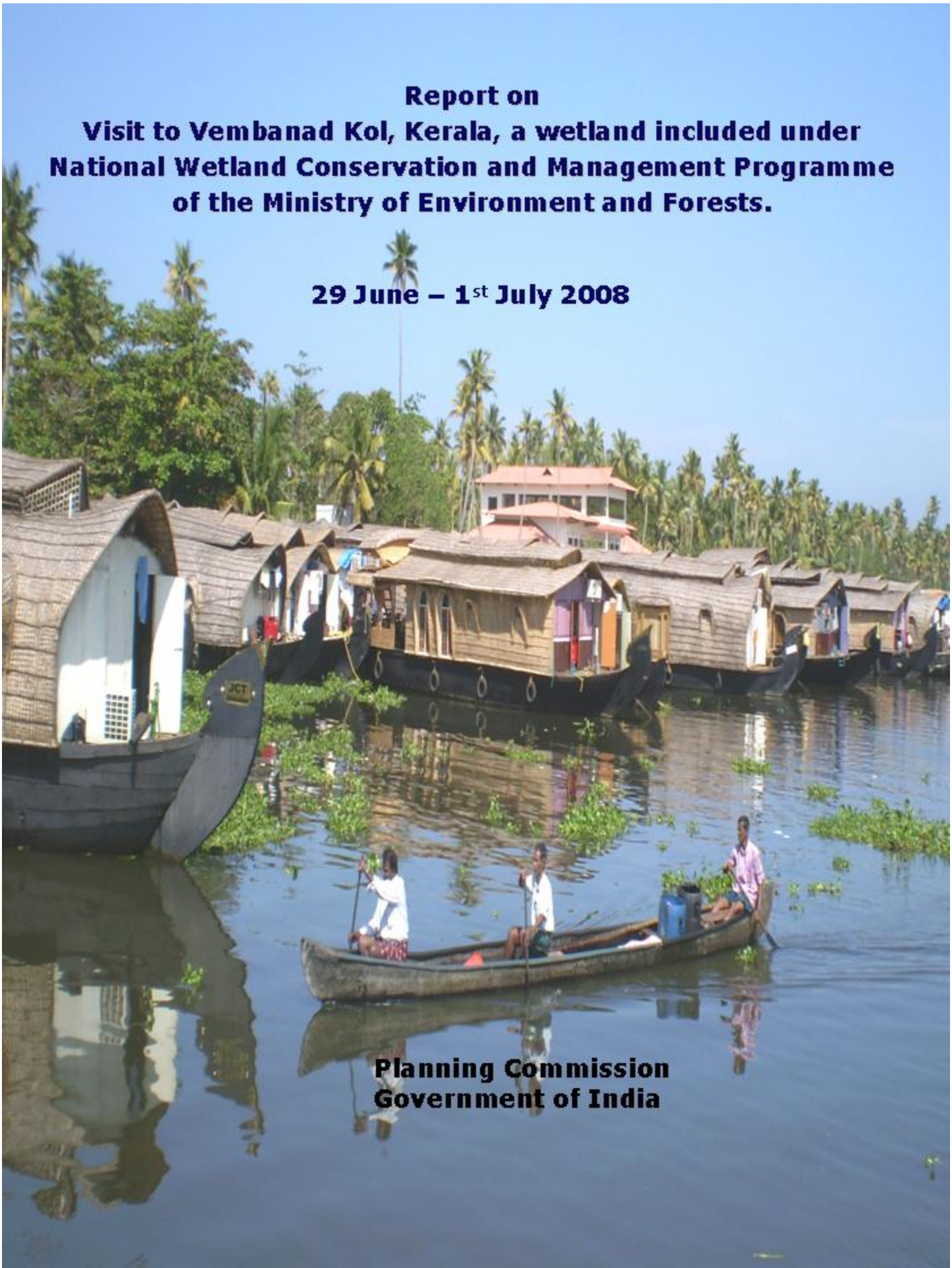
Report on
Visit to Vembanad Kol, Kerala, a wetland included under National Wetland Conservation and Management Programme of the Ministry of Environment and Forests.

29 June – 1st July 2008



Planning Commission
Government of India

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1. Context

To enable Half Yearly Performance Review of the programmes of the Ministry of Environment & Forests, the Planning Commission, Government of India, on 13th June 2008 constituted an Expert Team (Appendix-1) to visit three wetlands viz. Wular Lake in J&K, Chilika Lake in Orissa and Vembanad Kol in Kerala, for assessing the status of implementation of the National Wetland Conservation and Management Programme (NWCMP).

2. Visit itinerary

The Team comprising Dr.(Mrs.) Indrani Chandrasekharan, Advisor(E&F), Planning Commission, Dr. T. Balasubramanian, Director, CAS in Marine Biology, Annamalai University and Dr. V. Sampath, Ex-Advisor, MoES and UNDP Sr. National Consultant, visited Vembanad lake and held discussions at the Vembanad Lake and Alleppey on 30 June and 1st July 2008. Details of presentations and discussions held on 1st July 2008 are at Appendix-2.

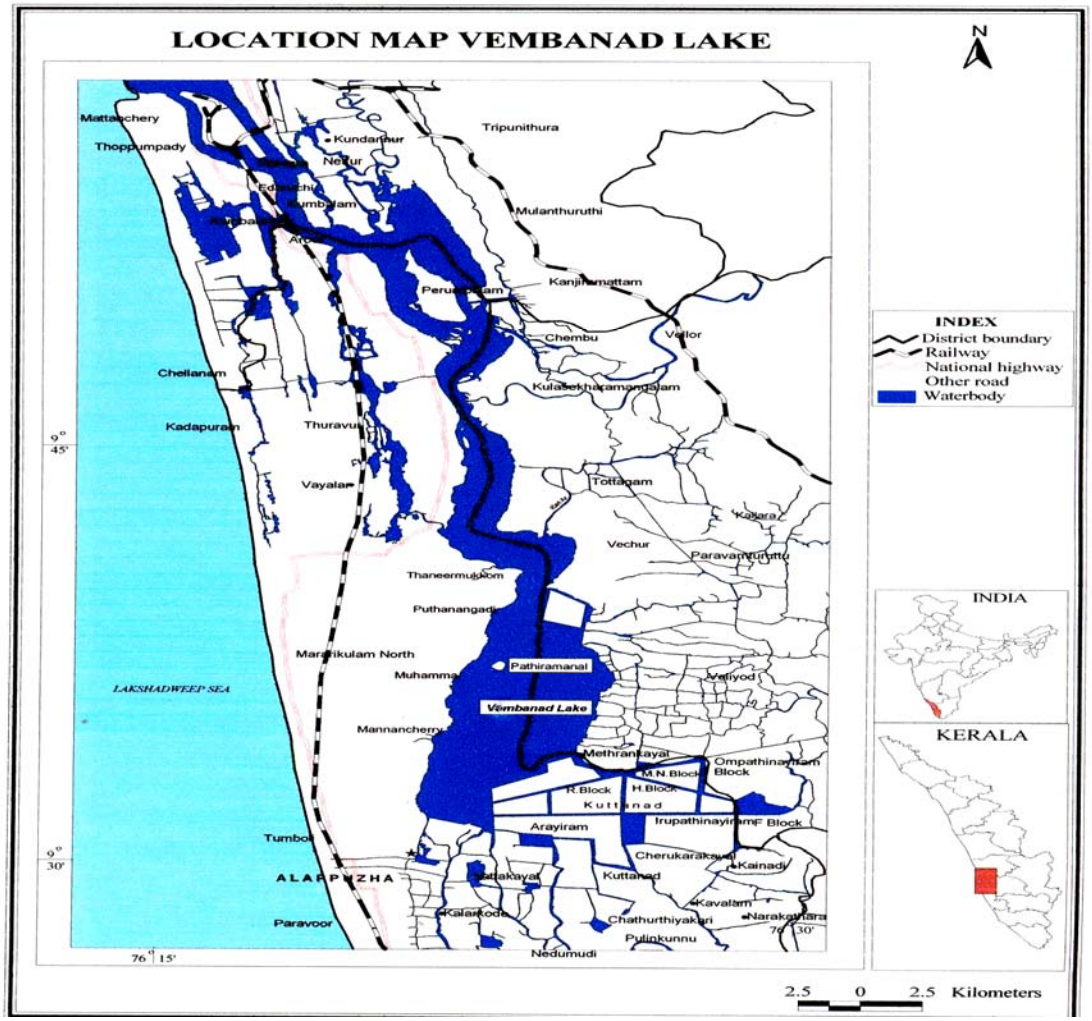
3. The Vembanad Lake

Kerala has a continuous chain of lagoons or backwaters along its coastal region. These water bodies are fed by rivers and drain into the Lakshadweep Sea through small openings in the sandbars called 'azhi', if permanent or 'pozhi', if temporary.

The Vembanad wetland system and its associated drainage basins lie in the humid tropical region between 09˚00' -10˚40'N and 76˚00'-77˚30'E. It is unique in terms of physiography, geology, climate, hydrology, land use and flora and fauna. The rivers are generally short, steep, fast flowing and monsoon fed. The Vembanad wetland system includes the Vembanad backwater, the deltaic lower reaches of the rivers draining into it and the adjoining Kol lands.

The Vembanad Lake is bordered by Alappuzha (Alleppey), Kottayam and Ernakulam districts of Kerala covering an area of about 200 sq km and extending 80 km in a NW-SE direction from Munambam in the north to Alleppey in the south. The width of the lake varies from 500 m to 4 km and the depth from <1m to 12m. Manimala, Meenachil, Pamba and Achenkovil flow into the lake south of Thanneermukkom and Muvattupuzha river flows into the Cochin backwaters north of Thanneermukkom barrage.

The lake has got a freshwater dominant southern zone and a salt water dominant northern zone, both separated by a bund at Thanneermukkom, where the lake has its minimum width. The bund was constructed in 1975 to prevent salt water intrusion and to promote double cropping of paddy in about 55,000 ha of low lying fields in the area (Padasekharams). To check the floods during monsoons, a slipway was constructed at Thottappally in 1955, for speedy drainage of water from the lake to the Arabian Sea. In the south where the lake attains its maximum width, the eastern half has been reclaimed for irrigation purposes and bunds have been constructed.



Kuttanadu is a marshy delta in the southern part of the lake, formed by four river network namely, Pampa, Manimala, Achankoil and Meenachi together with the backwaters in and around the Vembanad Lake. Large parts of the vast estuary lie below the sea level up to a depth of about 2.5 m, waterlogged for most part of the year subject to flood and inundation during the monsoons and saline water intrusion during the summer months.

Kuttanadu comprises 66048 ha of wetland, 31086 ha of garden land and 18632 ha of lakes and backwaters. Paddy and coconut cultivation are the major activities in the region followed by fishing.

The major interventions in the river basins of the wetland systems are irrigation and hydroelectric schemes and network of roads with a number of bridges in the Kuttanadu region. The irrigation project in operation is the Pamba Valley in Pamba River. The Sabarigiri hydroelectric project is situated in the Pamba river basin. There are other hydroelectric projects utilizing tail water from Sabarigiri project. The other interventions include:

- Bunding of shallow parts of the lake for punja cultivation (Padasekharam)
- Road across drainage canals
- Development of Commercial Places
- Encroachment of Lake.

The Thottappally spillway consists of a leading channel 1310 m long 365 m wide with a bridge cum regulator across the spillway channel. The bridge cum regulator is 365 m along with 40 vents, each having 7.6 m clear span. The designed discharge capacity is 1915 m3/s at + 1.06 m.

Thottappally spillway

Thrikkunnapuzha Lock has been constructed, to prevent saline intrusion in the Kuttanadu region, which is open to Kayankulam Lake through Thrikkunnapuzha lead canal, without blocking navigation. This lock however, is in ruined condition.

Thanneermukkom Barrage

The Thanneermukkom Barrage is constructed across a narrow portion of Vembanad Lake between Thanneermukkom in the west and Vechoor in the east. The 1252 m long barrage is planned with 93 vents each 12.15 m X 5.47 m. For navigation, a twin lock is provided at Thanneermukkom side and a single lock at Vechoor side.

The Vembanad Lake is important from the point of view of its flora and fauna, supporting a population of over 20,000 water-fowls in India during winter months. It is renowned for its live clam resources and sub-fossil. The soft organically rich sedimentary substratum of the inshore region is an ideal habitat for shrimps. Vembanad serves as a habitat for a variety of fin and shell fish, and a nursery of several species of aquatic life. Mangrove is found to grow in the Kumarakom region. The Vembanad Lake was declared as a Ramsar Site in November 2002.

For centuries, the backwaters have provided a safe and efficient means of transportation for goods and people moving between the interior and the port towns along the coast. The major commercial and economic activities in the lake include agriculture, fisheries, lime shell mining, backwater tourism, etc. It is reported that there are over 1000 house boats (kattuvallams) crisscross the lake carrying the tourists into the lake.

Bird sanctuary at Kumarakom

There are a number of tourist resorts nestling on its banks. Vembanad bird sanctuary is located at Kumarakom and Pathiramanal, where a large number of tourists congregate during October-March every year – it being the peak season for visiting these bird sanctuaries.

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 Programme (NLCP) by the National River Conservation Authority, chaired by the Hon.'ble Prime Minister under the Ministry of Environment and Forests (MoEF). Under the NLCP, projects of conservation and management of polluted lakes are taken up on 70:30 cost sharing between the Central and State Governments as in the case of river action plans.

4. Field visits

On 30th June 2008, the Team accompanied by Shri K. Sajeevan, Superintending Engineer, Kerala Pollution Control Board and his staff members, Mr. N.K. Sukumaran Nair, General Secretary, Pampa Parirakshana Samithy and Fr. Thomas Peelianickal, Executive Director, Kuttanad Vikasana Samithy – both NGOs, went on a 7 hour cruise inside the Vembanad Lake in

a House boat from Ponnamada Kayal (near Alleppey) to Kumarakom, crisscrossing the entire lake and the canal systems including the leading channel, kayal areas near C&D blocks and Rani Chithira blocks, Alleppey-Changanacherry canal, main lake area where the Pampa river flows into the lake and Thanneermukkom bund.

House boats

Fishing boats operating in the northern part of Vembanad lake

While on the cruise the Team observed that the entire lake was highly eutrophicated with sparse to dense infestation of water hyacinth and other submergent weeds. In some places the profuse growth of water hyacinth was found to block the free passage of the boats. Besides the house boats, a number of dug out canoes and transport boats, were seen plying the entire length and breadth of the canals and the main lake. A snake bird, its slender neck like the periscope of a submarine, rests amongst a patch of water hyacinth in the entire stretch of the lake, for catching the fish.

A portion of Vembanad lake infested with water hyacinth

Padasekharam (low lying rice fields)

The Team could see large areas under agriculture (Padasekharams) along the length of the canals. The area of agriculture land is around 26000 ha. It is reported that over 25,000 – 30,000 people living on both sides of the canal system are dependent on agriculture for their livelihood.

Fishing activity was found to take place only near the main lake area just below the Thanneermukhom bund and not anywhere inside the southern part of the lake, indicating that this part of the lake is virtually dead – a biological desert, in all probability due to high levels of eutrophication and low levels of

dissolved oxygen (anoxic conditions reported at Punnamada area) and acidic pH.

The Team was informed by the KPCB officials and the NGOs that for preventing flooding of the agricultural lands, the main course of Pamba river inside the lake has been obstructed by the local community, resulting in diversion of the river water into a 40 m narrow leading canal and consequent stagnation of water in the main lake adjoining the river course.

The Team then reached Kumarakom, where there are a number of resorts in the backwater setting. The Team visited one such resort “Coconut Lagoon”, which has won the KPCB award for the best eco-friendly resort, as it hosts a butterfly garden, wherein 90 species of butterflies are reported to have been recorded; different birds like Indian koel, small green barbet, sunbirds, tailor bird, plain-wren warbler, magpie robin, etc., and different species of wasps, spiders, bees including honeybees, dragon and damsel files. An extensive garden with a good collection of a rare and endangered species of trees and plants numbering about 190 species, is also there in the resort.

There is also a fish sanctuary in the Resort, where the breeding of pearl spot (*Etroplus sp*) – curry mean, a delicacy for Keralites, is taken up. The Vechur cow an endemic species to the region, which is threatened, is being rehabilitated at the resort in collaboration with the Centre for Advanced Studies in Animal Genetic and Breeding under the Kerala Agricultural University, Mannuthy.

At the end of the cruise inside the lake, the Team visited the Thanneermukkam bund which divides the Cochin backwaters into a brackish northern sector – the Cochin Backwaters and the freshwater Vembanad Lake in the southern sector. The Team was informed that the construction of this bund was completed in 1975 for protecting the standing agriculture crop from salt water intrusion by retaining the freshwater from the rivers draining into the upper part of the wetland, for saving the punja cultivation from floods, for increasing the area under paddy cultivation, for improving the domestic water supply in Kuttanadu area and consequent improvement in public health, for reclamation of shallow portion of the lake for paddy cultivation, for providing an important road link between the two shores of the Vembanad lake and the district headquarters of Alleppey and Kottayam. While the structure is reported to have been successful in keeping the water in the Kuttanadu free from salinity, thereby enabling increased cropped area in the dry season, after the partial commissioning of the barrage, several environmental and ecological problems have emerged in the wetland system,

the major ones being reduction in fish catch, concentration of pollutants and increase in weed growth upstream.

On completion of the field visits, the Team retired to the guest house at Alleppey.

5. Recommendations

1. Lake Conservation Plan

The shrinkage of Vembanad Lake as a result of land reclamation, has been the most important environmental consequence of various human interventions. The water carrying capacity of the system is reported to have reduced to an abysmal 0.6 km^3 from 2.4 km^3. Every year, 44,000 MT of liquid insecticides, weedicides, fungicides and chemical fertilisers (21,000 MT) reach this wetland. The water quality in the lake, particularly in the southern part of the lake and in the lead canals, appears to be too bad for supporting any useful flora and fauna. The fragile ecosystem of the wetland, is influencing the life and health of people living in and around the region and is important for conservation of biological diversity and for sustaining human life.

Reclamation of the lake for developmental activities needs to be reassessed, including the encroachments on the lakefront, canals, drains, etc. A narrow band of land on the lake's periphery be declared as "ecotone" to protect and restore the ecosystem of the lake.

Conservation of the Vembanad wetland system, which was included in the National Lake Conservation Plan (NLCP) in June 2003, still remains a non-starter, as the Government is yet to assign the preparation of an Action Plan. It is absolutely essential that the authorities evolve a sustainable action plan to restore and conserve the Vembanad wetland system at the earliest..

2. Inventory of the lake

With a view to make a realistic assessment of the status of the Vembanad Lake and its resources, the *Team recommends that the project implementing agencies should develop a critical habitat information system (CHIS) by making use of the techniques such as remote sensing and geographical information system.*

3. Conservation of the catchment areas

To protect and conserve the catchment areas of the lake, it is recommended that water and soil conservation measures such as forest enrichment and rain water harvesting be taken up, besides maintaining a constant flow in the

four rivers flowing into the lake through out the agriculture season, desilting certain portions of the lake or the lead canals, rejuvenation and maintenance of water shed areas.

4. Improvement of Lake Hydrology and hydraulics

After an extensive field visit of the Vembanad lake, the Team *recommends that there is an urgent need to improve the lake hydrology and hydrodynamics with a view to rejuvenating the natural streams flowing into the lake, by clearing the obstruction to free flow of water in the lake from the rivers for ensuring free flow of water within the lake, regulating the operation of the hydroelectric project, the Thanneermukhom bund and Thottappally spillway, strengthening of the outer bunds along the agricultural fields, etc. It is recommended that the Thanneermukkam bund be modernised to manage the salinity and flood management in Kuttanad and to minimise the ecological decay of the lake, with all the shutters of the barrage made operable.*

5. Vembanad Lake Conservation Body

The Team noting with concern the virtual lack of coordination between the various State Government Departments in protection, conservation and management of the lake and its resources, calls for unified efforts from all concerned for restoring this fragile ecosystem.

The Team is of the view that for ensuring the revival of the clean freshwater regime of the Vembanad lake, revival of its fishery and its conservation and management, there is an urgent need for an Independant Authority with full powers , constituted by a statute, to be set up by the Government of Kerala. as the present arrangement lacks the requisite state support . It is understood that the Department of Science and Technology , Government of Kerala has recently initiated steps for setting up an Authority/Agency by amending the State Irrigation Act.. *It is recommended that the State Government set up the Vembanad Lake Development Authority/Agency immediately with full powers and autonomy for enforcing the legal mechanisms for protecting and revive the ecosystem.*

6. Pollution and water quality

Noting that major portion of the Lake is highly eutrophicated along the southern sector reducing it to a virtual biological desert, with poor water quality, and that the water/soil quality data for the lake beyond the year 2004 does not appear to be available, the Team *recommends that all out efforts be made by the authorities concerned to carry out extensive water*

quality and pollution monitoring studies on a regular basis across the lake to make an assessment of the status of pollution, identify the point and non-point sources of pollutants and take remedial measures for mitigating the adverse impacts of these pollutants on the lake's ecosystem and its resources, which have already reached a point of no return.

The Team also recommends that the State Pollution Control Board take immediate steps to control/restrict the entry of untreated liquid and solid wastes both from the nearby settlements, resorts and the house boats; industries; dewatering of the padasekharams containing pesticides, insecticides,fertilizers etc; prevent spillage of fuel oil from boat cleaning operations, into the waterways flowing into the lake for improving the water quality of the lake. This will help in alternating the paddy crop with fish crop (Oru Nellum Oru Meenum) within the lake area.

7. Impact of Tourism

Over 1000 house boats ,the highlight of the tourist attraction , operate from Ponnamada Kaya within the lake and over 100 transport boats ply within the lake connecting the nearby towns/villages , which have lasting impact on the lake ecosystem. The Team recommends regulation of tourism in the lake by regulating, the number of house boats operating in the lake ,Solid waste and sewage generated by them and enabling proper upkeep of parking bay. *The Team observed that except for Kumarakom, the small bird sanctuary, the Vembanad lake has no unique flora or fauna visible and is largely infested with water hyacinth. To attract tourisst and sustain interest of the visitors it is recommended that efforts be made to clean the lake, introduce fresh water fishes, Mangroves and create a few scenic spots within the lake to provide entertainment to the visitors.*

8. Biodiversity

Except for some studies on biodiversity ,conducted in the late 1990s and in 2001, there appears to be no systematic study of the biodiversity of the lake ecosystem in the recent past. While Water Bird count is being done on an annual basis, information on other flora and fauna of the lake is scanty and unauthentic. It is therefore*, recommended that a complete study on the biodiversity of the lake should be undertaken in close collaboration with the Central Inland Fisheries Research Institute, Barrackpore; Central Institute of Brackishwater Aquaculture, Chennai – both under the ICAR; Botanical Survey of India and the Zoological Survey of India, to update the information on floral and faunal biodiversity of the Vembanad lake.*

9. Restoration of Vembanad lake fishery

For restoration of the fishery resources of the lake, the Team recommends promoting captive breeding of select species of finfish and shell fish for resource enhancement through re-stocking/ranching, declaring closed seasons for fishing, banning the destructive types of fishing operations, promoting sustainable freshwater aquaculture practices, developing fallow lying marshy and weed infested flood plains for fish and freshwater prawn farming.

10. Sustainable livelihood options

The Team recommends promotion of ecosystem based management options for restoring the lake's resources, eco-friendly fishing, fish farming and paddy cultivation practices as a source of food, employment and income for the local community.

11. Socio-economic issues

The Team noticed that inhabitants in and around the padasekharams are exposed to serious health hazards, because of poor access to drinking water, , pollution and unhygienic condition of the lake due to disposal of untreated sewage and domestic wastes. *During presentation the team* was also informed that the inhabitants of Kuttanad also face the same problem.

Cleaning of the lake and restoration of the fauna and flora is the only way to ensure that the population dependant on the lake have access to clean water.

With regard to improving the public health, sanitation and drinking water supply to the people living along the periphery of Vembanad lake and padasekharams,immediately it is recommended that the State Government create requisite infrastructure, , at selected locations.

12. Legal framework and mechanism

Noting that there is no legal framework and mechanism in place for protecting and conserving the Vembanad lake and its resources, regulation of tourism, controlling/preventing domestic, agricultural and industrial pollution and over-exploitation of the resources, the Team recommends that the State Government frame rules r and enforce them strictly, by setting up an institutional mechanism for this purpose.

13. Nalagrass infestation

The Team while on sail inside the Vembanad lake could see patches of nalagrass (Pragmatis karka) growing in the abandoned paddy fields, along the dykes of padasekharam and even on clusters of water hyacinth. This weed which is predominantly a freshwater species, was found to be growing profusely in the northern Chilika, Orissa and a menace, as it could not be eradicated that easily. The Team was informed by KPCB officials that the farmers plant this grass for protecting the dykes during monsoon months. Since a similar situation as in the Chilika lake could arise over the years, the team recommends that adequate measures be taken to closely monitor the spread of this weed in the lake area and to eradicate them at the beginning itself.

14. International funding support

Considering the present poor status of Vembanad lake wetland ecosystem, the huge investment that would be required to restore the water quality within the lake for making it suitable for commercial fishery, besides agriculture, tourism promotion and mode of transport, water supply, and creation of the requisite basic infrastructure, human resource, capacity building, etc., it is strongly recommended that the State Government explore the possibility of seeking the support of international funding agencies like World Bank, GEF., etc., for Vembanad lake conservation and development. The State should also draw up proposals for funding by the ministry of Environment and Forests

Appendix – 1

Planning Commission's order constituting the Team for Reviewing the implementation of National Wetland Conservation and Management Programme.

D.O. No. 12074/1(27)/2007-E&F ***June 17, 2008.***

It has been decided with the approval of Competent Authority that a team consisting of the following experts would visit Chilika Lake (Orissa) and Vembanad Kol (Kerala) for a review of conservation efforts being carried out under the National Wetland Conservation Programme (NWCP):

i) ***Dr. Indrani C.S.,***
Adviser (E&F), Planning Commission,
New Delhi.

ii) ***Dr. T. Balasubramanian,***
Professor & Director,
Centre for Advanced Study in Marine Biology,
Annamalai University,
Parangipettai – 608 502 (Tamil Nadu).

iii) ***Dr. V. Sampath,***
Sr. National Consultant,
UNDP,
99, 6th Cross, KRM Nagar,
Annamalai Nagar– 608 002
Cuddalore District, (T.N.)

iv) ***Dr. S. Kaul,***
Director (Wetlands)
Ministry of Environment & Forests,
Paryavaran Bhavan, CGO Complex,
Lodi Road, New Delhi-110003.

Note: Dr. T. Balasubramanian and Dr. V. Sampath will be treated as 'Non-officials' of highest grade under SR – 190 (a) and they will be allowed TA/DA in that capacity. Planning Commission is likely to purchase Electronic Air Tickets for both of them and advise the travel agent to e-mail the tickets to them. Alternatively, their TA/DA could be reimbursed by Planning *Commission.*

Appendix-2

Details of Presentation and Discussion

Presentation by Mr. Anil Kumar, Water Resources Department, Govt. of Kerala

Selected Hydrologic parameters of river basins (1997 data)

- Drainage area of the five river basins 7392 sq.km.
- Monsoon flow 10348 million cu.m.
- Lean flow 2817 cu.m.

Meteorological data

- Temperature Range: 21^0 To 36^0C
- Relative Humidity :80 To 95%
- Two Distinct Rainy Seasons
    - S-W Monsoon(June To Aug), 60%
    - N-E Monsoon(Sept To Nov), 30%
- Summer Rains (10%)
- Average Rainfall: 3200mm

Thottappally spillway

- Constructed in 1954 as part of Kuttanadu development scheme for relieving flood condition in Kuttanadu by diverting part of the flood waters of river Pamba and river Achenkovil directly to the sea.
- Spillway 365m long and controlled by 40 regulator gates.
- Span 7.65m and height 2.74m.
- Spillway Channel improved to a width of 365 m and length of 1310m and bed level at -6ft(-1.85m).
- Total discharge capacity 1812m3/sec (64000 cusecs)
- Leading Channel to spillway, 70m wide and 6200m length from Nathirampally to Thottapally.
- Average maximum discharge passed through the spillway much less than its designed capacity.(average 630m3/sec only).

Thottapally Pozhi cut open D/S of Spillway

Measures to improve the spillway

- To widen and deepen the leading channel from Thottapally up to Veeyapuram i.e. 9020m.from the existing 70m to 250m up to 5200m (Mathirampally) and thereafter to 225m, with the depth of flow under maximum flood condition is 4.2m.
- At the confluence with river Pamba the mouth of river Achenkoil is reduced to about ¼ of the width upstream.

- About 2km downstream of the confluence the river takes a circuitous route with two right angled bends, causing in-efficient discharge.

Padasekharams

- Padasekharams “meaning groups or blocks of paddy fields”.
- Each Padasekharam bound by bunds which separate it from surrounding water courses and protect it from floods
- Over last century land holdings on wet lands under paddy cultivation have been partitioned, leading to land fragmentation.
- Land Reforms Act in Kerala sets an upper limit for land holdings.
- Individual holdings have dwindled, considerably due to large scale land transfers.

Wetlands

- Kuttanadu region has 66000 ha of wetlands classified into :
    - Dry lands: elevated lands ranging in level from 0.5 to 2.5m above MSL extending to about 31000 ha.
    - Wetlands: Wetlands are either low formations above MSL or areas below MSL reclaimed from the surrounding backwaters. Mostly waterlogged with levels ranging from 0.6 to 2.00m below MSL.
    - Water spread

Agronomic zones

Six agronomic zones identified in the Vembanad lake based on flood risk, soil fertility and saline water intrusion. They being Upper Kuttanadu, Kayal, Vaikom, Lower Kuttanadu, North Kuttanadu and Purakad.

Thanneermukkam Barrage/Bund

- *Constructed across the Vembanad lagoon to prevent salinity intrusion, partially commissioned in 1975.*
- *Major problem encountered in construction of barrage was reduction in fish catch.*
- *Closure period of Thanneermukkam is 15thDec to 15thMarch.*

This barrage was constructed to:

- safe guard puncha crop(Sept to March) from floods, spring tides and saline intrusion,
- improve a second crop (June to Sept) cultivation and keep lake free from salt intrusion,

- improve domestic water supply to Kuttanadu and the river banks upstream and Public health.
- enable reclamation of shallow portions of the lake for paddy cultivation.
- provide continuous employment to a large number of unskilled workers in the coastal belt.
- provide an important road link between the two shores of Vembanad lake and the district headquarters of Alleppey and Kottayam district.

Some of the benefits envisaged by creating this barrage include:

- Silt accumulation in the upstream and downstream of the central bay to make flood flow easier.
- Save Punja cultivation from floods and more area can be brought under paddy cultivation.
- Restricting spring tides and salinity intrusion to a considerable level.
- Easing interruption of the central bay for migratory route of marine fish and prawns.
- Area south of the barrier when the barrier is kept open can be brought back as a nursery ground for post larval prawns which need salinities of about 15 ppt for optimal growth.
- Weed growth can be prevented if the central bay has shutters. This would ease the process of flushing the weeds to the sea during the monsoon period.
- Health risk created by flooding of latrines and other premises will be considerably reduced.

Black clam fishery

- Average amount of black shell, collected daily per licensed fisherman is higher downstream than upstream of the salinity barrier.
- Before construction of barrier the highest yields of black shell per capita were from the estuarine stretch north of Thannermukkam.
- Commissioning of the Idukki Hydroelectric project created a perennial flow in the Muvattupuzha river and reduction in salinity downstream of Vaikkom during the dry season, affecting black clam fishery.

Presentation by Dr. N. Unnikrishnan, SVRNSS College, Vazhoor

Dr. N. Unnikrishnan, made a presentation on the biodiversity of Vembanad lake, highlighting the various aquatic and marginal flora, fauna and the ways and means of protecting and conserving the biodiversity of Vembanad lake. Following is a summary of his presentation:

- Vembanad one of the largest wetland systems, comprising lake, paddy fields, marches, canals, palm groves,
- Possess all attributes of wetlands – mangroves, waterfowl habitat and fish diversity.

- Has rich plant diversity –wetland flora – mangroves (7 species), mangrove associates and other aquatic species numbering about 180 species.

Pistia stratiotes

Avian fauna

- Vembanad wetlands including Kumarakom important bird congregating area for both resident and migratory birds.

- In all 225 species recorded, of which 112 are wetland dependent and 70 migratory.

Darter (Cherakozhi)

- Major groups include ducks, teals, cormorants, herons, egrets, gulls, terns and birds of prey.

Fishery

- The total number of fish species in the lake declined to 45 as compared to 150 in 1987. Major species recorded are *Channa striatus* (murrel), a few species of catfish, freshwater prawn, *Wallago attu, Etroplus suratensis, etc.*
- Black clam, frogs, snakes, tortoise, monitor lizard, and otter are also recorded from the lake.

Major threats

- *Reclamation & Construction- Habitat Loss*
- *Pollution From Sewage, Pesticides, Industrial Effluents*
- *Pollution From Unscientific Tourism Activities*
- *Over Exploitation of Resources*

Recommendations

- Stop Unscientific Filling, Construction
- Scientific Tourism Management
- Treatment of Industrial Effluent, Sewage
- Sustainable Utilisation of Resources
- Awareness Creation
- Proper Implementation of Law
- Conservation or Community Reserve

Presentation on Biodiversity by Dr. S. Bijoy Nandan, CUSAT

Dr. Bijoy Nandan, School of Ocean Science & Technology, Cochin University of Science & Technology, Kochi made a presentation on the biodiversity of Vembanad lake and conservation strategies. In his presentation he touched upon the salient features of the lake and its biodiversity, based on a study conducted during 1989 – 2002. Study was conducted at 12 sampling points across the Vembanad lake fom Punnamada to Thanneermukkam. Salient features of his presentation are as under:

Objectives

- To investigate the selected water quality parameters and productivity,
- To assess the biodiversity of plankton and benthos from the selected zones,
- To estimate fish and prawn landings and catch structure in the context of the prevailing environmental quality, and
- To take appropriate measures for conservation

Environmental status

- Drastic reduction in water holding capacity of lake, due to siltation.
- Average pH 6.8. Dissolved oxygen levels ranges from 6.0 to 7.2 except at Punnamada where it was 3.16mg/l during the pre-monsoon period and sometimes below detectable levels.
- Lowering of the salinity from an average summer value of 18.47 ppt. during pre-barrage phase to 2.8 ppt. during post-barrage phase.
- Accumulation of organic carbon and clay in the sediment.
- Increase in primary production levels during post-barrage phase.
- Pesticides within safe limits.
- Mean salinity recorded to be between 3.87 (2001) and 23 ppt (1971) near Thanneermukkam.
- In Vembanad Lake the mean value for salinity was 1.2 ppt, DO 6.6 mg/l, H_2S 2.59 mg/l, Nitrate -N 0.087 mg/l, Phosphate -phosphorous

0.020 mg/l, gross primary productivity 0.87 gC/m^3/day, with net primary productivity 0.75 gC/m^3/day.

Biodiversity changes

- Pre-monsoon showed highest mean value for plankton biomass (4.7ml/m^3) followed by post-monsoon (4.4ml/m^3) and monsoon (3.4ml/m^3) periods.
- During pre-barrage phase only about 30 species of phytoplankton was reported. Species present during monsoon and post-monsoon period qualitatively different from that of pre-barrage phase.
- Benthic forms present showing its maximum mean density (39 nos./m^2) during the monsoon.
- The high organic carbon content in combination with the higher percentage of sandy clay during the post-monsoon and pre-monsoon periods was a positive element in maintaining a high density of the benthic organisms.
- 58 species of fish, 6 species of shrimps and prawns and 4 species of molluscs were recorded.
- Total fish landings from the lake during 1996-97 were 15.751 tonnes. Landings of freshwater prawn dropped from 400 tonnes in 1965 to 62 tonnes in 1996-97 and that of shrimp from 123.35 tonnes in 1995-96 to 102.20 tonnes in 96-97.

Molluscan resources

- Major molluscan resources reported are *Meretrix casta* and *Villorita cyprinoides,* the former distributed in saline zone and the later in fresh water zone contributing to lucrative fishery.

Major environmental threats to the molluscan resources include:

- Habitat destruction through human interference (e.g.:- Thaneermukkam barrage),
- Industrial pollution,
- Over exploitation of natural resources,
- Illegal poaching,
- Destruction of Mangroves,
- Large scale shrimp farming.

Mesh size regulation, declaring clam sanctuaries, ranching of clam seeds, value addition to discarded clam meat, regulating the operation of mechanised dredgers, creation of awareness among fishermen etc., are some of the measures for conserving the clam stock.

Mangroves

- *39 species of mangroves and mangrove associates recorded from Kumarakom area in 1994 and 44 species in 2001.*

Ecological repercussions

- Disruption of physical and biological continuity with rivers, coastal systems fuelled decline of endemic prawn *M. rosenbergii*, in its home ground.
- Closure of the barrage during post monsoon months for summer rice, disrupted breeding migration down stream
- Continued closure during post monsoon prevented migration of post-larval prawns back to home grounds – Kuttanadu
- Salinity a 'critical ecological master factor' in the abundance and distribution of fishes.

Measures for revival of fishery

- Captive breeding and propagation of the endemics,
- Creation of a sanctuary for pearl spot,
- Ranching of mullet and pearl spot seed in the lake.

Pearl spot (Etroplus suratensis)

- Development of aquatic vegetation *Apnogeton appendiculatus* considered as ideal fish/prawn habitat.
- Creation of open water fish nurseries in the lake.
- Taking up open water fish culture in cages to reduce pressure on fishing, integrating fisheries with paddy, horticulture, coconut plantation, poultry, duckery, piggery, animal husbandry, etc., on the dykes of padasekharams, besides rotation of fish/prawn and paddy crops.
- Approaches to conservation of fish biodiversity including banning introduction of exotics, declaration of closed fishing seasons, establishment of fish sanctuaries, etc.

Conclusions derived from the study

- Reduction in depth of backwater leading to lowering of the water holding capacity of the backwater.
- Tidal influence reduced from 80km upstream to 40km till the barrage during summer.
- Increase in weed growth and a severe restriction on natural flushing of pollutants entering the sector during summer months when the barrage remains closed.

- Changes in spatial and temporal variations in water and sediment quality-a steep reduction in the salinity (optimum 14-16ppt), an elevation of nutrient level in the water phase, and an elevation of organic carbon in the sediment. Changes more pronounced in southern end of the sector, where eutrophication existed, geared by the stagnation, consequent to closure of the barrage during December to April.
- Breeding migration of *M. rosenbergii* and *M. idella* is affected by salinity barrier, the Thannermukkam barrage.
- Marked reduction in the upstream and downstream migration of fish and prawns.
- About 13 euryhaline migratory species no more contribute to the fishery of this sector, and about 16 stenohaline freshwater species found an entry to the commercial fishery of the Sector.

Suggestions

- There is a necessity of maintaining continuity of the lake by keeping the barrage open so that tidal washings during pre-monsoon months will enable natural flushing out of the wastes and thereby reducing stress on the environment at this Sector.
- The upward and downward migration of fish and prawn any time during the year to be ensured, making the whole lake available to the euryhaline species. This would substantially improve the fishery of the lake as a whole.
- Protection and ecological restoration of the water spread area.
- Improving the efficiency of the TSW and leading channel.
- Regulation of floodwater in Kayal area near C and D and Rani-Chithira blocks.
- Complete construction of AC canal with removal of all blocks.
- Monitoring and assessment.
- Measures for pollution control to include preventing dumping of municipal solid and sewage waste, hospital and industrial wastes into Kuttanadu river systems and other water bodies and create local waste treatment and disposal facility as per the approved guidelines.
- Preventing fuel spillage from boat cleaning centres.
- Prevent discarding of wastes by the house boats into the waterways.
- Promote low pesticide use with a shift to biocides.
- Introduce public health guidelines for Kuttanadu.
- Ensure that fish processing wastes do not pollute the waterways.
- Ensure total elimination of aquatic weeds particularly water hyacinth.

- Promote mangrove afforestation/restoration.
- Protect Pathiramanal Island, the hotspot of biodiversity.
- Revive pearl spot fishery by increasing its productivity.
- Promote rainwater harvesting, land based health and sanitation measures.
- Declare Kuttanadu as a special agriculture zone,
- Promote location specific research, training and capacity building activities,
- Strengthen economic viability of the activities.