The Nature Conservancy India

Care Earth Trust
Biodiversity. People. Conservation

An Integrated Approach for Urban Wetland Restoration – A Case Study of Sembakkam Lake, Chennai, Tamil Nadu, India

PRELIMINARY REPORT

Acknowledgement

We sincerely appreciate the support of the Tamil Nadu Water Resource Department, Chengalpet District Collectorate, Tambaram Corporation, Tamil Nadu Pollution Control Board, Tamil Nadu Department of Environment Forest and Climate Change and especially the local community for their continuous support and participation in the lake restoration process. We are also thankful to all the donors who made this effort possible.

Contents

1. Introduction

நீரின்றி அமையாது உலகு – திருவள்ளுவர்

The world cannot exist without water – *Thiruvalluvar*

This famous couplet by Indian poet Thiruvalluvar reinstates the importance of water for the existence of life on Earth. The same was stressed more than a thousand years ago by our ancestors. However, with the rise of industrialisation and urbanisation over the last century, humans have created irreversible changes to landscapes and contributed to greenhouse gas emissions affecting the global climate. It is to be noted that over 40% of the world's land area has been converted to urban or agricultural land. Currently only 13% of the oceans and 23% of inland areas remain as 'wilderness area' with no human impact and such places exist in remote areas such as in tundra biomes, ocean gyres[1]. This explains the expanse of human impact that has spread far and wide resulting in climate change and vulnerability.

Wetlands, as with other natural resources such as land and forests have been degraded in recent years. The global wetland extent trend index shows 87% decline in the extent of natural wetlands between 1700 to 2000 across the world. Further, observation on extent of permanent water cover between 1980s and 2015 shows a decrease of 13% for natural wetlands, while about 16% increase was noted for man-made reservoirs. The trend indicates that human developmental impacts have shrunk the natural wetlands, while on the other hand have pushed their dependency on man-made wetlands[2,3], which hardly fares co-existing in an urban environment. With depletion of water resources and increasing effects of climate change, it is estimated that about half a billion people experience severe water scarcity all year round, and

by 2050, an estimated one in four people is projected to live in a condition with recurring and long-term shortages of fresh water[4].

To address this situation caused by the rapid urbanisation and climate change, United Nations Sustainable Development Goals (SDGs) - especially SDG 11 (Sustainable Cities and Communities), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action) and SDG 14 (Life Below Water) - focus on global communities and measure to conserve natural resources to build resilience against climate change[5]. India had encompassed these goals in its National Mission on Sustainable Habitat (NMSH) under the National Action Plan on Climate Change (NAPCC) in 2008 and has formulated various plans and schemes to effect implementation at national and sub-national levels. Under the NMSH, India has launched programs to cover 60% of the country's population concentrated in urban areas. The program is aimed at influencing planned urban transformation and encompasses the conservation of nature as one of its main pillar and use of SMART technologies for efficient energy consumption and minimising environmental footprint[6]. At the 26th Conference of Parties (COP26) of the United Nations Framework for Climate Change Convention (UNFCCC) held in Glasgow last year, India flagged off a mass movement for adoption of *LiFE – Lifestyle for Environment* that advocates mindful and deliberate utilisation of resources to protect and preserve the environment[7]. Several national and subnational initiatives have been a part of this movement with active participation from local governments and communities.

Planned urban development with integration of blue-green infrastructure has been an important component under the national initiatives like the Smart Cities, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Heritage City Development and Augmentation Yojana (HRIDAY). Initiatives like the Green Tamil Nadu Mission and the State Wetland Mission launched by the Tamil Nadu state government encourages increasing green cover and wetlands protection, which are highly beneficial in an urban context where natural landscapes are disturbed anthropogenic pressures.

The topic of urban blue-green infrastructure is continuously featuring in international, national and subnational policies, making it highly relevant to develop evidence-based solutions for implementation of climate actions and realising successful outcomes[8].

In view of the above, The Nature Conservancy-India's project titled 'Eco-restoration of Sembakkam Lake', an urban wetland is presented as a case study for ecosystem-based adaption measures. The project utilises scientific, economical and participatory approach for tangible outcomes and restoring the 100-acre Sembakkam Lake. This report presents the details of the ongoing work and its achievements so far with an aim to disseminate best practices for wetland restoration across India and beyond.

2. Wetland Conservation

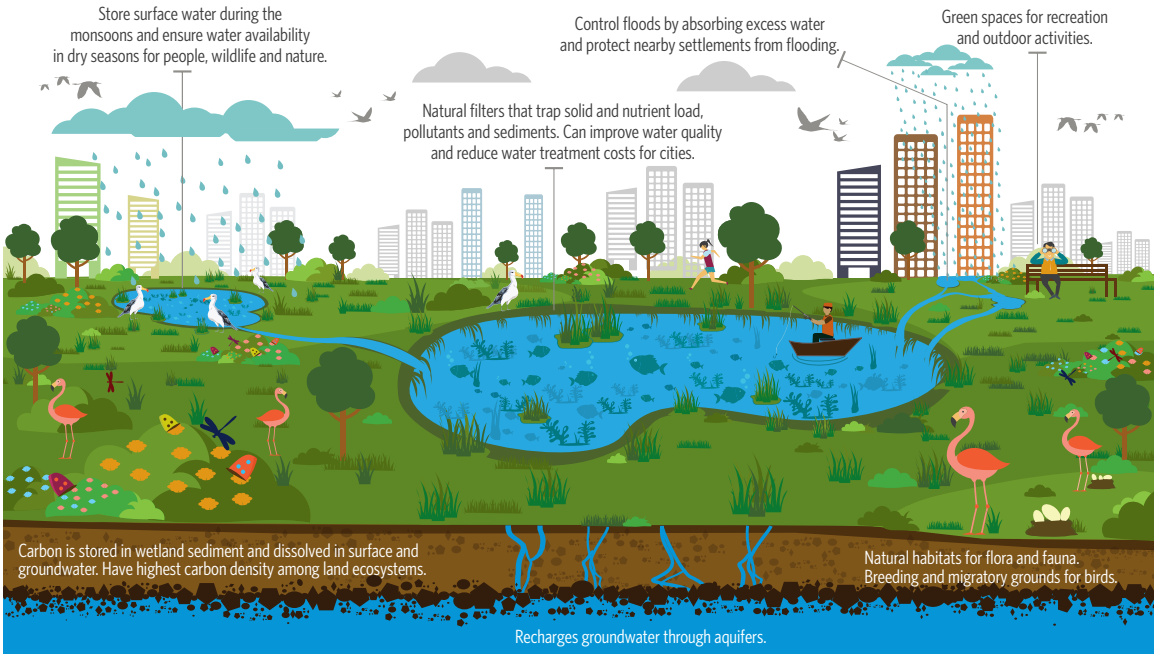
Urban wetlands are facing mounting pressures due to developmental activities that have resulted in its negligence and mismanagement. The wetlands are thus impacted by alteration of natural hydrology, resultant change in land use, dumping of both liquid and solid wastes eventually leading up to its loss and disappearance. With change in land use and impacts on ecosystem, a small fraction of invasive floral and faunal species gain dominance displacing the natives and in worse cases, the endemic species.

Wetlands act as a green infrastructure and its protection offers multifarious ecosystem benefits to humans and biodiversity. They help in maintaining hydrological balance in a region, offer resilience against floods and drought by storing water, enable ground water recharge, mitigate heat island effects and are home to a wide range of aquatic flora and fauna[9,10].

Chennai, the capital city of Tamil Nadu is the fourth populous metropolis in India. Being a coastal city with a flat topography, where smooth drainage is challenging, the city is highly prone to cyclonic floods[11]. Alternatively, absence of perennial water supply and the city's entire dependency on monsoons and erratic rains expose it to droughts. Conservation of wetlands thus becomes inevitable for the city to mitigate effects of extreme climatic events for its 10 million population, while securing native flora and fauna habitats.

The Wonder Of Wetlands

A wetland is any land area that has the ability to hold surface water and support aquatic flora and fauna. In urban spaces, wetlands occur in the form of lakes, ponds, marshlands and swamps.



The Government of India has notified Wetland (Conservation and Management) Rules 2017 which gives powers to the states for decentralised management of wetlands, allowing its wise use in accordance with its principles of conservation and management of wetlands[12]. Actions of protection and conservation of wetlands are gaining attention across Chennai, where the state government has demonstrated leadership in restoring and rejuvenating these precious ecosystems. Under the State Wetland Management Authority, works are underway to identify wetlands across the state that need to be conserved and rejuvenated. The Pallikaranai Marshland is one of the last remaining natural wetland of the city. It is also, declared as a Ramsar Site recently in July 2022. In Chennai, the Water Resource Department, Chennai Metropolitan Water Supply and Sewerage Board, Chennai River Restoration Trust, Commissionerate of Revenue Administration and Disaster Management, Environment and Forest Department are the other line departments that work on water management in the city, managing water storage, supply, drainage, flood mitigation and environmental protection. Further, the Greater Corporation of Chennai along with the Smart Cites Mission of Chennai has identified nearly 200 water bodies, out of which restoration work is completed for more than 100 of them. There are also several NGOs along with corporate companies who have joined hands for water restoration efforts and action on the ground.

Keeping the momentum going, The Nature Conservancy (TNC) India along with Indian Institute of Technology - Madras (IIT-M), and Care Earth Trust (CET) have come up with an ecosystem-based restoration approach for wetland rejuvenation.

Further, subject matter experts from FINISH consortia comprising FINISH Society, Indian Leather Institute Foundation (ILIFO), and The Solutions Centre (TSC), and Oasis designs and Madras Terrace Architects were engaged in developing eco-friendly solutions for pollution treatment, and creating a community space around the Sembakkam Lake.

Additionally, TNC India's platform partner Chennai Resilience Centre had greatly supported throughout the restoration process.

The project approach envisioned a holistic approach to address the cause and effects of the deterioration of urban wetlands and working towards its long-term sustainability.

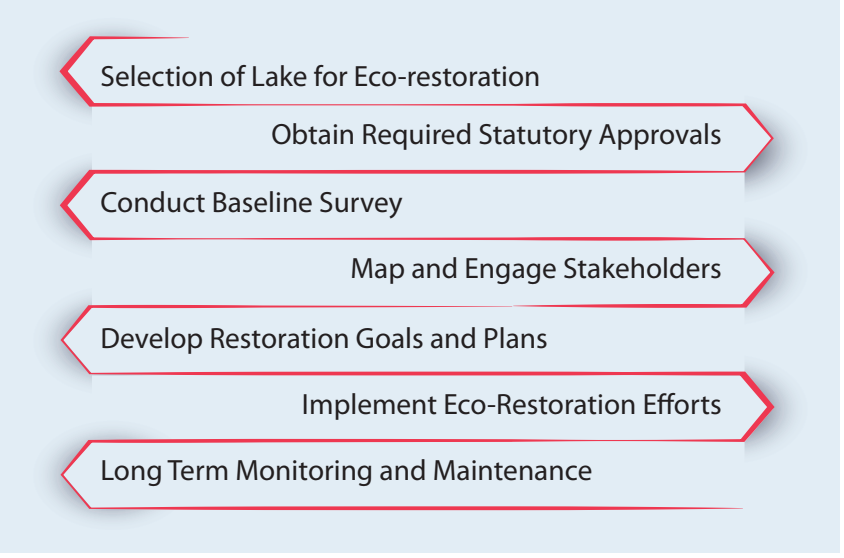
The Sembakkam Lake in the Pallikaranai watershed basin is a typical representation of a wetland impacted by the effects of urbanisation, but still supporting rich and native biodiversity, reflecting the connectivity to the Nanmangalam Reserve Forest and the Pallikaranai Marshland.

The approach, challenges and outcomes of the project are documented in this report for the purposes of disseminating the learnings to scale similar efforts across Indian cities and beyond. The ultimate objective is scale and implement the learnings to catalyse use of ecosystem-based approaches for the restoration of wetlands, while also scaling the biodiversity conservation agenda for a city to be healthy.

3. Project Description

The project on eco-restoration of an urban wetland involved a comprehensive approach from conducting a reconnaissance survey for the choice of the urban wetland for restoration, obtaining requisite permissions from concerned government authorities to developing and implementing an eco-restoration plan for tangible outcomes. The method included adaptive management which resulted in tailor-made solutions based on the wetland conditions and allowed flexibility to manage unanticipated events during execution.

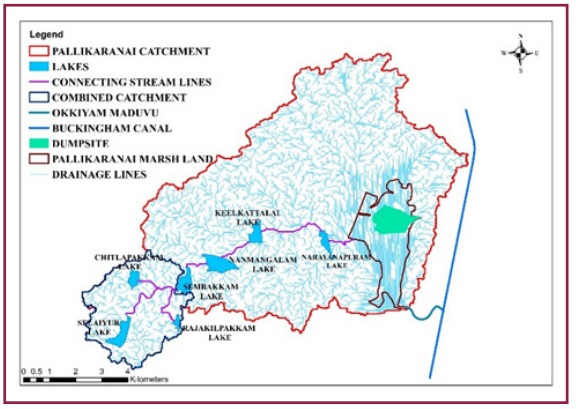
This section briefly gives an overview of the various steps involved in the eco-restoration project.



3.1 Selection of Lake for the Eco-restoration Project

Sembakkam Lake, a peri-urban lake in Chennai was chosen for the eco-restoration project based on a reconnaissance survey and preliminary interactions with the neighbouring community and respective stakeholders. The following criteria were evaluated to determine the importance of the selected wetland restoration.

i. **Existing hydrological linkage in a watershed basin:** The Sembakkam Lake, aka Hastinapuram Lake is a manmade wetland forming a part of 34 network of wetlands connected through the cascading system of 7 lakes to the Pallikaranai Marshland (PML), one of the last remaining natural wetlands in the city. The PML currently extending over 694 hectares is under a 'Protected Status' as notified by the Government of India for its unique combination of both inland and brackish water ecosystems that serves as a home to large number of native species and migratory birds. The hydrological linkage of the Sembakkam Lake to PML through a cascading set of wetlands made a strong case for its protection. Moreover, the benefits of Sembakkam Lake restoration will influence the health of the connecting lake systems and finally the ecosystem habitat of PML in the watershed basin.



Pallikaranai Watershed Map showing cascading system of lakes connected to Sembakkam Lake

ii. **Potential for improving biodiversity habitat, revival of native biodiversity and conservation of endemic species:** The Sembakkam Lake with perennial storage of water serves as a home to a large number of birds both residential and migratory with a high potential of improvement as a biodiversity habitat. Some of the residential birds observed were Egrets, Cormorants, Herons, Painted Storks and the migratory species were Common Sandpiper, Barn Swallow etc. Some of the 'Near Threatened' birds found in the wetland include Oriental Darter, Spot-billed Pelican and River Tern. The Indian Black Turtle which is a near endangered species and the Fan Throated Lizard which is endemic to the Indian East coast were also present in the lake. Further, the lake also managed to sustain remnants of the region's native plants such as the Brahmi (Water Hyssop), Thootuvalai (Purple Fruited Pea Egg Plant), Keezhanelli (Gale of the Wind) which have medicinal and culinary values. However, the proliferation of invasive species - both terrestrial and aquatic and the water pollution posed a clear threat to the existence of native flora and fauna which flagged the urgent need to protect the lake.

iii. **Benefits of drought and flood mitigation in the local region**: There is continuous inflow of wastewater into the lake, significant siltation and muck deposits that compromise the water storage and groundwater recharge potential of the lake. By increasing the storage capacity of the waterbody, potential benefits on both drought and flood mitigation were envisaged. Additionally, the lake's disturbed but intact hydrological connectivity to the upstream and downstream lake systems indicated that the restoration benefits if any, will be realised in the connected wetlands in the watershed basin, thereby positively impacting the health of the wetlands downstream up to the Pallikaranai Marshland. Further, the increased water storage capacity will help keep up the hydrological balance within the connected watershed, influencing groundwater levels positively. It was also noted that the government and also local communities were undertaking restoration efforts and lake clean-ups in the connecting lake systems, where the proposed project will contribute to cumulative restoration benefits across the watershed.

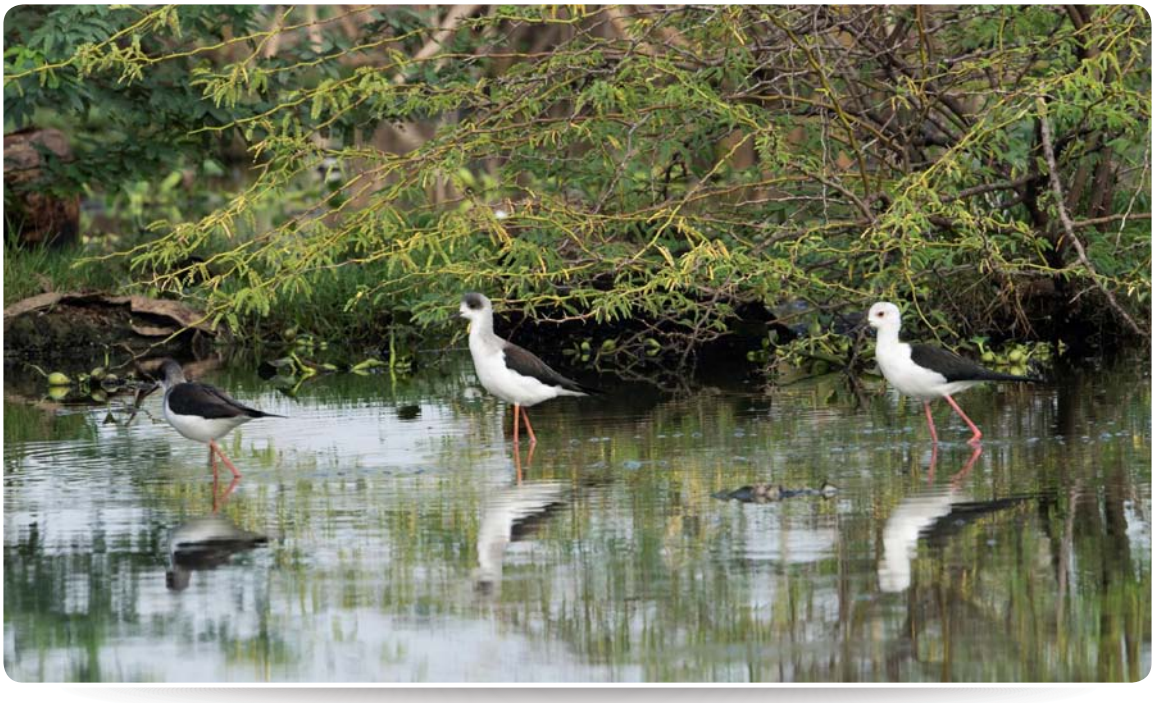
iv. **Community interest in restoration and ownership for long term sustainability:** Community involvement in lake protection was observed from the initial meetings conducted and from the media information which revealed the communities' active participation in protecting the lake. The local community acclaimed the lake for its cool breeze, medicinal plants, beautiful bird sighting, ground water recharge and that it served as a communal swimming pool three decades ago.

Local community picking medicinal herb - Purple Fruited Pea Egg Plant from the Sembakkam Lake.

v. **Environmental threats:** Some of the environmental issues observed from the reconnaissance survey are noted below:

- Solid wastes found around the lake periphery.
- Proliferation of invasive terrestrial plants with remnants of native and endemic plants.
- Biodiversity habitat of flora and fauna under threat.
- Water pollution due to continuous wastewater inflow.
- Huge siltation affecting the storage capacity of the lake.
- Increased flood risks due to proposed connections of inlet surplus water channels.

The lake mirrored the environmental problems faced by urban lakes, thus serving as a



Black Winged Stilt at Sembakkam Lake

representative sample of an affected urban waterbody, which when restored can provide huge replication benefits not only across the city but also India.

After consultation with multiple stakeholders such as the State Water Resources Department, Urban Local Body, District Collectorate and Commissionerate of Revenue Administration and Disaster Mitigation, the Sembakkam Lake was chosen for the eco-restoration work with strong interest from the local communities.

3.2 Obtaining Required Statutory Approvals

For the eco-restoration of Sembakkam Lake project, statutory approvals were obtained from the Tamil Nadu Water Resource Department (TNWRD) who have the ownership for the protection and maintenance of the Sembakkam Lake.

3.3 Baseline Survey

Post obtaining the required permissions, a detailed survey to assess the baseline conditions of Sembakkam Lake was carried out. Baseline survey allowed gathering information on the existing site conditions and in-depth assessment of the restoration needs. Additionally, the survey also enabled recording pre-restoration data which will be used to compare post-restoration scenario on a long-term basis and measurement of outcomes.

A detailed technical assessment comprising the lake morphological and hydrological features, water quality and biodiversity were carried out over pre and post monsoon season from April 2018 to November 2019. A community perception survey around the lake was also conducted to understand the views, expectations, and support from the community. It gave a better understanding of the stakeholders involved, such as the key roles of the local municipalities in the protection and long-term sustainable management of the restoration efforts.

3.3.1 Location

The Sembakkam Lake forms a part of the Pallikaranai watershed basin, in the Chennai Metropolitan Area. The geo-coordinates of the lake are 12.9234° N and 80.1588° E extending across Sembakkam, Pallavaram, and Chitlapakkam local body limits. It is a lake typical of an urban wetland located amidst built-up environments. It is well connected network to roads

Aerial view of the Sembakkam Lake

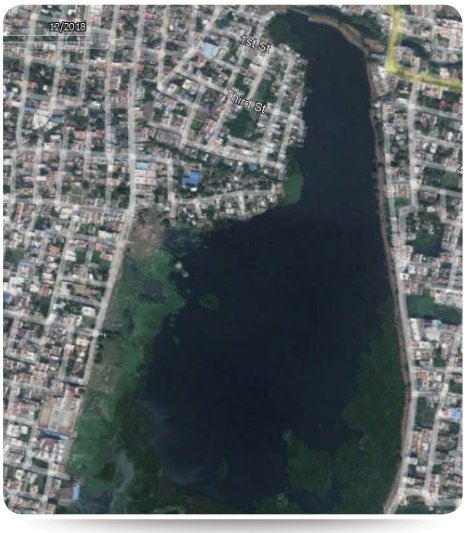
such as National Highway NH 48, SH 109, 200 ft radial road and is near the IT hub of Old Mahabalipuram Road and Chennai International Airport. It is for these reasons and for the availability of groundwater, the area became a preferred residential locality booming with educational institutions and other hospitality industries.

3.3.2 Morphology

The lake extends over about 100-acres (39.8 hectares) and exhibits a shape of a pitcher with its tip facing the Northwest. The lake receives inflow from the South and West directions, with a high embankment on the Eastern side. The surplus flow weir is on the Northwest side of the lake through which the surplus drains into the outflow channels.

Table 1: Features of Sembakkam Lake

Full tank level (m)	**15.5**
Bed level at the deepest point (m)	13.25
Water spread area (hectares)	34.05
Land area (hectares)	3.96
Dump yard area (hectares)	1.79
Total tank area (hectares)	39.8
Storage capacity (million cu. m)	0.286 (10.12 million cu.ft)



Satellite Imagery of the Sembakkam Lake

3.3.3 Water Quality

Water quality is an important parameter indicating health of the lake. The Central Pollution Control Board Standrads prescribing various criteria for water usage[13] and the results of basic parameters tested at the Sembakkam Lake are presented below.

Table 2: Water Quality Criteria prescribed by CPCB

Designated-Best-Use	Class of water	Criteria
Drinking water source without conventional treatment but after disinfection	A	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20C 2mg/l or less
Outdoor bathing (organised)	B	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20C 3mg/l or less
Propagation of wildlife and fisheries	D	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, controlled waste disposal	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

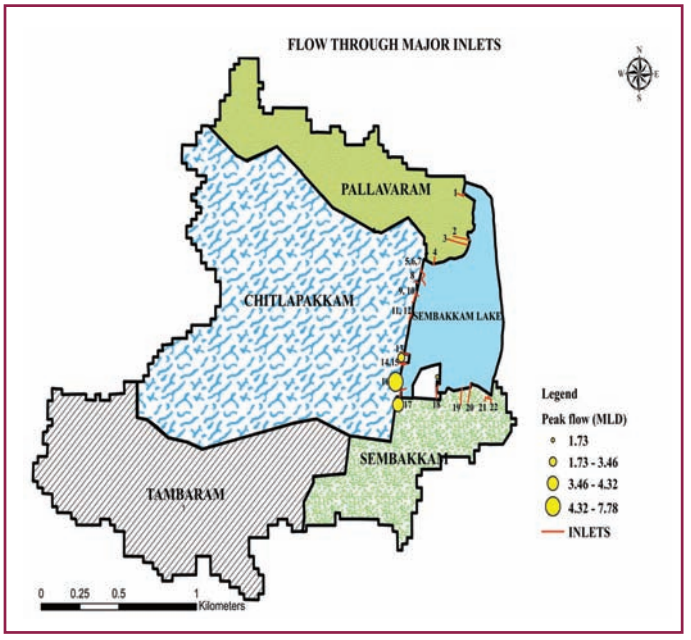
Table 3: Water Quality of the Lake

Water Quality Parameter	Value (mg/L)
pH	7-8.5
BOD	40-150
COD	64-350
Free Ammonia (N)	2-6.4
Total Phosphates	0.5-6
Dissolved Oxygen	<2
Total Coliforms (MPN/100 mL)	>5000

The western boundary of the lake is identified as the hotspot for pollution, where the flow of untreated wastewater entering the lake is visible. Though pH values were found to be within the prescribed standards for designated best use for surface water category A to E, the BOD and COD values were very high to approve the water body for any activities involving human contact. Further, disposal of wastewater into the lake has caused extensive eutrophication of the Lake. The IIT-M report on the water quality of the lake has revealed that the quality of the lake did not meet even the criteria for Class – D for wildlife propagation

3.3.4 Sources of Pollution

Twenty-two inlets have been identified around the lake, that carry surplus from the upstream lakes of Chitlapakkam, Selaiyur and Rajakilpakkam. Quantity and characteristics of incoming wastewater was analysed to work out an appropriate treatment scheme and design for treating the incoming pollution.



Inlet Points of the Sembakkam Lake

Four of the twenty-two major inlets were noted for its significant flow quantity, totalling about five million litres of wastewater per day. There were also other inlets that brought trickling flow into the lake, but their quantity was insignificant to be considered as an issue.

3.3.5 Biodiversity

The components of biodiversity chosen for the inventory were flowering plants and birds. These components are on the top and bottom of the ecological pyramid of the wetland. Flowering plants are primary producers and they are the best indicators of the health of an ecosystem. Being primary producers, they are at the bottom of the pyramid. Birds are at the top of the pyramid. In the absence of predators like crocodiles and otters, birds are the top predators in most of our wetlands including in the Sembakkam Lake. Inventorying birds and monitoring their diversity and dynamics

200
species of flowering plants

34
species of trees

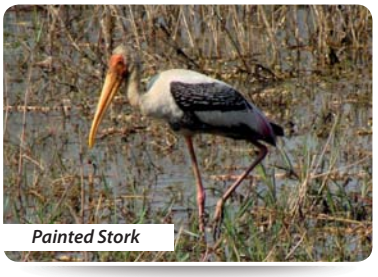
72
species of birds

14
species of reptiles and amphibians

is therefore important for the sustainable management of wetlands. In addition to flowering plants and birds, reptiles and amphibians were opportunistically inventoried. The surveys were conducted thrice covering three seasons viz., summer, pre-monsoon and post-monsoon (winter) and the results are highlighted below.

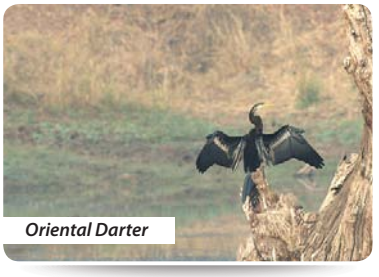
Birds


Spot Billed Pelican


Painted Stork


River Tern


Black Ibis


Oriental Darter

Amphibians


Flap Shell Turtle


Indian Black Turtle

Reptiles


Russell's Viper


Indian Cobra


Green Vine Snake

Plants and Flowers

Brahmi
(Bacopa monnieri)
Ayurvedic medicinal herb for enhancing memory

Thootuvalai
(Solanum trilobatum)
A herb known for its anti-inflammatory, anti-microbial, and anti-oxidant properties

Kandankathiri
(Solanum virginianum)
A nightshade species, used in Ayurveda to treat cold, cough and rhinitis

Nochi
(Vitex negundo)
Aromatic leaves with medicinal use for treating cold and repelling mosquitoes

Kizhanelli ***(Phyllanthus amarus) and***
Karisalanganni ***(Eclipta prostrata)***
Popular herbs in Siddha and Ayurvedic medicine practice for treating liver diseases

3.4 Stakeholder Engagement

Mapping and reaching out to the stakeholders were crucial activities in the project[9,10]. The discussions with stakeholders such as the community, local municipalities, and representatives of the government provided valuable insights and information pertaining to the restoration process and desired outcomes of the project. Information such as previous restoration activities if any, role of stakeholders in protecting the lake and supporting efforts thereof, threats to the lake ecosystem, and extraction of resources such as water, fish, lake sand, etc. were understood from the discussions.

Further, developing a holistic view of restoration was enabled by the discussions with the local communities and government bodies including the Tamil Nadu Water Resource Department (TNWRD), the Urban Local Body, and the District Collectorate. Following all of the above steps, a tailor-made restoration approach and project goals were developed.

3.5 Project Goals

Based on the baseline survey that revealed the underlying environmental and social issues, and from the consultation with stakeholders, the project goals and desired outcomes were planned for the lake restoration. The goals were developed using a triple bottom-line approach for protecting nature and offering socio-economic benefits to the communities and government stakeholders involved.

Table 4: Sembakkam Lake - Project Goals

Project Goals	Activities	Outcomes
Increase water storage capacity of the lake	• Dredging and silt removal	• Improves surface water storage and ground water recharge. • Minimises risks of drought and flooding • Enhances biodiversity habitat
Minimise flood risk	• Dredging and silt removal to improve lake storage capacity • Strengthen lake embankments • Construct flood regulator gates • Unclog connecting channels to ensure free flow of water	• Minimises risks of flooding in downstream areas
Improve lake water quality	• Establish cost-effective and eco-friendly wastewater treatment systems to improve the water quality of the lake. • Achieve Central Pollution Control Board (CPCB) surface water quality criteria 'D' to meet fisheries and wildlife propagation.	• Enhances the biodiversity habitat • Improves quality of groundwater recharge • Better aesthetics and accessibility to community
Improve biodiversity habitat and conserve native flora/ fauna, comprising rare, endemic and threatened (near threatened) species.	• Remove invasive plant species – both terrestrial and aquatic • Plant native species of plants/ trees • Improve water quality to standard 'D' of CPCB surface water quality standards supporting fisheries and wildlife propagation.	• Conserves the biodiversity and native flora and fauna

Project Goals	Activities	Outcomes
Create natural landscaping around the lake benefitting people and biodiversity	• Remove solid wates around lake periphery. • Establish eco-friendly waterfront landscaping for community access, recreation, and perching areas for bird	• Community gets accessibility to lake. • Helps in building community connectivity and ownership for lake protection. • Enhances the habitat for avifauna and aquatic fauna
Building awareness on conservation of natural resources	• Organise lake clean-up activities • Keep sign boards that are educational and informative on conservation of natural resources and biodiversity habitats	• Builds community responsibility and ownership for protection of natural resources • Provides recreational space for the community and children • Provides opportunities for learning conservation values of natural resources and biodiversity. • Improves knowledge on the values of native flora and fauna.

3.6 Lake Monitoring and Maintenance Plan

A lake maintenance plan is essential to monitor, maintain and sustain the restoration outcomes on a long-term basis. So, any anomalies in the desired outcomes of the restoration efforts are checked and addressed. A plan comprising avoidance of solid wastes, maintenance of wastewater treatment systems, landscaping plans and removal of weeds as necessary were worked out with supporting financial models and timelines.

Parameters considered for post restoration monitoring

a. Measuring water levels at the staff gauge stations
b. Water quality monitoring at 0.5 m depth at the Centre, Southwest and Northeast locations
c. Parameters to be monitored for water quality include
   - pH, Total Dissolved Solids, Turbidity, Dissolved Oxygen Biological Oxygen Demand, Free ammonia, Nitrates
   - Phosphates, Total coliforms, E.Coli

Staff gauge installed at the surplus weir of the Sembakkam Lake for measuring water levels

d. Biodiversity present

For examining the impact of the restoration efforts on the biological diversity of the Sembakkam Lake, a two-tier cluster of metrics is proposed to be monitored twice a year.

- The first of these is at the scale of habitats and includes:
  - Retention of the wetland area
  - Percentage area change in wetland area to sub types within
  - Number of dry lake bed days and full tank level
- The second would be at the scale of species and includes:
  - Overall change in species diversity
  - Overall change in population
  - Change in herbaceous plants
  - Change in bird diversity
  - Change in fish diversity and
  - Trends of Invasive Alien Species.

4. Steps to Eco-restore the Sembakkam Lake

The development of the eco-restoration plan was guided by several factors to comprehensively address restoration requirements. The approach was guided by the stakeholder consultations, findings of the baseline survey, and the inputs provided by subject matter experts for treating pollution and creating an enhanced biodiversity habitat.

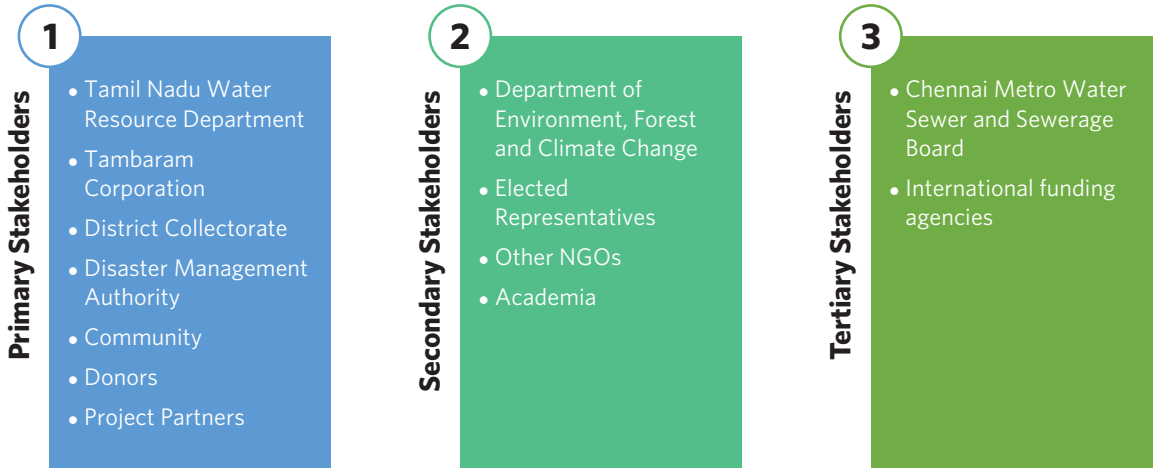
Table 5: The various steps taken for restoring the lake are outlined and depicted below:

Planned Measures	Steps Involved
Stakeholder consultations and engagements	• Mapping of various stakeholders • Consultations to solicit inputs and support
Lake clean-up	• Removing solid wastes
Removal of invasive plant species	• Removing aquatic weeds such as Water Hyacinth and Lettuce, Duckweeds • Removing terrestrial weeds such as *Prosopis Julifora*
Improve water storage capacity	• Removing silt from the lake
Flood mitigation measures	• Unclogging and rehabilitating existing inlet channels • Creating adequate inlets into the lake to avoid flooding in upstream area • Strengthening embankments • Constructing flood regulators

Planned Measures	Steps Involved
Treatment of water pollution	• Setting up constructed wetland systems for treatment of incoming wastewater
Improve biodiversity habitat and create recreational landscape for the local community	• Planting native plant (tree and herbs) species which support biodiversity • Creating mudflats and perching areas for birds
Build community ownership	• Engaging with the local community
Develop lake maintenance and monitoring plan	• Forming lake protection committees within the local community • Developing lake monitoring plans and maintenance plans • Developing financial model for sustainable lake maintenance

4.1 Stakeholder Engagement

Stakeholder consultations were given high priority while developing the restoration plan as it provided key information on the lake and the crucial issues to be addressed. The interactions with stakeholders at various levels provided valuable insights regarding their perceptions and expectations from lake restoration.



Some of the important points discussed with the community members that helped shape the restoration plan are:

The community wanted the lake to be cleaned and deepened for increasing the water storage capacity.

- They believed that without addressing the incoming wastewater issues, the lake will get polluted and the realisation of restoration benefits will be incomplete. However, when discussed about an in-situ nature-based wastewater treatment system, a mixed response was received from the community where some members welcomed the idea while others were apprehensive citing stagnation and odour issues.
- Women highlighted safety concerns and suggested having a fencing around the lake.
- The Water Resource Department reviewed the restoration plans and issued approvals that aided implementing on-ground work. The department directed to construct flood regulator gates to mitigate floods, as two more upstream channels were planned to be connected to the lake.
- The local urban body was consulted to support solid waste removal and to provide power supply for work execution.
- Elected representatives emphasised the need to incorporate flood mitigation as well addressing wastewater issues.

4.2 Lake Clean Up

About 6000 sq.m around the lake was cleaned and garbage disposed with the support of local bodies and community members.

Since the lake boundary in the southern part once used to be a solid waste dumpsite, the process of cleaning the remaining waste was a challenging task. However, with the support of the Government, the solid wastes are being cleaned.

Awareness campaigns and lake clean-up activities were also conducted with the community to prevent throwing garbage in public and natural spaces.

Photo taken during lake clean up activity - July 2019

4.3 Removal of Invasive Plant Species

Terrestrial Weeds

The terrestrial weeds such as the *Prosopis juliflora* and *Leucaena leucocephala* and the aquatic weeds such as *Eichhornia crassipes*, Water lettuce and Duckweed were removed from the lake. However, periodical removal of these weeds is required which continue to proliferate until the discharge of untreated wastewater is addressed. It is envisaged that once the setting of the in-situ wastewater treatment system is completed and the systems is functional, the eutrophication levels at the lake will go down, inhibiting further growth of aquatic weeds.

Before: *Invasive terrestrial plant species*

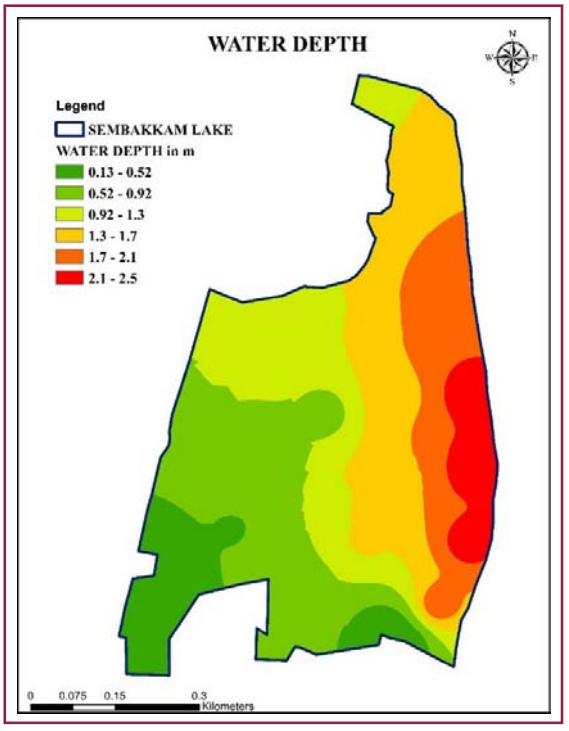
After: *Invasive terrestrial plant species removed*

Before: *Weed removal in progress in April 2020*

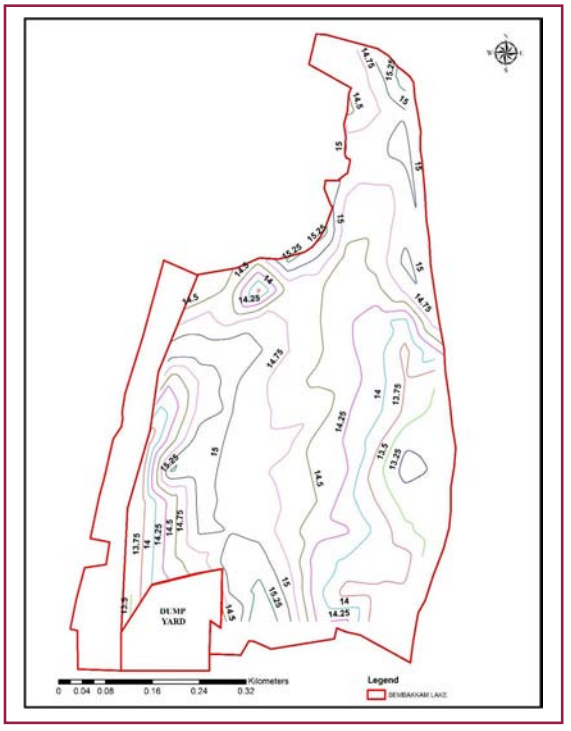
After: *Weeds cleared in July 2020*

4.4 Improvement of Water Storage Capacity

Dredging and Silt Removal: Topography and Bathymetric survey revealed that there is an uneven topography in the lake. The lake is rising from west to centre and was then taking a dip towards the eastern bund, which may be due to illegal sand mining or unscientific dredging.



Water Depth at Sembakkam Lake



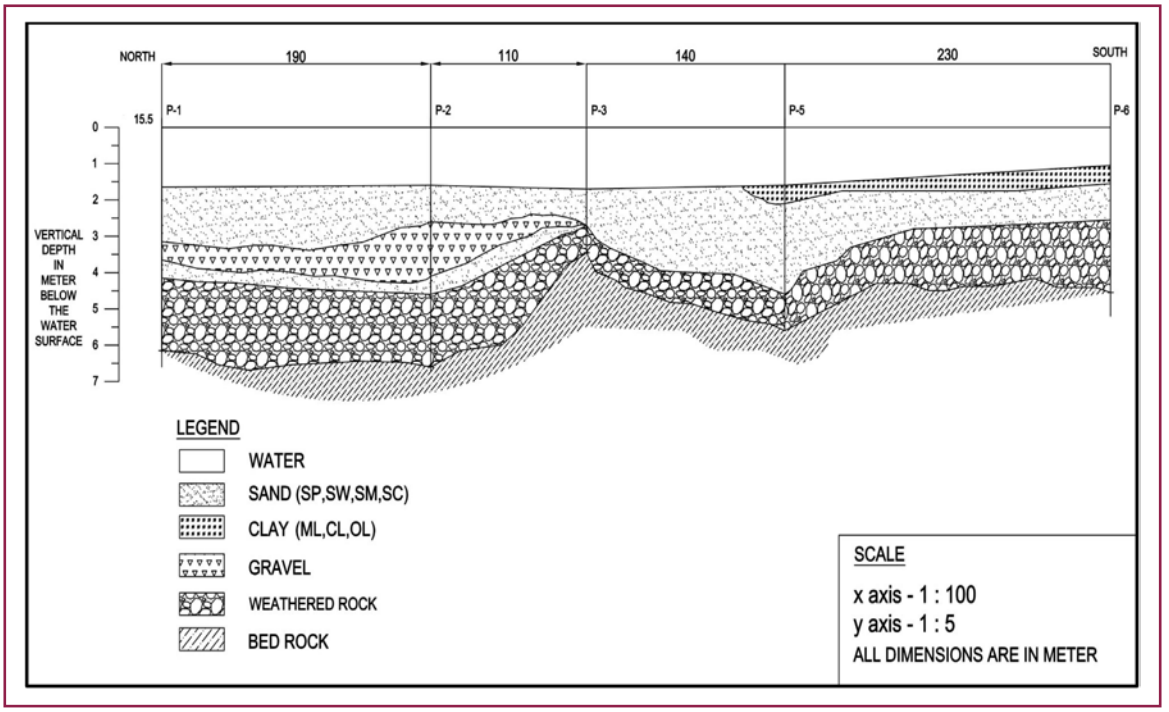
Contour Levels of Lake bed

The Lithological studies revealed that the lake had a shallow depth and cannot be dredged beyond 2.0 m bgl as it had weathered rock at 2 m depth. Dredging beyond this limit may result in increased percolation of surface water below ground accelerating drying up of the lake much faster than usual. Hence, dredging was restricted to 1 m to 1.5m bgl for silt removal and increasing the water storage capacity.

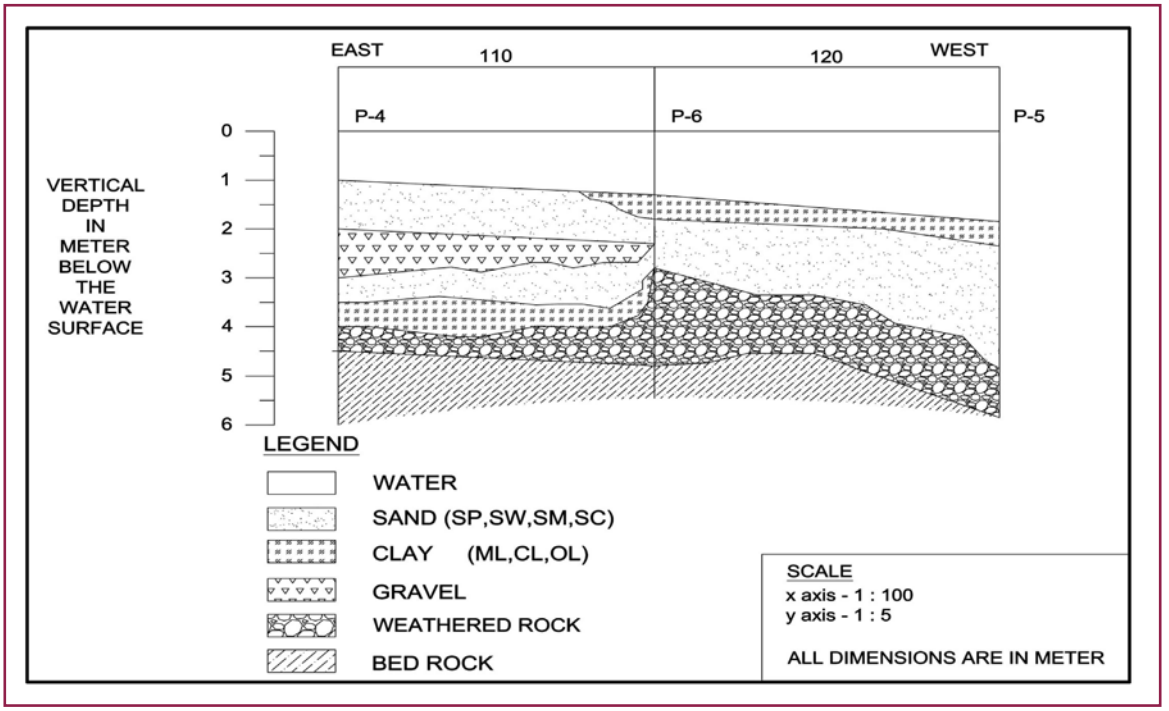
Drilling and collecting samples for Lithological analysis

As the southwestern periphery of the lake received most of the wastewater inflow, these areas showed increased silt and sludge accumulation that compromised the volume of the lake. Hence, it was decided to dredge these areas on priority to increase the lake volume.

About 1,00,000 cum of silt was removed by dredging contributing to 36% increase in water storage capacity of the lake and increased water recharge capacity by 50,000 cum/ year.



Sub-surface soil profile (North-South transect)



Sub-surface soil profile (East-West transect)

4.5 Flood Mitigation

The field survey with local communities revealed flooding along the downstream channels of the Sembakkam Lake and at the connecting inlets that were clogged with solid wastes.

To alleviate these issues, the following measures were completed, all aimed at flood mitigation benefits at the lake:

- strengthening the embankments using the silt removed
- unclogging connecting channels
- construction of flood channels and flood regulators

Before construction of flood regulator gates

After construction of flood regulator gates in May 2019

4.6 Eco-friendly Methods for Treating Pollution

High organic pollution at the lake was evidenced through the baseline survey, which necessitated suitable remedial actions for achieving holistic restoration outcomes. The water quality analysis at the lake revealed that the quality of the lake was below the Central Pollution Control Board (CPCB) surface water quality standards. The water quality did not meet the A to D criteria, rendering it unsuitable for consumption and contact by humans and for wildlife and fisheries propagation. Further, the organic pollution along with the incoming nitrogen and phosphorus load had greatly influenced the eutrophication and growth of invasive plant species across the lake.

In dealing with the above problem, TNC India along with its partners adopted a novel approach to treat the wastewater in-situ. They chose an an eco-friendly treatment method which utilises constructed wetlands to ensure a steady supply of water for the lake year-round. Traditional approaches treat wastewater by re-routing the wastewater the lake receives and treating it in the closest sewage treatment plant using conventional systems. Unfortunately, this approach also rids the monsoon dependant lake of the perennial source of water it has.

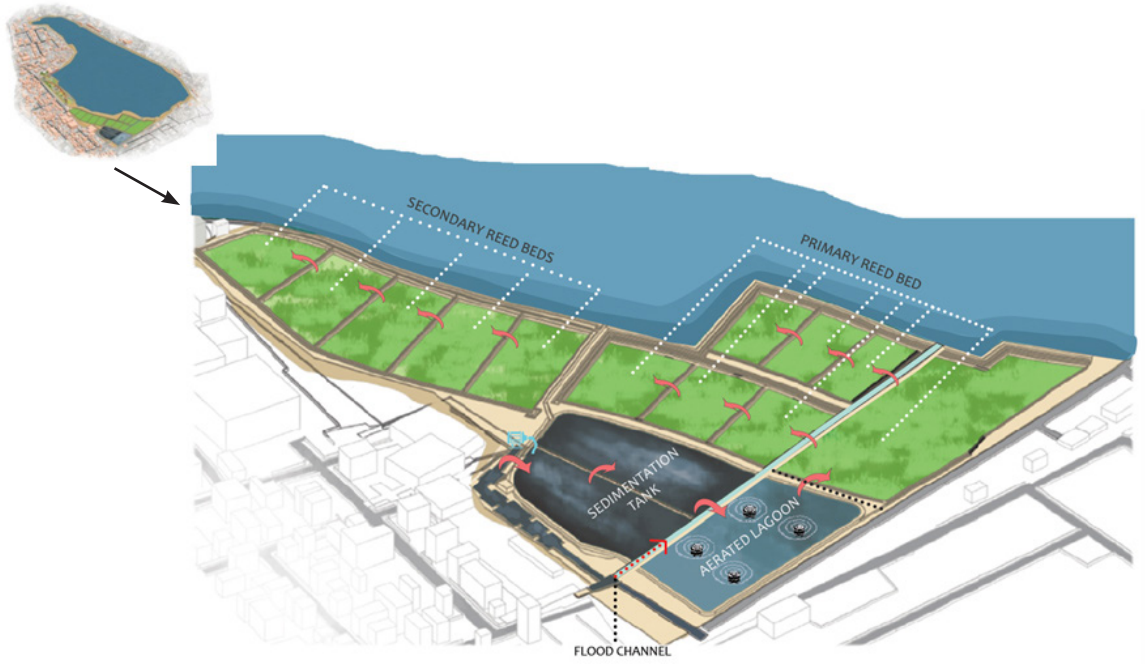
The approach in the current project emulates the natural treatment process of a lake using constructed wetland systems that use minimal energy, require zero chemical additives, are inexpensive and can be maintained easily by locally available semi-skilled personnel. The novel technology involves passing untreated water through reed bed systems made of gravel and sand and planted with water-loving plants. The plants absorb atmospheric oxygen and release it through their roots to microbes in reed beds. Both the plants and microbes at the root zone assimilate the nutrients and clean up the pollutants.

The constructed wetland system is widely recognised as an ecosystem-based approach for remediation of pollution. However, the system has not been practiced as it should be. The reason for this is increased dependence on conventional treatment systems, lack of space for constructed wetlands and lack of knowledge on its implementation as a wastewater treatment system of waterbodies. Addressing this gap, and to present a live model of wastewater treatment using constructed wetlands with the native plants of the region, this eco-friendly method was adopted in the project.

An added advantage is the opportunity to create an aesthetically-pleasing, functional area around the lake that can be used by the community as a recreational space. This nature-based approach nurtures aquatic life in the lake and enhances the biodiversity habitat of the area, boosting community pride. The energy saved as a result implies lower expenses for Corporation authorities.

The project includes a hybrid methodology that uses a combination of mechanised treatment such as aerated lagoon as well as constructed wetland treatment system. The capital and operational costs are about 30% and 70% lower than the conventional treatment systems, respectively.

In the process of lake rejuvenation, self-bioremediation of the lake is expected to kick-in after the process of dredging and recharging the lake with treated water begins. Options such as assisted remediation using aeration and utilisation of specialty bacteria has not been recommended considering the very low water depth and the cost/maintenance involved. The self-rejuvenation period has been estimated as two to three years.



When completed, this will be one of the largest contructed wetland treatment system in India.

Existing Southwest area proposed for constructed wetlands in the lake periphery.

Projected Southwest area with constructed wetlands in the lake periphery.

4.7 Creation of Recreational Landscape with Enhanced Biodiversity Habitat

Wetlands are a rarity in urban spaces and their protection is of high importance owing to the ecosystem benefits it provides to people and biodiversity. Besides the climatic resilience it offers to people, the beauty of aesthetics, natural space for relaxation, and the heat island mitigation benefits to urbanites are invaluable for the well-being of mental and physical health.

Further, these natural spaces serve as a haven for a wide range of birds both native and migratory in times of their dwindling habitats. With the revival of the native flora, the potential of the landscape to attract more native fauna will be improved.

Building a recreational natural space with integrated benefits of biodiversity enhancements was one of the project goals. The landscaping exercise was undertaken carefully covering the nuances of biodiversity conservation principles and the hydrological sensitivity of the area.

With these envisaged outcomes, an eco-friendly landscape plan was designed and is being implemented comprising the following components:

- Fences
- Pathways around the lake
- Benches
- Informative signage boards on biodiversity
- Tree plantation
- Gardens
- Native plants
- Herbs of medicinal and culinary values
- Horticultural plants

A painted mural of birds placed at the Lake

5. Project Outcomes

1. 1,00,000 cum of silt removed from lake, resulting in improved water storage capacity by 36%. Increase in groundwater recharge of about 50,000 cum/ annum and improved flood mitigation capacity.
2. Strengthening the embankments of about 2.0 km length.
3. Construction of two flood regulators for flood mitigation.

Photo showing dredging operations at Sembakkam Lake

4. Creation of an ecofriendly landscape for community access and improvement of biodiversity habitat.
5. 'Creation of a hybrid treatment system using aerated lagoon and constructed wetlands for treating incoming wastewater. The treatment system aims to improve the lake water quality to category D of Central Pollution Control Board Surface Water Quality Standards. The constructed wetland system is aimed at providing evidence-based solutions for decentralised and nature-based treatment system with less environmental footprint.
6. Demonstrate strong stakeholder engagement involving various government departments such as Water Resource Department, urban local bodies, District Collectorate, local communities who are forthcoming to support the on-groundwork.
7. Long term monitoring, evaluation and maintenance and plans to use IoT (Internet of Things) to regularly monitor the water quality with reference to Central Pollution Control Board surface water quality standards.

6. Conclusion

Restoration of urban wetlands offer promising solutions to build climate resilience in times of increasing climate change effects. These wetlands offer ecosystem-based adaptation in mitigating floods and droughts while also providing a natural habitat for the biodiversity and healthy living environment for people. Using a science-based approach and locally available materials for pollution treatment this restoration efforts demonstrates and embodies the movement introduced by Indian Prime Minister Shri Narendra Modi at the 26th Conference of Parties called LiFE (Lifestyle for Environment) for achieving sustainability.

AUTHORS: Nisha Priya Mani[1], Alpana Jain[1], Jayshree Vencatesan[2], Indumathi Nambi[3], Balaji Narasimhan[3], Emmanuel Varghese K[4]

[1]The Nature Conservancy, [2]Care Earth Trust, [3]Indian Institute of Technology- Madras, [4]Indian Leather Institute Foundation

7. References

1. IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673
2. Ramsar Convention on Wetlands. (2018). Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat.
3. Davidson, N.C. (2014). How much wetland has the world lost? Longterm and recent trends in global wetland area. Marine and Freshwater Research, 65(10), 934-941.
4. Mekonnen, Mesfin M., and Arjen Y. Hoekstra. "Four Billion People Facing Severe Water Scarcity." Science Advances 2, No. 2 (2016): e1500323.
5. https://pib.gov.in/newsite/erelcontent.aspx?relid=44098
6. Transformingourworld:the2030AgendaforSustainableDevelopment,https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

7. Impact of Climate Change and National Action Plan on Climate ChangeMinistry of Environment, Forest and Climate Change, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1831364
8. Sayli Udas-Mankikar and Berjis Driver, "Blue-Green Infrastructure: An Opportunity for Indian Cities," ORF Occasional Paper No. 317, May 2021, Observer Research Foundation.
9. Advisory on Conservation and Restoration of Water Bodies in Urban Areas, Ministry of Urban Development Government of India http://moud.gov.in
10. Urban Wetland/ Water Bodies Management Guidelines – A toolkit for local stakeholders published by Namami Gange, National Mission for Clean Ganga and School of Planning and Architecture, New Delhi, 2021
11. http://tnenvis.nic.in/files/CHENNAI.pdf
12. Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017 MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE GOVERNMENT OF INDIA
13. https://cpcb.nic.in/water-quality-criteria/

The Nature Conservancy (TNC) *is the leading conservation organization working to make a positive impact around the world in more than* ***76 countries and territories.*** *Founded in 1951, the mission of The Nature Conservancy is to conserve the lands and waters on which all life depends.*

As a science based non-profit, The Nature Conservancy in India has been advancing projects since 2017 to support India's efforts to develop win-win solutions for people and nature. TNC - India works closely with the Indian government, research institutions, NGOs, private sector organizations and local communities to develop science-based, on-the-ground, scalable solutions for securing food, water and clean air.

TNC-The Nature Conservancy Centre is a not-for-profit entity registered in India under the Companies Act with 80G certification.

For more information, please visit www.tncindia.in or contact indiapr@tnc.org