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AN ASSESSMENT OF THE PRESENT CONDITION OF A WETLAND IN A DEVELOPING CITY: THE CASE OF PALLIKARANAI MARSH, CHENNAI, INDIA

Mythili MADHUSUDHAN[1*], N.K.AMBUJAM[2]

[1]School of Architecture, Meenakshi College of Engineering, Tamilnadu, India Email: mythili.m@mce.edu.in, [2]Centre for Water Resources, Anna University, Chennai-25, India, Email: nk.ambuj@gmail.com

The impact of human habitation on ecosystems in developing countries, while studying the case of a wetland situated in the city of Chennai, India, is the focus of this paper. City growth resulted in increased attention towards the wetland site and simultaneously, an influx of population in this area. This also resulted in shrinking of the marsh accompanied by deterioration of nearby water bodies. Highlighting the need for appropriate monitoring of environmental resources, the region could be viewed from the perspective of sustainable management and tools for the same are called for. Time series data from Landsat images and historical cadastral maps from the same time period are used for analysis. Trend analysis, studies from secondary sources, field observations and key-informant interviews have culminated in this research. The primary losses were found to be in terms of landscape value, changes in hydrology, biodiversity and anthropogenic impacts. The authors have found that in this transformation of the water-landscape, the problems characterizing the resultant urban unit such as inundation and storm water conveyance are a direct consequence of the loss of natural resources, and this emphasizes the need to save the water body. The present condition of the marsh is thereby evaluated, the major issues examined and recommendations for the governing authorities and the public are made.

Keywords: *Impacts of urbanization, Eco-social, Water bodies and Wetlands, Land use Land Cover changes, Mapping of Water bodies, Chennai, Pallikaranai marsh*

INTRODUCTION

The transformation of eco-social landscapes (1), its drivers and consequences have caught the attention of ecologists, landscape architects, urban planners and engineers alike. Cities often prioritize economic growth over the environment, and in the case of Chennai, India, one can see the city boasting of 'Lakeview roads' on reclaimed land, once water bodies. Incidentally, land reclamation is not an uncommon occurrence in many cities in India, such as Mumbai (2), Kolkata (3), Bengaluru (4), Hyderabad (5) besides Chennai (6). This paper addresses and approaches urban water bodies and wetlands, giving due attention to recent research which highlights the possibility of the emergence of 'novel ecosystems' (7) or 'hybrid ecosystems'(7) through dialectic interaction of competing human occupation and natural processes.

Wetlands have biological and sociological implications on the lives of people. Wetlands may be inland or coastal, including human-made wetlands (such as rice-paddies, dams, reservoirs and fish ponds). Wetlands are central to water and food security of the region. On a global scale, the aggregate value of the ecological services generated by wetlands has been estimated to be $4.9 trillion/year (8). In all, these comprise the various ecosystem services provided by wetlands, which are of provisioning, regulating, cultural and supporting types (9,10). The Millennium Ecosystem Assessment identifies 14 ecosystem services (11), though certain other sources give larger numbers.

Wetlands are a coalesce of land and water, combining the characteristics of terrestrial and purely aquatic ecosystems. The primary characteristics of wetlands include the presence of water at or near the surface at least for part of the year, plants sensitized to wet conditions (hydrophytes), and soils that are saturated or flooded long enough to develop anaerobic conditions (hydric soils) (9). Management of wetlands is not given adequate attention in the national water sector agenda (12). At an international scale, it has been seen that the city wields greater power for the promise of economic growth and increased prosperity. In China, (13,14) in spite of establishing more than 550 National Wetland Nature Reserves and 100 National Wetland Parks the annual rate of disappearance of wetlands is still around 1%. In certain parts of the USA, wetlands are being conserved by mitigation in alternative sites (15) or by 'habitat conservation plans' (16). In Canada (17); population and industry are found to be responsible for wetland loss in spite of conservation agencies like Ducks Unlimited Canada. In Brazil, the inclusion of wetlands in the Ramsar list has ensured wise-use of wetlands (18). In Bogota (19), Kakadu wetlands, Australia (20), biodiversity has garnered attention and in Lagos (21), Zimbabwe (22), Dhaka (23) and SriLanka (1,24), there are instances of encroachment or myopic development plans on the part of the government. At this juncture, one may need to recall Henry Lefebvre's theory of the production of space and right to the city, in which he argues that urbanization is a significant part of the changing world which may generate conflicts over land (25).

The Pallikaranai marsh, one of the few and last-remaining natural marshes of southern India (26), extended to more than 5000 hectares 60 years ago (6,26,27) and now stands reduced to one-tenth of its original area. It was subjected to various human-centric activities like development of roads and urban infrastructure, establishment of a dump yard on its surface water, due to its non-recognition as a wetland. Though the marsh has evoked some public awareness, the inhabiting community continues to face negative consequences. The drivers of these changes, extent of losses and possible mitigative solutions need to be identified at the earliest.

This study illustrates the use of remote sensing and GIS techniques in the analysis of wetland catchment (28–30) as a prerequisite for outlining restoration measures. The methodological focus of this paper is the utilisation of cadastral maps worked with Arcgis software (31) and Landsat satellite images used to perform a study of land use conditions over four decades. Even though scientific studies of the Pallikaranai marsh by various individuals and agencies exist, they primarily deal with water quality, environmental impacts, and biodiversity, whereas this study is of a socio-spatial kind and is based on an understanding of the existing conditions from documented sources and field conditions.

In this paper we address the following research questions investigating the social and land use drivers and consequences of ecological transformation of the wetland under question.

- What are the kinds of eco-social changes occurring in the wetland?
- What are its drivers and consequences?
- How did incremental ecological changes add up over time into an overall transformation of ecological and social character of the wetlands?
- How can we enable the present financial capital and social capital to enhance ecological capital in the study area?

The paper is structured as follows: firstly, the introduction and statement of objectives followed by description of study area, followed by the methodology adopted, which is followed by an explanation of results obtained and discussion based on issues relating to the eco-social changes and environmental drivers, concluding with recommendations.

MATERIALS AND METHODS

Study Area

Pallikaranai Marsh, situated on the geo-coordinates of 12.949371°N latitude and 80.218184°E longitude, is among the last existing natural wetlands of Chennai City, India. Locally known by the generic Tamil name 'Kazhuveli' which translates to 'marsh' or water logged area (6), the marsh is bound in the east by Old Mahabalipuram Road (OMR), in the west by Tambaram-Velachery road, Velachery village and Velachery lake in the north and by Medavakkam-Karapakkam road on the

southern side. It drains about 250 km^2 area through two outlets viz., Okkiyam Madavu channel and the Kovalam creek and empties into the Bay of Bengal (Figure 1). The marsh area had spread to an extent of 6000 ha (60 km^2) around the 1906s, of which there is a 90% loss of habitat resulting in the presence of only 593 ha of marsh at present (26). In 2007, the State Government, in response to an advocacy programme of a concerned NGO (Non-governmental organization) and civil society network (26), known as 'Save Pallikaranai Marsh Forum', notified the southern portion of the marsh spanning 317 ha initially, as reserved land which was later upgraded to Reserve Forest.

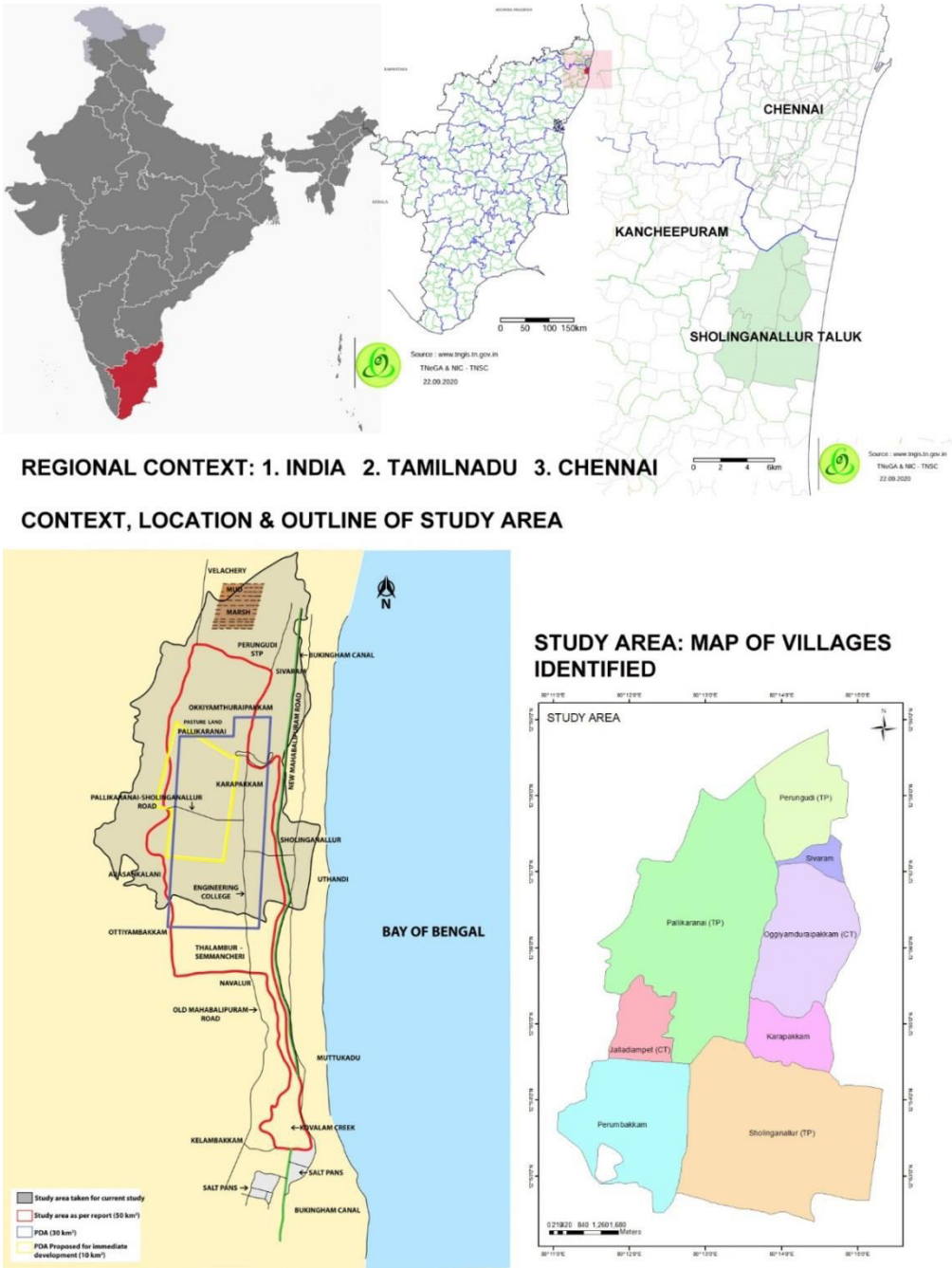

Figure 1. Study area, **Image source: Author**

The first master plan for Chennai Metropolitan Area came into effect in 1975 for a period of 20 years till 1995 (32). The much-delayed second master-plan was approved by the government only in 2008 (32,33). In 1993, Chennai Metropolitan Development Authority (CMDA), the predicated planning authority of the state, engaged consultants to study Pallikaranai and propose measures for drainage of

the region. They facilitated a Flood Relief Storm Water Drainage Master Plan Study (34,35) which recommended that the 'Pallikaranai Development Area' 'could be developed as a light/medium scale industrial area without much adverse environmental impact'. This sums up the planning history of the Pallikaranai region from the governmental perspective.

As for the public perspective, this part of the city achieved a hitherto unforeseen popularity as a real estate destination for buyers big and small, following the construction of the road, hereafter referred to as 200 ft Radial Road, the Mass-rapid transit system (MRTS) and a series of grandiose residential projects in the early 2000s (36,37).

With reference to the CMDA study on drainage and the subsequent Environmental Impact Assessment (EIA) (35) addressing the wetland area and its catchment, it is intended to address this associated wetland area in our work. Thereby, a study area surrounding the Pallikaranai village (village is the term for the unit of administrative boundary) including seven villages, comprising an area of 5657.032 hectares has been identified. The villages identified include, Perungudi, Seevaram, Okkiyamthoraipakkam, Karapakkam and Sholinganallur on the eastern side and Pallikaranai, Jalladampettai and Perumbakkam along the west. Pallikaranai village includes most of the present extent of the marsh.

Analysis by geospatial methods

In an effort to study the available records relating to water bodies from older revenue maps, the maps dating to the year 1985 were obtained from the Survey and Settlement Department, Survey House, Chennai. These maps were scanned to a resolution of 300 dpi and joined and stitched together using Adobe Photoshop software.

The tiff layer comprising the merged maps was then georeferenced. These maps were used to create a layer comprising of the water bodies in Arcmap, following Madry et.al., (31). This layer of water body polygons was digitized in a scale of 1:8500 from the cadastral maps. It gives the location, exact outlines, areas of the water bodies in vector format and acts as a database for the period before the present spate of urban development. The numbers and areas of water bodies in the abovementioned eight villages were obtained from the Arcmap attribute table.

In order to determine extent of various land use changes and to obtain changes in water extent, remote sensing methods were used. Using the boundary described in the introduction, Land Use Land Cover (LULC) classification was performed. Landsat images were acquired from USGS Earth Explorer and processed. Post-monsoon imagery from the month of February for all four decades was used. The images date to, 6 February 1988, 17 February 1998, 29 February 2008 and 25 February 2020. The first three are Landsat 5 "TM" images and the fourth is Landsat 8 "OLI_TIRS". All of them are of spatial resolution 30m and sourced from USGS Earth Explorer.

The images were classified with the help of Erdas imagine software and processed in Arcmap 10.0 (38). An appropriate number of bands were classified in each case, including visible and near infra-red (and in Landsat 8, SWIR 2 also) to obtain a land-urban false color composite showing vegetation, water and built-up areas. To obtain changes in land-cover dynamics, NDVI and NDWI were also mapped for the four years.

Classes identified for LULC

For the LULC, five classes were identified in the images which decreased to four classes in the more recent images. The classes include vegetation (including vegetation covering water, urban, mangrove and scrub vegetation), water body (including wetlands, tanks, canals, streams and shallow water), marshland (seen in some imagery around water bodies), sand (mixed barren land and along the coast) and built-up cover class (including residential, commercial, industrial, transportation and mixed-use and utilities).

The watershed basin of the study area is also delineated with the help of Arcmap software using the DEM file from the National Remote Sensing Centre (NRSC) Bhuvan source. The basin profile for the study area is thereby provided in the map. A comparative study of the existing water bodies from the 1985 revenue maps, and the state of the corresponding water-bodies in latter period, viz., 2008, sourced from the CMDA masterplan maps, exhibits certain trends (39). The water bodies were identified by comparing their survey numbers and their areal extents were determined by Arcmap software.

RESULTS AND DISCUSSION

The results demonstrate that Pallikaranai wetland and its associated regions were impacted both by government decisions to develop the region and encourage industrial growth and subsequent urban development, and public behavior, viz., population dynamics, migration and occupation of lands in proximity to the water body, encroachments by public and private bodies and lack of attention.

Changes in wetland and watershed land-use

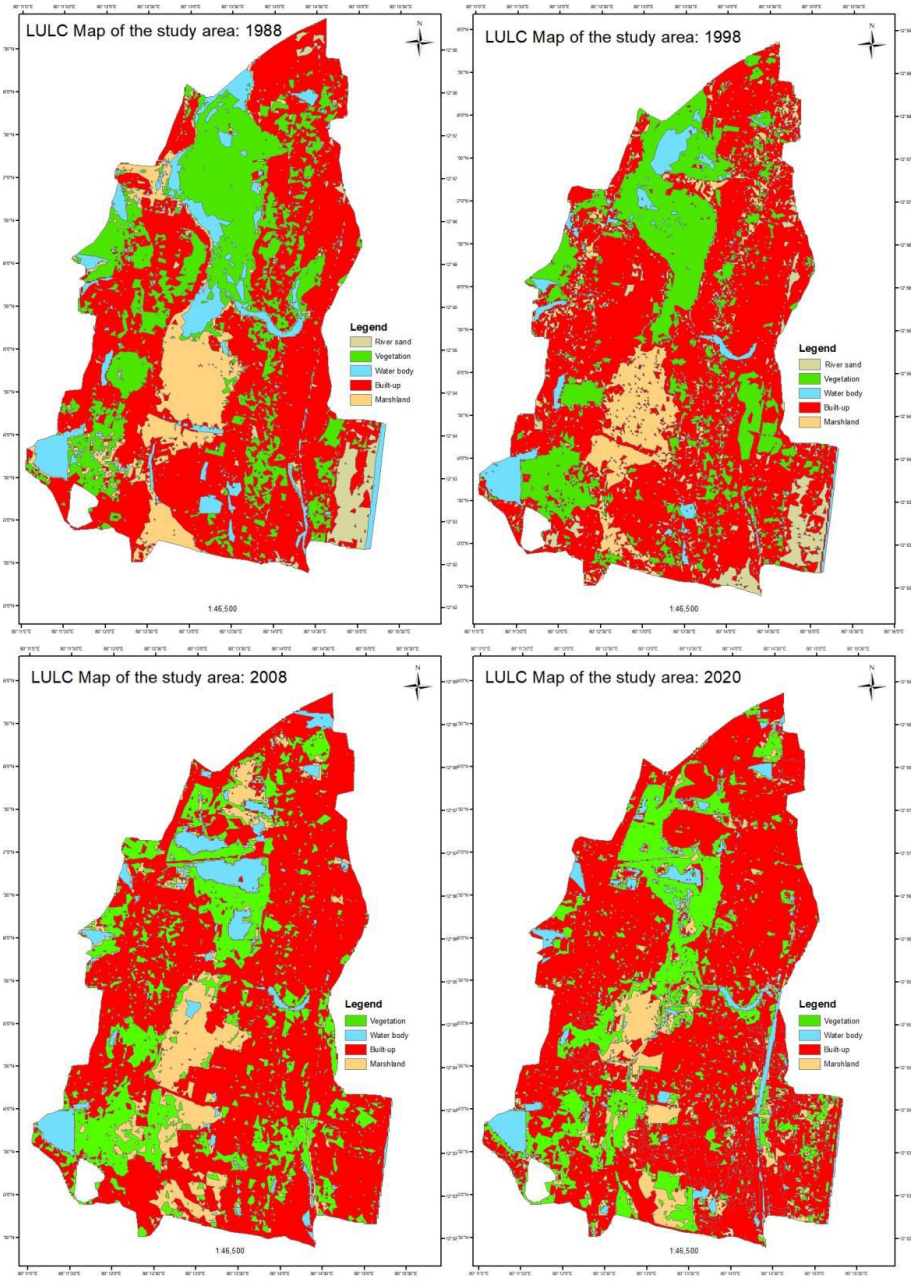

Figure 2. Land Use Land Cover analysis maps. **Image source: Author**

LULC change status 1988

The findings of the 1988 imagery classification are as follows. Vegetation is present both covering the water bodies and in the land area. A number of water bodies are also seen in this stage. A fair extent of marshland and sand cover class is visible all over the extent. Built-up cover class is seen

occupying the rest of the area to an extent of 51.68% of the total area. Vegetation area totally occupies 25.91% of the total area.
The prevalent landscape comprised of numerous water bodies as studied from the revenue maps, including the marsh and the channel, and wetland vegetation including grasses and other varieties were supported by it. These features predominated and further, marshland and sandy soil were present and only the rest was built-up cover class occupying 51.68% of the area boundary. In 1985, Pallikaranai was not very much urbanized, agricultural villages were present and water availability was copious. Numerous canals were found in the revenue maps in some villages and correspondingly the water extents as seen in the LULC analysis are higher.

LULC change status 1998

The findings of the 1998 imagery classification go to show that vegetation is present covering both the water bodies and the land area. This is indicated by the extent, and may include both deep and shallow water areas. The extent of marshland and sand has decreased compared to the 1988 extents. Built-up cover class occupies the rest of the area and has gone up to an extent of 58.57% of the total area. Vegetation, in this analysis, occupies 22.32% of the total area. The extent of water body appears to have decreased.
The marked change in the 1998 study happens to be the introduction and growth of the dump yard on the water body, seen in the north-eastern side of the marsh boundary. Vegetation has begun to disappear on the western side of the marsh and water bodies and vegetation on the eastern side of the marsh have also disappeared and are replaced by built-up areas. Subsequently the marshland area has also been thinning along the edge. This may be the effect of the 'Pallikaranai Development Area' policy mentioned earlier.

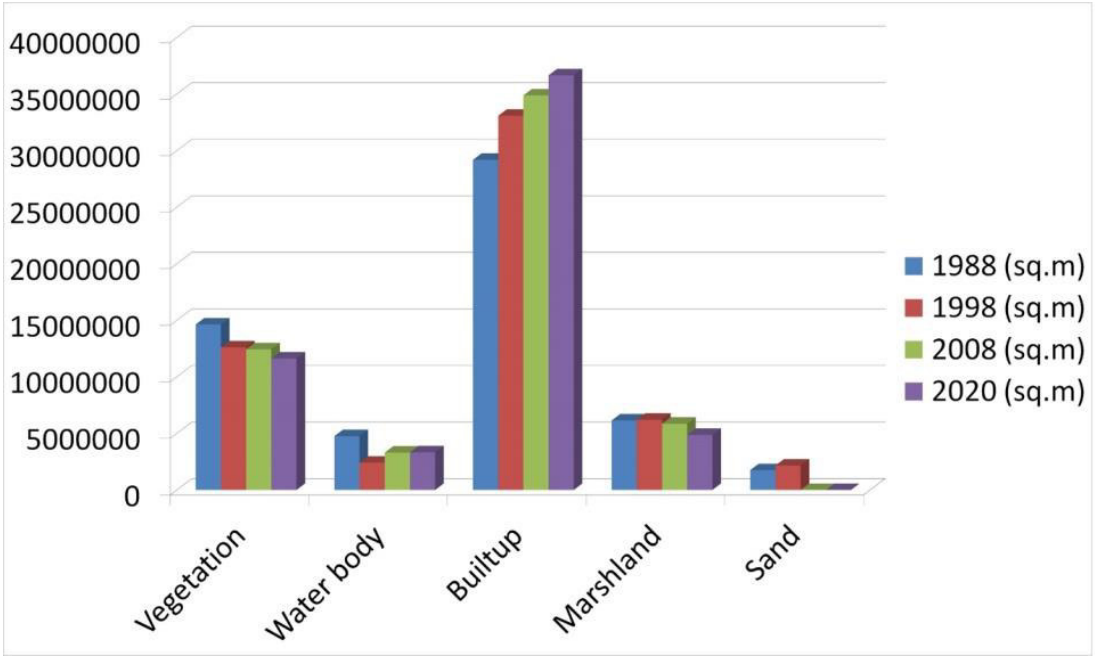

Figure 3. LULC analysis data

LULC change status 2008

The findings of the 2008 imagery classification show that the extent of vegetation has come down to 22.02%. The major difference in this decade is the introduction of the 200ft Radial Road, dividing the marsh, running along the east-west direction. This road was added in the early 2000s and it divided the marsh physically, with a number of culverts beneath, to convey storm water flow. It has led to a plethora of inundation issues and with the passage of time, sedimentation and accumulation of deposit, there has been a reduction in availability of water. In this map, more water extent is visible and is exposed (less covered by vegetation), suggesting an area greater than in 1998, but it may be shallower

water. Built-up area has increased compared to 1998, to 61.77% and marshland is still present, exhibiting a decreasing trend. Areas which were classified as sand in the previous years have become urbanized in this stage and hence its value is zero.
This is the period succeeding the introduction of the east-west 200-ft Radial Road, which divides the marsh into north and south fragments. The growth in the dump yard is visible in this map. Connectivity between east and west has seen an improvement because of this road and hence urban development (to an extent of 61.77%) and subsequent disappearance of water bodies and vegetation.

LULC change status 2020
The findings of the 2020 imagery classification are: vegetation extent in this map covers an extent of 20.58% and has come down. The proportion of water body also has decreased compared to 2008 and built-up area exhibits a drastic increase to the extent of 64.94%, post economic cum infrastructural development which forms part of the region.
The IT (Information Technology) Expressway, which is home to a number of multistoried commercial and residential buildings, the 200ft Radial Road mentioned earlier, and the Velachery-Tambaram Road, which connects to the south-western part of the city, have spurred a city expansion at a relatively rapid scale. Incidentally, the Old Mahabalipuram road (IT expressway) and the Velachery-Tambaram Road were identified from as far back as 1975 in the topo sheets that were digitized and surveyed. Built-up cover class has taken over completely and vegetation (20.58%), water body (5.89%) and marshland have dwindled. The dump yard also seems to have grown as seen from its enlarged outline.

Accuracy assessment of Land covers classification
To assess the accuracy of the LULC classification, around 600 raster cells were randomly selected, converted into polygons and transferred to Google Earth. The predicted classification, as obtained from ArcGIS was compared with actual land cover classes for these cells numbering approximately 600. Based on this error matrices was computed and overall accuracy was estimated to 95.5% for the year 2008 and 93.2% for the year 2020 (40). Since Google Earth images were available only for these periods, we have used this methodology for those years only.

Disappearance of water bodies and related issues
Simultaneously, the water bodies covering the whole study area were mapped for the years 1985 and 2008 from cadastral maps and second master-plan land use maps from the portal of the CMDA (41) respectively. The changes in the water extent according to this data are presented below.
The various types of water bodies in the study area date back to much earlier times, and bear historical names, with generic names like ‘kulam’ (for bathing), ‘kuttai’ (for rainwater collection), ‘thangal’ (other types of water bodies) (42) and also ‘natham’ referring to commons.
The water bodies were both of natural and manmade types and though many occurred in common lands, some were privately owned and some were registered in recent times by individuals. The information on status of water bodies, land use and ownership was sourced directly from the Public Relations Officer of the Collectorate by filing an RTI (RTI stands for Right to Information Act, 2005 which enables citizens to access data which is not directly available) application.
Information obtained reveals that in the village of Okkiyamthuraipakkam, 14 water bodies still exist out of the 32 identified in from the 1985 map all of which are found to have been converted to other land uses in the masterplan.
In Pallikaranai 6 water bodies out of the 14 numbers identified from the 1985 map are still existing while other water bodies have transformed into built-up areas (it is interesting how the streets in these built-up areas follow the shape profile of the water body formerly in existence), and in Karapakkam, 3 water bodies out of 10 are still existing all of which are shown as other land uses in the master plan.

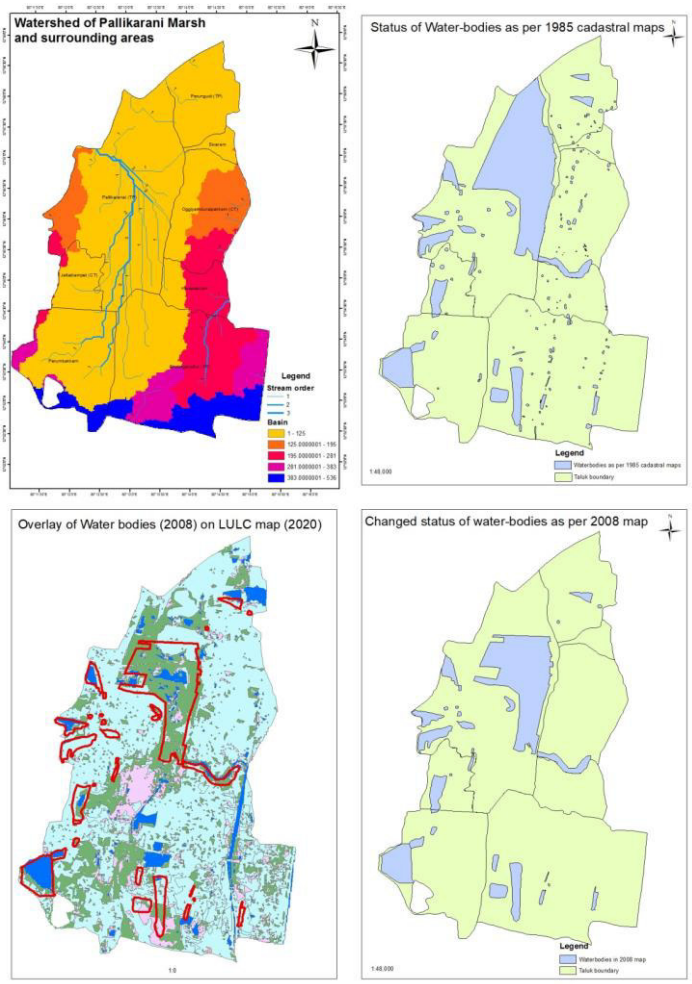

Figure 4. Water body analysis maps, **Image source: Author**

This could also be because the concerned department records were outdated, but an observation from Google Earth engine reveals that these parcels are existing as shrunken water bodies or regions which get inundated in monsoon and remain dry otherwise. Further, the webportal data from the CMDA was examined to collect details from the available dates viz., 2001 onwards, for the villages under study. Predominantly in the cases of Perungudi and Jalladampettai, and also in Pallikaranai, Perumbakkam, there are mentions of land registration to residential use and rarely to other uses, adjacent to water bodies as can be ascertained from the survey numbers of parcels (41).

Also in Perungudi village one of the water bodies extending to an area of 6.23ha has now physically transformed into a residential area known as 'Ambedkar Nagar'. This was noticed while comparing the historical revenue maps and later land use maps and this became the empirical motivation of this paper. Land use change is one of the most important influential factors in wetland condition according to Zhang (14).

The water body analysis maps show the hydrology of the region, analysed from DEM source (top left, Figure 2).

The ArcMap shapefiles of 1985 (top right) and 2008 (bottom right) and the overlay of the Arcmap 2008 shapefile layer on the LULC classification of 2008 (bottom left) are seen in Figure 2. This analysis details the loss of water resources and magnitude of the loss with data that is 23 years apart. The pie-charts in Figure 3 indicate the change of water bodies to various land uses for each village.

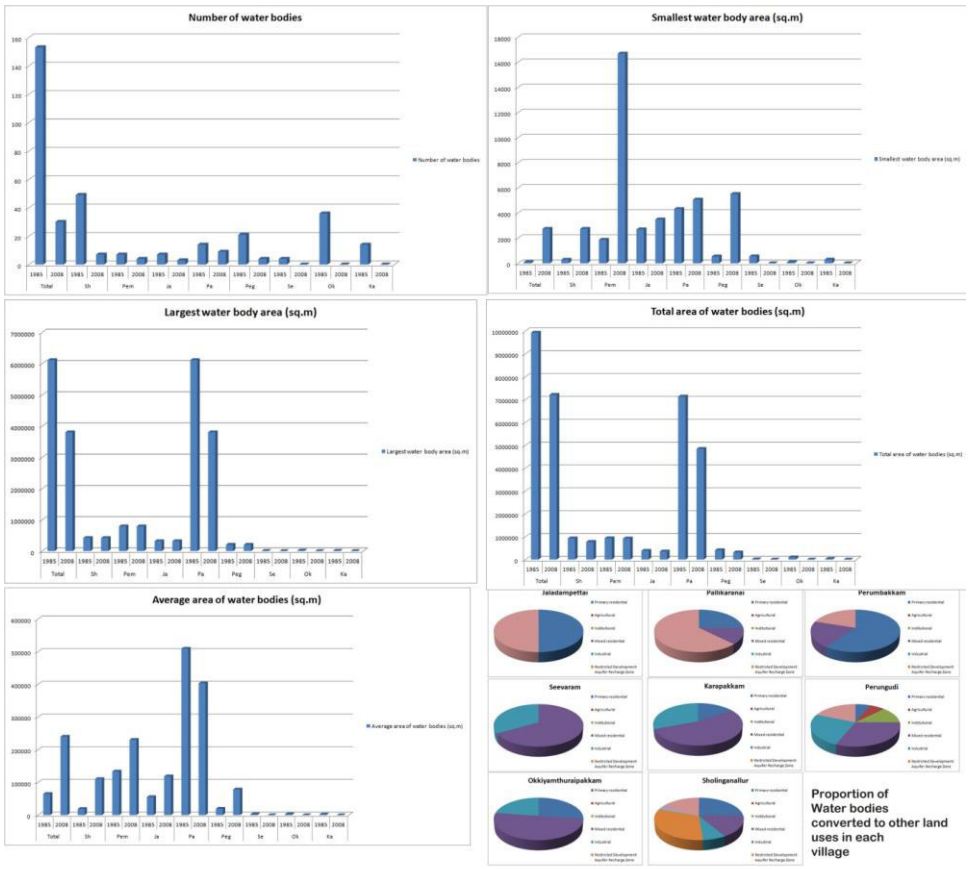

Figure 5. Water body analysis data, **Image source: Author**

The (bottom-left) map in Figure 2 shows the overlay of the outline of water-bodies layer from the 2008 delineation on the LULC classification of the most recent data. From this we can observe the extent of water-bodies as per both datasets. The revenue maps outline shows the remnant water-body outlines and the classified data show the extent of available water as per recent data. How the two correlate is a direct visual observation. It can be observed that there is no coincidence of data in some places implying as we have been observing, that water bodies have disappeared, and in some places, water bodies have shrunk either marginally or grossly.

History of land-use and other changes in the wetland area and associated regions

As early as 1985-86 Pallikaranai was identified by the Government of India as one of the 94 wetlands under the National Wetland Conservation Programme (NWCMP) (43,44). In 2007, the state government (26,44) declared (Gazette notification GO. Ms. No. 52, Environment dated 9th April, 2007) a portion of the Pallikaranai marsh (3.17 sq.km) as a reserve forest under Section 4 of the Tamil Nadu Forest Act, 1882 after understanding the ecological importance of the marsh in the city context (6). In 2012, 115 wetlands were listed under the National wetland conservation programme by MoEF (Ministry of Environment and Forests) and this list includes Pallikaranai (45).

Public movements like the 'Save Pallikaranai Marsh Forum' gained a lot of attention and attracted media support and also response from the government. In 2011, an Adaptive Management plan for the Pallikaranai marshland was prepared by a Chennai-based NGO Care Earth, in order to ecologically conserve the marsh. In the same year, the process of handing over the marshland following a request from the forest department was initiated and the forest department plan was to undertake restoration of the marshland. In 2018, the state government announced that it would commence the restoration of 695 hectares of the wetland under the National Adaptation Fund for Climate Change over 5 years from 2018 to 2023 (46). But there are shortcomings in the pertaining law particularly with the 'wise-use of wetlands' as stipulated by the Ramsar convention. The Wildlife (Protection) act of 1972 provides for the establishing of sanctuaries, and wetlands which fall within

the protected area are protected. But grazing is strictly banned within a sanctuary, and this reduces human impact and influences the wetland ecosystem once it is declared as a national park. This and other aspects of the functioning of the forestry department imply that the areas with highest protection are not capable of protecting in the manner of 'wise-use of wetlands' (47).

Hydrological changes and history of flooding

As discussed, the 200ft Radial Road divides the marsh into two fragments and constrains the flow of water from north to south. There are primarily two instances where it has been felt that storm water flow is constrained and needs to be improved. One is with respect to the culverts beneath the 200ft Radial road, which amounts to only 2.6% of waterway provided compared to the total length of the road dividing the marsh (48). In the past 2 years, construction of drains and widening of waterway has been underway, to regulate the man-made impediments and allow for better conveyance of flood waters. Encroachments in the northern half of the marsh also impede flow towards the south.

The other instance is the channel which is historically a salient feature of the Pallikaranai marsh, the Okkiyam Maduvu channel, flowing in a south-eastern direction which helps in draining the marsh into the Bay of Bengal. It also permits flow from the sea, which sustains the partly saline ecosystem of the marsh. Widening of the Maduvu has been discussed, and recommended by a few. For instance, Andimuthu et.al., (49) have studied flooding impacts in the region at various hotspots and recommend deepening and widening of the Okkiyam Maduvu channel in order to improve its carrying capacity. But ecologists have expressed concern about the impacts of such physical interventions.

Changes in vegetation and ecological characteristics

The landscape surrounding the Pallikaranai marsh was a predominantly agricultural landscape. Local people who have been over time a part of these villages, have stated they grew paddy and horticultural crops using only water that inundated the area, without dug-out wells or ponds in the vicinity. The wetland habitat constitutes aquatic grass species, scrub, marsh and water-filled depressions. The abundantly growing Typha and other aquatic macrophytes have been found to serve as bio filter for the wastes discharged into the wetland. The species inventory carried out in the preparation of the report by Centre for Climate Change and Advanced Research (CCC & AR), Anna University (50) states that 90 species belonging to 77 genera of 36 families are found to be present in the marshland. The marsh being a source of livelihood to many locals has been discussed in a 2007 report which explains that inhabitants of seven villages partially depend on the wetland for subsistence. Of these some ethnic groups are highly reliant, including for fishing and reed-gathering, grazing and agricultural groups (36).

Demographic and Socio-economic changes

The population density of Chennai city changed from 186.65 P/Ha in 1981 (51) to 265.53 P/ha in 2011 (52). The population density of Pallikaranai town panchayat (Town panchayat is the current administrative status of Pallikaranai which lies within the Chennai corporation) changed from 2.225 P/ha in 1981(51) to 25.05 P/ha in 2011(52). According to the 2020 data, the population of Chennai as a percentage of India's population is 0.312%. The population of Pallikaranai as a percentage of the city population has increased from 0.12% in 1981(51) to 0.613% in 2011(52) which implies that the average decadal increase in population of Pallikaranai town panchayat is 0.164%. Key-informant interviews including technological experts and about 55 residents in surrounding the marsh from a radius of 1-5km from the marsh edge revealed that there has been a huge migration into this region since 2000 onwards. The interviews covered a range of topics including topography, sociological status and occupations, infrastructural improvements, policies and changes in administration, changes in flora and fauna and the public view of the marsh, in terms of their perception of ecosystem services. The images in Figure 4 from Google Earth historical imagery show the southern portion of the marshland including the channel, Okkiyam Maduvu, the extent of urban growth and nature of the water body on 17-09-2002 (above) and 28-11-2020 (below).

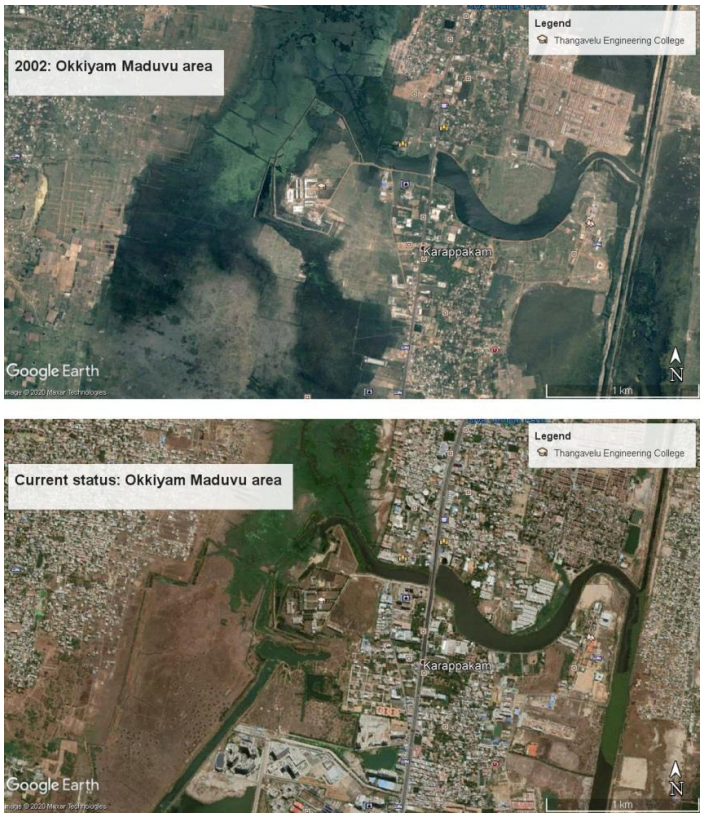

Figure 4. Change in Marsh condition 2002 and 2020, **Image source: Google Earth**

State of anthropogenic changes affecting the environmental quality of the wetland: whether to the extent of an emerging 'novel' or 'hybrid' ecosystem

Severe environmental degradation especially in terms of water quality, both groundwater and water in the marsh has been noted since the late 90s. The challenge involved with respect to this marsh is that the aquatic grasses or reeds may eventually transform into a terrestrial ecosystem which is part of the evolution process. As such, the influx of saline water from Okkiyam Maduvu and its mixing with freshwater is sustaining the marsh. Inundation, siltation, pollution of land and water are having an impact on the soil-water-vegetation interaction which is peculiar to the marsh and these effects may have compounded into the evidences of a 'hybrid' ecosystem (1,7), acknowledging the data on environmental quality from studies (6,43,53,54). How stable the ecosystem can be and to what extent will the impact of negative uses and activities be overcome is hard to predict.

CONCLUSION

In this context, one needs to dwell upon certain key aspects resulting from this discussion. These aspects may be listed as (i) the Society-Nature Cartesian divide which has come about from western philosophy and engulfs our thinking where society is the one and nature is the 'other' and turns nature into merely a passivity (55). (ii) there needs to be a complete thinking through or rethinking or rather, unthinking of our convention-based understanding of the natural sciences and its relationship to sociology, and hence to society. This will emphasize the fact that the crisis we are witnessing is to be seen not as an environmental crisis but as a crisis of society or a crisis of modernity.

As outlined in the introduction, from our analysis we have tried to bring out and discuss the eco-social changes in the region and drivers that led to the environmental and social modifications in the marshland and associated regions. Over the period from 1985 to the current times, incremental changes have compounded into an ecological transformation and this has led us to ponder how to address this region for developing policies and to what extent the damages resulting from anthropogenic activities will be acknowledged in the context of decision making for the future. The

development agenda typically deals with water resources from a sectoral perspective, and like we have mentioned earlier, wetlands do not find a mention in the National Water Sector agenda. In these circumstances bottom-up measures can be given priority, and it is essential for planners to acknowledge the needs and stewardship of the resident community. Community engagement is needed (25) while social capital and financial capital need to reinstate the benefits of a flourishing ecological capital. Studies that promote a pro-wetland governance, and making such information available in the public domain and spreading the ideas for the benefit of all are the need of the day.

Authors contribution: Conceptualization: Mythili Madhusudhan & NK Ambujam; Methodology: Mythili Madhusudhan & NK Ambujam; Formal analysis and investigation: Mythili Madhusudhan; Writing (Original draft preparation): Mythili Madhusudhan; Writing (Review & editing): NK Ambujam; Resources: Mythili Madhusudhan; Supervision: NK Ambujam

Biographical notes:

Mythili Madhusudhan, B.Arch., M.L. Arch., is a landscape architect and professor in School of architecture, Meenakshi College in Chennai, India. Her interests include landscape design, urban ecology and landscape urbanism theory. She is currently pursuing her doctoral studies.

N.K. Ambujam is a professor in Centre for Water Resources, Anna University for over 35 years. She is a pioneer in the field with many publications in international journals and fellowships.

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