.00 | Kottayam | Vaikom |
| 3. | Edakochi fish farm | 10.93 | Ernakulam | Kochi |
| 4. | Malippuram fish farm | 21.14 | Ernakulam | Kochi |
| 5. | Njarakkal fish farm | 22.40 | Ernakulam | Kochi |
| 6. | Poyyar brackish water fish farm | 49.09 | Thrissur | Kodungallur |
| 7. | Kadappuram fish farm | 6.33 | Thrissur | Kodungallur |
| 8. | Eranholi estuarine fish farm | 10.96 | Kannur | Thalassery |
| | **Total** | **207.74 ha** | | |

A major landuse category under paddy and filtration ponds are not covered under these data bases. Besides, a great number of tanks and ponds belonging to public and private ownership are also not included in this inventory as reproduced here (Table-7). Other details available on various wetlands of Kerala are provided in Tables-8, 9 &10.

Table-7. Pond, tanks and other small wetlands of Kerala

| Sl. No | Name of the District | No. of Panchayat Ponds | No. of Private Ponds | No. of Public Ponds | No. of Quarry Ponds | No. of Irrigation tanks | No. of Holy Ponds and streams |
|---|---|---|---|---|---|---|---|
| 1. | Thiruvananthapuram | 1633 | 171 | 00 | 06 | 34 | 69 |
| 2. | Kollam | 581 | 825 | 503 | 82 | 17 | 188 |
| 3. | Pathanamthitta | 390 | 456 | 654 | 138 | 06 | 59 |
| 4. | Alappuzha | 340 | 11400 | 00 | 04 | 03 | 303 |
| 5. | Kottayam | 226 | 1641 | 491 | 84 | 75 | 208 |
| 6. | Idukki | 66 | 558 | 77 | 19 | 47 | 23 |
| 7. | Ernakulam | 732 | 3450 | 296 | 164 | 72 | 204 |
| 8. | Thrissur | 984 | 5861 | 182 | 43 | 213 | 258 |
| 9. | Palakkad | 633 | 3070 | 242 | 134 | 61 | 314 |
| 10. | Malappuram | 555 | 3632 | 245 | 145 | 45 | 272 |
| 11. | Wayanad | 29 | 1489 | 01 | 16 | 61 | 03 |
| 12. | Kozhikode | 94 | 855 | 110 | 33 | 24 | 284 |
| 13. | Kannur | 292 | 626 | 470 | 25 | 35 | 301 |
| 14. | Kasaragod | 265 | 1858 | 86 | 11 | 145 | 148 |
| | **TOTAL** | **6820** | **35892** | **3357** | **904** | **838** | **2634** |

Table-8. Rivers of Kerala

| Sl.No. | Name of river | Length (km) | Catchment area ($km^2$) | Run off 1000 MC ft. |
|---|---|---|---|---|
| 1 | Manjeswaram | 16 | 90 | 3.0 |
| 2 | Uppala | 50 | 250 | 20.0 |
| 3 | Shiriya | 67 | 587 | 43.0 |
| 4 | Mogral | 34 | 132 | 91.5 |
| 5 | Chandragiri | 105 | 1406 | 110.2 |
| 6 | Chittari | 25 | 145 | 7.0 |
| 7 | Nileswaram | 46 | 190 | 16.5 |
| 8 | Karingote | 64 | 561 | 50.36 |
| 9 | Kavvai | 31 | 143 | 6.87 |
| 10 | Peruvamba | 51 | 300 | 23.6 |
| 11 | Ramapuram (Ezhimala) | 19 | 52 | 2.79 |
| 12 | Kuppam (Payangadi) | 82 | 539 | 44.7 |
| 13 | Valapattanam | 110 | 1867 | 97.7 |
| 14 | Anjarakandy | 48 | 412 | 8.7 |
| 15 | Tellicherry | 28 | 132 | 4.8 |
| 16 | Mahe | 54 | 394 | 18.2 |
| 17 | Kuttiyadi (Kotta) | 74 | 583 | 46.98 |
| 18 | Korapuzha | 40 | 624 | 58.7 |
| 19 | Kallai | 22 | 96 | 7.2 |
| 20 | Chaliyar (Beypure) | 169 | 2923 | 185.0 |
| 21 | Kadalundi | 130 | 1122 | 77.3 |
| 22 | Tirur | 48 | 117 | 9.5 |
| 23 | Bharathapuzha | 209 | 6876 | 311.8 |
| 24 | Keecheri | 51 | 401 | 16.0 |
| 25 | Puzhakkal | 29 | 234 | NA |
| 26 | Karuvannur | 48 | 1054 | 42.0 |
| 27 | Chalakudy | 130 | 1704 | 42.0 |
| 28 | Peiryar | 244 | 5398 | 434.8 |

| Sl.No. | Name of river | Length (km) | Catchment area (km²) | Run off 1000 MC ft. |
|---|---|---|---|---|
| 29 | Muvattupuzha | 121 | 1554 | 93.68 |
| 30 | Meenachil | 78 | 1272 | 96.27 |
| 31 | Manimala | 90 | 847 | 72.67 |
| 32 | Pamba | 176 | 2235 | 222.796 |
| 33 | Achencoil | 128 | 1484 | 76.0 |
| 34 | Pallickal | 42 | 220 | NA |
| 35 | Kallada | 121 | 169 | 76.0 |
| 36 | Ithikkara | 56 | 642 | 42.0 |
| 37 | Ayroor | 17 | 66 | NA |
| 38 | Vamanapuram | 88 | 687 | 52.08 |
| 39 | Mamom | 27 | 114 | NA |
| 40 | Karamana | 68 | 702 | 38.75 |
| 41 | Neyyar | 56 | 497 | 29.6 |
| 42 | Pambar | 26 | 384 | NA |
| 43 | Bhavani | 39 | 562 | NA |
| 44 | Kabani | 63 | 1920 | NA |

**Table-9. Freshwater Lakes of Kerala**

| Sl.No | Name of the Wetland | District |
|---|---|---|
| | Pookot | Wayanad |
| | Muriyad | Thrissur |
| | Kattakambal | Thrissur |
| | Enammakkal | Thrissur |
| | Manakkodi | Idukki |
| | Sasthamkotta | Kollam |
| | Vellayani | Thiruvananthapuram |

**Table-10. Unique wetland Ecosystems of Kerala**

| Sl.No | Name of Ecosystem | Location-District |
|---|---|---|
| 1. | Kol Lands | Thrissur |
| 2. | Pokkali Lands | Ernakulam |
| 3. | Kuttanad | Alappuzha |
| 4. | Myristica Swamps | Thiruvananthapuram & Kollam |

## 4. PRESENT METHODOLOGY

The methodology adopted here for delineating the stipulated wetland patches have been achieved by integrating the spatial distribution of wetlands in 1:50,000 Survey of India (SOI) topographical sheets with IRS P6 Satellite imagery of 5.8 m spatial resolution. The salient features of the methodology adopted are:-

Generation of a standard spatial data frame work with WGS 84 Datum and UTM Zone 43 projection for seamless spatial data integration. Geo-referencing of satellite imagery with respect to the standard spatial data framework. Identification of wetlands with the content accuracy of 1:50,000 SOI maps. Onscreen digitization of wetland using Arc GIS software. Integration of base layers such as major roads, drainage, locations and administrative units from Natural Resources and Environmental Data Base (NREDB) of Kerala. District-wise wetland vector data merging and coding for the preparation of map layouts. Area statistics generation of wetlands based on wetland codes. Preparation of district-wise map layouts for all fourteen districts of Kerala . Preparation of layouts of each coded wetland in 1:50,000 scale for easy reference in A3 format. Printing of maps for the production of wetland atlas. The spatial data operations and analysis were carried out using ERDAS Imagine and ARC-GIS software.

As per WCMR, 2010, the minimum size of the wetlands that could be mapped in the proposed study is 5 ha on a scale of 1: 50,000 in a high altitude wetland / wetland complexes at or above an elevation of + 2500 m. The size of the wetlands / wetland complex that could be mapped below that elevation should have an area equal to or greater than 500 ha. If this criterion is followed thre is hardly any wetland to be mapped further. Therefore, we have devised a system giving more thrust on the environmental issues and ecological significance in identifying wetlands of importance to cover maximum wetlands of the state. The final maps are prepared after incorporating the ground truth information as well as the interpreted details as envisaged from image classification and image analysis to the base maps prepared from Survey of India topographical maps. Various prominent features like rivers, streams, major settlements, roads, railway lines etc are incorporated in the database during the

preparation of base maps on 1:50,000. The maps would show the broad geographical delineation of the wetland, including towns, city, and district and state boundaries in a table format with details shown like; general profile/geographical delineation showing District, Taluk, Block, Grama panchayat, Village, local name, size/area (ha), location (lat. and long.), with map (in GIS platform) and zone of influence of the wetland with a corresponding reference map.

Account of the per-existing rights and privileges consistent or not consistent with ecological health of the wetland is also given under explanation to the plates in a table format. The major driving forces of wetland degradation are: (i) population/household growth and urbanization, (ii) industries (iii) infrastructure (iv) agriculture (v) aquaculture (vi) fishing (vii) poaching (viii) mining (ix) deforestation (x) services (xi) water transport and (xii) tourism, etc which are self explanatory (SOE, 2007).

## 5. RESULTS AND DISCUSSION

Though small in size, Kerala is a land rich of water resources. There are 44 rivers draining the land, of which 41 are west flowing and 3 flow east. Apart from these 44 rivers, their tributaries and distributaries and a countless number of streams and rivulets crisscross the land making it green and fertile and also serves as inland waterways. Major rivers include Pampa, Periyar, Achenkovil, Manimala, Bharathapuzha, Chalakudi, Valapattanam, Kallayi, Meenachil, Muvattupuzha, etc. Beside these rivers, Kerala is bestowed with a number of lakes and backwater/lagoons which add to the beauty of the land. The important wetlands of Kerala are Ashtamudi, Vembanad and Sasthamkotta. Vembanad lake is the largest in the state while Sasthamkotta is the largest natural fresh water lake. The other important backwaters are Anchuthengu, Veli, Edava, Kadinamkulam, Kayamkulam, Paravoor, Kavvai and Agalapuzha and Chetwai. Kerala has the finest beaches like Kovalam, Shangumugham, Varkala, Cherai, Fort Cochin, Kappad, and Bekkel. Reservoirs are the major wetlands that form the source of hydroelectricity viz. Neyyar, Peppara, Kallada, Kakki, Idukki, and Idamalayar, etc.

The results of the study identified 1, 25,822.4 ha wetlands in the state covering 14 districts against 1, 27,930.07 ha identified in the previous survey. An interesting aspect of the report is the mapping of the reservoirs from the inland, and mangroves (46 km2) from almost all the coastal districts with approximate areal extension. The district-wise figures of the wetlands of the state with area, mangrove/marsh and corresponding map details are given below (Table-11).

TABLE-11. WETLANDS-DISTRICT-WISE

| Sl.No | WET LANDS | Mangrove/marsh | Total area | Plate |
|---|---|---|---|---|
| KASARAGOD | | | | |
| 1 | Manjeswaram estuary | 18 | 101.76 | 1,5,19 |
| 2 | Muttam | 3 | 12.68 | 1,5,19 |
| 3 | Kumbla estuary | 75 | 315.93 | 1,5,19 |
| 4 | Mogral estuary | 13 | 90.01 | 1,5,20 |
| 5 | Chandragiri estuary | 50 | 556.98 | 1,5,20 |
| 6 | Kalanad estuary | Nil | 22.82 | 1,5,21 |
| 7 | Kottikulam | Nil | 4.45 | 1 |
| 8 | Bekal hole | 1 | 49.47 | 1,5,21 |
| 9 | Chittari_hole | 6 | 99.08 | 1,5,21 |
| 10 | Kavvai estuary | 356 | 1989.93 | 1,5,22,23,105 |
| 11 | Sand / beach | Nil | 7503 | |
| 12 | Rocky coast | Nil | 773 | |
| | **Total** | **522** | **11519.11** | |
| KANNUR | | | | |
| 1 | Kavvai estuary | 391 | 1243.69 | 1,6,24,105 |
| 2 | Palayangadi (Kuppam)-Valapattanam | 2319 | 5600.62 | 1,6,26 |
| 3 | Dharmadom estuary | 31 | 238.73 | 1,6,28 |
| 4 | Thalassery estuary | 32 | 208.19 | 1,6,28 |
| 5 | Mahe river | 15 | 76.74 | 1,6,28 |
| 6 | Pazhassi reservoir | NA | 590.93 | 1,6,27 |
| 7 | Sand / beach | Nil | 89 | |
| 8 | Rocky coast | Nil | 143 | |
| | **Total** | **2788** | **8190.9** | |
| WAYANAD | | | | |
| 1 | Banasurasagar reservoir | NA | 393.74 | 1,7,29 |
| 2 | Karaipuzha reservoir | NA | 568.92 | 1,7,30 |
| 3 | Pookode lake | NA | 3.7 | 1,7 |
| | **Total** | **Nil** | **966.36** | |
| KOZHIKODE | | | | |
| 1 | Kottakkal estuary | 5 | 614.36 | 1,8,31 |
| 2 | Elathur estuary | 10 | 1544.05 | 1,8,32 |
| 3 | Kottuli wetlands | 16.3 | 19.49 | 1,8,33 |
| 4 | Kallayi estuary | 11 | 78.87 | 1,8,33 |
| 5 | Beypore estuary | 37 | 723.13 | 1,8,35 |
| 6 | Kadalundi estuary (part) | 14 | 53.72 | 1,8,35 |

| Sl.No | WET LANDS | Mangrove/marsh | Total area | Plate |
|---|---|---|---|---|
| 7 | Peruvannamoozhy reservoir | NA | 1013.78 | 1,8,34 |
| 8 | Kakkayam reservoir | NA | 104.14 | 1,8,34 |
| 9 | Sand/beach | Nil | 4501 | |
| 10 | Rocky coast | Nil | 789 | |
| | **Total** | **93.3** | **9441.54** | |
| **MALAPPURAM** | | | | |
| 1 | Kadalundi estuary (part) | 38 | 263.62 | 1,9,36 |
| 2 | Poorappuzha estuary | 01 | 82.06 | 1,9,36 |
| 3 | Ponnani estuary (Tirurpuzha) | 10 | 2154.68 | 1,9,37 |
| 4 | Biyyam kayal & Puduponnani estuary | 5 | 939.55 | 1,9,37 |
| 5 | Sand/Beach | Nil | 4686 | 1,9,38 |
| | **Total** | **54** | **8125.91** | |
| **THRISSUR** | | | | |
| 1 | Viyyam kayal | Nil | 84.79 | 1,11,45 |
| 2 | Chetwai estuary | 19 | 861.48 | 1,11,46 |
| 3 | Kodungallore estuary | Nil | 941.84 | 1,11,47 |
| 4 | Chimoni reservoir | NA | 821 | 1,11,49 |
| 5 | Peechi reservoir | NA | 1014 | 1,11,48 |
| 6 | Peringalkuttu reservoir | NA | 297 | 1,11,50 |
| 7 | Sholayar reservoir | NA | 918 | 1,11,51 |
| 8 | Vazhani reservoir | NA | 160 | 1,11,48 |
| 9 | Sand/Beach | Nil | 3860 | |
| | **Total** | **19** | **8958.11** | |
| **PALAKKAD** | | | | |
| 1 | Kanjirapuzha reservoir | NA | 497.34 | 1,10,39 |
| 2 | Siruvani reservoir | NA | 179.26 | 1,10,39 |
| 3 | Malampuzha reservoir | NA | 2257.73 | 1,10,40 |
| 4 | Meenkara reservoir | NA | 218.12 | 1,10,41 |
| 5 | Moolathara reservoir | NA | 104.56 | 1,10,41 |
| 6 | Chulliyar reservoir | NA | 204.53 | 1,10,41 |
| 7 | Pothundi reservoir | NA | 320.65 | 1,10,42 |
| 8 | Mangalam reservoir | NA | 323.31 | 1,10,42 |
| 9 | Peruvarippalam reservoir | NA | 140.03 | 1,10,43 |
| 10 | Thunakkadavu reservoir | NA | 164.94 | 1,10,43 |
| 11 | Parambikulam reservoir | NA | 2265.42 | 1,10,43 |
| 12 | Walayar reservoir | NA | 159.99 | 1,10,44 |
| | **Total** | **Nil** | **6835.88** | |
| **IDUKKI** | | | | |
| 1 | Kundala reservoir | NA | 68.05 | 1,13,58 |
| 2 | Mattupetti reservoir | NA | 247.37 | 1,13,58 |
| 3 | Anayirangal reservoir | NA | 446.6 | 1,13,56 |
| 4 | Chengulam reservoir | NA | 30.92 | 1,13,57 |
| 5 | Kallarkutty reservoir | NA | 75.43 | 1,13,57 |
| 6 | Ponmudi reservoir | NA | 230.98 | 1,13,55 |
| 7 | Lowerperiyar reservoir | NA | 42.34 | 1,13,57 |
| 8 | Idukki reservoir | NA | 5156.44 | 1,13,54 |
| 9 | Irattayar reservoir | NA | 31.02 | 1,13,54 |
| 10 | Malankara reservoir | NA | 360.7 | 1,13,52 |
| 11 | Mullaperiyar reservoir | | 2395 | 1,13,53 |
| | **Total** | **Nil** | **9084.85** | |

| Sl.No | WET LANDS | Mangrove/marsh | Total area | Plate |
|---|---|---|---|---|
| ERNAKULAM | | | | |
| 1 | Vembanad lake (part) | 636 | 9713.05 | 1,12,62,63, 64,65,91 |
| 2 | Idamalayar reservoir | NA | 3157.52 | 1,12,66 |
| 3 | Bhoothathankettu reservoir | NA | 620.28 | 1,12,66 |
| 4 | Sand / beach | Nil | 2654 | |
| | **Total** | **636** | **16144.85** | |
| KOTTAYAM | | | | |
| 1 | Vembanad lake (part) | 34.01 | 6162.03 | 1,14,67,68,69 |
| | **Total** | **34.01** | **6162.03** | |
| ALAPPUZHA | | | | |
| 1 | Vallikunnattu chira | Nil | 5.84 | 1,15,73 |
| 2 | Vaiyankara chira | Nil | 35.61 | 1,15,73 |
| 3 | Pudu chira | Nil | 0.72 | 1,15 |
| 4 | Kayamkulam kayal | 18.96 | 1689.54 | 1,15,74 |
| 5 | Vembanad lake (part) | 302.67 | 10,722.32 | 1,15,70,71,72 |
| 6 | Vattakayal west | Nil | 99.86 | 1,15,72 |
| 7 | Vattakayal | Nil | 28.87 | 1,15,72 |
| 8 | Puduppandam kayal | Nil | 68.91 | 1,15,72 |
| 9 | Karingalil chal | Nil | 223.25 | 1,15,73 |
| 10 | Cherukarakayal | Nil | 216.56 | 1,15,72 |
| 11 | Sand / beach/bar/spit | Nil | 7964 | |
| 12 | Changapadam | Nil | 27.17 | |
| 13 | Pallonnilchal | Nil | 3.27 | |
| 14 | Kuthiravattamchira | Nil | 6.91 | |
| 15 | Poomalachal | Nil | 9.10 | |
| | **Total** | **321.63** | **21,101.93** | |
| PATHANAMTHITTA | | | | |
| 1 | Kakki reservoir | NA | 1824.23 | 1,16,60 |
| 2 | Pamba reservoir | NA | 203.01 | 1,16,59 |
| 3 | Gavi reservoir | NA | 19.08 | 1,16,59 |
| 4 | Maniyar dam | NA | 23.08 | 1,16 |
| 5 | Panniveli chira | NA | 10.97 | 1,16,61 |
| 6 | Karingalil chal | NA | 5.68 | 1,16,61 |
| | **Total** | **Nil** | **2086.05** | |
| KOLLAM | | | | |
| 1 | Kilimukkam/Nadayara kayal | 5 | 304.85 | 1,17,77 |
| 2 | Kayamkulam kayal | 19.54 | 221.16 | 1,17,75 |
| 3 | Ashtamudi kayal | 42.11 | 5892.28 | 1,17,79,80,92 |
| 4 | Vatta kayal | 3 | 386.06 | 1,17,75 |
| 5 | Valumel punja & Vatta kayal | Nil | 308.29 | 1,17,76 |
| 6 | Sasthankotta kayal | Nil | 347.09 | 1,17,76 |
| 7 | Paravur kayal | 3 | 500.89 | 1,17,77 |
| 8 | Iravipuram kayal | Nil | 105.04 | 1,17,77 |
| 9 | Adichanallur kayal | Nil | 281.56 | 1,17,77 |
| 10 | Paravurtekke kayal | Nil | 121.66 | 1,17,77 |
| 11 | Cheloor kayal | Nil | 80.35 | 1,17,76 |
| 12 | Chendurni reservoir (Kallada) | NA | 2072.8 | 1,17,78 |
| 13 | Beach | Nil | 610 | |
| 14 | Rocky coast | Nil | 10 | |
| | Total | 72.65 | 11242.03 | |

| Sl.No | WET LANDS | Mangrove/marsh | Total area | Plate |
|---|---|---|---|---|
| THIRUVANANTHAPURAM | | | | |
| 1 | Vellayani kayal | Nil | 230.96 | |
| 2 | Nadayara kayal | 5 | 146.57 | 1,18,81 |
| 3 | Anchuthengu kayal | 10 | 395.55 | 1,18,81 |
| 4 | Kadinamkulam kayal | 7 | 548.80 | 1,18,82 |
| 5 | Chovara | 1 | 3.06 | 1,18,85 |
| 6 | Akkulam lake | 5.39 | 87.57 | 1,18,83 |
| 7 | Neyyar reservoir | NA | 934.12 | 1,18,86 |
| 8 | Edava kayal | 2 | 13.17 | 1,18,81 |
| 9 | Poonthura kayal | 3 | 28.74 | 1,18,84 |
| 10 | Puvar lake | 7.12 | 61.38 | 1,18,85 |
| 11 | Peppara reservoir | NA | 428.34 | 1,18,87 |
| 12 | Aruvikkara reservoir | NA | 41.55 | 1,18,87 |
| 13 | Sand / beach | Nil | 2570 | |
| 14 | Rocky coast | Nil | 657 | |
| | **Total** | **40.51** | **6009.3** | |

**Table-12. Area under Mangroves in Kerala**

| Sl. No | District | Area (ha) |
|---|---|---|
| 1 | Kasaragod | 522 |
| 2 | Kannur | 2788 |
| 3 | Kozhikode | 93.3 |
| 4 | Malappuram | 54 |
| 5 | Thrissur | 19 |
| 6 | Eranakulam | 636 |
| 7 | Kottayam | 34.01 |
| 8 | Alappuzha | 321.63 |
| 9 | Kollam | 72.65 |
| 10 | Thiruvananthapuram | 40.51 |
| | **Total** | **4581.10** |

Kannur district is having maximum area under mangroves and marshes followed by Ernakulam and Kasaragod. They are distributed as isolated patches and often found far away from the estuarine mouths.

## 6. CONSERVATION OF WETLANDS

The wetlands in Kerala are currently subjected to acute pressure owing to rapid developmental activities and indiscriminate utilization of land and water. As a result, the system is being degraded, at an alarming rate. Though, there were no quantitative estimates on the rate of destruction of wetlands in Kerala, the qualitative degradation of the ecosystem is, more or less, well understood. The major issues facing the wetlands of Kerala are mainly related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss. The unscrupulous exploitation of the fragile wetland system and undesirable input of residues exceeding the wetland as the assimilative capacity is now increasingly resulting in various kinds of pollution in the wetland systems. Eutrophication, which is defined as the nutrient enrichment of waters stimulates an array of symptomatic changes. Encroachment and Reclamation of wetland for various activities along with unauthorized occupation is continuing in the wetlands from time immemorial. Major resources of the wetlands which are being unwisely harvested are sand, lime shell, fish and other bioresources. The threats to wetland biodiversity are at an all time high, caused by detrimental human activities. Our mismanagement of land and water is reflected in the decline we see today in the extent and quality of wetlands and the important biodiversity they support. The degradation of the major wetlands of Kerala has been driven by various direct and indirect forces. The major driving forces of wetland degradation are: (i) population/household growth and urbanization, (ii) industries (iii) infrastructure (iv) agriculture (v) aquaculture (vi) fishing (vii) poaching (viii) mining (ix) deforestation (x) services (xi) water transport and (xii) tourism (SOE, 2007).

The Government of India has accorded wetlands conservation a high priority and, the National Environment Policy (NEP) 2006 seeks to set up a legally enforceable regulatory mechanism for identified wetlands to prevent their degradation, enhance their conservation and wise-use by all the Stakeholders. The following activities within the notified wetlands shall be prohibited, namely:-Conversion of wetlands to non-wetland use with appropriate benchmarks in time for land use; reclamation of wetlands; setting up of new industries and expansion of existing industries; manufacture or handling or storage or disposal of hazardous

substances solid waste dumping; the existing practices, if any, shall be phased out within a reasonable time period not exceeding one year from the date of notification of the wetland under these rules; discharge of untreated wastes and effluents from industries, cities or towns and other human settlements; the existing practices, if any, shall be phased out within a reasonable time period not exceeding two years from the date of notification of the wetland under these rules;

The wetlands lying within the protected areas of National Parks and Wildlife Sanctuaries shall be regulated under the provisions of Wildlife (Protection) Act, 1972. The wetlands lying within the notified forest areas shall be regulated by the provisions of the Indian Forest Act, 1927, Forest (Conservation) Act, 1980; and Environment (Protection) Act, 1986. While the gaps, if any, under the provisions of the Indian Forest Act, 1927; Wildlife (Protection) Act, 1972; and Forest (Conservation) Act, 1980 shall be plugged by invoking provisions of the Environment (Protection) Act, 1986. The wetlands situated outside the protected or notified forest areas shall be regulated by the relevant provisions of the Environment (Protection) Act, 1986. Enforcement of regulated activities.- In view of the multi-disciplinary character of the wetlands, the Central Wetlands Appraisal Committee, State Wetlands Appraisal Committee may be formed at the earliest for activities to be regulated as given below:

(a) The identified activities for management and wise use of wetlands situated within the forest and protected areas shall be enforced by the forest department.

(b) The identified activities for management and wise use of wetlands situated outside the forests are yet to be devised for the state.

The study highlighted the need for conservation of all the wetlands. But the following wetlands need immediate attention for conservation and management action plans on a priority basis as their use is not consistent with their designated use. The three wetlands identified are unique in the sense that the first one –Vellayani- is a freshwater body situated very near to the capital city of the state. The other two wetlands are the last asylum of unique species and ecological communities of the state such as mangroves and associated biota. Brief details of these wetlands are given below.

## 6.1. VELLAYANI LAKE

Location

The Vellayani lake, the second largest freshwater lake of Kerala is located in the outskirts of Thiruvananthapuram city. It lies between North Latitudes 8°24'09"-8°26'30" and East Longitudes 76°59'08"- 76°59'47" (Plate-84). The lake is about 230 ha, and the water-spread was about 5.5 km2 in the near past. The depth of the lake varies from 2 to 6 m. The north-western part of the lake is converted to a temporary reservoir for irrigation purpose. Apart from a distributary of Karamana River, the Pallichal thodu also empties into the Vellayani Lake. The present environmental account of Vellayani lake is mainly based on Krishnakumar, et al., 2002 and 2006.

Four major litho-units of different characteristics and ages are noticed in the surroundings. The lake basin floor in the north-eastern part is by Precambrian crystallines composed of quarto-feldspar-hypersthene granulite, charnockite gneiss, hypersthene-diopside gneisses and khondalites. The south-western part is occupied by the tertiary hillocks composed mainly of the sandstones and clays with seams of lignite known as the Warkalli Formation. Quarternary sediments composed of coastal sand and alluvium dominate in the north-western part. The lake is drained by the second and fourth order streams of smaller sizes, in addition to major contribution from the Karamana river. The lake is surrounded by hillocks with steep to moderate slopes. The regions adjacent to the lake basin exhibit nearly leveled/gently sloping surfaces. The watershed areas of the Vellayani Lake are utilized extensively for a variety of cultivation, but the predominant one is coconut palms. Rice, banana, vegetables, etc are also cultivated extensively on the banks of the lake.

The various physical, chemical and biological parameters of the water resources of Vellayani Lake such as odour, total dissolved solids, pH, nitrates, sulphates, chlorides, hardness, calcium and magnesium fall within the prescribed limits of Indian standards. The turbidity values are slightly higher than the Bureau of Indian Standards (BIS) for drinking

water. The content of iron is almost agreeable, however, vary marginally compared to BIS prescriptions. On a bacteriological point of view, the raw water of the Vellayani Lake is not at all good for drinking purpose as it contains high coliform counts. From the overall water quality evaluation, it can be concluded that the water resources of Vellayani lake should be thoroughly treated prior to using it for consumption. The various treatment processes like aeration (to precipitate impurities like iron), coagulation and flocculation (to remove turbidity), sedimentation (to separate suspended solids) and filtration (to remove very fine particles of silt, clay, micro organisms including algae, bacteria, viruses etc) and disinfection (to destroy all the disease producing organisms etc should be adopted to treat the water of Vellayani Lake prior to consumption. As such, the water is not suitable for drinking purpose, instead, can be used for irrigation and/or industrial uses.

Conservation potential/ implications

Vellayani lake, is one among three rain fed freshwater lakes of Kerala State which plays a natural role in storing rainwater, in maintaining the recharge of groundwater, and as an aquifer for dug-wells in the neighborhood. It collect and store large quantities of water during the monsoon period and serve as very useful system in conservation of water, more especially in the topographical situation as existing in the State. The Vellayani lake included itself in extensive paddy fields, reservoirs and lagoon, a major part in possession of the Agricultural college. The freshwater lake, which once enriched the natural beauty and was the sources of several water supply schemes are degrading due to severe environmental problems in and around the lake. Now about one third of the lake is in the hand of individuals, allotted under reclamation scheme for agricultural purposes. Besides, encroachment, reclamation etc are going on in several parts of the lake mainly in areas in possession of government and agricultural college. Fish farming in the lake is also doing much havoc to the ecosystem. Artificial fish feeds, pesticides etc pollute the water in the lake.

Scenic natural hill settings near the lake act as the sources of water flow in the lake. But, almost all hillocks in the region are flattened by soil quarrying. It is in the sharp rise in the price of real estate that persuades

the land owners to mine these hillocks. The operation causes silting up of the lake, and this in turn results the decrease of depth. The after effects of these processes affect the people who are living in the near by places. The wells are being dried up before summer, and more over the nutrient rich top soil lost in the process of sand mining. The indiscriminate soil quarrying activities of the areas can catalyze land failures particularly during monsoon. The Assembly Committee on Environment in 1992 reported about the different problems affecting the freshwater lakes of the State including the Vellayani lake. But till this time, not any actions are taken for the better conservation and sustainable use of the Vellayani lake system. Although, it is too late, urgent measures have to be taken for the wise use of this precious freshwater reserve of our State.

The requirement of water for Thiruvananthapuram city by 2021 A.D. is predicted to the tune of 400 million liters. The existing Aruvikkara and Peppara dams do not have much storage capacity. The studies relating to the Vellayani lake convinces beyond doubt that this lake will offer an addition to the drinking water requirement of the capital city and its suburbs. It is inevitable that Vellayani lake scheme is undertaken in order to tide the insufficiency of water supply from the Aruvikkara scheme. When this scheme materializes, 70 million litres of freshwater will be available for distribution in the city, according to finding of some studies by KWA in 1997. The Vellayani project can be implemented at comparatively less expenditure.

## Recommendations for the Sustainable use of the Vellayani lake

The government should have taken over the entire lake and declare it as protected. The cultivable area in the ownership of the private individuals should be demarcated and separated. The lake area including the reservoir should be deepened to sufficient depth level to enhance the storage capacity of the lake. People who have encroached upon the lake area should be evicted and further encroachment banned. Besides, the catchment area of the lake should be protected by constructing necessary low cost engineering structures to prevent soil erosion. And steps should be taken to reduce the input of residues/remains of chemical fertilizers and pesticides form the adjacent fields reaching the lake.

The level of Kakkamoola road-bridge across the northern part of the Vellayani lake should be raised sufficiently so as to prevent the lake water over flowing road-bridge during heavy monsoon showers. The free flow of water under the road can be facilitated by providing additional sluice provisions. Promotion of tourism facilities is likely to adversely affect the eco-balance of the lake and therefore such activities should be discouraged. People living around the lake should be made conscious of the necessity to adopt proper/scientific land use practices in the catchment areas of the lake. And proper arrangements should be made regularly to assess the water quality of the lake and for taking remedial measures for improving the quality of Vellayani lake water.

## 6.2. KUPPAM-VALAPATTANAM ESTUARY

Valapattanam estuary is formed by the confluence of Kuppam/Kuttikkol River (Payangadi River) and Valapattanam rivers. The wide estuary, backwaters and the extended wetlands cover about 56 km2 are famous for mangroves, paddy lands (especially seasonally inundated Kaipad lands) occasional fish farms and other land uses. The Valapattanam estuary is connected to the Lakshadweep Sea through a tidal inlet at Azheekkal. The maximum tidal range is about 1m. The uninterrupted tides facilitate the migration of marine fishes to the estuaries and even to the less saline areas upstream. Up to 6 km upstream, salinity is equal to that of the sea- 2.4 to 3.6%. Beyond that, salinity is reduced due to neap tide and flow of the river. As there are mangroves and mangrove-associated species found up to 10 km upstream from the estuary, the environment is conducive to breeding and movement of marine fish species. There are lot of people who make their life from fishing in the Valapattanam estuary. A network of canals is seen connecting the tidal flats with the rivers. The filtration ponds have bunds that separate them from the river and further divide the tidal flats into different compartments. Sluices on the bunds facilitate and maintain tidal flow and exchange of water between the river and filtration ponds. The major river systems forming the wetlands are the following:-

Kuppam (Payangadi) River

The Kuppam river otherwise known as Payangadi river flows through the Taliparamba and Kannur taluks. It originates from the Padinalkad Ghat reserve forest in Coorg district, Karnataka at an elevation of 1630 m. The

length of the river is 82 km. The Kuppam system drains a total area of 539 km2 of which an area of 70 km2 is in Karnataka. Its main tributaries are the Pakkattupuzha, Alakuttathodu, Kuttikole puzha, Mukkutta thodu and the Chiriya thodu. The river has a steep course in its initial reaches but on entering Kerala after a run of 12 km, the bed-level falls to 115 m. It follows a course almost parallel to that of Valapattanam river but at Payangadi takes a sudden twist to the south and flows parallel to the coast. It therefore joins the Valapattanam estuary before its exit into the sea at Azhikkal.

Valapattanam River

Valapattanam river originates from the Brahmagiri Ghat Reserve forest within Karnataka at an altitude of 900-1350 m above mean sea level and drains into the sea at Azhikkal after combining with Koppam river. About 19 km of its upper reach is within the boundaries of Karnataka. Entering Kerala, it flows through the villages Iritty, Perunana, Irikkur, Kalliasseri and Valapattanam. The major tributaries of this river are the Sreekantapuram river, Valiapuzha, Venipuzha and the Aralam puzha. The basin is very undulating, the cultivable land lying mostly in the valleys. The total drainage area of this river basin is 1867 km2 of which 546 km2 is outside the state. The length of the river is 110 km and of all the rivers in the Malabar region, maximum volume of water is drained by the Valapattanam river system.

This rich and diverse wetland also forms the foundation of a wide range of economic activities, especially agriculture, fishing, aquaculture, fish landing centre, coastal guard station etc. Destruction of mangroves and other wetlands are taking place in the entire area. Obviously the formation of mud platforms, widening the paths, excavation of the wetlands, has led to the near total destruction of the natural vegetation that existed in the area. A major part of the developed area was originally Kaipad land, abandonment of rice cultivation a few years ago, had helped this area being recolonized by mangrove species in undisturbed areas. The intense development activity has also affected the soil characteristics and the local hydrology, affecting regeneration and the natural succession.

The mangrove vegetation seen here are of estuarine nature commonly seen in other parts of the state. The zonation pattern is such that most salt tolerant species like Avicennia officinalis and A. marina are on the river bank with the floor being covered with a thick network of breathing pneumatophores. Kandelia candel, Rhizophora mucronata, with their characteristic hanging propagules is in plenty. Excoecaria agallocha, Aegiceras corniculatum, and Sonneratia caseolaris make their presence in some areas. In exposed and less dense inner regions, Bruguiera cylindrica, Derris trifoliata, Acanthus ilicifolius, Clerodendrum inerme, Dolichandrone spathacea, and Stictocardia tilifolia are commonly seen. The water fern Acrostichum aureum and a few grasses make their presence in disturbed inner areas. Eleven true mangrove species and 3 major associates constitute the major flora of the region. Two species viz., Isachne pappinisseriensis (grass) and Furiena zollingerii (sedge) are two taxa new to science recently described from the mangrove wetlands of Pappinisseri.

These wetlands support rich faunal species. The two very important among them are fishes and wetland birds. The micro-flora and micro-fauna associated with the system serve in controlling pH, leaching of metals and nutrient cycling. Faunal diversity of Valapattanam estuary is rich with microorganisms, Planktonic forms, and various invertebrate and vertebrate species. They harbour a rich community of planktons, forming the source of food for crabs, prawns and fishes. The faunal components could be distinguished into epiphytic, benthic and nektonic communities based on their ecological niches (Khaleel , 2004). During monsoon and pre-monsoon, the estuary is rich in Phytoplanktons and Zooplanktons. The common phytoplankton found in the Valapattanam estuary and mangrove areas are: Scenedesmus, Navicula, Closterium, Netrium, Pleurosigma, Eunotia, Nitzschia, Cyclotella Coscinodiscus, Ankistrodesmus, Surirella, Pedisastrum, Cosmarium, Ulothrix, Triploceras and many species of Diatoms, Euplotes, Rotifer, Paramecium, Euglypha, Difflugia, Euplotes, Stylonichia, etc. The benthic fauna of the Valapatanam estuary consists of many species of arthropods; especially mud crabs, aquatic leeches, polycheates, molluscs and larvae of various animals (Sreedharan, 2005).

The common crab species found in the estuary are: Scylla serrata (Mud crab, Kurisunjandu), Charybdis cruciata (Mask crab, River crab), Portunus pelagicus (Spotted crab), Portunus sanguinolentus (Kandal njandu) Maluta lunaris (Armed crab), Euca sp. etc. Crabs dig deep burrows in the mud and thereby help soil aeration. The mangrove litter is broken up into minute particles by crabs. These are then decomposed by a multitude of bacterial population. The nutrients released thus become available for plankton. Clams, Mussels, Oysters, Shells and Barnacles are the molluscs found in the estuary. Perna indica, Perna virdis (Kallummakka), Meretrix casta (Elambakka), Paphia malabarica (Poovan Elambakka) Katelysia opima (Kakkan elambakka), Villorita cyprinoides ( Koorka) are the edible molluscs having good commercial value in the Valapattanam area Telescopium sp. (Purikka), Barnacles, Murex sp. and Bullia sp. could be seen along the mud during low tides. Economically important crustaceans like Penaeus monodon (Tiger prawn), Penaeus indicus (Naran, Chemeen (local) ), Metapenaeus dobsonii (Poovalan), Metapenaeus affinis (Kalanthan), Metapenaeus monoceros (Choodan Chemeen), Macrobrachium idella (Attukonchu), Macrobranchium rosenbergii (Chittakonchu), etc are also abundant in the estuarine waters. The spiny lobster (Panulirus sp.) is also seen in Valapattanam. Asian giant soft–shelled turtle (Pelochelys cantorii), a largest turtle species of India which is included in the Endangered category of the IUCN Redlist and listed in Schedule 1 of Indian Wildlife (Protection ) Act,1972 is present in the area. Other turtles such us Flap-shelled turtle, (Lissemys punctata) and Indian pond terrapin (Melanochelys trijua) are also recorded from the region. The important snakes found in the region are Naja naja (Cobra), Vipera russeli (Russels viper) etc.

A good population of Smooth-coated otter (Lutra perspicillata) and Jungle cat (Felis chaus) has been recorded from the area. Rare sighting of the highly endangered fishing cat (Prionailurus viverrinus) has also reported from the vicinity of the mangrove area (MNHS 2010). The mudflats, mangroves, marshes, kaipad fields and the extended waters of Valapattanam estuary make a good habitat for many water birds, both resident and migratory. The avian fauna also depends on the wetland for food, shelter and breeding. The list of birds observed in the rich wetlands of Valapattanam estuary are: Little Cormorant (Phalacrocorax niger), Cattle Egret (Bubulcus ibis), Pond Heron (Ardiola grayii), Purple Heron

(A. purpurea), Grey Heron (Ardea cinerea), Black Kite (Milvus migrans), Ospray (Pandion haliaetus), Red Shank (Tringa tetanus), Palm swift (Cypsiurus valasiensis), Pintail snipe (Gallinago stenura), Jungle babbler (Turdoides stenura), Common tailor bird (Ortho tomus sutorius), Common Lora (Aegithina tiphia), Paddy field pipit (Anthus novaeseelandiae), White cheeked barbet (Megalaima virdis), Blue Tailed Bee eater (Merops philippinus), Small Blue Kingfisher (Alcedo atthis), Blue roach Pigeon (Columba livia), Crab Plover (Dromas ardiola), Marsh sandpiper (Tringa stanstagnatilis), Ashy prinia (Prinia socialis) and Brown shrike (Lanius cristatus).

In Valapattanam the large assemblage of birds evidenced by a record of more than 60 species, which include 15 migratory species, 4 Globally threatened species-Greater Spotted Eagle (Aquila clanga) and Darter (Anhinga melanogaster), Oriental White Ibis (Threskiornis melanocephalus) and Black–tailed Godwit (Limosa limosa). The very presence of these birds makes a suggestion to put the area under Important Bird Area (IBA) category of the Birdlife International, London in 2010. The area also forms the breeding place of Night Heron and roosting place for many species of waterfowls like Grey Heron, Purple Heron, Pond Heron, Median Egret, Little Egret, Large Egret, Open bill Stork etc.

The common fishes found in the Valapattanam estuary are: Etroplus suratensis (Karimeen), Etroplus maculates (Chootachi), Mugil cephalus (Thitutha), Mugil parsia (Malan), Chanos chanos (Poomeen), Lates calcarifer (Narimeen), Megalops cyprinoids (Palankanni), Eleotris fusca (Nongal), Leognathus sp. (Mullan) Scatophagus argus (Kachai), Arius sp. (Aeta), Anguilla sp. (Sping Eel), Parastromatus niger (Aral), Zenara copterus gilli (Kolavan), Glossogobius giurus (Payathan), Plottossus sp (Aeta, Choora), Puntius sp (Paral), Xenetodon cancilia (Koyala), Stolephorus commersonii (Nanthal), Solea enlogata (Nankumanthal), Orechochromic mossambica (Thilopi), Kowala coval (Vellori) etc.

Some of the salient biodiversity features of the area include: Two species viz., Ischaemum pappinisseriensis (grass) and Furiena zollingeri (sedge), new to science are recently described from the mangrove wetlands of Pappinisseri. The Asian giant soft shelled turtle (Pelochelys cantorii), the largest turtle species of India which is included in the

endangered category of the IUCN Red list and listed in Schedule I of the Indian Wildlife Protection Act 1972 is present in the area. The mudflats, mangroves, marshes, Kaipad fields in the Valapattanam estuary form an important habitat for many water birds, both local resident and migratory. Birds list include 15 migratory species and 4 globally threatened species- Greater spotted eagle (Aquila clanga), darter (Anhinga melanogaster), oriental white ibis (Threskiornis melanocephalus) and Black- tailed Godwit); The mangroves and the mudflats team with life, especially crabs and fishes fully taking advantage of the humus rich soil, the regular changes in salinity on account of tidal action. The Valapattanam estuary is considered as particularly important for inland and marine fisheries.

Mangrove forests found along the coastlines and river banks protect the shores from erosion; trap sediments washed off from the land, and provide breeding, nursery, and feeding grounds for several of species of invertebrates, fishes, amphibians, reptiles, birds and other animals. Being the transition zone between sea water and fresh water, it supports several flora and fauna specifically adapted to the frequent changes in the salinity levels. Many mangrove species have developed unique adaptive mechanisms for survival, including pneumatophores, stilt roots and vivipary. It is these specific adaptations that make mangroves a unique ecosystem worth protecting for posterity.

The mangrove vegetation and the wetlands (especially the Kaipad land) in the Kannur district as also in other districts are under severe stress on account of the various developmental activities, including real estate development establishment of industries, ecotourism projects, waste dumping and discharge of effluents. Throughout the area there are signs of mangroves being destroyed and wetlands leveled to make space for residential and commercial buildings, industrial units, etc. It is also important to consider the implications of the ongoing ecotourism development initiative- Malabar Mangrove Ecotourism Circuit being implemented by the Department of Tourism at a cost of about 3.5 crores. The proposal covers a number of key mangrove areas in Malappuram, Kozhikode, Kannur and Kasaragod districts. Establishment of interpretation centre, visitor facility, children's play area, wooden boat jetty, angling yard, and development of land, side protection and

pavement work are some of the activities envisaged. Whether these come under the purview of the CRZ Rules require detailed examination. However, the Eco tourism Department till now has not sought any clearance for the proposed project.

Another major development that will have significant impact on mangrove wetlands is the proposed Thermal Power and the Cement Clinker factory under consideration by KINFRA in the Irinav area of Kannur district. KINFRA has leased out an area of 164 acres to Jai Prakash Power Venture Limited for a period of 90 years for Rs. 13.8 crores. Most of the area is mangroves and Kaipad lands and will attract the provisions of the CRZ Rules, although till now KINFRA or the lessee has not sought any clearance for the proposed investment. Given the intense pressure described above and the inadequate legal/ institutional measures, there is strong likelihood of near total destruction of mangroves and wetlands in the next 5 to 10 years, especially in areas adjoining the expanding urban centres as in the case of the Valapattanam estuary.

A number of threats have been identified in the case of the mangrove forests and related wetlands in the Pappinisseri area due to the Mangrove Theme Park and other developments. Regulatory approaches including the CRZ Regulations and the Kerala Conservation of Paddy land and Wetland Act 2008 have not been effective. Currently the Government is initiating an incentive scheme, providing an annual grant of Rs. 4,000/acre to private land owners, to protect and improve mangroves in their land. It will take quite some time to know the effectiveness of this incentive scheme in protecting vulnerable mangrove areas. In Kerala the Kannur district, accounting for about 60% of the State's mangrove forests, is the last frontier of mangrove destruction. The areas surrounding the Mangrove Theme Park at Pappinisseri indicates that what has happened in the name of Mangrove Theme Park is the tip of the iceberg of mangrove destruction.

Being located in densely populated coastal zone subjected to urban expansion, real estate development, roads and other infrastructure, industrial development, shrimp farms and ill-conceived ecotourism initiatives, etc are having a severe impact on the wetland ecosystem.

There is an urgent need to bring the mangrove forests under public control to arrest their decline. The process of acquisition of mangroves which are ecologically fragile needs to be stepped up. Those areas managed by individuals and community may be protected with the involvement of local communities. Land owners having small extent of mangroves may be provided financial incentives to protect and manage the mangrove areas. The Forest Department has already initiated this and as experience is gained the approach could be refined and improved ensuring that land owners are adequately rewarded for protecting and managing mangroves.

## 6.3. THE KAVVAI LAKE

The Kavvai lake is a 32.34 km2 stretch of brackish water lagoon extending parallel to the shoreline between Ezhimala and Nileshwaram, with 5 rivers viz., Karingote, Nileshwaram, Kavvai, Ramapuram and Peruvamba (Perumba) draining into it. It is perhaps the most conspicuous lacustrine system in the coastal tract of northern Kerala. This backwater system has few major islets like Edayilakad, Madakkal, Vadakkekad, Chembantemedu, Oari, Thekkekad, Purathal, Kokkal, etc. The characteristic shape of these islets is indicative of the past fluvial patterns. The protected shores and vast mudflats along the coast and the sandy/muddy ridges surrounding the islets are found with potential stock of estuarine and marine influence. The Kavvai lake has two openings in to the Lakshadweep sea, one at Thaikkadappuram, located 18 km from Nileswaram and another one south of Ezhimala. The major rivers in the drainage are:-

Nileswaram River

Rising from Kinanur in Hosdurg taluk, the Nileswaram river is known as Pallichal thodu in its initial reaches. Its main tributaries Aryangal thodu and Baigote Hole join the main river 8 km. downstream of its origin. Though the source of the river is at about 140 m above Mean seal level the bed falls to 15 m elevation within a course of 8 km. It joins the Karingote river towards its mouth at Kottappuram to the South-West of Nileswaram town. The length of the river is 46 km, the last 10 to 11 km reach being tidal. It has a drainage area of 190 km2.

Karingote River

Originating at an elevation of 1520 m in Coorg district, Karnaataka, the Karingote, flows down the steep of the Western Ghats in the initial reaches until the bed level falls to 460 m, within a distance of 8 km. Its two main tributaries, the Mundore and the Padianmala Hole join at a level of 250 m. Another tributary, the Mundroth hole joins the main river at a bed level elevation of 36 m. Almost all the main streams in Karingote system flow in a south-westerly direction. After the confluence with the Nileswaram river, the channel gets split into several distributaries before falling into the Kavvai kayal. The Karingote river has a length of 64 km with a catchment area of 561 km2. About 132 km2 of its catchment lie within Karnataka.

Kavvai River

This is a small river which originates in Cheemeni village at 385 m. above mean sea level and flows past Alpadampa and Vadasseri before emptying into the Kavvai Kayal at Udamanthai. It has a length of 31 km and a catchment area of 143 km2.

Perunvamba River

Rising from Perkkunnu in the slopes of Western Ghats 325 m above mean sea level, the 51 km long Peruvamba river flows through the villages Peringoni, Kuttur, Mathamangalam and Kunhimangalam. To the east of Ezhimala the river bifurcates: one branch falls into the Kavvayi kayal and the other empties directly into the sea through Ezhimala estuary. The Macharuthodu, the main tributary of this river also originates from Pekkunnu and joins the river Mathamangalam. Peruvamba has a drainage area of 300 km2.

Ramapuram River

This is a small river 19 km long which joins the southward branch at Peruvamba river and empties into the sea through the Ezhimala estuary. It has its origin at 57 m above mean sea level in the Iringal hills, flows through the villages of Pariyaram, Kolapratvayal, Cheruthazham and Madai and has a total basin area of 52 km 2.

This is the downstream estuarine area of Kavvai River with mangrove growth and is well influenced by tidal rhythms. The bar mouth is common for the Karingote, Nileswaram, Kavvai and Peruvamba rivers. The following are the important mangroves. Acanthus ilicifolius L., Aegiceras corniculatum (L.) Blanco, Avicennia marina (Forssk.) Vireh, Avicennia officinalis L., Bruguiera cylindrica (L.) Blume, Excoecaria agallocha L., Kandelia candal (L) Druce, Lumnitzera racemosa Willd., Rhizophora apiculata Blume, Rhizophora mucronata Poir, and Sonneratia caseolaris (L.) Engl. Recorded from here. Major parts of the banks have stone bunding to protect coconut plantations leaving very little area of sandy shore near the bar mouth. The Karingote and Nileswaram River join Kavvayi estuary. Populations of Crassostrea (Mollusca), Uca, Sesarma, Gelasims (Arthropoda), Rhizostoma (Coelenterata) and Asterias (Echinodermata) inhabiting the rocky/sandy shore, fishes like Elops machnata, Gerres filamentoses, etc. wave action mechanized fishing boats to and from the nearby Thaikkadappuram fish landing centre, etc. are peculiar to this site. Intensive fishing is carried out here and in the open sea. The sea shore here is a breeding ground for turtle (Olive ridley), which is a endangered species.

The holoplankton of Kavvai River consisted of 55 genera, comprising of 7 genera of Rhizopoda, 2 of Actinnopoda, 14 of Ciliophora, 4 of Coelenterata, 1 each of Dinoflagellata, Platyhelminthes and Nematoda, 11 Rotifera, 4 Annelida and 10 Arthropoda, and 12 groups of meroplankton comprising of eggs and larvae of crustaceans, insects and other arthropods, annelids, echinoderms and chordates etc.

The Kavvai River recorded 35 crustaceans comprising 4 crabs and 9 prawns/shrimps. The edible, economically/commercially important crabs include Scylla serrate, Portunus pelagicus and Prawns/shrimps like Fenneropenaeus indicus, P. monodon, Macrobrachium rosenbergii, etc. Economically important mollusks include bivalves like Paphia malabarica, Meritrix casta, Meritrix meritrix, Villorita cyprinoides, Cassostrea madrasensis, Saccostrea cucullata etc., Cephalopods like Sepia and Loligo. Some of them are edible and others are exploited extensively for lime production. Gastropods like Telescopium, Murex etc. are ecologically important, their shells being serve as protective cover for hermit crabs.

Export of edible crustaceans and meat of mollusks from Kavvayi estuary fetch good foreign exchange. Kavvai also have 158 species of fish belonging to 111 genera, 2 classes, 24 orders and 67 families. Nalini Nayak et al. (2000) reported 36 fish species from the backwaters of Kannur alone.

Avian fauna of Kavvai River comprised of 120 species from 82 genera, 14 orders and 34 families, 39 species being winter migrants. Herons and egrets are abundant in these estuaries, and are more numerous in Kavvayi. Among reptiles, Testudines like Olive ridley was found entering into sand on the river mouth for laying eggs. A group of people (Naithal) at Thaikadapuram is taking initiative every year to protect the eggs in a temporary and artificial fencing till hatching, and to release the young ones safely into the sea. The mangrove ecosystem of Kavvayi has bat (Pteropus giganteus), jackal (Canis aureus), smooth coated otter (Lutra perspicillata), rat (Rattus rattus) etc. The jackal feeds on crabs and rats. The proposal for inclusion of this wetland as a Ramsar site is already under consideration (Harikumar, per. Comm.).

## 7. CONCLUSIONS

Vembanad-kole, Ashtamudi and Sasthamkotta, are the three designated Ramsar sites of Kerala. In addition to this, two more wetlands - Kottuli in Kozhikode district, Akkulam-Veli in Trivandrum district and Kadalundi between Kozhikode and Malappuram districts - have been identified by the Ministry of Environment and Forests, Government of India, under National Wetland Conservation Programme. The components include mangrove afforestation, pollution abatement, fishery development, social interventions and monitoring and evaluation which have been formulated and implemented with multi-institutional participation. A number of management programmes were initiated during the last five years for developing and implementing sustainable management plans for wetlands. The Kerala State Council for Science, Technology and Environment (KSCSTE) has prepared Management Action Plans for Vembanad, Sasthamkotta and Ashtamudi lakes. Centre for Water Resources Development and Management (CWRDM) has initiated Management Action Plan preparation for Vembanad, Ashtamudi, Sasthamcotta and Kottuli wetlands which are being implemented with the support of Ministry of Environment and Forests (MoEF). CESS has prepared the Ashtamudi management plan. Many of the wetlands in Kerala including Vembanad-Kole are being monitored as part of the Asian Waterfowl Census implemented under the auspicious of Wetlands International.

Wetlands include water, soil, vegetation and wildlife, as modified and exploited by human activities. Early civilizations arose in fertile river valleys, and wetlands continue to be essential for modern human society. Wetlands provide many resources for people who live in or derive economic benefits from them. In addition, wetlands serve important, but less tangible functions like water supplies and high levels of biological productivity and biodiversity. As major sources and sinks for carbon, wetlands play critical roles in the global carbon cycle with significant consequences for greenhouse gases and potential climate change. Therefore, conservation of the remaining wetlands without further intervention is the prime concern. More wetlands of the state are to be brought under the National Wetland Conservation and Management Programme.

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