J. mar. biol. Ass. India, 1983, 25 (1 & 2): 131 - 141

THE SHRINKING BACKWATERS OF KERALA

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ABSTRACT

The most serious anthropogenic environmental alteration taken place in the estuaries of Kerala in the living memory, is it's alarming rate of reduction in extent. *Vembanad Kayal*, the largest backwater system on the west coast of India, had an area of 36,500 ha in the last century. It has undergone man-made shrinkage at an alarming rate by bunding and reclamation for agriculture, aquaculture, harbour and urban development and other uses. As a result, only about 35% of its area remains as open brackishwaters at present, about half of which has been identified as suitable for developing into aquaculture farms in the coming decade. This shows that only about 17% of Vembanad system will be left as open brackishwaters by the dawn of 21st century, provided it is not further encroached for other purposes. The mean depth of the backwaters has also been decreased to 65.67% during the past fifty years as a result of siltation. The resultant reduction in volume together with other environmental alterations have adversely affected the fishery resources in this region. The carrying capacity of the system has been further threatened by the growing inflow of effluents from domestic, agricultural and industrial sources. The situation warrents multidisciplinary approach to understand the system in depth and to evolve effective management techniques.

INTRODUCTION

KERALA has been endowed with an expansive body of brackishwaters, the various sectors of which are referred to as backwaters, lakes, lagoons and estuaries including mangrove swamps. From south to north they are named as Veli, Kadinamkulam, Paravoor, Ashtamudi, Kayamkulam, Vembanad, Cranganore, Valiyangadi, Korapuzha, Valiyapatnam and Kavvai. This chain of backwaters on the coastal plane is interconnected by an extensive network of canals which facilitate transport of men and materials. These backwaters have played a significant role in the socio-economic and cultural history of Kerala. As a result of the studies carried out in different parts of the world, it has been realised that estuaries are one of the most important coastal life support systems and an indispensable medium for the existence of various economically important marine as well as fresh water living resources. This calls for the imperative need to protect the backwaters which have been subjected to continued man-made alterations.

Of the various sectors of backwaters in Kerala, the central region, or the Vembanad Lake, particularly the Cochin Backwaters being the seat of a major port has attracted the attention of scientists, harbour engineers, planners and administrators since 1920. A series of studies on the physco-chemical and biological processes of the backwater system has been carried out by various authors (Bristow, 1938; Desai and Krishnankutty, 1967; Qasim *et al.*, 1968; Qasim and Gopinathan, 1969; Qasim *et al.*, 1969, Sankaranarayanan and Qasim, 1969; Nair and Tranter, 1971; Wellershaus, 1972; Haridas *et al.*, 1973). These studies have revealed the high life carrying capacity of this ecosystem, as well as its problems and potentialities for development of fisheries, navigation and recreation.

Some of the recent studies have pointed at the rapid rate of environmental deterioration

taking place in the backwaters of Kerala (Gopalan and Nair, 1975, Unnithan *et al.*, 1975; Sankaranarayanan *et al.*, 1978; Qasim and Madhupratap, 1979; Gore *et al.*, 1979; Remani, 1979). As the system has been subjected to irrational economic exploitation and consequent ecological degradation, Gopalan (1984) has stressed the need for evolving legal measures to conserve this vital ecosystem. The present communication mainly focuses on various factors contributing to the horizontal and vertical shrinkage of the backwater environment (not strictly geological) and examples of its impact on resources in Kerala.

The authors are thankful to Dr H. N. Siddiquie, Director, National Institute of Oceanography, Dona Paula, Goa for encouragement and to the Cochin Port Trust for providing useful references.

Genesis of Backwaters

According to geological records most of the worlds barrier-beach-lagoon systems had their origin during the post-glacial sea level rise, 5000–6000 years ago. However, the Vembanad Lake (Fig. 1) extending between Alleppey and Azhikode (between latitude 9°30′ and 10°12′ and longitude 76°10′ and 76°29′) now a typical estuarine system, and the largest one of its kind on the west coast of India, is believed to have attained its present configuration in the 4th century A.D., according to historians (Anon., 1973). Geomorphologically, all the sectors of the existing backwaters may not be of common origin. It was primarily a marine environment, bounded by an alluvial bar parallel to the coast line and interrupted by the Arabian Sea at intervals. As a result of a catastrophic deluge which took place in 1341 A.D., parts of the Alleppey and Ernakulam Districts including a number of islands arose, thus separating a distinct water body from the sea with connecting channels at Thottapally, Andhakara Azhi and Cochin (Menon, 1913).

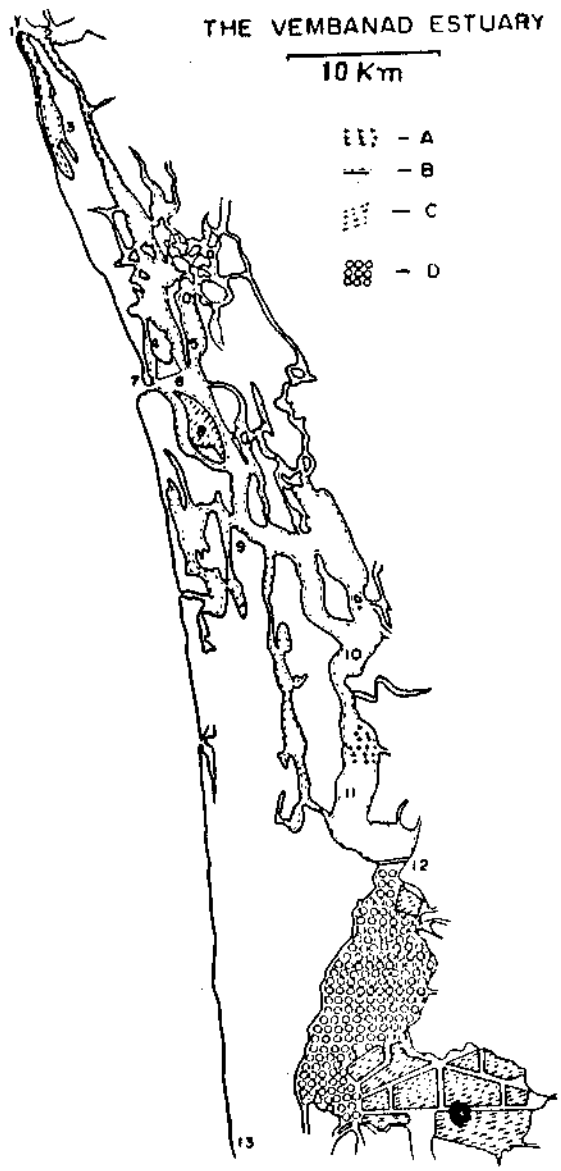

Fig. 1. Reclamations in the Vembanad Backwater system and various localities.

A. Proposed clam sanctuary; B. Reclaimed by private owners; C. Reclaimed for agriculture, harbour and urban development; D. Ecologically severed due to bunding at Thanneermukkom. Localities: 1. Azhikode; 2. Munambam; 3. Cherai; 4. Vallarpadom; 5. Bolgatti; 6. Ramanthuruthu; 7. Cochin bar mouth; 8. Willington Island; 9. Aroor; 10. Paravoor; 11. Vaikom; 12. Thanneermukkom and 13. Alleppey.

It is at this period the river Periyar which was emptying at Cranganore (Kodungallur), took a diversion through Varapuzha and opened the Cochin channel, giving rise to a number of islands lying scattered in the backwaters by deposition of alluvium in its course. This transformation of an originally marine environment into an estuarine system is evidenced by the occurrence of large quantities of typically marine shells deposited in the Vembanad region (Preston, 1916). Currently the fresh water discharge from major rivers like Periyar and Chalakudy on the north and Pamba, Achankovil, Manimala, Meenachil and Moovattupuzha in the south, makes the backwater typically estuarine in character as defined by Pritchard (1967). The existing geomorphological features of this estuarine sector, brought about by natural and man-made alterations can be clearly seen in the satellite imagery trace of the Landsat Frame E 1202–04454 of the EROS data Centre, USA reproduced by Mallik and Suchindan (1984).

Horizontal Shrinkage of Backwaters

An estuary might naturally undergo gradual changes in the course of its history. But as regards the backwaters of Kerala, the human interaction have caused serious alterations in the system particularly during the past 150 years. Backwaters have been continuously subjected to reclamation for various purposes such as agricultural expansion, aquaculture practices, harbour development, urban development and other public and private uses. Of these, reclamations for agricultural purposes particularly paddy cultivation and paddy-cum-shrimp culture has contributed immensely to the horizontal shrinkage of the backwater system. It has been estimated that the Vembanad Backwaters had an area of nearly 365 km^2 till 1834. The then Government of Travancore encouraged the farmers to reclaim the backwaters by advancing intetest-free loans (Anon., 1971). Pillai and Panikkar (1965) have mentioned that in the early phases, land reclamation and flood control work were largely undertaken at the initiative of private farmers with active assistance from the state government. As shown in Table 1, about 2,226.27 hectares have been reclaimed till the beginning of this century. Thereafter, reclamation activities have been banned in 1903, according to a government notification on the presumption that, these activities would adversely affect the Cochin Harbour development by siltation (Kurien, 1978). However, it was resumed in 1912 and an area of 5,223.15 ha were reclaimed by 1931 (KSSP, 1978). The latest large scale reclamations for agricultural purposes include 700 ha known as QST - blocks and 620 ha known as R-block in the relatively deeper areas of southern Vembanad region between 1941 and 1950 (Kurien, 1978). All these reclamations were mainly confined to the Kuttanad region of the Vembanad Lake under the support of the then state government. Apart from these it has been roughly estimated that, an area of about 1,500 ha has been reclaimed by private owners for the purpose of agriculture, cottage industry and housing along the banks of the main channels, connecting canals and islands all along the backwater during the present century. Of this, the coconut husk retting ground enclosures alone occupy an estimated area of about 500 ha.

In the areas reclaimed in Kuttanad region it was possible to cultivate only one crop of paddy a year. Exploring the possibility of raising two or more crops in a year, in the reclaimed lands, the government constructed a spill-way for flood control at Thottapally in 1955 and for checking the intrusion of saline water, a barrier at Thannermukkom was also constructed and commissioned in 1974. Thus, in effect an area of 69 km^2, of brackishwater lying south of Thannermukkom has been ecologically cut off from the backwaters.

The bunding and utilization of backwater for the purpose of paddy-cum-shrimp culture has been carried out mainly in Ernakulam District and has been later extended to Alleppey and Kottayam Districts. A total of 5,100 ha has been converted into paddy cum shrimp culture systems till 1970. The expansion in this field has been faster during the past 15 years and a further area of about 800 ha has been converted into paddy-cum-shrimp culture fields and for other aquacultural purposes.

Harbour and urban development

The project on development of Cochin into a major port on the west coast of India commenced in 1920 under the direction of an eminent harbour engineer Sir Robert Bristow and was completed in 1936. During this period of constant dredging, Willington Island, the present seat of Cochin Port having an area of nearly 365 ha had been reclaimed. Thereafter, there were no major reclamation till 1970s, when the fishery harbour having an area of 10.78 ha had been reclaimed. This was followed by an integrated project for the development of Cochin Port, under which, Vallarpadom–Ramanthuruth Candle Island complex having an area of 141.7 ha had been reclaimed. Further, under the same project a similar area is being reclaimed as a southerly extension to the Willington Island. Under urban development 23.91 ha have been reclaimed by the Greater Cochin Development Authority (GCDA) and Cochin Town Planning Trust mainly for the construction of a marine drive on the foreshore of Ernakulam. Some other minor reclamations have been made for the purpose of Cochin Shipyard, Central Institute of Fisheries Technology (CIFT) and also for the Cochin Port for additional berth facilities as shown in Table 2.

Plans have also been made by GCDA to reclaim 640 acres (269.7 ha) of land on the northern foreshore of Ernakulam for urban development in future.

Siltation and vertical shrinkage

Siltation is the major factor contributing to the progressive shallowing of backwaters. The process of siltation occurring as a result of river discharge and tidal inflow has been accelerated by man-made alterations such as deforestation, construction of dams, reservoirs and barriers. The magnitude of siltation in the backwaters of Kerala is reflected in the removal of 2.5 million cubic yards of silt by dredging every year in order to maintain the shipping channel at Cochin Harbour, where the rate of silting is 180 cm/year (Kurup, 1971).

Examinations of bore-hole data from various stations at Cochin and Azhikode shows the presence of lumps of degraded wood at depths of 30–50 metres which might have been deposited at a time when the river bed was at this level. Dating of wood sample from 30 m depth at Azhikode indicated that it is about 1500 years old (P.S.N. Murthy, Per. Comm.). This shows a high sedimentation rate of 20 mm/year. It has to be mentioned here that Azhikode was an important port on the west coast of India from the pre-Christian era and has later become practically disfunct due to sand bar formation and siltation, presumably after the deluge in 1341 A.D., when the river Periyar took a diversion and opened up the Cochin gut.

Bore hole data from Cochin Harbour area also reveals that shell deposits of estuarine oyster *Crassostrea madrasensis*, extend upto a depth of over 5 m below the present bed level. The bottom level of these reef shells indicate the bed level of the backwaters at the time of their early settlement. In the southern Vembanad region, the shell deposits are known to occupy a depth of 2–5 m below the present bed level. Such shell deposits are available from almost all over the backwater system. These indicate hat the backwater was deeper in the past than what it is today. It is presumed

that, the settlement of estuarine oyster commenced only after the deluge of 1341 A.D., from which time a typically estuarine condition began to prevail in the environment. From the available data it has been deduced that in the course of fifty years, the average depth of Vembanad Estuary has been reduced from 6.7 meters to 4.4 meters (Table 1).

TABLE 1. *Reclamations in the Vembanad Estuary for agricultural and aquacultural purposes*

Period	Area reclaimed (ha)	% reclaimed	Purpose
1834–1903	2226.72	6.100	Agricultural
1912–1931	5253.15	14.392	–do–
1941–1950	1325.00	3.630	–do–
Till 1970s	5100.00	13.972	Paddy-cum-shrimp culture
1970–1984	800.00	2.191	–do–
1900–1984	1500.00	4.109	Housing, agriculture and traditional industries including coconut husk retting by private owners.
1975	6900.00	18.904	Ecologically severed from backwaters as a result of bunding at Thanner-mukkom.
Total	23104.87	63.298	

As a result of the reduction in area and depth the total volume of the brackishwater system between Alleppey and Azhikode has been reduced from 2.449 km^3 in the beginning of this century to 0.559 km^3 (22.83%) in 1985.

IMPACT OF SHRINKAGE ON THE RESOURCES

As regards the backwaters of Kerala, the most serious alteration taking place, is the progressive shrinkage of the estuarine system as a result of man-made reclamations and siltations. The adverse effect of this is reflected in the decline in the production of estuarine dependent fishery resources, of which the following are the most important.

Penaeid shrimp fishery

The penaeid shrimps such as *Penaeus monodon, P. indicus, Metapenaeus dobsoni, M. monoceros, M. affinis* and *Parapenaeopsis stylifera,* are the most valuable commerial sea-foods of Kerala. The life history of these species except the last one involves an estuarine phase, as their post-larvae and juveniles migrate to estuaries which provide their nursery grounds. As the shrimps grow, they move into deeper waters of the estuary and from there to the sea where they contribute to the marine prawn fishery. The soft organically rich sedimentary substratum of the inshore region is a preferred habitat of the penaeid shrimps. This particular texture of the sediment is brought about by the filtering effect of the estuary (Nair and Hashimi, 1986) thereby exerting its influence on the inshore habitat of shrimps as well. Estuarine depended species which contributed to the main bulk of India's marine shrimp landing in the initial stages of development of export trade (Banerji, 1969) is overtaken by exclusively marine species in the course of two decades. This can be considered as a direct result of the unfavourable alterations taking place in the backwaters.

From time immemorial, a rich juvenile shrimp fishery existed in the low saline upper reaches of the estuary. Prior to the commissioning of Thanneermukkom bund, an average daily catch of 5 tonnes of shrimps was available during the summer months (Kannan, 1979). The bund has reduced the extent of backwater

nursery grounds by 25%, which led to the total collapse of the juvenile shrimp fishery of this region. The decrease in the expanse of backwaters and the increase in the demand for shrimps has resulted in a more intensive exploitation of backwater nursery grounds (Menon, 1967). This has probably led to the shortage of shrimp seeds in the estuarine farms, in which, rate of production has been progressively declining during the past 3 decades. From the figures given by the earlier investigators, the average rate of production in 1950s works out to 1131 kg/ha (Menon, 1954; Gopinath, 1956). Afterwards through 1960s and 1970s the production has declined to the level of 600–700 kg/ha in the traditional shrimp farms (Gopalan *et al.*, 1980) and the continuation of the regressive trend is reflected in the low yield of 300–400 kg/ha reported by Purushan and Rajendran (1984).

Giant fresh water prawn

Bunding and prevention of saline incursion has led to the extinction of fishery of all migratory species which depends on both fresh and brackishwater for the completion of their life cycle. The giant freshwater prawn *Macrobrachium rosenbergii* used to contribute to a lucrative fishery in the middle and lower half of the Vembanad Lake, with a total production of 300–400 tonnes/yr (Rabanol, 1982; Rao, 1981). The characteristic annual breeding migration of this species from the fresh water region to the high saline lower reaches of the estuary was disrupted by the construction of Thanneermukkom barrage, which led to the near extinction of this fishery in Kerala.

Shell fishery

Extensive beds of oysters and clams of commercial importance was available in the backwaters. Of particular importance is the edible estuarine oyster *Crassostrea madrasensis*. Remants of their beds known as 'Muringa Madu' are still existing in the region of Cochin Backwaters. Till 1960s the growing beds of oysters were leased out for fishing by the government department of fisheries (V. S. Narayanan, per. Comm.). The fishery began to show a downward trend ever since the commencement of dredging and spoil spillage activities in Cochin Backwater for harbour development. Vembanad Lake is well known for its clam fishery, both live and dead, with an annual output estimated to be 1,70,000 tonnes in 1970 (KSSP, 1978). Reduction in the area of backwaters, dredging

TABLE 2. *Reclamations in the Vembanad Estuary for harbour and urban development*

Period	Area reclaimed (ha)	% reclaimed	Purpose and location
1920–1936	364.37	0.9982	Creation of Willington Island for harbour development.
1978	10.78	0.0295	Fishing harbour project.
1981–1985	141.70	0.3882	Vallarpadam – Ramanthuruthu – Candle Island complex under Integrated Development Project.
–do–	141.70	0.3882	Southern extension to Willington Island.
–do–	23.91	0.0655	Foreshore urban development by GCDA and Cochin Town Planning Trust.
–do–	11.73	0.0321	Reclaimed for the use of Cochin Shipyard, CIFT, North Tanker Berth and other berths.
Total	694.19	1.9017	

for reclamations as well as for mining the subsoil shells and salt water extrusion projects have affected this fishery adversely. Major species contributing to the fishery like *Villoritta cornucopia*, are adapted to saline conditions and thrive at salinities as high as 15 ppt. The existing subsoil shell deposits, estimated around 2-4.5 million tonnes (Rasalam and Sebastian, 1976) might be available for a few years more for commercial exploitation. But in the long run the regeneration of the shell resources will be hampered by the changing ecology of this region. This apprehension has given rise to the proposal, by the Fisheries Department of Kerala for the establishment of a clam sanctuary at a suitable site in the backwaters (Rasalam and Sebastian, 1976).

Mangrove swamps

According to an estimate there were 70,000 hectares of mangrove marshes in Kerala, a few centuries ago (Blasco, 1975). Vannucci (1984) stated that the whole backwaters of Kerala was once a mangrove swamp. In the south Vembanad region, the swampy areas (Kari lands) with black peaty soil having high proportion of carbonaceous wood, represent areas which were dense mangrove in the past. These areas come to a total of 61 km². Similarly, in the middle and northern sector of the backwaters, about 60 km² of paddy-cum-shrimp culture fields, were also converted from mangrove marshes. Even now the remnants of mangrove vegetation can be seem in almost all such fields. Mangrove swamp is an ecosystem supporting the productivity of estuarine fish and prawns. It is essential for the existence of some of the animals like estuarine crocodile *Crocodilus porosus* which used to nest in this highly specialised habitat. In the mangrove ecosystem, salt water crocodiles feed preferably on predator fish and promote the growth of certain fish populations of human interest (Sidensticker and Hai, 1978). However, these animals have become totally extinct in Kerala following the large scale reclamations of mangrove marshes.

TABLE 3. *Variation of depth range in different sectors of the Vembanad Estuary during the past 50 years*

Sectors	Depth range, 50 years ago (in meters)[2]	Depth range at present (in meters)[3]
South of Thannermukkom bund	8–9	3–3.5
Between Thannermukkom bund and Vaikom	8–9	3–4
Between Vaikom and South Paravoor	7–9	4–5
Between S. Paravoor and Aroor	5–6	3–4
Between Aroor and South of Willington Island	7–8	7–8
Cochin Harbour Region	7–8	7–8*
Bolgatti to Cherai	3–4.5	2–2.5
Cherai to Munambam	3–6	2.5–4

*. Cochin ship channel maintained at 15 m depth by constant dredging.
2. and (3) Based on actual measurements, available references and evidences collected by the authors.

CONCENTRATION OF EFFLUENTS

The decreasing volume and the limited exchange rate with the sea reduces the diluting capacity of the backwaters. The rate of inflow of industrial effluents, has increased from negligible level to 260 million litres/day (Anon., 1982) in the course of past 50 years. Similarly, with the increasing population the rate of discharge of domestic effluents have also increased to the present level of 80 million litres/day in the Cochin region. The adverse effect of this

has already been reflected in the incidence of mass fish kills and the increased bacterial activity reported from the backwaters in recent years (Unnithan *et al.*, 1975, 1977; Venugopal *et al.*, 1980). Agricultural runoff in the backwater system involves the drainage of about 1000 tonnes/year of pesticides in the districts of Alleppey and Kottayam every year besides the use of large quantity of inorganic fertilizers. The concentration of organochlorides and organophosphates at their insufficient levels to control many insect pests can inhibit or paralyse the activity of shrimps and fishes (Eisler, 1970) in the backwaters.

Growing trend of eutrophication

The visible indices of eutrophication can be seen in the explosive growth of several species of filamentous algae and vascular hydrophytes like *Salvinia* and *Eichornia* sp. in the low saline reaches of the estuarine system. According to an estimate about 1 kg/m^2 of the macrophyte weed matter in decaying state is accumulated at the bottom of the backwater system (Gopalan and Nair, 1975). The floating vegetation gets smothered in the petroleum oil film on the surface of backwater (about four million tonnes/year of petroleum oil is handled at Cochin Harbour) and renders the weed biomass toxic to the benthic organisms when they settle at the bottom, besides depleting dissolved oxygen and liberating toxic gases like hydrogen sulphide and methane. High BOD (5) values (6.21 to 280.40 mg/l), low dissolved oxygen values (0.05 to 3.081 mg/l) and high sulphide content in the bottom water have been reported from some localities in the backwater (Unnithan *et al.*, 1975).

The trend in eutrophication is further evidenced by the progressive concentration of nutrients (Nitrates and Phosphates) in the backwaters. The growing concentration of nitrate nitrogen can be seen from the recorded minimum value of 0.31 µg at/l in 1965–66, 1.5 µg at/l in 1973–74 and 4.0 µg at/l in 1978-79 (Sankaranarayanan and Qasim,1969;Sreedharan and Mohammed Salih, 1974, Sankaranarayanan *et al.*, 1983). Similarly, the recorded minimum value of phosphate phosphorus also shows considerable increase during the period. A minimum of 0.36 µg at/l was observed in 1965-66 (Sankaranarayanan and Qasim, 1969). By 1974, the minimum value had ascended to 0.85 µg at/l in the region south of Cochin, and 2.0 µg at/l in the region north of Cochin (Sreedharan and Mohammed Salih, 1974).

Characteristic to the eutrophic system the excessive inflow of nutrients stimulate productivity of certain resistant species in the initial stages which eventually leads to a condition of dystrophy. Besides the vascular hydrophytes, blooms of phytoplankton have also been reported from certain areas of the estuary (Sankaranarayanan *et al.*, 1982). *Corophium* sp. (Amphipoda) which was not documented earlier as a major species has been attaining dominance in the macrobenthos of Vembanad Lake in recent years (Gopalan *et al.*, 1981). Similarly *Tilapia mossambica* a well known resistant species which was not an entity in the species composition in the inland fish landing in Kerala three decades ago has now emerged as a major item in the catch contributing to the tune of 5000 tonnes in 1984–85 (Anon., 1985). Symptoms of eutrophication and reduction in the quantity and diversity of benthic organisms in the Cochin Backwater have also been noticed by Qasim and Madhupratap (1979).

Conclusion

From the foregoing account it becomes evident that Vembanad Lake, the largest backwater system in Kerala is undergoing man-made shrinkage, at an alarming rate by bunding and reclamation for agriculture, aquaculture, harbour and urban development and

other uses. Out of 36,500 ha of backwater existed till the middle of 19th century, only 12,700 ha (34.8%) is remaining now as open waters.

Plans are also being made by the development agencies for further reclamation and conversion of backwater areas for urban development, aquaculture and other purposes. Half of the existing brackishwater areas have been identified as suitable for the expansion of aquaculture, (Varghese *et al.*, 1985). GCDA has been planning for urban development a further reclamation of 640 acres on the foreshore at Ernakulam. This shows that by the turn of this century the area of the backwater will be reduced to about 17%. This naturally arouses apprehension especially in the context of over exploitation and dwindling of resources.

As mentioned earlier, several centuries ago the backwaters of Kerala was predominantly mangrove marsh extending to about 70,000 ha. (Vannucci, 1984; Blasco, 1975) which was subjected to natural process of evolution, has now been overtaken at a faster rate by the man-made alterations. This has created an imbalance in the ecosystem, exemplified by the reduction in the carrying capacity of the medium, disruption in the life cycle of organisms, distruction of natural habitats, accumulation of pollutants, symptoms of eutrophication, tendency for overexploitation and dwindling of resources.

However, it may not be possible to take the system back to its pristine glory and hence new methodologies have to be evolved to maintain the system in good health. This necessitates multidisciplinary in-depth studies, on various components of the system so as to generate adequate information for evolving simple mathematical models with which management methods could be arrived at.

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