WETLANDS OF KERALA

"Wetlands are kidneys of our landscape

We are cutting out our kidneys to enlarge our stomachs"

Eric Freyfogle, Illinois law professor

2.1. INTRODUCTION

2.1.1. Background

Wetlands are ecotones or transitional zones that occupy an intermediate position between dry land and open water. Wetland ecosystems are dominated by the influence of water, they possess characteristics of both terrestrial and aquatic ecosystems and properties that are uniquely of their own. Wetlands support a wide array of flora and fauna and deliver many ecological, climatic and societal functions. Scientists often refer to wetlands as the "kidneys" of the earth and forests as the "lungs" of the earth. India by virtue of its extensive geographical stretch and varied terrain and climate, supports a rich diversity of inland and coastal wetlands.

Kerala is well known for its wetlands. These wetlands provided livelihood to the residents in the area in the forms of agricultural produce, fish, fuel, fiber, fodder, and a host of other day-to-day necessities. As long as human intervention remained minimal, the ecosystem, through its all-encompassing balancing nature, was self-cleansing. But the development demands that determine the choice of the paths upset the natural harmony. Infrastructure development in the form of roads, railways, and other lines of communication fragmented the contiguity of the wetlands, and destroyed extensive tracts of coastal vegetation thereby upsetting the entire complex ecology; rapid

urbanisation encroached into the rich and luxuriant mangrove forests, while industrial development not only caused pollution but prevented any regeneration possibilities as well; modern shrimp farms brought in the final onslaught - the irreversible destruction of wetlands. Coastal Kerala with its high density of population cannot bear such onslaughts any longer. The degradation of the wetlands of Kerala is not an isolated event. Worldwide, wetlands are in peril. They are either being polluted, drained or filled up to give way for development. The rate of wetland loss has accelerated in recent years. Thus the wetlands are now the most threatened ecosystems of our planet.

This report is the result of a multidisciplinary study and analysis of the status of the wetlands of Kerala mainly based on the earlier studies and is presented in four sections. The section I gives an introduction to the wetlands with background, concept and definition, origin and classification, status of wetlands in India and Kerala, biodiversity, previous studies and institutional and legislative mechanisms. Section II describes the issues in conservation and sustainable management frame work for reporting of the wetlands of Kerala, using the DPSIR (Driving forces of environmental change, Pressures on the environment, State of the environment, Impacts on population, economy, ecosystems and Response of the society) framework. The status of five wetlands, three Ramsar sites, one national site and one manmade reservoir in the State is critically anlysed using the DPSIR framework, in the section III. The conclusions and recommendations of the study are given in section IV.

2.1.2 definition of wetlands

The Ramsar Convention (1971) defines wetlands as:

areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty including areas of marine water, the depth of which at low tide does not exceed 6 meters. It may also incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies of marine water deeper than 6 meters at low tide lying within the wetlands.

Cowardin et al (1979) define wetlands as "the lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water". This includes three attributes that help to delineate a wetland: (i) the area must be permanently or periodically inundated or water must be present for at least seven successive days during the growing season, (ii) the area must support hydrophytic vegetation and (iii) the substrate is predominantly hydric soils that are saturated or flooded for a sufficiently long period to become anaerobic in their upper layers. From the utilitarian point, wetlands can be defined as transitional areas between permanently flooded deepwater environm ents and well drained uplands

that contribute a wide array of biological, social and economic benefits (Watzin and Gozzelink, 1992).

2.1.3 Significance of wetlands

Wetland systems directly and indirectly support lakhs of people, providing goods and services to them. They help check floods, prevent coastal erosion and mitigate the effects of natural disasters like cyclones and tidal waves. They store water for long periods. Their capacity during heavy rainfall to retain excess floodwater that would otherwise cause flooding results in maintaining a constant flow regime downstream, preserving water quality and increasing biological productivity for both aquatic life as well as human communities of the region. Inundated wetlands are very effective in storing rainwater and are the primary source for recharging ground water aquifers.

The importance of wetlands was clearly demonstrated by 2004 Indian Ocean *Tsunami*. Wetlands may have provided a green barrier to protect coastli nes and the coastal comm unities that live there. There were localized and anecdotal

Box 2.1: Warblers and wetlands

(Editorial by the `The Hindu' -19-03-2007)

The rediscovery in Thailand of a bird believed to be extinct, the large-billed reed warbler, far away from the Sutlej Valley of Himachal Pradesh where it was first found 139 years ago, illustrates the incomplete nature of biodiversity knowledge. Almost a year ago, ornithologist Philip Round of Mahidol University recorded a single individual of the small wetland bird species in the Laem Phak Bia Environmental Research and Development Project area in Thailand. He published his exciting discovery recently after Staffan Bensch of Sweden's Lund University confirmed the bird's identity through DNA analysis. This warbler is genetically distinct from two similar birds, including the familiar Blyth's reed warbler. The rediscovery will set off a race among bird watchers and experts to find the group of large-billed reed warblers of which the Thai specimen is a part. Its range, believed to be somewhere between Thailand and Northwest India, presents an opportunity for Indian ornithologists to collaborate with those abroad and come up with critical data about the bird. Much work needs to be done on its distribution, preferred habitat vegetation, and behaviour. Moreover, the rediscovery of a long-lost bird during a routine study is a pointer to the need for more work in field biology in India. Only last year, nature lovers were elated when painstaking research by a professional astronomer, Ramana Athreya led to the confirmed recording in Arunachal Pradesh of a new babbler species, the *Bugun liocichla.*

The rediscovery of the warbler underscores the importance of wetlands as a biodiverse habitat. According to a comprehensive study by the Salim Ali Centre for Ornithology and Natural History, India lost about 38 per cent of its wetlands during the 1990s. In some districts, the loss is as high as 88 per cent. Wetlands, apart from providing many resources to local communities, act as flood buffers and afford water security. This newspaper has repeatedly editorialised on the need for greater recognition of the role of wetlands and stronger legislative protection. The current revenue classification of many wetlands as wasteland betrays poor understanding of their importance and encourages their use as garbage dumps.

Continuous monitoring of wetlands for spatial transformations and changes in water, vegetation, and biodiversity is essential for their long-term viability. Birds are a key marker of wetland health and this habitat is crucial for the survival of many migratory species that come as winter visitors to the sub-continent.

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reports from around the Indian Ocean region of how the dam aging impact of the *Tsunami* was reduced behind mangrove stands and coral reefs.

Many wading birds and waterfowl like egrets, herons and cranes nest in wetlands. Of the 78 endangered species of birds in India, 55 depend on wetlands (37 threatened species such as the Sarus crane and the spot-billed pelican and 18 near threatened species led by the lesser flamingo and the white ibis). Wetlands also provide food and shelter for mammals. They act as natural filters and help remove a wide range of pollutants from water, including harmful viruses from sewage and heavy metals from industries. Wetlands retain nutrients by storing eutrophic parameters like nitrogen and phosphorus and accumulating them in the sub-soil, thereby decreasing the potential for eutrophication.

Mangrove forests are valued for production of fish and shell-fish, live-stock fodder, fuel and building materials, local medicine, honey and bees-wax and for extracting chemicals used in tanning leather. Apart from that, they provide durable timber, fuel wood, and protein rich fodder for cattle, edible fruits, vegetables and traditional medicines.

The importance and usefulness of wetlands was first brought to the notice of the world through a Convention on Wetlands held at the Iranian city of Ramsar, in the year 1971. The Convention was an inter-governmental treaty that provided the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. As of 9th March 2007 there are 154 Contracting Parties to the Convention, with 1650 wetland sites, totaling 149.6 million hectares, designated for inclusion in the Ramsar list of Wetlands of International Importance.

2.1.4 Origin and classification of wetlands

Formation of wetland is a function of climate (precipitation, temperature, wind and insolation), hydrology (internal and external drainage), chemistry (water and soils), geomorphology (landform and soil parent material), and biology (fauna and flora). Wetland development is dynamic as different types of wetlands represent transitions from one type to another. As a result, wetlands often share characteristics of more than one wetland class, form, subform or type.

Three major factors characterise a wetland: water, substrate (physico-chemical features) and biota. Of the three factors that characterise wetlands, water has

special status because neither the characteristic substrates nor the characteristic biota of wetlands can develop in the absence of specific hydrologic conditions. Disturbance of the biota or substrate can produce a wetland in which the characteristic substrates or organisms are absent at least temporarily. In contrast, elimination of the characteristic hydrology of a wetland eliminates the wetland, even though the characteristic substrate and organisms can persist for sometime after the hydrologic change. Thus, when hydrology has been altered, the presence of organisms and substrate that are characteristic of wetlands is not necessarily indicative of wetlands.

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The Ramsar Bureau has coined a Ramsar Classification System for "Wetland Type" as approved by Recommendation 4.7 and amended by Resolution VI.5 of the Conference of the Contracting Parties (COP). The categories listed herein are intended to provide only a very broad framework to aid rapid identification of the main wetland habitats represented at each site.

I. Marine/Coastal

A - **Permanent shallow marine waters less than six meters deep at low tide;** include sea bays and straits.

B - **Marine sub tidal aquatic beds;** includes kelp beds, sea-grass beds, and tropical marine meadows.

C - **Coral reefs.**

D - **Rocky marine shores;** includes rocky offshore islands, sea cliffs.

E - **Sand, shingle or pebble shores;** includes sand bars, spits and sandy islets; includes dune systems.

F - **Estuarine waters;** permanent water of estuaries and estuarine systems of deltas.

G - Intertidal mud, sand or salt flats.

H - **Intertidal marshes;** includes salt marshes, salt meadows, salting, raised salt marshes; includes tidal brackish and freshwater marshes.

I - **Intertidal forested wetlands;** includes mangrove swamps, nipa swamps and tidal freshwater swamp forests.

J - **Coastal brackish/saline lagoons;** brackish to saline lagoons with at least one relatively narrow connection to the sea.

K - **Coastal freshwater lagoons;** includes freshwater delta lagoons.

Zk(a) **-** Karst and other subterranean hydrological systems**,** marine/coastal

II. Inland Wetlands

L - **Permanent inland deltas.**

M - **Permanent rivers/streams/creeks;** includes waterfalls.

N - **Seasonal/intermittent/irregular rivers/streams/creeks.**

O - **Permanent freshwater lakes (over 8 ha);** includes large oxbow lakes.

P - **Seasonal/intermittent freshwater lakes (over 8 ha);** includes floodplain lakes.

Q - **Permanent saline/brackish/alkaline lakes.**

R - **Seasonal/intermittent saline/brackish/alkaline lakes and flats.**

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Sp - **Permanent saline/brackish/alkaline marshes/pools.**

Ss - **Seasonal/intermittent saline/brackish/alkaline marshes/pools.**

Tp - **Permanent freshwater marshes/pools;** ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.

Ts - **Seasonal/intermittent freshwater marshes/pools on inorganic soil;** includes **sloughs, potholes, seasonally flooded meadows, sedge marshes.**

U - **Non-forested peat lands;** includes shrub or open bogs, swamps, fens.

Va - **Alpine wetlands;** includes alpine meadows, temporary waters from snowmelt.

Vt - **Tundra wetlands;** includes tundra pools, temporary waters from snowmelt.

W - **Shrub-dominated wetlands;** Shrub swamps, shrub-dominated freshwater marsh, shrub Carr, alder thicket; on inorganic soils.

Xf - **Freshwater, tree-dominated wetlands; includes freshwater swamp forest, seasonally flooded forest, wooded swamps;** on inorganic soils.

Xp - **Forested peat lands;** peat swamp forest.

Y - **Freshwater springs;** oases.

Zg - **Geothermal wetlands**

Zk(b) - **Karst and other subterranean hydrological systems; inland**

Note: "floodplain" is a broad term used to refer to one or more wetland types, which may include examples from the R, Ss, Ts, W, Xf, Xp, or other wetland types. Some examples of floodplain wetlands are seasonally inundated grassland (including natural wet meadows), shrub lands, woodlands and forest. Floodplain wetlands are not listed as a specific wetland type herein.

III. Man-made wetlands

1 - **Aquaculture ponds** (e.g., fish/shrimp)

2 - **Ponds; includes farm ponds, stock ponds, small tanks;** (generally below 8 ha).

3 - **Irrigated land; includes irrigation channels and rice fields.**

4 - **Seasonally flooded agricultural land.**

5 - **Salt exploitation sites;** salt pans, salines, etc.

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6 - **Water storage areas;** reservoirs/barrages/dams/impoundments (generally over 8 ha).

7 - **Excavations;** gravel/brick/clay pits; borrow pits, mining pools.

8 - **Wastewater treatment areas;** sewage farms, settling ponds, oxidation basins, etc.

9 - **Canals and drainage channels, ditches.**

Zk(c)- **Karst and other subterranean hydrological systems**; human-made

According to Ministry of Environment & Forests, Government of India, wetlands are broadly divided into Inland wetlands and Coastal wetlands and each class is further divided into different types.

Geomorphologically, the wetlands in Kerala may be divided among five major systems at the broadest level as marine, estuarine, riverine, and lacustrine and

palustrine. Due to the unique physical characteristics Kerala endows, like backwater systems and a diverse terrain of high land, midland and low land within a thin strip of landmass of about 38864 sq km, there exists much ambiguity in the classification of wetlands. Thus, major classes and types of wetlands are redefined keeping the MoEF classification system as the standard. Accordingly the following major wetland classification system is suggested by the detailed study on wetlands of Kerala by CED (2003a), and is given in table 2.1.

Table 2.1: Classification Scheme for Wetlands of Kerala (CED, 2003a)

Wetland classes	Wetland types
Inland Wetland	Fresh water lakes
	Fresh water swamps
	Reservoirs
	Large Ponds
Coastal Wetlands	Estuaries/ Backwaters
	Mangrove Forests
	Kol, Kuttanad and *Pokkali* wetland Systems
	Coastal Swamps
	Mud flat
	Aquaculture Pond
	Islets/*Thuruthu*

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Delineation of wetlands into the above said categories is mainly done on the basis of various parameters like location, physical extent, depth, salinity, bio-diversity etc.

2.1.5. Status of wetlands in India

The Ministry of Environment and Forests, Government of India (1990) estimated that different types of wetlands occupies 4.7 million ha, of which 1.5 million ha are natural, 2.6 million are man made and 0.6 million ha are Mangrove vegetation. The results of the nation wide wetland inventory (Garg et al., 1998) reveals that there are 27,403 wetland units in the country occupying 7.6 million ha, of which coastal Wetlands are 3959 units with 4.0 million ha, whereas inland wetlands are 23,444 units with 3.6 million ha. So far, India has designated 25 wetland sites as Ramsar sites of International Importance (table 2.2).

Table 2.2: Wetlands in India designated as Ramsar Sites (WI, 2007)

No.	Name	State	Date of Declaration
1.	**Ashtamudi Backwater**	**Kerala**	**19/08/02**
2.	Bhitarkanika Mangroves	Orissa	19/08/02
3.	Bhoj Wetland	Madhya Pradesh	19/08/02
4.	Chilka Lake	Orissa	01/10/81
5.	Deepor Beel	Assam	19/08/02
6.	East Calcutta Wetlands	West Bengal	19/08/02
7.	Harike Lake	Punjab	23/03/90
8.	Kanjli	Punjab	22/01/02
9.	Keoladeo National Park MR	Rajasthan	01/10/81
10.	Kolleru Lake	Andhra Pradesh	19/08/02
11.	Loktak lake MR	Manipur	23/03/90
12.	Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu	19/08/02
13.	Pong Dam Lake	Himachal Pradesh	19/08/02
14.	Ropar	Punjab	22/01/02
15.	Sambhar Lake	Rajasthan	23/03/90
16.	**Sasthamkotta Lake**	**Kerala**	**19/08/02**
17.	Tsomoriri	Jammu & Kashmir	19/08/02
18.	**Vembanad-Kol Backwater system**	**Kerala**	**19/08/02**
19.	Wular Lake	Jammu & Kashmir	23/03/90

20.	Upper Ganga*	Uttar Pradesh	08/11/05
21.	Surinsar-Mansar*	Jammu & Kashmir	08/11/05
22.	Hokera (Hokersar)*	Jammu & Kashmir	08/11/05
23.	Rudrasagar*	Tripura	08/11/05
24.	Renuka*	Himachal Pradesh	08/11/05
25.	Chandertal*	Himachal Pradesh	08/11/05

MR- sites under Montreaux Record.

· Wetlands identified as Ramsar sites during the CoP 09 meeting held at Uganda during 8-15 November, 2005.

The total area covered under the 25 sites is 6, 77,131 ha. These 25 wetland sites represent different habitats. Of these three Ramsar sites are in Kerala - Vembanad backwater and Kole lands, Ashtamudi backwater and Sasthamkotta fresh water Lake.

2.1.6 Wetlands of Kerala : Present scenario

In Kerala, despite its small land area of 38864 km^2 has about 590 km long coastline studded with world's best string of beaches. It is bestowed with a vast network of backwaters, lagoons, natural lakes, rivers and canals.

The State has two clearly distinct rainfall seasons i.e., south west monsoon and north east monsoon resulting in near water-logged conditions in almost 20% of the total geographic area of the State. Thus, as much as one fifth of its total landmass is wetlands. Nair *et al* (2001) reported a total of 217 wetland areas in Kerala (table

2.3), of which157 greater than 56.25 ha with an aerial extend of 127930 ha, in which 64 designated as "inland wetlands" (area 34199.5 ha), whereas 93 are "coastal wetlands (area 93730.5 ha).

Table 2.3: Area under wetlands of Kerala (Nair et al, 2001)

Wetlands	Area(ha)	% Area	No. of units
Inland wetlands			
Natural	2180.00	1.70	11
Man-made	32019.57	25.03	53
Total	34199.57	26.73	64
Coastal Wetlands			
Natural	85671.50	66.97	86
Man- made	8059.00	06.30	07
Total	93730.50	73.27	93
Grand Total	127930.07	100	157

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There are 32 major backwaters/estuaries in Kerala (table 2.4)

Table 2.4: Backwaters/ Estuaries of Kerala (CED, 2003a)

No	Name	District
1.	Koringote estuary	Kasaragode
2.	Nileswar backwater	Kasaragode
3.	Kava backwater	Kannur
4.	Dharmapatanam backwater	Kannur
5.	Mamayed estuary	Kannur
6.	Mahe estuary	Kannur
7.	Kattampally	Kannur
8.	Kotta backwater	Kozhikode
9.	Korapuzha estuary	Kozhikode
10	Payyoli backwater	Kozhikode
11	Elathur backwater	Kozhikode
12	Kallayi backwater	Kozhikode
13	Beypore estuary	Kozhikode
14	Kadalundi estuary	Kozhikode/Malappuram
15.	Conolly Canal	Kozhikode
16.	Puraparamba backwater	Malappuram
17.	Purathur / Ponnani estuary	Malappuram
18.	Chettuva backwater	Thrissur
19.	Azhekode estuary	Thrissur
20	Kodungallor backwater	Thrissur
21	Akathumuri lake	Thrissur
22	Cochin estuary	Ernakulam
23	Vembanad backwater	Kottayam & Alappuzha
24	Kayamkulam backwater	Alappuzha
25	Ashtamudi estuary	Kollam
26.	Paravoor backwater	Kollam
27.	Edava Nadayara backwater	Thiruvananthapuram
28.	Anchuthengu backwater	Thiruvananthapuram
29.	Kadinamkulam backwater	Thiruvananthapuram
30.	Veli lake	Thiruvananthapuram
31	Poonthura backwater	Thiruvananthapuram
32	Poovar backwater	Thiruvananthapuram

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Compared to coastal land, the highland and midland hold very few wetlands. There are 7 major freshwater lakes in Kerala, which have no direct connection with the Arabian Sea (table 2.5).

Table 2.5: Freshwater Lakes of Kerala (CED, 2003a)

No.	Name	District
1.	Pookode	Wayanad
2.	Muriyad	Thrissur
3.	Kattakambal	Thrissur
4.	Enammakkal	Thrissur
5.	Manakkodi	Idukki
6.	Sasthamkotta	Kollam
7.	Vellayani	Thiruvananthapuram

Manmade lakes and reservoirs created by constructing dams across various rivers in the Western Ghats contribute to a sizeable proportion of artificial wetlands of the State (table2.6).

Table 2.6: Reservoirs of Kerala

(Compiled from various sources, mainly from KSEB website, www.kseboard.com)

No	Reservoir	River Basin	District	Area (ha) - @ FRL
1.	Pazhassi	Valapattanam	Kannur	849
2.	Kuttiyadi	Kuttiyadi	Kozhikode	1052
3.	Malampuzha	Bharathapuzha	Palakkad	2313
4.	Mangalam	Bharathapuzha	Palakkad	393
5.	Meenkara	Bharathapuzha	Palakkad	259
6.	Chulliyar	Bharathapuzha	Palakkad	160
7.	Pothundi	Bharathapuzha	Palakkad	383
8.	Walayar	Bharathapuzha	Palakkad	260
9.	Parambikulam	Bharathapuzha	Palakkad	2092
10.	Thunakadavu	Bharathapuzha	Palakkad	288
11.	Kanjirapuzha	Bharathapuzha	Palakkad	512
12.	Peechi	Karuvannur	Thrissur	1289
13.	Chimmony	Karuvannur	Thrissur	1010
14.	Vazhani	Kechori	Thrissur	265
15.	Sholayar	Chalakkudi	Thrissur	970
16.	Peringalkuthu	Chalakkudi	Thrissur	268
17.	Pamba	Pamba	Idukki	570

18.	Kakki	Pamba	Idukki	1800
19.	Anathodu	Pamba	Idukki	1700
20.	Gavi	Pamba	Idukki	1000
21.	Idukki	Periyar	Idukki	5150
22.	Anayirankal	Periyar	Idukki	433
23.	Kundala	Periyar	Idukki	230
24.	Mattupetti	Periyar	Idukki	324
25.	Sengulam	Periyar	Idukki	33
26.	Periyar lake	Periyar	Idukki	2890
27.	Cheruthoni	Periyar	Idukki	1700
28.	Azhutha	Periyar	Idukki	*Not available*
29.	Ponmudi	Periyar	Idukki	260
30.	Kallarkutty	Periyar	Idukki	548
31.	Neriyamangalam	Periyar	Ernakulam	413
32.	Bhoothathankettu	Periyar	Ernakulam	508
33.	Idamalayar	Periyar	Ernakulam	2930
34.	Malankara	Muvattupuzha	Ernakulam	566
35.	Kallada	Kallada	Kollam	2590
36.	Neyyar	Neyyar	Thiruvananthapuram	1600
37.	Aruvikkara	Karamana	Thiruvananthapuram	256
38.	Peppara	Vamanapuram	Thiruvananthapuram	582
39.	Lower Meenmutty	Vamanapuram	Thiruvananthapuram	*Not available*

There are many other water resources such as ponds and tanks which is one of the specialties in Kerala. Each Panchayat/Urban local body has number of both public and private ponds and tanks, the details of which is given in table 2.7.

Table 2.7: Ponds, tanks and other small wetlands of Kerala

(Pan Fish book, 2002)

No.	District	Number of Ponds					
		Panchayat Ponds	Private ponds	Public Ponds	Quarry ponds	Irrigation tanks	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	18	47	23

7	Ernakulam	732	3450	296	164	72	204
8	Thrissur	984	5861	182	43	213	258
9	Palakkad	633	3070	242	134	81	314
10	Malappuram	555	3632	245	145	45	272
11	Wayanad	29	1489	01	16	81	03
12	Kozhikode	94	855	110	33	24	284
13	Kannur	292	626	470	25	35	301
14	Kasaragode	265	1858	88	11	145	148
TOTAL		**6820**	**35892**	**3357**	**904**	**838**	**2634**

By virtue of its unique location Kerala provides a wide variety of aquatic habitats, harbouring unique types of vegetation of their own. The most important among them are the Mangrove ecosystems which are very rich in species diversity. The important mangrove sites of Kerala are shown in table 2.8.

Table 2.8: Mangrove Ecosystems, Kerala (CED, 2003a)

No.	Mangrove Area	District
1.	Chittari	Kasaragode
2.	Dharmadom	Kannur
3.	Nadakkavu	Kannur
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	Kannur
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/Kumbalam	Ernakulam
23.	Kannamali	Ernakulam
24.	Puthuvypin	Ernakulam
25.	Aroor	Alapuzha
26.	Kumarakom	Kottayam
27.	Asramom	Kollam
28.	Veli	Thiruvananthapuram

The unique wetland ecosystems of Kerala (table 2.9) include marshy and waterlogged areas and vast Polders (paddy cultivating areas) associated with the backwaters and lakes (which also store the flood waters and storm waters) and the Myristica Swamps in the Western Ghat forests. About 53 patches of Myristica swamps have been recorded from the Kulathupuzha, Anchal forest ranges and Shendurny Wildlife Sanctuary of the Kollam and Thiruvananthapuram districts of Southern Kerala.

Table 2.8: Unique Wetland Ecosystems of Kerala (CED, 2003a)

No.	Ecosystem	District
1.	*Kuttanad Paddy fields*	Alappuzha
2.	*Pokkali Lands*	Ernakulam
3.	*Kol Lands*	Thrissur
4.	*Kaipad lands*	Kannur
5.	*Myristica Swamps*	Kollam/ Thiruvananthapuram

Wetlands of international/national importance in Kerala:

Vembanad-kol, Ashtamudi and Samsthamkotta, are the three designated Ramsar sites of Kerala. In addition to this, two more wetlands - Kottuli in Kozhikode District and Kadalundi in Kozhikode and Malappuram Districts - have been identified by the Ministry of Environment and Forests, Government of India, under National Wetland Conservation Programme. The Ministry, in 2004, had approved a

programme to prepare Management Action Plan for Kottuli Wetland. 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.

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2.1.7. Institutional Structure, Policies and Legislation

At the International level, Wetlands International is providing necessary institutional support to various wetland conservation activities in different countries. It is an independent, non-profit, global organization, supported by Government membership from all continents of the world, extensive specialist networks and volunteers. It currently works through 15 country offices — in Central and Eastern Europe, Africa, South, East and North Asia, Oceania and South America; with its head office in Wageningen, the Netherlands. Wetlands International has adopted the following four long-term, strategic global goals to provide direction to its future work.

i) Stakeholders and decision makers are well informed about the status and trends of wetlands, their biodiversity and priorities for action,

ii) The functions and values of wetlands are recognized and integrated into sustainable development,

iii) Conservation and sustainable use of wetlands is achieved through integrated water resource management and coastal zone management, and

iv) Large scale, strategic initiatives result in improved conservation status of species, habitats and ecological networks

The MOEF, GOI is the apex body at the national level to co-ordinate the activities related to Wetland Management in the country. At State level, the Department of Environment and Forests or Department of Science and Technology is in charge of the wetland management activities in the respective States. Realising the importance of wetlands and developing an inter-sectoral framework for conservation of wetlands, a National Committee on Wetlands was constituted. State Steering Committees have been constituted in all the concerned States under the chairmanship of Chief Secretary having members from various subject matter departments relating to wetland conservation in the State.

They also include NGOs, academicians and representatives of stakeholders, including member from the Ministry. This model has worked out very well as all conflicts within various departments concerning wetland issues are resolved under the chairmanship of the Chief Secretary of concerned State Government. Under the National Wetland Conservation Programme, 94 sites have been identified for

conservation in the country, 49 being recently added to the conservation list including 35 mangroves, 4 coral areas and 10 urban lakes. Identification of these wetland sites is based on Ramsar criteria which include aspects of waterfowl population, dominance of various plant/animal species, biodiversity values, cultural aspects, religious and sacred sanctities, socio-economic aspects, sustainable fisheries, traditional knowledge and other such issues. Furthermore, in the proposed National Wetland Strategy, a great deal of

emphasis has been given to the significance of wetlands for water supply, coastal protection, and food security and livelihood improvements of the wetland dependent people.

A number of R&D organizations in the State are involved in the study of various aspects of wetlands. Interestingly the different wetland units are under the administrative control of different departments and agencies in the State. The Kerala Forests and Wild Life Department is in charge of the mangrove areas and the fresh water lakes, backwater areas, reservoirs, etc., are under the administrative control of Water Resources Department. The Science and Technology Department is co-coordinating the Coastal Regulation Zone activities which also includes the mangrove areas.

The Ramsar Convention is a historical Convention in many respects particularly, as it is one of the oldest ecosystem specific Conventions that speaks of wise use of wetlands and not conservation alone. India is also a signatory to the Ramsar Convention. As a part of the conservation strategy a data book called Montreaux Record is kept of all those wetlands that require international help for conservation. The inclusion of a site in this list makes it eligible for a global package for conservation related activities. It also enjoins the Parties to the Convention to formulate and implement their planning so as to promote the conservation of listed wetlands and as far as possible, the wise use of wetlands in their territory (Art 3.1). The review of legal and institutional issues related to wise use of wetlands is mandated further by the Additional Guidance for the implementation of the wise use concept (I-2 of the Additional Guidance).

The major legislations in India related to wetlands are:

i) The Indian Forest Act,1927

ii) The Indian Fisheries Act, 1897 as amended by Indian Fisheries (Madras Amendment) Act, 1927.

iii) The Port Trust Act, 1963

iv) The Wildlife Protection Act (WPA), 1972

v) The Water (Prevention and Control of Pollution) Act, 1974

vi) The Water Cess Act, 1977

vii) The Air (Prevention and Control of Pollution) Act, 1981

viii) The Forest (Conservation) Act, 1980

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Box 2.2: Criteria for identifying wetlands of international importance

Group A of the Criteria (Sites containing representative, rare or unique wetland types)

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Group B of the Criteria. (Sites of international importance for conserving biological diversity)

Criteria based on species and ecological communities

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Specific criteria based on waterbirds

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Specific criteria based on fish

Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Specific criteria based on other taxa

Criterion 9: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Adopted by the 7th (1999) and 9th (2005) Meetings of the Conference of the Contracting Parties, superseding earlier Criteria adopted by the 4th and 6th Meetings of the COP (1990 and 1996), to guide implementation of Article 2.1 on designation of Ramsar sites.

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ix) The Environment Protection Act, 1986

x) The Coastal Regulation Zone Notification,1991

xi) The Environmental Impact Assessment Notification, 1994

xii) The Municipal Solid Wastes (Management and Handling) Rules, 2000

xiii) The Biodiversity Act, 2002

xiv) The Coastal Aquaculture Authority Bill, 2004

The Environment (Protection) Act, 1986, is an umbrella Act, which was enacted with the objective of protecting and improving the environment and for matters connected therewith. `Environment' as defined in Section 2 of the Environment (Protection) Act included water, air and land and the interrelationship which exists between water, air and land and human beings and other living creatures, plants and micro-organisms and property. This Act has been instrumental in protecting wetlands and groups of wetlands. Several significant regulations and notifications have been passed under this broad Act for monitoring pollution and safeguarding the environment. The Coastal Regulation Zone Notification, 1991 which in fact imposes restrictions on industries, operations and processes in the coastal zone

areas (500 meters from the High Tide Line and the area between the High Tide Line and the Low Tide Line) has been issued under this Act. The Environment Impact Assessment Notification of 1994 was also issued under this Act. Section 3 of the Environment (Protection) Act deals with the power of the Central Government to take measures to protect and improve the environment. The section reads as follows:

Section 3 (1) Subject to the provisions of this Act, the Central Government shall have the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. Such measures may include:

Section 3 (v) restrictions of areas in which industries, operations and processes or class of industries, operations or processes shall not be carried out or carried out subject to certain safeguards.

There are four key policies relating to environmental protection in India. They are:

· The National Forest Policy, 1988

· The Policy statement for Abatement of Pollution, 1992

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· The National Conservation Strategy and Policy Statement on Environment and Development, 1992

· The National Environment Policy, 2006

There are also provisions in the Indian Penal Code for environmental protection. The Indian Penal Code has a chapter on offences affecting Public Health, Safety, Convenience (Chapter XIV). Sec. 268 provides that "a person is guilty of a public nuisance who does any act or is guilty of an illegal omission which causes any common injury, danger or annoyance to the public or to the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger, or annoyance to persons who may have occasion to use any public right." The section further explains that a common nuisance is not excusable on the ground that it causes some convenience or advantage. Other concerned provisions are: a "negligent act likely to spread infection or disease dangerous to life" (Sec. 269 I.P.C.), a "malignant act likely to spread infection or disease dangerous to life" (Sec. 270 I.P.C.), "making atmosphere noxious to health" (Sec. 278 I.P.C.).

Various acts, rules and regulations that have been passed by the State of Kerala regarding the governance of the water resources. Important ones among them are:

i) The Travancore Cochin Public Health Act, 1955.

ii) The Travancore _ Cochin Irrigation Act, 1956

iii) The Travancore - Cochin Fisheries Act, 1956.

iv) The Kerala Land Reforms Act, 1963

v) The Kerala Land Utilization Order, 1967

vi) The Kerala Panchayat Raj Act, 1994

vii) The Dam Safety Act-2000

viii) The Kerala Ground Water (Control and Regulation) Act, 2002

ix) The Kerala Protection of River Banks and Regulation of Removal of Sand Rules, 2002

x) The Kerala Irrigation and Water Conservation Act 2003

xi) The Kerala WaterPolicy (draft), 2007.

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2.2 MAJOR MANAGEMENT ISSUES

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, especially in the tropics, at an alarming rate of around one percent per year. 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's assimilative capacity is now increasingly resulting in various kinds of pollution in the wetland system of Kerala. 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 major issues identified for the wetlands of Kerala are analysed here using the DPSIR framework of reporting (Fig. 2.2).

2.2.1 Driving Forces

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/households 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.

2.2.1.1 Population/household growth and urbanization

The human settlements were traditionally concentrated around the wetland systems and the reasons for this are obvious. According to the census data (2001), the population in Kerala doubled over five times in the last century (6 million in 1901 to 32 million in 2001) whereas India's population could grow slightly more than three times (238 million in 1901 to 1027 million in 2001). However, the trend has changed now

and Kerala has registered the lowest growth rate during 1991-2001 among 35 States and Union Territories in India. The population growth rate in Kerala during the last decade works out to be 9.42 per cent (for the whole India it is 21.34%), the lowest after the formation of Kerala State.

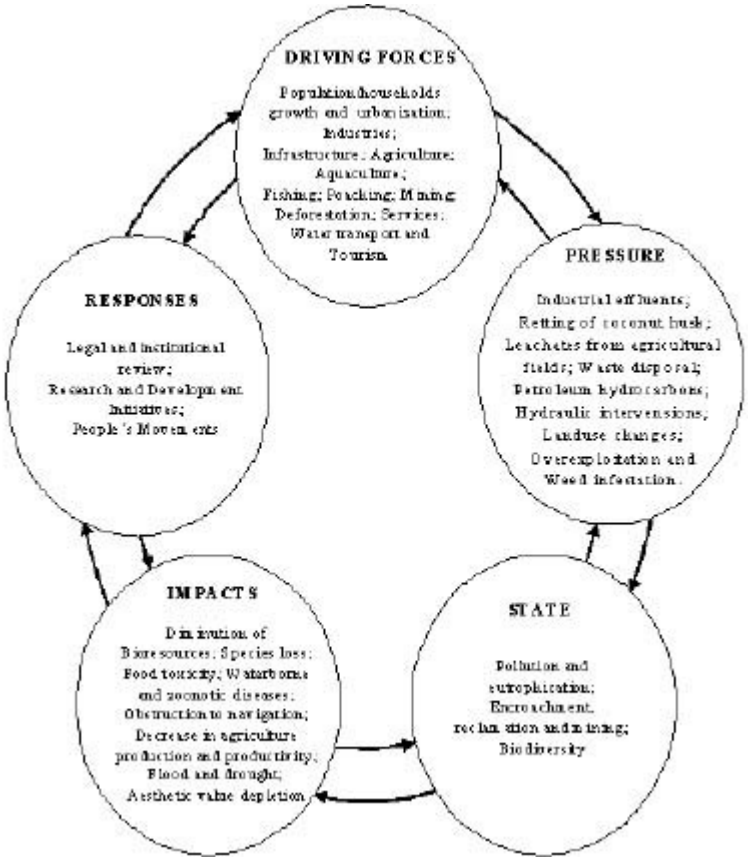

Fig. 2.2 : DPSIR framework for wetlands of Kerala

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The present trend in Kerala is a shift from joint family to nuclear families resulting in increase in households. According to the census data, the number of households in Kerala has increased from 55 lakh in 1991 to 67 lakh in 2001. The average size of households in the State has declined from 5.3 persons to 4.7 persons during this period.

Rapid urbanisation and the consequent development of infrastructure have taken a heavy toll to the wetlands. The urban sector in Kerala comprise of five Municipal Corporations and 53 Municipalities. Unlike the other parts of the country, the urbanization in Kerala is not limited to the designated cities and towns. Barring a few Panchayats in the hilltracts and a few isolated areas here and there, the entire State depicts the picture of an urban- rural continuum. Given the level of modern activities, a good number of people engaged in traditional activities found them being gradually marginalized from the mainstreams of the economy. This has created a lot of livelihood insecurities and led to large-scale migration of people into cities and towns in search of different kinds of jobs. According to 2001 census, 25.97% of the population lives in urban areas. During 1981, it was 18.74%. Interestingly, most of these urban areas are lying adjacent to major wetland systems. All Municipal Corporations except Thrissur are very close to the

important wetland systems of the State.

The increase in population and households and urban expansion thus becomes major driving forces for most of the wetland issues identified. The urban expansion requires more wetland areas to be converted resulting to ecosystem changes and biodiversity loss. The household activities harmful to the wetlands include more waste generation and disposal to the wetland system, direct/indirect defecation, small scale encroachment and reclamation, mining and destruction of biodiversity.

Fig. 2.3 Wetland reclamation for housing

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2.2.1.2 Industrial development

Industrialization, in the past century was considered as the major activity for solving the unemployment problem in the State. For promoting industries, exemptions were given, especially in environmental management related activities. Thus, many small, medium and large modern industries emerged on the banks of the backwaters and rivers and they dump their wastes into the waterbed in an attempt to save the costs of pollution abatement. A good number of large, small and cottage industries are now located near the wetlands and drainage basins of Kerala. The Aluva _ Kalamassery belt is one of the major industrial area of Kerala located adjacent to Vembanad wetlands. The major industries adjacent to the wetlands include various chemical industries, paper, Aluminium, refinery, ceramic, spinning mills, match factories, cashew processing, milk pasteurization, etc. Coir units are the main small scale industry in the coastal belt. In addition there are many small scale units like fish processing, food processing, motor and welding workshops, etc., functioning adjacent to many of the wetlands.

2.2.1.3. Infrastructure development

The infrastructure development activities are in full swing in Kerala in the areas adjacent to the major wetlands and drainage basins, for many years. The major activities include construction of roads, bridges, dams, railway lines, air ports, harbours and ports, landing centres for water transport, commercial and residential buildings etc. The construction activities are the need of the day, but what is lacking is proper development planning and environmental monitoring in almost

all the cases. Most of the activities create some kind of interventions in the system causing degradation.

2.2.1.4. Agriculture

Agriculture expansion accompanied by intensive use of agrochemicals has become a major driving force for wetlands causing encroachment, reclamation, pollution, eutrophication, and biodiversity loss. Paddy cultivation is prevalent in the low land areas like Kuttanad, *Kole*, *Pokkali* and *Kaipad* lands. Mixed cultivation with coconut as main crop is also predominant in many wetland areas. Vegetable cultivation is also common in summer season in many parts of the reservoirs and river banks. The catchment areas of most of the wetlands are cultivated mainly with rubber, coconut, pepper, tapioca, plantain, mixed vegetables, etc.

2.2.1.5. Aquaculture

Like agriculture, aquaculture has also various dimensions and scales of operation in the wetlands of Kerala and has become a driving force for pollution, eutrophication, Encroachment, and Biodiversity loss. Most of the aquaculture farms are using commercially available organic and inorganic feeds and are using artificial techniques for filtration. In earlier days rice cultivation and shrimp farming (`*Chemmeen kettu'*)

were done alternately in the same areas, during the natural infiltration periods. Recent developments in the field of aquaculture, especially culture of high valued species like shrimp has brought aquaculture under the focus of attention of the people in general and the entrepreneurs and exporters in particular. Aquaculture is also practiced in many of the inland wetlands, like ponds, reservoirs, etc. This includes integrated fish culture in reservoirs and larger ponds and culture of Tilapia, Catfish, Ptunis, etc., in family ponds.

2.2.1.6 Fishing

Backwater fishing is one of the major economic activities of the rural coastal communities. In the inland wetlands, fishing is mainly an alternate income generation activity. The current level of inland (including backwaters and estuaries) fish production of Kerala is to the quantum of about 75000 tones/year (www.kerala.gov.in/dept_fisheries/dept_fisheries.htm). The population engaged in this sector in Kerala is currently 2, 51,482 of which 41,223 are active fishermen. Overexploitation of the fishery resources is a major threat to the wetlands now.

Fig. 2.4: Brahminy Kite - found killed in a wetland

Photo courtsy: Nameer P.O. (KAU)

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2.2.1.7 Poaching

Intensive poaching of water birds, including migratory birds for food is one of the major threats to the birds of wetlands. Poaching is carried out using shotguns and poison.

2.2.1.8.Mining

The state of Kerala is blessed with large deposits of black sands (containing ilmenite, monazite, rutile and zircon) glass sands (pure silica) , clays, bauxite, iron-ore, lime stone, graphite, lime shell (raw material for white cement) and river sand (construction material). The occurrence of these deposits are controlled by specific geological formations consisting of crystalline rocks including charnockite, khondalite and the Sargur group; sedimentary rocks of Tertiary age, laterite cappings on crystallines and sedimentaries, and subrecent to recent sediments. Even though all the above deposits are available, the mining activities are restricted to black sand, glass sand, clays, laterites, lime shell and river sand.

Fig. 2.5: Sand Mining

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In order to meet the demand from the construction sector, indiscriminate mining of sand from the river basins, estuaries and even paddy fields are practiced in almost all areas. The Licenses for sand and shell mining are given by the Local Self Government Institutions in almost all river basins. Mining will not be a major issue, if we adopt a scientific method of exploitation of resources.

Another major mining activity in the coatal wetlands is for the collection of lime shell for industrial purposes. The traditional lime shell mining has little effect to the wetlands. But recently, the industrial sector has started in-depth (upto 7 m) lime shell mining in Vembanad Lake using mechanical devises which is an emerging threat to the system.

2.2.1.9 Deforestation

Due to various pressures and continuous onslaught, the extent of forests dwindled during the 19th and 20th centuries. In 1905, forests covered 65 percent of Kerala. An estimate on the changes in forest cover in the southern part of the Western Ghats using satellite data, between 1973 and 1995 by Jha et al (2000) showed a loss of 25.6% in forest cover over 22 years. The dense forest was reduced by 19.5% and open forest decreased by 33.2%. As a consequence, degraded forest increased by 26.64%. According to official sources, the State's forest accounted for 27.83 percent of its land area (GOK, 2006). The vanishing forests cover in the watershed of the rivers leading to soil erosion and subsequent siltation and eutrophication problems in the wetlands.

2.2.1.10 Services

The activities related to services comprise water supply, sanitation, irrigation, electricity, etc. Most of these activities require interventions in the wetland system in various ways, causing threat to the system

2.2.1.11 Water transport

The water transport system is intended for providing facilities for transport and cargo transportation at cheaper rates to the people residing in the water logged areas and is provided mainly by the State Water Transport Department (SWTD). There are also some private operators in this field. Mechanized boats are mostly used for the purpose. The inland water transport system in Kerala consists of 1895 kms of waterways. This includes navigable river, backwaters and man- made cross canals.

2.2.1.12. Tourism

The national and international leisure industry has introduced many measures to promote tourism related activities in the wetlands. Wetland tourism is now progressing

in Kerala concentrating the backwaters, reservoirs, lakes and major ponds. The main attractions in almost all the cases are house boats, majority of them are mechanised. The unimpeded tourism activities contribute to the increased pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss in the wetlands.

2.2.2 pressures

The outputs from various activities in the land and water exert heavy pressures on the system and become threats to the sustainability of the system. The major pressures identified are from (i) industrial effluents (ii) retting of coconut husk (iii) leachates from agricultural fields (iv) waste disposal (v) petroleum hydrocarbons (vi) landuse changes (vii) hydraulic intervensions (viii) overexploitation of resources and (ix) weed infestation.

2.2.2.1. Industrial effluents

The effluents from the industries situated on the banks of the rivers and wetlands are the main sources of chemical pollution of wetlands of Kerala. These effluents contain a large number of toxic ingredients such as acids, alkali, heavy metals, suspended solids and a number of other chemicals, which have immediate and long-term effects on the organisms. Several estuarine and river systems in Kerala are now hot spots of heavy metallic pollution. Depending on the natural and

anthropogenic inputs in an area, the association of heavy metals varies with different fractions of the sediments.

2.2.2.2. Retting of coconut husk

Coconut husk retting, a widespread activity causing organic pollution of the wetlands of Kerala, results in release of, large quantities of organic substances like pectin, petosan, fat and tannin are liberated into the water by the activity of bacteria and fungi. The decomposition of pectin results in the production of hydrogen sulphides - the basis of the nauseating smell in and around retting zones. High organic content (6-13%), high BOD (5,137 mg/1), low oxygen (0.05 ml/l) and high sulphide (4.97 mg/1) characteristic of retting zones are found to be devastating for the bottom fauna.

Fig. 2.6: Coconut husk retting

2.2.2.3. Leachates from agricultural fields

Wetlands, usually found adjacent to paddy fields and there is great likelihood that human habitations develop in adjacency to these wetland ecosystems. The present intensive agriculture practices are using large quantity of both inorganic and organic fertilizers and pesticides. The fertilizers and pesticides being applied in the paddy fields and home gardens, ultimately reach the wetlands during rainfall and floods. The intensive aquaculture farms also using commercially available feeds, the excess quantity of which is reaching the wetland system causing eutrophication problems.

2.2.2.4 Waste disposal

Municipal solid waste and sewage are the major pollutants of almost all wetlands in the State, and are the main sources of pathogens in the system. There is no sewerage system in any of the cities and towns in Kerala, except for a partial system in Thiruvananthapuram City, where there is no proper sewage treatment plant. So ultimately, the waste reaches the Parvathy Puthanar, a river running along the western edge of the City. The urban wastes include hospital wastes, market and slaughter house wastes and sewage and wastes generated from other commercial and residential areas including overflow from latrines. It also contains large quantities of non-degradable solid wastes, mainly plastic bags and containers. There is no proper hospital waste management system for most of the major hospitals, including the government medical colleges.

Fig. 2.7: Municipal solid waste in wetlands

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The people living near the wetlands in the rural stretches are also depositing the household wastes into the system. Hanging latrines (with outlet directly to water body) are common scene in the banks of most of the wetlands. According to an estimate the latrines of about 60 per cent of houses near to the wetland areas and canals are directly or indirectly opening into the wetlands. There is no proper slaughter house waste management practices in most of the cities and rural areas. The present practice is to dump the wastes in the sides of wetlands or rivers during night. The infrastructure development activities in the State along the sides of the wetlands generate a huge quantity of debris which consists of organic and inorganic materials and toxic compounds like cement, clay, wood, oil grease, paints, insect repellent substances, etc. A good quantity of these, are dumping directly into the wetlands. The tourism activities in the wetlands generate large amount of wastes both in the land and water. The wastes generated in the houseboats are directly reaching into the system.

2.2.2.5 Petroleum hydrocarbon

The wetland ecosystem in Kerala is also threatened by petroleum hydrocarbon (PHC) pollution. Numerous oil tankers and other vessels plying through the waters are major sources of pollution. The input of PHC to the aquatic system is purely of anthropogenic nature. It is found mostly in the form of unburned fuel and oil and the tarry nature of these residues adheres to the respiratory system of aquatic organisms. The oil spread as film over the water in Akkulam-Veli Lake system inhibits free exchange of oxygen with atmosphere and light penetration resulting in impairment of primary production. Oil and grease spills from the boats used for water transport, fishing and tourism are other sources for PHC pollution. Wash out from the motor workshops, bus stands, boat building yards, etc., situated on the outer reaches of the wetlands and the construction wastes are also sources of PHC pollution.

2.2.2.6 Land use changes

The wetlands are currently subjected to acute pressure of rapid developmental activities. Most of the government sponsored projects especially in urban areas are finding space in wetland areas for which large scale reclamation is going on. Unauthorized encroachment of wetland areas for non-wetland purposes are still continuing in the State especially areas adjacent to low land paddy fields, mangrove areas and other backwater areas. Initially most of the encroachments are for agriculture purposes; later these areas were reclaimed and used for various other purposes.

The unscientific land use and agricultural practices along with forest clearing in uplands and in wetland areas exert major pressure on wetlands leading to soil erosion. This causes siltation leading to vertical shrinkage and related problems like salinity

intrusion, ecosystem change and biodiversity loss. The eroded soil contain large amount of nutrients which causes eutrophication. Utilization of low lands for purposes other than the originally envisaged, like paddy lands for vegetable cultivation, aquaculture, etc., are common practice in many places, which lead to the change in the ecosystem

Reclamation of the private owned low land areas for construction purposes, for industries, etc., are common activities in many places. In addition to this, some areas are excavated for clay and soil for making country bricks. The wetland loss due to various anthropogenic activities has been responsible for bringing to the verge of extinction of countless species of medicinal and economically important plants and animals.

2.2.2.7. Hydraulic interventions

Most of the hydraulic interventions in the rivers and wetlands are for providing the basic needs of the people like drinking water, electricity and for providing suitable condition for agriculture and fisheries. These create changes in ecosystem and related issues.

Box 2.3: Hydraulic Interventions in Vembanad

Wetland system

One can identify roughly four hydraulic _ hydrologic interventions within the entire Vembanad wetland system. The first and the oldest was the reclamation and creation of the Wellington Island and the Shipping channel maintained near the Kochi mouth., Then came the major reclamation and bunding works in the Kuttanad area for improving agriculture in the area. This started about a century ago and came virtually to a halt four or five decades ago. The third intervention was the construction of the Thottapally spillway (1955) to divert floodwaters of Achankovil, Pamba, Manimala and Meenachil directly to the sea. The last intervention was the Thanneermukkom barrier (1975) built to prevent salinity ingress into the Kuttanad agricultural area during summer. All the above interventions, except the first significantly altered the original flow pattern, salinity ingress, pollution dispersion and other characteristics, turned out to be insufficient, requiring for the flood prevention works. The capacity of the Thottappally Spillway especially that of the leading channel, turned out to be insufficient, requiring for the flood prevention works. As for the Thanneermukkom barrier, although only 2/3rd of the originally designed numbers of gates were constructed, yet this structure has fulfilled its envisaged function. The barrier has, however led to social conflicts, especially between the fishermen above the barrier and the Kuttanad farmer, since brackish water fish such as prawns have disappeared

upstream of the structure. In addition, the barrier has reduced the flushing of pollutants and also increased pollution in the stagnant waters upstream, including infestation with weeds.

2.2.2.8. Overexploitation of resources

The unsustainable commercial exploitation of wetland resources exerts major pressure on the system. The present practices in the fisheries sector have adverse effect to the system like blocking the migratory pathways of fish and other organisms, destruction of fish larvae, poisoning wetlands during capturing, etc. Even small sized fishes were also caught for using as cattle feed.

Sand mining and mining of other resources like lime shell are carried out without any studies or taking in to consideration the sustainability aspects. In addition to the licensed mining, there are a lot of people engaged in illegal sand mining activities in the wetlands and rivers.

Fig. 2.10: Aquatic weeds

2.2.2.9 Weed infestation

Increased trade and commercial activity has brought with it, a large number of aquatic weeds, into this area. The excessive growth of weeds like *Salvinia molesta, Eichhornia crassipes* and *Damasonium flavum,* etc., exerts great pressure on the biodiversity of wetlands. The alien weeds have found great competitive advantage over the native aquatics.

2.2.3 State of Environment

2.2.3.1 Pollution and eutrophication

Most of the pollution sources are man made and include industrial effluents, sewage and faecal disposal, pesticides and chemical fertilisers, retting of coconut husks, slaughter house waste, domestic waste, etc.

· The pollution of wetland ecosystem in the State is considerably high especially in Vembanad-Kol backwater system due to the various types of pollution in the upstream area of Pamba, Achenkovil and Periyar rivers which ultimately drain in to Vembanad-Kol backwater system as well as various anthropogenic activities in the proximity of the backwater. The low water level in the summer months in these rivers also lead to salinity intrusion in to the river water which makes the river water unsuitable for drinking and other uses like irrigation. The same situation prevails also in many other wetlands in the State.

· The concentration of total metal content varies with location and sediment texture. It also shows seasonal variation. The concentration of Hg, Pb, Zn, Cr and Cd are found to be high in fine-grained sediments and low in sandy sediments. The estuarine region also exhibit high organic carbon content, especially at the point of effluent discharge. In general, the highest concentration of heavy metals in sediments was observed during pre-monsoon. During the monsoon season, the sediment exchange, a part of the exchangeable phase of the metals, to the water column due to high influx from the rivers. The high metal concentrations observed in Kochi harbour area during the pre-monsoon season are also attributable to the intrusion of high saline waters and precipitation of particulate matter. The heavy metal pollution has a long-term impact, which is evident from Beypore estuary, where considerable amounts of mercury has been found retained in the sediments even after the stoppage of industrial effluent discharge.

· Analysis of particulate metal content indicates high concentration of Zn, Cr, etc., due to industrial pollution in Kochi region of the backwater system. The benthic organisms such as mussels and oysters are found to have high accumulation of zinc beyond the permissible limits. High concentrations of Zn, Cu, and Fe were also observed in the backwater oyster, *Crassostrea madrasensis* (Preston) from Kochi region. The distribution of trace metals (Cd, Cu, Fe, Mn, Zn and Hg) in *Crassostrea* of Kochi region was found to exhibit seasonal variation. The oyster is found to be a suitable indicator organism for metal pollution in backwaters.

· The pathogen limit in many of the wetland systems in the State seem to be on the higher side, compared to the standards. These create a situation of drinking water scarcity in many of the places where people are mainly depending on wetlands for their drinking water needs.

Fig. 2.11: Eichhornia crassipes

· Many of the lake systems of Kerala are facing serious environmental problems due to intense weed growth resulting from high degree of eutrophication. Due to excessive eutrophication and the resultant weed growth, the Akkulam-Veli backwater system is in the verge of total degradation. Other backwater systems especially parts of Vembanad, Ashtamudi, etc., are also affected by excessive weed growth. Aquatic weeds are characterized by spontaneous growth and appearing without being sown or cultivated and also have high reproductive capacity.

Fig. 2.12: Eutrophication process

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· At present the prolific growth of two species of aquatic weeds, viz. *Eichhornia crassipes* (Water Hyacinth) and *Salvinia molesta* (African Payal) has created serious environmental problems in many wetland ecosystems of the State. In fact, the prolific growth of Water Hyacinth has grown to the level of a difficult managerial problem in backwaters. In most cases, upstream wetlands are acting as a `nursery - cum - store-house' of this perennial weed, posing constant threat to the native flora. Flash floods bring in `mats' of this aquatic weed, masking the entire water body for days together. This prevents capture of sunlight by the submerged

plants for photosynthesis and hence even lead to their total elimination. As a result, the common submerged and floating aquatic plants, which are part of the local ecosystem, are gradually replaced by water hyacinth. Plants facing threat and total elimination under this category include *Nymphaea, Nymphoides*, and *Vallisneria*.

Fig. 2.13 Nymphoides indica

· The aquatic plants and animal species are affected due to eutrophication causing either their elimination or species change. The increased growth of aquatic weeds, pollution of water, etc., has been obstructing the growth of other aquatic plants and animals hindering the resource conservation.

2.2.3.2 Encroachment, reclamation and mining

· Wetlands under extreme threat are more in Kerala than in any other State. Studies carried out in recent years have pointed out the unfavorable changes taking place in the physical, chemical, biological and geological environment of the wetlands. Segmentation of wetland by constructing bunds, dredging, reclamation and consequent shrinking have been implicated as major reasons

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Box 2.4: Kuttanad, the Rice bowl of Kerala

The Kuttanad landscape comprises around 1100 km^2 of which about 304 km^2 lies below sea level. The land, which is presently inhabited by human population, is developed by reclaiming the waterlogged areas over the years. Kuttanad is drained by a network of rivers and man-made channels. The main feature of the drainage system is the Vembanad Lake that was formerly a large lagoon. The tidal flow into this lake is controlled by a regulator at Thaneermukkom. This network of canals and bunds throughout its entire extent gave it the sobriquet *Holland of Kerala*.

The landform of Kuttanad comprises of *Kayalnilangal, Karinilangal and Karappadangal. Kayalnilangal* comes to around 8,100 hectares while *Karinilangal* around 6,075 ha and *Karappadangal* around 42,505 hectares. *Kayalnilangal* is below the sea level. Though the soil is acidic, if the saline

intrusion is prevented, the area can be utilised for paddy cultivation twice in a year. Karinilangal is waterlogged and due to the presence of high acidity, this contributes only very little to the cultivable land. *Karappadam* is the land, which has been reclaimed over the years. North Kuttanad, mid Kuttanad, upper Kuttanad and Kuttanad comprises the *Karappadams*. This is comparatively fertile and is less affected by saline water intrusion. North Kuttanad is prevented from salt intrusion by the Thaneermukkom Regulator.

The water inflow of Kuttanad is mainly controlled by four river systems originating from the Western Ghats region viz., Meenachil, Manimala, Pamba and Achenkovil, which ultimately drain into Kuttanad. Hydroelectric and irrigation projects in these rivers determine the water flow to the Kuttanad. The human interventions and resulting land use changes in the upstream of these rivers cause serious consequences in the ecological conditions of the downstream areas.

The total basin area of these four rivers comes to around 5838 km^2. The floodwaters enter Kuttanad from the upstream catchments during the monsoon period. The floodwater from these rivers carries considerable sediment load that spreads out on the lowland. During high floods water overflows bunds over to the roads and homesteads and cause serious havoc.

Farmming is the main occupation of the people of Kuttanad. Paddy cultivation predominates in the low land. Coconut palms are planted on bunds and reclaimed lands. The extent of coconut cultivation is increasing. Pepper, banana and yarms are also cultivated in certain areas. The reclamation of land for habitation and raising homestead cultivation has reduced the available area for floodwater storage, which results in the rise of flood levels.

The problem of Kuttanad is mainly attributed to the mismanagement of its hydrological regime. When the development was under way, hydrological aspects were not given due consideration which finally resulted in its present ecological crisis.

The area suffers regularly from:

· Flooding and salt-water intrusion which limit the growing season to a few months

· Lack of drinking water in the dry season because of salinity intrusion, various types of pollution etc.

· Lack of dry land to build settlements, leading to very high population densities on the reclaimed bunds

· Poor road network because of the number of criss-crossing water courses, leading to a dependence on water transport

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for the habitat destruction and dwindling of resources.

· Erstwhile Government of Travancore encouraged the farmers to reclaim Vembanad backwater in the Kuttanad region for paddy cultivation. In the initial stages of these reclamations, according to an estimate in 1834, Vembanad backwater had a total area of nearly 36500 ha. (Gopalan et al, 1983). A total area of 23104.87 ha, has been reclaimed from the backwaters for the purpose of paddy cultivation, paddy cum-shrimp culture and coconut husk retting during the period between 1834 and 1975. This brought about a horizontal shrinkage of around 64 per cent of the total area of the Vembanad backwaters.

· The aspiration for raising two or more crops of paddy in the reclaimed area in Kuttanad, Government constructed a spillway for flood control at Thottapally in 1955 and a barrier for checking the intrusion of saline waters atThanneermukkom (commissioned in 1974). This has ecologically severed nearly 6900 ha of brackish water lying south of Thanneermukkom from the main body of Vembanad backwater system.

· Projects for developing Cochin Harbour (1920-1936), Fishery Harbour (1978), Integrated Project for the Development of Cochin Port, Urban Development Project of the Greater Cochin Development Authority (G.C.D.A) and Town Planning Trust (1981-1985) and such other activities claimed a total wetland area of 720 ha, from the Vembanad backwater of Kochi region. Thus it is amply clear that, though the conversion of wetlands began in 1834, major reclamations were carried out in the course of past hundred years during which Vembanad backwater reduced itself from an area of 36500 ha to 12675 ha. i.e., 35%.

· The loss of Mangrove area associated with the backwaters of Kerala, due to encroachment and reclamation is not correctly estimated. According to Chand Basha (1992) during the last century, the reduction was from around 700 sq km to 17 sq km.

· All the rivers of Kerala are now vulnerable to saline incursion. Efficiency of the backwaters acting as a buffer zone between the sea and the rivers has declined due to such aerial shrinkage.

· The Vembanad backwaters in Kochi region and the coastal areas in Alappuzha, Kayamkulam, Kollam, Paravur and Veli are identified as some of the hotspots in the State. The Water Balance Study of Kuttanad conducted by the Indo-Dutch team reveals that about 90600 ha. (20%) of Kayal was reclaimed between the years 1968-1983. Erosion, transportation and deposition of sediments are natural processes controlled by mainly geologic, climatic, physical, vegetative and other conditions throughout the geologic times. However, during the present century, because of deforestation, manmade structures and change in cropping system in the uplands, the rate of transport of sediment from the

wetlands can also be from the sea, in which case the entire dynamics will be different.

· The availability of minable sand/lime shell in Kerala is not yet well studied and doccumented. Amidst the strong intervention of the judiciary on the over exploitation of river sand mining, Kerala could not come up with sensible solutions on where and how much to be mined from each of the rivers available in the state. Very little published data is available on the quantification of lime shell and river sand mining, which is mostly the propriety of the respective Grama Panachayats wherever these materials are available.

2.2.3.3. Biodiversity

Western Ghats of Peninsular India is one of the eighteen `Global Hot Spots' of biodiversity. The diversity of climatic, edaphic and biotic regimes have shaped the evolution of over 4000 taxa of angiosperms, 117 amphibians, 150 reptiles, 508 birds, 79 mammals and an unknown number of taxa from less studied groups. By virtue of its unique location (sandwitched between the Arabian Sea on the west and the Western Ghats on the east), topography (ranging from the coastal lowlands to mountain regions intervened by vast expanse of undulating midlands) and high rain fall, Kerala provides a wide variety of aquatic habitats like rivers, streams, pools, ponds, lagoons, estuaries etc. harbouring unique types of vegetation of their own.

The wetlands of Kerala are treated as sites of exceptional biodiversity in the country and are characterized by several endemic species. The coastal plains have been ravaged since early times of human habitation and most of the land is now used for housing and agriculture. Even these disturbed habitats are potential location for rapid speciation has been amply proved from the long list of new taxa discovered and described form here during the last two decades. Increased trade and commercial activity has brought with it a large number of aquatic and wetland weeds into this area. Moreover, such activities have also resulted in the creation of man-made reservoirs, abandoned granite quarries and clay pits which, in course of time, have provided ideal habitats for aquatic biota.

2.2.3.3.1 Flora

Though the benthic algae and other macro vegetation also contribute significance to the primary production, in wetlands phytoplankton plays a major role and has received much attention. The phytoplankton in the wetlands varies from freshwaters to truly estuarine and marine species. Phytoplankton in coastal wetlands has reproductive rates to offset their population, which is lost by the downstream drift. Predominance of certain species depends on favorable conditions that facilitate their rapid reproduction. There are many studies on the phytoplanktons of Kerala; most of them are confined to the Ramsar sites. A total of 100species of phytoplanktons were recorded from the backwaters of Kerala

(Unnnithan et al, 2005). There are some scattered studies by Madhusoodhanan and his students of Calicut University and Panikker of SN College. A study on marine fungi of the Kerala coast was attempted

by Ravindran (2003). A compilation all available data revealed the presents of about 90 species of Cyanobacteria, 275 species of marine/fresh water algae, 35 species of aquatic fungi.

Joseph (2002) recognised the three groups of aquatic macrophytes in Kerala. The first group, plants growing in running water are highly reduced, thalloid Podostemaceae plants, growing attached to submerged rocks in mountain torrents and those and plants like Aponogeton crispus, A. appendiculatus, Cryptocoryne consobrina and Vallisneria spiralis etc generally growing in slow-flowing water like rivulets and canals comes in this group.

The second group of plants growing in stagnant water can broadly be divided into two subgroups: free-floating (eg members of the family Lemnaceae and Pistia stratiodes of Araceae) and anchored (eg Ceratophyllum demersum, Eriocaulon setaceum, Hydrilla vertcillata, Najas indica and some species of Utricularia etc). Among the anchored hydrophytes four different types were recognised as follows: i) Anchored-submerged: Blyxa aubertii B. octandra, Ottelia alismoides, Rotala cookii, R. vasudevanii and Vallisneria spiralis etc, ii) Anchored-floating-leaved: Aponogeton nadans, species of Nymphaea and Nymphoides and Sagittaria guayanensis are a few common examples of this kind, iii) Anchored with floating or trailing shoots: They are somewhat intermediate between the floating leaved and emergent types. Many of them have specialised structural adaptations for this kind of life, such as swollen petiole, in Eichhornia crassipes and Trapa natana, aerophores as in Ludwigia adscendens and some species of Nymphoides, spongy internodes in Neptunia prostrata and floats as in some species of Utricularia and iv) Anchored-Emergent hydrophytes: Important representative of this group are: Aeschynomene indica, A. aspera, Acorus calamus, Dopatrium junceum, species of Eleocharis, Bergia capensis, Hygrophila balsamica, H. triflora, Damasonium flavum, Limnophila, Monochoria vaginalis, Sacciolepis interrupta, Typha angustata and Wiesneria traindra.

The third group includes species belongs to several genera of diverse families seen in the marshy areas.

Mangroves are the most important group of plants present in the coastal wetlands of Kerala. The extent and health of mangroves have a marked influence on the migratory species and the abundance of the offshore fisheries in Kerala. The prop roots of mangroves penetrate deep into anaerobic mud flats and activate mineral cycling and maintain productivity of the ecosystem. They also provide a suitable substrate for sessile organisms of economic importance such as oysters. The crown

of mangrove species provides resting and nesting place for many birds. The flowers of the trees are good source of honey for the honeybees, which are excellent pollinators.

There are clear evidences to show that very rich mangrove vegetation existed along the coastal tracts of Kerala and once supported about 700 sq km of mangroves along its Coast (Ramachandran et. al., 1986) and what exist now are only relics of the past. The total in 1992 was estimated as 16.71 sq km (Chand Basha, 1992), distributed

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in the coastal districts of which Kannur (755ha) has the largest area followed by Kozhikode (293ha), Ernakulam (260ha), Alappuzha (90ha), Kottayam (80ha), Kasaragode (79ha), Kollam (58ha), Thiruvanthapuram (23ha), Thrissur (21ha) and Malappuram (12ha). There is no detailed study thereafter regarding the extent of

Box 2.5: Mangalavanam

Mangalavanam is a wetland area dominated by mangroves near to the Kerala High Court in Kochi city. The total protected area now is 3.44 ha, of which 2.74 ha is core area. The area comprises of a shallow tidal lake in the centre with its edges covered with thick mangrove vegetation. Mangroves are also present along the small island in the middle of the lake. This water body is connected with Vembanad backwaters by a canal. The area is well protected from natural predators and not many similar communal roosting sites are available to birds in a crowded city like Ernakulam. This site is crucial to the city dwellers also, since it serves as greenery in the middle of the urban expanse. Apart from the much needed breeding and roosting site for birds, the rare and threatened mangrove vegetation is preserved here.

Studies by Jayson (2001) recorded 41 species of birds representing 25 families. The most common bird species found at Mangalavanam were Little Cormorant (*Phalacrocorax niger*) and Black-crowned Night Heron (*Nycticorax nycticorax*). Out of the 15 true Mangrove species available in Kerala coast, 9 are present in this small area. A good number of mangrove associates are also present.

Even though considered a wetland area, it attracts a large number of species from passerine group. Mangalavanam qualifies the criteria for declaring it as an International IBA (Important Bird Area) of the Birdlife International due to the presence of more than 1500 Little cormorant and the presence of more than 1000 Black-crowned Night Heron, which form one per cent of the total global population.

In addition to birds, some other species of vertebrates like: Indian Flying Fox (*Pteropus giganteus*), Painted Bat (*Kerivoula picta*), Three-striped Palm Squirrel

(*Funambulus palmarum*), House Rat (*Rattus rattus*), Bandicoot-rat (*Bandicota* sp.) were also recorded from the area (Jayson, 2001).

The important conservation issues in this area are:

Accumulation of plastic wastes and invasion by weeds in the lake: Polythene bags and floating waste materials enter the water during high tide and get entangled among the aerial roots of mangrove in the lake, thus clogging the lake. Apart from these, unwanted materials (including hardened cement bags from the nearby railway store), are also found thrown in the lake. Invasion of the lake by various weeds, particularly by Eichhornia during the monsoon (June to January) is another disturbance to the mangrove community. These activities cause siltation in the lake. Finally this may result in conversion into terrestrial land. This will seriously affect the food availability of water birds.

Air pollution due to the unloading of cement bags: On an average, 70 trucks operate in the nearby railway goods yard at a given time. The cement dust produced from the unloading of cement is deposited on the vegetation of the area. This may lead to the death or retarded growth of plants and trees.

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mangroves in Kerala. Mohanan (1999) estimated as it to be "less than 50 sq km".

The existing mangrove forests of Kerala are highly localizedand can be classified into three categories.

i) More or less undisturbed mangrove areas like Puthuvypin, Mangalavanam, Kadalundi, etc.,

ii) Degraded mangrove areas where there are still few patches of good mangroves and where regeneration measures can be tried out. Areas like Kumarakam, Asramom, Kunjimangalom and Kavvai belong to this category,

iii) Completely degraded areas where regeneration is almost impossible. These include areas, which had been already converted for various purposes like ports, agriculture farms, built up areas, etc.

A recent investigation by Anupama & Sivadasan (2004) could identify 15 true Mangroves belonging to 9 genera and 7 families and 49 Mangrove associates from Kerala. The true Mangrove species listed by them are: *Acanthus ilicifolius* L., *Aegiceras corniculatum* (L.) Blanco, *Avicennia marina* (Forssk.) Vierh., *A. officinalis* L., *Bruguiera cylindrica* (L.) Blume, *B. gymnorrhiza* (L.) Savigny, *B. sexangula* (Lour.) Poir., *Exocoecaria agallocha* L., *E. indica* (Willd.) Muell., *Kandelia candel* (L.) Druce, *Lumnitzera racemosa* Willd., *Rhizophora apiculata* Blume, *R. mucronata* Poir., *Sonneratia alba* J. Sm. and *S. caseolaris* (L.) Engler.

The family Rhizophoraceae is the most represented one with 6 species belonging to 3 genera. This indicates fairly rich species diversity even in the present, highly degraded condition. The true mangrove species are confined to the salty-marshy environment along the backwaters and rivers, whereas the mangrove associates were also found outside the mangrove environments.

Important mangrove associates are Acrostichum aureum, *Aniseia martinicensis, Alternanthera sessilis, Ardisia littoralis, Bacopa monnieri, Barringtonia racemosa, Caesalpinia crista, C. nigra, Calophyllum inophyllum, Cerbera odollam, Clerodendum inerme, Crinum defixum, Cyperus spp., Dalbergia candanatensis, Derris trifoliata, D. scandens, Dolichandrone spathacea, Eclipta prostrata, Fimbristylis cymosa, F. ferruginea, F. polytrichoides, Flagellaria indica, Heliotropium curassavicum, Ipomaea campanulata, I. pes-capre, Lagenandra sp., Mariscus javanicus, Melastoma sp., Morinda citrifolia, Pandanus ododartissimus, Parsonia alboflavascens, Paspalum distichum, Phragmites karka, Premna serratifolia, Samadera indica, Sauropus bacciformis, Scaevola sericea, Sphenoclea zeylanica, Syzygium travancoricum, Taliparithi tiliaceum, Thespesia populnea, Tylophora tetrapetala, Wedelia chinensis, Zoysia matrella* etc.

The unique Myristica swamps are one of the major biodiveristy rich wetlands in Kerala. About 53 patches of Myristica swamps have been recorded by Kerala Forest Research Institute (KFRI) from the Kulathupuzha, Anchal forest ranges and Shendurny Wildlife Sanctuary of the Kollam and Thiruvananthapuram districts of Southern Kerala.

A total of 63 tree species and 97 species of shrub-herb-climber combine were recorded from the Myristica swamps (Sabu & Babu, 2007). Many of the plants seen

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Fig. 2.14: Mangrove forest at Kannur

Fig. 2.15: ***Acanthus ilicifolius***

Fig. 2.16: ***Calophyllum inophyllum***

here are endemic to Western Ghats. Two species of earthworms, three species of crabs, ten species of fishes, thirty four species of amphibians, thirty three species of reptiles, fifty eight species of birds and twenty one species of mammals have been recorded as present in the swamps. In addition to this annelids and arthropods are also being recorded.

Box: 2.6 : Myristica Swamps

From among the incredible diversity of ecosystems, there is rare fresh water wetlands found in Western Ghats with unique assemblage of floral and faunal biodiversity. Popularly known as Myristica swamps. These freshwater swamp forest ecosystem is confined to low altitudes characterized by slow flowing streams of Western Ghats river systems. Myristica swamps have been recorded from Goa, Karnataka and Kerala in India. Trees belonging to a primitive family of angiosperms; "Myristicaceae" are the dominant tree species of this unique wetland ecosystem. Most of Myristicaceae family members are capable of producing aerial

roots when faced with unfavorable conditions. Hence the Myristica species found in these exceptional wetlands have adaptations such as knee roots for the anaerobic condition of the swamps, and stilt root for anchoring the tree species in damp soil. Other than Myristicaceae family species members of other families such as Celestraceae, Diptereocarpaceae, Anacardiaceae, Xanthophyllaceae and others are significant part of this swamp community. Ground vegetation is not dense and the dominant ground vegetation is belonging to Araceae, Zingiberace and Acanthaceae families. Some of these swamps are considered even as sacred groves and have thus ecoheritage value. These swamps having variety of microhabitats which provides favorable conditions for survival and procreation of many annelids, arthropods, molluscs, fishes, amphibians, reptiles, birds and mammals. Many of these animals found in the Myristica swamps are endemic and some are on the red-list of IUCN. More importantly this wetlands also play a critical role in water storing and maintaining ground water level. Myristica swamps are critically endangered ecosystem in Western Ghats.

www.wetlandsofindia.org:8080/wetlands/freshwater.jsp

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Fig. 2.17: Myristica swamps

2.2.3.3.2 Fauna

Zooplankton is a major group in the energy transfer at secondary level and plays an important role in the secondary production of wetlands. Long-term variability of zooplankton is significant to differentiate whether these fluctuations are due to natural causes or due to man made changes. Incidence of specific plankton may prove to play useful role in environment gradually management studies. Extreme mobility of plankton and patchiness of plankton are certain constrains in assessing the effects of man made changes. The study by Unnithan et al (2005) recorded 20 groups of Zooplanktons in eleven backwaters of Kerala. Much diversity is observed during the post monsoon season. Detailed studies in other wetland areas are lacking.

The backwaters and adjoining environments of Kerala have been famous for its islands and fisheries. Fishes have evolved a diversity of life history pattern. Some species are short lived, others live for decades. Even within a species, there may be major variations in life history patterns exhibited by different populations living at different geographic locations in the wetland.The wetlands are endowed with rich and diverse fish fauna characterised by many rare, endangered and endemic species. Out of the 170 and odd fresh water fishes reported from Kerala, the status of over 90 species has been red listed by the IUCN. Out of the above, 18 have been classified as critically endangered facing serious risk of extinction; 31 species have been classified as endangered of which 13 are endemic only to Kerala and 18 species have been classified under vulnerable category.

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The prawn infiltration in the areas of Vembanad backwater together with the inundation and movements of water in accordance with the micro-ebb and flood tidal regime of the estuary is a unique feature. There has been a drastic change in the hydrography of the estuary following the construction of Thottappally Spillway and Thanneermukkam Barrage.

The long stretches of coastal zones and its associated backwater and brackish water bodies are habitats for many wetland avifauna. Wetlands of Kerala are on the central Asian-Indian Flyway. Vembanad, Ashtamudi and Periyar lakes, Kulathoor, Purathoor and Kadalundi river mouths, and jheels like Azhinijlam provide suitable habitats for many migratory species. Terns, sea gulls, sandpipers, plovers, teals, etc., are some of the important avian visitors. Besides several paddy fields like Kole lands in Thrissur and Kuttanad in Alappuzha are places for avian visitors.

Out of the 475 species of birds of Kerala, 128 species are wetland dependant. Out of which 52 (40.63%) are winter migrants, while 59 (46.09%) species have been reported breeding in Kerala for sure. Around 5 % are vagrants which are essentially oceanic/pelagic birds that are blown to the shores because of monsoon winds or cyclone. According to Birdlife International (2003), Kerala has 16 threatened species of wetland dependant birds, out of which five are vagrants. Out of the 16 species one is Critically endangered, three are Vulnerable, while twelve are Near threatened species.

Endowed with wetlands, including inland wetlands such as lakes, reservoirs, ponds and paddy fields, the North Malabar region is found to be of great conservation value as they were habitats of 114 species of birds in the water bird census conducted jointly by the Kerala Forest and Wildlife Department and the Malabar Natural History Society. The preliminary report on the Census says that 75,683 birds consisting of 114 species belonging to 25 families have been counted from 65 sites where the census was carried out. All the major wetlands from Purathur (Bharathapuzha estuary) in the south to Manjeswaram in the north, in various

categories such as sea shore, estuaries, tidal mudflats, mangrove swamps, backwaters, brackish as well as fresh water marshes, ponds, reservoirs, river banks and paddy fields, were covered for the census. Birdlife International has stipulated certain criteria for identifying IBAs. In the case of congregatory water bird species, a site is considered important if it has on a regular basis greater than or equal to one per cent of bio-geographical population. Five wetlands - Kattampally, Kasaragode, Kumbala-Shiriya, Purathur and Muzhappilangad - fall in this category.

The census has found Brown-headed Gull, Black-headed Gull, Northern Pintail, Garganey, Pallas' Gull, Yellow-legged Gull, Lesser Whistling Teal, Lesser Sand Plover, Cattle Egret, Little Cormorant, Pond Heron, Little Egret, Purple Moorhen and Median Egret as the most numerous species of the wetlands in the region. As many as 25

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species have been found in numbers ranging from 100 to 1,000. Kattampally in Kannur tops the list of 11 important sites with high number of birds and high species diversity followed by Purathur estuary. While Kattampally has 18,622 birds belonging to 51 species, Purathur estuary has 10,411 belonging to 43 species.

Fig. 2.18 : Wetland Birds

A good number of insects are seen associated with the wetlands. Some species of butterflies, like the Peacock Pansy and Grey Pansy are found abundantly along with waterbodies because their larval host plants grow profusely close to the water. However, the insect diversity of Kerala wetlands was not well studied. The wetland study by CED (2003a) attempted the collection and identification of insects of the wetlands. The short term study identified 104 species of insects, mainly butterflies. The major families represented are Nymphalidae (35 species), Papilionidae (15 species), Pieridae (14 species), Satyridae (9 species) and Lycaenidae (9 species).

The reptilian fauna of the wetlands include the crocodiles, fresh water snakes and

turtles. Out of these, estuarine crocodile (Crocodylus porosus) has been ruthlessly hunted down to near extinction and only a few remain in isolated areas. The Indian Flying Fox (Pteropus giganteus), Painted Bat (Kerivoula picta), Three striped Palm Squirrel (Funambulus palmarum), House Rat (Rattus rattus), Bandicoot rat (Bandicota sp.) were recorded from the wetland areas.

However, a comprehensive account on the present status of the biodiversity of the wetlands in Kerala is still lacking.

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2.2.4 Impacts on Population, Economy, Ecosystem

2.2.4.1 Diminution of bioresources

Many developmental activities like construction of huge buildings , roads, railways and other infrastructure and town ship development has largely destroyed our biodiversity in the wetland areas . Destructive fishing such as dynamiting, poisoning, wanton destruction of spawners, habitat alternation for hydroelectric projects, etc., construction of barrages, bunds, anicuts, dams, etc., also result in impairment of natural habitats of some of these species.

The effects of industrial pollution are clearly seen in the form of depletion of biota, especially benthic organisms, fish mortality and presence of high ammonia in water. The large doses of heavy metals in the estuarine waters are biologically non-degradable and remain in the food chain of plants and animals. The destructive process leads to considerable reduction in the density of bivalves/gastropods and isopods in the backwaters with time. Weed menace leads to blockage of recreational and communication facilities in a wetland. Dead plants settle to the bottom resulting in shoaling of the water body. As a result of biodegradation of plant debris, anoxic conditions develop, which is deleterious to aquatic life. Only those fish species, which can withstand below par water quality conditions, can survive and commercially important fishes disappear. Fish population is alarmingly reduced in coconut husk retting areas (Bijoy, 2004). The fisheries sector is facing pressure from excess fishing fleet, habitat degradation, over fishing and juvenile fishery. Overexploitation had led to massive changes in the species composition of the catch and the disappearance of previously important species.

Consequent on the reduction in the expanse of backwaters, most of the 45000 active fisherman using 38000 fishing artisanals (28000 are unauthorized) are now concentrating their fishing effort in the remaining open backwaters for their livelihood. Fish production per ha in the water south of Thanneermukkom bund was found to be only 7 per cent of that available per hectare from the open backwater. This has reflected in the socio-economic condition of the rural

fishfolks.

2.2.4.2. Species loss

Aquatic ecosystems and wetlands are usually looked down upon as wastelands and are being reclaimed for various developmental needs, bringing several taxa, which would be of great potential value in medicine and other industrial uses, are on the verge of extinction. The encroachment, mining and reclamation in many locations lead to loss of biodiversity as well as make changes in the ecosystem functioning. Loss of wild species including endemic species is a phenomenon associated with ecosystem changes. In the backwaters, the stake net method of fishing removes a wide array of non-target organisms, which are functionally important to the aquatic environment. Other destructive type of fishing and pollution has also impact on the ecology. Excessive weed growth and algal blooms caused by eutrophication also causes ecosystem changes. The cumulative deposition of macrophytic biomass in bringing out a gradual alteration in the estuarine benthic communities due to the

disturbance in the food chain. The plastic wastes dumped into the system cause blockage, water stagnation and related problems in the system leading to biodiversity loss.

Mangroves are the most affected ones through out the coastal reaches of Kerala from south to north. There were reports from Kerala about the occurrence of mangrove species like Bruguiera eriopetala, B. malabarica, B. parviflora and Ceriops tagal in the past. (Drury, 1864; Hooker, 1879-1885; Gamble, 1919; Rama Rao, 1914; Chand Basha, 1992). But the recent investigation by Anupama and Sivadasan (2004) could not able trace these species in Kerala. Destruction of the mangrove habitat has wiped out several species including salt-water crocodile *(Crocodylus porosus)* from Kerala.

The loss of biodiversity especially the loss of mangroves has indirectly affected the fish diversity as well as avifaunal diversity especially the migratory fauna. This was evident in many of the studies conducted in the State recently. The construction of the Thanneermukkom barrier and the subsequent obstruction of the migratory pathways is said to be one of the major reasons for the disappearance of the largest fresh water prawn, Macrobrachium from the Vembanad backwaters. The entire wetland system in Kerala has turned to be an endangered one due to shrinkage, pollution and over exploitation. Specialized gears were operated by the fishermen to capture Elasmobranches till about 60 years ago. Regular mass migrant species like Teals from Siberia has considerably reduced in their numbers.

However, a comprehensive study on the species disappeared from the wetlands of Kerala is lacking.

2.2.4.3. Food toxicity

Certain micro-organisms are capable of converting inorganic mercury into more toxic mono-methyl and di-methyl mercury. Mono-methyl mercury, the most toxic mercury compound, is not tightly bound to the sediments and hence could be rapidly assimilated by living organisms. The Kochi estuary also receives effluents containing mercury from Chlor-alkali plants and therefore needs caution. There are instances related to food toxicity in many areas of the estuaries on consumption of fishes. Cadmium is also a highly toxic metal, which is responsible for the Itai Itai disease.

The aromatic hydrocarbons like benzene, toluene, etc., associated with oils and lubricants are acute poisons to the aquatic organisms. It is found that hydrocarbons subjected to bioaccumulation in an organism are stable regardless of their structure and remain in the food chain without alteration. Chemosensory disruption, anesthesia, narcosis, cell damage, etc., are some of the effects of oils on organisms.

2.2.4.4. Waterborne and zoonotic diseases

The untreated sewage contains organic and inorganic pollutants and pathogenic micro-organisms of various water-borne diseases like typhoid, cholera and dysentery.

There are numerous latrines along the banks of the estuary, mostly of single leach-pit type, causing direct feacal contamination. Water borne diseases, gastro-enteritis in particular, is widespread in most habitations of wetland region, which becomes acute during monsoon months. The domestic sewages that contain oxygen-demanding wastes, infecting wastes, infectious agents, organic chemicals and inorganic minerals, affect the water quality of wetland system.

The changes in landscape - blockage of wetlands, waste accumulation in the wetland areas are reasons for the resent emergence of many zoonotic diseases in the State.

2.2.4.5 Obstruction to navigation

The encroachment, mining and reclamation has also lead to the decrease in the depth of water courses in many stretches which has badly affected the water transport in many places Excessive weed growth due to eutrophication leads to high rate of siltation resulting in shallowing of a wetland. Growth of rooted weeds in shallow water results in the shrinkage of water spread area and ultimately transforms it to dry earth. It is a common sight and experience in backwaters that during rainy season, 'rafts of water hyacinth' float in water and obstruct navigation. Even though, the problems created by water hyacinth are many, it is to be noted that they have the ability to absorb toxic substances (especially heavy metals) from

the water body.

Fig. 2.19 : Blocked water way

The clogging of the water channels due to the siltation and sedimentation of many stretches of wetlands in the State and lake area has been preventing the smooth functioning of water transport system. The reduction in water transport system has led to increased pressure on the road transport especially in the Kuttanad and its adjacent areas which has been exerting much pressure on the environment.

2.2.4.6. Decrease in agriculture production and productivity

Agricultural land has considerably reduced during the last three decades mainly because of the conversion and reclamation of the low lands and other wetland areas for construction and other purposes. This has also amount to reduction in food production. The productivity of agricultural land is also reduced due to erosion and

loss of soil fertility due to pollution. The reduction in agriculture has automatically affected the economic condition of the people of the area, especially, the farmers and farm workers. The Kuttanad, Kole, Pokkali and Kaipad areas are the most affected ones due to this.

2.2.4.7. Scarcity of potable water

Potable water scarcity especially during the summer months is a major issue in many parts of Kerala. Major reasons for this are pollution and subsequent eutrophication in wetland areas and salinity intrusion. The excessive growth of weeds as a result of eutrophication has created the situation of utilization of excess quantity of dissolved oxygen in the water. This has affected the water quality very badly in many places. Reduction in the ground water recharge and depletion of ground water resources is one of the major impacts of wetland conversion and reclamation. The extent of ground water pollution is also very high in most of the wetland areas, because of the release of the toxic chemicals from the industries, urban solid wastes, hospital and slaughter house wastes, etc., are the main causes.

2.2.4.8. Flood and drought

The reclamation and conversion in many places has been leading to excess flooding of the area during monsoon. Weeds impede run off causing anoxic

conditions in the wetland. Choking of main drainage channels has augmented siltation, thereby affecting drainage capacity of channels. As a result, flash floods are common in low-lying areas even during very early phases of monsoon. On the other hand, the uncontrolled water runoff and reduced ground water recharging is leading to severe drought conditions in the summer season.

2.2.4.9. Aesthetic value depletion

Due to encroachment, reclamation and waste dumping activities, the aesthetic value of many wetland regions are highly affected. Vellayani kayal of Thiruvananthapuram is a good examplefor this. The eutrophication and pollution problems in the wetlands of Kerala also have much aesthetic impacts, especially affecting the tourism sector.

2.2.5 RESPONSES

2.2.5.1. Legal and institutional review upon ratification of the Ramsar Convention

· At the level of the Executive, the Ministry of Environment and Forests has constituted a National Committee on Wetlands, Mangroves and Coral reefs which has representatives from departments and agencies, non-governmental sector, academic

Box 2.7: Vellayani Kayal: The shrinking economy and vanishing beauty

Vellayani Kayal, (N.Lat 80 24' 90"- 80 26' 30" and E.Long 76o 59' 68"- 76o 59' 47") is one of the largest fresh water kayal in the State and the only one of its kind in Thiruvananthapuram District. The kayal basin falls in Venganoor, Pallichal and Kalliyoor grama panchayats and Thiruvallom and Nemom divisions of Thiruvananthapuram Corporation and is approximately 11.0 km south of Thiruvananthapuram City center. The campus of College of Agriculture, Kerala Agricultural University (KAU) housed in the Koyikkal Kottaram of Travancore royal family, falls on the western side.

Though kayal had a water spread of area of over 750 ha in 1926, it had shrunk to 650 ha in 1972. Since then, it had alarmingly shrunk further in area and now covers hardly 400 ha. In a 1994 map, lake measures a length of 3.7 km and a maximum width of 2.1 km. Though bathy-data suggest a maximum depth of 3.0 m, evidences exist for having a greater depth. The drinking water needs of a population living in about 4-5 km radius of the lake are now fully met by this kayal.

As the catchment of the Kayal stands at an average elevation of 29.0 m, the surface run off (through some thing like 64 streams) and underground recharge into it helps to maintain a large reservoir of fresh water even through the summer season. The chief outlet, the man made Kannukalichal (length=2.50 km and width=13.0 m) delivers the surplus waters to the Karamana river to the north through a regulator with sluice gates and pumps. The floor of this canal is " nearly at the same elevation" of the adjacent cultivated fields. Further, canal is largely silted up partly due to erosion of the bunds and partly from accumulation after death of luxuriant aquatic weeds and rooted reed grass that line the canal shores, making smooth flow of water difficult.

Even though the original extent of Kayal comprised land north of reservoir bund, the same is now dewatered and used for cultivation. The KAU, by dewatering parts adjacent to Kayal shore, used to cultivate punja paddy, but this was done away with from 1992 onwards. Since 1992, cultivation is confined only in the northern part of reservoir bund Pandarakari, Punjakari, Nilamelkari, Mankilikari and Kanjirathady are the sectors which are not actively cultivated.

The aesthetic beauty of the kayal and its shores as an interface of natural landscape and waterscape is now lost for ever. The major reasons for this are:

i) Four roads embankments, allowing poor or inadequate cross flow of water, built across the kayal segmented it into five distinct sectors. .

ii) Past and present land owners with shore front went on reclaiming the kayal to aggregate more land. Such encroachments continue even to day, but on a lower scale, and protect their booty with gated compounds.

iii) "Visionless" activities like creation of a reservoir of 32 ha in the kayal by KAU, dewatering for punja crop, kayal reclamation activities and coconut farming in the paddy field are some of the reasons for shrinkage of the lake and loss of its aesthetic beauty.

iv) The recent illegal sand mining from the lake basin creates problems of water quality and consequent stress on the ecosystem

v) Once known as the rice bowl of South Kerala, the Vellayani farmlands are nearly devoid of rice paddy farming. The beauty of the farm lands is lost in many areas created a devaluation of original aesthetic value.

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institutions, etc. The Committee meets at least twice a year to review wetland related activities. Recently this committee was divided into two distinct committees- the Wetlands/Lakes Committee and the Mangroves and Coral Reefs Committee. Further State level committees have been appointed that look into the conservation and wise use of the listed wetland sites in their States.

· The Ministry of Environment and Forests, Government of India, has also formulated a National Lake Conservation Plan (NLCP). Vembanad Backwater from Kerala was identified as one of the sites under NLCP. The main objectives under the programme would include the following:

· prevention of pollution from point and non-point sources,

· catchment area treatment,

· desilting and weed control,

· research and development studies on floral and faunal activities and related ecological aspects and

· other activities depending on the lake specific conditions such as integrated development approach, including interface with human populations.

· The National Environment Policy (NEP) 2006 prepared by the Ministry of Environment and Forests, outlines a significant number of new and continuing initiatives for enhancing environmental conservation. These require the coordinated actions of diverse actors, for the major part organized and stimulated by one or more public agencies.

The following actions will be taken as part of the NEP2006

(i) Set up a legally enforceable regulatory mechanism for identified valuable wetlands, to prevent their degradation and enhance their conservation. Develop a national inventory of such wetlands.

(ii) Formulate conservation and prudent use strategies for each significant catalogued wetland, with participation of local communities, and other relevant stakeholders.

(iii) Formulate and implement eco-tourism strategies for identified wetlands through multistakeholder partnerships involving public agencies, local communities, and investors.

(iv) Take explicit account of impacts on wetlands of significant development projects during the environmental appraisal of such projects; in particular, the reduction in economic value of wetland environmental services should be explicitly factored into cost-benefit analysis.

(v) Consider particular unique wetlands as entities with "Incomparable Values", in developing strategies for their protection.

(vi) Integrate wetland conservation, including conservation of village ponds and tanks, into sectoral development plans for poverty alleviation and livelihood improvement, and link efforts for conservation and sustainable use of wetlands with ongoing rural infrastructure development and employment generation programmes. Promote traditional techniques and practices for conserving village ponds.

· The Law Commission in its 186th report has *inter-alia* recommended establishment of "Environment Courts' in each State, consisting of judicial and scientific experts in the field of environment for dealing with environmental disputes besides having appellate jurisdiction in respect of appeals under the various Pollution Control Laws. The commission has also recommended repeal of the National Environment Tribunal Act, 1995 and the National Environment Appellate Authority Act, 1997. After examining the Report and discussing the modalities in several consultation meetings held by Secretary (E&F) with senior officers of the Ministry and the representatives of the Ministry of Law & Justice, the Ministry has decided to implement the recommendations of the Law Commission with some modifications. The Ministry is in the process of preparing draft legislation for the purpose in consultation with the Ministry of Law and Justice.

2.2.5.2 Research and Development Initiatives

A good number of management programmes were initiated during the last five years, for developing and implementing sustainable management plans for wetlands. CWRDM has initiated Management Action Plan (MAP) preparation for Vembanad, Ashtamudi, Sasthamkotta and Kottuli wetlands with support of MoEF. The MAP is now started implementing in Kottuli wetlands of Kozhikode.

The studies on the waterfowl of the State got an impetus after the inception of the Asian Waterfowl Census (AWC) in 1987. The Vembanad Kole Wetlands were practically unknown to the birdwatchers before the inception of Asian Waterfowl Census. Presently, 32 wetlands of Kerala are being monitored as part of the Asian Waterfowl Census, which is an International Waterbird monitoring programme done under the auspicious Wetlands International.

In Kadalundi the Kerala Forest Department is implementing the MAP prepared by CED (2003a). CED has successfully completed two Mangrove afforestation projects, one in Kumarakom, Kottayam (CED, 1999) and other in Kalliasseri, Kannur (CED, 2003b).

Fig. 2.20: Mangrove afforestation, Kalliasseri, Kannur

2.2.5.3 People's Movements

There are many community based organization in the State engaged in activities related to conservation of landscapes and natural resources. Protection groups ("Samrakshana Samithi') are functioning in almost all areas of individual lakes, rivers and even large ponds. The activities of these groups to some extent are helping in conservation of these areas. To list some of them are:

i) Kerala Sastra Sahitya Parishad (KSSP)

ii) Thanal Conservation Action and Information Network

iii) Society for Environmental Education in Kerala (SEEK)

iv) Group Endeavour for Environment and Natural Sustenance (GREENS)

v) The Vellayani Jagratha Samithi

vi) Association for Environment Protection, Aluva

vii) Kerala Nadi Samrakshana Samithi

viii) Mangalavanam Paristithi Samrakshana Samithi

ix) Periyar Samrakshana Samiti

x) Pampa Parirakshana Samithi

xi) Chalakudy Puzha Samrakshana Samiti

A good number of writ petitions were filed in the courts by these action groups against reclamation of wetland areas and for preventing wetland pollution.

2.3 Status of Environment of Selected Wetlands

In this section status of environment of five selected wetlands in Kerala are described. Out of these, three wetlands, viz., Vembanad - Kol wetland, Ashtamudi wetland and Sasthamkotta Lake are listed as Ramsar Sites. The Periyar Lake is in the Periyar Tiger Reserve, one of the major Protected Area in the State and Kadalundi Estuary, which holds one of the best Mangrove area (now selected under national conservation plan) are the other two wetlands described here.

2.3.1. Vembanad - Kol Wetland (Vkw)

2.3.1.1 Introduction

2.3.1.1.1. *Location and area*

Vembanad - Kol - Wetland _ System, one of the three Ramsar sites in Kerala (November 2002), is the largest estuarine system of the western coastal wetland systems (09^0 00' _ 10^0 40' N Latitude and 76^0 00' -77^0 30' E Longitude), and is spread over the districts of Alappuzha, Kottayam, Ernakulam and Thrissur, Kerala. The VKW is a complex aquatic system of 96 km. long coastal backwaters, lagoons, marshes, mangroves and reclaimed lands, with intricate networks of natural channels and man-made canals extending from Kuttanad in the south to the Kol lands of Thrissur in the north. The total area of the wetland system is 1521.5 sq. km.,- approximately 4% of the State's geographic area. The wetland is mostly waterlogged with depths ranging from 0.6 m to _ 2.2m and is typically divided into two distinct segments - the freshwater dominant southern zone and the saltwater dominant northern zone.

2.3.1.1.2 *Physical features*

Based on physiography, Kerala is divisible into three near-parallel and north-south trending tracts, viz., the highland (>75.0 amsl), the mid land (7.5 m _ 75.0 amsl) and the lowland (<7.5 m amsl). Geologically, the highland is typically underlain by crystalline rocks of Pre-cambrian age, where as coastal land and parts lowermidland are covered by sedimentary rocks of Tertiary age. A ubiquitous laterite capping occurs over crystalline rock basement of midland and the Tertiary sedimentaries. Recent and sub-recent sediments occur in low-lying areas and river valleys. VKW is fed by 10 rivers, all originating in the Western Ghats, flowing westwards through the wetland system to join the Lakshadweep / Arabian Sea. The area enjoys the full benefit of the southwest monsoon. The estuarine zone and organics rich sedimentary substratum of the inshore region makes it a highly preferred and desirable habitat for shrimps breeding. Vembanad is renowned for its live clam resources and sub-fossil deposits.

2.3.1.1.3 Hydrology

The entire VKW receives drainage from ten rivers, Keecheri in the north to Achankovil

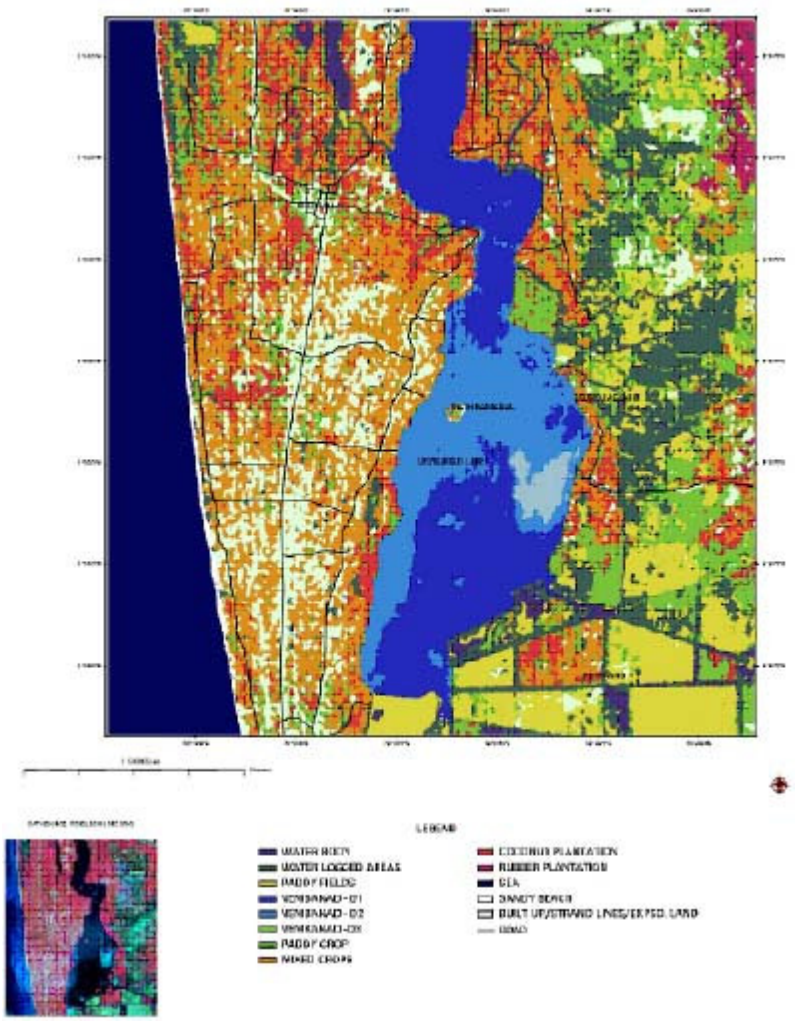

Fig. 2.21 : Vembanad wetland - Kumarakom area and its Environs (CED, 2003a)

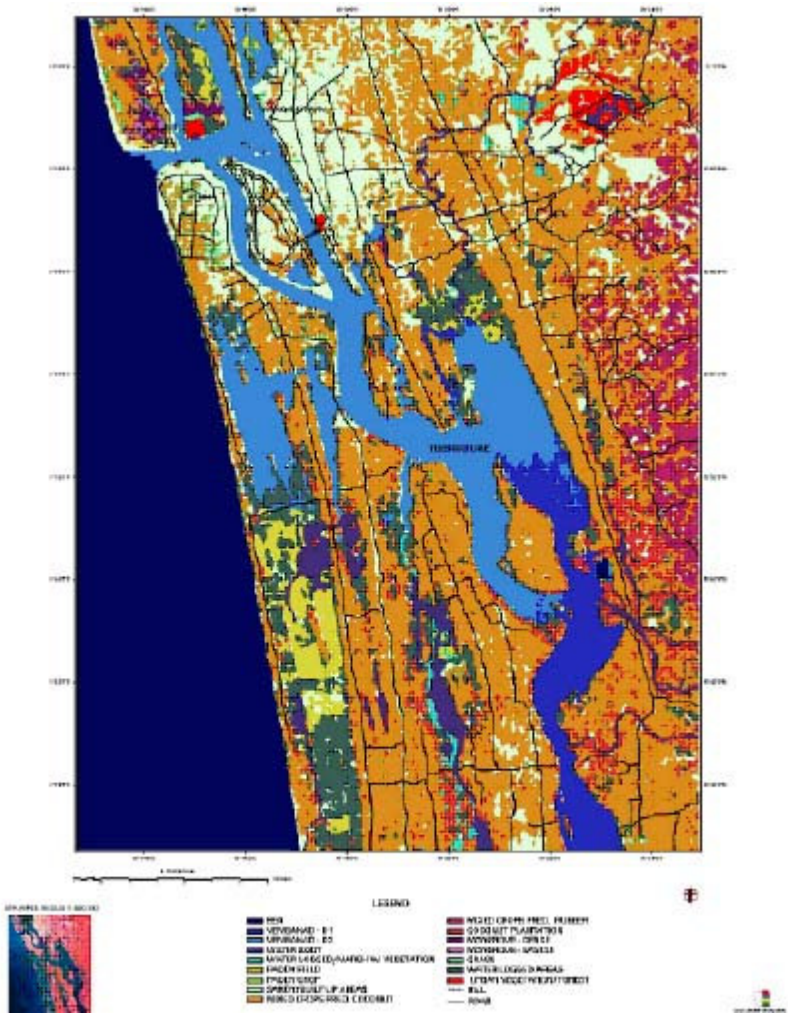

Fig. 2.22: Vembanad Wetland north of Kuttand upto Puthuvypin (CED, 2003a)

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in the south, adding up to a total drainage area of 15,770 sq km (40% of the area of the State), and an annual surface runoff of 21,900 Mm^3 (almost 30% of the total surface water resource of the State). Physiographic peculiarities have always been the major constraint that adversely affected the utilization of water resources in the region. Total annual utilizable yield of the ten rivers draining into the wetland system is estimated to be 12582 Mm^3. In Keecheri-Puzhakkal, Karuvannur, Chalakudy, Muvattupuzha and Meenachil rivers, the total requirement for various purposes considerably exceeds the utilizable yield, and therefore, the scenario underscores the need for better management strategies.

The total storage for irrigation and power generation, in the bsins of rivers draining into the VKW, is of the order of about 6000 Mm3, which is nearly half of the

average flood flow to the wetlands. So, the reservoirs help in containing the floods to the wetlands to a larger extent (Indo-Dutch Mission, 1989). In general, reservoirs often act as sediment and nutrient traps. The major interventions in the river basins of this wetland system are irrigation and hydroelectric projects, besides the network of roads and a number of bridges. There are three irrigation projects in operation and five others nearing completion. The total irrigation potential is estimated to be 100200 ha with a total storage capacity of around 1345 Mm3. Nine of the Kerala's hydroelectric projects are built in this area, with an installed capacity of 1400 MW.

Muhammed and Nambudripad (1999) of CWRDM successfully applied the Hydraulic Research Station (Wallingford, UK) model for long-term salinity prediction for Vembanad wetland, which can also be used for the study of optimum operation of the Thanneermukkom barrier and the Thottappally spillway and for analyzing the impact of future interventions and water withdrawals from the river basins and the estuary.

The Thanneermukkom barrier, (at least 1250 m long) was constructed in a narrower part of the Vembanad Lake, in order to prevent the ingress of salinity into the polders of Kuttanad during summer season and also to retain the fresh water inflow from the rivers into the lake. Only two-thirds of the original number of gates is opened in July to release flood flow, but the gates are closed mid-November. The structure has been relatively successful in keeping the water in the Kuttanad free of salinity and adding another crop in dry season. Drawback of the structure has been the loss of opportunity for marine fish and prawns to migrate upstream, an increase in weed growth in the upstream and finally, severely restricted the natural flushing of pollutants too.

The usually flooded areas of the Thrissur Kol also suffered from salinity intrusion through the inlets at Chetwai and Kottappuram. Enammakkal barrage was constructed about five decades ago, to prevent salinity intrusion into the Kol lands from Chetwai. Regulator at Enammakkal and the minor one at Kottenkottuvalavu in the lower reach of the Karuvannur river act both as spillway for the flood waters from the Kol land and

as a regulator of salt water entry. As the capacity is, somewhat less, a new proposal is on the way.

A sample of tidal data at Thirunallur (36 km from mouth) shows semi diurnal character and several kinds of cyclicities and harmonics. Tidal range attenuates rapidly from the mouth, up to about 15kms, but near the Manappuram bottleneck, very high tidal ranges of 110 and 133cm have been attained in certain summer months. As expected, the range is lower during heavy monsoon flow.

During the monsoon, flow propels towards the sea during the entire tidal cycle, except very close to the mouth. With decrease in river discharge, flow reversal occurs. Velocity variations are quite pronounced during a tidal cycle, while depth-wise changes are relatively small.The flushing time, is time required to replace the existing freshwater in the estuary at a rate equal to the river discharge. By applying the modified tidal prism method to the Kochi estuary, the flushing time was found to be of the order of 16 - 21 days during summer.

2.3.1.1.4 Biodiversity

Though wetland system is extensively rich in biodiversity, there hasn't been any comprehensive study on its flora and fauna. Table 2.10 is a summary of available data.

Table 2.10: Biodiversity of Vembanad Kol Wetland

Groups	No. of species
Flora	
Phytoplanktons	67
Herbs, shrubs, Climbers	308
Trees	26
Fauna	
Zooplanktons	32
Fishes	102
Insects	26
Birds	189

In a study of Vembanad lake, Bijoy and Unnithan (2004) recorded 24 species of green algae, 10 species of blue green algae, one species of yellow brown algae, 13 species of desmids and 19 species of diatoms from the Vembanad lake. The Indo - Dutch Mission study (1989) listed the aquatic plants of the area. The major aquatic plants of the area include: *Eichhornia crassipes, Salvania molestsa, Nymphaea stellata, N. nouchali, Nymphoides Hydrophylla, N. indica, Hydrilla verticellata, Najas indica,*

Limnophila heterophylla, Aponogeton natans, Potamogeton pectinatus, Cyperus corymbosus, Ischaemum barbatum etc. The study conducted by Sabu & Babu 2007 recorded 8 pteridophytes and 326 Angiosperms of which only 26 are trees.The floristic diversity of the area includes 13 Mangroves and more than 30 Mangrove associates, present in the area, of which the true mangrove, *Exoecaria agallocha* and *Bruguiera sexangula* are considered as rare species.

The wetlands support diverse fauna, including a large variety of fish, prawns and clams, reptiles and birds and provide a habitat for both anadromous and catadromous fish species. Almost all the 20 groups of Zooplanktons recorded from Kerla backwaters are present in VKW.

The growth and distribution of fish in the backwaters are greatly affected by the

salinity range of the water. With the onset of southwest monsoon, in the estuary, salinity declines rapidly to almost that of fresh water, resulting in a decline of a number of estuarine fish species. From September onwards, the brackish water habitat gradually re-emerges in the backwater and marine fish, tolerant to a wide salinity ranges, appear in the lower reaches of the estuary. During the pre-monsoon period, the physico-chemical conditions at the mouth and lower reaches of the estuary are very similar to those of the adjacent sea. Coastal marine fish, tolerant to wide salinity fluctuations, migrate over long distances into the estuary. The fish fauna identified from the whole area comes to 102 species, mainly of mullets. Molluscs include the black clam *(Velorita cyprinoids; V. cornucopia)*, *Mertrix meretrix, M. costa and Ostria calculata.* The mussels, *Perna viridis* and *P. indica* and the brackish water oyster, Crassostrea madrasensis, occur abundantly in the backwaters and river mouths. The soft-organic matter rich - sediment-substrata of the in-shore region are an ideal habitat for shrimps. Estuarine zone plays an important role in the life cycle of many shrimps caught and the entire Vembanad-Kol, acts as nursery for important shrimps like *Penaeus indicus, P. monodon, Metapenaeus dobsoni, M.monoceros, M. affinis, Macrobrachium rosenbergii.* Marine prawns, belonging to the family Penaeidae, are exploited both in the marine and estuarine waters. They spawn in the sea and the larvae migrate to the estuary to feed on the nutrient-rich environment. Among other Penaeids are *Penaeus indicus, Metapenaeus monodon* and *M. dobsoni.* The fresh water prawns of Kochi backwaters include *Macrobrachium rosenbergii* and *M. idea.* These fresh water prawns live in both fresh and brackish waters. The crustaceans include the edible crab *Scylla serrata* also.

The avifauna of this area requires special mention. During the winter months, the Vembanad supports the third largest population of more than 20,000 waterfowls in India. The birds come from different region and stay here for breeding and feeding. Kol lands provide a congenial habitat for a wide variety of birds including the waterfowls.

In Mangalavanam, primarily a bird refuge, 149 birds were identified of which 50 were migratory.

The area is also rich in insect biodiversity. CED study identified 26 species of insects from the area. Majority of them are butterflies belonging to the order Lepidoptera.

2.3.1.1.5 Inland navigation

The waterways formed by backwater, estuaries, lagoons and canals, spread over 196 km in the north-south and 29 km in the east-west directions, play an important role in the transportation system of the Vembanad region and practically, almost all the villages can be accessed through water transport. Muvattupuzha, Meenachil,

Pamba and Achencoil rivers, draining into the lagoon, are navigable upto distances of about 30 km upstream in the tidal reach. The Kottappuram-Chetwai waterway supports the inland navigation through the heart of Kol lands. A survey in 1986, revealed that out of a total of 14.74 million tons of cargo, of which inland waterways handled 1.74 million tons (11.84%). The Government of India has declared the Kollam-Kottappuram segment of west-coast canal system, passing though the Vembanad-Kol system, covering a distance of 209 km, as a National Waterway

2.3.1.1.6 Tourism

The VKW with its extensive network of rivers, lakes, canals, and lagoons fringed by lush green coconut groves and paddy fields, harbouring a variety of birds, is one of the most attractive backwater systems in the world. There are many historic places situated on the shores and hinterlands of the Vembanad-Kol backwaters. The offset of SW monsoon, is marked by scheduling of spectacular rowing competition involving several magnificient and large wooden canoes in the backwaters, which obviously attract thousands of spectators including foreign tourists. Further, the VKW is a treasure trove for ornithologists and bird lovers because of its rich avifauna. Tourism industry in this belt is now flourishing well especially in Kumarakam, Alappuzha and Kochi, of which Kumarakam has the top tourism potential. As a result, many new tourism facilities (like resorts and hotels) are coming up without any care or concern to the natural system or culture or heritage of the area.

2.3.1.2 Major management issues

2.3.1.2.1 Driving forces

All the nine driving forces (cited in ch.II), viz. i) population growth and urbanization, ii) industrial development, iii) infrastructure development, iv) agriculture, v) aquaculture, vi) fisheries, vii) deforestation, viii) services, ix) households, x) water transport and xi) tourism, do exist in the Vembanad kol wetland system.

Among all wetlands of Kerala, Vembanad is the most affected one as a result of urbanization and population growth, industrial development, agriculture and aquaculture, services, water transport, tourism etc. An analysis of population data reveals that population density of this area now stands at 3000 (Census, 2001), a fairly steep rise from 2400 (Census, 1991). Areas like Kumarakam, Njarakkal, Vypin, etc., are swiftly urbanizing. These areas and the urban centres like Kochi, Alappuzha, Cherthala, N. Paravur, etc., are expanding at the expense of Vembanad wetlands.

Deforestation is rampant in all the 10 drainage basins leading into the wetland. Interventions in the system for meeting the basic needs like water, electricity etc is relatively high. There are 778 (32 urban and 746 rural) water supply projects in the five districts (viz., Kottayam, Alappuzha, Ernakulam, Idukki and Thrissur) and most of them are using the water from one or other of the 10 drainage basins. Release of domestic waste into the system and defecation in the open has become common place among the people settled along the shores. For several island communities in the Vembanad, the waterscape acts also as "highway" for the movement of personnel and goods and services.

2.3.1.2.2 Pressures

The unplanned development and economic activities for supporting the needs of increasing population continues to exerted ever growing pressure on the ecosystem. The types of major pressures identified are same as in the list in section II

The Vembanad estuary receives effluents from chemical and engineering industries, food and drug manufacturing industries and also from paper, rayon, rubber, textiles and plywood industries. It is estimated that nearly 260 mld of such industrial effluents reach the estuary from the industrial belt of Greater Kochi. In addition, the Cochin shipyard and port are releasing sizable quantities of waste oil, paints, metal and paint scrapings. The traditional retting practice in coir sector of this area also exerts pressure on the system.

The annual fertilizer consumption in Kuttanad alone is estimated as 20000 tons (CWRDM). Agriculture and aquaculture practices prevalent in the drainage basins are also partly responsible for eutrophication through deposition of eroded top soil and agrochemicals and pesticides.

Kochi city alone generates 2550 mld of urban sewage that enters the Vembanad directly. Slaughter house wastes from the markets and hospital wastes also reach the system through the extensive network of canals in Kochi and through the rivers. Construction and industrial sectors here depend on wetlands for mined materials fuelling an extensive mining operation - a brisk business.

Present status of this land-water system is the result of a series of massive human interventions and consequences. The hydraulic/hydrologic interventions within the entire wetland system also exerted pressure in the sustainability of wetlands. The first and the oldest were the reclamation and creation of the Wellington Island and the Shipping channel maintained in the Cochin harbour. Then came the major reclamation and bunding works in the Kuttanad area for improving agricultural output in the area. The third intervention was the construction of the Thottapally

Spillway (1955) to divert floodwaters of Achankovil, Pamba, Manimala and Meenachil directly to the sea. The last intervention was the Thanneermukkom barrier (1975) built to prevent salinity ingress into the farmland of Kuttanad in summer. All the above interventions, except the first significantly altered the original flow pattern, salinity ingress, pollution dispersion and other characteristics. The Pathalam bund, a temporary barrage, is constructed each year on the Eloor branch of Periyar River since 1981, to prevent salinity ingress from Vembanad backwater and contamination of the water supply to the industrial units (rare earths, fertilizers, insecticides, catalysts and chemicals). But the enormous quantities of wastewater (about 8000 m3) discharged daily into this branch are not flushed out, leading to stagnation and buildup of pollution to toxic levels

Fig. 2.23: Thottapally Spillway

Authorised and unauthorized sand mining is common in all areas of Vembanad wetland system. The uncontrolled mining of shells from the lake is also posing a threat to the eco system. Dredging of the sub-fossil lime shell to a depth of 7 m for industrial purpose is also going on.

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Fig. 2.24 : Thanneermukkom barrier

2.3.1.2.3. State of Environment

The Vembanad estuary serves as a sink for domestic and urban sewage from Kochi. In addition, sewage of other municipalities is also directly discharged into

the Vembanad lake without any treatment. Kochi Corporation sewage collection system empties its wastes containing high particulate organic matter into the estuary through Padiyathupalam, Kalvathi, Rameswaram, Pulimutty and Thevara canals. 16 major industries discharge nearly 0.104 mm3 of wastes including organic wastes of the order of 260 tons per day. The river discharges of 19,000 mm3/year also carry a fertilizer residue of 20000 tons/year. The Point and Diffuse Sources of pollution is shown in fig. 2.25.

The effect of domestic sewage on the ecology of the lagoon is significant. Faecal coliform counts up to 1800/100 ml large quantities of polyphenols along with hydrogen sulphide are released from the coconut husk retting, ground leading to anoxic conditions. Hydrobiological conditions of the estuary are greatly influenced by seawater intrusion and influx of freshwater (Lakshmanan et al, 1982). Organic carbon in the sediments was higher during monsoon due to the contribution from land run off (Remani, et al, 1980). The study with reference to the indicator bacteria reveals that the principal source of faecal pollution is of the non-human type originating from land drainage, sewage and organic discharge (Gore et al 1979). Higher COD (Chemical Oxygen Demand) values observed are probably due to the domestic sewage and water discharged into the harbour area (Sarala Devi et al 1979). Studies also showed that there is appreciable degree of organic pollution in the harbour area (Unnithan et al, 1975).

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The effluents from industries carrying a heavy load of ammonia (432-560 ppm which is far above the accepted lethal limit of 2-5 ppm) pouring into the system along with many other pollutants such as acids and suspended solids in varying quantities, have changed the hydrochemistry conditions to extreme toxic levels, so as to cause heavy mortality of the animals. Total dissolved solids in water rise as high as 53750 mg/l in summer, which may come down to 16 mg/1 during the rainy season. Water is found to be highly acidic, loaded with ammonia, fluorides and phosphates, resulting in massive fish kills. Remani (1979) reported that in some of the polluted waters, BOD (Biological Oxygen Demand) values reach 513.76-mg/ l, sulphide 4.97 mg/l and oxygen less than 0.05 ml/l.

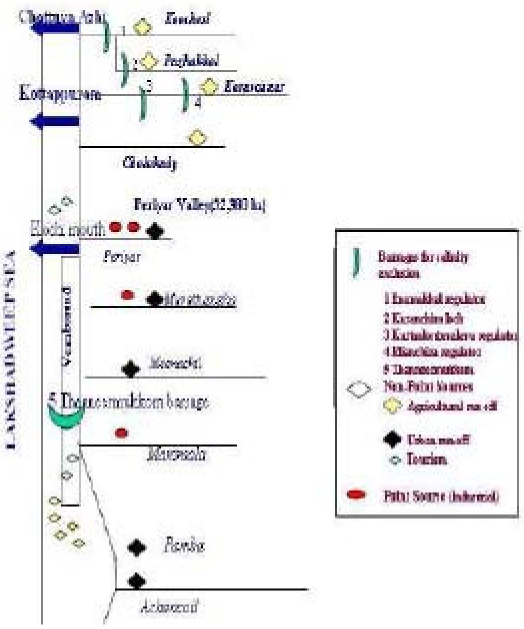

Fig. 2.25 : Point and Diffuse Sources of Pollution

It was observed that pollutants like Copper, Zinc, Cadmium, Lead, Nickel and Iron (dissolved metals) were highest at the effluent discharge point gradually decreases towards the bar mouth. But it was lowest in the upstream reaches of the Periyar

River. Seasonal data show that the level of pollutants is higher during the pre-monsoon season and due to fresh water influx lowest during the monsoon season.

A study on the wetlands of Kerala by CED (2003a) analysed the water quality parameters of the Vembanad wetland system (table 2.11).

Studies by Rajendran et al (1987) showed that concentration of mercury in the oyster *Crassostrea madrasensis* collected from the Cochin estuary showed levels of mercury, ranging from 15 to 48ppb in a small size oyster and 7.0 to 37.0 ppb in larger size. The concentration of mercury in the sediment samples ranged from 31 to 144 ppb. A paper mill and other factories engaged in chemical manufacturing release mercury to the system.

A high level of organic pollution is noticed in the system, especially in Kochi. Large values of hydrogen sulphide were observed at the points of discharge of organic waste into the estuary. Lower oxygen values showed higher values of BOD and hydrogen sulphide. The extent of pollution in these areas is well above the tolerance level of estuarine fauna. Retting of coconut husk is another major source of organic pollution in the backwaters of Cochin.

Detention time (hydraulic residence time) of a lake influences the vulnerability to pollution of the lake too. A larger value for detention time indicates that the lake is more receptive to pollution. Pollutants from such a lake are removed at a slower rate. A study by CWRDM determined the residence time of the Vembanad Lake as 114 to 185 days based on the volume of the lake and inflow to the lake.

Phosphorous concentration in the lake over the years is given in fig 2.26 Increase in the yearly average phosphorous concentration resulted in the favourable conditions for the plankton production. The higher concentration of phosphate noticed especially during monsoon and pre-monsoon seasons are probably associated with bottom turbulence and tidal influences (Padmakumar et al 2002). Balachandran et al (1986) reported that phosphate and nitrates were present in very low levels up to mid 70s' from where, due to the combined effect of increased industrial and agricultural activities, the levels increased during 80s' and 90s'. During 1965, the surface phosphate and nitrate were 0.75 and 2.0 µM, which has climbed to 2.9 and 6 µM respectively by 2000 even though, between the years it showed still higher levels. The trend of build up of nitrogen and phosphorus fractions after 1975 and from 1980 onwards, remained rising. Enrichment of phosphorus with respect to nitrogen is more leading to mesotrophic waters. The build up for inorganic phosphate since 1973, and the subsequent increase in waste discharge had ultimately led to extreme levels of ammonia, phosphate and nitrate in the estuarine region. During 1980-81, nitrate and phosphate levels stood at 40 and 12 µM with upstream peaks at 108 µM and 186µM. Phosphate levels up to 88µM during 1982-83 was reported the northern upstream stations. During 1990,

Table 2.11: Water quality, Vembanad - kol wetlands (CED 2003a)

Parameters	Location		
	Kumarakam (Backwater near resort)	Kochi (Mangalavanam)	Thrissur Kol (Perumpuzha)
Colour	Colourless	Colourless	Colourless
Odour	Nil	Nil	Nil
Depth (meter)	1.5	1	1
pH (NTU)	5.38	7.70	
Turbidity (mg/l)	-	-	25.3
Dissolved Oxygen (mg/l)	4	8.4	2
Hardness (mg/l)	2516	3800	16
Acidity (mg/l)	8	10	30
Alkalinity (mg/l)	2	7.85	40
Salinity (ppt)	23.524	19.539	0.0053
Total Solids (mg/l)	10740	34800	1800
Total Dissolved Solids (mg/l)	7200	29800	800
Total Suspended Solids (mg/l)	3540	5000	1000
Chloride (mg/l as NaCl)	21142	24576	18.43
Sulphide (mg/l)	6.4	0.8	60
Nitrite (mg/l)	-	-	0.095
Phosphate (µg Po_4- P/l)	1.3	2.4	0.0035
Primary Productivity (mg/l/hr)	0.4	-	3.2 (gross) 2.4 (net)

nutrient maximum reported was 98.48 for nitrate and 15.11 µM for phosphate. Sheeba (2000) reported nutrient enrichment in this system and recorded nitrate up to 451µM and phosphate up to 33 µM at the bar mouth.

Recently CWRDM modeled eutrophication of the Vembanad Lake, using the Aquatox Ecological risk assessment model of the US Environmental Protection Agency (Aquatox, 2004). The primary data on water quality of Vembanad Lake was collected during 2003 and 2004 was used. A constant loading data in grams/day were used for the nutrients based on the available secondary data. The mean monthly inflow values

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were calculated based on 13 years dataset available. The non-point source pollution load to the lake was estimated using primary field data.

The lake was simulated using daily mean average value for inflow and annual average for nutrient loading. The simulation predicts the maximum chlorophyll values during pre monsoon season. The bottom turbulence and tidal influence also may be contributing to the higher concentration of phytoplankton biomass during these months.

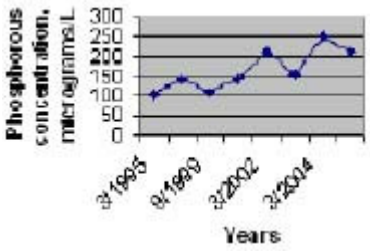

Fig. 2.26: Concentration of Phosphorous in Vembanad Lake

The results of the study reveal that eutrophication of the Vembanad Lake is mainly phosphorous related. The lake is infested with growth of phytoplankton especially during pre monsoon and beginning of monsoon months. In addition to the nutrient load received by the lake from point sources, the lake is also polluted in the southern, eastern and western parts by diffuse pollutants such as agricultural and municipal effluents. The simulation studies of the lake predicted eutrophication of the lake with high concentration of phytoplankton growth and clarity indicated by lower seechi depth. The simulation also suggested that, the total phosphorous load to the lake should be regulated at 12.5 % of the present phosphorous load input to the lake to transform to oligotrophic type.

Shrinkage of Vembanad Lake to 37% (13224 ha) of its original area (36329 ha), as a result of land reclamation, has been the most important environmental consequence. About 23105 ha of land have been reclaimed from the lake during 1834-1984 amounting to 63% of the lake area. Incentive given by the government after the Second World War by way of interest-free loans for intensive rice cultivation further encouraged reclamation activities. During the period from 1941 to 1950, almost all shallow regions of the lake have been reclaimed by constructing dykes. It is estimated that 21% reclamation has taken place during the span of last 15 years.

The depth of the Vembanad Lake has been reduced by 40-50% in all zones except between Aroor and Wellington Island and the Cochin port zone. The water carrying

capacity of the system has been reduced to an abysmal 0.6 km3 from 2.4 km3 with a decline of 78%. The comparative data shows that the average depth of Vembanad backwater has been reduced from 6.7 m to 4.4 m over the 50 years from 1930's to 1980's (table 2.12).

Erosion, transport and deposition of sediments are natural processes controlled by mainly geologic, climatic, physical, vegetative and other conditions. However, during the present century, due to deforestation, manmade structures and change in cropping pattern in the uplands, rate of release of sediment from watersheds and supply to the wetlands have grown up, causing environmental problems.

2.3.1.2.4 Impacts on Population, Economy and Ecosystem

The threat posed by activities of most of the stakeholders on the health of Vembanad ecosystem is severe and dangerous to levels exceeding the carrying capacity of the system. Studies on the biological processes of Cochin estuary reveals that biodiversity of Cochin backwater has been on the decline. The VKW had a much greener past when significantly large portions of the region were covered with a lush growth of various types of mangrove vegetation (Vannucci, 1987). Extensive Mangrove vegetation that once existed in this area is now detached with stunted Rhizophora and Sonneratia with scattered reed beds in areas close to Kumarakom, Kannamali, Mangalavanam, Kumbalam and Puthuvypin. In the polluted and marginal zones bivalves are lesser in number. The effects of industrial pollution manifests as depletion of biota, especially benthic organisms. Density of benthic fauna got reduced as well as fish mortality due to ammonia content (Unnithan et al., 1975). Saraladevi et al (1991) found that benthic organisms were totally absent in the polluted areas of Cochin backwater. Jayapalan (1976) reported deleterious effect of effluents on plankton productivity of Cochin backwater due to pollution.

Table 2.12 : Depth ranges in various sectors, Vembanad Estuary (Thomson, 2003)

Stations	Depth range in 1930s	Depth range in 1980s	Depth range in 2001
Between Thanneermukkom bund & Vaikom	8 - 9	3 - 4	3.5 - 4
Between Vaikom & South Paravoor	7 - 9	4 - 5	3.5 – 4.0
Between South Paravoor & Aroor	5 - 6	3 - 4	3 - 4.5
Between Aroor & South of Willington Island	7 - 8	7 - 8	7 - 8
Cochin Harbour Region	7 - 8	7 - 8	7 - 8
Between Bolgatti & Cherai	3 - 4.5	2 - 2.5	1.5 - 2
Between Cherai & Munambam	3 - 6	2.5 - 4	2.5 - 4

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Influence of sewage and the heavy load of organic matter into the lake are responsible for the decrease in summer. Unnithan et al, (1977) reported fish mortality (Ambassis gymnocephalus) due to industrial pollution reported from the upper reaches of Cochin estuary. Kurian (1972) and Ansari (1977) reported that density of bivalves, gastropods and isopods in the backwaters have considerably diminished. Fish shoal entering the polluted zone is unable to tolerate the combined effects of pollution, resulting in the sudden death due to asphyxiation. Reclamation and bunds in the river channel do affect the breeding and migration of aquatic species.

Accumulation of sediments in Cochin estuary created serious imbalances on the eco system functions of backwaters seriously in recent years especially. Sediment accumulation has reduced the mean depth of estuaries in many sectors affecting

fisheries, water transport and trade.

Sewage borne pathogenic micro-organisms, causing diseases such as Typhoid, Cholera and Dysentery also affect the fish wealth. Periodic outbreaks of such diseases are reported from Kuttanad and other areas along the shores of Vembanad Lake in Alappuzha district. Periodic outbreak of fish disease is also common in Kuttanad region of Vembanad Lake.

Problems associated with eutrophication of the Vembanad Lake are many. Luxuriant growth of aquatic plants like Eichornia crassipes, Salvania molesta, Nymphoides spp., Aponogeton crispium etc noticed in the lake (Indo Dutch Mission, 1989), hinder the navigation, create anoxic conditions in the bottom of the lake and choke the main drainage channels.

Industrial dredging of the sub-fossil lime shell to a depth of 7 m had made the lagoon bed unsuitable for the growth of black clam.

2.3.1.2.5. Responses

Inclusion of the area in the Ramsar list in 2002 offers huge opportunities for development and implementation of a scientific management plan for the use of the Vembanad- Kol wetland system.

Considering the fragile ecosystem of the wetland, deterioration of water quality and consequent damage to aquatic organisms and the shrinkage of Vembanad Lake, this wetland system was included in the National Lake Conservation Plan (NLCP) by the National River Conservation Authority, chaired by the Prime Minister under the Ministry of Environment and Forest (MoEF) in June 2003. Under the NLCP, projects of conservation and management of polluted lakes are taken up on 70:30 costs sharing between the central and state governments as in the case of river action plans.

Several NGOs like Kerala River Conservation Council, the Kuttand Foundation etc are approaching the government for implementing an integrated management-action-plan for this wetland. Recently the GOI entrusted the M.S. Swaminathan Commission to submit recommendations for revival of agriculture and allied sectors in Kuttanad region and preserve its ecosystem. The commission is expected to submit a report with detailed action plan for the sustainable use resources of the area.

2.3.2. Ashtamudi Wetland (Aw)

2.3.2.1 Introduction

2.3.2.1.1 Location and area

Ashtamudi Wetland (Ashtamudi Kayal, area = 61.4 km2), Ramsar site No. 1204, is near Kollam City (08°57'N 076°35'E) in Kerala and falls in Kollam City Corporation and adjoining Grama Panchayats. This extensive estuarine system, the second largest and deepest in Kerala, is connected to sea and is of extraordinary importance for its hydrological functions and biodiversity. Like fingers of a palm, it has multiple branches viz. Ashtamudi Kayal, Kumbalathu Kayal, Kanjirakkottu Kayal, Kandanchira Kayal and Karipuzha Kayal and opens to the sea through an inlet at Neendakara. The major river discharging into the AW is Kallada whose chief tributries are Kulathupuzha, Chenduruni, and Kalthuruthy rivers.

2.3.2.1.2. Physical setting

Seaward portion of the AW is in the lowland, while toward east and south, i.e., landward, the hinterland falls in the midland. Geologically, the lake basin and environs are underlain by the Quaternary and Tertiary sediments and sedimentary rocks, in that the former is made of marine and fluvial alluvium of recent age, and the latter consists of Laterite, sandstones and clays of Warkalai formation.

The various landforms noticed are:

· Coastal plain: This unit consists of sandy plain with alternating ridges and swales and a narrow modern beach. Mostly utilised for human settlement and mixed crops.

· Undulating uplands: These are dissected uplands of 10-20m in height to the east and south with nearly flat tops and gentle slopes, carved out of tertiary formations.

· Valley fills: Broad valleys formed by dissection and erosion of Tertiary formations, are filled with alluvial materials. Such valleys are intensely cultivated with paddy.

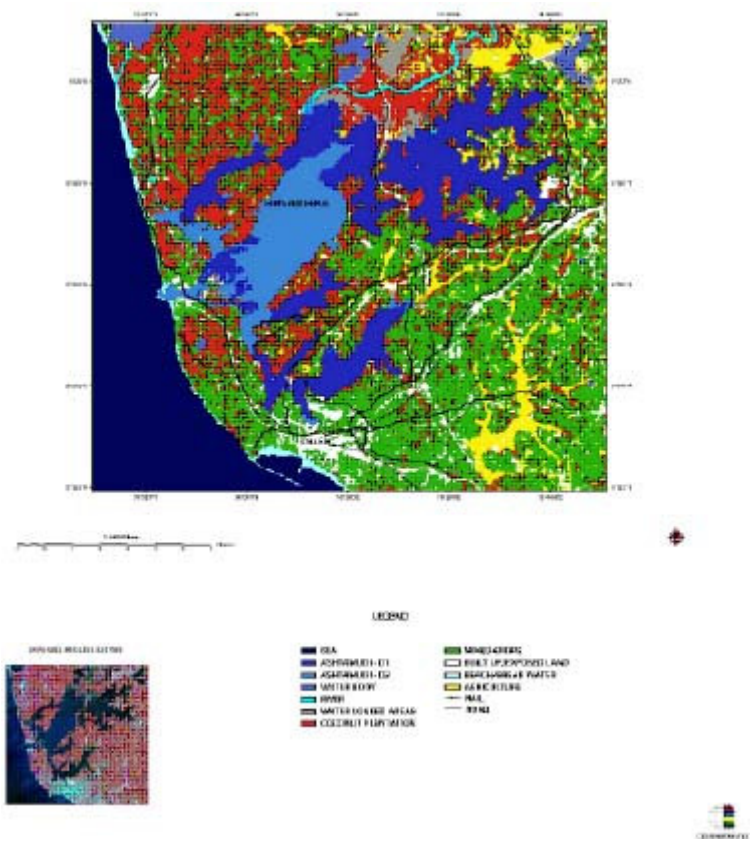

Fig. 2.27: Ashtamudi Wetland and Environs (CED, 2003a)

· Alluvial plain: Vast alluvial plains of the Kallada River constitute this unit. This plain consists of several topographic lows, formed of marshes, water logged areas and palaeochannels.

· Islets: There are a number of islets or 'Thuruths' in the Ashtamudi Kayal. They possibly formed by erosion of loose tertiary sediments from parts of hinterland and deposition in the lake.

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2.3.2.1.3. Hydrology

Ashtamudi, the deepest estuary in Kerala, receives discharge of Kallada River (length = 120 km; Basin Area = 1700 km^2 and discharge = 3375 $Mm^{3)}$ basin receiving an average annual rainfall of 2400 mm. The Ashtamudi wetland also serves the role of containing the flood waters, which otherwise would have had an adverse impact on the thickly populated coastal land and parts of the city of Kollam. A major intervention affecting hydrology of the wetland was the construction of Kallada dam in the upper catchment, built to irrigate 61630 ha of paddy and upland crops. This 85.3 m high 35 m long (area - 23 km^2 @ FRL) straight gravity masonry dam created a large reservoir of storing 505 Mm^3 of

water, is the largest irrigation dam and reservoir. The dam reduced the summer flows significantly, aggravating salinity ingress in the wetland and into the river.

2.3.2.1.4 Biodiversity

Ashtamudi wetland ecosystem, a home to a wide variety of flora and fauna (table 2.13.), once had very good mangrove vegetation, but now stands reduced to a very small patch near the Asramom Park. Around 7 species of true and mangrove associates occur in this area. The floristic diversity covers around 225 species of herbs, shrubs, climbers and 31 trees of which about 35% are medicinal plants have been identified from the area.

Table 2.13: Biodiversity of the Ashtamudi Wetland (Compiled from various sources)

Groups	No. of species
Flora	
Phytoplanktons	9
Herbs, shrubs, climbers	225
Trees	31
Fauna	
Fishes	97
Insects	45
Birds	57
Zooplanktons	29

Asramom area was once a repository of a variety of plants and its dependant animal species. The woody trees like *Holigharrna arnottiana, Syzigium travencoricum, S. zeylanicum* etc., are still present of which *Syzigium travencoricum* is an endangered species (IUCN), *Calamus rotang*, vulnerable species is also present in this site.

Rhizophora apiculata, R. mucronata, Ardesia littoralis and *Avicennia marina*, once abundant in this mangrove area, have almost completely degraded.

The wetland supports 57 species of birds (6 migratory and 51 resident species) and 97 species of fish (42 typically marine, 3 estuarine, 9 estuarine-riverine and 15 marine-estuarine). About 40 species of wetland dependant birds are noted in Ashtamudi Lake, out of which 45% are long distant migrants. Terns, plovers, cormorants and herons are most abundant birds.

The CED (2003a) study reported 45 insect species, including 26 species of butterfly, 5 odonates, 9 hymenopterans, and 2 orthopterans, 1 hemipteran and 2 coleopterans. About 29 zooplankton species have also been identified. From the water body, 9 phytoplanktons such as Amphora, Borosigma, Cyclotella, Cymbella, Gyrozigma, Meloziva, Navicula and Nitzschi have also been identified.

2.3.2.1.5 Tourism

Ashtamudi Lake promises high potential in tourism industry, especially in areas like Backwater cruises; hotel facilities along the lake shore, etc. The internationally famous Ashtamudi Resort known for its ayurvedic treatments and oil massages are situated right on the shore of Ashtamudi Lake. The Kerala Tourism Development Corporation (KTDC) operates luxury boat for cruises for domestic as well as international tourists. Tourism related activities in and around Ashtamudi Lake is already earning sizable revenue for the State. Due to all such factors, economic potential of the lake is also very high.

2.3.2.2 Major Management Issues

2.3.2.2.1. Driving forces

All the nine driving forces listed in section II are equally applicable here also. Number of Paper, Aluminium and ceramic industries are functioning in the basin of Kallada River. Coconut husk retting is a common pursuit. Public and private sector construction activities for developing infrastructure are also noticed. Human settlements, traditionally centered in the hinterland of the backwaters led to the deposition of household wastes along with feces from hanging latrines. The lake acts as the water-route of transport and exchange among the island - village - communities and regular boat services are operating to Chavara south and Perumon in addition to more than 50 native canoes serving the transport and trade needs.

Fishing is the major activity in the wetland. Aquaculture activities like prawn culture, mussel culture etc are also common. Legal and illegal sand mining is on the rise in estuary as well as the river channel. There are 88 (7 urban and 81 rural) water supply

projects in the district, most of them are sourcing water from the Kallada drainage basin. Of late, backwater tourism using houseboats is a flourishing industry.

2.3.2.2.2 Pressures

More and more industries including tourism coming up adjacent to the shores and basin are without effluent and waste treatment facilities. Effluents from the industries like ceramic, aluminium, paper, match, spinning mills and cashew factories, located in the drainage basin of Kallada river and the backwater are released into the system. Small scale industries and other livelihood earning activities like fish processing units, boat building yards, food processing units, slaughter houses, etc., are also noticed. The effluents released from such units include fish spoilage and residues, slaughter house wastes, waste oil, paints, metal

and paint scrapings etc. Coconut husk retting and related operations, though of small scale, are intensive, contributing heavily to the organic pollution load of the open water bodies. Wastes from the houseboats and resorts are also ultimately released into the wetland, raising nutrient levels, pathogens and other organic substances leading to pollution and eutrophication and finally degradation of the ecosystem. The lack of a well planned waste management programme for urban as well as rural areas also exerts great pressure on the system.

The fishing boats fitted with outboard engines releases large quality of hydrocarbons into the system. Legal and illegal encroachment and reclamation of wetlands are on the rise in many areas for creating infrastructure facilities to the rising urban population. Such actions cause shrinking of the wetlands and destruction of biodiversity.

The agricultural practices warrant the use of chemical/organic fertilizers and insecticides/pesticides, and the residues on entering the system cause pollution and eutrophication. The modern aquaculture also demands the use of many nutrients, inducing changes in the ecosystem.

Land use changes and deforestation in the watershed as well as the increase in withdrawal of surface and ground water from the river basin for irrigation, domestic, industrial and other uses have also put forth pressure on the system through stream flow changes. Hydrological interventions, like the Kallada Dam also exert pressure on the system. Natural process like floods, erosion, sedimentation and natural disasters do exert pressure in the AW. The hydro period of the wetland has changed due to the seasonal variations in the fresh water inflow into the wetland. Since hydrology is the single most important factor of the wetland and the hydro-period is the signature of the wetland, the changes is the hydro-period are sure to bring about changes to the wetland ecosystem.

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2.3.2.2.3. State of Environment

Ashtamudi Lake serves as source of water and sink for various industries in and around Kollam District. Retting of coconut husk, discharge of sewage, organic wastes from fish and seafood processing industries and oil waste from fishing boats etc are chief polluters of the water body. It is also a sink for excess nutrient loads shed from agricultural lands. Physical pollution is enhanced by dumping of washings from KSRTC Bus Depot located along the shore of the Ashtamudi.

Water quality data at selected sites are within permissible limits (table 2.14). Pollution - indicator - parameters, like values for sulphide, nitrite and phosphate though show considerable variation, can be attributed to industries located along the banks of the Ashtamudi Lake, discharging their effluents into the lake. Also slaughter house wastes too add to the organic content.

It is estimated that the total extent of the wetland underwent shrinking to the tune of 61.4 sq km.

Table2.14: Water Quality, Ashtamudi wetland **(CED, 2003a)**

Parameters	Location				
	Kakkat-huruthu	Thekkum-bhagam	Perumpe	Vincent thuruthu	Asramom
Colour	Colorless	Colorless	Colorless	Colorless	Colorless
Odour	Nil	Nil	Nil	Nil	Nil
Depth (meter)	3	2	3.5	3	2
pH (NTU)	7.99	9.0	9.1	7.9	9.2
Turbidity (mg/l)	17.5	17.2	17.4	17.5	19.1
Dissolved Oxygen (mg/l)	6	6.8	6.4	7	7.5
Hardness (mg/l)	6020	5820	4280	4940	5280
Acidity (mg/l)	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l)	76	76	88	84	108
Salinity (ppt)	22.9	22.4	17.7	26.59	26.59
Total Solids (mg/l)	20600	27700	26100	12500	24700
Total Dissolved Solids (mg/l)	20000	26300	22900	10900	22300
Total Suspended Solids (mg/l)	600	1400	2200	1600	2500
Chloride (mg/l as NaCl)	20972.3	20492.0	16169.6	23373.7	23373.7
Sulphide (mg/l)	14.4	11.2	11.2	9.6	12.8
Nitrite (mg/l)	0.00125	0.0016	0.0026	0.004	0.004
Phosphate (µg Po··· P/l)	0.001	0.002	0.003	0.0013	0.0035
Primary Productivity (mg/l/hr)	_	0.4	_	_	

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2.3.2.2.4 Impacts on population, economy and ecosystem

Natural habitat faces serious degradation caused by reclamation and consequent shrinkage of the estuary. The mangrove areas in the Asramom are nearly lost. Reclamation and bunding affect the natural facility for breeding and migration of species. As a result, impact to the system is the depletion of bioresources and economic loss. Comparison with past data proves that, the fish diversity as well as its abundance declined considerably in Ashtamudi Lake, and is attributed to various parameters like change in physiography, change in climate, unscientific fishing methods, over exploitation etc. The large population of fishermen living around Ashtamudi is finding it very difficult to earn a livelihood from the scarcity of fish and poor catches.

Pollution of the system though not severe, compared to the other areas, ground water pollution in many areas are considerable leading to scarcity of potable water. Increase in organic content in the soil resulted in heavy weed growth, which is creating problems to agriculture, fishing, and water transport.

2.3.2.2.5 Responses

After declaration of the area as Ramsar site in 2002, the Ministry of Environment and Forests initiated action for sustainable management of the area. A Management Action Plan was prepared by CWRDM and submitted to MoEF in

1999. The MAP aims at comprehensive development and management of the natural resources associated with the Ashtamudi Wetland System for its sustainable utilization and conservation. The major components included in the MAP are, catchment treatment (afforestation and soil and water conservation), conservation of flora and fauna, pollution control measures, scientific management of wetland fisheries, social interventions, monitoring and evaluation. The programmes are expected to be implemented through Departments and Agencies like, Department of Forests and Wild Life, Department of Fisheries, State Fisheries Resource Management Society (FIRMA), Soil Conservation Wing of the Agriculture Department, etc. The MAP was approved by the Ministry of Environment and Forests (MoEF), Government of India (letter No. J/22012/2/86-W dated 23.03.2000), is being implemented with the support and overall supervision of Kerala State Council for Science Technology and Environment, Govt. of Kerala.

2.3.3 Sasthamkotta Lake (Sl)

2.3.3.1 Introduction

2.3.3.1.1. Location and area

Placed at an elevation of 33 m above MSL, the Sasthamkotta Lake, the largest freshwater lake in Kerala (373 ha), is a designated Ramsar site since November,

2002. The lake is surrounded by low standing hills on all sides except south, where a bund (embankment) has been built to store larger volume fresh water and separate the lake from adjacent rice paddy fields. Water in the lake is special in that, it does not contain common salt or other minerals and metals.

SL is located in Kunnathur Taluk of Kollam District, (76 °36¢ 27² - 76 °39 ¢55² E. Long and 9 °00 ¢40 ² - 9 °04¢ 05² N Lat. Average depth of the lake was measured as 6.53m and maximum depth as 15.2m.The soil around the lake for about 10 - 20 m is mostly Kaolinite rich (derived from laterite) and hence, does not allow water to flow into the lake to any appreciable quantity. Earlier it was believed that the lake owed its supply mainly to the infiltration of ground water (Menon, 1967). However, later studies showed that Sasthamkotta Lake is a rain fed lake showing increases in water level at the end of monsoon rains. The yearly rainfall in the catchment area (area = 12.69 km2) of the lake is 282.16 cm and it has a storage capacity of 22.4 Mm3. It also consists of extensive marshy land, wet paddy fields and water bodies like 'Chelur pola' and 'Chirayathu Kayal'. An ancient Sastha Temple on its northern shores with resident troupes of monkeys, lends its name to the lake and town, adds sanctity to the waters and it is an important pilgrim centre

2.3.3.1.2 Physical setting

SL consists of two water bodies, viz., the main Sasthamkotta Lake and the adjacent Chelur Kayal, separated by a laterite ridge. These water bodies are surrounded by gently undulating lateritic hills on all sides except south where it is bordered by the alluvial plains of the Kallada River. A number of smaller water bodies and waterlogged areas occur in the river flood plains in the south and southwestern parts of Sasthamkotta Lake.

Geomorphologically the area can be divided into the following units:

· Undulating uplands: This unit consists of nearly rounded or flat topped lateritic mounts or hills with gentle slopes and intervening valley fills. The hill slopes are fairly thickly vegetated mostly with mixed crops and plantations.

· Valley fills: These are irregular valleys occupying the low-lying areas between lateritic hills, mostly filled by alluvial and colluvial deposits. Presently they are cultivated and densely populated.

· Flood Plains/Alluvial plains: Vast alluvial deposits occur in the flood plains of the Kallada River to the south. This unit is underlain by river alluvium mainly sand and silt and is mainly cultivated. Several water bodies and waterlogged areas occur in the flood plain.

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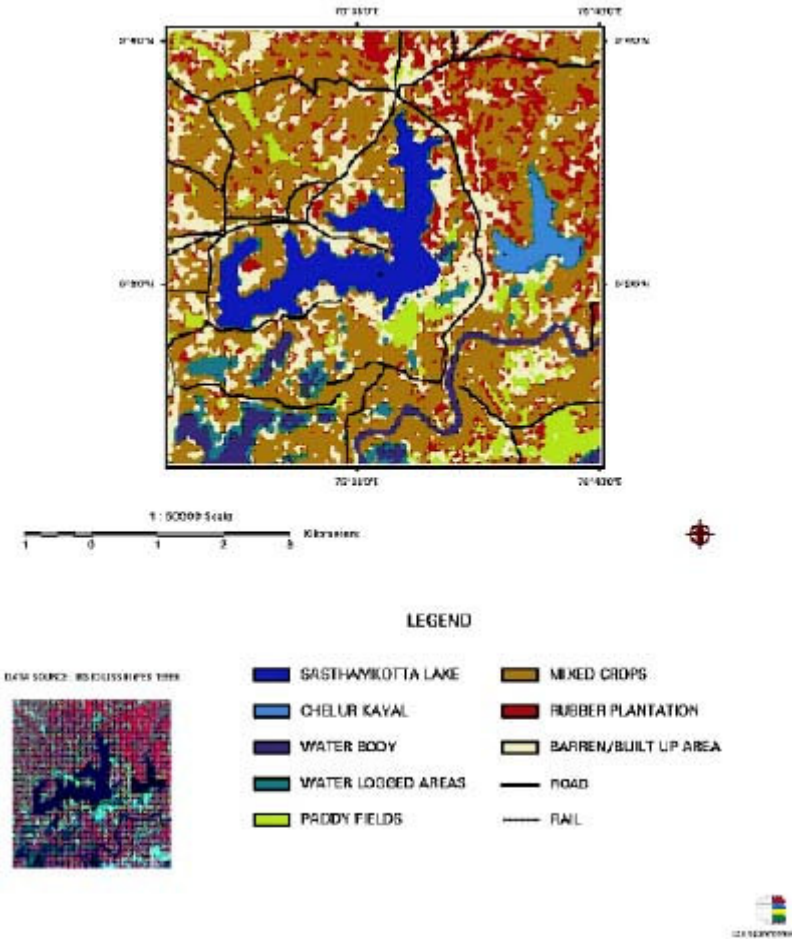

Fig.2.28: Sasthamkotta Lake and Environs (CED, 2003a)

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2.3.3.1.3. Hydrology

The lake is separated from the flood plain by a 1.5 km long earthern embankment constructed prior to 1956. The mean annual temperature is 26.70 in winter and 29.20 in summer, and the average annual rainfall is 2180mm. The hills, surrounding the lake, cover an area of 935 ha, drainanage empties into lake.

The quantity of water stored in the lake is estimated as 22.4 Mm3. The maximum water depth in the lake is about 13m. Water input to the lake is partly from of direct rainfall on the lake basin (8 Mm3), from surface runoff and groundwater inflow from the 935 ha. catchment (12 Mm3, assuming 60% runoff coefficient), thus making up a total of 20 Mm3.The average depth to water table in the area is around 3.89 m below ground level. Outflow from the lake is in four ways: spillage, groundwater seepage, evaporation from the Lake surface, and pumpage for water supply. Only the last two are known, the annual evaporation loss is of the order of

5 Mm3 (assuming 3.5 mm/d average evaporation), and the annual water withdrawal is 8 Mm3 at a pumpage rate of 22 MLD (million litres per day) (KWA figures). These jointly constitute about two- thirds of the inflow.

2.3.3.1.4. Biodiversity

About 110 species of herbs, shrubs and grasses and around 21 species of trees have been listed from this site (table 2.15). The land adjacent to shore line is dominated by grass species. In some areas, wild pineapple varieties have been planted for increasing soil stability and to prevent soil loss. The watershed of the lake has mainly coconut based agroforestry system with trees such as Mangifera indica, *Anacardium occidentale, Artocarpus integrifolia* etc.

Table2.15: Biodiversity of the Sasthamkotta Lake (Compiled from various sources)

Groups	No. of species
Flora	
Herbs, shrubs, climbers	110
Trees	21
Fauna	
Fishes/prawns	29
Insects	13
Birds	34

About 13 species of insects have been identified from the area out of which 9 are butterflies, 2 odonates and 2 hymenopterans. Twenty-seven species of fresh water

fish and two species of prawns were reported from Sasthamkotta Lake. Nearly 11 species of fishes are now available from Sasthamkotta Lake. This is attributed to the fact that, Sasthamkotta Lake is a stand alone water body and does not have connection with any other type of water bodies, whether stagnant or flowing. Migratory fauna is also very scarce in and around Sasthamkotta. Since drinking water is supplied to Kollam area from Sasthamkotta Lake, entire water body is separated from any inflow by a long 'bund'.

Migratory birds like teals are also present in this wetland. A total of 34 species of wetland dependant birds are reported from Sasthamkotta Lake. Out of which around 21% are long distance migrants.

2.3.3.1.5 Tourism

An ancient Sastha temple present near the lake lends its name to the town. So mostly religious tourists visit here, their frequency is very low. However, tourism in this lake is not welcomed by the people residing in Sasthamkotta as it alters the water quality. Presently one privately owned row boat permitted by District Tourism Promotion Council (DTPC) is being used for sight seeing. Accommodation is available at the PWD (Public Works Department) Rest House.

2.3.3.2 Major Management Issues

2.3.3.2.1. Driving forces

The major driving forces of environmental change are agriculture (especially in the banks of the lake), fisheries, services like water supply, sanitation, etc., households and human settlements, pilgrimage, locally specific activities like washing of clothes(dhobis) etc. The number of residents settled in the catchment has been on the rise recently. Residents usually cultivate tapioca, paddy and plantain on the slopes. The unscientific agricultural practices force soil erosion. Residues of fertilizers and other chemicals used in the agricultural fields are draining into the lake. A good amount of sewage and garbage from the homesteads in the catchment area is also reaching the lake. The hut-dwellers soak dry leaves of coconut palm before matting which used for thatching huts. Water is polluted by soaps and detergents used for washing clothes and bathing.

2.3.3.2.2 Pressures

The water of Sasthamkotta Lake is used for supply of drinking water by Kerala Water Authority to Kollam Municipality and suburbs. The lake serves as a major source of water, sink for various pollutants and transformer in the cycling of nutrients, chiefly carbon, nitrogen, sulphur and phosphorus. It also serves as an ideal habitat for diverse flora and fauna. The lake offers considerable scope for fresh water aquaculture.

Population growth will put added pressure on resources because of the rising demand for land for housing and other developments, demands on living resources for food, recreation and fresh water. The increasing human settlements in the catchment area of the lake also increases various types of stresses in the ecosystem in terms of pollution due to solid waste, sewage, fertilizer residues and other chemicals, aesthetic issues, etc

Other major pressures are (i)Reclamation of the land for agriculture along the banks and adjacent areas, unscientific cultivation practices such as Tapioca cultivation in hill slopes causing soil erosion (ii) Entry of agricultural and domestic waste including sewage from surrounding area entering the lake, (iii) Pollution by used by professional washer men (dhobis), (iv) Pollution from pilgrimage ultimately reaching lake and (v) Land use Change - encroachment into the wetland creating various environmental pressures on the landscape and habitat transformation and reduction in biodiversity. The native inhabitants say that the area surrounding the lake supported greater number of trees in the past and that it is now denudated. The number of residences on the banks of the lake has been on the increase recently. There occurs pollution from local tourists who visit the area. There is a ferry service across the lake transporting people between West Kallada

and Sasthamkotta. Dhobis are using the lake for washing clothes.

2.3.3.2.3 State of Environment

The water quality data of lake are given in (table 2.16). Water quality meets all standards of drinking water prescribed by regulatory bodies. Lake is kept protected by separating it from any inflow of water from any source. The oxygen content of water is usually high and turbidity is always below 10.

Table 2.16: Water Quality, Sasthamkotta lake (CED 2003a)

Parameters	Site 1	Site2
Colour	Colorless	Colorless
Odour	Nil	Nil
Depth (meter)	16	17
pH (NTU)	7.06	7.06
Turbidity (mg/l)	19.4	19.2
Dissolved Oxygen (mg/l)	7.2	7.2
Hardness (mg/l)	12	8
Acidity (mg/l)	10	20
Alkalinity (mg/l)	12	12

Salinity (ppt)	0.007	0.0052
Total Solids (mg/l)	4000	3400
Total Dissolved Solids (mg/l)	3500	3200
Total Suspended Solids (mg/l)	500	200
Chloride (mg/l as NaCl)	6.403	4.80
Sulphide (mg/l)	11.2	20
Nitrite (mg/l)	0.0002	0.0003
Phosphate (µg Po_4- P/l)	0.004	0.003
Primary Productivity (mg/l/hr)	-	0.4

A study conducted by Centre for Earth Sciences Studies, Thiruvananthapuram shows that the dissolved oxygen is usually 4.49 mg/l and 3.33 mg/l (standard dissolved oxygen should be >6). Magnesium content, which contributes to the hardness of water, is very meager. The faecal Streptococci count is also within the limits. The slight variation in acidity / alkalinity may be attributed to the fact that a lot of detergents are getting added to the water body from 'bathing ghats' located by the side of temple along the northern shore.

2.3.3.2.4 Impacts on population, economy and ecosystem

The unscientific cultivation of hill slope especially for annual crops like tapioca has increased the soil loss by erosion and runoff into the lake basin leads to decrease in water storage capacity. The change in land use and increasing agriculture in the catchment indirectly reduce the ground water recharge, which has its repercussion in the water availability in the lake.

2.3.3.2.5. Responses

The Sasthamkotta Fresh water Lake is one of the designated Ramsar Site in Kerala. Prior to this declaration, several studies had been taken up by different agencies on the conservation and management of the Sasthamkotta Lake.

Proposal for the implementation of Management Action Plan (MAP) for Sasthamkotta Wetland was submitted by CWRDM through Govt. of Kerala to the Ministry of Environment and Forests (MoEF), Government of India, during 1999. The MAP aims at comprehensive development and management of the natural resources associated with the Sasthamkotta Wetland System for its sustainable utilization and conservation. The component of activities in the MAP included agro-forestry in the catchment, sanitation and drainage, pollution abatement, limited desilting, weed control, conservation of flora and fauna, fishery development, and awareness campaigns among

the local inhabitants. The programmes are expected to be implemented through Kerala Water Authority (KWA), Department of Forests and Wild Life, Department of Fisheries, State Fisheries Resource Management Society (FIRMA), District Rural Development Agency (DRDA), CWRDM, etc. Sanction for MAP was accorded by the MoEF. The action plan is being implemented with the support and overall supervision of Kerala State Council for Science Technology and Environment, Govt. of Kerala

2.3.4 Periyar Reservoir (PR)

2.3.4.1. Introduction

2.3.4.1.1 Location and Area

Periyar Tiger Reserve (PTR) is located between 90 15' and 90 40' N Latitude and 760 55' and 770 25' E Longitude in Idukki District. The Reserve is unique and world famous for its variety of large mammals. The formation of the reserve is closely associated with the construction of Mullaperiyar Dam across the river Periyar in 1895 for diverting water to Tamil Nadu. As early as 1899 itself, the area consisting of 600 sq. km surrounding the dam was declared as Reserve Forests (Periyar Lake Reserve Forests) by the then Maha Rajah of Travancore. The intention might have been to protect the catchment area so as to prevent the dam from silting. This later led to the formation of Wild Life Sanctuary in 1934. In 1950 another 177 sq km was added to make the total area of 777 sq km, and was designated as Periyar Tiger Reserve in 1972. Recognising the importance of the reserve it was brought under the Project Tiger in 1978 and to be known as Periyar Tiger Reserve. For management purposes, the entire reserve is divided in to Core zone (350 km2), Buffer zone (377 km2) and Tourism zone (50 km2). The core

zone of the sanctuary was declared as National Park in 1982.

2.3.4.1.2 Hydrology

Two streams Periyar and Mullayar and the lake with an area of 26 sq km form the major aquatic ecosystem of the reserve. The Mullayar originating at an altitude of about 1780 m at MSL has a length of 31 km and joins the southern tip of the lake. The periyar Stream with a length 41 km, joins the eastern tip of the lake from south originates at an altitude of 1593 m at MSL. The system is more or less a closed one due to the presence of Mullaperiyar dam. The water from the reservoir overflows to the down stream when it reaches 41 m though this happens very rarely (twice for a couple of days in a decade). The only outlet of the reservoir is the tunnels from the lake to the plains of Tamil Nadu. It also harbors the largest contiguous stretch of evergreen forest. Due to all the above factors, Periyar area including the Lake holds high conservation value.

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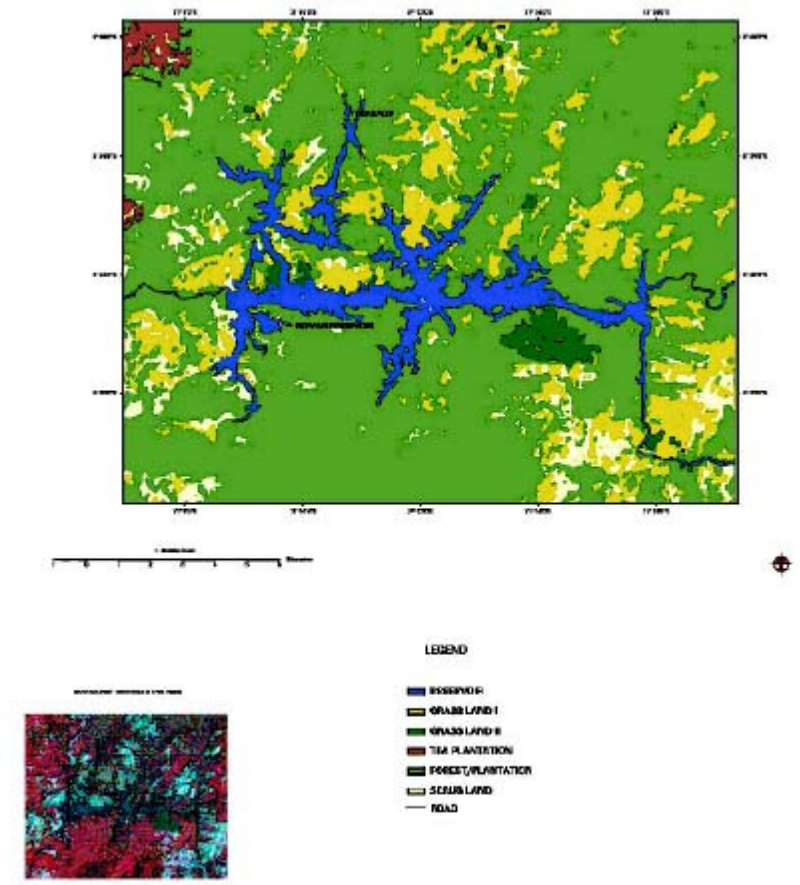

Fig.2.29: Periyar Reservoir and Environs **(CED, 2003a)**

2.3.4.1.3 Physical setting

The area in highland setting terrain characterized by steep to moderate hill tops, rounded hill tops, ridges and escarpments. The most distinct feature of the physiography

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is the straight courses of stream segments oriented in specific directions, indicating r strong control by major lineaments along N-S, E-W, NE-SW AND NW-SE directions. The altitudes vary from about 870m to over 1300m. These hills are mostly covered by dense to open forest, grass and plantation crops. Presently, the Periyar reservoir fills a valley network.

Geomorphologically, the entire area comes under the denudational landforms. The underlying lithology consists of the Archaean crystalline rocks such as charnockite, hornblende and biotite gneisses and pink granite gneiss with basic dykes. The topography is strongly controlled by major fractures (lineaments) and stream courses are largely controlled by the latter. Denudational hills with smooth vegetated slopes dominate the terrain. Though these are steep slopes and escarpments, most of the summits are rather rounded. Fluvial terraces and valley fills occupy the valleys, but most of these are cover by water at FRL.

2.3.4.1.4 Biodiversity

Periyar Tiger Reserve (PTR) has been known to be a mega biodiversity zone due to the rich and diverse ecosystems (table 2.17). There are five distinct vegetation types identified within the sanctuary viz. evergreen, semi-evergreen, deciduous, grasslands and secondary eucalyptus plantations. Evergreen and semi-evergreen forests are found in the buffer and core zones and cover about 40% of the area of the reserve. Due to the heavy stocking and presence of different layers, light penetration is low and hence ground vegetation is not significant. The common tree species found in similar forest types are also present here such as *Cullenia exarillata, Dipterocarups bourdilloni, Vateria indica, Canarium strictum, Artocarpus hirsutum, Callophyllum tomentosum, Xylia xylocarpa* and *Gluta travancoria*. The area surrounding the lake and tourist zone has a mixture of semi-evergreen and moist deciduous forests

Table 2.17: Biodiversity of PR (Compiled from various sources)

Item	No. of species
Flora	
Herbs, shrubs, climbers	42
Trees	30
Phytoplankton	11
Fauna	
Fishes	39
Insects	36
Birds	28

interspersed with grassland both in the valley and hilltops. Large variety of common deciduous trees such as Bombax malabaricum, Careya arborea, Pterocarpus marrsupium, Lagerstroemia lanceolata, Tectona grandis and many species of Terminalia and Fiscus are common place in these forests.

The grasslands are a distinctive feature of PTR, which are found often scattered with clumps of dwarf Phoenix. Two type of grass lands are identified such as the South Indian subtropical hill Savannah (grass lands with trees like Terminalia paniculata and Emblica officinalis) and southern montane wet grass land (only grasses). The main variety is elephant grass, which are commonly grazed by elephants, deer and bison.

The rich flora of PR also supports large number of mammals, birds, reptiles, amphibians and fish. Nearly 120 species of lower vertebrates and amphibians are found in PR, of which 85 are endemic. There are 49 mammals identified which include tiger, panther, wild dog, jungle cats, elephants, gaur, sambar, barking deer, mousedeer, Nilgiri langur, bonnet macaque, lion tailed macaque, bear, porcupine jackal, Indian giant squirrel, Malabar flying squirrel, wild boar, small Indian civet, common palm civet, mongoose, hare, pangolins, Nilgiri Thar etc.

Periyar has a thick vegetation of forest and non-forest species. But only those species lying in close proximity and under the influence of the Periyar Lake have been considered here. Around 42 species of herbs, shrubs, grasses and 38 species of trees were reported from here. Flora is mainly forest type dominated by tree species, in the surrounding areas. But the sectors adjacent to the shore line have herbs, shrubs and grasses. Other vegetation types in the vicinity include evergreen, moist deciduous, grassland, scrub and degraded savanna. Eleven species of phytoplankton have also been identified, of which many species are endemic to Western Ghats.

In a pioneering study fishes of Periyar reserve Chacko (1948) reported 35 species in the system, While a recent study by Arun (1997) reported only 27 species from the Periyar aquatic ecosystem (lakes and streams). Of these 14 are endemic to Western Ghats and/or Periyar and 14 species have threatened status, while 9 are threatened and endemic. All species of loach, except Malabar loach

(Lepidocephalus thermalis) are endemic to Western Ghats, and one among them - Travancore jonesi - has the threatened status. Though two snakeheads are known in the system, these rarely find a place in the catches. Of the 13 cyprinid species, 8 are endemic to Western Ghats and 3 are exclusively endemic to Periyar Lake and streams. All endemic cyprinids except Gara mullya are threatened, so are the cat fishes *(Heteropneustes fossils and Glyptothorax madraspatanam)* and spiny eel *(Mastacembelus armatus)*. Two species viz., Tilapia *(Oreochromis mossambicus)* and European Carp *(Cyprinus carpio communis)* are the exotics in the system, and were absent in Chacko (1948), which confirms the

fact that these were latter introduced in the system after 1948. These species also occur in the Idukki reservoir down stream, again by introduction in mid 70s as part of Fisheries Development programme (Gopinathan and Jayakrishnan, 1984).

Food - niche - competition between Tilopia and endemic species is one of the reasons attributed for the vanishing of endemic species. Further, endemic species are mostly restricted to flowing water conditions. But exotic species prefer stagnant habitats, a positive factor utilizable for management of fisheries in this wetland. The chief fish types are Kuil, Kooral, Gold, Tilopia, Chottavala, Aarakom, Kari, Varal, Karian, Karimpachi, Pavukan, Kallotti, and Vazhakavarayan.

Bird population is considerably high in and around the water body, with about 30 species of migratory and endemic species, and many of these roost with nests at top of the tree stumps. About 28 species of wetland - dependant - birds are on record from Periyar Lake, out of which 27 % are long distant migratory type. Cormorants, the most abundant birds at Periyar Lake, are followed by egrets, herons and storks. Around 36 species of insects (i.e., including 20 butterfly species, 2 dragonflies, 5 wasps, 7 grasshoppers and 2 beetles) have been recorded. Land around Periyar Lake has considerably fair grass population and tree species and the highest insect diversity can be attributed to this.

2.3.4.1.5. Tribal Groups

Four tribal groups, viz., Mannans, Paliyans, Malaarayans, and Uralis, inhabiting the environs of PTR, though once lived deep inside the forest were relocated at the boundary of buffer zone, while creating the reserve. Now these communities live in three settlements around the reserve, viz., Mannan and Paliyan at Labbakkandam near Kumily, Malaarayans in Moozhikkal and Uralis at Vanchivayal settlement. The Labbakandam colony is near the Lake. Among the tribal groups, Mannans are the traditional fishermen. Considering the importance of fishing for the livelihood, forest department has vested fishing rights to this community. Paliyans primarily depend on dry wood gathering for sale and casual jobs, and at times though engaged in fishing.

2.3.4.1.6. Eco Development Committees (EDC)

EDC was launched in November 1998, has families residing around forest area as members. There are 92 EDCs in the PTR, which helped reduce dependency on forests and its products, by ensuring peoples participation in wild life conservation. EDCs also help to control illegal felling of trees and poaching of animals and forest fire. The EDC gets aid from local self-governments and intern provides assistance to fishermen, deploys members as guides to visiting tourists, undertakes group farming, assists in setting up cattle farms and help in starting provision stores.

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2.3.4.1.7 Tourism

Thekkady, which comes under the confines of Periyar Tiger Reserve, is a major tourist center in Kerala. Annually, thousands of domestic and foreign tourists frequent this area to feel the thrill and joy of boating in Periyar reservoir for a glimpse of wild elephants, tigers, leopards, bison, etc. in their natural habitat. Flora and fauna of the area are nearly intact and protected with strictly monitored and controlled human intervention. The use of plastics is strictly banned. The economic value of the wetland may be considered the highest, when compared to other wetlands, because of the income accruing from tourism.

2.3.4.2. Major management issues

2.3.4.2.1 Driving forces

Agriculture in the downstream areas, fisheries, households and human settlements, services like water supply and irrigation, industry, tourism, research and academic activities, local tribal activities etc are the major driving forces. Fishing in Periyar river which runs through the Periyar Tiger Reserve is by tribals who use gill nets, traps, hooks and baits. Water stored in the Mullaperiyar dam is utilized for irrigating three districts of Tamil Nadu.

2.3.4.2.2 Pressures

Periyar is one of India's most visited but protected areas, hence environment around the Lake suffers great pressure. Adequate steps are already positioned to protect and conserve the area through many eco- development programmes.

2.3.4.2.3 State of environment

PR and environment do not face problems with regard to pollution, since; it is enclosed by evergreen forest on all sides. Water quality analysis is given in (table 2.18). (CED, 2003a) reported that there is no pollution and the only possible source

of pollution may be the motorized boats casting use of oil and grease.

Table 2.18 :Water Quality, Periyar lake (CED 2003a)

Parameters	Site 1	Site2
Colour	Colorless	Colorless
Odour	Nil	Nil
Depth (meter)	1	9
pH (NTU)	-	-
Turbidity (mg/l)	18.8	20.2
Dissolved Oxygen (mg/l)	6.4	7.6

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Hardness (mg/l)	12	16
Acidity (mg/l)	10	10
Alkalinity (ppt)	32	32
Salinity (mg/l)	0.07	0.021
Total Solids (mg/l)	900	1200
Total Dissolved Solids (mg/l)	400	600
Total Suspended Solids (mg/l)	500	600
Chloride (mg/l as NaCl)	9.8	13.13
Sulphide (mg/l)	52.48	51.2
Nitrite (mg/l)	0.0003	0.0005
Phosphate (µg PO_4- P/l)	0.24	0.256
Primary Productivity (mg/l/hr)	_	3.2(gross) 2.4 (net)

2.3.4.2.4 Impacts on population, economy and ecosystem

Arun (1997) demonstrated that the number of fish species in Periyar Lake reduced to 27 from 35 reported by Chacko (1948), warranting a complete ban on of fisheries in the Lake, especially where it has the status of Tiger Reserve.

Prior to the founding of sanctuary, the tribals, viz., the Mannans and Paliyans were totally depended on forests for their livelihood. But the creation of the sanctuary curtailed their rights on forests, and infact were relocated to the periphery, along with mandated concessions most important being fishing rights to Mannans in the Lake and collection of dead-wood from the buffer zone, as well as the collection of non-timber forest products. As the part of the management and protection activities, forest department employs number of tribals as firewatchers and protection watchers. Besides, forest land is allotted to the tribals for cultivation; which has created a positive impact on the quality of life of the tribal as well as their involvement in conservation activities.

2.3.4.2.5 Responses

The PTR is a good example for how non-consumptive tourism and related activities can be effectively implemented without causing any degradation to the forest ecosystem. The EDCs working in the area utilized for the activities. The Periyar model of participatory bio-diversity conservation is emerging as a dynamic

and sustainable example for the entire developing world.

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2.3.5 KADALUNDI ESTUARY (KE)

2.3.5.1 Introduction

2.3.5.1.1 Location and Area

Kadalundi estuary, lying at the boundary of Tirur taluk of Malappuram district and Kozhikode Taluk of Kozhikode district (N lat 11049'36" and 1108'28" and E long 75049'36" and 75053'20"), is spread over 60 acres of mud flats rich in alluvium, brought by Kadalundi River. The mud flats is exposed from September to May and completely covered by water from June to August.

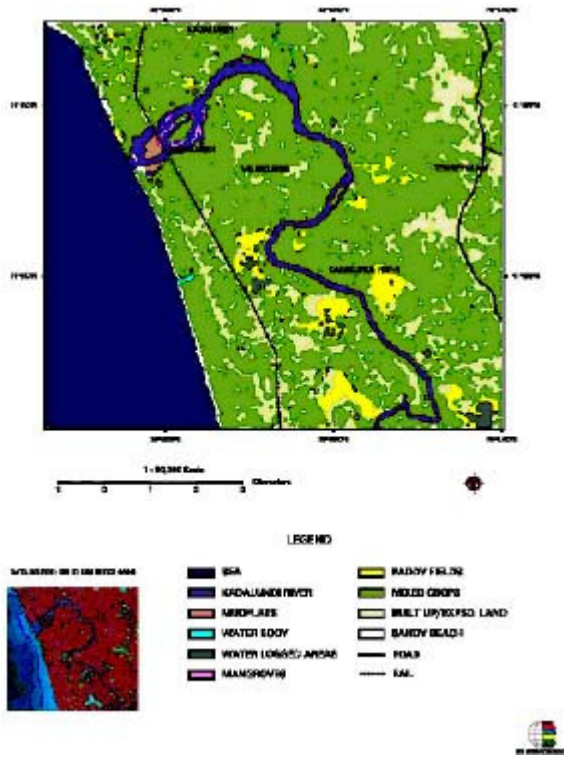

Figure 2.30 : Kadalundi Estuary and Environs **(CED, 2003a)**

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2.3.5.1.2 Hydrology

The Kadalundi estuary has a very constricted neck and an unusually wide and shallow wetland upstream dotted with small islands and mangroves. A large portion of the shallow wetland is exposed during (diurnal) low tides with an average tidal cycle of 12h 25m. The frequent exposure of the bed attributes unique characteristics to the wetland. The main tributaries to Kadalundi are Olipuzha, Velli Ar and another passing through the Perinthalmanna area. Kadalundi River originates at 1160 m at MSL from Cherakkambam Mala, and has a channel length of 130km, before discharging into the Arabian Sea.

As the summer discharge is very low, salinity intrudes into the estuary as far as Mannathupara, 14 km upstream from the confluence, where a substantial urn structure exists. The tidal fluctuations in this wetland are similar to what is observed in medium- sized estuaries elsewhere in the State (table 2.19).

Table 2.19: Tidal Fluctuation of Kadalundi Estuary (CWRDM)

Date	High Tide	Low tide	Diff.	High Tide	Low tide	Diff.
25.04.03	0850 228	1200 257	29	1650 230	2200 249	19
26.04.03	0710 230	1230 258	28	1800 245	2300 255	10
27.04.03	0900 190	1500 252	62	1000 174	0525 248	71
28.04.03	1100 196	1700 254	56	2300 170	0515 260	90
29.04.03	1100 189	1640 249	60	2250 185	0600 246	63
30.04.03	1210 201	1700 256	55	2220 196	0550 257	61
01.05.03	1225 182	1735 256	74	2315 180	NA NA	
02.05.03	1300 188	1825 251	63	2335 187	0650 255	68
03.05.03	1305 182	1900 252	60	NA NA	0715 256	
04.05.03	1330 202	1950 247	45	NA NA	0800 256	
05.05.03	1400 208	2010 239	31	NA NA	0835 259	
06.05.03	1440 211	2100 236	25	NA NA	0910 249	
07.05.03	1500 217	2050 241	24	NA NA	0945 241	
	1515	2105		NA	1020	
08.05.03	219	251	32	NA	258	

2.3.5.1.3 Biodiversity

Kadalundi estuary has good mangrove vegetation along the sides of abutments and pillars of the railroad bridge. Studies on the mangrove and other plant species carried out by CED (2003a), reported that the predominant mangrove species is Acanthus ilicifolius followed by Avicennia officinalis. Mangrove vegetation is almost truly composed of true mangrove species but associates are very few. For

this area Simpson's index and Shannon Wiener's diversity index are 0.49 and 1.5 respectively. Proper conservation and management efforts can ensure sustenance of very good thick mangrove vegetation. The chief species are: *Acanthus ilicifolius, Acrostichum aureum, Aegiceras corniculatum, Avicenia marina, A. officinalis, Bruguiera cylindrica, Derris trifoliata, Exocoecaria agallocha, Kandelia candel, Lumnitzera racemosa, Rhizophora apiculata, R. mucronata, Sonneratia alba etc.*

Kadalundi estuary has considerably good fish population as it is in close proximity to the sea due to which both fresh water and marine fish - species are available. There is a large fishworker community here dependent on this valuable resource, with common species like Poozhan, Thirutha, Malan, Chemmeen (different varieties) etc.

The flora of the area consists of 19 tree species and 180 herbs, shrubs and climbers (table 2.20). Around 34 species of fish and 19 species of insects including 12 butterflies have also been identified (CED, 2003a)

Table 2.20: Biodiversity of Kadalundi Estuary (CED, 2003a)

Item	No. of species
Flora	
Herbs, shrubs, climbers	180
Trees	19
Fauna	
Fishes	34
Insects	19
Birds	53

Kadalundi estuary has very large bird population of about 53 species, birds of the order Charadriform, particularly family Caridae (Gulls and terns) dominate the estuarine bird community. Brown and black-headed gulls are the most common. Terns, plovers, sand pipers and stints are the next most numerous forms in that order. There are also a large number of resident land birds like crows, bee-eaters, mynas, pigeons, parakeets and water birds like reef and pond herons. The birds are seen mainly resting on the

mud flats adjacent to the Railway Bridge, only to feed on the very rich treasure of small organisms like worms, crabs and other tiny creatures in the mud flats.

2.3.5.1.4 Tourism

Kadalundi area is scenically very beautiful with the estuary on one side and the sea on the other and with thick luxuriant mangrove vegetation, where the latter is home to a large number of migratory as well as resident birds. Consequently Kadalundi holds very high tourism potential. The details of the non-consumptive tourism potential for the Kadalundi estuary area are listed below:

a. Potential for development as non-consumptive tourism hub with special thrust to bird watching, game fishing etc.

b. Boating using pedal and row boats has high potential in the area.

c. A Biodiversity Interpretation Centre can be developed with special focus to avifauna, mangroves and fishes.

d. In addition to the local community support, the assistance from the Calicut University can also be availed.

2.3.5.2 Major Management issues

2.3.5.2.1 Driving forces

The driving forces of environmental change are fisheries, aquaculture, small indutries, household, shell mining, services like water supply and sanitation, activities of researchers and academicians, and to certain extent tourism. there are around 200 persons engaged in fishing and around 50 families are involved in mussel cultivation usually in high saline waters. Sand mining is also common in this area.

2.3.5.2.2 Pressures

· The major issue in conservation of the mangrove area is the conflict between local residents and conservationists (e.g., KFD, NGOs like KSSP etc.). Natives are afraid of the growth of mangrove areas as it might affect their livelihood, expose them to nuisance from the animals like otter, snakes etc., inhabiting the mangrove and reduction of available waterspread areas for coir retting. For instance, at some locations mangrove trees have grown (intruded) into the private households and the department prohibits clipping of the branches. Such factors led the local community to block measures of mangrove conservation.

· Dumping of solid waste, excreta coming of hanging latrines etc are common. A number of conventional latrines with outlets leading to the water body is also present.

· Several sites in the area are used for coir retting, leading to pollution of water. Recent KFD decision to stop the coir retting adjacent to mangrove areas, adversely affected the livelihood of people involved in coir making.

· Siltation has affected many locations of the estuary especially when sand mining is completely banned. Reclamation of estuary carried out by members of local community, affecting the ecology of the estuarine ecosystem.

2.3.5.2.3 State of environment

Water quality parameters do not show much variation. Pollution indicators show slight variation in values (table 2.21). This may be attributed to the fact that Kadalundi estuary is receiving a lot of pollutants in the form of domestic sewage. Also coconut husk retting, which was once widely practiced in the area at one time and had been banned in the open water body by the Kerala Forest Department, is now being carried out in tanks and these effluents are also being let out into the estuary.

Table 2.21: Water quality, Kadalundi estuary (CED 2003a)

Parameters	Location			
	Balathuruthu 1	Mannenn-edu	Bala-thuruthu 2	Penayenn-edu
Colour	Colorless	Oily	Brown	Colorless
Odour	Nil	Nil	Nil	Nil
Depth (meter)	1	0.4	0.45	0.25
pH (NTU)	7.60	8.03	8.07	8.18
Turbidity (mg/l)	18.7	23.4	38.6	48.1
Dissolved Oxygen (mg/l)	5.6	5.6	6.4	6.4
Hardness (mg/l)	6170	6100	6030	6110
Acidity (mg/l)	20	10	Nil	Nil
Alkalinity (mg/l)	100	96	104	108
Salinity (ppt)	32.6	33.4	33.3	34.76
Total Solids(mg/l)	41400	41300	41900	43300
Total Dissolved Solids (mg/l)	40200	41000	41600	39400
Total Suspended Solids (mg/l)	1200	300	300	3900
Chloride (mg/l as NaCl)	29773.27	30515.5	30433.05	31752.65
Sulphide (mg/l)	1.6	5.6	4.8	2.4
Nitrite (mg/l)	0.04	0.099	0.051	0.095
Phosphate (µg Po4-P/l)	0.159	0.08	0.2	0.17
Primary Productivity (mg/l/hr)	_	0.4	_	_

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Sanitation issues especially the "hanging Latrines" in the river shores, directly discharging human excreta into the water body, is creating many environment and health problems. The coconut husk retting creates pollution in many sites. The traditional coir retting process has so many limitations and also makes use of land and water body for the purpose.

In addition to mangroves present in public land there is one major mangrove patch of 3.5 hectares, which is a private property. From the fishery point of view, the mangroves here play an important role as a nursery ground for the early life stages of fish and shellfish affording protection to these organisms from adverse conditions of the open waters. The "capture" fishery does not interfere with the environment, resource and recruitment of the coastal fisheries in any appreciable manner.

2.3.5.2.4 Impacts on population, economy and ecosystem

· Depletion of bioresources due to loss of mangrove vegetation and intensive aquaculture is a major threat to the environment.

· The reduction in fishery resources leads to many socio-economic problems.

· The activities initiated for non-consumptive tourism generates revenueas well as helps in conservation is a positive impact on the economy and environment.

2.3.5.2.5 Responses

Keral Forest Department, based on the recommendations of a CED (2003a) study, is now implementing an Integrated Approach to Mangrove Management by cpacity building in the local communities, government agencies and grassroot level institutions to restore conserve and utilize the mangrove wetlands in a sustainable manner. The success of the project will ensure a symbiotic link between the "livelihood security of coastal communities" and the "ecological security of coastal areas".

2.4 Conclusion And Recommendations

2.4.1 Conclusion

Loss of the world's wetlands poses an increasing problem because of loss of important, ecological and economic values, perhaps irreversibly, when natural wetland is transformed or degraded. Role of biodiversity in supporting the wetland system and its resilience are not well known; however, the values offered by many wetland systems to human society are extremely important. Although difficult to estimate, the total life support function of wetlands may be particularly significant, as wetland comprises a diverse range of marine, coastal, estuarine and freshwater habitats.

In Kerala, wetlands are under more extreme pressure compared to any other State, which is attributed to relatively very high population density. Studies carried out in

recent year's point out the undesirable changes taking place in the geological, physical, chemical and biological environment of the wetlands of Kerala. Partitioning by bunds, reclamation and consequent shrinkage have been implicated as major reasons for the destruction of habitat and dwindling of resources

With the rising population, pressure on land for agriculture, aquaculture, urban expansion etc., too has increased. As a result of denuding, polluting, draining, filling etc., these ecologically vital areas all over the globe have been under severe threat.

Threats to wetlands may be man made, natural or both. Direct human interventions like reclamation for agriculture, urban expansion, housing development etc., totally obliterate wetlands. Mining of wetland, construction of dams and check dams for flood control, discharge of sewage, pesticide and weedicide residues degrade the wetland to a large extent. Indirect threats include increased siltation due to unscientific land use practices in the catchment area, mining, oil exploration etc. Added to these are the natural causes like eutrophication, erosion, storm damage, drought, biotic interferences other than anthropogenic etc. All these lead to the destruction of wetlands, partly or totally.

The existing body of laws (within the federal structure of the Government of India) applicable to wetlands can be classified into four categories, viz., central laws, state laws, municipal laws as well as customary laws (sanctioning wise use or management of wetlands). Under the Wildlife Protection Act (WPA) and other central acts, like the Indian Forest Act, wetlands are not even defined as a separate category of ecologically important areas, but instead generally form part of protected areas, especially when wetlands are habitat of endangered wildlife (and exist within sanctuaries or national parks). The existing laws would be amended to incorporate a broad inclusive definition of wetlands (specifically in the WPA), to facilitate and make it legally binding for wetland managers to draw up wetland conservation plans. Equally, it would make it mandatory for the Government agencies (central and state) to offer institutional and financial support for local wetland management and its wise-use-practices. The Wildlife (Protection) Act of 1972 provides for establishing sanctuaries (section 18) and national parks (section 35) and thus offers protection to wetlands which are within the protected areas. However National Wildlife Law places a strict ban on grazing within a national park, and hence human impact and thus helps the wetland ecosystem. This restriction in national parks (which are zones of highest protection in protected area categories) makes wise use or non-consumptive use of the wetland virtually impossible.

In India the conservation and wise use of wetlands are vested in the Ministry of Environment and Forests (MOEF), the Department of Fisheries, the Ministry of Agriculture, the Ministry of Water Resources, the Ministry of Surface Transport, the Ministry of Power, the Ministry of Tourism and the Department of Ocean Development

of the GOI. Since land is a State subject, various State government agencies are also involved in making decisions on wetlands (which are equated with land).

Keeping biodiversity under public good has been cited as one of the reasons for the steady degradation. People's movements play a crucial role in influencing policy matters. Ensuring community participation in planning and decision making at all

levels and local vigilantism with the involvement of Local Governments, and NGOs may help in the effective implementation of the Environmental Management Plan (EMP). For such reasons, a whole series of measures, concerning land-use in tourist areas should be launched to remedy damages.

2.4.2 Recommendations

2.4.2.1 Legal, policy and institutional requirements

As a valuable natural resource, wetlands are to be preserved under the policy resolution of sustainable development and environmental protection. Yet, there is no comprehensive legislation for protection, conservation and management of wetlands in Kerala. The term management is inclusive of utilisation, maintenance and development of the wetlands, within the framework of a conservation policy. Hence, there is an urgent need for enactment of policy procedure for the conservation and management of wetlands in the State.

Local Self Government can help the sustainable development activities by formulating and monitoring activities with people's participation. Effective implementation of solid waste management programme in all households shall be facilitated by the local governments and in other sectors by implementation of Solid Waste Disposal Act, 2000. What is needed is a political will to go ahead. Legislation for conservation and management of wetlands shall address the following aspects like:

(i) Regulatory Mechanism

(ii) Administrative Mechanism

(iii) Enforcement Mechanism

(iv) Participatory Management Approach

(v) Adjudicatory and Appellate Agencies

(vi) Punitive and Reformatory Measures

Additionally following measures need to be adopted:

· National Wetland Policy by the Ministry of Environment and Forests

· Legal actions and policy decisions both at National and State level, to prevent unauthorized and unscientific land reclamation.

· EIA for all reclamation and development projects, at or near the wetlands and drainage basins and a mechanism for strict monitoring of the EIA recommendation.

· Pollution Control Board is to co-ordinate activities of various development departments, and KSCSTE to reduce and eliminate wetland pollution.

· Wetlands have archaeological, historical, cultural and scientific values. Kerala has good potential to develop tourism industry centered on wetlands. So the carrying capacity of wetlands vis-à-vis tourism should be scientifically evaluated to regulate development activities. The following multi-point check list should be verified in the process.

o Preparation of an inventory of basic tourist resources.

o Implementation of measures to conserve resources listed in the Inventory.

o Plans for tourism development are best used for tourism development.

· Entrust tasks of conservation and management of bioresources with the LSGs, like

o Effective implementation of solid waste management programme in all households, to prevent dumping into the wetlands

o Ensure community participation in planning and decision making local vigilantism with involvement of LSGs and NGOs.

o Environmental awareness and capacity building programme for community and members of LSGs monitoring wetlands.

o Mechanism to promote responsible tourism

o Mangrove ecosystem though has a major role in the conservation of wetlands, it faces a steady decline. Therefore, conservation of existing mangroves and measures of regeneration of degraded ones, as part of wetland management, are essential and can be achieved by implementation of the Coastal Regulation Zone Act under 6(1) category I (CRZ-I).

o The Forset department shall adopt a programme for people-centered, process-oriented and science-based Joint Mangrove Management (JMM). The benefits and lessons learned by JMM shall be shared with, the mangrove user community (particularly the women), local administrative departments, and NGOs,

especially in the management functions like resource mapping, planning, regeneration, protection, and benefit sharing.

o Mangrove Conservation Corps (MCCs) and Green Police shall be formed to be in charge of mangrove with the responsibility of conservation and protection of the mangrove areas and in providing leadership to regeneration/afforestation activities. The members shall consist of representatives of local population, NGOs, different stakeholders etc.

o Eco - Adoption - Programmes: As many of the mangrove areas in Kerala are in vested lands, facing severe threats in the form of deforestation and reclamation. For example, Kadalundi a major mangrove of about 3.5 ha, is a private land. Such land can be purchased for conservation purpose by a consortium with funds contributed by individuals / institutions, who are interested in conservation of mangrove ecosystem. Such land shall be apportioned among the members of consortium based on an individual's level of contribution and with an agreement to utilize the area only for conservation purpose.

2.4.2.2 Research Needs

Inspite of the fairly large volume of work carried out on the various aspects of wetlands of Kerala, there is no public repository of data and summary embodied in the documents. A programme for digitization and aggregation of all work irrespective of bulk or origin or even language is highly imperative. Digital maps and cadastral maps of wetlands shall be part of the repository and KSCSTE is the appropriate institution for maintaining this archival data base. This data base should form the physical and ecological backdrop of any new design for developing wetlands directly or indirectly like the alignment of right of way of a new road or rail road.

Wetland maps presently available are in the scale of 1:2, 50,000 and 1:50,000 which are less than adequate for a detailed study. Formulation of management plans, need maps of the scale of at least 1:25,000 scales or even lower. Remote sensing data comes quite handy, in this respect, to map all the wetland areas.

There is a great need for inventorying the aquatic and wetland taxa in the tropical world, especially in the face of the rampant habitat destruction that is taking place. Aquatic ecosystems and wetlands are usually considered as wastelands and are being reclaimed for various developmental needs, forcing several taxa, (which otherwise would have a great potential value in medicine and other industrial uses), to the verge of extinction. In Kerala, rising population pressure and the increasing demand for land

are taking a heavy toll of wetland. The presently available biodiversity studies on wetlands of Kerala are mainly concentrated on the three Ramsar sites and some other major sites. Most of the reports are chiefly with respect to the higher plants, fish, avifauna and limited groups of micro-planktons. Comprehensive studies covering entire biodiversity is lacking. Fauna other than fish and birds are almost neglected. Similarly there is no account of most of the Pteridophytes, Bryophytes etc. The degree of endemism in wetland areas is barely touched upon. So also there are no accounts on the vulnerability of species and status of medicinal plants.

Though eco-tourism is an area now at sharp focus, today's emphasis on tourism and tourism development are not devoid of ill effects. Proper documentation should be carried out for each specific tourism site based on its carrying capacity with regard to tourist inflow in order to design and to properly ensure the sustainability of tourist trade.

Technological interventions are needed at times for the wise use of the wetlands. The water quality of wetland system needs improvement and this could be best achieved through various management interventions like, pre-treatmenting effluents prior to discharge, regulating industrial growth, sustainable port and fisheries development, improved transportation and modernization of coir industry. Enthusiastic use of chemical fertilizers and pesticides needs to be regulated by integrated management of agricultural practices, promoting organic farming etc. Non-intrusive construction of road/rail bridges, against today's cost-cutting schemes of leaving a narrower right of way for stream or estuary, needs to be practiced even at the design stage itself, inorder to facilitate free flow of tidal currents which enhance the quality of aquatic life.

A number of fishermen face fall-in-daily-catch often leading to group clashes among them. Obviously, any new initiative regarding wetland or wetland related-region needs careful scientific scrutiny prior to design and budgeting process.

Considering all the foregoing facts, the following research studies are suggested.

· Documentation of wetland geometry, geomorphological setting, hydrology, ecosystem status, trend etc., using synoptic satellite imageries and field checks in a temporal mode.

· Survey the existing mangrove forests quantitatively for the exact area, climatic regime, rate of growth of trees and seasonal variations of environmental parameters.

· Election of suitable sites for "Conservation Reserve" and "Community Reserve".

· Capture data on responsible tourism potentials. An analysis shall be done based on the following data:

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