ECOSYSTEM SERVICES LOSS OF PALLIKARANAI MARSHLAND:

A CASE STUDY FROM CHENNAI, INDIA

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Abstract

Urban marshlands play a vital role in maintaining ecological balance and supporting urban resilience. The Pallikaranai marshland, one of the last remaining natural marshlands in Chennai, India, offers a diverse array of ecosystem services that are increasingly under threat due to rapid urbanization and land-use change. This study aims to assess and categorize the ecosystem services provided by the Pallikaranai Marsh majorly focusing on provisioning, regulating, cultural, and supporting services and to what extent they have been lost due to several factors.

It is found that the marshland offers various ecosystem services to the local communities including agricultural produce, fisheries, tourist attractions etc.

The study also reveals that the marsh performs critical regulating functions such as flood mitigation, groundwater recharge etc. It also serves as a biodiversity hotspot, providing habitat to numerous endemic and migratory species. Cultural services, especially aesthetic, recreational, and spiritual values, were strongly acknowledged by the public.

Findings highlight the undervalued role of marshlands in urban planning and the need to integrate ecosystem services into Chennai's development plans. Protecting Pallikaranai marsh is not only crucial for ecological health but also for the socio-economic resilience of the city.

Key words

Ecosystem services, Livelihood, Marshland degradation, Urbanization, Urban marshland

1. Introduction

- **Background on urban marshlands**

Urban marshlands are vital ecological systems embedded within or near rapidly growing cities. They act as natural buffers that manage stormwater, recharge aquifers, and regulate microclimates. Despite their importance, urban marshlands are often undervalued and degraded due to encroachment, pollution, and unplanned urbanization. These ecosystems provide a wide range of ecosystem services including water purification, flood mitigation, carbon sequestration, and habitats for diverse flora and fauna. Moreover, they hold cultural and recreational value for urban populations. However, urban development tends to treat marshlands as wastelands, leading to large-scale reclamation and biodiversity loss. In India, cities like Chennai, Bengaluru, and Hyderabad have witnessed the disappearance or severe degradation of marshlands due to real estate expansion and infrastructure projects. Recognizing the multifunctional value of urban marshlands is critical to ensuring

sustainable urban growth, ecological resilience, and climate adaptation in the face of increasing environmental challenges.

- **Importance of Ecosystem Services**

Ecosystem services are the direct and indirect benefits that humans derive from natural ecosystems. They are broadly categorized into provisioning, regulating, cultural, and supporting services. These services form the foundation of human survival and well-being - providing essential goods like food, water, and raw materials, while also regulating climate, air quality, and disease control. In urban contexts, ecosystem services are crucial for maintaining liveability and resilience. Marshlands, forests, and green spaces help mitigate urban flooding, reduce heat island effects, and improve mental health through access to nature. Recognizing and valuing these services ensures that natural assets are not overlooked in decision-making processes. Integrating ecosystem service assessments into planning and policy helps balance development with conservation, making cities more adaptive to climate change, sustainable in resource use, and inclusive in environmental governance.

- **Brief on Pallikaranai Marshland**

The Pallikaranai Marshland is a freshwater swamp located in the southern part of Chennai, Tamil Nadu. Spanning over 1,200 hectares, it is one of the last remaining natural marshlands in the Chennai metropolitan region and is recognized as a vital ecological hotspot. This marshland has also been recognized as a Ramsar site of international importance in 2022. Designated as a Reserved Forest under the Tamil Nadu Forest Department, the marsh supports rich biodiversity, including over 350 species of flora and fauna, and serves as a critical habitat for both resident and migratory birds. The marshland plays a key role in flood mitigation, groundwater recharge, and carbon sequestration, making it indispensable for urban climate resilience. Despite its ecological significance, the marshland faces severe threats from urban encroachment, solid waste dumping, sewage inflows, and infrastructure development. Pallikaranai stands as a compelling case of a struggling urban ecosystem whose ecosystem services are vital not just locally but for the broader regional environment.

2. Review of literature

The paper of Adhya, T., & Banerjee, S. (2022). “Impact of Marshland Development and Degradation on the Livelihoods of Marshland-dependent Communities: a Case Study from the Lower Gangetic Floodplains” examines how the degradation of the Dankuni marshland in Eastern India affects local communities relying on its resources. Through 37 semi-structured interviews, the researchers identified 18

ecosystem services provided by the marshland, including 12 provisioning services such as farming, molluscs, fuelwood, fodder, fibre, and fish, which have historically subsidized living costs and offered diverse livelihood options to residents community.

A study by Kakuba, S. J., & Kanyamurwa, J. M. (2021). on the “Management of marshlands and livelihood opportunities in Kinawataka marshland, Kampala-Uganda” revealed that between 1992 and the time of the study, Kinawataka marshland experienced a significant degradation, with its degradation level rising from 49% to 95%, indicating a substantial loss in marshland quality and function. Specifically, 84% of households who were dependent on marshland fish as their primary source of protein, lost their food security and income generation.

A study by Assefa, W. W., Eneyew, B. G., & Wondie, A. (2021). on “The impacts of land-use and land-cover change on marshland ecosystem service values in peri-urban and urban area of Bahir Dar City, Upper Blue Nile Basin, Northwestern Ethiopia” has revealed that between 1984 and 2019, marshlands in Bahir Dar City shrank by over 75%, primarily due to rapid urban expansion. This led to a significant drop in marshland ecosystem service values—from USD 29.73 million to USD 20.84 million—affecting crucial services like water regulation, waste treatment, and biodiversity support. The authors recommend integrated land-use planning and marshland restoration to sustain these services amidst urban growth.

Kiran Rajashekariah, Nilanjan Ghosh, G. Areendran, Suresh Babu (2015). studied “Valuation of ecosystem services of Kunigal lake in Tumkur District, Karnataka” and concluded that the Lake provides significant economic value through various ecosystem services, with a total value of 1030.45 million INR. The ecosystem services provided by the lake are 24% higher than the average incomes of the households, indicating a high level of dependence on the lake.

3. Study Area Profile

- **Location and extent of Pallikaranai marshland**

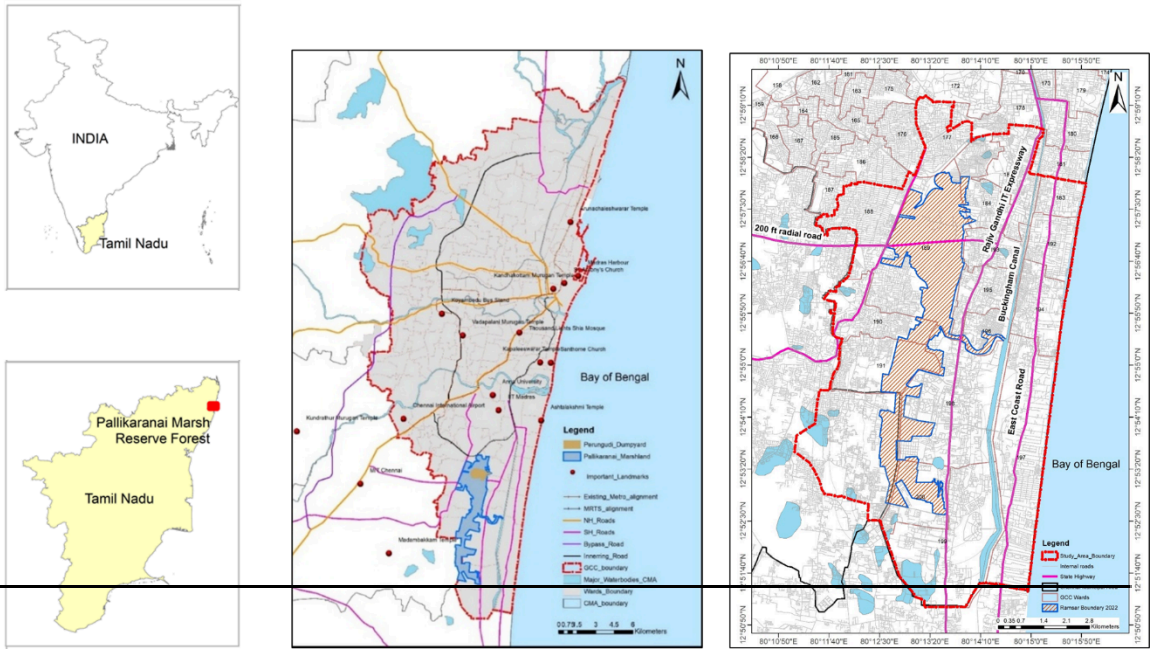


*Figure SEQ Figure * ARABIC 1 Location of Pallikaranai Marshland*

Pallikaranai Marshland is located in the southern part of Chennai, Tamil Nadu, between Velachery, Pallikaranai, Perungudi, and Thoraipakkam. It lies between 12°56′N and 13°01′N latitude and 80°13′E and 80°18′E longitude, within the Chennai Metropolitan Area. The marsh originally spanned an area of about 5,500 hectares, but due to rapid urbanization, its extent has now reduced to approximately 650 hectares. It is one of the last remaining natural marshlands in the city and serves as a critical drainage basin for the southern suburbs. The marsh is part of the larger Adyar River floodplain system and plays a vital role in flood mitigation, groundwater recharge, and biodiversity support.

- **Ecological Significance and Biodiversity**

The Pallikaranai marshland is classified as a freshwater swamp ecosystem situated within the Coromandel coastal plain, serving as a critical ecological buffer in an increasingly urbanized environment. Pallikaranai plays a crucial role in maintaining the hydrological balance by storing seasonal floodwaters, recharging aquifers, and regulating the local microclimate.

A part of it designated as a Reserved Forest in 2007, the marshland supports a diverse array of species and is recognized as a biodiversity hotspot within Tamil Nadu. According to studies by the Tamil Nadu Forest Department and independent ecologists, Pallikaranai is home to over 350 species, including plants, birds, fish, reptiles, amphibians, and insects. The marsh supports around 114 species of birds, of which nearly 20 are migratory. Key avifauna include the Purple Swamphen, Glossy Ibis, Black-winged Stilt, and Pheasant-tailed Jacana, while threatened species like the Spot-billed Pelican and Marsh Harrier have also been recorded.

The marshland also provides a unique habitat for freshwater turtles, marsh frogs, and endemic aquatic vegetation such as Ipomoea aquatica and Typha angustata. Its location along migratory routes makes it an essential stopover for wintering birds traveling across South Asia.

Unfortunately, the marsh’s biodiversity is under threat due to habitat fragmentation, pollution from untreated sewage, and encroachments. Invasive species such as Prosopis juliflora and water hyacinth have also altered its ecological balance.

- **Urbanization and Anthropogenic Pressures**

Located within Chennai’s rapidly developing southern corridor, the marshland has been subjected to uncontrolled land use changes, infrastructure development, and pollution - all contributing to the fragmentation of its ecological functions. According to a 2020 report by the Tamil Nadu State Marshland Authority, over 50% of the

marshland area has been lost between 1970 and 2020, primarily due to urban sprawl and encroachments.

One of the most damaging anthropogenic pressures is the operation of the Perungudi dump yard, which occupies over 100 acres of the marsh's core area. It receives nearly 2,000 tonnes of solid waste daily, much of it untreated, releasing leachate into surrounding water bodies and reducing water quality. In addition, untreated domestic sewage and industrial effluents from neighbouring localities such as Velachery, Pallikaranai, and Perungudi flow directly into the marsh through stormwater drains and canals.

Road infrastructure, including the Velachery–Tambaram Road and portions of the Inner Ring Road, have further fragmented the marshland, disturbing wildlife corridors and altering natural drainage patterns. Encroachments by real estate projects, institutions, and residential colonies have drastically reduced the flood-holding capacity of the marsh.

The cumulative impact of these pressures is a loss in biodiversity, decline in groundwater recharge, increased flood risk, and disruption of key ecosystem services. Addressing these issues requires integrated urban-marshland planning, stricter enforcement of buffer regulations, and active community participation in restoration efforts.

- **Existing Land use and Governance issues**

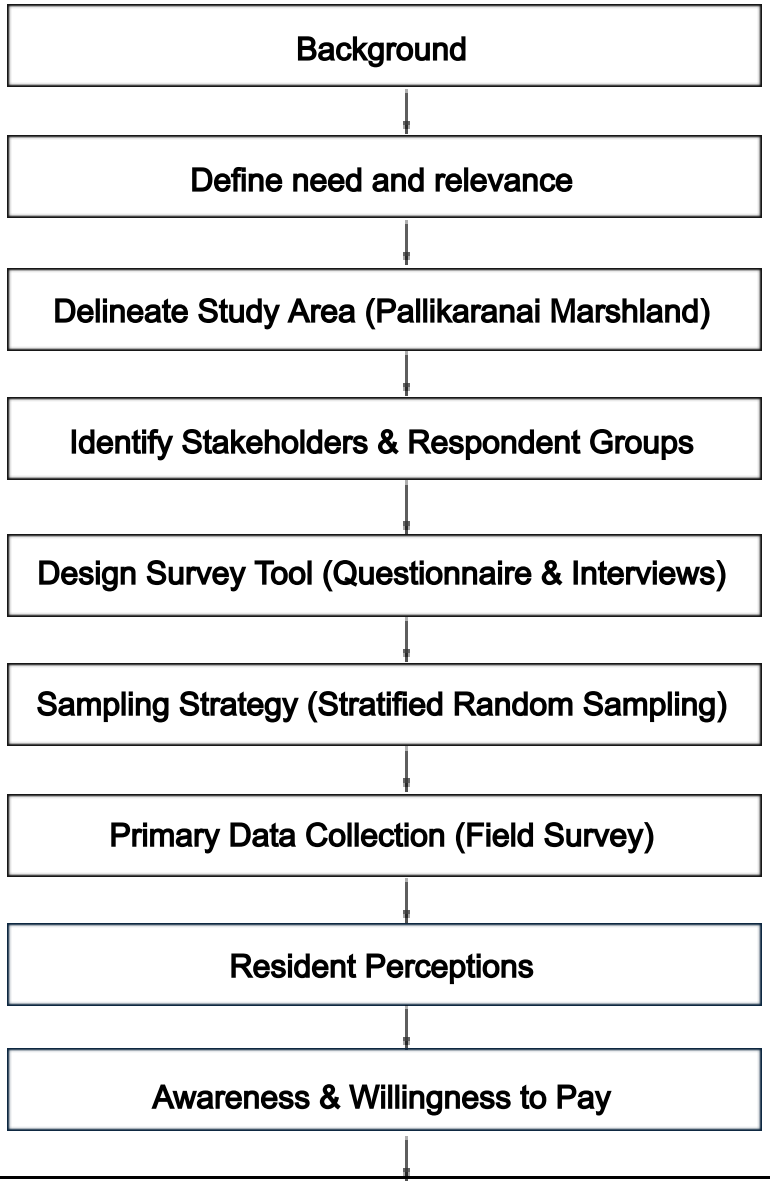
The land use pattern in and around the Pallikaranai Marshland reflects the classic conflict between ecological conservation and urban development. Despite being declared a Reserved Forest under the Tamil Nadu Forest Act in 2007, the marshland continues to face land conversion, encroachments, and incompatible developments. The marshland's core ecological zone is fragmented by a mix of land uses — including solid waste dumps, institutional buildings, road infrastructure, and informal settlements.

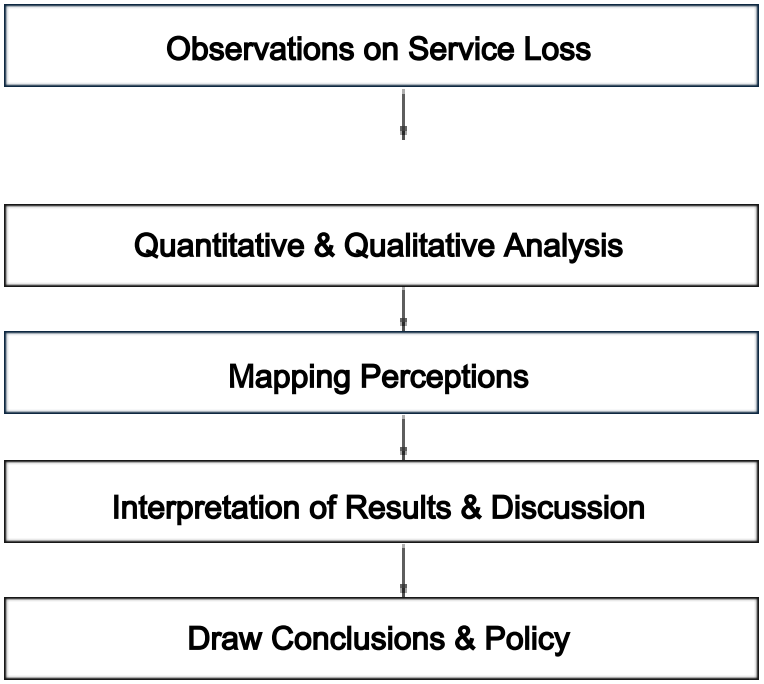
Large portions of the marsh have been occupied by state institutions such as the National Institute of Ocean Technology (NIOT), residential developments, Chennai Corporation facilities including the dump yard, and the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB). Additionally, unauthorized residential layouts have mushroomed along the periphery, especially in areas like Pallikaranai, Narayanapuram, and Velachery. The Perungudi dump yard, situated within the marsh, not only violates ecological norms but also occupies ecologically sensitive terrain meant for water storage and biodiversity conservation.

A major governance issue is the lack of coordinated authority for marshland management. While the Tamil Nadu Forest Department oversees the reserved forest portion, other parts fall under the jurisdiction of the Greater Chennai Corporation, CMDA, and multiple revenue departments resulting in fragmented and overlapping responsibilities. This fragmented governance has hindered unified restoration strategies, enforcement of buffer zone regulations, and eviction of encroachments.

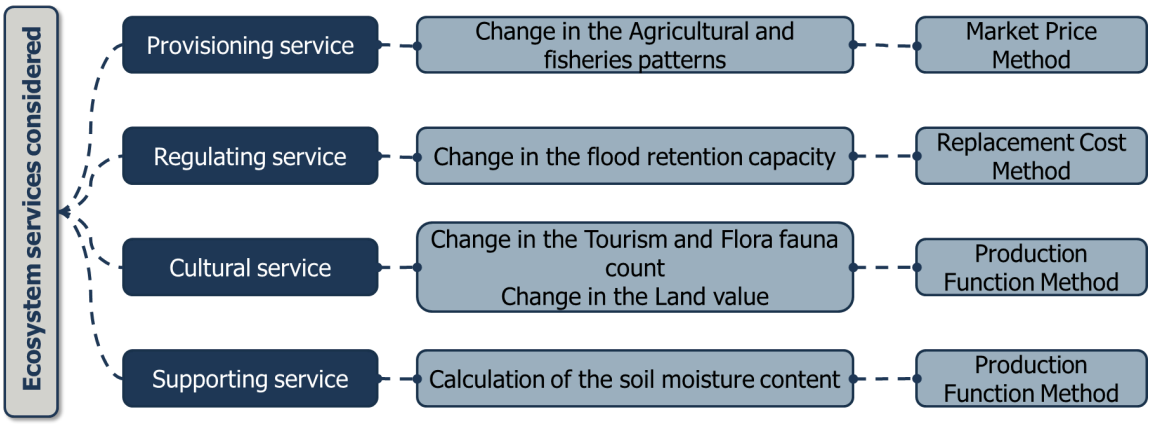
There is also inadequate implementation of environmental safeguards despite the marsh being identified as a priority marshland under the National Marshland Conservation Programme. Environmental Impact Assessments (EIAs) are either bypassed or diluted for nearby infrastructure projects. Although the Tamil Nadu State Marshland Authority has taken steps for mapping and restoration, actual on-ground enforcement remains weak.

4. Methodology





5. Assessment of Ecosystem Services



5.1 Provisioning Services

Provisioning services refer to the tangible goods and resources that ecosystems provide to people. In the case of the Pallikaranai Marshland, agriculture and fishing have historically been the primary provisioning services supporting the livelihoods of surrounding communities. Although these services have declined over the past two decades due to rapid urbanization, traces of their socio-economic importance still remain.

The marshland has traditionally contributed to agricultural productivity in adjacent areas by maintaining sub-surface water tables and enriching soil fertility. During the monsoon season, floodwaters from the marsh bring in nutrient-rich sediments that naturally fertilize the surrounding low-lying lands. Farmers in areas like Narayanapuram, Pallikaranai village, and Medavakkam have practiced seasonal

cultivation of paddy, medicinal plants, fodder grass, vegetables and other crops. The marsh also supports the growth of aquatic plants such as *Typha* and *Cyperus*, which are occasionally harvested for use as cattle fodder and traditional roofing materials.

Local residents engage in subsistence fishing using traditional techniques, catching species such as *Channa striata* (murrel), *Catla*, and small indigenous carps. These fish are used mainly for household consumption, though occasional surplus is sold in informal markets within nearby neighborhoods. For marginalized communities, especially those without formal employment, the marsh acts as a seasonal safety net.

The sharp decline in water quality, encroachments, and solid waste dumping have led to a reduction in fish diversity and water availability for agriculture.

Change in the agricultural pattern over years

2008				
Cereals	**Production (in kgs)**	**Area (in hectares)**	**Price (per kg)**	**Estimated Market price (in Rs) per year**
Kar /Kuruvai	38000	29.365	140	156221800
Samba / Thaladi	27000	32.698	260	229539960
Navarai /Kodai	35000	28.214	220	217247800
Paddy	16000	22.467	32	11503104
Black gram	15000	19.754	80	23704800

2024				
Cereals	Production (in kgs)	Area (in hectares)	Price (per kg)	Estimated Market price (in Rs) per year
Kar /Kuruvai	15000	16.656	150	37474875
Samba / Thaladi	12000	7.888	220	20824320
Navarai /Kodai	18000	15.150	180	49085352
Paddy	8000	6.727	35	1883532

Black gram	6000	8.828	64	3389875.2

Estimated Market Price = Total production (in kgs) x Minimum Selling Price/kg (INR)

Ecosystem service Loss (2008 – 2024) : 74,26,39,669 INR

Change in the fisheries pattern over years

Fish variety	2008		
	Production (in kgs)	Minimum selling price (per kg)	Total revenue generated
Panchax	12,500	390	4875000
Mosquito fish	8700	410	3567000
Tilapia	9800	280	2744000
Giant African Catfish	7600	110	836000
Armored Catfish	10200	150	1530000
Black-line Rasbora	9300	300	2790000
Orange Chromide	8400	190	1596000
Spot-fin Barb	11200	480	5376000
Flying Barb	9500	230	2185000
Common Carplet	8800	210	1848000
	96000	Total revenue generated	27347000

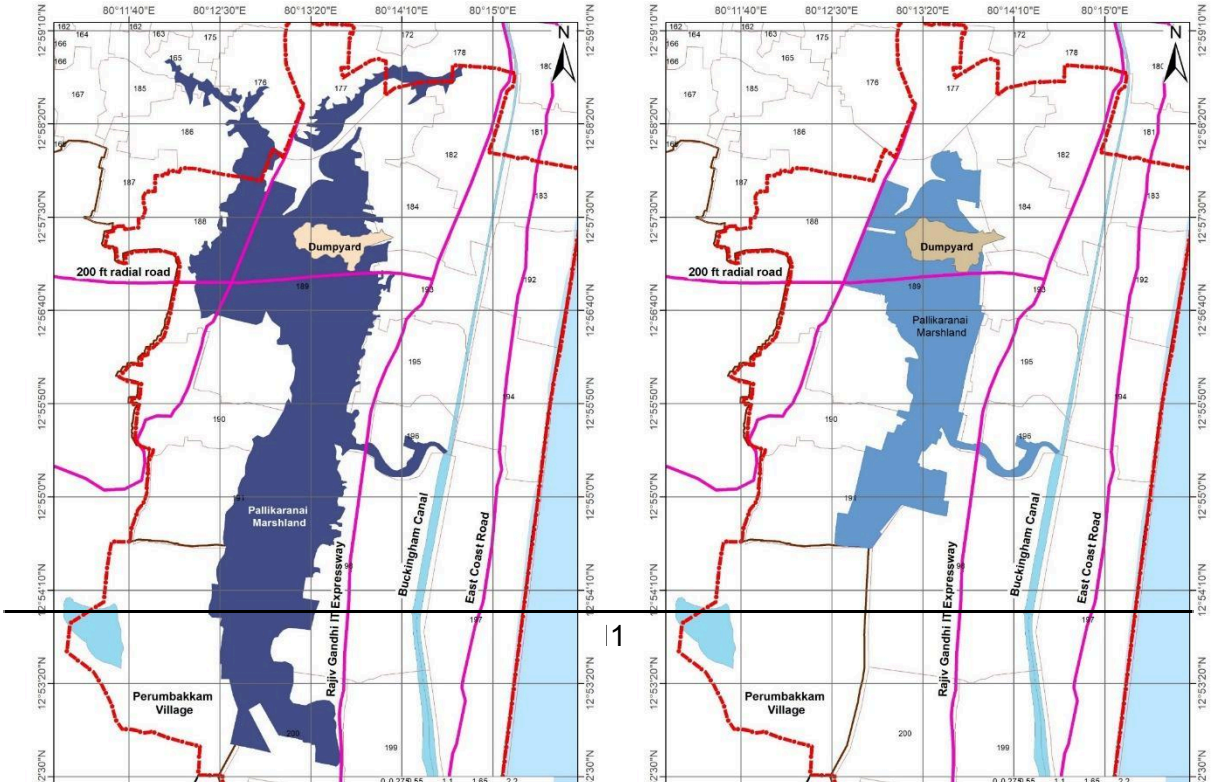
Fish variety	2024		
	Production (in kgs)	Minimum selling price (per kg)	Total revenue generated

Panchax	1800	360	648000
Mosquito fish	1200	390	468000
Tilapia	1600	225	360000
Giant African Catfish	1400	75	105000
Armored Catfish	1700	150	255000
Black-line Rasbora	1300	240	312000
Orange Chromide	1500	120	180000
Spot-fin Barb	1200	270	324000
Flying Barb	1900	180	342000
Common Carplet	1400	175	245000
	15000	**Total revenue generated**	**3239000**

Estimated Market Price = Total production (in kgs) x Minimum Selling Price/kg (INR)

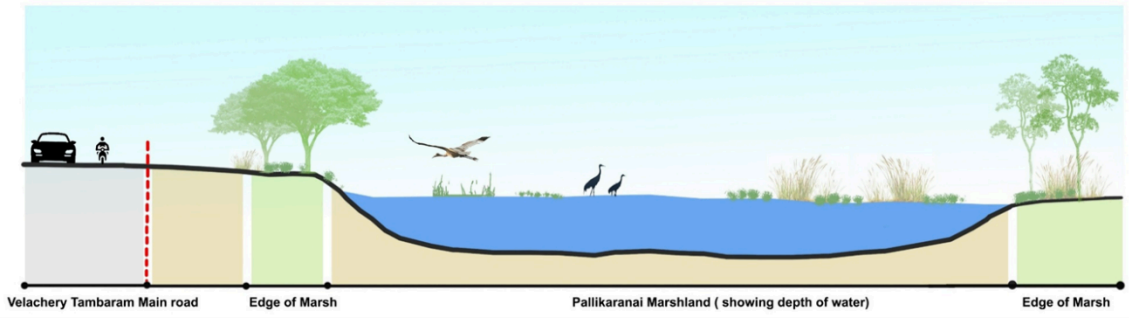
Ecosystem service Loss (2008 – 2024) : 2,41,08,000 INR

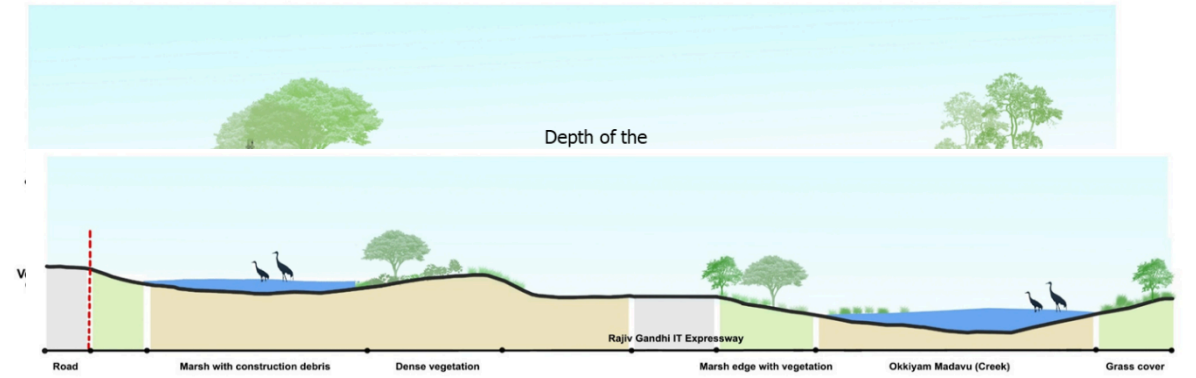
5.2 Regulating Services

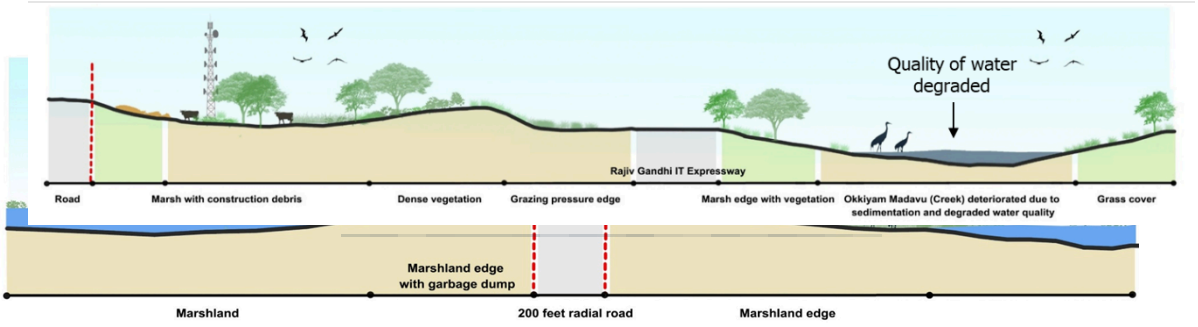


Year	Area of Pallikaranai Marshland (Sq.m)			Area of Perungudi Dumpyard (In Sq. km)	Change in area (In Sq.km & %)
	Unchanged area	Erosion	Accretion		
2001 - 2008	8071006.05	10001952.66	9153.80	0.588	-
2008 - 2015	5116861.43	2963298.43	119635.92	0.784	0.196 (+33.3 %)
2001 - 2015	5234950.87	12838007.84	1546.48	0.964	.18 (+22.9 %)

Cross sections of the marshland







One of the most critical regulating services provided by the Pallikaranai Marshland is its natural ability to store excess rainwater and mitigate urban flooding. Strategically located in a low-lying basin, the

*Figure SEQ Figure * ARABIC 6 Extent of the marsh - 2015*

*Figure SEQ Figure * ARABIC 5 Change in the area of the marsh*

marsh acts as a sponge during the monsoon season, absorbing runoff from adjoining areas such as Velachery, Medavakkam, Perungudi, and Pallikaranai.

However, over the past two decades, the flood-holding capacity of the marshland has drastically declined. Satellite data and land use studies reveal that more than 50% of the original marshland area has been lost due to encroachments, road networks (such as the Velachery–Tambaram Road), institutional developments, and the establishment of the Perungudi solid waste dump yard. In the 1980s, the marsh extended across nearly 5,000 hectares; today, only around 1,200 hectares remain under partial protection.

The shrinkage has had direct implications for urban flood vulnerability. Events such as the 2015 Chennai floods highlighted the consequences of marshland loss, where blocked natural drainage led to widespread inundation in adjacent residential areas. Stormwater that would have previously been absorbed by the marsh now overwhelms urban infrastructure, causing repeated flooding even during moderate rainfall.

In addition, the accumulation of solid waste and sewage inflows has reduced the marshland's infiltration capacity, further limiting groundwater recharge. Studies by agencies such as the Centre for Climate Change and Adaptation Research (Anna University) confirm that the marshland's hydrological function has been severely impaired.

Type	Area (Sq.m)	Rainfall intensity (m/hr)	Total Rainfall recharge	Extractable quantity (20% of recharge)
Pallikaranai marsh	80,80,159.85	0.022	1,77,763.516	35,552.703

Type	Area (Sq.m)	Rainfall intensity (m/hr)	Total Rainfall recharge	Extractable quantity (20% of recharge)
Pallikaranai marsh	5236497.346	0.022	115202.9416	23040.588

LULC Type	Area (Sq.m)	Rainfall intensity (m/hr)	Runoff coefficient (C)	Q (Cu.m / hr)= C*I*A
Water body	15047041	0.022	0	0
Vegetation	12097079	0.022	0.25	66533.9345

Builtup	38597230	0.022	0.9	764225.154
Barren land	18122253	0.022	0.2	79737.9132
			Total runoff	**910497.0017**
		Total annual rainfall (Cu.m)		**117553744**

Total Annual Recharge =
Total rainfall - Runoff from different LULC - ET)

=

104048.203 ML

LULC Type	Area (Sq.m)	Rainfall intensity (m/hr)	Runoff coefficient (C)	Q (Cu.m / hr)= C*I*A
Water body	11958389	0.022	0	0
Vegetation	8258428.600	0.022	0.25	45421.3573
Builtup	41209031	0.022	0.9	815938.8138
Barren land	22320099	0.022	0.2	98208.4356
Capacity		13091243.36	**Total runoff**	**959568.6067**
		Total annual rainfall (Cu.m)		**100760352**

Total Annual Recharge =
Total rainfall - Runoff from different LULC - ET)

=

87205.739 ML

Change in Total runoff (2008 – 2024) : 49071.605 ML

Change in Annual recharge (2008 – 2024) : 16842.463 ML

5.3 Cultural or aesthetic Services

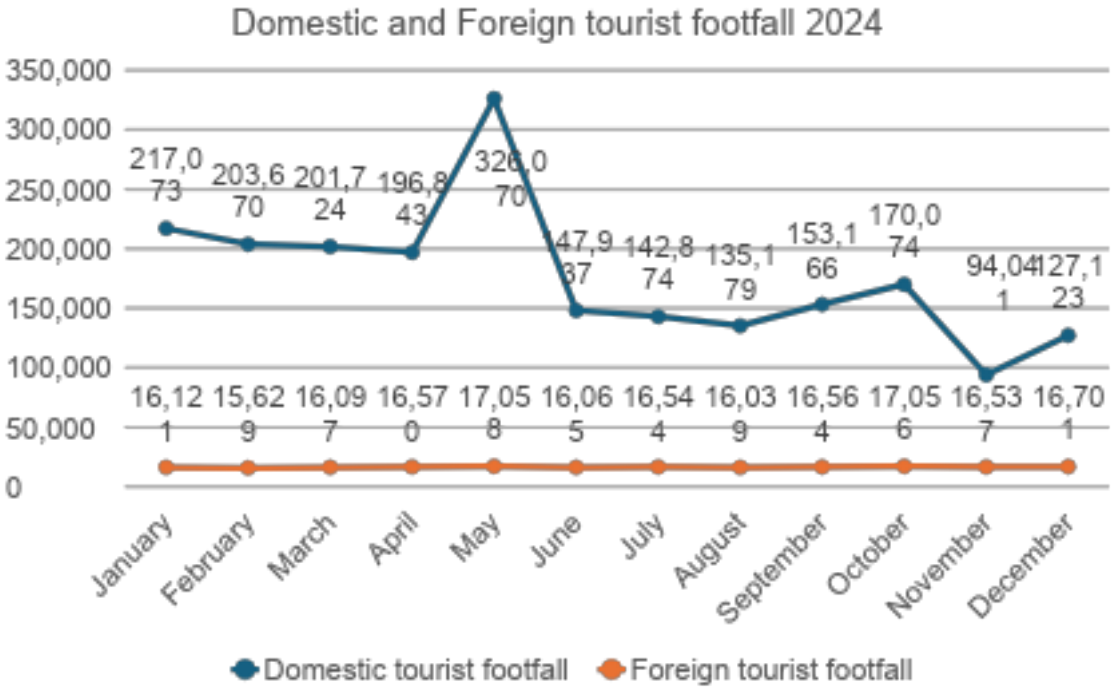
Pallikaranai Marshland, though situated within Chennai's urban fabric, holds significant ecotourism potential due to its rich biodiversity. The marshland is home to over 300 species of flora and fauna, including over 115 species of birds, many of which are migratory, such as the Glossy Ibis, Purple Heron, and Greater Flamingo.

This makes the marsh a popular bird-watching spot, particularly during the migratory season between November and March.

Over the past two decades, Pallikaranai Marshland has gradually gained attention as a niche destination for eco-tourism and nature-based recreation within the city of Chennai. In the early 2000s, the marsh was relatively unknown to the public, primarily frequented by bird watchers and local environmentalists due to its rich avian diversity. However, with increasing reports highlighting its role as a habitat for rare and migratory birds, awareness steadily grew.

By the mid-2010s, the Tamil Nadu Forest Department initiated steps to enhance the marsh's visibility through the development of the Pallikaranai Eco Park near Velachery. Walkways, signage, and observation decks were introduced to attract urban visitors and students. Organized birding trails and biodiversity awareness programs became occasional features, especially during peak migratory seasons.

Despite these efforts, the number of visitors has not significantly increased in recent years, largely due to the marsh's deteriorating condition—including solid waste pollution, sewage inflow, and reduced bird sightings. Local bird count data and surveys show a notable decline in migratory species post-2018, which directly impacted the site's tourism value.



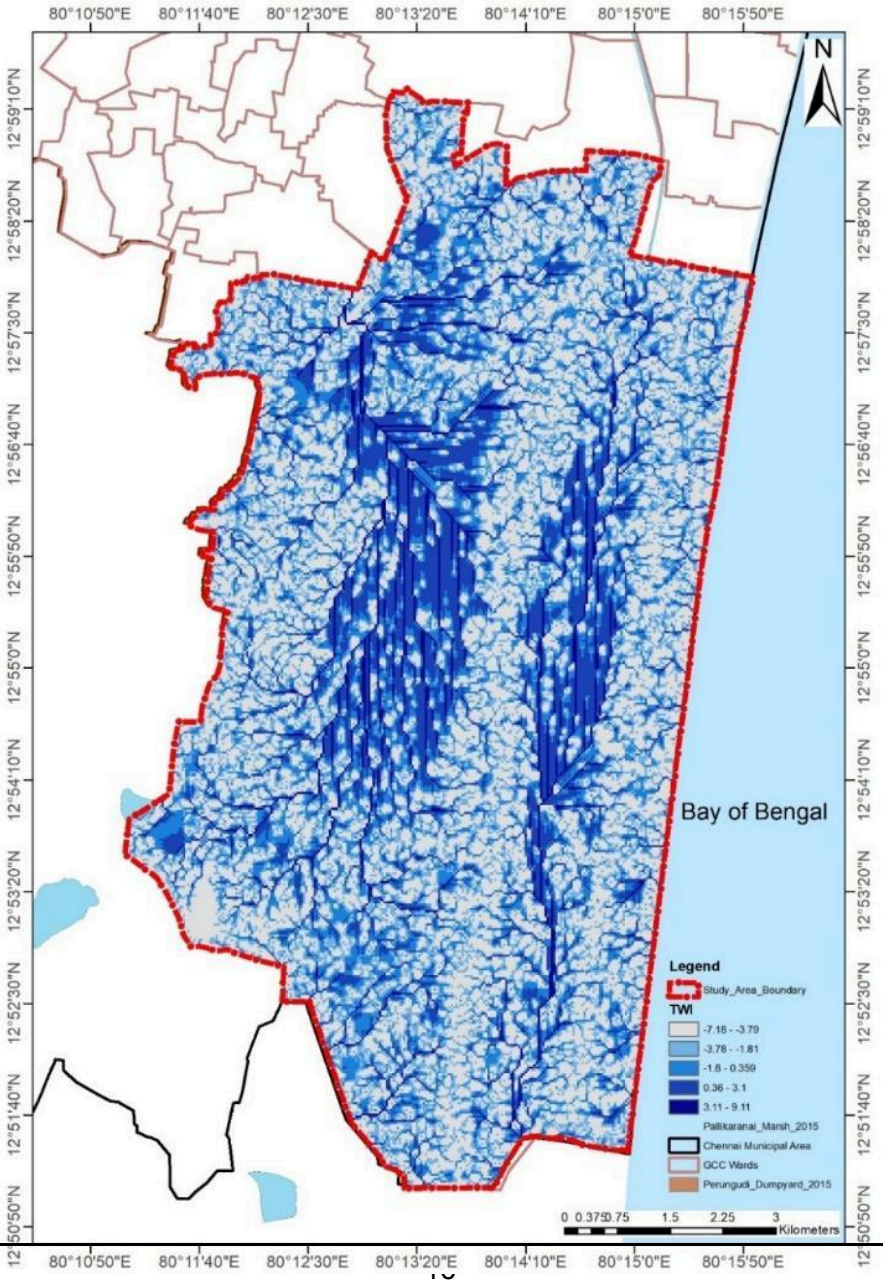
5.4 Supporting Services

In Pallikaranai Marshland, Topographical Wetness Index (TWI) acts as a supporting ecosystem service by influencing nutrient cycling, soil formation, and the maintenance of marshland habitats, which are vital for sustaining the marsh's ecological balance. Historically, Pallikaranai's flat topography and natural drainage

ensured high wetness levels, which supported a wide range of marshland flora, benthic organisms, and avifauna.

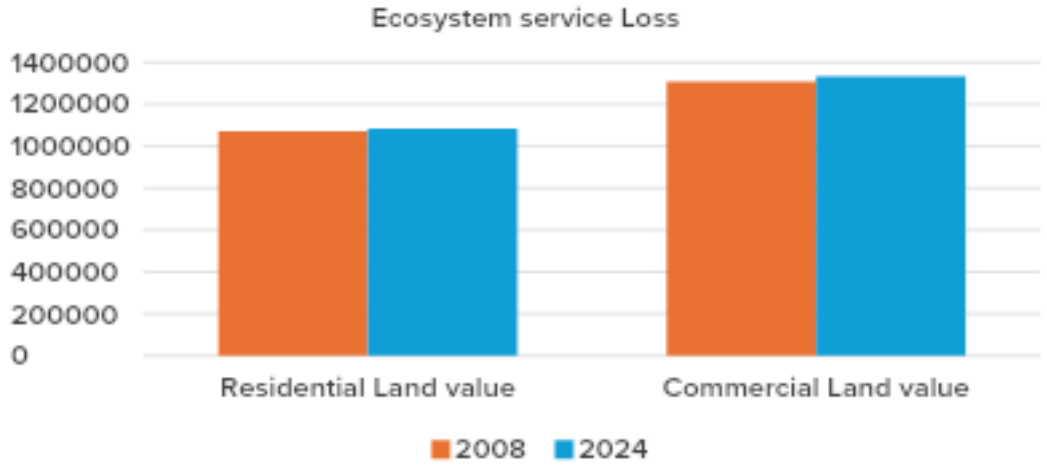
Over the past two decades, the Topographic Wetness Index (TWI) values in Pallikaranai Marshland have shown a declining trend, indicating a reduction in the marshland's natural capacity to retain and accumulate surface water.

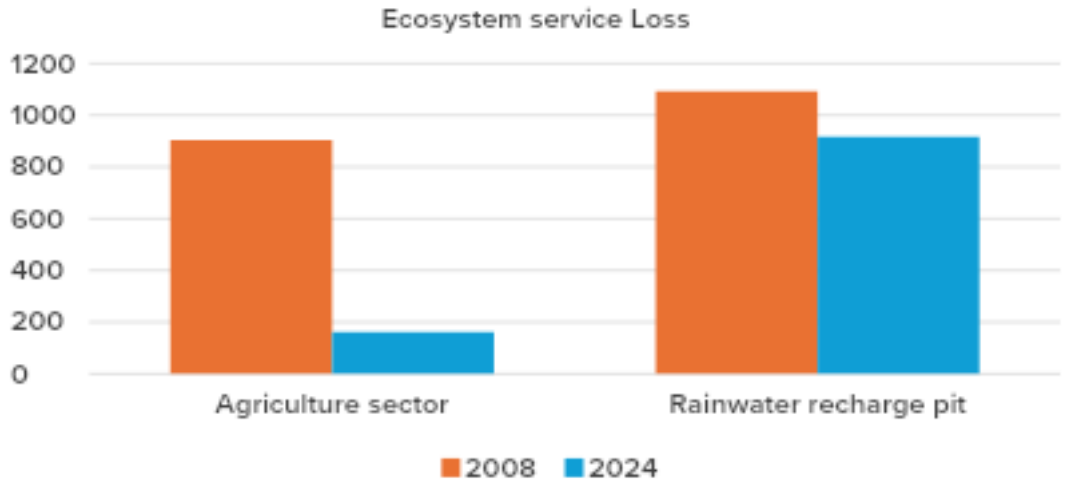
In the early 2000s, TWI values across the marsh were relatively high due to its undisturbed flat terrain and natural drainage connectivity, supporting a wide distribution of water-logged areas. However, with increasing urban encroachment, solid waste dumping (notably the Perungudi dump yard), road construction (e.g., Velachery–Tambaram Road), and canal blockages, the natural water flow has been disrupted. This has led to a localized drying of marshland patches, fragmentation of hydrological pathways, and an overall decline in saturated zones — reflected in lower TWI values across many parts of the marsh.



5.5 Summary of Ecosystem Service Loss

An estimation of the ecosystem service loss in the Pallikaranai Marshland from 2008 to 2024 reveals a significant decline in both tangible and intangible benefits. The cumulative loss, when accounting for provisioning, regulating, supporting, and cultural services, is approximately ₹187.072 crores which is the unrealized potential of the marshland. Provisioning services, such as agriculture and fisheries, have witnessed substantial degradation, with agricultural losses amounting to ₹74.26 crores and fisheries-related losses estimated at ₹2.41 crores. The degradation of regulating services is reflected in the construction cost of artificial rainwater recharge pits, calculated at ₹106.22 crores, highlighting the economic burden of replacing natural hydrological functions.





Additionally, cultural ecosystem services have suffered, with tourism-related losses estimated at ₹4.17 crores. This analysis underscores the critical economic implications of ecosystem degradation and emphasizes the urgent need for conservation and restoration strategies in rapidly urbanising wetland regions like Pallikaranai.

6. Key Findings and Discussion

The total estimated ecosystem loss of around ₹164 crores highlights the significant impact of ecological degradation on human well-being and environmental sustainability. This loss encompasses a wide range of ecosystem services, each contributing differently to the overall value. Regulating services, such as flood control, water purification, and climate regulation, account for the largest share, reflecting their crucial role in maintaining ecological balance and protecting communities from environmental risks. Provisioning services, including freshwater supply, food, fuelwood, and medicinal resources, form the second-largest component, underscoring their importance for local livelihoods and resource security. Cultural services, offering recreational, spiritual, and aesthetic benefits, also face degradation, impacting community identity and well-being. This monetary estimate reinforces the urgency of preserving and restoring ecosystems to ensure the continued flow of vital services for both present and future generations.

7. Conclusion

- **Significance of preserving Pallikaranai marshland**

Over the years, the degradation of the Pallikaranai Marsh has led to a substantial decline in the ecosystem services it once consistently provided. The regulating services, especially flood mitigation and water purification, have been severely impacted, increasing the vulnerability of surrounding areas to seasonal flooding and water quality issues. The loss of provisioning services such as food crops, medicinal plants, and freshwater has affected both ecological productivity and the livelihoods of communities that once depended on them. Supporting services like biodiversity conservation and soil wetness index have also diminished, disrupting ecological balance and species habitats. Cultural services, including recreational and educational values, have seen a gradual erosion, disconnecting people from the marsh’s ecological and cultural identity. The cumulative economic loss of these services is estimated at nearly ₹164 crores, emphasizing the long-term costs of neglect and unsustainable development. This valuation reaffirms the critical need for restoration and policy measures aimed at safeguarding the marsh's remaining ecological functions.

- **Scope for future research**

Future research on the Pallikaranai Marsh can focus on quantifying the dynamic changes in ecosystem services over time using geospatial analysis and ecological modelling to assess the impact of urban expansion. Detailed valuation studies that incorporate intangible cultural and spiritual services could provide a more holistic understanding of the marsh's total value. Longitudinal studies on biodiversity loss and its cascading effects on ecosystem stability would offer critical insights for conservation planning. Additionally, exploring the socio-economic dimensions—such as the willingness of local communities to engage in conservation efforts or contribute to ecosystem restoration through payment for ecosystem services (PES) models—can guide participatory management frameworks. Research into nature-based solutions tailored to marshland restoration, climate resilience, and flood management within the Pallikaranai region could also inform future urban ecological planning and policy-making.

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