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Wetlands And Urban Environment

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Preface

The demand for land within the city and its periphery increases in the process of urban growth, particularly at accessible locations. Consequently land prices increase. Left to the market forces, each piece of land in the city and its periphery will be developed some day or other and put to some profitable urban use. The wetlands in and around the city are an easy target of the process, but the wetlands are crucial for the ecological and environmental balance in urban areas. They act as a source of oxygen generation and heat absorption, as a retention basin and a provider of low cost sewage and waste water recycling facilities. As the benefits from the wetlands are largely social rather than private in nature, these are either ignored or given an inadequate weight in the market-oriented individual decision making. Further, in view of difficulties in measurement and valuation of these benefits, they are conveniently ignored even in the social decision making by the planners. Therefore, what to do with the urban wetlands presents a difficult choice in respect of urban development planning.

The contributions in this discussion paper discourse various beneficial dimensions of the urban wetlands and demonstrate that there is a prima facie case for the preservation of urban wetlands. Even without subscribing to the environmentalists' absolutism that all wetlands should be preserved, one would have to concede that a scheme for the filling up of an urban wetland for augmenting the supply of urban land should be recommended only on the basis of a comprehensive social-cost benefit analysis.

The paper includes three contributions with tolerable bits of overlap. The first one is by A.K. Ghosh and gives a broad perspective of wetlands and their importance for the urban environment, with special reference to east Calcutta. The second contribution by S. Chatterjee discusses the importance of east Calcutta wetlands, with some technical details. K. J. Nath examines the existing system of pisciculture in east Calcutta wetland fisheries and how these could be used more effectively for low cost city sewage treatment.

What comes out from these contributions is that in order to decide whether to preserve wetlands or not, one must compare the vector sum of the multiple benefits that the urban system derives from the wetlands with the value of the urban land. Further, an increase in the productivity of wetlands in terms of fish production or waste-water treatment would strengthen the case for wetland preservation.

This discussion paper is the outcome of deliberations at the Centre for Urban Economic Studies at different seminars and workshops. The three contributors are well-known in their own fields. Dr. Ashis Kumar Ghosh was the former Director of Zoological Survey of India, Dr. Sivabrata Chatterjee, is a Chemical Engineer and Environment Consultant and Professor K. J. Nath, is the Director and Professor of Environmental Sanitation and Head, Department of Sanitary Engineering, All India Institute of Hygiene and Public Health, Calcutta.

1. Wetlands and the Urban Environment

A. K. Ghosh

1.1. Wetlands - An Overview

The movement of water over land, one third of the surface area of the planet, is often hindered by the physical characteristics of the surface. It leads to the formation of areas of standing water - transitional or permanent in nature - like marshes, swamps, lakes and ponds. Varying in depth and dimension, these wetlands harbour plants, micro-organisms, animals including the rich sources of protein food, fishes and crustaceans - after all, the origin of life was in water.

As wetlands are characterised by flat lands and shallow water, there is a trend all over the world to reclaim the natural wetlands to meet the demands of agriculture, new settlements, roads, industries and other community uses. In the history of reclamation, the Netherlands comes first - a country which reclaimed large coastal wetlands by dyking to solve its acute land scarcity. In the 1930s, Denmark reclaimed a quarter of its one million hectare marshland. Examples can also be cited from countries like Belgium and Finland in Continental Europe. In the United States 40 per cent of the wetlands have been drained or filled between 1850 and 1985. In Brazil, the world's most extensive wetlands, about 110,000 square kilometres in area, is being encroached upon by agriculture (World Resource Institute, 1986). In Asia, Japan leads the way by reclaiming the second largest lake area in the world for paddy cultivation and about 33 per cent of the tidelands have been converted between 1945 and 1978.

In India, West Bengal and Kerala have a long history of wetland reclamation. In Kerala, earlier reclamation was confined to the shallow waterbody of Kuttand; however, there has been encroachment into Vemland Lake and other areas with deeper waters in the recent period. In West Bengal, in the Sundarbans, coastal wetlands are converted for agriculture, while wetlands in the eastern fringe of Calcutta, commonly known as Salt Lake, have been reclaimed for urban settlements.

1.2. Wetlands in the Urban Scenario

While wetlands are reclaimed in various parts of the world, the choice between conserving wetlands and their reclamation for other uses in the urban scenario is a difficult one because of conflicting interests.

Urban settlements are centres of population, production and consumption. They function as dynamic entities in social and eco-nomic systems. The larger settlements generate, on the one hand, the positive advantages of economies of scale and agglomeration, and, on the other, a high degree of environmental degradation including air, water and noise pollution. Many of the urban areas in India are fast becoming very large because of population explosions not only within the core city but in peri-urban and suburban areas. The trend will continue in the absence of adequate decentralisation of economic activities and the provision of essential social services. Consequently, the demand for residential land increases steadily. In the absence of proper land-use planning, environmental conditions become increasingly critical as well.

We have to consider wetlands in urban settlements against this backdrop, which is not at all an alien feature in India. The cities and towns in the coastal belt and along the major rivers like the Ganga have often been endowed with natural wetlands. There are also wetlands elsewhere, mostly comprising man-made lakes, for example, in Hyderabad and Secunderabad in Andhra Pradesh and in Udaipur in Rajasthan. The urban areas derive benefits from these water bodies, although wetlands occupy precious urban land.

Thus, whether to treat wetlands as a resource or as an obstacle to development is still an unresolved debate for town planners. No generalised prescription can be made, because the hydrology of the wetlands depends on geographical and topographical circumstances. Therefore, whether a waterbody in an urban setting could be a resource or not can be ascertained only through a complete understanding of the wetland environment and its interaction with neighbouring areas (Roy, 1989). We may consider wetlands as resources for an urban settlement from several aspects. We discuss the issue with special reference to Calcutta city here.

Firstly, urban wetlands act as a retention basin in general, and a backup for the city drainage system. While provision of a storm-water drainage system is a part of urban planning, it is built with pre-assumed frequency and volume of rainfall. A combined drainage-sewage system further assumes a particular population-water use model. The maintenance of such a system often remains in a questionable state. With the passage of time, waterlogging and flooding become frequent and disrupt civic life for a considerably longer period of time. Ponds, lakes and other waterbodies within the urban limit act as detention centres, and provide essential spill basins outside the core area. Any change of these areas can lead to serious flooding problems. The point in question can be well illustrated from the growth profile of Calcutta. With increased urbanisation, many of the water bodies within the city have been reclaimed, many more have become atrophied and at the same time the natural spill basin in the eastern part of the city has been systematically converted into residential land. During the same period crores of rupees have been spent on the laying of underground storm water pipes but with every monsoon rain lasting for a few hours, vast areas of the city become waterlogged, sometimes for days together. The worst affected areas invariably lie on the west side of the Eastern Metropolitan Bypass which acts as a virtual dyke cutting off the natural spill basin in the erstwhile Salt Lake swamps.

We may compare this with what town planners in the developed countries with far greater financial and technological resources at their disposal are doing. A report prepared by the American Public Works Association Research Foundation reveals that more than 200 civic authorities have detention facilities, either natural or created, in the form of ponds and dry basins, for stormwater management and many civic bodies which do not have such facilities are creating them on a priority basis.

Secondly, the wetlands may be used as low cost sewage treatment facilities. The discharge of untreated city waste water into surface water has caused damage beyond redemption in many parts of India. The glaring instance is the pollution of the Ganga from waste water discharges, which include industrial effluents too. It became so polluted that a special action plan (the Ganga Action Plan) was initiated on a priority basis. The action plan has accepted a model (based on the east Calcutta experience) of utilising wetlands for sewage treatment with an added benefit of pisciculture. A recent World Bank Report describes 2,500 hectares of wetland (sewage-fed) fisheries of east Calcutta as the single largest system of its kind. Besides India, China has a total of 670 hectares of such a system in 42 cities; and Israel, Hungary and Germany also have similar fisheries on a limited scale.

Further, effluents from sewage treatment fisheries are used for irrigation in agriculture in vast areas of east Calcutta. A study of the east Calcutta wetlands by the Institute of Wetland Management and Ecological Design (IWMED), Calcutta, identified 12,000 hectares as the single largest urban waste recycling system (Ghosh, D. and Sen, S., 1987).

Thirdly, wetlands help in nutrient recovery and cycling, releasing excess nitrogen, inactivation of phosphates, and removal of toxic chemicals and heavy metals through absorption by aquatic vegetation and finally treating wastewater (Ghosh, A. K., 1987). It may be noted here that there are at least 15 other large wetlands within the city of Calcutta apart from the east Calcutta wetlands, varying in size between 119 acres (Rabindra Sarobar) to 40,000 acres (Dankuni Marsh) (see Table 1.1) which also help to maintain the ecological balance.

Considering the immense value of wetlands as an ecosystem, co-operative societies in urban settlements have been formed for productive fisheries by marginal people. The example of Mudialy Fisheries Cooperative Society in south Calcutta is now being cited more often than before. This society with 225 members has shown that an 100 acre wetland could be preserved for an aesthetically pleasing urban park, and be used for highly productive sewage-fed fisheries leading to the natural treatment of millions of litres of city sewage and discharging the same in a much better, cleaner state to the surface system.

Fourthly, wetlands in the urban environment as such are to be evaluated on a functional matrix. Water being a scarce commodity in many urban settlements, the natural and man-made ponds and lakes often serve as the only sources of water for domestic use. The dense urban settlement also demands an adequate protection against fire hazards and wetlands remain the most dependable source of water in such contingencies. (Ghosh, A. K. 1987).

Finally, apart from the practical and materialistic functions of wetlands in an urban system, one must mention that the wetlands in Calcutta act as the habitat for water-fowl, both resident and migratory, which points to their role in the conservation of biological diversity, which is currently emphasised for sustainable development.

Thus wetlands in an urban environment act as a multifunctional system for drainage spill, pollution abetment, effluent treatment, fishery production, irrigation, a water source for fire fighting and domestic uses and wildlife habitat. Before deciding the conversion of wetlands, therefore, the total value of the wetlands including the ecological price tag has to be considered.

1.3. Government Policy towards Urban Wetlands

Concern about the wetlands is just emerging at the government level. The Central Ministry of Environment and Forests has adopted a positive policy to assess the wetland resources state-wise (Government of India, 1989), which would facilitate the comparision of the area under two vital ecosystems, namely, forests and wetlands. The national wetland policy has emphasised the socio-economic (fish, aquatic vegetation, reeds), hydrological, bio-geographical and biodiversity values and also research and educational values of wetlands, but failed to mention its waste-recycling value. The National Wetland Management Committee has identified 16 wetlands of national importance in 12 states of India.

Moreover, studies on various aspects of wetlands - biological resources, hydrology, landscape feature, socio-economic uses, identification of problems, and conservation-management measures - have been undertaken by national survey organisations, state departments and educational institutes. An inventory of wetlands (State/Union Territory-wise) has also been published showing the total wetland area, natural and man-made wetlands, with a key to the location and area for each of the wetlands (Government of India, 1990).

At the state level, in West Bengal, the policy for conservation of wetlands is so far based on the provisions of the Town & Country Planning Act, 1979, which seems to be not very effective in the face of unplanned, erratic but motivated conversion of wetlands in urban areas with the singular objective of immediate profit-making. It is essential to have a stricter rule, in the form of a wetland conservation and management act, to ensure the survival of this vital ecosystem within a fast-changing urban scenario.

Besides, the government has multiple planning authorities and it is necessary therefore that the government policies regarding wetlands should be consistent and clear. It is often amazing to note the contradictory decisions being made by the different planning bodies of the same government. A fitting example is the case of the preservation of the east Calcutta wetlands vis-a-vis the expansion of the city. The State Planning Board was entrusted by the West Bengal Government to prepare a perspective plan for the city upto 2011 AD. The draft document was released in January 1991 and discussed in detail at a three-day workshop. There was no controversy about the recommendations to preserve east Calcutta wetlands and they suggested alternative sites for satellite townships in the (i) Uluberia-Bagnan area (ii) Barasat-Barrackpore area (pp. 89-90). The maps prepared with the help of satellite imagery support the idea and the criteria set up for future growth centres are all met in these areas. Besides, the document, while calculating settlement patterns in the future, has excluded waterbodies, marshy land and defence land (p. 92). These recommendations are in conformity with the suggestions given by a group of four experts at a seminar in July, 1990 at the Calcutta Information Centre (convened by the Institute of Local Government and Urban Studies). The reasons as to why the city's expansion should be avoided in the east and should be advised towards the north and west were summarised point by point (Table 1.2). In addition, the rationality of such a policy is amply justified on the grounds of the biological resources of urban wetlands of the Calcutta region (Ghosh, A. K. 1990a, 1990b).

However, recent decisions announced by other authorities within the same government seem to totally contradict such recommendations and policy-adoption. It goes against the expert advice of IUCN specialists (Proc. IUCN, Vol.III, 1971) or Indian scientists and engineers (IWMED, 1980, Government of West Bengal, 1991). It seems that there is a lack of basic understanding about the functions of wetlands. While sanitation engineers emphasise waste-recycling and supportive functions, biologists talk of biodiversity, sociologists try to drive home the point of employment of marginal populations, environmentalists talk of microclimates and so on, all these should be considered together in assessing the environmental impact of any proposed conversion of wetlands. The so-called development lobby try to pick up one of the many functions of wetlands and harp on what will happen if acres of wetland are further converted. When a wetland area has been reduced from 20,000 acres to 8,000 acres, such pleas can only focus on ulterior motives. Moreover, the development lobby will never come up with the declaration 'thus far and no further'. Options are always kept dangerously wide open. Even the oft-quoted provisions of the Town & Country Planning Act are observed to be openly flouted on one pretext or the other. The lessons learnt from history are ignored.

A firm policy is needed immediately cutting across political, social and economic interest groups. Otherwise, the preservation and management of urban wetlands for sustainable development with a better environment would not be feasible.

Table 1.1: Some of the large wetlands (more than 100 acres) in Calcutta Metropolitan Area

Name of Wetlands	Location	Approximate Area (acres)
1. Dankuni Marsh	22° 36'00"-22° 4 9'00"N, 88° 16'00"-88° 21'00"E	40000
2. East Calcutta wetlands	22° 26'34"-22° 34'31"N, 88° 23'43"-88° 31'43"E	19050
3. Mathura bill	22° 56'00"-22° 57'52"N, 88° 27'15"-88° 31'00"E	763
4. Bariti bill	22° 47'29"-22° 48'30"N, 88° 25'16"-88° 26'30"E	694
5. A cluster of water bodies near Halisahar	22° 55'30"-22° 57'00"N, 88° 25'47"-88° 26'27"E	606
6. Marsh northeast of Bariti bill	22° 48'20"-22° 49'30"N, 88° 26'34"-88° 27'00"E	606
7. Water bodies in Garden Reach area	22° 31'23"-22° 33'00"N, 88° 17'15"-88° 18'26"E	537
8. Baisar Bill	22° 59'00"-23° 00'23"N, 88° 27'20"-88° 28'54"E	444
9. A cluster of water bodies north of Belghoria railway station and around Ghola	22° 40'00"-22° 41'29"N, 88° 22'53"-88° 24'00"E	313
10. Kulia Bill	22° 57'00"-22° 58'00"N, 88° 26'50"-88° 28'57"E	306
11. A waterbody near Santragachhi	22° 34'46"-22° 35'07"N, 88° 16'45"-88° 17'26"E	238
12. A waterbody south -west of Kantalia	22° 42'53"-22° 43'20"N, 88° 31'47"-88° 32'46"E	181
13. A marsh southwest of Bariti Bill	22° 46'30"-22° 47'25"N, 88° 23'47"-88° 24'24"E	156
14. Patharghara Bill	22° 45'10"-22° 45'45"N, 88° 23'00"-88° 23'34"	125
15. Dhokradaha Bill	22° 58'00"-22° 59'00"N, 88° 26'25"-88° 27'00"E	125
16. Rabindra Sarovar	22° 30'14"-22° 30'46"N, 88° 21'00"-88° 22'00"E	119

Table 1.2 : Comparison of the Environmental Impacts of the East and South Eastern versus Northwards Growth of Calcutta City

Parameters	East and South Eastern Growth	Northwards Growth
1. Environmental consideration	Loss of wetlands; increase air pollution; destruction of valuable eco-system waste treatment facility	The wetland eco-system remains intact
2. Drainage; flood cushioning and health	Reclamation and urban construction cause major loss of drainage outfall basins. Less facilities for disposal of rainfall excesses; increasing health hazards	Wetland facilities in the Eastern Metropolitan fringe can be utilised. Healthier environment.
3. Water supplies	Increasing mineralisation and hardness of water; unpredictable salinity in groundwater. Consequent need to tap and treat Hugli water	Prolific ground water supplies from major basin; less pumping costs and mineralisation problems (only iron removal called for); Safe and potable for humans
4. Sewage treatment & solidwaste disposal	Natural Dhapa system being lost through reclamation. Calls for very costly treatment plants. Gradual loss of garbage disposal sites as well.	Natural facilities retained. Additional systems can be designed in Eastern Metropolitan fringe wetlands.
5. Economic products	Rich fish haul as primary source of protein rapidly dwindling. Vegetable growing areas shall also be usurped for urban construction ultimately.	Fisheries development can be further strengthened with State/ Panchayati control; more vegetables/mixed framing products.
6. Hinterland communications	Away from city's hinterland- increased freightage and communication/traffic problems in core Calcutta.	Nearness to hinterland; easier disposal of heavy vehicles. Utilisation of trans-Hugli facilities. Shall need strengthening of North communication corridors.
7. Social factors	Loss of primary sector livel (fisheries, farming). Increasing tertiary sector problems. Control by land speculators to take over reclaimed land parcels at the cost of middle and lower income groups.	Distance from core shall discourage such speculators. Cleaner urban development - more healthy due to lesser drainage congestion and lesser preventive health costs. Greater land/water based employment in primary sector.

Table 1.2 : Comparison of the Environmental Impacts of the East and South Eastern versus Northwards Growth of Calcutta City (Contd.)

Parameters	East and Souteastern Growth	Northwards Growth
8. Hugli Conservancy	Larger extraction of water for urban supplies with consequent flow reduction and increased pollution and salinity, which in turn escalates the cost of treatment.	Tapping Hugli avoidable. North- wards reach of river less polluted with less tidal salinity.
9. Land availability	Only by reclamation at high cost and degradation of system.	Good lands available in Kalyani -Haringhata zone. Dairy to be shif ted to east Calcutta reclaimed zone.

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2. Wetland Preservation and Its importance for Calcutta

Sivabrata Chatterjee

2.1. Introduction

Although there has been a spate of public debate around the preservation of the east Calcutta wetlands since the late 1980s, awareness about its importance is not really new. In 1944, India's National Institute of Science organized probably the world's first symposium on utilizing sewage for fish culture, in Calcutta city, under the shadow of the Bengal Famine of 1943. There was surprise amongst the foreign delegates that so many people had died on the streets of Calcutta from starvation during the famine while the city's vast watery hinterland could supply both fish and vegetables. Again, in 1988, Calcutta city was the location of an international seminar on Waste Water Reclamation and Reuse for Aquaculture (6 to 9 December 1988). The city was considered to be the most appropriate setting because the sewage- fed fisheries of east Calcutta, covering some 40 square kilometres, constitute the world's largest single establishment of wastewater reclamation and reuse for aquaculture for over four decades.[1] However, the concern for using the potentials of the wetlands and their preservation optimally is a relatively recent phenomenon.

What is a wetland? Wetlands are lands containing a good amount of soil moisture, usually classified into three categories: swamps, marshes or bogs. A swamp is a wet spongy land saturated and intermittently covered with water. A marsh is a tract of soft wetland usually characterised by grass or similar monocotyledon plants while a bog is a poorly drained area. The water may be sweet, salty, brackish or degraded depending on the origin of the area.

Out of a global land area of about 149 million square kilometres, an area of 2 million square kilometres (roughly 1.3%) is covered with swamps and marshes. In India the total area of wetlands is about 17,091.37 square kilometres of which 14,508.71 square kilometres (84.9%) is natural wetland and the rest is man-made wetland. The corresponding figures for West Bengal are 3,445.27 square kilometres. and 2,919.63 square kilometres (84.7 per cent).[2]

2.2. Features of Wetlands

Wetlands are important from the environmental viewpoint for the following features, of which some are particularly significant for the environment of large urban settlements:

Production of Biomass: All wetlands are productive in te- ms of biomass yield - on an average the annual generation rate is 15 kilograms per square metre, which means a global total of 30,000 million tonnes a year. This is the primary product created from the sun's energy, water and carbon dioxide in the air, through a process called photosynthesis which fixes the carbon into carbohydrates and releases oxygen. Although the total amount of solar energy that reaches the earth is of the order of 3,400 kcal per square metre a day, only a small fraction of 5 per cent of it (170 kcal per square metre) is used in photosynthesis, on which depends the whole organic life. The tiny blue green algae (of size 1 to 10 micron) that play a prime role in the conversion process and production of green chlorophyll is noticed in all water bodies (sweet or saline) even in those of the arctics and deserts.

Generation of Oxygen: While the release of oxygen from the photosynthetic process is going on worldwide, the oxygen from the oxygen present in the global atmosphere (about 70 per cent) is accounted for by the ocean - oxygen released by the floating botanical matter (phytoplankton) on its 361.3 million square kilometre surface. However, the other inland water bodies also have an important role in providing oxygen, particularly in the congested urban areas, where, apart from human beings - the primary consumer of oxygen, consuming about 2.1 grams oxygen per minute- the automobiles, the industrial furnaces and even domestic ovens consume a large amount of oxygen at a great speed. In Calcutta, the loss of oxygen is partly replaced by the oxygen born in the wetland on the eastern side of the city of Calcutta, known as Salt Lake,[3] and other water bodies in the city. The other sources providing oxygen to Calcutta include the trees in the city, the wind from Bay of Bengal coming over the forests of Suderban.

The yield of photosynthetic oxygen from a water body depends on geographical location and climatic conditions. For instance, in Calcutta, which is situated slightly above 22^0 north latitude and has temperatures ranging from 10° Celsius in winter to 40.3° Celsius in summer, and receives an average annual rainfall of 1,605 millimetres, one square metre of water surface can produce 23.75 grams of oxygen on a cloudless day. The natural sunlight supplies sufficient energy for carbon dioxide of the air to chemically combine with water to produce oxygen and carbohydrates. A part of this oxygen remains dissolved in water and the remaining portion is released to move with air currents towards the city and its metropolitan area. Summer is the best period for oxygen generation compared to winter when the sun's rays are less strong. It is estimated that on an average Salt Lake releases 226.75 kg oxygen/day/ha every day (Table 2.1). When computed for 365 days on 3,000 hectares of wet surface, the figure becomes 82,763.75 kg/ha/year or 248,291.25 tonne oxygen per year from 3,000 hectares. The amount cannot be ignored from the air pollution control point of view as well.

As stated above, an average man needs about 2.1 grams of oxygen per minute; at that rate, the daily requirement of 3,024 grams oxygen of a Calcuttan can be obtained from a water body of 127.3 square metres area. Therefore, the preservation of the Salt Lake wetlands, which initially had an area of about 40 square kilometres but shrank afterwards to 30 square kilometres has been a matter of serious concern for the environment-conscious people of Calcutta.

Carbon-dioxide Absorption: The alarm for the greenhouse effect due to the accumulation of carbon dioxide in the air has now gained ground. There is a frantic attempt to reduce deforestation and increase afforestation so that the gas can be fixed in trees.

It is clear from the foregoing that carbon dioxide is also fixed as carbohydrate on watery surfaces. For every kilogram of oxygen generated 1.375 kilograms of carbon dioxide are fixed. For Calcutta, which produces carbon dioxide through human breathing and burning of fuel, it is interesting that a part of it can be used constructively. For about 248,291 tonne oxygen released to the atmosphere, an equivalent 341,400 tonne carbon dioxide gets removed from the air. Actually the figure is a little more if we take into consideration the carbon dioxide equivalent of oxygen dissolved in water, and the total amount becomes 467,872 tonne carbon dioxide a year removed by the Salt Lake water.

Heat absorption: Soil has a smaller heat dissipation capacity than water. During the day, the land becomes hot, whereas water maintains its heat equilibrium by evaporative cooling and dispersion of heat within its body. The Calcutta area receives solar heat of an average 4,170 kcal/square metre per day. In the absence of ventilation , many city areas have become heat islands. Such a possibility does not exist in the water realm and its surface temperature rises hardly by 2 to 4 ^{0} Celsius. Without water's special qualities for holding heat, much of the earth would be uninhabitable. Water bodies are coolants of the concrete city - moderators of temperature. Water bodies are part of the city landscape for beauty and survival; these are part and parcel of human civilization from time immemorial.

Water recharging: Wetlands, like any open unbuilt lands, are areas through which rain water percolates the soil and reple- nishes the subsoil water.

Aquaculture and Sewage Treatment: Aquaculture means water farming just as agriculture means field farming. The growth of algae in ponds is a highly efficient process treating sewage, with protein yields far in excess of those obtained in conventional agriculture. The sewage-grown algae may be used as supplementary animal feed for chickens, pigs, cattle and sheep. However, algae protein in waste ponds is most conveniently exploited by growing algae-eating fish in the maturation ponds. The tilapia (sarotheradon mossambical), carp (catla and laboe rohita), channel catfish (ictalurus punctatus) and mosquito fish (gambussia spp.) also grow well there.

The daily diversion of Calcutta sewage to the eastern direction is of the order of 800 million litres. It carries 220 tonnes of nitrogen, 55 tonnes of phosphorus and 110 tonnes of potash daily whose aggregate value is Rs. 20.50 crores (ten millions) per year.

Experiments carried out at Burdwan University showed that about 6.5 hectares of land would be required for the treatment of five million litres of sewage per day; the annual yield per hectare would be 110 tonne water hyacinth, 8-10 tonnes of fish, one tonne algae, and one tonne snails. A low rainfall territory like Israel has demonstrated by actual sewage farming that it is capable of producing eight tonnes of fish in eight months compared with 4.7 tonnes in a chemically fertilized pond of equal area during the same period.

Deep water paddy cultivation: Wetlands can be used for paddy cultivation. In March 1987, Faizabad Agricultural University developed a new variety of paddy, named Jal Madhu, which could be grown in 4.5 metres deep water and can remain in water for three to four months at a stretch. Such varieties would open up the possibility of more productive use of the Calcutta wetlands.

Preservation of top soil and prevention of loss of nutrients: Soil erosion is a natural process. In an undisturbed ecosystem soil is regenerated almost at the same rate that it is removed. In India, 1.4 million square kilometres area out of a total of 3.3 million square kilometre area suffers from excessive soil loss, estimated at 4,700 million tonnes/ year, to a large due to degradation of land by deforestation in hills and plains. But such soil loss does not take place if the soil is moist. Therefore, the wetland system has natural advantage in preserving the top soil.

The loss of soil is associated with the loss of soil nutrients. The annual loss in India is estimated as six million tonnes of nutrients. This does not happen in wetlands.

2.3. Government Policy

In spite of the importance of the wetlands, government initiative and policy measures for the preservation of wetlands is far from satisfactory. It is the Central Government's primary responsibility. In 1972, India signed the U.N. declaration adopted in the U.N. conference on Human Environment in Stockholm. The declaration stressed, particularly in Principle 4[4], that nature conservation should receive utmost importance in planning for economic development. According to the Constitution of India, the responsibility of implementing international agreements lies with the Central Government (Items 12 and 14 of the Union List). In fact, laws relating to the protection of air quality and environ- ment have been enacted by Parliament. There is the Forest (Conservation) Act of 1980 to protect forest lands from conve- rsion of such land for non-forest purposes, but no such law with respect to the protection of wetlands has been enacted by the Central Government, output in the area would be raised to 20,000 tonnes annually. The West Bengal State Planning Board had instructed the municipal bodies to help improve sewage-fed ponds instead of making efforts for setting up sewage treatment plants. Many municipalities thereafter put notice boards by the side of water tanks that these would not be permitted to be filled.

However, in 1988, to go by the news reports in the Calcutta dailies, the West Bengal Government decided to extend Salt Lake city by immediately acquiring about 3.2 square kilometres of swamp land under the State Land Acquisition Act. If the proposal were carried out, a total 18.1 square kilometres of the Salt Lake wetlands would be solidified (Table 2.2). The rationale of the governmental decision has not been disclosed. It is not clear why the government had to revise its own delared policy and to build housing accommodation on this part of the city at the cost of productive renewable resources - the wetlands, while land is available or may be developed with similar facility in other parts of the Calcutta Metropolitan Arca.

In conclusion, it appears to be expedient to put the proposal for further reclamation of Salt Lake in abeyance until the evolution of a national policy on wetlands. Housing schemes for the medium and low income groups may be relocated elsewhere in the metropolitan region.

because land is on the State list.

Another important aspect relates to the documentation of existing wetlands and their mapping. The Union Ministry of Environment has undertaken an All-India Wetland Survey and circulated about 2,000 copies of the questionnaire among State Governments seeking information on various ecological aspects of wetlands. On receipt of the required information and data from all sources, a status report on the subject will be brought out by the Central Government. It may become necessary to establish a National Wetland Development Board on the lines of the National Wastelands Development Board (established in 1985) which has taken up the programme of greening of five million hectares of waste lands every year.

In its guidelines for environmental impact assessment, the Central Government has put the conversion of fisheries to other purposes in Schedule III projects, for which consultation with the Environment Department is mandatory before giving approval.[5]

Role of the West Bengal State Government

The West Bengal Government's policy, as evident from ministerial statements and committee reports, is to preserve the wetlands. Thus, the West Bengal Minister of Fisheries said on 11th May 1985 at a seminar on Alternative Proposals for Balanced Land Use Development of East Calcutta that the Government would not encourage destruction of the sewage-fed fish ponds, known as the 'fish bowl' of the city, on both sides of the Eastern Metropolitan Bypass.[6] An Advisory Committee set up by the Land and Land Reforms Department made it clear in its report that there would be no further extension of any buildings or commercial structures on the eastern fringe of the city. To enhance the eco-nomic returns from the wetlands, the State Fisheries Department announced that the fish

Table 2.1: Oxygen generation and release from Calcutta's Salt Lake (3000 hectare) (kg/day)

Period	Oxygen			Total oxygen released
	Produced	Dissolved water	Released in atmosphere	(3000 ha)
Summer (May)	371.5	76	295.5	886500
Winter (Dec)	250.0	92	158.0	474000

Table 2.2: Salt Lake reclamation 1960-1988

Phase	Year	Sq.Km.
1*	1960	9.7
2*	1966	5.2
3 (proposed)	1988	3.2
Total		18.1

*Government of West Bengal, Public Accounts Committee Reports (1960 to 1966)

Notes

1. It was mentioned in the Message of Mr. S.A.M.S. Kirbia, the Executive Secretary for the ESCAP (Economic and Social Commission for Asia and the Pacific) to the organisers of the seminar. It was a joint effort of the ESCAP, UNDP and the World Bank's Waste Recycling Project and supported financially by the Federal Republic of Germany.

2. Government of India, 1990, **Wetlands of India**.

3. A look at the hostory of Salt Lake seems useful. As revealed by pollen analysis and radio-carbon dating, Calcutta was once a part of the Sundarbans. Names of localities in the city, such as Entally from Hental (phoenix paludosa), Garanhata from Goran (ceriops tagel) and Garia from Goria (kandalia kandal) indicate that these trees must been very common in what is now metropolitan Calcutta. In the 14th Century, the main flow of the Ganga changed course from the Bhagirathi to the Padma. As the sweet water flow was reduced, salinity increased which made some plant species disappear. Earthquakes (of 1707, 1737, 1867, 1895 as also

in recent times 1942, 1970, 1973 and 1981) in this region are recorded. The surge of sea water to such devastating extents must have been due to tectonic and atmospheric disturbances. When the sea receded, it left behind a trail in the form of salty riverine channel interspersed with lakes born of local topographic upheavals. The strip of land lying between the Ganga river and the saline lake land was found to be a safe haven for the East India Company as it was less vulnerable to attack from both east and west. The river bank was at a higher level than the salt lake which provided the natural drainage for Calcutta township. The town became a teeming metropolis by gradually filling salty marsh lands - a process started in the 17th century. However, the inhospitable vast salt lakes were left undisturbed. The non-habitat became the fishery and dumping ground of the city's refuse. As the saltiness of the water disappeared, vegetables began to be grown there.

4. There are 26 Principles.

5. Vide, the Circular of Chief Secretary, West Bengal, Circular no. 4897-AR dated the 8th December 1986. It has inserted rule 10A, in the Allocation and Disposal of Business which states that

-No department shall, without the previous consultation with, and without the concurrence of the Department of Environment, accord administrative approval to any scheme or project ... Although the cabinet retains its overriding power to any decision to which the Department of Environment has not concurred, in this particular case, such a controversy seems not to have arisen. Moreover, the Department of Environment has not made public its views.

6. The West Bengal Minister for Fisheries reiterated this stand at the Institution of Engineers, Calcutta, on 16th June 1987 on the occasion of the first Wetland Day celebration.

3. Wetlands and Waste Recycling in Calcutta

K. J. Nath

3.1. Introduction

The use of excreta and waste water in acquaculture is an age old practice, particularly in Asia, and most of the excreta and waste water reuse systems at present are found in Asia, though some waste water reuse systems operate in Europe too. Calcutta does possess a unique system for the utilisation of sewage in the eastern suburbs of the city. For a long time now, the vast wetland there has supported sewage-fed fisheries which supply a considerable quantity of fish to the Calcutta market. Sewage irrigation is also practiced to produce vegetables which constitutes a major portion of the vegetable supply to the city.

The wetland in Calcutta originated largely from the interdistributary marshes created by the shifting of the main river Hooghly. It is estimated that out of 11,000 hectares of wetland existing in 1945, an area of 5,200 hectares of land were used for sewage-fed fisheries. By 1985 the wetland area under sewage-fed fisheries had declined to only 2,500 hectares. While the wetlands provide various environmental benefits to the city and represent a unique ecosystem, it must be emphasized that initially these wetlands were and are used for harvesting fish. At present approximately 2,500 hectares of ponds, fed by sewage, yield on an average 7,000 tonnes/year for the Calcutta market. Fish reared in the ponds are either Indian major carp or tilapia.

3.2. Aquaculture in east Calcutta

The sewage-fed fisheries in east Calcutta function as maturation ponds when low flow input sewage gets diluted in the pond. The dissolved oxygen content in the pond water remains in a favourable condition maintaining a symbiotic relation between algae and bacteria. These ponds basically receive very low organic loading, with the primary objective of a high yield in fish production. In the course of the process, however, the quality of fed-sewage gets upgraded.

Usually some of these ponds are drained in February to March for the removal of vegetation and mud. Sewage and water are fed in 1:5 proportion. In three weeks time, the water turns greenish due to phytoplankton growth. After stocking the fish, sewage is subsequently introduced slowly about once in a month for a period of 5 to 10 days, so that the proportion of sewage to water in the pond is about 1:4. Considerable skill and experience in feeding the ponds with raw sewage to avoid de-oxygenation of the water has been acquired by the fish farmers. In 5 to 6 months, the fish attains marketable size and are harvested continuously until these are exhausted and the methodology is repeated from February to March again.

In this context we may refer to similar practices in other countries. The feeding of night-soil in fish ponds is practiced in China, Malaysia,Thailand and Vietnam. In Munich, Germany, fish ponds treat 25% of its settled sewage. The fish are deported to clean ponds before marketing.

3.3 Public Health Aspect of Acquaculture

There are potential threats to public health from excreta and sewage feeding in fish ponds. However, the danger of diseases from eating well-cooked fish is limited since the heat destroys pathogens but if consumed raw or partially cooked, it may cause serious health hazards. Perhaps the most significant health hazard, which is generally overlooked, is the danger from handling and preparing contaminated products.

It is believed that fish carry pathogens passively in their intestines and body surfaces. A study in Israel highlighted that bacteria and viruses may be present in fish tissues if these are present in a concentration of 10000/100 ml. and 1000/100 ml.

3.4 Ecologically Balanced System : Technological Options

The waste stabilisation pond functions by maintaining a symbiotic relationship with algae and bacteria. The requirement of pond surface area for treatment of domestic sewage is basically dependent upon available solar radiation which varies from place to place. In Calcutta, approximately 4.5 hectares of faccultative pond area is required to treat 1 mgd (million gallons per day) of domestic sewage. The requirement of land can be minimised by adopting an anaerobic pond before the faccultative pond. Such a combination would reduce the pond area by at least 40 per cent. In order to reuse the treated sewage from the public health point of view, it is advisable to keep the treated sewage in the maturation pond to allow the die away of bacteria. The said maturation pond may be used for harvesting fish.

Presently about one third of the dry-weather flow of the city per day is utilised in the fish ponds in east Calcutta. These ponds were established with the primary intention of growing more fish by adding fish food in sewage in a controlled manner. Today, we consider that sewage-fed fisheries in Calcutta also treat Calcutta sewage. However, an ecologically balanced combination of pond models as described earlier could treat 100 per cent of the dry weather flow for the city in approximately 500 hectares of land and the remaining 2,000 hectares could be used as maturation pond-cum-fish ponds. The wetlands could be made more effective for waste treatment and recycling.

A combination of anaerobic-faccultative-maturation (fish pond) would be an ideal solution which would establish a rational ecological waste water treatment system. The effluent from these maturation ponds after treatment is upgraded not only in chemical quality but also in bacteriological quality and could be utilized for sewage farming. Some sort of treatment mechanism is also considered to be ideal in the case of discharging the effluent of the maturation pond into any water bodies as the bacteriological count in the effluent remains in the range 1000 to 10000/100 ml.

As there exists no conventional system of treatment of Calcutta sewage, the wetlands in east Calcutta should be preserved and their functioning as sewage treatment and recycling facility should be improved. If land availability is not a problem in the context of other cities or towns, a combination of anaerobic-faccultative-maturation (fish pond) would be an ideal system for sewage treatment and recycling. Even with a conventional sewage treatment system, it would be prudent to adopt a waste stabilisation pond combination to upgrade the bacteriological quality of the treated effluent, as the conventional sewage treatment system fails to upgrade the bacteriological quality significantly.