

ROLE OF PUBLIC GOVERNANCE IN THE CONSERVATION OF URBAN WETLAND SYSTEM: A STUDY OF PALLIKKARANAI MARSH

*Dr B.P. Chandramohan

**D. Bharathi

1. Introduction

Among all the planets in the solar system, Earth is a unique natural paradise comprising of biotic and abiotic factors. Both biotic and abiotic factors are interconnected, interwoven and interdependent by all means. Ecological functions provided by various ecosystems are unique and astonishing. Such ecological functions provide innumerable goods and services to the society free of cost. The abiotic factors are the habitats of ecosystem without which ecosystems cannot exist. One such peculiar habitat is the natural wetlands. Among the various abiotic factors for a strong and healthy habitat, sustainable land use development is very important which requires planning for ecological integrity. Public management of common property resources improves the sustainability of such resources. Ecological integrity exists due to startling cross correlations between climate, geology, landscape, soil fertility and availability of usable water. Therefore, land use has to be planned after assessing the interrelationship of the said characteristics.

World has come to realise that wetlands are not wastelands, only over the past two decades. Many studies have been conducted by ecologists and biologists to show various unknown uses of wetlands. All these have resulted in an appreciation of the need to take care of precious wetland resources. The efforts of the Convention of Wetlands (Ramsar Convention) have been instrumental in attracting the attention for protecting wetlands.

2. Nature of Wetlands

Wetland is a peculiar kind of landform called natural wonder. By definition, wetlands are ecosystems whose physical, chemical and biological characteristics are determined by the constant or recurrent presence of water at or near the soil surface. They cover approximately 4 to 6 per cent of the Earth's land surface, expressing existence of a greater portion of different wetland ecosystem. Some are seasonal and some are permanent. Some are fresh water wetlands and some are salt water wetlands.

But each type of wetland has a unique function to perform viz., kidneys of landscape, biological supermarkets, flood buffer, carbon sequestration etc. In addition, many stakeholders are benefited by a mere existence of wetland. Wetlands provide the necessary environment for biodiversity to exist. Wetlands are found at all places except in the Polar Regions. Though found everywhere the presence of wetland in rural and urban areas makes a difference hence it is of quite significant for conducting such a study.

The degradation of rural wetland is dominated by agricultural activities. Eutrophication affects the water-bodies as a result of nutrient enrichment that is caused by fertilizer use in agriculture. Eutrophication threatens the existence of several life forms in rural wetlands. However, the problem of the degradation of urban wetland has to be perceived in a different angle. Urban wetlands are mainly affected by developmental activities and encroachments. This has an impact on the ecological functioning of the ecosystems.

A major cause of wetland degradation is precisely the lack of knowledge of government planners, natural resource managers and wetland users. The ecological

* Reader, Department of Economics, Presidency College (Autonomous), Chennai-600 005.

** Lecturer, Department of Economics, SIVET College, Gowriwakkam, Chennai-600 073.

processes of wetlands provide diverse benefits and the ignorance of these benefits themselves led to the wetland degradation. Even in scientific community, there is a large gap in the understanding of the effect of land and water in the wetlands on hydrological process in the catchments.

3. Management of Common Property Resources

Public administration plays a vital role in the sustainability of common property resources. Efficiency and economy in the use of common property resources are the components of a conceived plan for a sustainable living. In order to get optimum benefits, a combination of government, society and experts act in the allocation and use of natural resources. Levels of hierarchy are in the form of government at the apex, experts at the middle level and stakeholders (society) at the lower level whose roles will help in good decision making, which will automatically enhance welfare. Both the bottom up and top down approaches can be used while managing a natural resource like urban wetland.

The government owes the responsibility of managing wetlands. It administers a range of social, economic and environmental programmes that impact on conservation and the wise use of resources. But government fails to take the lead role in wetland conservation as best performed in cooperation with the community and business sector. There is an urgent need of a public policy aiming at wetland conservation within the broader framework of environmental management. The reason is the loss of one square kilometre of wetlands in an urban area which has much greater impact on humanity than the loss of one square kilometre of wetlands in a less populated area of abundant wetlands (Lee et al.1996).

A successful wetland policy is one that recognises the need to harmonise with various other policy instruments, goals, objectives and strategies. The wetland governance could succeed only when it is committed to working cooperatively with all spheres of the government to achieve sound wetland management outcomes. Considerable benefits can be gained from governments (Central, State and Local) working together to share approaches, solutions and resources for achieving common outcomes.

Since the conservation of wetland is neglected in the earlier phase of development, the current cost incurred for obtaining such a natural resource is exorbitant. In otherwords ecological function has zero administrative and maintenance costs when performed naturally by these wetlands, if such wetlands would have been properly protected by good governance. Good governance is only a means to an end, and not an end in itself.

4. Functions of Wetlands

Wetlands are a critical element of national and global ecosystems and economies. At the most fundamental level, wetlands are the key part of water-cycle, playing critical roles in maintaining the general health of water-bodies, estuaries, and coastal waters. Wetlands protect the shoreline from wave action, mitigate the impact of floods, absorb pollutants and act as habitats for flora and fauna, including a number of species that are threatened or endangered. Wetlands are important for the maintenance and improvement of the quality of human life. They provide tangible benefits such as employment opportunities. Wetlands purify water and are a focal point for recreational activities. They form nurseries for fish and other fresh water and marine life. In some areas, especially in developing countries wetlands support grazing, forests and cropping.

Wetlands are important for the following reasons: biodiversity and conservation. It serves as nursery and breeding grounds (fish and water birds),

improve water quality, biological productivity, aesthetic value, cultural and heritage value, nutrient cycling, flood mitigation through water storage and retention, ground water recharge, scientific research, education, foreshore protection (from waves and erosions), soil and water conservation and finally grazing, forestry and cropping.

Despite a growing understanding of their many values and functions, urban wetlands remain one of the most threatened common property resources in India. They continue to be regarded as wastelands even now and therefore their destruction continues. Once urban wetlands were abundant in South India, however, they have been destroyed or altered without recognition of the long term quality of life.

The threats to urban wetlands are varied and many. In most cases it can be found acting as a stumbling block for further urban expansion, by far the greatest threat remains ignorance of the importance of wetlands and the roles they play. A shining example of the failure of polity and bureaucracy in developmental planning is the degradation of wetlands of South Chennai which has been classified as wasteland under land use. Land use and land cover classification is the basic and fundamental information based on which lands can be allotted for various developmental activities.

5. Profile of Chennai City Wetlands and Water Bodies

It is estimated that in Chennai City more than half of the wetlands have been converted to other uses. Chennai City had about 150 small and big water-bodies in and around the city but today the number has been reduced to 27. The important water-bodies include Adyar Estuary, Adambakkam lake, Ambattur lake, Chitlapakkam lake, Ennore creek, Korattur swamp, Madhavaram and Manali Jheels, Pulicat lake, Vyasarpadi lake, besides Buckingham canal, Coovum and Otteri Nullah.

During the early phase of development of Chennai City, natural resources, especially land and water, was abundant. Between 1991 and 2001, 10.19 lakh people moved to suburbs, while the inward migration from rural areas to Chennai stood at 9.37 lakh (The Hindu, 29th November, 2006). According to Chennai Metropolitan Development Authority (CMDA) Chennai City will have 10 million or more residents in another 20 years. It is necessary to take steps to provide houses for 8.2 lakh urban poor currently living in high dense and objectionable slum areas such as river embankments. Migration from rural to urban and suburbs have caused threat to land and water resources. As the city limit expands encroachments and land-filling are the ultimate resort of habitation of the poor and slum dwellers. Urbanisation imposes heavy demands on ecosphere, especially encroachment on sensitive areas like wetlands.

Naturalists pointed out that the last wetland died was the Koyambedu Marshland. About 15 years ago the area used to have a lot of wild growth attracting large number of birds. This marshland maintained the groundwater table in the western part of the city. Due to the ignorance on the part of the government about the treasure house of wetland, this was taken over by the government for the purposes of housing, bus terminus and vegetable and fruit markets.

6. Pallikaranai Marsh Land

Pallikaranai Marsh Land (PML) is located at the South Eastern sub-urban areas of Chennai City. It is located 20 kms South of Chennai with an area of 50 sq kilo metres. PML is surrounded by Old Mahabalipuram in the East, Tambaram Velachery Road in its west, Pallikaranai Perumbakkam road in the North, and Medavakkam-Karapakkam road in the South.

It came into existence as a salt marsh created by the backwaters of Bay of Bengal. With the construction of Buckingham canal in 1876, the inflow of sea water was virtually stopped, thereafter the copious inflow of rain water turned the swamp

into a freshwater body. PML is a few feet above the sea level. The low lying swamp land consists of black and shallow water mud in which many water plants grow. Since the soil of marshland is spongy, this area could retain excess water during monsoon.

The central and northern portion consists of a marsh predominantly maintained by sewerage outfall that is conducive for the growth of reeds. The northern portion of Pallikaranai and Southern half of Pallikaranai area drain towards Buckingham canal via the Oggiyammaduvu.

PML constitutes less than 0.1 per cent of the total Coromandel Biogeographic Province (CBP) of the Indo Malayan Realm. The criteria was developed by International Union for the Conservation of Nature and Natural Resources (IUCN) for classifying World's biotic areas for conservation purposes (1975). Though the PML has no legal protective status, it is considered biologically significant by the Tamil Nadu Scientific Community and it is included in the All India Bird Survey as a water fowls habitat, home to a variety of birds, reptiles and amphibians. In spite of the existence of rich species, this marshland is being destroyed by anthropogenic activities.

Historically the development of Chennai City regularly involved in the filling of wetland for industrial, commercial, housing and waste disposal. Many water bodies associated with PML have been polluted and converted into waste water drains resulting in the loss of habitat. The apathy is that many urban poor in slums are heavily concentrated very close to the water bodies of wetlands. Wastes generated by slums are directly discharged into the wetland polluting the water bodies. In Chennai City due to the nature of environment and the distribution of population, losses have been heavily concentrated in permanent wetlands.

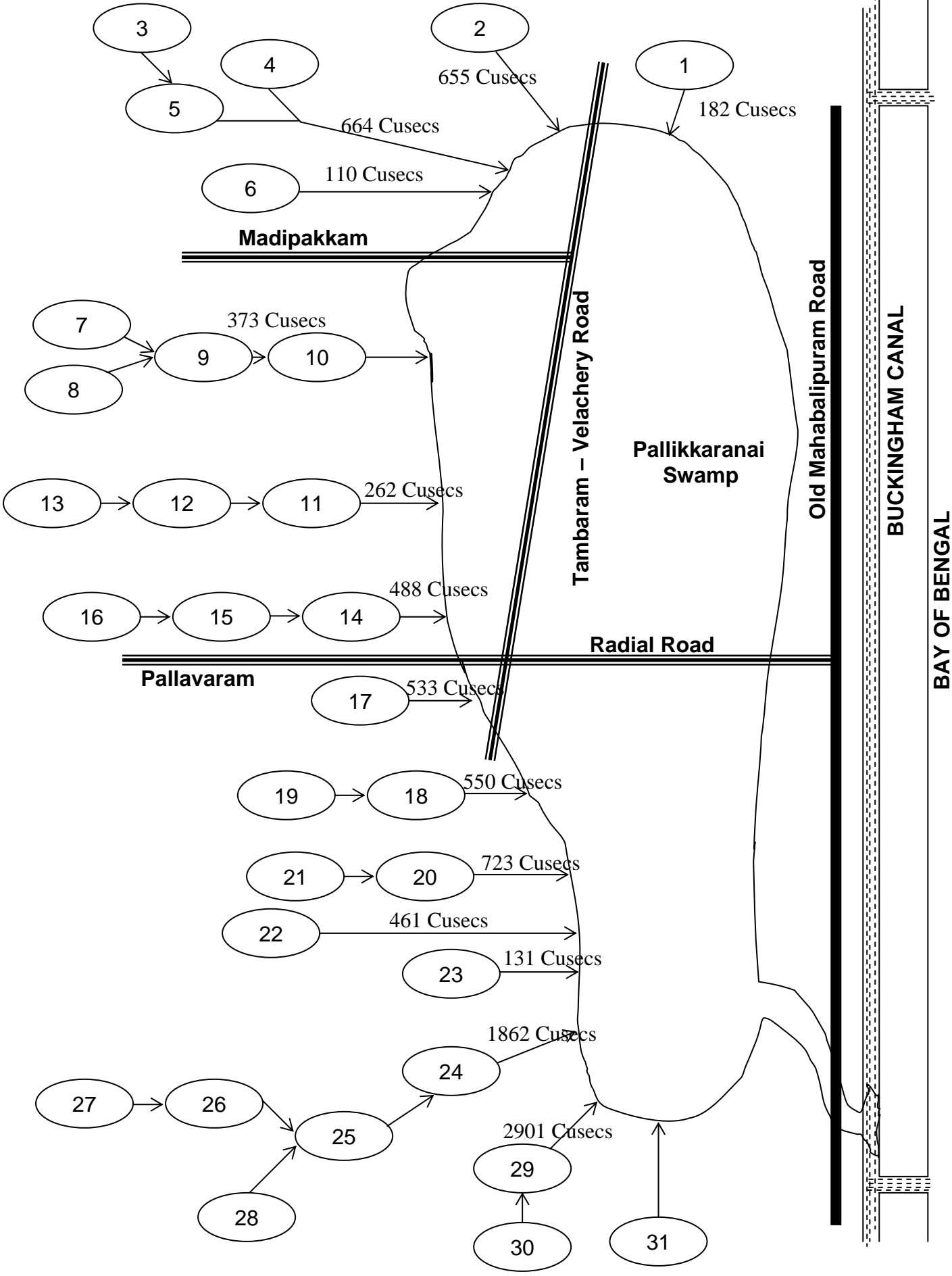
7. Historical Perspectives of Maintaining Water Bodies

During the Pallava, Chola, Pandya and Vijayanagar kingdoms, the department of irrigation was kept with the central government and it was under its direct scrutiny. Only the maintenance of lake was with the local authorities. Those responsible for tampering with lakes and waterways were severely punished. The recent abolition of *Maniyakarans* and *Karnaves* who prevented encroachments in the past and their absence led to a free ride on marshland by the village authorities. With the introduction of corporations for managing the growth of cities, Village Administrative Officers were assigned with the responsibilities of maintaining and protecting water-bodies. These VAO's hardly remain in their villages. Most of the lakes disappeared after encroachments, and local panchayats merrily tamper with the water systems. History has taught the best administrative practices of conserving the Common Property Resources (CPRs) but the bureaucrats failed to sustain this ideal framework in maintaining water-bodies. But at present the extent of environmental degradation as a result of economic development and shrinkage of CPRs establishes the fact that it is against this welfare objective.

8. Network of Tanks and PML

There are 31 tanks located at the West, South and Northern catchment area of the swamp release the surplus water during rainy seasons to the swamp. The sustainability of this marshland is linked with vitality and sustenance of these tanks. Moreover the shrinking of wetland will have a natural death of the tanks and vice-versa because they belong to a single system of water bodies. The single flow channels that would naturally help in percolation of groundwater and stands as an excellent rain water harvesting model. Evidence reveals that not only the marshland has shrunk, but also the tanks. For instance, the Adambakkam tank, one of the water sources of the swamp has reduced from its original size of 70 hectares to 20 hectares due to encroachments.

Flow Chart of City Suburban Tanks in Tambaram Taluk Falls in PML



Valachery Tank and other similar tanks, a supportive water-body of PML has also reduced drastically due to urbanization and infrastructure development. The disappearance of water-bodies will have a telling impact on the sustainability especially of the groundwater availability in the south of Chennai City.

Map of the Network of the Water Tanks

Chennai City which is already categorised as a water stress region has to face further water shortages due to poor maintenance of tanks and water-bodies. Lack of good governance on the part of public authorities has not only disrupted and depleted PML but also polluted many water bodies linking it.

Table 1. Chennai water: Growing shortfall

Year	Demand in Mn. Liters	Availability in mn liters	Shortfall in Mn liters
2011	1630	1615	15
2021	2003	1615	388
2026	2248	1615	633
2031	2700	1615	1085

Source: Municipal Administration and Water supply department, The Hindu 18th August 2008.

Groundwater is becoming costlier day-by-day. The rate of harvesting of ground water in Chennai City is higher than its recharge. Chennai City is the most water starving metropolitan city of India mainly due to the disappearance of small water bodies converted for developmental activities. Experts say "there is enough water, what we want is water management as the ownership of water bodies is scattered among various government departments" (The Hindu, April 21, 2007). Political lobbying and reluctance of bureaucrats has failed to protect the water bodies which is the only and last resort for supplying water to Chennaites. Three big lakes namely Pallavaram big lake, Kizhkattalai lake and Narayanapuram lake were destroyed due to laying of radial road from Pallavaram to Old Mahabalipuram Road. Industries, educational institutions, hospitals, multistoried buildings etc, have crippled the spongy soil of wetland which acts as a flood buffer and ultimate water storing cabinet. Such shrinkage of wetland gradually weakens the water bodies and ultimately their death. Network of tanks connected with marsh is losing its own life. The marsh is being unscrupulously grabbed due to various man made activities. Natural tanks are being mercilessly killed. There is no 'natural saver pack' to protect this marshland.

CAUSES FOR SHRINKAGE

As Velachery was brought under city limits, and mushrooming growth of IT companies in the East Cost Road (ECR), Old Mahabalipuram Road (OMR), and Pallavaram Ring Road increased the land prices. Naturally Perungudi, Pallikaranai, Vijayanagar, Velachery, Taramani etc., which were part of the PML started enormously shrinking due to various development activities. The areas in and around PML were once water logging, are now raised to the ground level by landfilling. A Road Over Bridge (ROB) is under construction in the Tambaram Velachery Road at a cost of Rs 220 lakhs. Various causes for the shrinking of PML help one to understand the ecological integrity and its cross correlations having greater impact on the society at large.

I. Roads

The map of PML shows the Tambaram Velachery Main Road, Pallavaram Radial Road, an over bridge on the Tambaram – Velachery Road, Taramani to OMR etc., have been laid in the PML and its interconnecting water bodies. Wherever roads have been laid on the marshland culverts have been constructed parallel for quick run off of water through Oggiyammadavu to reach the sea. All these roads

have bifurcated the marshland, outcome being loss of species and habitat, loss of water spread areas, loss of groundwater recharge etc.

II. Dumping Yard

On the Eastern side of the Tambaram Velachery Main road, there is a dumping yard exclusively for Alandur Municipal Corporation. On the Northern side of the Pallavaram Radial road there is another dumping yard for Chennai Corporation. The total area allotted for dumping solid waste was only 75 acres but at present more than 850 acres have been used for the purpose of dumping waste. Both Chennai Corporation and Alandur Municipality dump 4000 tonnes of solid waste into the marshland. Approximately one quarter of the existing PML has been lost due to disposal of solid waste. Apart from dumping municipal solid waste, there is also unorganised and illegal disposal of construction debris and tyre and untreated sewage water.

There are six local bodies which discharge untreated water in and around PML. All these local bodies during the year August 2005 to July 2006 have discharged 9973 tanker lorries of untreated sewage into the PML. In addition to these local bodies there were unauthorised waste dumping along the newly laid radial road. As a result Pallavaram – Thorapakkam ring road was flooded with garbage and other wastes causing havoc to the motorists and commuters using this road.

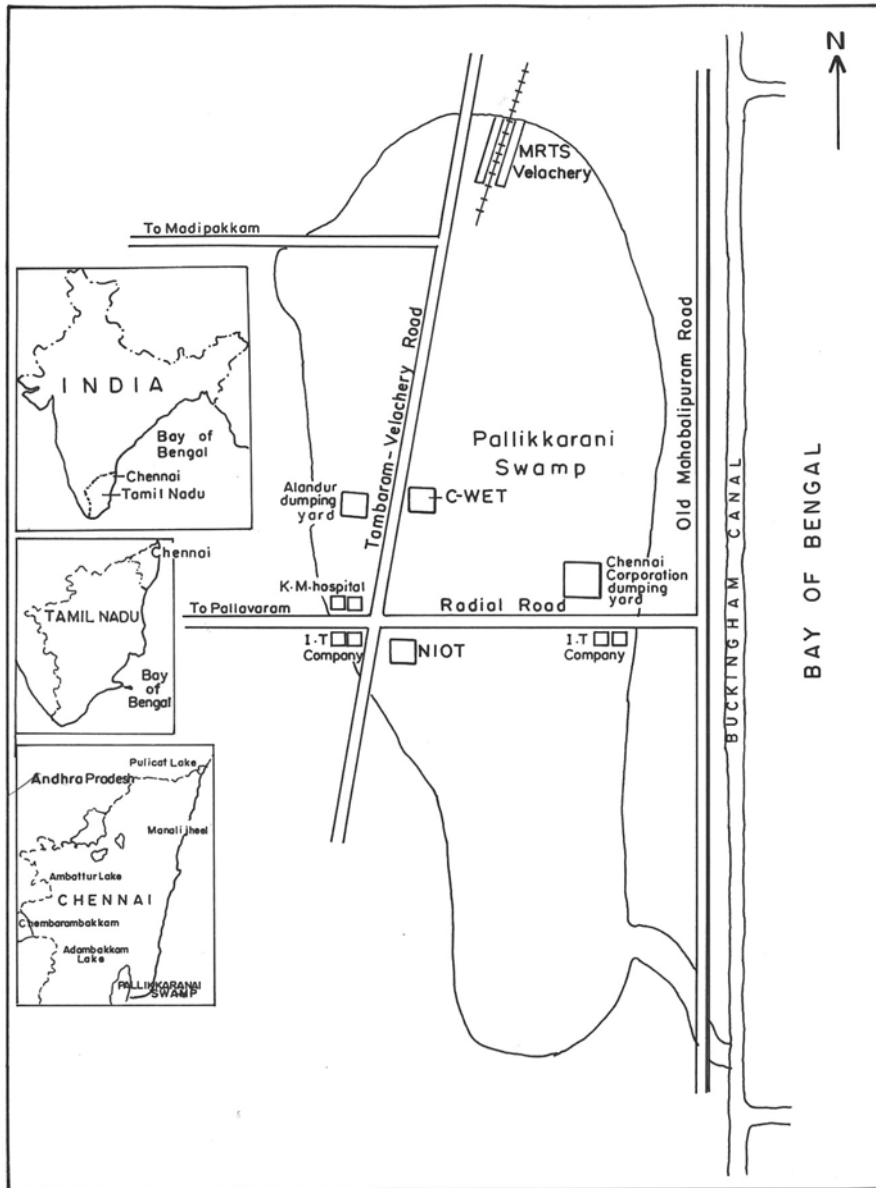
III. Landfilling

Landfill is another upstream source of contamination. Ideally a landfill should not be located up gradient of any drinking water source. But PML which was once water supplying source that have been destroyed by landfilling. The slum households for MRTS project who lived along the banks of Buckingham canal were allotted resettlement areas by landfilling. This is named as Mylai Balaji Nagar which covered marsh area of approximately 10 acres. A road over bridge which is laid on the Tambaram Velachery road is taken up in the marshland area. On the Eastern side of the Tambaram Velachery main road, a private hospital has been constructed facing radial road in an area of 13.600 hectares. Almost all houses, commercial establishments in between radial road and Madipakkam Road are constructed mainly by landfilling. The process destroyed many species and shrunk the area of PML. Landfills are a perpetual activity in the area for various construction activities gradually weakening the eco-functions of the marshland.

IV. Construction Activities

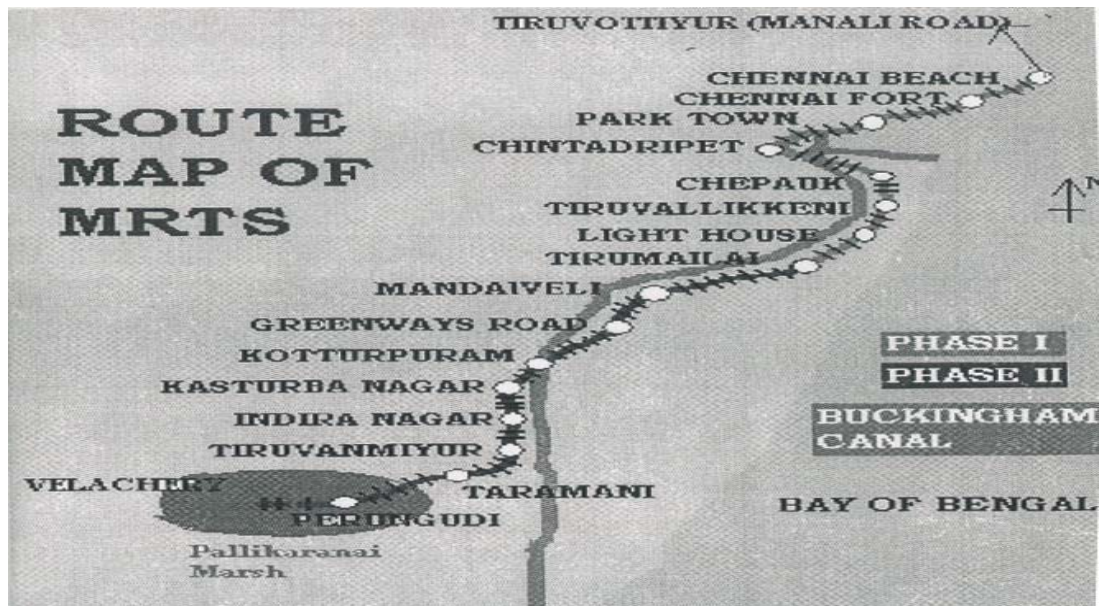
Various central government buildings are constructed in the PML after landfilling. The construction of MRTS has taken up a marshland area of approximately 100 acres, National Institute of Ocean Technology (NIOT) with 20.250 hectares. Central Wind Energy Technology (C-Wet) is also located in the PML. The boom of IT industry captured the banks of the wetland. All these construction activities depleted the total area of PML.

MAP SHOWING THE ENCROACHMENT ON PALLIKKARANAI MARSH,
SOUTH CHENNAI TAMIL NADU.



V. Urbanisation

During the past one decade, rapid urbanisation has caused significant environmental impacts on the basins. As Velachery, Vijayanagar, Taramani, Perungudi and Madippakkam areas have become congested residential areas. Many restaurants, fast food centres, shopping complexes, transportation, parks, skyscrapers, multistoried buildings, hospitals and educational institutions have rapidly mushroomed.



Chennai Corporation is responsible for providing drinking water and discharge of wastes and sewage but it could not manage the situation. A scientific approach in disposal of solid wastes by the use of scientific technique is immediately required for arresting further contamination of PML though it is costly. During floods urban areas experience inundation as pavements and buildings do not allow for infiltration. Urban runoff is usually polluted water; as a result urban streams show poor water quality. Till now the beneficiaries of real estate and business feel that PML is a barrier to their development.

For earmarking garbage dumps Indian Space Research Organisation (ISRO) has prepared a 3 dimensional model and this is used to find garbage dumps so that the waste do not flow into the water-bodies in low lying areas. Application of remote sensing and GIS can be used to facilitate the selection of site for solid waste disposal. The Ranchi Municipality in Jharkhand which has 37 wards with an area of 177.19 sq.km is using customised solutions of ISRO in tracing suitable land fill sites, the areas that generate highest amount of waste and shortest possible route to transport them to landfill site.

Encroachments in various forms have subsequently reduced the quality of wetland offering various eco functions to the society. Shrinkage of wetland reduced both direct use values and net environmental benefits. Encroachments in various forms shrunk the area by 474 hectares. Developmental activities such as MRTS, C-Wet, NIOT, Perungudi Sewerage Treatment Plant (STP), solid waste disposal of Chennai Corporation and Alandur Municipality have spoiled the serenity of PML.

Poor knowledge about wetlands is the reason for the conversion and degradation of wetlands. Decisions made due to ignorance and lack of absolute functional knowledge might have been the reason for the loss of benefit from PML. If this marshland of 5000 hectare had been maintained in sterile conditions, it would have generated more revenue to the government by way of recreation, flood buffer, aquifer recharge, gas regulation etc., than the economic benefits of development activities. Some stakeholders in Chennai City rely only on PML for their livelihoods. Lack of proper decision by the authorities resulted PML losing its inbuilt capacity to perform ecological functions.

CAUSES OF POLLUTION

1. Discharge of Sewage Water

PML has been contaminated by the discharge of partially treated or untreated sewage water considering it as a wasteland. The Chennai Metropolitan Water Supply

and Sewerage Board have been letting out 32 million litres of untreated sewage water every year directly into the marshland. Even treated sludge when discharged in marshland depletes the quality of PML. This is the main reason for the deterioration of surface water and ground water quality in South Chennai. As a result, water in the wells of the adjoining areas and bore wells is totally unfit for household consumption.

2. Burning of Garbage

The dumping of solid waste contaminated groundwater and surface water. Over a period of time such waste dumping can release highly acidic and toxic leachates. No scientific methods or incinerators have been used to protect these leachates from reaching the groundwater. The contaminated groundwater is virtually impossible to clean. Burning of garbage releases most toxic environmental contaminants cause health damage. It includes dioxins, furans and heavy metals (Lead, Mercury, Cadmium etc). The dioxins released affect the nervous system, the respiratory system, liver, kidney etc., of the water users. Even at a distance of 1 km from the burning place people face the problem of air pollution. Sometimes the gases discharged by burning looks like a fog and nobody could even identify what is coming on the opposite side of the road. Severe eye and throat irritation was reported at the time of smoke.

PML, ecologically sensitive area with various natural habitats has been gradually polluted and degraded due to dumping and burning of garbage and letting out of untreated or treated sewage water. Complaints have been registered by public institutions, flats and residential localities for stopping burning of garbage at the dumping site with the TNPCB.

During 2007 part of the dumping yard of Alandur Municipality was converted into green belt area where environment related issues were painted in the compound walls in order to disseminate the importance of environment. Despite warnings from the Madras High Court garbage continues to be burnt at PML by both Chennai Corporation and Alandur Municipality.

EFFECTS OF SHRINKAGE AND POLLUTION

Encroachment through landfills has led to shrinkage of PML. Most of the water bodies supplying water flows into the PML have also been encroached by residential localities, complexes, huts and tenements. The basic reason for the cause of floods during the monsoon is such encroachments. A spongy nature of the wetland has been affected due to the changing soil conditions. The simile is that, water that already occupied in a beaker is to fill in a cup; automatically the excess water will overflow. No proper outlets have been channeled in such a manner so as to conserve the surplus water flow into the PML.

If average depth of water is considered as 1 metre, the volume of water the marsh can hold will be 5 million cubic metres as the area of the marsh is 5 million sq.metres. The natural water flow pattern has been diverted due to many anthropogenic activities; therefore the holding capacity of water in the PML has been decreasing. As a result, indirect use values which could have been ascertained by the built-in-flexibility of performing ecological functions like aquifer recharge, biological control, refugia etc., have almost reached the stage of critical minimum.

I. Flooding

Conversion of marshland for various developmental activities drastically reduced the storage capacity of PML. Recent floods in South Chennai are caused by the reduced storage capacity of PML. In Pallikaranai, many houses are disconnected from the rest of the city due to inundation. Many of them took refuge in the porticoes of individual houses. Flooding recurred every year due to flow of rainwater from nearby areas such as Medavakkam and Jalladampettai. Water could recede in

these localities only when excess water drained into the Bay of Bengal through the Buckingham canal and PML.

Residents of these localities recall the situation started worsening in the past 10 years or so because of the rapid construction activity inside the marshland and in the fringes. For the last two decades, institutions including Murugappa Chettiar Research Centre, Centre for Ultrafast Process, Institute of Road Transport, Vikram Sarabhai Industrial Estate and many others have been the victim of water logging during the monsoon.

With the fast expansion of the city towards South some of the sensitive stretches like IT corridor face untold misery during floods. Residents complaint water logging was a problem earlier also, but the retention time had increased alarmingly during monsoon. Some experts opine that the creation of new waterways and storm water drains would solve the problem of flooding and it will allow free flow of water to the Buckingham canal at the cost of the ecological functions of PML.

New channels each with a width of five metres and length of 1.7 km are formed to facilitate flow of flood water from Veerangal Odai to the swamp on the eastern side of the Tambaram Velachery Road. The new channel would cost Rs.7.5 lakh. The canal which begins at Nanganallur and flows through Madipakkam and Adambakkam, is blocked abruptly near Ullagaram – Puzhuthivakkam, leading to inundation in many residential areas (The Hindu, 26th September 2007).

According to PWD sources around Rs 3.7 crores had been allocated to expedite rehabilitation work at lakes in Velachery, Pallavaram and Perungudi. A sum of Rs 1.5 crores has been earmarked for Velachery, Rs 1.2 crores for Pallavaram, and Rs1 crore for Perungudi (The Hindu 9th September 2007).

Perungudi Lake which is being rehabilitated at a cost of Rs 1 crore which is spread over 35 acres. Residents use this lake for bathing, washing clothes, animals and vehicles. Rehabilitation work includes clearing of bushes around the lake, leveling and strengthening of 816 metre bund and fencing the lake (The Hindu, 5th March 2008). PWD has proposed to desilt 13 small culverts on radial road for providing free flow of rainwater into PML. So that inundation of some portions of residential colonies can be prevented. Removal of weeds from Velachery canal will also be taken up for channelising the flood water of the Veerangal Odai and the Velachery Canal into the PML.

Effective flood control structures can be eliminated by preserving natural wetlands. Public policies and the bureaucrats at this juncture do whatever approach to manage the floods but they are detrimental to the functioning of PML. Many culverts are constructed across the water- bodies causing quick run off and water diversion.

II. Hydrologic Alterations

Volume of water flow and water course patterns of PML has changed significantly over the years. This is due to the construction of culverts where flood water quickly runs off to Buckingham canal via Oggiyammaduvu. Being a permanent wetland, the natural water flow pattern of PML has changed completely; this may have an impact on the hydrological functioning of the wetland. Conversion of marshland has reduced the water percolation activity.

The water quality of PML has also been affected due to dumping of garbage and directly letting out treated and untreated sewage into marshland for the past several years, causing eutrophication. Eutrophication has led to pollution of water affecting biological and chemical processes within wetlands.

Public residing near the belts of PML said that during floods rain water mixes with the sewage water, enters the residential localities and gets stagnated. The wetland which is spongy in nature does not serve the purpose of draining water into

the aquifer. At present they have become the carriers of domestic and industrial sewage.

The loss of environmental benefit increases as the areas of wetland shrinks. Shrinkage of wetland not only reduces the level of social, ecological and economic benefits but also the same quality of service cannot be able to provide per hectare of wetland in the future. The loss of benefit is because of the perception that wetland is an administrative unit rather than as a hydrological unit.

III. Ground Water Quality

Dumping of garbage and letting out of untreated sewage in the heart of PML have resulted in an irreversible damage to the quality of subsurface water in the fast developing neighboring areas of Thoraipakkam and Perungudi. Water drawn from domestic and deep bore wells in Thoraipakkam was orange in colour and accompanied by pungent foul smell. A few thousands of well in these areas were contaminated. Affluent sections could afford for purifying equipment but the poor were left with no other option of using the contaminated water. Leachates seeped into subsurface and entered recharge channels through which groundwater entered the domestic and deep bore wells.

The subsurface water quality was polluted in Okiyam, Thoraipakkam and Perungudi and far of places including Muttukadu through which Buckingham canal meandered. A study revealed those fishermen were deprived of their normal catch of fish as large number of fishes died knowing to the sewage content in Kovalam creek. Laying of Pallavaram -Thoraipakkam Radial Road has made easy for rural and urban local bodies to dump their solid wastes on both sides of the roads in PML. The groundwater quality of PML was affected due to large concentrations of chloride and electrical conductivity, concentration of chemical oxygen demand in Perungudi dumping site is very high.

IV. Surface Water Quality

Water colour in PML is reddish, attributed to dumping of garbage in PML. The discharge from the freshly dumped garbage has killed the chlorophyll based life in water, resulting in the change of colour to red.

Motorists and road users were in peril due to dumping of garbage along the Pallavaram – Thoraipakkam Radial Road near PML. Corporation used earth movers to push the waste into the marsh again. The water had wiped out the vegetation, which has driven small water fowl, local migrants, flora and micro organisms along the area. Many lakes connecting swamps are being polluted by dumping garbage, poultry and meat waste by the local town Panchayats and private vehicles pollute not only PML but the net work of water tanks.

V. Air Pollution

Burning of non-biodegradable waste continues unabated in the marsh. A plan of action to protect the marsh from burning of waste was submitted by the authorities. Already the researchers recorded the presence of 25 species of grass in a small patch in marsh. But burning of garbage will have a direct impact on the growth of marsh vegetation. Air Quality Tests done in 2001 and 2005 at Pallikaranai by research group revealed presence of several cancer causing chemicals. This is to be treated as a biggest environmental disaster in Chennai similar to the Bhopal Gas Tragedy.

MEASURES CHECKING CONVERSION OF PML

It is a sorry state of affair that so far no governmental agencies or authorities have taken any initiative of raising voices against such rapid conversion. It is ironic that at one side allowing aesthetic degradation of an urban wetland and on the other travelling more than 30 kms in weekends and holidays to visit Vedanthangal Birds

Sanctuary. Water-bodies linking PML provide valuable services to the mankind in the absence of any other resource providing the same service.

Since conversion of wetland is neglected in the earlier phase of development, the current cost incurred for obtaining such a natural resource is exorbitant. Save Pallikaranai Marshland Forum (SPMF) was formed in 2002 by many environmentalists and ecologists who participated in the forum to control the abuses leveled against PML. Thousand members in 2003 participated in a human chain rally. This initiative drew the attention of the Union Minister and constituted a committee under the Director of Salim Ali Centre for Ornithology (SACON) to understand and analyse the problems of PML. Issues focused were: (a) basically on dumping (b) letting out of untreated sewage. In subsequent years of 2004, 2005 and 2006 fasting was carried over under the forum. As a result in April 2007 part of the PML in the Southern side of the MMRD Road was declared as a protective area.

Known well the network of tanks and the wetland in the absence of the coordination between PWD officials, local VAO's, revenue officials, and bureaucratic bodies if at all the little efforts to frame and implement policies for protecting and preserving water bodies would give no result. River Rhine took 20 years to clean up. Cleaning of PML is not a big problem but its maintenance is more difficult. In order to solve the water crisis in Chennai City the ecological functions of the PML need to prune up. The marsh which was a boon once has become a threat to the society. Lack of knowledge and poor governance highlights high operation and maintenance cost, which could have been otherwise used for developmental activities.

The PML is a home of about 225 species of birds, mammals, fishes, mollusks, crustaceans and amphibians and 114 flora species. The eye openers for the protection of wetland were activists, residents, environmentalists and ecologists. Using the media they could find some success in preserving the wetland with out much fanfare. Thanks to the present government for passing an order to protect and preserve the marshland and declared 317 hectare (793 acres) under Reserve Forest Area. This marshland is now no more a wasteland. The District Forest Officer is of the opinion that they are in the process of consolidation to make the place one of the nature lover's paradise. The state government for the welfare of citizens declared the area protected. The Forest Department tries to protect the quality of wetland from further damage and disturbance, misuse and mismanagement by providing an orderly process. There is a need to protect the environment and ecology of PML in order to guarantee both use and non-use values for the future generations.

An activist of SPMF said as per court direction, committee has been formed along with the officials of the government to provide a report within a period of three months regarding stoppage of dumping and burning of garbage. Storing heaps of garbage at one site for a long time is a bad idea. The purpose was to protect another 300-400 acres on the northern side of the marsh to be given a protective status. In spite of court direction not much has been done with regard to dumping and burning of garbage. Even today it is a routine affair.

I. Goondas Act

Forest department had arrested 3 men who were responsible for killing 57 birds in PML of which most of these birds were rare and protected species. Poachers had country guns and all the three were booked under Forest Act and Arms Act. Forest officials reported that 4 staff of the department was on duty. Before this particular arrest PML was a heaven for the poachers who not only killed the birds of rare species but also collected the eggs waiting for hatch. (The Hindu, 14th May 2007).

II. Revoke Land Areas

The total land area around 211.885 hectares were allotted to the housing purposes of the employees of silver screen and International Flower Auction Market. Except the few public institutions like MRTS, Radial Road, NIOT, C-Wet the other areas were revoked and allotment of land was cancelled as per court direction.

III. Prevention and Control of Pollution, Act 1974

Issues of the wetland from getting polluted due to various reasons and to protect its ecosystem certain powers are conferred under section 33A of the Water Act, 1974.

IV. Municipal Solid Waste (M and H) Rules 2000

As the treated sludge meets the standards prescribed for compost, efforts are made to compost the organic wastes on a suitably designed compost yard away from PML.

V. Tank Protection Act 2007

PWD is being entrusted with the work of removing encroachments and rehabilitate lakes in the fringes of Chennai City as per Tank Protection Act 2007. Eviction notices have been served on the owners of 1000 dwellings who allegedly encroached on lake. The protection of Tanks and Eviction of Encroachment Act, came into effect on 1st October 2007. It states that people encroaching on poromboke land of the tanks are liable to get 3 months prison or fine of Rs.5000. But in a democracy little was the success in evicting the encroachers of the lakes and marshland. There was also a proposal in PML for opposing housing projects against encroaching for software professional on PML.

The farmers from Siruseri and activists registered their protest at a public hearing in collectorate. The farmers registered a complaint that Singapore realty was assigned a project for constructing 4500 houses for IT professional at Siruseri, SIPCOT had filled over 2 feet of gravel in the marshland leading to a flooding of 800 hectares of agricultural land. The activists said that construction work had begun in 3 of the 5 projects in violation of the Environment Impact Assessment notification, 1994 and Supreme Court Order prohibited post factor clearance of commercial projects.

Apart from housing projects, 2 more proposals for software parks along the corridor were also objected by the activists. The activists criticised District Administrators and Tamil Nadu Pollution Control Board for treating public participation as a mere formality and not perceiving the issue seriously.

If administrators lack managerial skills, the society has to give up the common property resources and the stakeholders ultimately lose their welfare. Administrators must have all the four skills like technical, human, analytical and diagnostic skills so that the whole issues can be viewed in totality and optimal policy decision can be taken accordingly. Reluctance on the part of the District Administrators and Pollution Control Board only reveals that rate of destruction of wetlands will bring to the society and stakeholders at large.

No body had much information about wetlands and its significance since this wetland was categorised as wasteland under land use and land cover classification by National Remote Sensing Agency, India. The bureaucrats and the authorities utilised this natural paradise for various ferocious activities such as dumping, burning and encroachments.

The fact reveals that mere negligence and reluctance on the part of the authorities is the one and only reason for such a poor state of affairs about PML. As many governmental agencies like Chennai Corporation, CMWSSB, CMDA, TNPCB, PWD and Town Panchayat, were involved in the conversion and encroachment of PML no action was being taken up by any governmental authorities who failed to

protect PML. When spoken to different authorities, they said that since this marshland is not under specific control of any one organization hence they can not stop the non-sense. Administrators are finding it complicated to put an end to any form of man-made activities. Chennai Corporation is dumping more than 3000 tonnes of solid waste into the PML. The composition of waste is shown in Table 2.

Table 2. Waste generation in Chennai City

Waste generation	Quantity (in percentage)
Residential	68
Commercial	16
Halls, Schools, Institutions	14
Industry	2

Source: Chennai Corporation, The Hindu, 1st July, 2006.

Hospitals and clinics, separately dispose medical waste. The dumping yard located in PML has been expanding year after year. The particulars are shown in Table 3.

Table 3. Analysis of change in the area and Perimeter of the Pallikaranai Marsh since 2003

Segment of the marsh	Year	Area (ha)	Perimeter (km)	Edge development
Garbage dump	2003	50.25*	5.785	2.30
	2005	57.54	6.046	2.24
Area impacted by garbage / sewage	2003	58.75*	-	-
	2005	132.25	-	-
Northern segment*	2003	227.00	12.11	2.26
	2005	150.56	7.6	1.74
Southern segment	2003	284.00	9.327	1.56
	2005	279.65	11.8	1.99
Total	2003	620.00	c.13.0	-
	2005	620.00	c. 13.0	-

Note: perimeter of the dump area along measured 5.1 km (22/3/2006 The Hindu) Sub-division wise area loss is shown in Table 4.

Table 4. Subdivision – wise Loss of Habitat in the Marsh

Subdivision	Area (ha) as in 2002-03	Area (ha) as in 2005	Loss (ha)
1A	50.73	36.8	13.93 (27 %)
1B	231.74	113.76	117.98 (51%)
3A1	2.2	2.2	Negligible
3A2	122.38	122.8	Negligible
3A3	168.68	136.8	31.88 (19.1)
4A	10.9	10.9	Negligible
4C	6.95	6.95	Negligible
Total	593.58	430.21	163.37 (28%)

* Estimated using maps and ground verification in 2005

Lack of Governance and Wetland Loss

Wetland means a physical loss of area of wetlands leading to a significant reduction of wetland function. Wetland loss issues are broadly divided into two: 1. Acute loss and 2. Chronic loss.

Acute loss of wetland occurs over a short span of time, usually less than one year. Chronic losses of wetland occur over several years and are due to multiple impacts over time. The environmental impact assessment of the disturbances to the PML is shown in Table 5.

An example of chronic loss is the gradual encroachment of PML for the construction of public institutions many residential complexes and multi- storied

buildings which is the case of acute loss of wetland. The unique ecology of wetland is linked to multiple components like waterways, habitats, plants and animals etc.

Table 5. Environmental Impact Assessment

Issues	Issues strongly associated	Issues moderately associated
Dumping of solid waste	3,6,8,10,11	4
Discharge of sewage water	1,3,6,10	-
Hydrologic alteration	1,2,6,7,9	8,10
WL inundation	3,6,7,10,11	1,2
Burning of garbage	1,8,10,11	-
Reduced water quality	1,2,3,4,7,9,11	10
Encroachments (Pub & Pvt)	1,2,5,7,9	3,6
Global climate change	5,9,10,11	4
Ground water depletion	3,7	4
Biodiversity and extinction	1,2,4,5,6,10	3,7
Health hazards	1,2,3,5,6	9,10

Source: Field Survey

Acute and Chronic loss

1. Dumping of Solid Waste

PML which was ecologically rich in terms of species and habitat variation has become pale. Dumping of solid waste has altered the resident biota, water quality etc. The pristine state of wetland has been gradually losing.

2. Discharge of Sewage Water

Vegetation and species of this marshland has been affected due to sewage water.

3. Hydrologic Alterations

Alterations in hydrology will cause changes in the character, functions, values and appearance of wetlands. In the study area many culverts have been constructed by the PWD authorities to manage floods. The present state of affairs is that permanent wetland now looks like a seasonal wetland.

4. Wetland Inundation

Though there is no elevation of any dams in the reference site but this area is prone to flooding during rains.

5. Burning of Garbage

The study area has been continuously used for burning garbage round the clock. The air pollution caused by burning has produced 27 toxic gases which affect different organs of a human body. It is said that another Bhopal Gas Tragedy is slowly and gradually taking place.

6. Reduced Water Quality

PML is largely affected by organic waste disposal and contamination as is indicated by high levels of chloride and sulphate. The Total Dissolved Solids in 1995 was 5120 mg/l and when the sample was tested on 2001 it was 9220mg/l (Care Earth, NGO). Sulphate level present in water in the year 1995 was 237 mg/l and when tested on 2001 was found to be around 1200 mg/l which is well above the dangerous mark of human consumption.

7. Encroachments

Land use pattern has been changed due to civilised society. Urban agglomeration and mushrooming of cities has necessitated provision of infrastructure to the public. PML has been encroached by both central and state government institutions. Apart from this both voluntary and involuntary encroachment is also seen along the periphery of marsh area.

8. Global Climate Change

The loss of wetland is both a cause and an effect of climate change. As a cause, wetlands are the single largest global emission source for methane, a gas which is a major contributor to the atmospheric trapping of heat that leads to atmospheric warming (Office of Technology Assessment, 1991). Atmospheric warming leads to drying, desertification and loss of wetlands over regions of the earth as well as predicted increases in global sea levels of 10-21 cms by the year 2025. In a country like India loss of small wetlands in a gradual scale would change the global climatic conditions. Loss of wetland is due to changing land use pattern. Changes in micro climatic alterations would be apparent due to the loss of smaller wetlands like PML.

9. Ground Water depletion

Advent of technological advances in tubewells, borewells etc has reduced the level of ground water table. The summer months of April and May 2006, the areas around the marshland like Velachery, Vijaynagar, Perungudi were facing acute water shortage problem inspite of the flood in October 2005.

10. Introduced species, extinction of native biota

Marshland is threatened by water hyacinth free floating nuisance plants pose problems by clogging waterways and out competing native vegetation (Mitchell and Gopal, 1990) Water hyacinth are capable of taking up and sequestering unwanted nutrients and heavy metals in the water column.

11. Health Hazards

Air Pollution, water contamination and bad odour are the major causes of concern affecting the health of the local residents in Maylai Balaji Nagar, Ram Nagar, Madipakkam, Velachery and Pallikaranai. Commuters passing through these roads face similar threats due to constant burning.

Role of Public in Monitoring Wetland Management

The state water resource control board should be directed and allocated adequate resources to:

- Wetlands are the basis of groundwater and therefore develop a program to protect wetlands resources.
- To develop the beneficial use process of wetlands by CMWSSB.
- Develop scientifically based water quality standards for wetlands.
- To implement wetlands anti-degradation policy.
- Regulate removal of vegetation, draining and hydrologic modifications to prevent loss of wetlands; and
- Protect and restore the managed and unmanaged water tanks connected to PML by providing sufficient outflow and utilizing appropriate migration techniques.
- Funds must be allocated to cover the direct, indirect and hidden cost based on the number of species being addressed, extent of spread, and eradication methods.
- To develop a comprehensive wetlands Regional Monitoring Program for PML.
 - Implement wetland project tracking data management and coordination.
 - Encourage local academic institutions to study wetlands and to communicate their findings.

PUBLIC PARTICIPATION

I. Storm Drain Stenciling

Painted messages must warn citizens 'Restore wetlands on earth at the right time', failing which – man has to use polluted water communities and must develop stencils and logo in protecting PML.

Municipalities must initiate in developing stencils, throughout the entire community, in areas with sensitive water or where biological oxygen demand, nutrients have stenciling work should be done only in areas of higher pedestrian traffic and to target drains leading to water bodies where illegal dumping has been identified as a source of pollution. If a municipality chooses to initiate stenciling program, seek the help of volunteer organisation strategies include:

1. Distribution of pamphlets and brochures to local people.
2. Placing article in local magazines.
3. Taking out newspaper advertisements.
4. Making presentations at community meeting.
5. Developing public service announcement through media.
6. Creating a web site with background and contact information as well as photos and stories.

Recognising Services of Service Organisation group

1. Providing participant with a certificate of appreciation.
2. Distributing logo items such as T-shirts hats, badges, or other items to participants before or after the event.
3. Arranging for picnic after the event with refreshments donated by a local business.
4. Providing coupons for light refreshment or movies donated by local merchants.
5. Taking pictures of stenciling fans before, during and after the event to create a pictorial record of volunteer activity.

Storm drain stenciling projects offer an excellent opportunity to educate the public about the link between storm drain system and drinking water quality.

II. Stream Cleanup and Monitoring

People are not aware that most storm drains discharge untreated water directly into local water bodies. Cleaning up of stream allows concerned citizens to directly involve in water pollution prevention. Volunteer record information about the quantity and types of garbage that has been removed.

All the 31 water bodies connecting PML should be cleaned up. Work can be shared by school children, youth groups, local association, local environmental groups and individuals. As there are many difficulties in cleaning up, there is something for people of all ages and skills to do.

Volunteer's safety should be maximised by providing safety vests and first aid kits. Cleaning up events is effective way to improve habitat, water quality and aesthetics.

III. Volunteer Monitoring

1. Build awareness on pollution problems.
2. Become trained in pollution prevention.
3. Help clean up problem sites.
4. Provide data for water that might have been unassessed.
5. Increase the amount of water quality information available to decision makers at all levels of the government.

Volunteers Conduct Variety of Activities

1. Analysing water samples for dissolved oxygen nutrient, pH, temperature etc.
2. Evaluating the health of the ecosystem by reviewing stream habitats and aquatic biological communities.
3. Cataloging and collecting details from the peripherals of marsh.
4. Restoring degraded habitats.

IV. Reforestation Programs

As in many parts of the country wetlands in Tamil Nadu are disappearing at an alarming rate, reforestation programs attempts to preserve and restore forested buffers. While planning for reforestation municipalities can accomplish tests like park improvement, neighbourhood and highway beautification and provision of shade in parking and pedestrian areas.

Reforestation program will help to create a buffer along stream corridors to filter pollutants and reduce flood hazards, provide aesthetic benefits.

V. Wetland Plantings

Wetland plants have the ability to improve water quality, filtering and accumulating pollutants, thereby protecting adjacent rivers, lakes and streams. Municipalities can plant wetland species to both preserve existing wetlands and enhance degraded wetland plant communities.

VI. Adopt – A – Stream Programs

This programme is an excellent public outreach tool where citizens of all ages and abilities can coordinate along with municipalities. Participants have to 'adopt' a stream, tank, river, cleanup, monitor, protect and restore.

VII. Water Shed Organisation

It must consist of local government, citizens' non-profit environmental groups and local universities. The purpose of watershed organization is to restore, protect and promote the natural resources of the watershed. Watersheds likely encompass municipal jurisdiction and involve multiple government participants. Municipality must support it, nurture it, and help to achieve its goal.

VIII. Stakeholder's Meetings

Public involvement naturally negates inclusion of stakeholders. Stakeholders are individuals or groups in the community that are most affected by municipality storm water program. Stakeholders must include beneficiaries or local citizens who earn their living by depending on wetlands, local school groups, community leaders, local and state government representative. This should be in the form of public meeting, interactive session, information sharing event.

IX. Attitude Surveys

Surveys can foster better planning and management programs in storm water management. The results can enlighten both PWD officials and public about the sources of pollution and effects of storm water on environmental programme. The planners can use this information to determine the policies for the interest of the public.

X. Community Websites

As the civic bodies and authorities cannot monitor all water bodies at once, they have to rely on public to keep them informed of water polluters. A hot line can be of toll free telephone number or an electronic form linked directly to a government agency such as water quality control board can be created.

Conclusion

Operation of administrative machinery is very poor. Since various governmental agencies are involved like Chennai Corporation, CMWSSB, CMDA, Forest Department, TNPCB, Local Panchayat etc. The depletion and degradation of PML is constantly on the increase. Authorities say that dumping has to be stopped only by Chennai Corporation and Alandur Municipality. Dumping and burning of solid waste is the only activity which has spoiled the environment of PM.

There are not even a single government institution which has a say on marshland for protecting and conserving. As this PML is an open land located in Chennai City is blocking the development activities, they perceive. Authorities on TNPCB say that their job is to check on industrial sewers alone. The authorities of TNPCB can not take any action if CMWSSB letting out residential sewers in to the

PML. But inspite of its limitations, the Board receives complaints and record them without taking any action on the erring agencies. There is no responsibility and accountability on any governmental agencies with regard to protection and preservation of PML. But in managing Common Property Resources like wetlands, a total negligence and reluctance continues to exist among the bureaucrats and the government. It is better to prevent than curing the losses of depletion and degradation of PML.

Utilize the best engineering practices available to minimize adverse impacts when project construction in a wetland is deemed to be the only practical alternative.

REFERENCES

1. Balakrishnan Mundanthra (1993): *"Wetlands of India: Their unique potential for Quality life improvement"* Environmental Problems and Prospects in India, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, pp 21-22.
2. City Bureau, Reprieve at Last for Battered Marshland, The Hindu, May 29, 2007.
3. Daniels R.J. Ranjit, Vencatesan Jayashree (2002): *"Conservation of Urban Wetland - Pallikaranai Marsh"*, baseline study, Care Earth, p 10.
4. Davidson, J. (1992): *"No Time to Waste: Poverty and Global Environment"*, Oxfam, Oxford.
5. Gerard (2004): *"The Economic, Social and Ecological Value of Ecosystem Services: A Literature Review"*, FAO Report (2001).
6. ISRO, Shows the Way for Urban Waste Management, GIS Asia Pacific Development, August 2006, Vol10, No.8,p13.
7. Jayashree Vencatesan, 2007, Protecting Wetlands, Current Science, Vol 93, No 3.
8. Jayashree Vencatesan, Marshland Gone Waste, The Hindu, 1st July 2008.
9. Kannal Achuthan, An Inconvenience Truth in Chennai, The Hindu 19th April 2008.
10. Lee, 2004, *Thematic Biodiversity Strategy and Action Plan*, ZSI, K. Venkatraman, Natural Aquatic Ecosystem in India.
11. Mukesh and Associates (1996): *"Environmental Impact Assessment of the drainage and Redevelopment proposal for the Pallikaranai Area"*, Prepared for MMDA by KBN Engineering & Applied Sciences Inc., Vol I & II, No, 14367C.
12. Oppili, P, Naturalists See Red as Marshland Water Changes Colour, The Hindu, 11th January 2008.
13. Parish Faizal and Looi CC, *"Wetlands Biodiversity and Climate change, Options and Needs for Enhanced linkage between the Ramsar Convention on Biological Diversity and UN Framework"*, Convention on Climate Change.
14. Patnaik C. Divankar (2004): *"Wetlands-Pallikaranai Marsh in Chennai"* http://us.geocities.com.envidankar_wetland/html.
15. PWD Report (2005): Status Report on Pallikaranai Swamp.
16. Reach Velachery (2005): December 1-15, Page 3
17. Save Pallikaranai Marshland Forum (2002): Brochure.
18. Special Correspondent, What We Get is Contaminated Water Say Thorappakkam Residence, The Hindu, 27th February 2008.
19. Srikanth, R, Flood Control Measures taken up at Velachery, The Hindu, 23rd October 2006.
20. Srikanth, R, Flood Protection Underway, The Hindu, 2nd October 2007.
21. Staff Reporter, Rise in the Number of City Dwellers Moving to Suburbs, The Hindu, November 29, 2006.

22. Staff reporter, Three Held for Killing Birds in Marsh Land, *The Hindu*, 14th May 2007.
23. Sundram, G (2006), *Waves and Water*, Madras Musings, 16th to 28th February.
24. The Wetlands Policy of the Commonwealth Government of Australia, January 1997. <http://www.anca.gov.au/index.html>.
25. TNPCB (2004, 2005, 2006), Pallikaranai Marsh, SWM / 4495, Vol 1,2,3.
26. Vencatesan, Jayashree (2006): "Wastelands:Time to Rethink" *Current Science*, Vol. 91. No.11, dated 10th December.
27. World Resources: 1996-97, "*A Guide to the Global Environment*", Published by The World Resources Institute, UNEP, UNDP, World Bank, Oxford University Press.