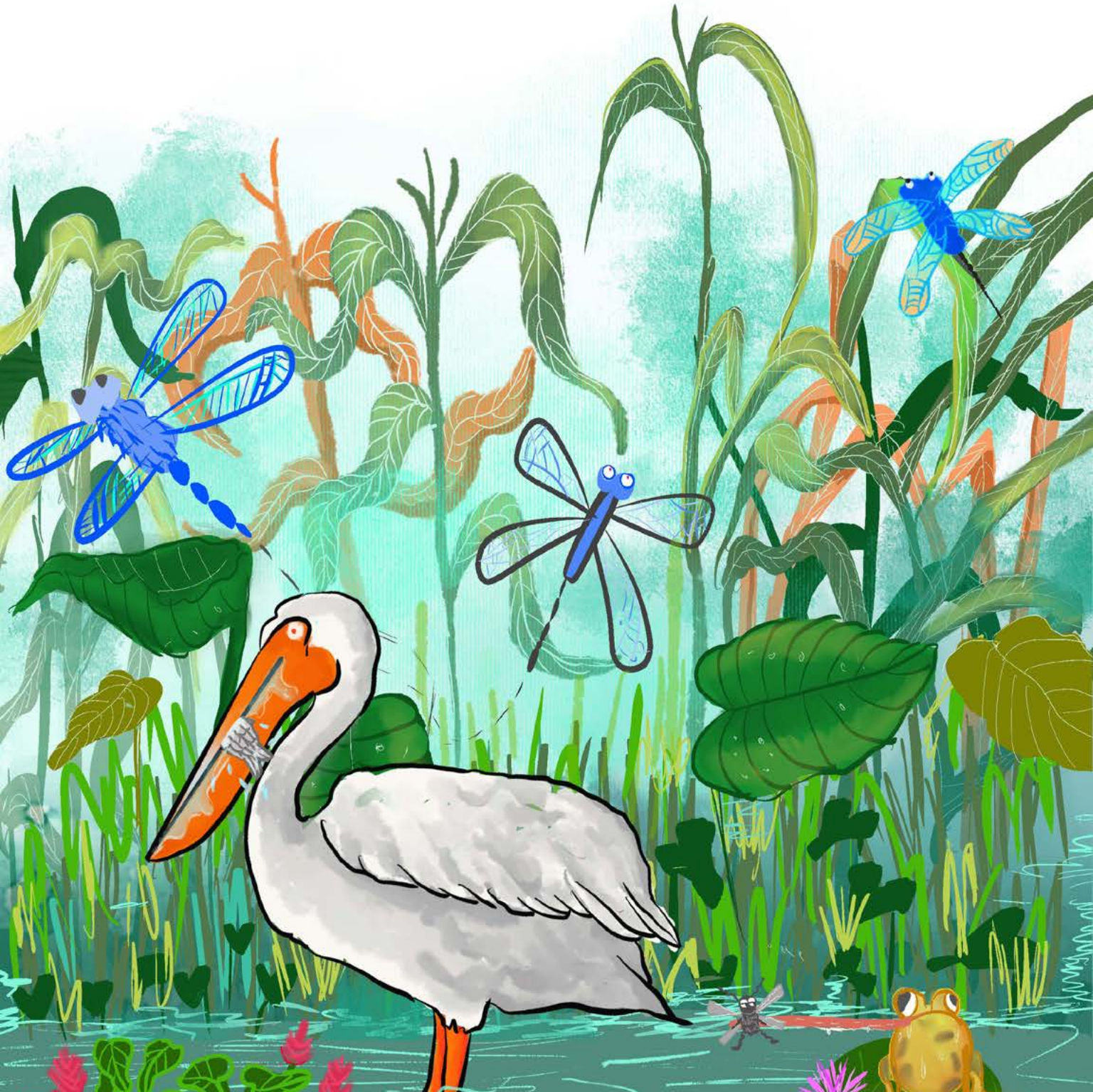
WETLANDS RESTORATION

A COMPREHENSIVE HANDBOOK
LEARNINGS FROM CHENNAI|OCTOBER 2021



WETLAND RESTORATION

A COMPREHENSIVE HANDBOOK

Learnings from CHENNAI

Authors: Jayshree Vencatesan, Parama Roy, Akshaya Ayyangar, Anjana Vencatesan, Urmika Venkateshwaran and S. Thirunavukkarasu

Citation: Vencatesan, J., Roy, P., Ayyangar, A., Vencatesan, A., Venkateshwaran, U. & Thirunavukkarasu, S. (2021). Wetlands Restoration: A Handbook, Case Studies from Chennai, Okapi Research & Advisory and Care Earth Trust, Funded by Azim Premji University

Prepared By: Okapi Research & Advisory and Care Earth Trust

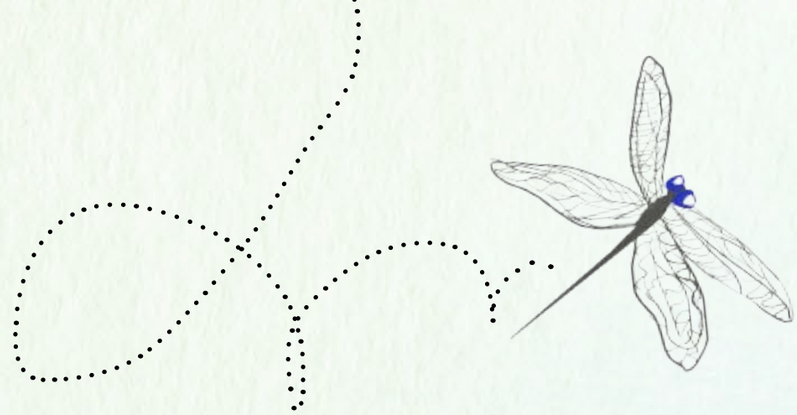
This research study is funded by Azim Premji University as part of the Research Funding Programme 2019 for Climate Change.

ABOUT THE ORGANISATIONS

Okapi Research and Advisory is a research and consulting group focused on helping clients better understand policy ecosystems, design resilient solutions, and facilitate sustainable social and environmental transformations in cities.
Reach us at: proy@okapia.co

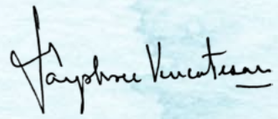
Care Earth strives to provide scientific services in the area of biodiversity by assessing human impact on the environment as well as strategizing methods to improve it. Care Earth Trust has been involved in implementing training and capacity building initiatives in the area of biodiversity conservation and has delved deep into developing and sharing resource-based material that push the conservation agenda forward.
Reach us at: +91 72004 35841

ACKNOWLEDGEMENT:
We would like to thank Prof. Balaji Narasimhan from the Indian Institute of Technology, Madras, for reviewing this document and providing us with valuable inputs. We would also like to thank all the participants who helped us develop the case studies.



FOREWORD

This document is a comprehensive handbook on wetland restoration. It not only provides an account of the key technical steps in restoration, but also highlights the importance of pre-project planning and research to inform us about the importance of the wetland in the local context and, develop an understanding of the spatial and temporal evolution of the wetland in question so that an appropriate restoration plan can be designed. The handbook also emphasises the need for continual monitoring and post-implementation management of restoration efforts for ensuring long-term sustainability. These critical aspects are often ignored due to limited financial, technical, and human resources during on-the-ground projects. We hope the depth and breadth of discussion on the policy context, stakeholders, restoration methods, monitoring, and management will appeal to a wider audience including policymakers, citizens, implementing NGOs, and funding agencies.



JAYSHREE VENCATESAN
Managing Trustee, Care Earth Trust

CONTENTS

CH 1: Introduction to Wetlands 12-31

What are Wetlands? 12
Why do we Need to Conserve Wetlands? 12
Climate Change Adaptation 13
Ecosystem Services 15
Rights of Nature 18
Legal and Regulatory Provisions for Protection 18
International: The Convention on Wetlands 18
India 19
Tamil Nadu Wetlands 20
Tamil Nadu: State Wetland Authority 20
Wetlands in Tamil Nadu 20
Wetlands of Chennai 22
Scope of the Handbook 29
Bibliography 30

CH 2: Chennai's Urbanisation Context 32-35

Managing Land Use and Encroachments 32
The Demand for Urban Infrastructure 34
Bibliography 35

CH 3: Governance of Lakes and Ponds in the CMA 36-41

Bibliography 41

CH 4: Implementation of Wetland Restoration 42-62

Principles of Restoration 42
Adaptive Management 42
Periodicity 42
Multi-institutional Collaboration and Engagement 43
Consultative Processes for Local Communities 45
Continued Engagement through Formal and Informal Mechanisms 45
Implementation 45
Step 1: Identify Candidate Wetland and Conduct Baseline Assessments 45
Step 2: Assess Wetland Character and Integrity 49
Step 3: Set Restoration Goals 52
Step 4: Restoration Activities 54
Step 5: Exit Strategy 61
Bibliography 62

CH 5: Monitoring and Evaluation 63-73

Official M&E guidelines for Lake/Wetland Restoration Efforts in India 64
Indicative Guidelines for Restoration of Water Bodies 64
The Guidelines for Implementing Wetlands (Conservation and Management) Rules, 2017 66
Water Bodies Protection Index 68
Volunteer Monitoring or Community Monitoring 69
Bibliography 73

CH 6: Sustainable Management of Restored Lakes 74-80

A Government Authority: Conservation Authority for the Pallikaranai Marsh 75
Sembakkam Lake Protection Committee: A Planned Public-private Collaborative 76
Community-based Groups 77
Chitlapakkam Rising 78
A Consortium for Integrated Restoration and Protection of Chennai's Lakes: A City-level Advisory Group 78
Lake Adoption Program by Corporates 79
Lake of the Year Contest 80
Bibliography 80

CH 7: Case Studies 81-101

Case Study 1: PWD: Climate Adaptive Restoration and Rehabilitation 81
Case Study 2: Chitlapakkam Lake Restoration: The Value of Collective Action and Media Attention 83
Case Study 3: Madipakkam Lake Restoration: More Than 20-Years Journey to Protect and Restore a Local Resource 89
Case Study 4: Sembakkam Lake Restoration: An Interdisciplinary/ Multi-stakeholder Team Attempting the Scientific and Holistic Process 93
Case Study 5: Vandalur Lake Restoration: Mobilising volunteer strength for lake clean-ups and neighbourhood action 98
Bibliography 101

CH 8: Conclusions 102

Annexure I: Classification of Wetlands 104

List of the Figures

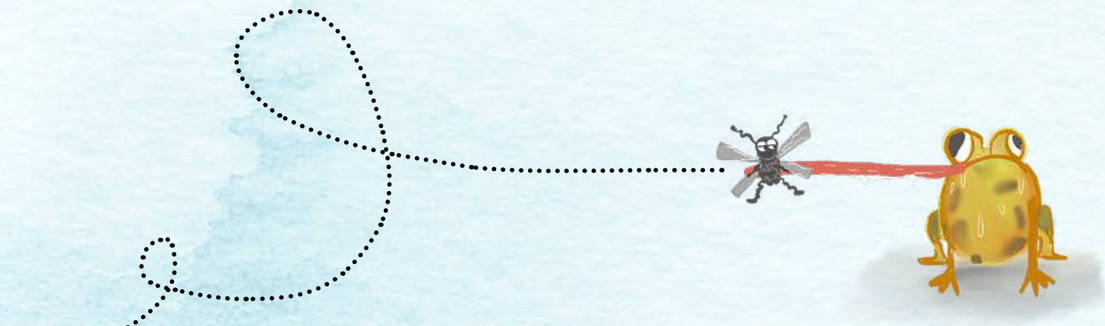
14 Figure 1: Why wetlands are critical for climate change adaptation
21 Figure 2: Wetland distribution
23 Figure 3: Chennai Metropolitan Area 1980
24 Figure 4: Chennai Metropolitan Area 1990
25 Figure 5: Chennai Metropolitan Area 2000
26 Figure 6: Chennai Metropolitan Area 2010
27 Figure 7: Chennai Metropolitan Area 2020
28 Figure 8: Historical Map of Madras 1816
33 Figure 9: Madambakkam Lake Time Series
34 Figure 10: Ottiyambakkam Lake Time Series
35 Figure 11: Sewage discharge in Pudhuthangal Lake
39 Figure 12: Stakeholders typically governing lake restoration and protection
44 Figure 13: Wetland-specific adaptive management framework adapted from Teal and Weishar (2005)
47 Figure 14: System Wetlands in the Palar Basin
47 Figure 15: Non-system, cascading water bodies in Pallikaranai
48 Figure 16: Polluted channel connecting Pudhuthangal Lake
50 Figure 17: Bathymetry Process
51 Figure 18: Pheasant-tailed Jacana (left) and Spot-billed Pelican (right)
54 Figure 19: Dredging at Ennore (below) and the dredging process explained (right)
55 Figure 20: Bund strengthening at Pudhuthangal Lake
56 Figure 21: Colonial-era Tower Head Sluice in Onamancheri Periya Eri (left). Rear cistern of the same sluice (Right)
57 Figure 22: Invasive species at Vandalur Lake48
58 Figure 23: Mound for birds in Puduthangal lake
58 Figure 24: Recharge wells being installed in Thalambur lake
59 Figure 25: Bund compaction at Thalambur lake with a vibrator roller
60 Figure 26: Palmyra planted on the bund of Thalambur lake
82 Figure 27: Provision of flood regulators & additional discharge arrangements at Selaiyur tank. The image on the right is before restoration & on the left, after.
83 Figure 28: Chitlapakkam Lake
84 Figure 29: Chitlapakkam, Sembakkam and Selaiyur Lakes
85 Figure 30: Map showing a temporal change in wetland area
86 Figure 31: The landfill in 2017 and being cleared in 2020
87 Figure 32: Concrete block acting as a bund, constructed around the lake
88 Figure 33: Snapshot of the activity progress chart maintained by Chitlapakkam Rising
89 Figure 34: A glimpse of the lake from the southern end in Nov 2020
90 Figure 35: Islands for birds to rest
91 Figure 36: Sewage being let into the lake
92 Figure 37: Madipakkam Lake post-monsoon (Nov 2020)
93 Figure 38: Aerial view of Sembakkam Lake from the North
94 Figure 39: Cut and cover drains constructed between Chitlapakkam and Sembakkam
94 Figure 40: Aquatic weed being removed from the lake
96 Figure 41: Silt being removed from the lake
98 Figure 42: Vandalur Lake
99 Figure 43: Map showing Vandalur and other connected lakes
100 Figure 44: Growth of invasive species

List of Tables

53 Table 1: Restoration goals and corresponding M&E parameters
65 Table 2: Water Quality Criteria-Designated Best Use
67 Table 3: Parameters for Wetlands Monitoring
68 Table 4: Data used for constructing the WBPI
69 Table 5: Classes of the WBPI

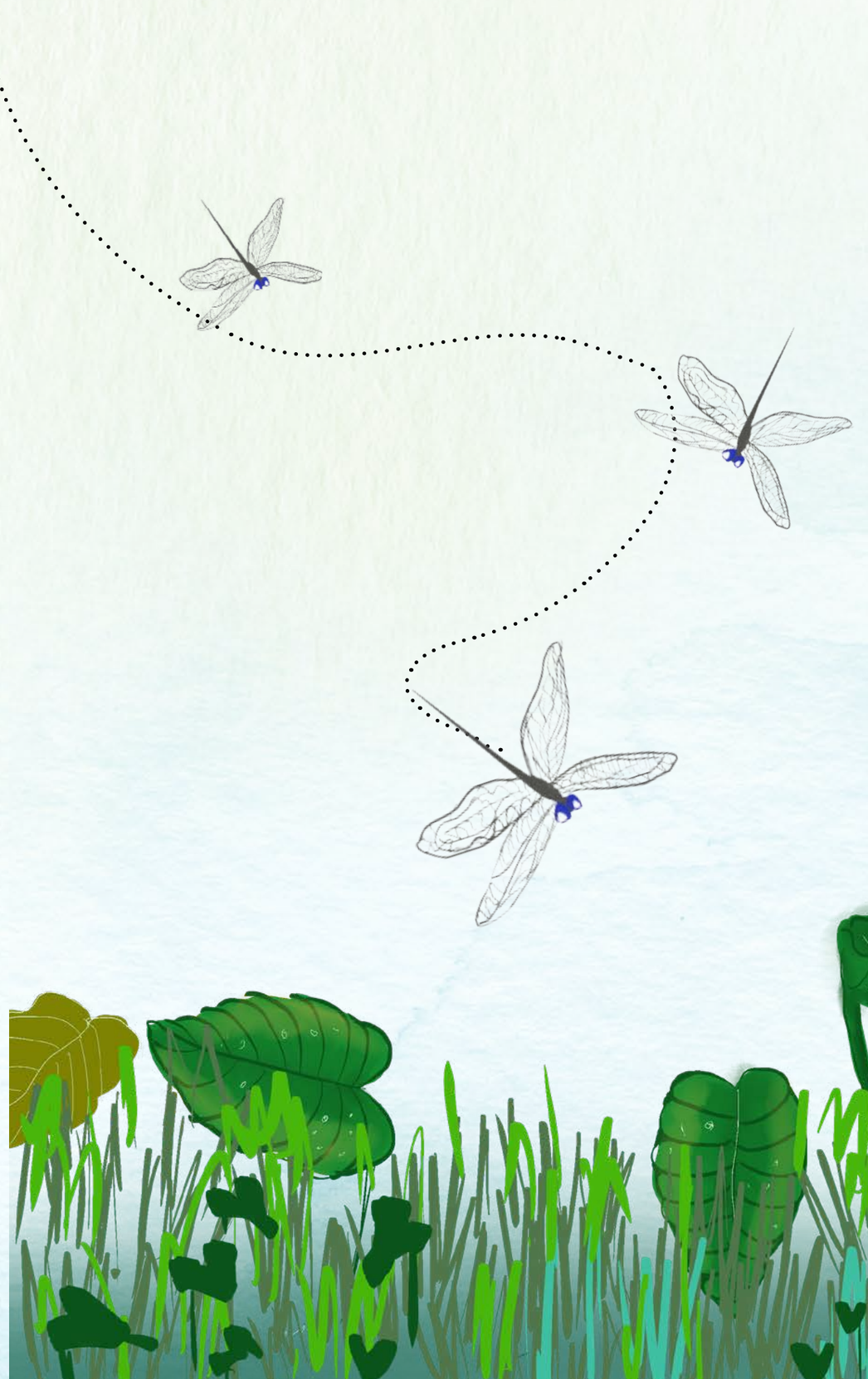
List of Boxes

43 Box 1: Adaptive Management
70 Box 2: List of parameters that can be measured by volunteers
74 Box 3: Makeshift structures coming up in the lake bed and catchment areas in Korattur Lake



List of Abbreviations

AM	Adaptive Management
BOD	Biological Oxygen Demand
CETP	Common Effluent Treatment Plants
CET	Care Earth Trust
CMA	Chennai Metropolitan Area
CMDA	Chennai Metropolitan Development Authority
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CPCB	Central Pollution Control Board
CSR	Corporate Social Responsibility
CRRT	Chennai Rivers Restoration Trust
DWS	Decentralised Wastewater System
DLWMC	District Level Wetland Management Committee
EFI	Environmentalist Foundation of India
EIA	Environmental Impact Assessment
ERA	Ecological Risk Assessment
GCC	Greater Chennai Corporation
IIT	Indian Institute of Technology
ISRO	Indian Space Research Organisation
MoEFCC	Ministry of Environment, Forest and Climate Change
MRTS	Mass Rapid Transit System
NDCs	Nationally Determined Contributions
NGO	Non-Governmental Organisation
NGT	National Green Tribunal
NIH	National Institute of Health
NOC	No Objection Certificate
NWCP	National Wetland Conservation Programme
PIL	Public Interest Litigation
PPP	Public-Private-Partnership
PWD	Public Works Department
RRR	Repair, Renovation, and Restoration
SEZ	Special Economic Zone
TDS	Total Dissolved Solids
TNC	The Nature Conservancy
TNSCB	Tamil Nadu Slum Clearance Board
TSS	Total Suspended Solids
ULB	Urban Local Bodies
USEPA	United States Environmental Protection Agency
WRPI	Water Bodies Protection Index
WRD	Water Resources Department



CHAPTER 1
INTRODUCTION TO WETLANDS

1: WHAT ARE WETLANDS?

The Convention on Wetlands (Ramsar, 1971) has a broad definition of what constitutes a wetland. As per Article 1 of The Convention, a "wetland" includes:
"Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." (UNESCO 1994).
The Central Government of India first notified the Wetland (Conservation and Management) Rules in 2010 and this was subsequently modified in 2017. The national definition specifically excludes river channels, paddy fields, and tanks from the scope of wetlands.
As per the latest definition, wetlands are defined as:
"An area of marsh, fen, peatland or water; whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters, but does not include river channels, paddy fields, human-made water bodies/tanks specifically constructed for drinking water purposes and structures specifically constructed for aquaculture, salt production, recreation and irrigation purposes[1]."
Wetlands can be classified as either coastal or inland and as natural or man-made. The types of wetlands that fall under these categories are provided in Annex 1.

2: WHY DO WE CONSERVE WETLANDS?

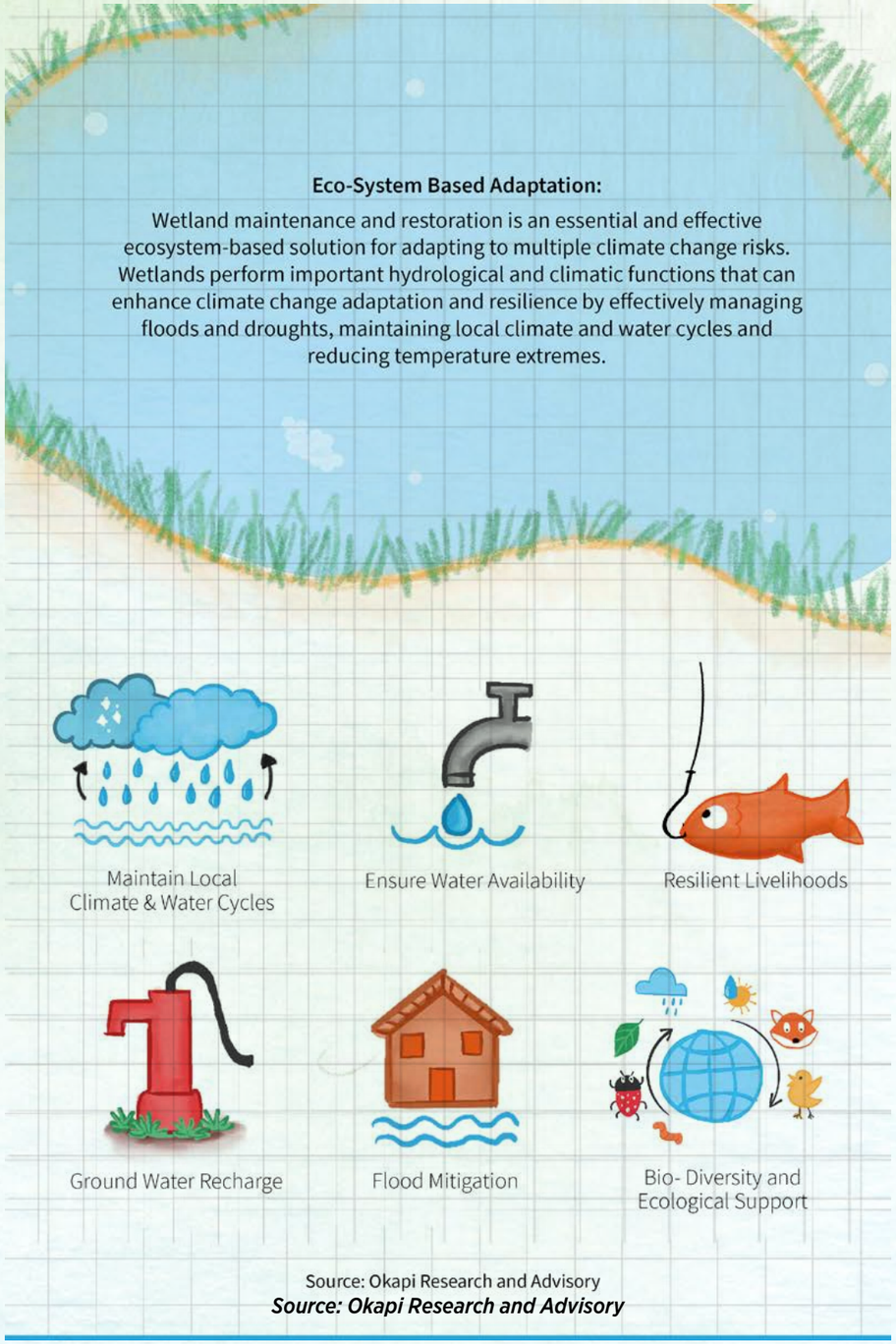
Wetlands are among the most biologically rich environments in the world. As the natural infrastructure of the planet, the interactions between soil, water, plants, and animals in a wetland, enable it to perform several critical functions such as climate adaptation through storm protection, flood mitigation, erosion control, etc.; economic functions through fisheries, water supply, nutrient retention in flood plains and so on (Ramsar Convention Secretariate 2016). This section discusses the role of wetlands in more detail.

1. The non-inclusion of human-made reservoirs refers specifically to dams and reservoirs that have been made exclusively for piped water supply or piped irrigation such as Chembarambakkam or Poondi or Mettur Dam and no other tanks or *erys* like Sembakkam which are human-made but used for irrigation and other allied services.

2.1: CLIMATE CHANGE ADAPTATION

Tamil Nadu has been experiencing an increased frequency of natural disasters and extreme weather events over the past few decades. It is prone to storm surges, cyclones, flooding, and droughts (SDMPP 2018). The entire coast of Tamil Nadu is divided into 3 hazard zones for wind and cyclone risk with the northern coast (including districts – Chennai, Thiruvallur, Kancheepuram, Villupuram, and Cuddalore) situated in a very high-risk zone. In Chennai, the frequency and intensity of heavy rain, cyclones, and droughts have increased within the city limits and extended Chennai Metropolitan Area (CMA) often shifting between cycles of too much and too little rain (Resilient Chennai 2019). Climate projections for the region predict a range of risks including declining seasonal mean precipitation but an increase in frequency and intensity of extreme precipitation events, rising seas, and increasing temperatures (Hijioka et al. 2014; ISRO 2012; DoE 2015, MoEF 2010). Adaptation to these changes requires system-wide solutions that are flexible yet comprehensive and involve a variety of measures that draw upon local, traditional, and indigenous know-how and techniques, such as the ancient ***ery*** system of Tamil Nadu. The ***ery*** system constituted a series of interconnected water bodies /tanks constructed to mediate flood risk and droughts through the slow, gradual movement of water from one tank to the next until it reached the sea, all the while allowing for groundwater recharge. However, with rampant urbanisation, this system, which covered most of Tamil Nadu and irrigated 4 million hectares in 1976 (Jameson and Baud 2016), has broken down.
Wetland maintenance and restoration is an essential and effective ecosystem-based solution for adapting to multiple climate change risks (Noble et al. 2014; Jones et al. 2012). They perform important hydrological and climatic functions that can enhance climate change adaptation and resilience by retaining water on the landscape, maintaining local climate and water cycles, and reducing temperature extremes (Figure 1). For instance, wetlands protect down stream areas from flooding and the erosive impact of storms by storing run-off and reducing peak flows. They play a critical role in determining the local climate and their loss can lead to increased absorption of solar radiation, increased temperatures, and reduced rainfall. Evaporation and transpiration of water can have a cooling effect on the local region (Ramsar Convention 2018). As such, wetlands are a crucial part of the water cycle supporting nutrient cycling (influences water quality) and carbon cycling (influences organic land cover and organic carbon in soils) (Care Earth Trust 2014). Therefore, they are a key determinant of the type and level of ecosystem services delivered, specifically concerning surface water flows, which mostly occur through wetlands themselves (Ibid).

Figure 1: Why wetlands are critical for climate change adaptation



Source: Okapi Research and Advisory

Source: Okapi Research and Advisory

Wetlands also buffer communities against storm surges, reduce wave damage and stabilise water supplies. Apart from these climate-related benefits, wetlands provide many ecological, cultural, and economic co-benefits that contribute to human well-being such as the provision of food, energy, clean water, support to biodiversity and livelihoods, and sites for spiritual and cultural importance (Ramsar Convention 2018). Actions to protect and restore wetlands are critical for countries to achieve their Nationally Determined Contributions (NDCs) under the Paris Agreement and contribute to the Sustainable Development Goals.

2.2: ECOSYSTEM SERVICES

Wetlands offer a range of ecosystem services that are critical for our society. According to the Millennium Ecosystem Assessment (2005), **"these include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits."** (pg. 55).

The range of ecosystem services derived from wetlands is highlighted in an infographic. Research has shown that the economic value derived from the ecosystem services of intact wetlands often exceeds that of converted or altered wetlands[2]. These ecosystem services, particularly those of water supply and wetland fisheries, contribute to livelihoods and poverty alleviation of communities living in proximity to these wetlands. As a result, the degradation of wetlands negatively impacts communities dependent on them.

2. An intact wetland is one in which the wetland area is maintained and its connectivity to other wetlands is also maintained. As a result, the biodiversity of the wetland and its ecosystem services are secure. While a converted wetland is one which has been modified for other purposes. For example, wetlands converted to irrigated land or coastal wetlands converted for aquaculture or shrimp farms.

Services

Provisioning

- **Food** — production of fish, wild games, fruits and grains
- **Freahwater** — storage and retention of water for domestic, industrial and agricultural use
- **Fiber and fuel** — production of log, fuelwood, peat, fodder
- **Biochemical** — extraction of medicines and other materials from biota
- **Genetic materials** — genes for resistance to plant pathogens, ornamental species, and so on.

Cultural

- **Spiritual and inspirational** — source of inpiration; many religious attach spiritual and religious values to aspects of wetland ecosystems
- **Recreational** — opportunities for recreational activities
- **Aesthetic** — many people find beauty or aesthetic value in aspects of wetland ecosystems
- **Educational** — opportunities for formal and informal education and training

Regulating

- **Climate regulation** — source of and sink for greenhouse gases; influence local and regional temperature, precipitation and other climatic processes
- **Water regulation (hydrological flows)** — groundwater recharge/discharge
- **Water purification and waste treatment** — retention, recovery and removal of excess nutrients and other pollutants
- **Erosion regulation** — retention of soils and sediments
- **Natural hazard regulation** — flood control, storm protection
- **Pollination** — habitat for pollinators

Supporting

- **Soil formation** — sediment retention and accumulation of organic matter
- **Nutrient cycling** — storage, recycling, processing and acquisition of nutrients

While fresh water was treated as a provisioning service within the MA, it is also regarded as a regulating service by variuos sectors.

Services of wetlands can be assessed and understood in different ways. In addition to recognising the value it provides as an ecosystem, wetlands also need to be recognised as an integral part of nature that has rights.

2.3: RIGHTS OF NATURE

"**Rights of Nature is the recognition and honouring that Nature has rights. It is the recognition that our ecosystems – including trees, oceans, animals, mountains – have rights just as human beings have rights. Rights of Nature is about balancing what is good for human beings against what is good for other species, what is good for the planet as a world. It is the holistic recognition that all life, all ecosystems on our planet are deeply intertwined. Rather than treating nature as property under the law, rights of nature acknowledge that nature in all its life forms has the right to exist, persist, maintain and regenerate its vital cycles.**" (Global Alliance for the Rights of Nature, n.d)

Whether seen from an ecosystem services approach or the Rights of Nature approach, the role of wetlands in nature is critical – especially as a means of climate change adaptation. Hence the need to prioritise the conservation of wetlands is clear.

3. LEGAL AND REGULATORY PROVISIONS FOR PROTECTION

3.1: INTERNATIONAL:THE CONVENTION ON WETLANDS

The Convention on Wetlands, also known as the Ramsar Convention after the Iranian city where the convention was held, was adopted in 1971 and came into force in 1975. The Convention declares its mission as "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar Convention, n.d).

One of the pillars of the Ramsar Convention's operations is the Ramsar List – a designated **"Wetlands of international importance" list. Each State, while becoming a party to the Convention, is required to submit a site to the Ramsar List. This site, post evaluation, is recognised as having international importance, "not only for the country or the countries in which they are located but for humanity as a whole." (Ramsar Convention, n.d).**

The submission of a wetland site to the Ramsar List is a commitment by the State to ensure "wise use" of the wetland through plans, policies, management actions, and education. "Wise use of wetlands is the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development." (MoEFFC 2010)

In India, the Ramsar Convention guides wetland management and currently, there are 39 Ramsar sites, with Asan in Uttarakhand and Kabartal Wetland from Bihar joining the list in October 2020. The sole Ramsar Site in Tamil Nadu is the Point Calimere Wildlife Sanctuary (MoEFFC, 2020).

3.2: INDIA

In India, The Wetlands (Conservation and Management) Rules, 2010, subsequently modified in 2017 ("Wetland Rules"), provides the regulatory framework for the management of wetlands and falls under the Environment Protection Act, 1986. Other regulations which impact wetland management include:

A. **Forest (Conservation) Act, 1980**
B. **Coastal Regulation Zone Notification 2011**
C. **Biodiversity Act, 2002 and Rules, 2004**
D. **Wildlife (Protection) Act, 1972**
E. **Air (Prevention and Control of Pollution) Act, 1974**
F. **Water (Prevention and Control of Pollution) Act, 1974**
G. **Municipal Solid Waste Act, 2016**

Wetland conservation at the national level is also managed through national-level programmes such as the National Wetland Conservation Programme (NWCP). In 1985, the Government of India established the NWCP in collaboration with State Governments. Under the NWCP, a list of 115 prioritised wetlands has been identified for "urgent conservation and management initiatives".

In addition to the above, policies such as the National Water Policy (2012), the Standing Committee on Water Resources (2012-2013) Report on the Repair, Renovation and Restoration of water bodies (2005), and the National Plan for Conservation of Aquatic Eco-systems (2013) also influence the conservation of wetlands. For instance, the National Water Policy (2012) endorses the need for conservation, promotion, and protection of water. The Report on Repair, Renovation, and Restoration of water bodies recognises that encroachments are threatening water bodies and related functions such as groundwater retention and suggests steps to remove encroachments.

The National Plan for Conservation of Eco-systems (2013) provides a framework for conservation and management of lakes and wetlands and financial assistance to states for the same (CPCB 2019).

4.TAMIL NADU WETLANDS

1.4.1. TAMIL NADU: STATE WETLAND AUTHORITY

According to the National Wetland Rules 2010, each state must constitute a State Wetlands Authority chaired by the state Minister of Forests and including members from multiple ministries. The Authority is also to include independent technical experts in the fields of wetland ecology, hydrology, fisheries, landscape planning, and socioeconomics nominated by the state government.

In accordance with these rules, the Tamil Nadu State Wetlands Authority was constituted in 2016 (Tamil Nadu State Wetland Authority, 2017). This Authority is tasked with preparing and maintaining a comprehensive list of wetlands in the state, preparing management plans for their wise use, advising the National Wetlands Committee on the management of wetlands, and guiding and monitoring the constitution of the District Level Wetland Management Committee (DLWMC) (Tamil Nadu State Wetland Authority, 2016). These committees have been constituted in Tamil Nadu via a Government Order in 2019, a recent move highlighting the increasing awareness on wetland conservation, and 141 prioritised wetlands have been identified for the state.

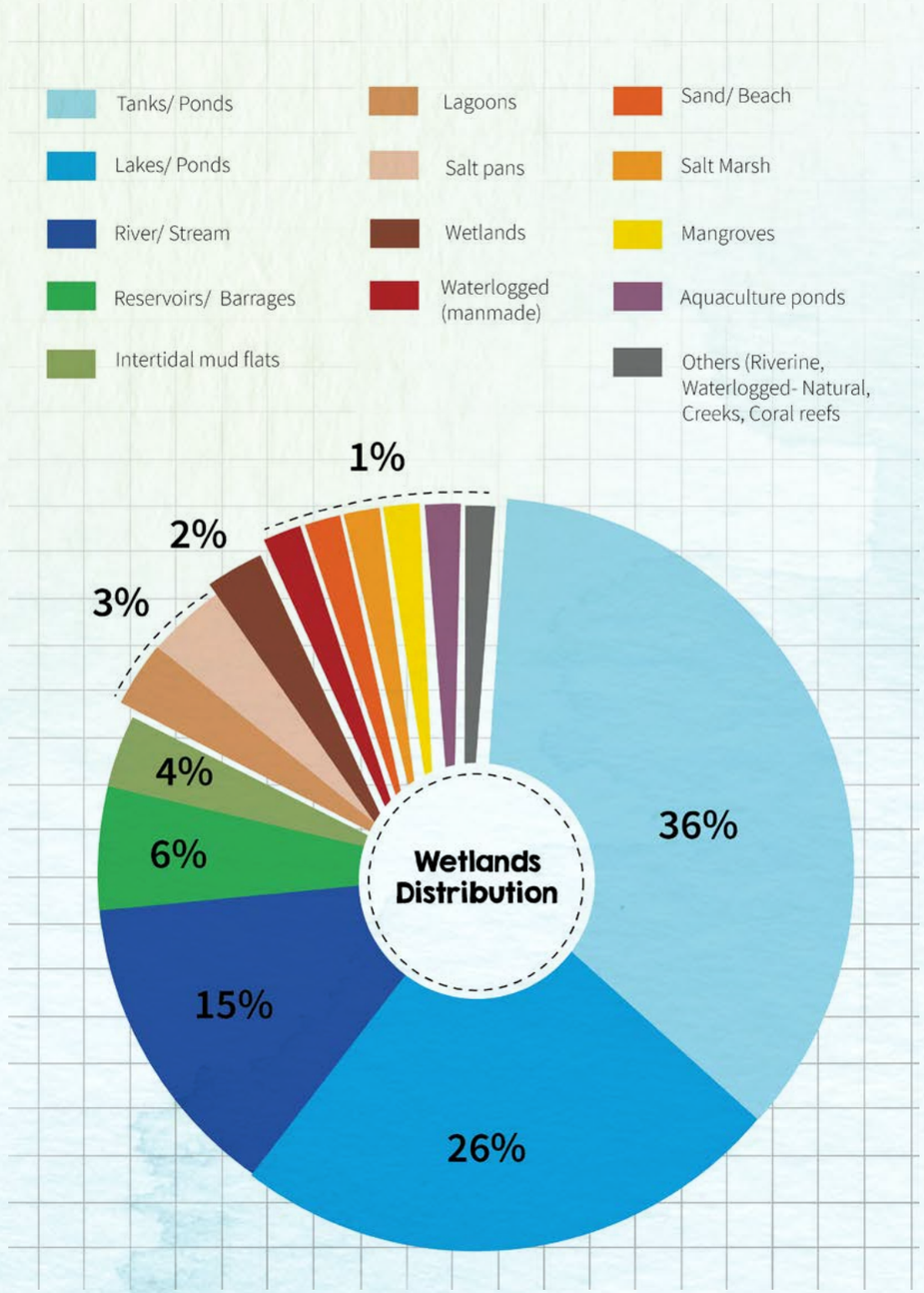
1.4.2. WETLANDS IN TAMIL NADU

In Tamil Nadu, the terminology of water bodies has historically been varied and detailed and the management of these has been customised according to the type. The classification of water bodies was based on three main parameters – area and extent, depth, and the flow pattern. Based on the above, some of the local nomenclatures for them include ***ery, kulam, kuttai, thangal, odai, madavu, and uruni***.

For instance, ***ery*** is the term used to define traditional storage reservoirs that are contained in earthen embankments or bunds. These reservoirs play an important role in irrigation, function as a storage device, help in groundwater recharge, and function as a flood control mechanism by preventing soil erosion and wastage of run-off (Mukundan, 2005).

In 2010, the National Wetland Inventory and Assessment was prepared by the Indian Space Research Organisation (ISRO)'s Space Applications Centre. Assessments were developed at the state and district levels. Using remote sensing methods, the National Wetland Atlas for Tamil Nadu estimated a total wetland area of 902534 Ha, accounting for close to 7% of the total geographic area (SAC 2010). Currently, 141 wetlands have been prioritised by the state. The wetland type-wise distribution is illustrated in Fig. 2.

Figure 2: Wetland Distribution



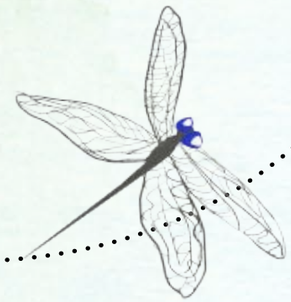
Source: Ibid

1.4.3. WETLANDS OF CHENNAI

The Greater Chennai Corporation (GCC) area (426 sq. km.) has an estimated total of 474 wetlands (Bhaskar et al, 2017). The Government of Tamil Nadu's Public Works Department (PWD) estimates that in Chengalpet, Kancheepuram, Chennai, and Thiruvallur districts, there are about 2100 major tanks and 2200 minor tanks[3] of which around 100 – 200 have lost their efficacy due to pollution and urbanisation (interview with PWD 2021).

The most critical wetland in Chennai's drainage system is the Pallikaranai Marsh, a freshwater Marsh which, along with its satellite wetlands, forms a large part of the floodplain on which South Chennai is located. The Pallikaranai marsh drains an enormous area of about 250 square kilometres, including 54 satellite wetlands and over the years, its size has drastically reduced from 6000 hectares in the 1990s to 593 hectares at present (Bhaskar et al, 2017). Apart from the Pallikaranai marsh, there are several *erys*, temple tanks, ponds, lakes, and five reservoirs that provide water to the city, dotting the landscape.

The following maps (Figs. 3 to 7) present a temporal illustration of the changes in the CMA since 1980[4]. All the maps have been mapped for November and December to show the peak water holding capacity of the wetlands. In general, the maps illustrate a decrease in the percentage of wetland area. The years 2000 and 2020 show an increase due to exceptional circumstances. In 2000, the increased wetland area (predominantly along the coast) is not a reflection of an increase in the water holding capacity of wetlands, rather it is due to overflow from the Buckingham canal[5]. While in 2020, the increase in wetland areas can be attributed to a productive monsoon and high unseasonal rainfall.



3. See chapter 3 for details.
4. The maps from 1980 to 2010 have been prepared using a sampling technique based on maximum likelihood classification while the 2020 map is based on visual interpretation.
5. Buckingham canal is a shallow canal which was designed in such a way that overflows from neighbouring wetlands could be accommodated.

Figure 3: Chennai Metropolitan Area 1980

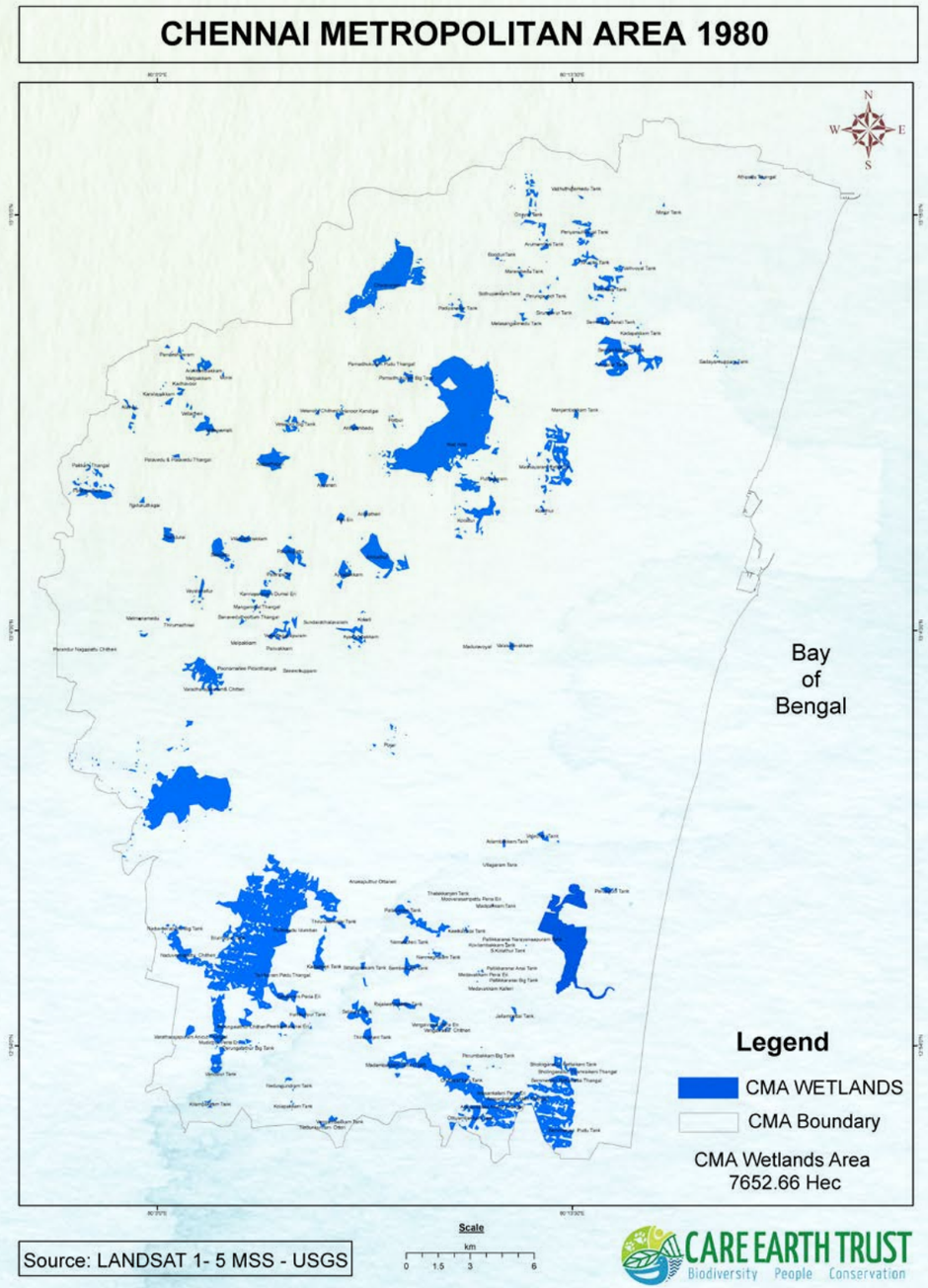


Figure 4: Chennai Metropolitan Area 1990

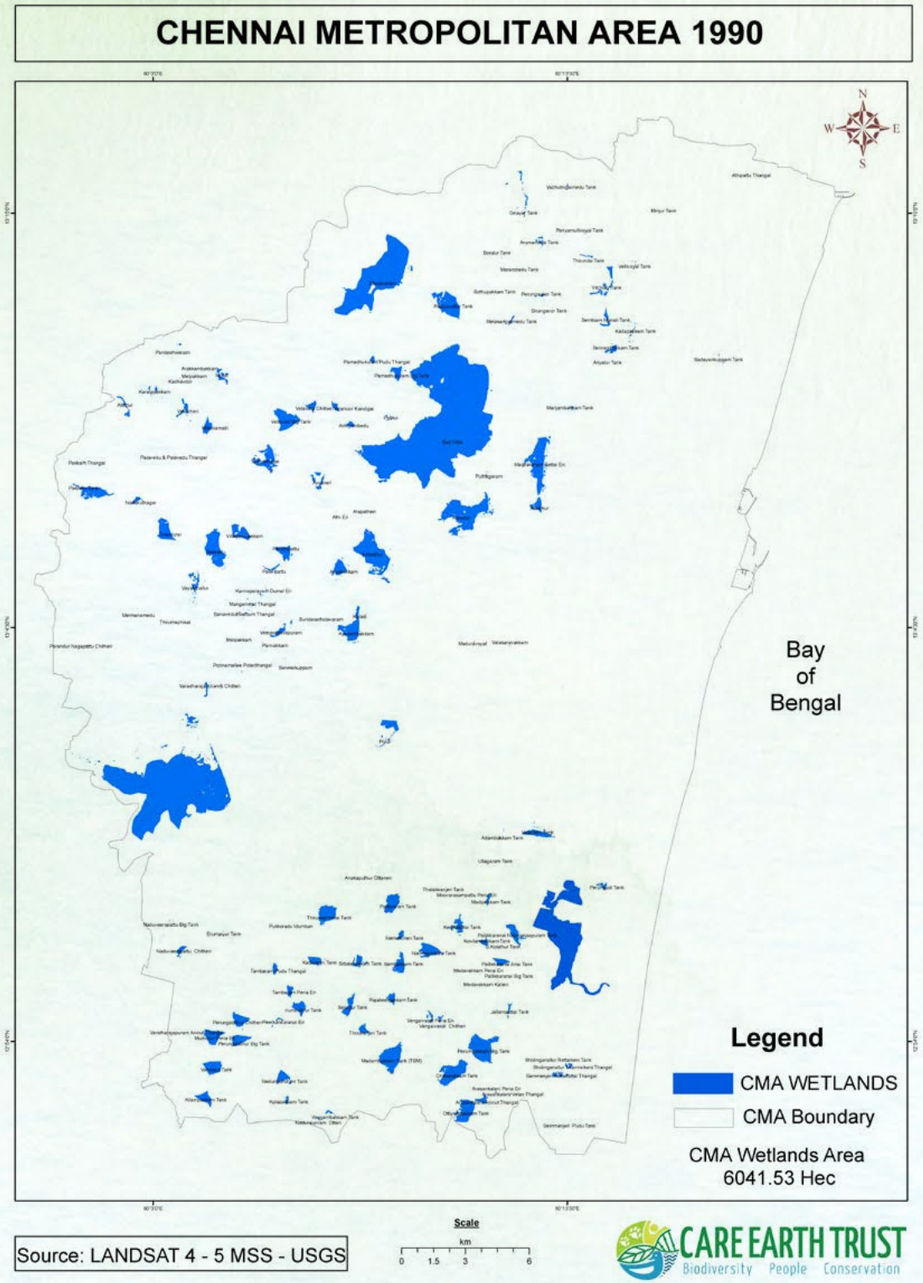


Figure 5: Chennai Metropolitan Area 2000

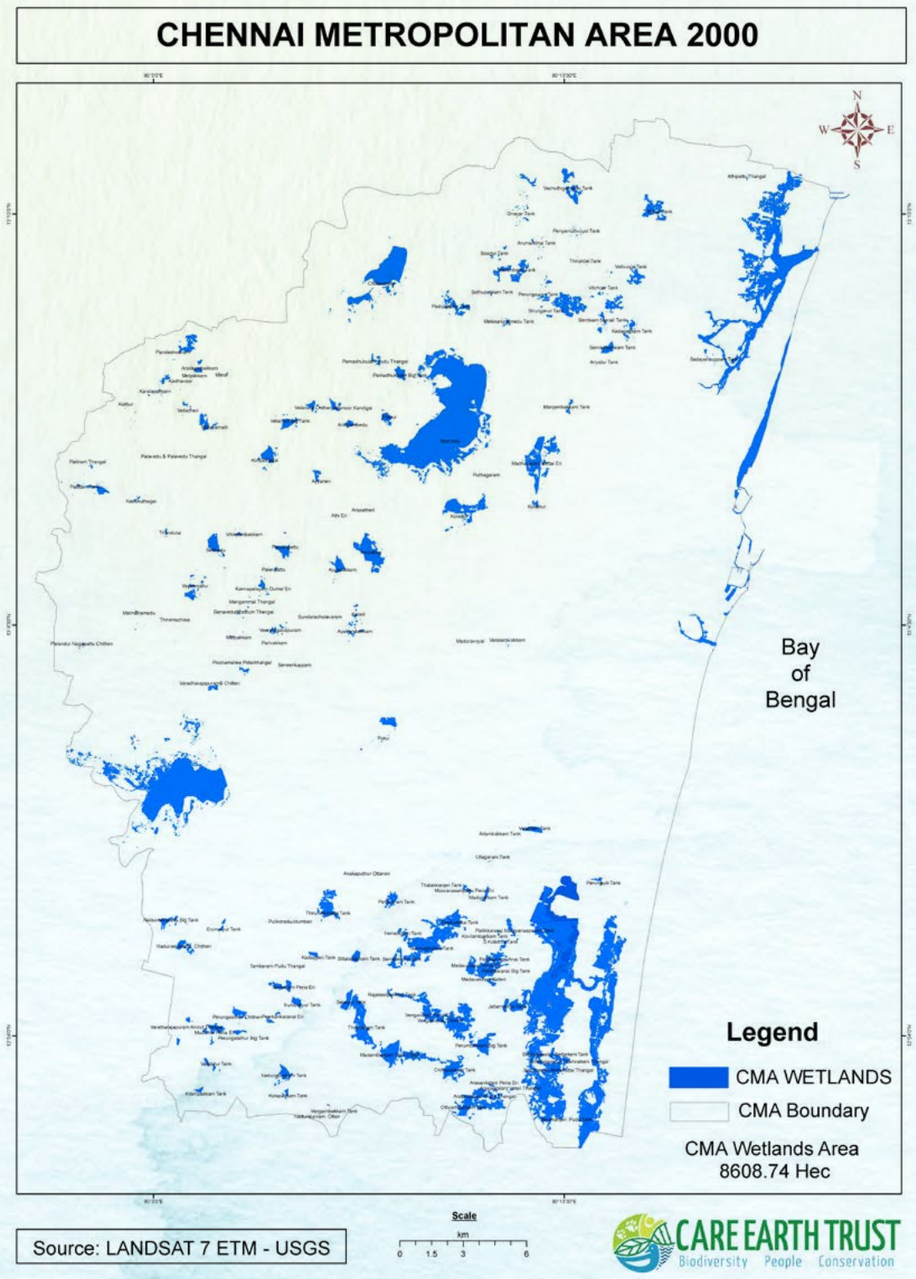


Figure 6: Chennai Metropolitan Area 2010

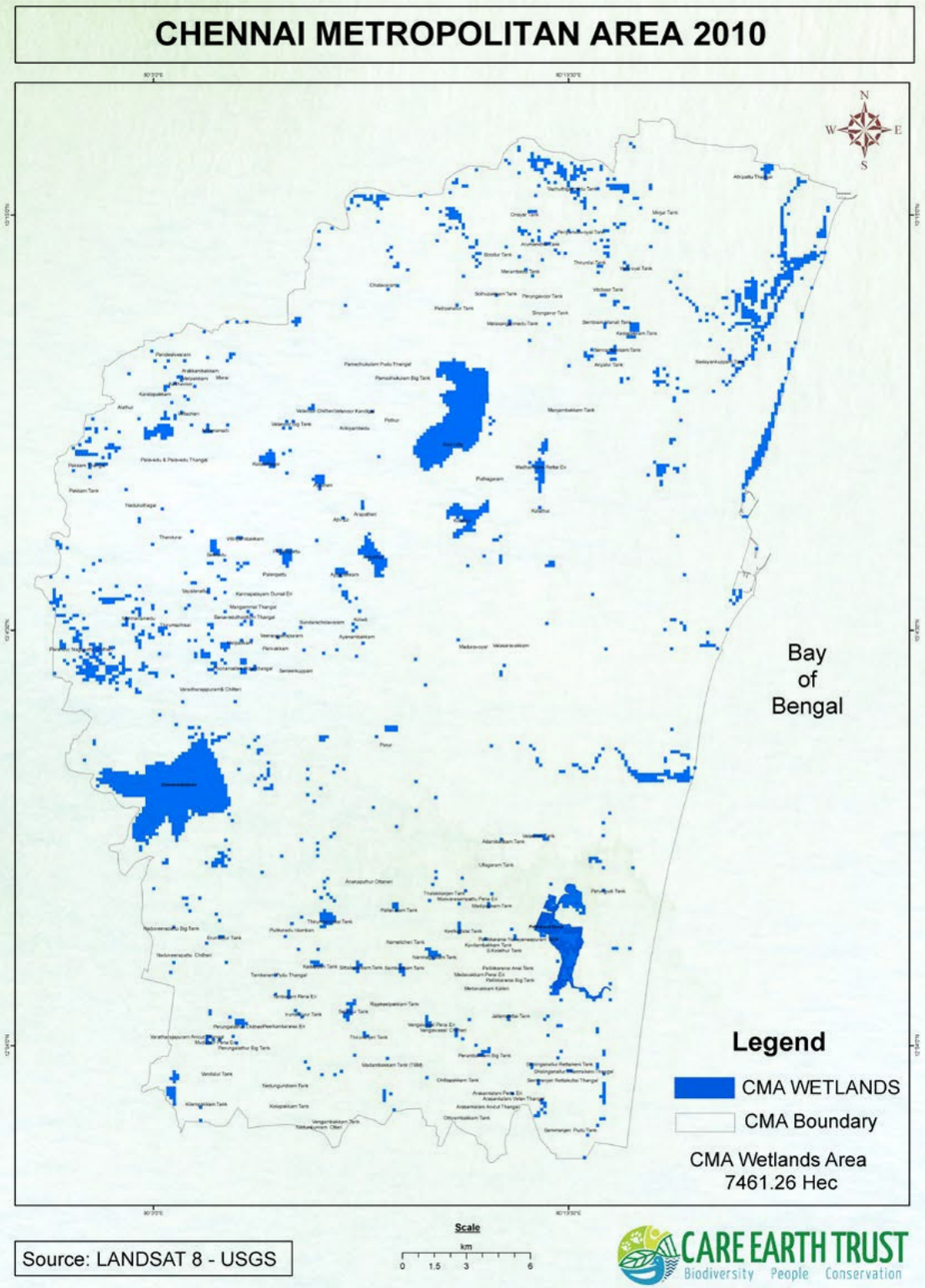
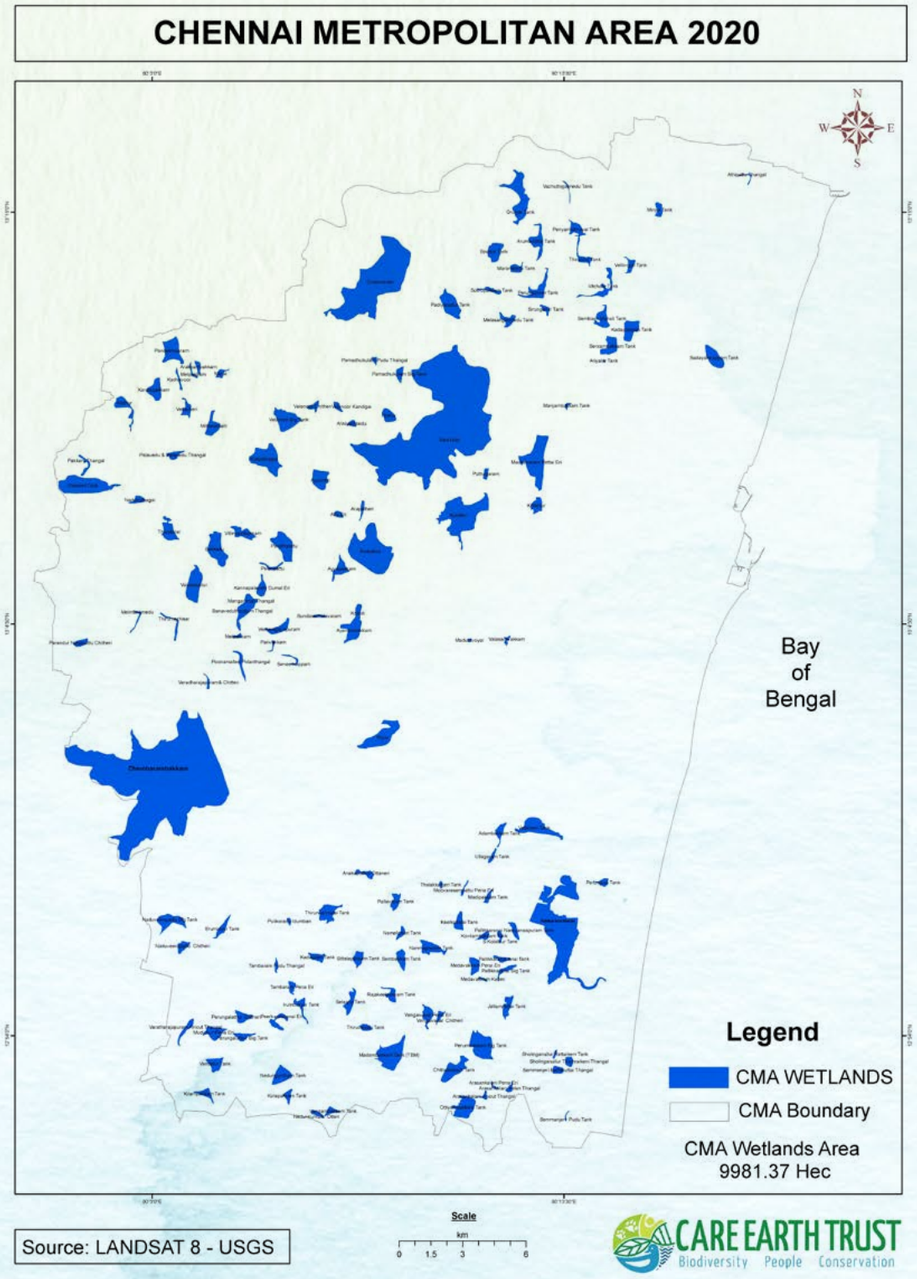
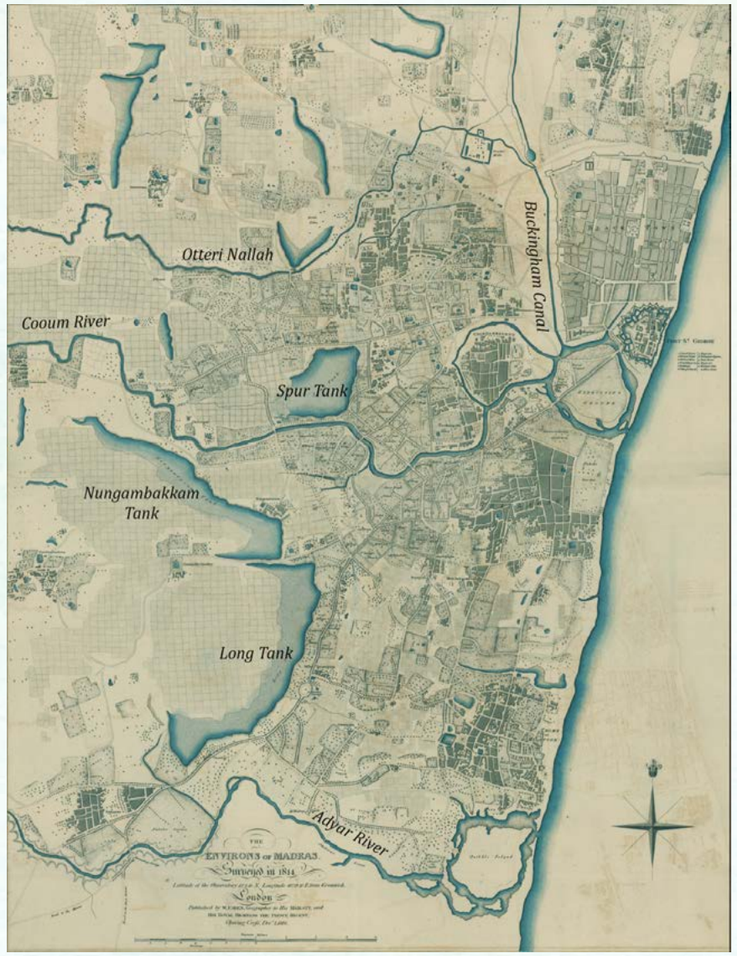


Figure 7: Chennai Metropolitan Area 2020



The above maps reveal a change (marginal increase and decrease) in the extent of wetlands in the CMA. They do not show the wetlands within the core city (426 sq. km) as the city only has wetlands of smaller size i.e. ponds that are too small to feature on the map. Almost all the sizeable wetlands which once dotted the city have all been reclaimed for various purposes. Some examples include the 'Long Tank' which was reclaimed to construct government buildings, the Nungambakkam lake reclaimed to construct Valluar Kottam (Fig. 8) The Lily Pond reclaimed for the new Moor market built in the 1980s, and Nehru stadium. Similar examples can also be taken from the CMA presented later in this report, where rapid and unchecked urbanisation has compromised not only the extent but also the quality and character of the wetlands.

Figure 8: Historical Map of Madras 1816



Source: Ruderman Antique Maps 1816

5. SCOPE OF THE HANDBOOK

Several restoration efforts have taken place and are underway in the CMA. A sizeable portion of these are volunteer-based cleaning efforts and as a whole, these efforts have contributed significantly to improving the local environment. However, ecological restoration is a more scientific, systematic, and effective process that ensures short and long-term benefits to the ecosystem and society. Therefore, the purpose of the handbook is to:

a. **present a step-by-step overview of the key steps involved in ecological restoration by demystifying the science behind the restoration process guiding readers on the right methods to follow and;**
b. **help stakeholders realise the importance of pre-project planning and research, continual monitoring, and post-implementation management of efforts to sustain long-term impact. This is something that is lacking in most restoration efforts thus far due to limited financial, technical, and human resources but is critical for success.**

The handbook will focus on wetlands that are static such as ponds, lakes, *erys*, etc. (and not rivers or streams) within the CMA.

The Handbook is organised into seven chapters. The first chapter is an introduction to some of the basic wetland terminologies, the wetlands of Chennai, and the regulatory framework governing the conservation of wetlands. The second chapter discusses how urbanisation has impacted waterbodies in Chennai while the third chapter illustrates how Chennai's lakes are governed and the role of stakeholders in this process. The fourth chapter offers a step-by-step description of the key measures/steps that should be undertaken as part of a static wetlands restoration process. The fifth chapter provides some thoughts on monitoring and evaluation of such efforts. The sixth chapter describes the importance of sustainable management to ensure restoration efforts have a long-term positive impact. Finally, the handbook presents five case studies of lake restoration efforts undertaken by different agencies across Chennai.

BIBLIOGRAPHY

Care Earth Trust. (2014). Comprehensive Management Plan for Pallikaranai Marsh 2014 – 2019, Conservation Authority for Pallikaranai Marsh, Government of Tamil Nadu.

Central Pollution Control Board. (2019). Indicative Guidelines for Restoration of Water Bodies, Ministry of Environment, Forest and Climate Change, Government of India.

Bhaskar, A., Babu Rao, G., Vencatesan, J. (2017). Characterization and Management Concerns of Water Resources around Pallikaranai March, South Chennai. In P. Rao & Y.Patil (Eds.), Reconsidering the Impact of Climate Change on Global Water Supply, Use, and Management (pp. 102 – 121). IGI Global.

Department of Environment (DOE). (2015). Tamil Nadu State Action Plan on Climate Change (TNSAPCC) final draft report. Government of Tamil Nadu. Retrieved from: http://www.environment.tn.nic.in/sapcc.html

Global Alliance for the Rights of Nature, n.d., What is Rights of Nature? https://therightsofnature.org/what-is-rights-of-nature/

Hijioka, Y., Lin, E., Pereira, J.J., Corlett, R.T., Cui, X., Insarov, G.E., Lasco, R.D. & Surjan, A., (2014). Asia. In Barros, V.R. et al. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1327- 1370). Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Indian Space Research Organisation (ISRO). (2012). Coastal Zones of India. Space Applications Center, ISRO. Ahmedabad: Chandrika Corporation.

Jameson, S. & Baud, I. (2016). Varieties of knowledge for assembling an urban flood management governance configuration in Chennai, India, Habitat International, 54. 112-123.

Jones, H.P., Hole, D.G., Zavaleta, E.S. (2012). Harnessing nature to help people adapt to climate change. Nature Climate Change, 2, 504 – 509

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-Being: A Framework for Assessment, Chapter 2: Ecosystems and Their Services. https://www.millenniumassessment.org/documents/document.49.aspx.pdf

Ministry of Environment and Forests (MoEF). (2010). Climate Change and India: a 4*4 Assessment. A Sectoral and Regional Analysis for 2030s. Government of India. Retrieved from: http://www.moef.nic.in/downloads/public-information/fin-rpt-incca.pdf

Ministry of Environment, Forest and Climate Change (MoEFFC) (2020). Ramsar Sites of India – Factsheets. Ministry of Environment, Forest and Climate Change, Government of India, http://moef.gov.in/wp-content/uploads/2019/09/Ramsaar-Factsheets_2020-Final-8-May-2020.pdf

Ministry of Environment, Forest and Climate Change (MoEFFC) (2016). National Wetland Conservation Programme. Ramsar Convention on Wetland and Salim Ali Centre for Ornithology and Natural History, Government of India, http://moef.gov.in/national-wetland-conservation-programme-nwcp/

Mukundan, T.M. (2005). The Ery System of South India. Akash Ganga Trust.

Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B & Villamizar, A., (2014). Adaptation needs and options. In Field et al. (eds), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, (pp. 833-868), Cambridge, United Kingdom, and New York, USA: Cambridge University Press.

Ramsar Convention Secretariate. (2016). An Introduction to the Ramsar Convention on Wetlands, 7th ed. https://www.ramsar.org/sites/default/files/documents/library/handbook1_5ed_introductiontoconvention_final_e.pdf

Ramsar Convention (n.d.). The Convention on Wetlands and its Mission. https://www.ramsar.org/about/the-convention-on-wetlands-and-its-mission

Ramsar Convention. (2018). Wetland Restoration for Climate Change Resilience. Briefing Note 10. https://www.ramsar.org/sites/default/files/documents/library/bn10_restoration_climate_change_e.pdf

Resilient Chennai. (2019). Resilient Chennai - Kaleidoscope: A city through my eyes. Chennai: 100 Resilient Cities, Greater Chennai Corporation, Okapi Research, and Advisory.

Ruderman, B.L., (1816). The Environs of Madras, Barry Lawrence Ruderman Antique Maps

Tamil Nadu State Wetland Authority (2017). http://tnswa.org/state-level-authority

Tamil Nadu State Wetland Authority (2016). https://www.forests.tn.gov.in/pages/view/Tamil-Nadu-State-Wetland-Authority/

Ramsar Convention (n.d.). Wetlands of International Importance (Ramsar sites). https://www.ramsar.org/about/wetlands-of-international-importance-ramsar-sites

Space Applications Centre (SAC) (2010). National Wetland Atlas: Tamil Nadu, SAC/RESA/AFEG/NWIA/ATLAS/22/2010, Indian Space Research Organisation, https://vedas.sac.gov.in/vedas/downloads/atlas/Wetlands/NWIA_Tamilnadu_Atlas.pdf

United Nations Educational, Scientific and Cultural Organisation. (July 13, 1994). Certified Copy of Convention on Wetlands of International Importance especially as Waterfowl Habitat. https://www.ramsar.org/sites/default/files/documents/library/scan_certified_e.pdf

INTRODUCTION TO WETLANDS

CHAPTER 2
CHENNAI'S URBANISATION CONTEXT

Southern cities are strongly influenced by the urban development agenda and the aspiration of a 'world-class city' and Chennai is no exception (Hommes et al. 2019; Roy et al. 2018a). A predominant focus on urban growth has significantly shaped how a city and its peri-urban regions have developed and has transformed the environmental landscape of the region (Roy et al. 2018a; Roumeau et al. 2015; Jameson & Baud 2016). For instance, the vision for making Chennai into an automobile hub manifested itself in the Western suburbs where special economic zones (SEZs) were demarcated with promises of 24/7 water and electricity supply and other incentives to attract large automobile manufacturers. Similarly, the idea of developing an IT corridor to promote economic development emerged in the early 2000s when several IT companies set up their offices along the Old Mahabalipuram Road (Roumeau et al. 2015) in the southern part of the city. In both these instances, as more and more companies started setting up their units, several hectares of land were converted from agricultural and natural uses to commercial, residential, and industrial use to meet the demand for not just office/ factory space but also other related services like housing, retail, and service industry (Roy et al. 2018a). This was also a period when the entire region was suffering from severe drought which exposed dry lake beds and barren land without any agriculture, making land conversions easier (Roumeau et al. 2015). The Chennai IT Corridor is built on fragile wetland systems such as Pallikaranai Marshlands and Muttukadu Laguna which comprise several inter-connected water bodies.

2.1. MANAGING LAND USE AND ENCROACHMENTS

With rapid urbanisation and development, legal land reclamations and informal encroachments have been and continue to be a key threat to Chennai's water bodies. Land reclamations through de-notification of whole or part of wetlands for various purposes have been a practice for several decades. Some prominent examples include the '*Ery* Schemes' in the 1970s and 1980s which was a World Bank Funded project that involved reclaiming dry lakes for housing blocks (Resilient Chennai 2019); land reclassifications of portions of Ennore Creek for a thermal power plant and large portions of Pallikaranai marsh for offices, housing blocks, resettlement colonies, transport corridors, and the Perungudi dumpsite. Another well-known example is the MRTS corridor in

Buckingham Canal. There have also been and continue to be informal encroachments which include parcelling and selling whole/portion of lakes for development, sewage, and solid waste dumping and by informal settlements due to inability to access affordable housing.

Preventing land reclamations requires more stringent planning and strengthening of mechanisms like the Development Control Rules, Master Plans, and the Environmental Impact Assessment (EIA) norms regarding "developments" on lands on flood plains and close to water bodies. While managing encroachments and preventing them is particularly challenging in any lake restoration effort and requires long-term monitoring of water bodies, as they often tend to return. Lakes, whose original water spread area is nearly intact and where encroachments have been effectively managed are those cases where the High Court or NGT have intervened or where private citizens have taken ownership and initiative to continue to either formally or informally monitor and report encroachment to public authorities so that action can be taken. As such this issue highlights the need for continued monitoring and the multi-stakeholder involvement in managing lakes to ensure the sustained impact of restoration efforts.

The following maps (Figs. 9 & 10) provide a temporal understanding of how the water spread area of some lakes in the CMA has reduced over time probably due to rampant urbanisation, encroachments, and other factors.

Figure 9: Madambakkam Lake Time Series

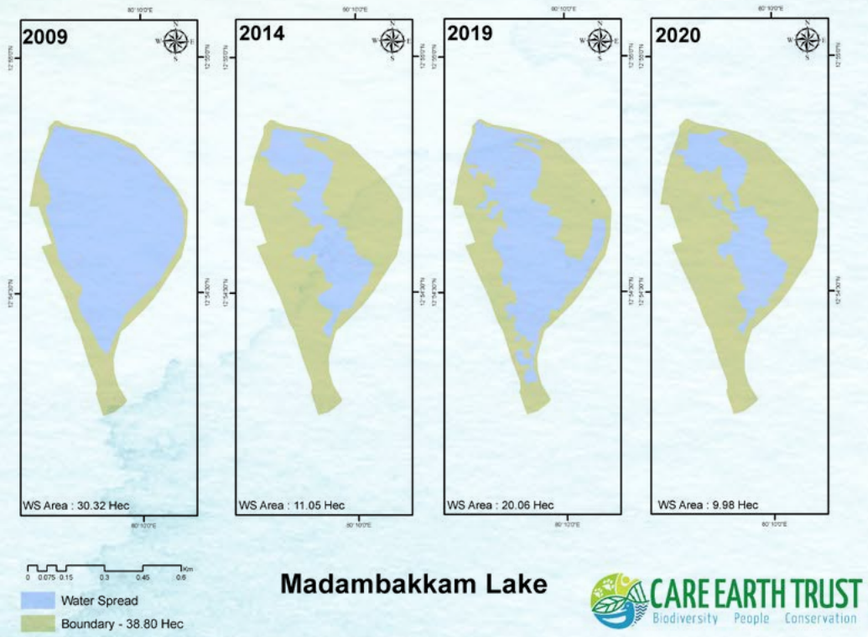
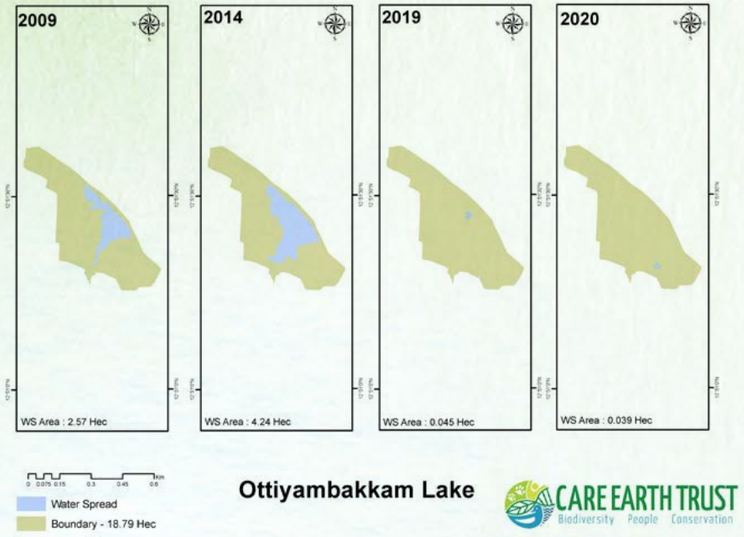


Figure 10: Ottiyambakkam Lake Time Series



2.2. THE DEMAND FOR URBAN INFRASTRUCTURE

Another critical issue related to the development and growth of peri-urban areas is that the demand for more and more urban services such as piped water and sewerage network, solid waste management, and better transport facilities far outpace the rate at which they continue to be provided by the government because neither the Urban Local Bodies (ULBs) (town panchayats and municipalities) nor CMWSSB (which is responsible for providing piped water and sewerage network to the IT corridor), have the resources to serve this sudden boom. Therefore lakes, *erys*, ponds, tanks, and other wetlands which are rain-fed and dry for most of the year have become common spots for dumping garbage and sewage (Roumeau et al., 2015) (Fig. 11 on the right side). As such, most of these water bodies now fail to offer the natural ecosystem functions that they are meant to (e.g., flood control and groundwater government recharge).

Successive disasters, namely the 2015 floods, cyclone Vardah in 2016 followed by drought in 2018-2019 underscored the plight of water bodies and the need for their restoration and revival to build Chennai's resilience to future risks. Local and state governments, as well as local communities, realised the critical role water bodies such as lakes, ponds, tanks, *erys*, and rivers play in flood and drought management. As a result, significant effort and resources were dedicated to the restoration of these environmental resources. Through the Smart Cities Mission, Greater Chennai Corporation (GCC) has planned to restore 210 lakes/ponds that they have identified in Chennai city.

Figure 11: Sewage discharge in Pudhuthangal Lake

Source: Care Earth Trust

BIBLIOGRAPHY

Graft, A., Mahalingam, A., Ramachandran, A., Ayyangar, A., Hemasree, O., Mankar, D., Naveen Sai, U. & Roy, P. (2018). Chennai: State of Water. Okapi Research and Advisory, Fields of View, Centre for Urbanisation, Buildings, and Environment, IIT Madras and Tamil Nadu State Planning Commission, Government of Tamil Nadu.

Hommes, L., Boelens, R., Harris, L.M., & Veldwisch, G.J. (2019). Rural-urban water struggles: urbanizing hydrosocial territories and evolving connections, discourses and identities. Water International, 44(2), 81-94;

Jameson, S & Baud, I. (2016). Varieties of knowledge for assembling an urban flood management governance configuration in Chennai, India. Habitat International, 54, 112-123.

Roumeau, S., Seifelislam, A., Jameson, S., Kennedy, L. (2015). Engaging with Sustainability Issues in Metropolitan Chennai. USR 3330 "Savoirs et Mondes Indiens" Working papers series no. 8.

Roy, P., Kumar, K., Karunakaran, Z., Ayyangar, A., Ramachandran, A., Banerjee, A., Graft, A. & Mahalingam, A. (2018a). Chennai: Urban Visions. Okapi Research and Advisory, Fields of View, Centre for Urbanisation, Buildings, and Environment, IIT Madras and Tamil Nadu State Planning Commission, Government of Tamil Nadu.

Roy, P., Kumar, K., Karunakaran, Z.& Ayyangar, A. (2018b). Chennai: Emerging tensions in Land, Water, and Waste Governance. Okapi Research and Advisory, Fields of View, Centre for Urbanisation, Buildings, and Environment, IIT Madras and Tamil Nadu State Planning Commission, Government of Tamil Nadu.

CHAPTER 3
GOVERNANCE OF LAKES AND PONDS IN THE CMA

Lake management and governance are characterised by the presence of multiple stakeholders. Typically, water bodies such as rivers, streams, and lakes and their inlets and outlets are owned by the PWD, Government of Tamil Nadu. If they are not owned by PWD, then they are owned by the Rural Development and Panchayati Raj Department or local bodies with management powers vested with the local bodies or other departments[6]. According to a water management expert, historically, a wetland would have two or three inlets, one outlet, and one surplus weir[7]. However, with urbanisation, stormwater drains are also connected to water bodies, increasing the number of channels and inlets[8] significantly and making management more challenging (Interview with CET 2020).

Further, the government is increasingly turning to NGOs / civil society groups and corporates to restore wetlands. This means, there is the presence of multiple stakeholders who are dependent on each other for different purposes which could range from administrative to knowledge sharing, vigilance, and finance which makes the governance of wetlands restoration complicated.

Some of these agencies/stakeholders are directly involved in the maintenance, use, and restoration process of the lakes, while others indirectly influence the socio-ecological condition around the water bodies by shaping aspects of land use, solid waste, sewerage, etc.

In this section, we list the common stakeholders involved in restoration along with their roles and responsibilities and provide a tentative stakeholder map.

A.PUBLIC WORKS DEPARTMENT (PWD):

The PWD owns all water bodies which serve a command area of *ayacut* area of 40 hectares (100 acres) or more. These are called major tanks. They also own all the system tanks[9] irrespective of the command area. Around 14,000 tanks are maintained under the custody of PWD whose right to own comes from the East India Company which created the PWD more than 153 years ago. Traditionally PWD is an irrigation department and funds for restoration and rehabilitation are typically provided for the major tanks which serve irrigation purposes. In 2000 the PWD was bifurcated into the Buildings and Water Resources Department (WRD) with the latter serving a larger scope that focuses on equitable distribution of water across sectors (Interview with PWD 2021). Within the Chennai Metropolitan Area (CMA), the PWD own

6. Temple tanks, for instance are managed by the Hindu Religious and Charitable Endowments Department.
7. A Surplus weir is a structure that is used to dispose surplus water from a water tank to a downstream water tank.
8. Inlets are pipe lines opening into the lake while channels are natural or man-made ways that link two or more water bodies.
9. System tanks are those which are connected to a riverine system where the flow from the river is directed to the tank.

several water bodies such as lakes and tanks which are no longer used for irrigation purposes, and which have been 'urbanised'[10].

According to the PWD, the 2005 floods (and later 2015) provided a wake-up call that urbanised tanks (those that no longer supply water for irrigation) also need to be taken care of (Ibid.). For this purpose, PWD is working with NGOs as they recognise that they do not have the necessary resources to restore all water bodies. Currently, water bodies are being taken up for restoration depending on the need and the interest around them. The PWD's Climate Adaptive Restoration Project is one such effort (more details in Chapter 7).

B. RURAL DEVELOPMENT AND PANCHAYATI RAJ DEPARTMENT:

Most water bodies that have a command area of fewer than 40 hectares are owned by the Rural Development Dept. However, these are vested with other government bodies such as local bodies - panchayats, ULBs, or Hindu Religious & Charitable Endowments Department (HR&CE), etc. In some cases, the ownership of water bodies may have been transferred to a local body such as Greater Chennai Corporation in Chennai city. Vesting powers give the department powers to maintain the water body but not manipulate it i.e., change its basic characteristics and attributes (Ibid.). The Rural Development Department also hosts the Government of India's Jal Shakti Abhiyan in Tamil Nadu.

C. FOREST DEPARTMENT:

Forest Department also owns several wetlands which are less than 40 hectares, and which are on Forest lands. Unlike PWD or other owning departments, the Forest Department has full powers to remove encroachments on wetlands within their jurisdiction without depending on other departments.

D. REVENUE DEPARTMENT:

Typically, the land on which the water body is located is owned by Revenue Department, especially for water bodies with a command area of fewer than 40 hectares. As they have the land records, Revenue Department is a critical stakeholder in identifying encroachments in water bodies and developing field map drawings demarcating the water body and dry land, which are the basis of PWD drawings (Roy et al. 2018b).

10. Urbanisation processes such as construction, excess ground water pumping, land use change etc. have changed the character of lakes.

E. URBAN LOCAL BODIES (ULBs)[11]:

The CMA consists of three districts – Chennai, Kancheepuram, and Thiruvallur with numerous ULBs such as Town Panchayats, Municipalities, and Greater Chennai Corporation (GCC). ULBs play a critical role in restoration – they either own the water body or in most cases have to vest powers to manage and maintain them.

ULBs are also responsible for ensuring that solid waste and sewerage are not disposed of in water bodies and if they are, to clear the waste. Often, they are pressurised by residents or the judicial system to do this. In Chennai, GCC has management powers for most of the ponds and lakes within the city limits of 426 sq. km. and according to the Chennai city Resilience Strategy 2019 (Resilient Chennai 2019), has identified and is in the process of restoring 210 water bodies in the city. GCC also provides building permission for small developments within the city, thereby having powers to ensure that permissions are not given close to water bodies.

F. CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY (CMDA):

The CMDA is tasked with ensuring that developments do not come up close to the water body and there are no encroachments on existing water bodies. For all large developments that require environmental clearances, a No Objection Certificate (NOC) must be obtained from the authority that owns the lake/ pond.

G. TAMIL NADU SLUM CLEARANCE BOARD (TNSCB):

If any informal settlements are identified as encroachments and must be removed, then TNSCB is tasked with relocating the families to resettlement colonies.

H. HIGH COURT / NATIONAL GREEN TRIBUNAL (NGT):

The Madras High Court and the NGT play an important role in hearing public interest litigations (PILs) to protect lakes and clear encroachments. They have also helped in several cases such as Chitlapakkam, to stay land conversions and prevent ULBs from parcelling and selling lake bed land for developments.

11. ULBs are defined as local bodies constituted for local planning, development and administration in urban areas, according the Statistical Year Book, available here: http://mospi.nic.in/sites/default/files/Statistical_year_book_india_chapters/local%20bodies.pdf

I. LOCAL COMMUNITIES:

Local communities are critical in bringing the plight of the lakes to the limelight, in monitoring the progress of the lake restoration efforts, and in ensuring restoration efforts are sustained over time. In some cases, like Chitlapakkam and Madipakkam (see chapter 7 for details), they are the driving force behind the restoration, pushing the government to engage actively in the effort and even holding community mobilisation activities to collect money for lake restoration.

J. NGOs AND OTHER PRIVATE ENTITIES:

Often, the ULB brings in an NGO to oversee/carry out either the entire or some portions of the restoration work. GCC, for instance, is working with the Environmentalist Foundation of India (EFI) and Care Earth Trust to restore several ponds within the city. In the case of Chitlapakkam lake, Care Earth Trust (CET) has been brought in to work on the flora. In the CMA, several companies such as Cognizant, Grundfos, Rane, Tata Consultancy Services, and HCL have funded lake restoration efforts. Apart from NGOs and private companies, academic institutions such as the Indian Institute of Technology Madras (IITM) and Anna University, are playing a key role in the future restoration of specific waterbodies.

Fig. 12 illustrates the stakeholders that are likely to be involved in lake restoration efforts in the CMA and their roles.

Figure 12: Stakeholders typically governing lake restoration and protection

From the above illustration, two learnings stand out. First, there are significant interdependencies between government agencies for a variety of reasons that range from administrative dependencies (e.g., approvals, permissions, clearances), knowledge dependencies (e.g., sharing of data such as historical land-use maps, land ownership details) to financial dependencies i.e., organisations depending on each other for funding (Roy et al. 2018b).

Second, restoration of water bodies in the CMA involves multiple stakeholders some of whom (e.g., PWD) play a direct role in the restoration process. While others such as CMDA are not central to the process itself but remain active partners in the endeavour to protect our water bodies through their role in controlling land use and/or managing solid waste and sewage disposal. To ensure long-term sustainability (ecologically, environmentally, and socially) and effectiveness, it is therefore vital that an integrated and holistic approach is adopted to restoring and conserving water bodies that are multi-stakeholder driven.

These suggestions are also reflected in scientific literature: Nagendra & Ostrom (2019) find the need for 'polycentric arrangements' whereby local communities can organise in diverse ways, cognisant of their capabilities whilst also working with governments to solve administrative and technical problems. The authors also discuss the need for 'designing participatory institutions for lake governance' in developing Indian cities which have large peri-urban fringes, that can actively engage with local communities in **"processes that include coordination of collective activities, design of inclusive and locally suited ecological and social restoration goals, and planning and enforcement of regulations limiting access and withdrawal"** (Colding et al. 2006). Rather than creating new institutions, too many of which already exist, it would be more prudent to redesign, revitalise and empower existing institutions to discharge their duties more effectively. Also, there is an urgent need for participatory planning in restoration activities which enables continuous involvement of local communities and understanding their needs and wants which may be very different from what the restoring agency has planned.

Formal recognition that restoration efforts in the future should consist of public-private partnerships or tripartite agreements involving the funding agency, the owner department, and the organisation implementing the restoration work would result in a more inclusive, sustainable, and resilient city.

BIBLIOGRAPHY

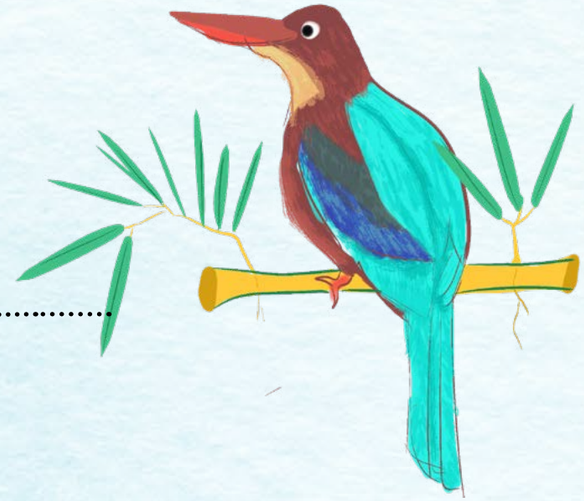
Colding, J., Lundberg, J. & Folke., C. (2006). Incorporating green-area user groups in urban ecosystem management. Ambio, 35(5), 237-244.

Graft, A., Mahalingam, A., Ramachandran, A., Ayyangar, A., Hemasree, O., Mankar, D., Naveen Sai, U. & Roy, P. (2018). Chennai: State of Water. Okapi Research and Advisory, Fields of View, Centre for Urbanisation, Buildings, and Environment, IIT Madras and Tamil Nadu State Planning Commission, Government of Tamil Nadu.

Nagendra, H. & Ostrom, E. (2014). Applying the social-ecological system framework to the diagnosis of urban lake commons in Bangalore, India, Ecology & Society, (19:2).

Resilient Chennai. (2019). Resilient Chennai - Kaleidoscope: A city through my eyes. Chennai: 100 Resilient Cities, Greater Chennai Corporation, Okapi Research, and Advisory.

Roy, P., Kumar, K., Karunakaran, Z.& Ayyangar, A. (2018b). Chennai: Emerging tensions in Land, Water, and Waste Governance. Okapi Research and Advisory, Fields of View, Centre for Urbanisation, Buildings, and Environment, IIT Madras and Tamil Nadu State Planning Commission, Government of Tamil Nadu.



CHAPTER 4
IMPLEMENTATION OF WETLAND RESTORATION

The process of restoring a wetland is a technical and evidence-based process involving rigorous research and analysis. The failure to understand the hydrology and other ecological characteristics of a wetland can lead to any restoration effort causing more harm than good.

4.1. PRINCIPLES OF RESTORATION

As we plan to restore lakes, we must recognise that only partial restoration of lakes is possible in Chennai. While many of these wetlands were originally constructed as part of a cascading system of lakes to facilitate overflow of water through designated drainage channels that supported irrigation of farms, currently much of the farmlands served by these *erys* are built up and so are many of the lakes and drainage channels, making full restoration impossible. Furthermore, we also need to plan restoration efforts to retrofit these wetlands into the current urban landscape keeping in mind the purpose of human habitation living around these lakes.

In 2014, CET drafted the Comprehensive Management Plan for the Pallikaranai Marsh and defined the principles that guide the Pallikaranai restoration effort. These principles, listed below, recognise the current urbanisation trends and are applicable for similar wetland restoration projects including lake restoration efforts.

4.1.1. ADAPTIVE MANAGEMENT

Adaptive Management is a flexible, inclusive, and knowledge-based approach. It is an iterative process where the key components are information gathering and system monitoring. The iterative nature of the process allows for course correction based on new information obtained during monitoring (See Box 1 for further details).

4.1.2. PERIODICITY

Restoration plans need to be long-term. For instance, the Pallikaranai Management Plan was for five years. A long-term management plan, the period for which depends on the size of the water body and other factors, is likely to have a much greater positive impact than quick, ad-hoc measures. Such a long-term plan, which factors in population growth and other urban stresses, needs to be accompanied by a quarterly review of progress to set benchmarks and ensure course correction. The emphasis on quarterly data monitoring and evaluation (M&E) is to ensure that data collection is done across seasons to account for seasonal variation and ensure data robustness.

4.1.3. MULTI-INSTITUTIONAL COLLABORATION AND ENGAGEMENT

The administrative management of any wetland typically involves multiple line departments of the government that have to be co-opted in the restoration process. In addition, it is necessary to engage with other non-governmental institutions such as research organisations, educational institutions, NGOs, and citizen-based groups (CBOs) for research and technical support and corporates who are located in the vicinity for CSR funding and volunteer support. Collaboration is also necessary to learn from others' experiences.

Box 1: Adaptive Management

Adaptive Management (AM) is a flexible, inclusive, and knowledge-based approach which provides an opportunity to course-correct management of a wetland through constant gathering of data on wetland integrity. AM is, at times, misunderstood as a process of trial-and-error when it actually differs from this by defining goals and parameters and involving rigorous data collection and analysis. A 2011 study by CET and City Connect modified Teal and Weishar's 2005 framework for AM of wetlands by adapting it to local conditions (fig 13).

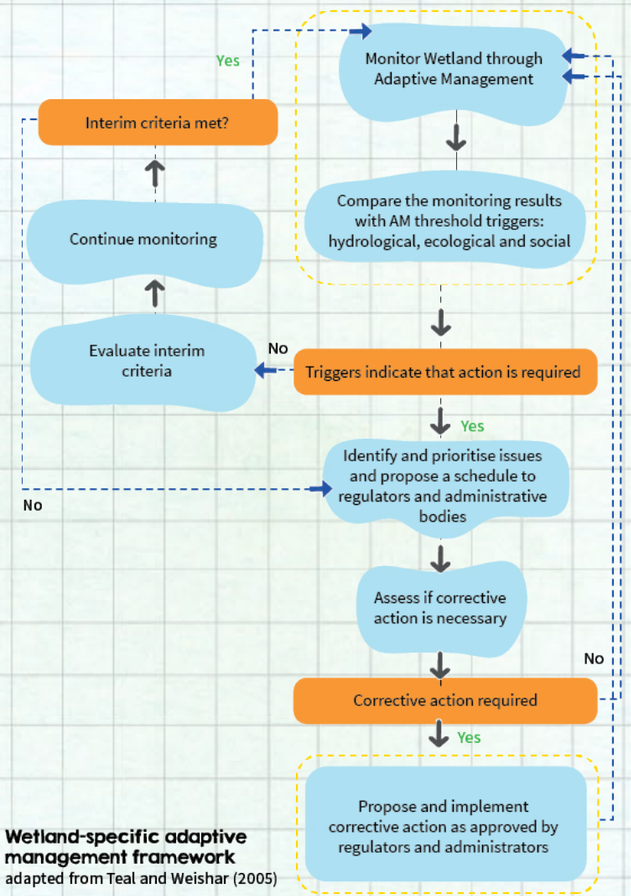
One of the critical steps in the process is the identification and measurement of threshold triggers (box 2 in fig. 13) which are defined as "measurement level of targets beyond which the targets are no longer acceptable for purposes of human and/or ecological health" (Vencatesan 2014). Monitoring of determined targets and comparison of these targets with the threshold triggers should be ongoing to ensure that the targets are at acceptable levels.

If a threshold trigger has been passed, the process moves to Step 3 (box 3) where the persons involved in restoration will need to assess whether or not any action is required by setting and meeting interim criteria. In this step, the priority is to identify if there are any underlying issue(s) associated with this trigger.

Note: A threshold trigger being reached does not immediately imply that correction

is necessary. Since the change may not be a reflection upon the ecological health of the wetland, rather occurring due to extenuating factors, in which case the decision – makers may conclude that no changes are needed to address this trigger and that a new trigger threshold is needed. The actions identified for corrective action must always factor in potential externalities, including how actions impact other ecological components of the wetland and also the social, economic, and environmental health of the larger region.

Figure 13: Wetland-specific adaptive management framework adapted from Teal and Weishar (2005)



4.1.4. CONSULTATIVE PROCESSES FOR LOCAL COMMUNITIES

It is important to engage local communities as stakeholders throughout the planning process in natural resource management such that they become active participants. Here organisations involved in restoration need to recognise that the local community's needs and wants may not always match theirs and both need to be reconciled optimally. Sensitising communities to protect wetlands can help align goals and achieve the best outcome for the environment and society. Participatory/consultative planning processes can build citizen responsibility towards natural and common resources and improve trust between government and citizens which is essential for ensuring that the efforts are sustainable over the long term.

4.1.5. CONTINUED ENGAGEMENT THROUGH FORMAL AND INFORMAL MECHANISMS

Following the implementation of a restoration activity, there is a need to ensure continued engagement for a longer period either through formal mechanisms such as authorities within the government or through informal mechanisms such as citizens groups who can help keep the momentum and influence residents to safeguard the lake or combination of the two.

4.2. IMPLEMENTATION

For the handbook, the process of implementation is broadly categorised into five stages as given below. The timeline for executing a wetland restoration project varies depending on the type and size of the wetland.

Step 1: Identify candidate wetland and conduct a baseline assessment

Step 2: Assess wetland character and integrity

Step 3: Set restoration goal

Step 4: Carry out Restoration

Step 5: Operationalise an exit strategy

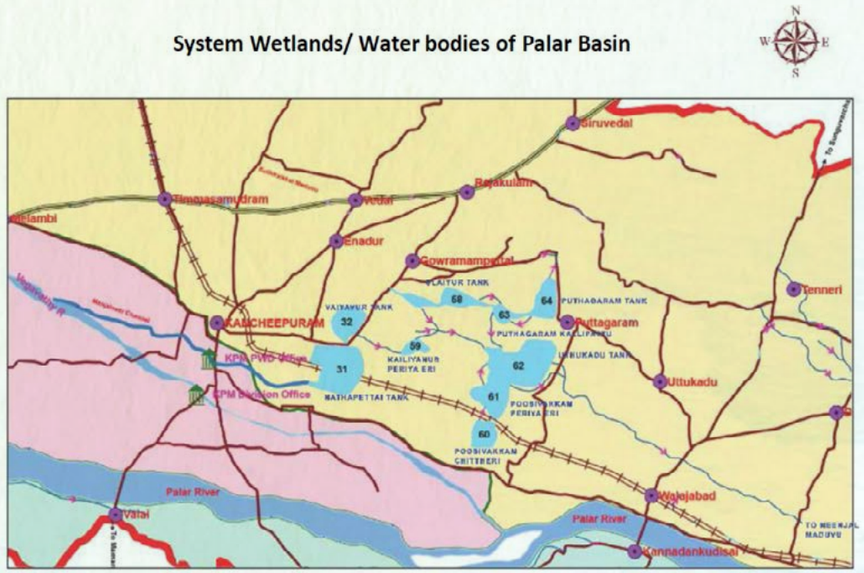
4.2.1. STEP 1: IDENTIFY CANDIDATE WETLAND AND CONDUCT BASELINE ASSESSMENTS

A. Identifying candidate wetland: A 'candidate wetland' refers to the project site that needs to be restored. The preliminary steps in identifying a candidate wetland are as follows:

- **Research from secondary sources:** The first step is to identify a candidate wetland and thoroughly investigate secondary sources to understand its history. These secondary sources may include District Gazettes, Revenue *Adangal* records, lake memoirs, working plans of Forest Department, and Town and Country planning records.
- **Assess if the candidate wetland is classified for provision of services:** Services provided may include but are not limited to drinking water sources, fisheries and agriculture or cultivation of aquatic food plants, recreational and aquatic sports, groundwater recharge, acting as a sink for sediments, habitat for noteworthy animal species and migratory birds. For instance, in the case of the Sembakkam Lake Restoration effort, the target is to achieve Category D of surface water quality as per CPCB guidelines, which is suitable for wildlife and fisheries propagation but not for human use. Accordingly, the restoration techniques and monitoring parameters have been identified by the team.
- **Assess if the wetland is a system tank or a non-system tank:** System tanks are those built off rivers, and the flows from the river are diverted to the tanks (Figs. 14 & 15). Non-system tanks are those in areas without natural waterways and are used to capture rainfall in a series of connected depressions (Gies, E. 2020). It is important to assess if the wetland is a system or non-system tank because the type of system determines the likely flow (channel and sheet flows) in the surrounding areas.
- **Assess if it is a wetland complex or a cascading wetland series:** A wetland complex is a group of wetlands that are connected functionally and hydrologically. Cascading wetlands are a series of interconnected wetlands, regulated by humans to ensure the excess water flows from one wetland to the other. There may be some isolated wetlands that do not fall under the above two categories.

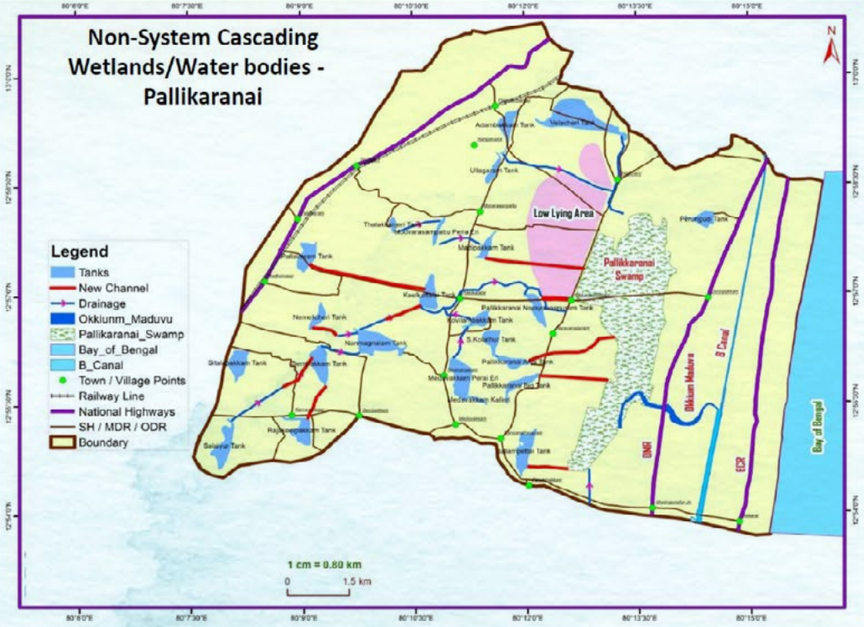
This classification is critical to understand the hydrology, particularly of lower down tanks to make sure they are not affected by interventions in upstream water bodies. For instance, if the candidate wetland is excessively deepened to hold water, this may affect the flow into the lower down tanks that depend on overflow from the candidate wetland and dry them out.
Identifying whether a candidate wetland belongs to the above-mentioned categories is critical for effective restoration. In the case of the Sembakkam Lake, the decision to work on it was influenced by the fact that it is part of a seven-wetland cascade connected to the Pallikaranai Marsh. As all the other wetlands of the cascade are part of other restoration interventions, The Nature Conservancy (TNC) and PWD collectively decided to work on Sembakkam to revive the entire cascade.

Figure 14: System Wetlands in the Palar Basin



Source: Care Earth Trust, 2021

Figure 15: non-system, cascading water bodies in Pallikaranai



Source: Care Earth Trust, 2021

B. Baseline assessments: Once the candidate wetland is identified, the following assessments need to be undertaken:

- **Mapping the wetland:** First, the temporal change in the wetland area over some time, preferably three decades is to be mapped. The mapping process should include an assessment of maximum water surface area in both lean and peak season, the perimeter of the wetland, and the shape of the wetland which is one of the most critical parameters that can help determine water holding capacity across seasons.
- **Conducting hydrology assessments:** The baseline hydrology assessment should include investigating:

– runoff from the catchment, duration of runoff, and maximum flood discharge
– adequacy of surplus weirs and surplus channels against maximum flood discharge
– the number and capacity of inlets, outlets, and surplus weirs[12]
– the number, capacity, and condition of channels (drainage channels from rivers/surplus channels from the upper tank) that enter and exit the water body including if any redundant channels need to be closed (fig. 16) and
– volume and duration of sheet flow[13] over some time

Figure 16: Polluted channel connecting Pudhuthangal lake

Source: Care Earth Trust

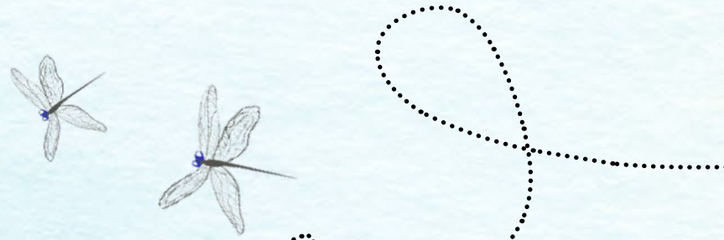
12. Weirs are defined as, "a notch of regular form through which water flows." (French 1985)
13. Sheet Flow is the shallow depth, slow velocity flow of water that occurs above the surface in a wetland, from the catchment of the wetland.

Often restoration does not include this background research because the agency restoring the wetland and /or the funding agencies do not comprehend the importance of it. Rather, they focus on the 'action' without the realisation that the action may be counterproductive. Hence, conducting baseline studies and research is essential to ensure the success of the restoration effort.

4.2.2. STEP 2: ASSESS WETLAND CHARACTER AND INTEGRITY

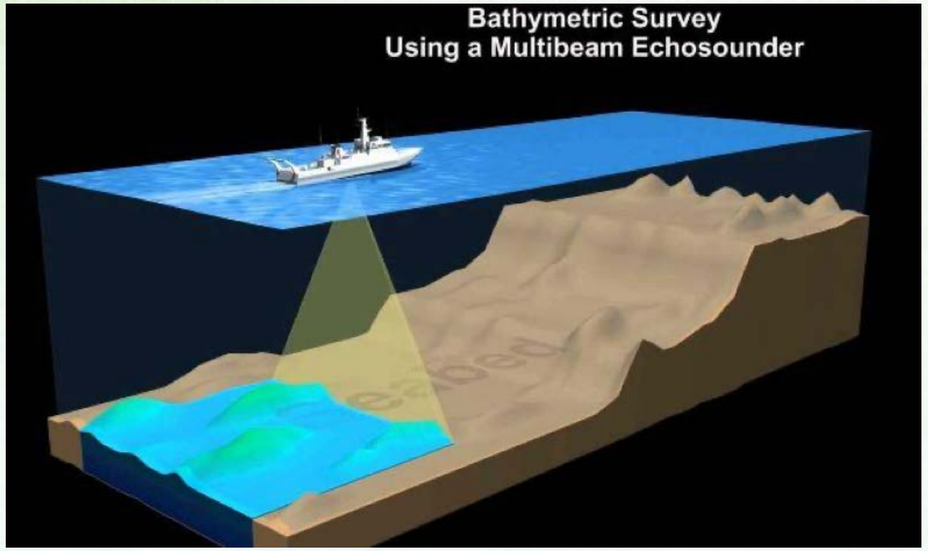
In many areas, most wetlands do not retain their integrity and have been compromised over several years due to rapid urbanisation which has resulted in the development of agricultural land, encroachment into water bodies, and over-extraction of water from surface water bodies and groundwater aquifers. One of the most significant impacts of urbanisation is the quarrying of sand from the lakebed, typically used for construction, which significantly reduces the retention capacity of the wetland. The practice was so common in the northern districts that the Government of Tamil Nadu brought out a regulation stating that the earth cannot be taken out of the waterbody elsewhere. Unfortunately, there are hardly any benchmark data on the extent of quarrying in water bodies, the quantity of earth scooped out of water bodies, the type of equipment used for quarrying, the conditions of the lake before quarrying, etc. which is needed to inform the restoration process. In this circumstance, understanding the lakebed itself becomes a complex but critical issue. The following steps are recommended to assess wetland character and integrity:

A. Assess the height, width, shape, and slope of the bund. The height, width, shape, and slope of the bund can be assessed based on old maps of the waterbody available with the PWD. This assessment should also include investigations of the lakebed. The lakebed character can be investigated by bathymetry[13] if water is available in the lake. If not, a contour survey using a total station theodolite can be used to draw contours at 0.30m or better contour intervals (Fig. 17). These investigations can help calculate the present water holding capacity. Once the assessment is complete, compare the results with historical data from secondary research.



13. Bathymetry is the study of underwater depth and shape of the lake or ocean floors.

Figure 17: Bathymetry Process



Source: avn.co.in

B. **Assess soil and water quality:** Several water and soil parameters may be assessed depending on the lake and the issues faced. Typical parameters include checking for biological content, oxygen levels, faecal matter, turbidity, heavy metals, nutrients (N, P, and K), pH, and so on. Please see Chapter 5: Monitoring and Evaluation for more details.

C. **Assessing and classifying vegetation and fauna of the wetland:** Wetlands may contain different kinds of vegetation and fauna. Historically all wetlands had aquatic vegetation which helped retain moisture on lake beds and allowed biodiversity to thrive. Vegetation types could include terrestrial vegetation (plants that grow on land), emergent vegetation (plants that live near the water's edge and grow with their root in water but stems and leaves above the water like a reed), floating vegetation (plants that have leaves which float on the water surface such as water lilies, lotus) and submerged vegetation (plants whose leaves grow underwater).

- **Assess the fauna of the wetland:** Like the vegetation, the fauna present in a wetland may also be quite diverse and can include amphibians, reptiles, fish, birds, mammals, and invertebrates such as aquatic insects, butterflies, and moths, dragonflies, and damselflies.
- **Classification of species and identification of flagship species:** The assessment of vegetation and fauna should enable classification and enumeration of the species found into rare, threatened, and endangered species. It should also help nominate indicator and flagship species and understand the extent and spread of invasive alien species.

Invariably, lower organisms (amphibians and reptiles – lower in the faunal hierarchy) are identified as indicator specifies and can help in monitoring restoration. Indicator species are those that reflect any changes in the environment. These are also called 'bio-indicators'. Some plants and animals are good indicators of pollution and other environmental disturbances. By monitoring such species, we can assess the health of the environment.

Species that are typical of a particular ecosystem are nominated by humans as flagship species in conservation efforts. They guide the approach and process followed for restoration and can help determine conservation efficacy. For wetlands, aquatic birds are nominated as flagship species as they can act as guides for understanding parameters such as depth of the water, an abundance of fish, etc. Flagship species vary depending on the characteristics of the wetland. For instance, in shallow wetlands like Perumbakkam lake, pheasant-tailed jacana can be a flagship species while in Sembakkam lake, which is a deeper lake, Spot-billed Pelicans are an ideal flagship species (fig. 18).

If the flagship species is doing well then, the inference is that the rest of the ecosystem is also in good health. While invasive alien species as the name suggests, are plants and animals that are introduced into newer geographical areas or habitats, soon establish themselves, multiply in large numbers locally and adversely impact the ecosystem.

Figure 18: Pheasant-tailed Jacana (left) and Spot-billed Pelican (right)

Source: Wikipedia.org and ebird.org

D. **Assess the local environment around the wetland:** Assessments should be conducted in a radius of 5km using transect walks, quadrates to understand land use land cover change, vegetation types, disruptive factors such as alterations to the hydrology of the wetland by over-extraction of water for irrigation and/or water contamination, natural processes like eutrophication, salinisation and acidification and loss of biodiversity due to over-extraction of wetland flora and clearing of native vegetation and drivers of fragmentation such as roads constructed over water bodies (Horwitz et al. 2012). The assessments should also include and

involve the local communities and their relationship with the water body.
For instance, the organisations working on restoring Sembakkam lake, CET and TNC, conducted a community survey which included obtaining data on water consumption of each household and how it differs seasonally during drought and floods and the expenditure incurred by households each month for treating water with a reverse osmosis system. This research helped determine the relationship between the community and the waterbody and how the community values the waterbody which would subsequently determine their environmental behaviour toward that waterbody. Community feedback obtained through the survey was also factored into the restoration plan.

E. Identify point and non-point sources of pollution: Point sources refer to pollution from STPs and/or industrial effluent treatment plants while non-point sources refer to pollution from land runoff which could include runoff from landfills, urban/agricultural areas, carried by stormwater, open defecation, etc. (USEPA, n.d.). Assessment of wetland character and integrity should therefore include:

- identification of sewage contribution from the towns, the total sewage that is being generated, the total number of existing sewage treatment plants (STPs) and their treatment capacities, if any
- identification of major industrial clusters or estates contributing to water pollution, total number of industries (sector-wise), sector-wise total industrial effluent generation, and existing industrial effluent treatment capacity [both captive and Common Effluent Treatment Plants (CETPs)]
- an assessment of the total waste generation (e.g., municipal solid waste, plastic waste, industrial waste, construction, and demolition waste), existing provision for collection, transportation, treatment, and disposal practices in the vicinity
- an assessment of any instance of open defecation around the ponds or lakes, by people living in the vicinity due to lack of sanitary facilities in their dwellings or colonies and fencing around the water body.

4.2.3. STEP 3: SET RESTORATION GOALS

After baseline assessment and wetland characterisation, a set of restoration goals need to be set. Defining the goals for a restoration project is a key component for formulating an implementation plan and choosing M&E parameters to track the progress, of the restoration effort.
While the project goals may vary depending on the context, typically a restoration effort aims at one or a combination of the following eight key restoration goals (Care Earth Trust 2014; CPCB 2019). Each goal requires a specific implementation strategy and can be linked to specific M&E parameters, and these are presented together in the table below (Table 1: Restoration goals and corresponding M&E parameters). A detailed discussion on M&E needs, common social-ecological M&E parameters, and mechanisms are discussed in Chapter 5.

Table 1: Restoration goals and corresponding M&E parameters

RESTORATION GOAL	DEFINITION	M & E PARAMETERS
Maintain current wetland area	Wetland area can be estimated through on-field analysis, remote sensing, and concerning village maps.	The Wetland area is in itself a reliable and easy-to-measure parameter.
Restore adequate water retention in wetland and surrounding watershed(s)	The amount of water that a wetland can retain is known as water retention or water holding capacity or simply, capacity. This in turn is an indicator of flood mitigation capabilities of the wetland.	The quantity and magnitude of flooding in a wetland/watershed over the years. This is measured by examining precipitation, streamflow, and flood frequency in the area over the years.
Eliminate groundwater depletion	Indicated by reduced groundwater recharge. If a wetland does not retain water, then a recharge is also lower.	The historical groundwater level, types of groundwater usage, number of pumping wells, and pumping rate.
To measure the level of contamination in the wetland	To measure the level of contamination in the wetland.	Identify an indicator species and conduct an ecological risk assessment (ERA) to assess the risk faced by the particular species.
Attain sufficient social valuation of wetland	Social-cultural perception regarding the importance of the preservation and restoration of the wetland.	Number of appearances in media, number of visitors, interest in birdwatching, community activities, economic activities like fishing and fodder collection.
Restore species diversity	Species composition is an indicator of ecological integrity, and hence species diversity is an absolute metric for assessing the wetland's level of ecological integrity.	Track the number of species in the wetland over time.
Maintain individual species	Individual species – including population levels and distribution over the area of the wetland over time.	Information on native and invasive species, including the number of different invasive species in a wetland, the percentage of the wetland area they cover, and how the dynamics change over time.
Supply for water for various purposes	Categorisation of the wetland according to 'Designated Best Use' criteria (see Chapter 5, table 3 for more details).	Chapter 5, table 3 for more details).

Source: CET (2014), CPCB (2019)

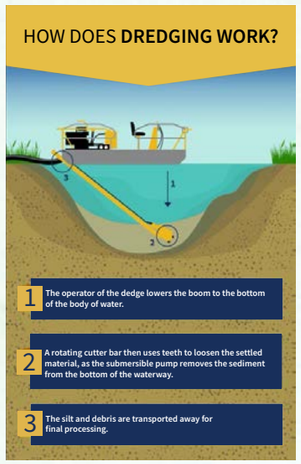
4.2.4. STEP 4: RESTORATION ACTIVITIES

Once the baseline assessment is completed as outlined earlier and restoration goals are identified, the following steps to implement restoration should be followed.

Note: All these steps should be conducted pre-monsoon.

A. **Prepare a desilting and dredging plan based on bathymetry:** The plan should include defining the area and extent to be dredged and the process for disposal of the earth (Fig. 19). The dredged earth cannot be sold in Chennai, Thiruvallur, Kanchipuram, and Chengalpattu districts as per a Government Order issued in 2014. In some cases, the dredged earth can be used as part of the restoration process such as for creating or strengthening the bunds or for creating constructed wetland systems. In the case of the latter, the silt is used to create an elevation, ensuring that the plantation does not get submerged. It must be noted that not all wetlands can be dredged. For instance, wetlands such as marshes that are naturally occurring should not be dredged while man-made lakes and ponds can be.

Figure 19: Dredging at Ennore (below) and the dredging process explained (right)



Source: New Indian Express and Geoform International

B. **Stabilise bund by sectioning and compacting it.** The PWD recommends the use of locally available soil if needed in addition to the desilted earth recovered through the process of dredging. Before stabilising the bund, any existing vegetation (i.e., roots, grass, etc.), solid waste and cobbles/gravels/boulders more than 7.5cm should be removed (Fig. 20). The PWD also recommends the density of the compacted soil be 95% of Proctor density at the optimum moisture content (PWD n.d.). In large water bodies, to reduce wave erosion, the pitching of stones on the lake bund can be done.

Figure 20: Bund strengthening at Pudhuthangal Lake

Source: Care Earth Trust

C. **Repair the weirs, channels, and sluice gates to ensure they are functional:** Repairing weirs, channels, and sluice gates is a challenge because channels tend to be compromised and weirs broke due to encroachments and developments. The type of restoration required for weirs, sluices, and channels depends on the characteristics of the water body. Sluices for instance, typically consist of a tunnel with a shutter or plug arrangement and are of different types such as tower head sluice or wing-wall (Fig. 21). The type of sluice required will depend on the height of the bund – tower head sluices should be used when the storage is more than 10ft while wing-wall **type should be used when the storage is less than 10ft.**

Figure 21: Colonial-era Tower Head Sluice in Onamancheri Periya Eri (left). Rear cistern of the same sluice (Right)

Source: Care Earth Trust

D. **Remove invasive alien species:** Waterbodies tend to be colonised by invasive species such as Prosopis Juiflora / *Seemai Karuvel* / Water Hyacinth (Fig. 22). Often removal of invasive species is the most expensive component of restoration because of the expenses involved in hiring a float, deploying machinery on the float, and sometimes labour to remove the plants. It can also often be a recurring expenditure if contamination into the water bodies is not curtailed. While the removal of invasive species is critical for the health of the water body, disposal of these species once removed from the water body is an equally challenging issue as they cannot be dumped in a dumpsite or buried because these are extremely resilient species that grow back easily. The most effective and sustainable solution to deal with invasive species is to prevent them at the source instead of having to remove them after they grow. For instance, most invasive species including water hyacinth will emerge only when the organic load is beyond permissible limits i.e., in the case of sewage inflow into the waterbody. Therefore, stopping sewage inflow into the waterbody will prevent the growth of the invasive species.

Figure 22: Invasive species at Vandalur Lake

Source: Okapi Research and Advisory 2021

E. **Flush the wetland:** Flushing is the process of completely removing water from the water body, allowing the bed to dry, and then refilling it with water so that it is cleansed. This step is recommended because when a wetland is typified by a lot of birds and pollutants, the wetland becomes enriched, with excessive nutrient content, and can become eutrophic.

F. **Allow system or wetland to stabilise for 15 days.**

G. **Create spaces for birds:** Traditionally wetlands in Tamil Nadu were Oxbow shaped and did not have structures or impediments within them to avoid any obstruction to the flow of water. In the absence of structures within the water bodies, the birds colonised trees in the buffer areas. However, considering the present context where the purpose of the wetland is more urban and human-centric, small mounds or mudflats can be created within the water body if the wetland is conducive for birds (the assessment of vegetation and fauna conducted earlier will reveal this). Also, mudflats or mounds are preferred by aquatic birds as they are closer to the water rather than hills/hillocks which are preferred by terrestrial birds. The mudflats and mounds should not be over 1m of the Full Tank Level to allow the free flow of water (Fig. 23).

Figure 23: Mound for birds in Puduthangal lake

Source: Care Earth Trust

H. Build recharge wells: Based on bathymetry, establish a series of recharge wells at fractures on the lakebed (Fig. 24). Apart from recharging groundwater, this will help in monitoring water holding capacity and water quality of the water body.

Figure 24: Recharge wells being installed in Talambur lake

Source: Care Earth Trust

I. Application of bio-enzymes: One of the methods suggested for improving water quality is the application of bio-enzymes for bioremediation during the first inflow of water into the water body. The enzymes such as EM.1 solution are commercially available widely. One litre of EM.1 solution should be mixed with 19 litres of non-chlorinated water and 6 – 8 kg of palm jaggery. This solution should then be left to rest in an air-tight container for 7 days, opening and closing the lid after the 4th day. On the 8th day, the solution should be taken to the waterbody and added to the water. For 8 acres of water spread area, 1 litre of EM.1 solution is required. The solution helps clean the water from biological contamination provided all the sources of pollution are contained.

J. Test water quality: As mentioned earlier, several water and soil parameters may be assessed. Typical parameters include checking for biological content, oxygen levels, faecal matter, turbidity, pH, and so on. Based on the values for these indicators, the waterbody may be classified as per the CPCB's standards which classify a water body into A, B, C, D, and E categories depending on the use it is put to, with A being the cleanest category. Please refer to Chapter 5: Monitoring and Evaluation for more details.

K. Conduct a second round of flushing of the wetland after 15-30 days. Typically, after the restoration of the wetland, the first waters that come in will carry impurities that need to be flushed out. Therefore, flushing is recommended. The second round of water coming into the wetland will be cleaner.

L. The bund will compact, and the height will be lower. At this point, use a vibrator roller to even the bund out. As mentioned earlier, the bund must compact to at least 95% so that water does not seep through (Fig. 25).

Figure 25: Bund compaction at Thalambur lake with a vibrator roller

Source: Care Earth Trust

M. **Undertake bund planting:** The Chennai region experiences a harsh and long summer, and the vegetation is impacted by sea breeze which can affect their growth and performance. Therefore, mortality rates of plants are high and limited options are available for plant species. Another factor that needs to be considered along the Coromandel coast, where Chennai is located, is that species are extremely slow growing. Therefore, when restoration programmes are linked with donor-driven goals, organisations carrying out the restoration activities are often pulled up for growing trees that are not fast-growing, or which are not resplendent. In Chennai, Palmyra is the most resplendent tree and is suitable for bund planting (Figure 26). Examples of other resplendent trees include *Terminalleia arjuna, Ficus benghalensis (banyan/fig), Syzygium cumini (Jamun), and Neem.*

Figure 26: Palmyra planted on the bund of Thalambur lake

Source: Care Earth Trust 2020

The best option ecologically would be to allow native vegetation to regrow by itself. If not, then natural methods such as planting native species may be used to strengthen the bund. These species, which vary according to the region, would include Pongamia, Palm, Terminalia Arjuna, Korukkai, or Nanal in the CMA, which have strong roots but not enough strength to damage the structure. Sometimes it might also be necessary to place tree guards around the trees/saplings to ensure they are not uprooted by cows or dogs.

N. **Ensure that the lakebed is not carpet-like.** Creating smooth / carpet-like lake beds with plants like grass that form a uniform cover over the ground, is popular in restoration projects. However, this is detrimental to the growth of species generally found in wetlands. Undulating lake beds are required and have been traditionally provided by local communities for breeding amphibians, reptiles, and fishes in the nooks and crevices.

In addition to the above, the Government, through the relevant department or the ULBs must ensure systems for management and disposal of wastes (such as municipal solid waste, sewage, industrial hazardous waste, construction and demolition waste, plastic waste, e-waste) including periodic removal and establishment of solid waste treatment systems at the site, if required (CPCB 2019).

4.2.5. STEP 5: EXIT STRATEGY

A detailed exit strategy needs to be drafted at the beginning of the restoration efforts so that they are sustained over time. This strategy needs to explicitly elucidate the approach and purpose of the restoration and, roles and responsibilities of the various stakeholders after the restoration activities such that there is no confusion amongst those involved. After the restoration activities are completed this detailed exit strategy can be put in place and would include the following steps:

A. **Fix boundaries of the wetland by providing boundary stones or fences** (latter preferable). It is important to demarcate the boundaries of the wetland. This can be done through different means including fencing, boards, and signage. The boards and signage can also illustrate details of the effort undertaken to restore the water body and restrict public misuse by directing people not to throw solid waste into the waterbody. In Madipakkam, the local CBO which is restoring Madipakkam lake has put up several boards that discourage people from throwing plastics and solid waste into the lake (see Chapter 7 for more details). Additionally, the boundaries of the water body need to be captured on a map, available with the governing agencies for future reference.

B. **Handover to owner department:** After all the above steps are completed, the wetland can be handed over to the owner department with thorough documentation that highlights the description of the conditions of the wetland before the project, details of the intervention, resultant effort translate into quantifiable indicators such as increased retention capacity, number of recharge wells, etc. and a long-term maintenance plan. Stakeholders need to ensure long-term management of the restored wetland through various, specific mechanisms. These could be formally instituted as a government authority such as the Conservation Authority for the Pallikaranai Marsh or informal, such as RWAs and other civil society groups. These kinds of groups must include representation from the local communities, have a good understanding of the functions of the water body and management system in place including the jurisdiction of various departments. A detailed discussion of what the long-term management of a restored wetland is and how it can be instituted are provided in Chapter 6.

BIBLIOGRAPHY

Care Earth Trust. (2014). Comprehensive Management Plan for Pallikaranai Marsh (2014-2019), Conservation Authority for Pallikaranai Marsh, Government of Tamil Nadu.

Central Pollution Control Board. (2019). Indicative Guidelines for Restoration of Water Bodies, Ministry of Environment, Forest and Climate Change, Government of India.

French, R.H., (1985), Open Channel Hydraulics, McGraw- Hill.

Gies, E. (2020, October). Chennai Ran Out of Water — But That's Only Half the Story. Biographic. https://www.biographic.com/chennai-ran-out-of-water/

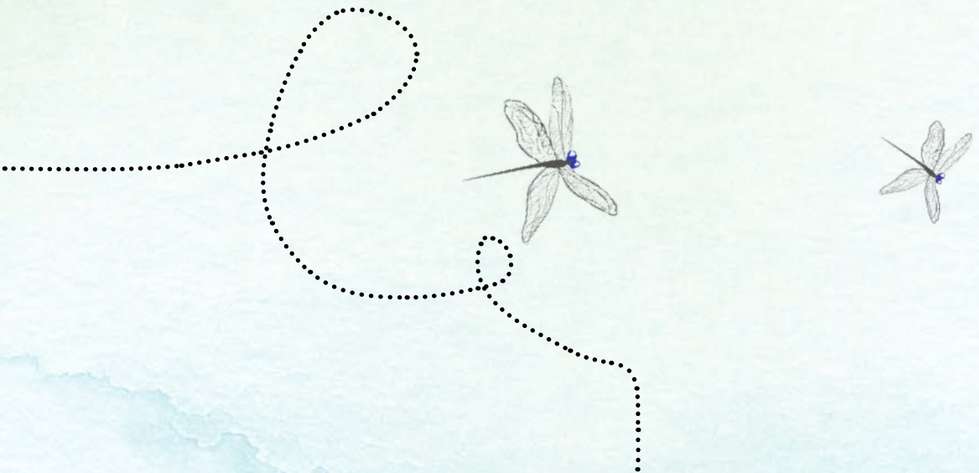
Horwitz, P., Finlayson, C.M., Weinstein, P. (2012). Healthy wetlands, healthy people: A review of wetlands and human health interactions. Ramsar Convention Secretariate and WHO. https://www.ramsar.org/sites/default/files/documents/pdf/lib/rtr6-health.pdf

Public Works Department (PWD). (n.d.). Best Construction Practices – Tamil Nadu Irrigated Agriculture Modernization Project – WRD. Government of Tamil Nadu.

Teal, J.M. & Weishar, L. (2005). Ecological engineering, adaptive management, and restoration management in Delaware Bay salt marsh restoration, Ecological Engineering, 25(3). 304-314.

United States Environment Protection Agency (USEPA). n.d. Basic Information about Nonpoint Source (NPS) Pollution. https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution

Vencatesan, J. (2014). Adaptive Management – the approach, metrics and application to wetland restoration and conservation, Care Earth Trust.



CHAPTER 5
MONITORING AND EVALUATION

M&E is generally seen as a means of assessing project efficiency, effectiveness, relevance, and causality. Traditionally, M&E has been useful to promote accountability and transparency to outsiders, and through systematic, scientific collection and analysis of data, it is expected to yield information about project progress and target accomplishments.

Ideally, M&E should be interwoven into the project cycle such that individual M&E activities (e.g., baseline surveys, process monitoring, impact evaluation) form a coherent, cumulative process of tracking change. In the US for instance, the United States Environmental Protection Agency (USEPA)'s guidelines on Monitoring Lake and Reservoir Restoration (Wedepohl,1990) suggest that stakeholders involved in restoration must prepare an M&E plan that covers the periods during and after the treatment phase and, typically, should call for measurement of both in-lake and watershed characteristics. In addition, it also mentions the need for a long-term monitoring program that should consider minimisation of costs, education of community for volunteer monitoring, and periodic, professional interpretations of data for the project and local sponsors. Such elaborate monitoring efforts are relatively rare in the Indian context largely due to time and resource constraints that characterise lake restoration efforts. Restoration efforts more often monitor the progress of the action plan as per a proposed timeline (The Program Evaluation and Review Technique (PERT)). But it is equally important to monitor and evaluate the effort in terms of its impact on social and ecological parameters to ensure the sustainability of the water bodies and to do so in such a way that the process is driven by specific targets(s) and goal(s) of the restoration effort – as explained in Table 2, Chapter 4. This has been officially recognised in government guidelines such as the Indicative Guidelines for Restoration of Water Bodies prepared by CPCB and The Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017.

5.1. OFFICIAL M&E GUIDELINES FOR LAKE/ WETLAND RESTORATION EFFORTS IN INDIA

5.1.1 INDICATIVE GUIDELINES FOR RESTORATION OF WATER BODIES

The CPCB in 2019 published the Indicative Guidelines for Restoration of Water Bodies (in compliance with Hon'ble NGT Order dated 10.05.2019 in M.A.No. 26/2019 in OA.No. 325 of 2015). Recognising the need to protect water bodies with the intent "(i) to make pollution-free water bodies and to meet the desired water quality criteria; (ii) to preserve excess water during monsoon, (iii) to restore and augment storage capacities of water bodies (iv) to serve and enhance groundwater recharge; (v) to increase availability of water for different intended purposes, etc." The document offers indicative guidelines for the restoration of ponds, lakes, polluted rivers, or streams.

Concerning monitoring, the CPCB guideline presents a clear set of criteria for water quality that should be monitored by designated best use for specific water bodies (see table 2).

For instance, in the case of Sembakkam, from the outset, it was agreed that the target would be to restore the lake's water quality to category D as per CPCB's surface water quality standards for designated best use, which is suitable for wildlife and fisheries propagation.

Based on the current level of pollution in Sembakkam Lake which is extremely high and ongoing uses which include fishing by locals, the team decided that this would be a reasonable goal to achieve using primarily nature-based solutions. Hence, it was agreed that water quality parameters identified in Annexure I of CPCB's Indicative Guidelines for Restoration of Water Bodies (2019) will be monitored to evaluate progress/success of the restoration effort in addition to certain other parameters such as turbidity, total dissolved solids (TDS), nutrients and heavy metals.

Table 2: Water Quality Criteria-Designated Best Use

DESIGNATED BEST USE	CLASS OF WATER	CRITERIA
Drinking water source withoutconventional treatment but after disinfection	A	• Total Coliforms Organisms in 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*	• Faecal Coliform in MPN/100ml: 500 (desirable) and 2500 (maximum permissible) • Faecal streptococci in MPN/100ml: 100 (desirable) and 500 (maximum permissible) • pH between 6.5 to 8.5 • Dissolved Oxygen: 5mg/l or more • Biochemical Oxygen Demand 3 Day BOD, 27°C: 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 20°C 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	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micromhos/cm Max 2250 • Sodium absorption ratio Max. 26 Boron Max. 2mg/l

**Class B as per Primary Water Quality Criteria for Bathing Water (Water Used for Organised Outdoor Bathing) as per Environment (Protection) Rules, 1986*
Source: CPCB 2019

5.1.2 THE GUIDELINES FOR IMPLEMENTING WETLANDS (CONSERVATION AND MANAGEMENT) RULES, 2017

Recognising the importance of monitoring, The Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017 (MoEFCC 2017) suggest that a key step in an Integrated Wetland Management Plan, is to prepare a detailed monitoring and evaluation plan – such a plan should detail: parameters to monitor, frequency of monitoring, responsible agencies, required resources, etc. The document also presents a generic listing of monitoring parameters and suggests the method of data collection and frequency of monitoring based on the size of wetlands (see table 3).

This table specifically recognises some parameters (marked with a single asterisk (*) sign) that are relevant for all wetlands while also identifying some parameters (marked with a double asterisk (**)) that are particularly relevant for wetlands located in urban and peri-urban areas.

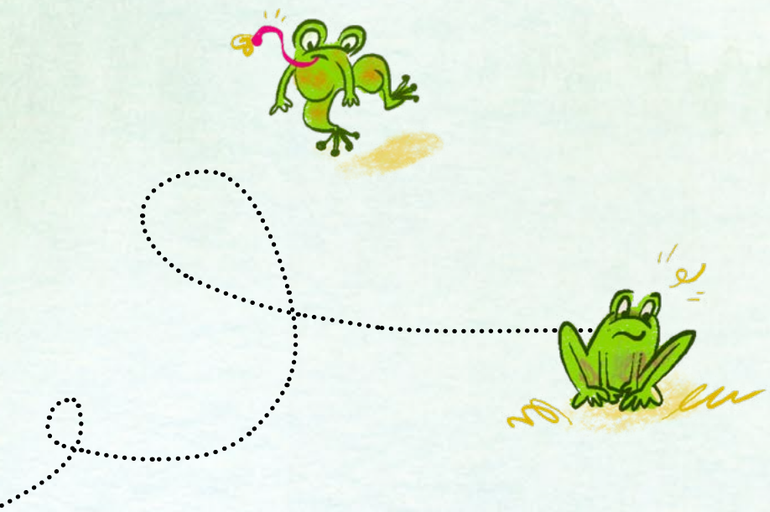


Table 3: Parameters for Wetlands Monitoring

WETLAND FEATURE	MONITORING PARAMETER	MONITORING METHOD	RECOMMENDED FREQUENCY
Wetland Extent	Wetland Area	Remote Sensing and ground-truthing	Once in a year
	Land use and land cover within the wetland area	Remote Sensing and ground-truthing	Once in a year
	Connectivity with other adjoining wetlands, river/ streams, coastal zone	Remote Sensing and ground-truthing	Once in a year
Wetland Catchment	Climate	Data from the nearest weather station	Monthly
	Land use and Landcover	Remote Sensing and ground-truthing	Once in 3 years
	Total sediment yield	Stream gauging station	Monthly
	Total nutrient yield	Stream gauging station	Monthly
Hydrological Regimes	Water inflow and outflow	Stream gauging station	Monthly
	Water holding capacity	Bathymetric Survey	Once in 5 years
	Peak Inundation	Remote sensing and ground-truthing	Once in 2 years
	DO, BOD	Data from water quality sampling stations	Atleast monthly
	COD	Surveys	Atleast monthly
	Number of point sources discharging untreated sewage into the wetland	Mid-winter counts	Once in a year
Biodiversity and Habitat	The population of major wetland-dependent species groups (such as waterbirds, mammals, etc.)	Mid-winter counts	Once in a year
	Habitat use by key species	Physical surveys	Once in a year
	Number of migratory species using the wetland as a habitat	Physical surveys	Once in a year
	The area under invasive macrophyte	Physical surveys	Once in a year
Ecosystem Services	Annual fish yield	Sampling	Monthly samples collated into an annual estimate
	Number of tourists	*Surveys*	Monthly samples collated into an annual estimate
	The volume of surface water abstracted from wetland	Hydrographic surveys	Monthly samples collated into an annual estimate
	The volume of groundwater recharged	Hydrographic surveys	Once in a year
	The proportion of floodwaters stored in the wetland	Hydrographic surveys	Once in a year
	Use of wetland for research and education	Surveys	Annual estimate
Livelihoods	Population living around the wetland	Surveys	Once in 3 years
	Population depends on the wetland for livelihood	Surveys	Once in 3 years
	No. of households around the wetland using safe sanitisation practices	Surveys	Once in 3 years
	Participation of communities in wetlands management	Surveys	Once in 3 years

Note: (i) The frequency, as above, is advisable for wetlands above 100 ha and is indicative. The Wetland Authority may suitably modify based on the logistics involved.(ii) For wetland less than say 100 ha, the frequency, maybe appropriately divided.
Source: MoEFCC 2017

5.2. WATER BODIES PROTECTION INDEX

In addition to such existing Government guidelines, experts also propose using indexes such as the Water Bodies Protection Index (WBPI) to monitor and evaluate the sustainability status of water bodies. Such kinds of indexes have not been used in practice and the suggestion of WBPI should not be considered as a prescriptive measure. Rather, the index offers ideas into what could be some potential monitoring parameters and how they can be calculated based on specific goals.

The WBPI is developed by using five factors which according to secondary research heavily influences sustainability status (in other words the social and ecological quality) of lakes and other freshwater bodies:

A. Water quality of the lake (WQ)
B. Biological diversity of the lake (BD)
C. Water spread area of the lake (WSA)
D. Role of community/lake users in management (CR)
E. Role of Government departments (GR)

Table 4 below explains what specific indicators associated with the five above-mentioned factors are measured and how.

Table 4: Data used for constructing the WBPI

WBPI FACTORS	DATA USED	SOURCE
Water quality of lake (WQ)- provides the water quality status of the lake	Water quality variables - physical (pH, EC, TDS, DO, temperature) hardness, chloride, alkalinity nutrients (phosphate, nitrate) and BOD	Primary data (in situ and laboratory analysis of water)
Biological diversity (BD) - indicates the pollution tolerant species and pollution status	Plankton diversity	primary data (laboratory analysis of water)
Water spread area (WSA) - indicated the reduction in water spread due to encroachment	Original water spread area of lakes and the area encroached	Secondary data (from the Public Works Department of the Government of Tamil Nadu)
Role of community (CR) - indicates the change in community attitudes, viewa on the lakes due to urbanization	level of awareness and participation toward protection of lakes	Primary data (transact walk, stakeholder's meeting, focus group discussion and questionnare survey
Role of government (GR) - based on the steps taken to protect the lakes and the loop holes in monitoring/ implementation of acts	Available acts on lake protection, level of upkeep and preservation	Secondary data (Arul 2008) and interviews with concerned officials

Source: Sudha et al, 2013

The factors or parameters are also assigned weightage based on expert opinion from public and private agencies involved in lake restoration and management. The final WBPI is calculated as follows:

$$\mathrm{WBPI} = W_{\mathrm{WQ}} \times R_{\mathrm{WQ}} + W_{\mathrm{BD}} \times R_{\mathrm{BD}} + W_{\mathrm{WSA}} \times R_{\mathrm{WSA}} + W_{\mathrm{CR}} \times R_{\mathrm{CR}} + W_{\mathrm{GR}} \times R_{\mathrm{GR}}$$

where W = weightage for the factor, R = rationalised value of the factor.

The factor or parameter values are rationalised to keep their values between 0 and 1 and the WBPI value between 0 and 10. The WBPI scores are then classified into five categories (see Table 5) to assess the current state of lakes and decide whether and in what respect they need attention.

Table 5: Classes of the WBPI

CLASS	INDEX VALUE	PROTECTION STATUS
1	<1	Poor
2	1-3	Below avergae
3	4-6	Require attention
4	7-9	Good
5	>9	Sustaiable

Source: Sudha et al, 2013

WBPI, once assessed to identify lakes in need for restoration, can be measured again post-restoration, at certain intervals to monitor the long-term sustainability of the water bodies. WBPI, therefore, can help rank and monitor changes over time and prioritise which water bodies need attention and regarding what aspects.

5.3. VOLUNTEER MONITORING OR COMMUNITY MONITORING

Baseline studies, continual monitoring, and long-term M&E are missing from restoration efforts - this is largely due to the time and resource constraints. As may be evident from Table 5 on data used for constructing WBPI, the process of collecting this information requires technical knowledge/expertise and other resources (access to labs, manpower, and time to conduct stakeholder/community surveys, etc). Hence, few lake restoration efforts can undertake a formal M&E plan. This was evident during the interviews conducted with NGO and community representatives involved in lake restoration efforts across Chennai to develop a few case studies (see Chapter 7).

Instead of formal mechanisms, informal and community-based measures to monitor visible changes (positive or negative) during the restoration process and beyond are more common and perhaps feasible; This involves, for instance, communities reporting an increase in the appearance of migratory birds, reduced garbage in and around lakes, or continued encroachment and hence reduction in water spread area, etc. These informal means of community-based monitoring have been identified as volunteer monitoring by the USEPA which recognises that effective participation of local communities in the monitoring process depends

MONITORING AND EVALUATION

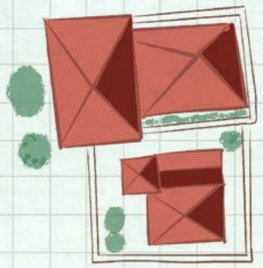
on the degree of awareness of important technical and social considerations of the local water bodies. But based on experiences from different case studies which reveal that participation of local communities and non-governmental organisations (NGOs) can significantly influence the outcome of conservation and management efforts in the lake basins, USEPA endorses the significance of volunteer monitoring and offers several resources to guide such efforts.

In the U.S. volunteer monitoring is coordinated either by the states or NGOs and groups observe and measure dozens of parameters, which range from water temperature, dissolved oxygen, and macroinvertebrates to phytoplankton and pesticides (see box 2). Along similar lines, USEPA highlights the role of 'Screening' as one of the most important steps that volunteer wetland monitoring involves in wetland conservation (USEPA 2001). Screening is an initial assessment that indicates areas in need of further action or study. Screenings by volunteers are not as detailed or finely tuned as professional surveys, but they can provide basic assessment information. They can also indicate the need for detailed study or remedial action. For example, deformities found in the indigenous fauna can indicate chemical contamination of the water, which needs to be further monitored. Volunteer monitoring also can create informed and knowledgeable citizens who become advocates for more sustainable approaches to land use and water management. In the US, many state agencies have used the data generated by volunteers to meet reporting requirements, inform management decisions, and assess various impacts.

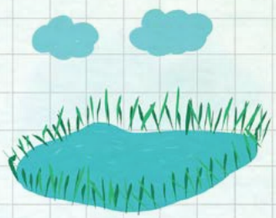
Box 2: List of parameters that can be measured by volunteers

Wetlands parameters often measured by Volunteers

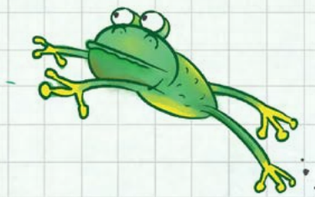
1 **Dominant vegetation type-**
This measurement, which requires some training, is often conducted using sample plots located on treas-ures and is a principal means ofdetect-ing change in a wetland.



2 **Adjacent impervious surface (e.g., pavement, roofs)-**
This can beestimated using maps or visual observations in the field and can be an important indicator of stresses to wetland.



3 **Hydrology-**
The timing, frequency an duration of water inputs can be critical to wetland health. Water fluctuation can be measured in many wetlands, and the observation of human built tidal restrictions (in costal wetlands) can un cover potential impacts on tidal marshes.



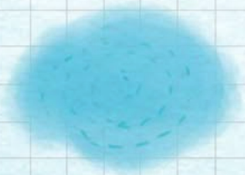
6 **Amphibian migration count-**
A varietynof methords are used to count anphibians, all of which require training and supervision. Anphibian counts can provide inside into the effects that land use or other stresses might have on wetland health.

5 **Macro invertibrate texa richness-**
Macro invertibrate monitoring takes considerable training, but data on this texa have been tested for many years specially in streams. the presence or absence of certain macro invertibrate texa can provide strong indications of wetland quality.

4 **Physical and chemical baseland parameters (e.g., Temperature, Ph, terbidity)-**
These are very common measuremnents and can provide valuabve data that may co-relate to other parameters.

7 **Bird sightings-**
Recognizing and counting birds and their calls takes training and can be a good screening mechanism in assessing risk or determining wetlands connecction to migratory corridors.

8 **Exotic plant species encroachment-**
This measurement uses some of the same methods used for measuring dominant vegetation types and can point to the need for eradication of exotic species.



9 **Wetland appearance/footprint (through photographs or maps)-**
This very simple information gathering methord is not scientifically vigorous but can help supplement other data and "freeze" a picture of a wetrlands condition at a certain times.

Underline drawing " wild lupine (Lupinus perrennis)

Source: USEPA 2001

In case of Chennai, and other Indian cities where, despite progress in wetland conservation and lake restoration efforts, monitoring and evaluation is not carried out as an essential part of such efforts, how well volunteer or community-driven monitoring and screening will work depend largely on the presence of sustainable management institutions or mechanisms such as active Lake Protection Groups/Committees or RWAs or other citizen-based groups like Walker's clubs in the locality of the waterbody in question. The next chapter presents a few examples of such mechanisms that may be conducive to sustaining the positive outcomes of restoration efforts in the long run.

Where such institutions or mechanisms do not exist, dedicated effort is needed to encourage community involvement. Interestingly the CPCB recommends that the following actions be taken in order to sustain the wetland rejuvenation efforts by encouraging public participation and use (CPCB, 2019):

A. Awareness Spreading: Awareness for citizen groups, resident welfare associations, local organisations, activist groups, educational institutions, and government agencies in the protection of the water bodies should be organised periodically by the concerned authorities through campaigns and media in vernacular languages.

B. Training: Organising periodic training relating to maintenance through reputed institutions during the post-restoration phase of the water body.

C. Promoting Public Participation: Promoting active public participation (with the help of schools, colleges and universities, NGOs) for periodic maintenance of the water body should be organised.

D. Dissemination of Information: Water quality of the pond or lake should be displayed at the main entrance of the pond or lake boundary and such water quality data is also connected to the servers of the concerned custodian State Department.

E. Recreational Centre: The creation of ponds or lakes can be converted into recreational centres with boating activities, parks, walkways, and benches for visitors on a charge basis to generate revenue for the operation and maintenance of the lake area.

The expectation is that through such activities it will be possible to maintain more public eyes on the water bodies while raising awareness and encouraging more citizens to get involved in volunteer monitoring and long-term maintenance of restored lakes.

BIBLIOGRAPHY

Central Pollution Control Board (CPCB). (2019). Indicative Guidelines for Restoration of Water Bodies, Ministry of Environment, Forest and Climate Change, Government of India.

Ministry of Environment, Forests and Climate Change (MoEFCC). (2017). Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017, Government of India.

Neelakantan, T.R. & Ramakrishnan, K. (2017). Protection of Urban Water body Infrastructure – Policy Requirements, IOP Conf. Series: Earth and Environmental Science, 80.

Sudha, M. C., Ravichandran, S., Sakthivadivel., R. (2013). Water Bodies Protection Index for assessing the sustainability status of lakes under the influence of urbanization: a case study of south Chennai, India, Environment, Development, and Sustainability, 15, 1157–1171.

United States Environmental Protection Agency (USEPA). (2001). Volunteer Wetland Monitoring: An Introduction and Resource Guide. EPA 843-B-00-001. Office of Wetlands, Oceans, and Watersheds, Wetlands Division.

Wedepohl, R.E., Knauer, D.R., Wolbert, G.B., Olem, H., Garrison, P.J. & Kepford. K. (1990). Monitoring Lake and Reservoir Restoration., EPA 440/4-90-007. Prepared by North American Lake Management Society for U.S. Environmental Protection Agency.

CHAPTER 6
SUSTAINABLE MANAGEMENT OF RESTORED LAKES

Despite current efforts by public and private stakeholders, restored lakes often start deteriorating on social and ecological terms due to continued encroachment, waste dumping, lack of continued monitoring, etc.

Box 3: Makeshift structures coming up in the lakebed and catchment areas in Korattur Lake

The WRD had removed encroachments around the Korattur Lake in west Chennai and laid a 750-metre-long bund in February 2020. By July, a newspaper article reported that "(T)he newly laid bund along the lake has been breached and new buildings have come up inside the lake boundary demarcated by the WRD" (Lakshmi 2020).

Source: Lakshmi, 2020

The above account is not an aberration but the norm. Therefore, one of the key components of restoration efforts should include a plan for long-term management to ensure that positive actions and outcomes are also sustainable over time.

This requires continued engagement either through formal institutions and mechanisms put into place by authorities within the government or through informal institutions and mechanisms involving citizens groups or a combination of both. Following are some examples of how this may be operationalised.

SUATAINABLE MANAGEMEN† OF RESTORED LAKES

6.1. A GOVERNMENT AUTHORITY: CONSERVATION AUTHORITY FOR THE PALLIKARANAI MARSH

One of the decisive steps in the protection of the Pallikaranai Marsh was when the Tamil Nadu Pollution Control Board in 2002, commissioned a study to map the extent of the marsh. The landmark study by Care Earth Trust indicated that the marsh had lost over 90% of its original area. The 2002 floods resulted in increased citizen interest in the conservation of the marsh, leading to the Save Pallikaranai Forum, spearheaded by RWAs. Increased attention to the marsh led to multiple studies on it, resulting in an increased momentum in the demand for protection. In 2005, a High-Level Committee chaired by the Chief Secretary was constituted to discuss a remedial plan and after a series of deliberations, 317 Ha of the marsh was declared a Reserve Forest in 2007.

In 2012, the Conservation Authority of Pallikaranai Marshland was formed with the primary goal of protecting, restoring, and conserving the wetland for the cause of biodiversity conservation and human well-being. This body is registered under the Tamil Nadu Societies Registration Act 1975 (TN Act 27 of 1975) and acts as the key technical advisory body for developing and maintaining the Marsh Lands in a self-sustaining manner.

The Authority is chaired by the Principal Secretary to Government, Environment and Forest Department and consists of the following members highlighting the involvement of all the relevant government agencies.

A. The Principal Secretary to Government, Finance Department (or) his representative, Fort St. George
B. The Principal Chief Conservator of Forests (Head of Forest Force), Tamil Nadu
C. The Principal Chief Conservator of Forests and Chief Wildlife Warden, Chennai
D. The Director, Department of Environment, Chennai
E. The Commissioner, Tourism Department, Chennai
F. The Commissioner, Corporation of Chennai
G. The Managing Director, CMWSS Board, Chennai
H. The Chief Conservator of Forests (P&D), Chennai
I. The Chief Engineer, PWD, WRO, Chepauk, Chennai
J. The District Collector, Kancheepuram District, Kancheepuram
K. The District Forest Officer, Chengalpattu Division, Kancheepuram
L. The District Forest Officer, Chennai Circle, Chennai
M. The Assistant Conservator of Forests, Pallikaranai

N. The Conservator of Forests, Chennai

The primary activities of the Authority include a) implementation of the conservation/restoration works agreed upon by the Governing Board of Conservation Authority of Pallikaranai Marshlands; b) offering conservation education and research facilities; and c) managing public and private funds for the cause of the marshland conservation.

The key objectives as outlined in the Government Order (GO) establishing the Authority are as follows:

A. To function as the apex technical advisory body for the Marshlands in the jurisdiction of Chennai, Kancheepuram, and Thiruvallur Revenue Districts
B. To develop and maintain the Pallikaranai Marshlands in a self-sustaining manner by receiving and utilising the funds from central/ state government and any other government undertakings, private industries, and private individuals for the development and conservation of Pallikaranai Marshlands and other adjacent Marshlands to be declared in future
C. To create understanding and awareness about the importance of wetland conservation and its unique floral and faunal diversity to the students and common public in and around Pallikaranai Marshlands through education and interpretation programme
D. To plant and propagate suitable wetland or Mangrove species in Pallikaranai Marshlands and other Marshlands within the jurisdiction of Chennai wherever possible
E. To develop an integrated approach in the conservation of these wetlands combining the indigenous knowledge of local people/ NGOs/ Authorities etc. and scientific inputs from the experts
F. To research various aspects like flora and fauna and water contamination etc. of Pallikaranai Marshland

6.2. SEMBAKKAM LAKE PROTECTION COMMITTEE: A PLANNED PUBLIC-PRIVATE COLLABORATIVE

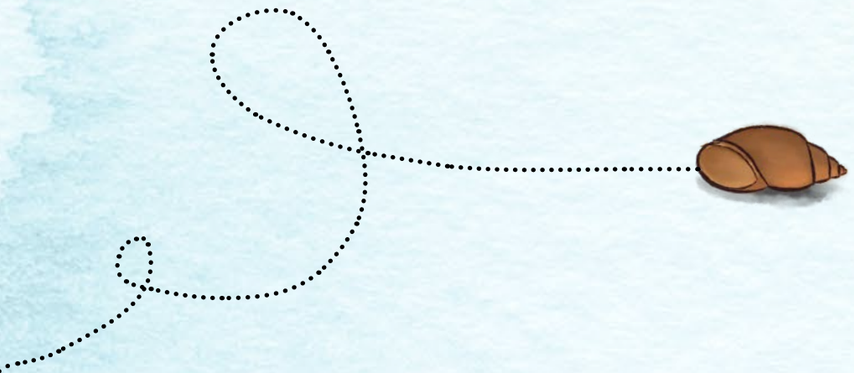
While the Sembakkam restoration work is still ongoing and is expected to be completed in the next 8-10 months, as the coordinating agency, TNC is planning an exit strategy to ensure that the work done can be well-maintained in the long run. The idea is to form a ‘Lake Protection Committee’, with representatives from the community, the supporting donors, corporates and the government, and local NGOs who can help maintain the lake longer. These collaborative and multiple stakeholder-involved committees will continue to monitor that the progress made in terms of removal of waste, improvement in water quality and biodiversity, and adding social use-value is not undone once the restoration process ends.

The fact that Sembakkam lake is surrounded by a lot of very active and well-informed RWAs across the three local bodies (Pallavaram on the North, Sembakkam on the South, and Chitlapakkam on the West) is extremely helpful in this work. While the proposed committee can help come up with a long-term management plan and periodically help monitor changes in and around the lake, the community through these RWAs, can keep a regular watch and update the committee as and when required.

Also, to ensure that specific interventions such as the wastewater treatment system, which is being set up, is well-maintained post-restoration, a long-term management plan is being put into place that would involve the government agencies. TNC is likely to help maintain this system for the first couple of years, after which, PWD and/or relevant ULBs will be required to take the responsibility of maintaining and upgrading the wastewater treatment system.

6.3. COMMUNITY-BASED GROUPS

There are innumerable examples that highlight the important leadership role local community and community-based groups play in keeping an eye on, raising the alarm, and demanding attention for restoring water bodies across Chennai. The Korattur Eri Padhukappu Makkal Iyakkam, the Madipakkam Walker’s Club, and Chitlapakkam Rising are some such examples. Based on case studies in Bengaluru, Nagendra & Ostrom, (2014) have highlighted the value of collective action and associated facilitating factors (e.g., operational community rules; networking with government and informal norms for monitoring by the community) as well as barriers (e.g., lack of leadership, and/or low social capital) that remain intricately connected with ecological status or performance of local water bodies. Here we highlight one example to discuss how community action has attempted to put in place mechanisms to support sustained management of local lakes.



6.3.1. CHITLAPAKKAM RISING

This citizen-based group was formed around 2012-13 by a group of like-minded middle-class individuals to make their neighbourhood cleaner and help raise Chitlapakkam to be a better place. Hence the name, Chitlapakkam Rising with a tagline suited for inspiring more local resident involvement - 'If not you, Who? And if not now, When?' The group continued to organise activities around street cleaning, wall art, etc. to raise community awareness and take legal measures to question and push government agencies on various accounts (e.g., relaying roads properly).

During the 2015 floods, when a large part of the neighbourhood went under nearly 9 ft of water, Chitlapakkam Rising took up the cause of doing something about it. Realising the role of the dilapidated Chitlapakkam Lake which has been abused for years by encroachment, solid waste dumping, and sewage, the group mobilised community action. Also, utilising public and media interest they managed to involve the government to take up a Rs. 25 Crores worth lake restoration effort.

While this work is undergoing, the group has been vigilant about the progress. A representative of Chitlapakkam Rising acknowledged that "all the good work will be lost unless we maintain it.' As such, the group maintains elaborate activity charts and graphs to track the progress of the restoration effort. In addition, a monitoring team visits the lake every day and documents the activities and takes pictures which are then shared through the Chitlapakkam Rising Facebook page.

As such Chitlapakkam Rising has taken it upon itself to continue to keep an eye on the lake and ensure that the efforts can have a sustained impact on the water body and its surroundings both socially and ecologically. In the future, any breaches into the lake are likely to raise an alarm and lead to collective action by the group/ the community which in its turn will also keep government agencies on their toes to maintain/ follow up the lake restoration work.

6.4. A CONSORTIUM FOR INTEGRATED RESTORATION AND PROTECTION OF CHENNAI'S LAKES: A CITY-LEVEL ADVISORY GROUP

According to the Chennai Resilience Strategy (prepared under the Rockefeller Foundation's 100 Resilient Cities program and launched in 2019 July by GCC), one of the key needs to ensure systematic and sustained lake restoration work is to create a consortium for integrated restoration and protection of Chennai's Lakes. This should be a city-level advisory group

comprising government agencies, directly and indirectly, affecting and managing the city's water bodies (i.e., agencies across sectors like water, solid waste management, housing, pollution, etc.), non-profits active in the lake restoration space, citizen groups and corporates involved and interested in restoration work. The main activities of this consortium would be to advise lake restoration efforts, share knowledge and learnings across efforts, monitor regulatory compliance, and to forge collaboration across various parties so that different agencies work efficiently and not at cross purposes. This multi-stakeholder group could meet once every quarter to reflect on the current status of restored water bodies and urge relevant agencies/organisations to take action where required. Such a consortium would complement existing Chennai Rivers Restoration Trust (CRRT) efforts to bring all government actors together for waterways rejuvenation efforts.

6.5. LAKE ADOPTION PROGRAM BY CORPORATES

Private companies like Grundfos and Cognizant are getting involved in water body restoration efforts across Chennai under their Corporate Social Responsibility (CSR) Activities primarily through funding and partly volunteering. However, many of them remain skeptical about the results due to relapsing conditions caused by a lack of continued engagement and monitoring. The corporates themselves could play a key role by "adopting" a lake in their locality and supporting its continued management. However, there are challenges concerning the operationalisation of the CSR laws which can impact sustained maintenance of lakes. According to BNY Mellon, a company involved in several restoration efforts across India and Tamil Nadu in particular, every company has to declare a minimum 2% CSR contribution every financial year. Since this declaration is a yearly mandate, it does not allow for planning lake management for several years at a time. Companies remain careful about committing to long-term lake maintenance. BNY Mellon, whose CSR contribution well exceeds the 2% mandate, is dealing with this issue by renewing projects every year (Interview with BNY Mellon, 2021).

Despite these challenges, Corporates remain a major source of funding. In 2019 July, GCC invited industry representatives to fund lake restoration efforts to support the current efforts funded primarily through the Capital Budget Fund and Chennai Smart Cities Fund. In addition, GCC could float an "Adopt a Lake" program whereby corporates commit not only to investing in one-time restoration, but a longer-term sustainability plan - such a plan need not involve huge financial commitment, rather more volunteer time commitment to organise activities, raise awareness, and keep an eye on adopted lakes alongside the local community.

6.6. LAKE OF THE YEAR CONTEST

GCC or PWD could introduce a “Lake of the Year” contest to encourage citizens and other private stakeholders to invest resources and time into better maintaining local water bodies beyond restoration work. The yearly evaluation for the “Lake of the year” title could ensure greater involvement by multi-stakeholder groups to sustain one-time restoration efforts in the long run. The Government of India’s Ministry of Jal Shakti has instituted the National Water Awards with the objective of “encouraging stakeholders to adopt holistic approaches towards water resource management in the country”. The Awards consist of 11 categories including Best State, Best District, Best ULB, and Best Industry for CSR activity. GCC / PWD can popularise these and other similar awards to encourage more community and industry-level involvement in restoration.

BIBLIOGRAPHY

Lakshmi, K. (2020, Jul 12). Encroachments sprout again on the lake bed. The Hindu. https://www.thehindu.com/news/cities/chennai/encroachments-sprout-again-on-lake-bed/article32054671.ece

Nagendra, H & Ostrom, E. (2014). Applying the social-ecological system framework to the diagnosis of urban lake commons in Bangalore, India, Ecology & Society, 19:2.

Resilient Chennai. (2019). Resilient Chennai - Kaleidoscope: A city through my eyes. Chennai: 100 Resilient Cities, Greater Chennai Corporation, Okapi Research and Advisory.

CHAPTER 7
CASE STUDIES

Since 2015 Chennai city and its peri-urban regions have witnessed numerous lakes restoration efforts. However, these efforts vary substantially in terms of the approach, the process followed, and the impact achieved. Some of these restoration efforts have involved the clearing of solid waste and setting up a fence around the lake while others have involved deeper and systematic approaches over some time. Here, we showcase five organisational restoration efforts that present interesting learnings on different aspects of lake restoration. The case studies have been put together based on interviews with relevant agency representatives, field trips, and secondary sources such as newspaper articles and websites.

CASE STUDY 1: PWD: CLIMATE ADAPTIVE RESTORATION AND REHABILITATION

After the 2005 floods and more so after the 2015 floods, **PWD recognised that climate change is already occurring and is manifesting itself through extremes in rainfall. According to a PWD representative, “the intensity of rainfall has gone up although there is no change in cumulative rainfall in a year. If there is rainfall for 90 – 120 days, this has gone down to 70 – 45 days and in this shorter duration there is high intensity of rainfall followed by droughts the year after”.** To adapt to this extreme water situation, PWD has formulated a Comprehensive Flood Mitigation Project. PWD is adopting a holistic approach in this project, which takes into consideration the occurrence of both high-intensity flood and drought by including changes to both “macro and micro drains such as river courses, (and) supply and surplus courses of irrigation tanks which play a vital role in mitigating the urban floods in Chennai and its Peri-urban areas” (Radhakrishnan 2020). Under the permanent structural measures introduced in this project, PWD is working on conserving flood waters which involve routine rehabilitation of ageing tanks, introducing climate-adaptive restoration and rehabilitation and, flood protection and river strengthening which together seek to strengthen the resilience of water bodies to climate change.

As part of this approach, we present a detailed description of the climate adaptive restoration efforts which are being implemented by remodeling and re-assessing the hydrology of the region based on the 2015 floods to revise understanding of capacity, water spread area, contour levels, and peak discharge.

For instance, urbanisation has led to an increase in a) paved surfaces leading to higher run-off

downstream and b) groundwater pumping resulting in significant inflow into groundwater aquifers both upstream and downstream. This is resulting in more and more energy being spent in sourcing water contributing to climate change. This is the cycle that PWD is trying to break by remodelling the region and implementing infrastructural modifications through restoration.
The remodelling effort has involved an investigation into how additional buffer capacity for on the surface and sub-surface levels can be created, how can the bund be safeguarded, and so on. Infrastructural modifications include deepening and reclaiming foreshore drains, the introduction of flood regulators parallel to the weirs and outlets, modifying weir length and, increasing carrying capacity of micro drains, buffering capacity of water bodies, and freeboard levels[14] (Fig.27). According to the PWD, the freeboard level is usually 3 ft. but is being increased by 5ft – 6ft (1.5 – 1.8mts) depending on the wave action, area, incoming water, etc. in many tanks in the CMA such as Manimangalam, Nandivaram, Mannivakkam, Urapakkam, Adhanaur, and others. Flood regulation gates have also been differently designed with screw-bearing sluices and the tunnels leading to the sluices designed with extra storage area to store excess water.
Apart from this PWD is constructing cut and cover drains for water bodies where hydraulic links between tanks are missing and is exploring the option of inter/intra basin transfers where possible. Amongst the cases presented in this document, Chitlapakkam and Sembakkam *erys* are part of PWD's climate adaptive restoration project.

Figure 27: Provision of flood regulators and additional discharge arrangements at Selaiyur tank. The image on the right is before restoration and the image on the left, after.

Source: Radhakrishnan, (2020).

14. Free board is the space kept between the top water level and bottom of the roof slab.

CASE STUDY 2: CHITLAPAKKAM LAKE RESTORATION: THE VALUE OF COLLECTIVE ACTION AND MEDIA ATTENTION

Figure 28: Chitlapakkam lake

Source: Okapi Research & Advisory, 2020

Chitlapakkam Lake is a 100-acre lake in Tambaram Taluk, Chennai. Originally spread over 100 acres, it has now shrunk to 50 acres. It is geographically situated such that, Sembakkam lake is on its East and Selaiyur lake is on the Southern side. These three lakes together are part of a connected cascading system. Historically, excess water from Selaiyur lake flowed into Chitlapakkam while excess water from Chitlapakkam flowed into Sembakkam (Fig. 29).

Due to years of neglect including lack of desilting, excess water from Selaiyur lake does not drain into the neighbouring Chitlapakkam and Sembakkam lakes. The channels linking the lakes have been lost due to urbanisation and development. However, PWD's Water Resources Department (WRD) has recently constructed a new cut and cover stormwater drain that connects Chitlapakkam and Sembakkam lake and other lakes further upstream as part of their Climate Adaptive Restoration and Rehabilitation Project.

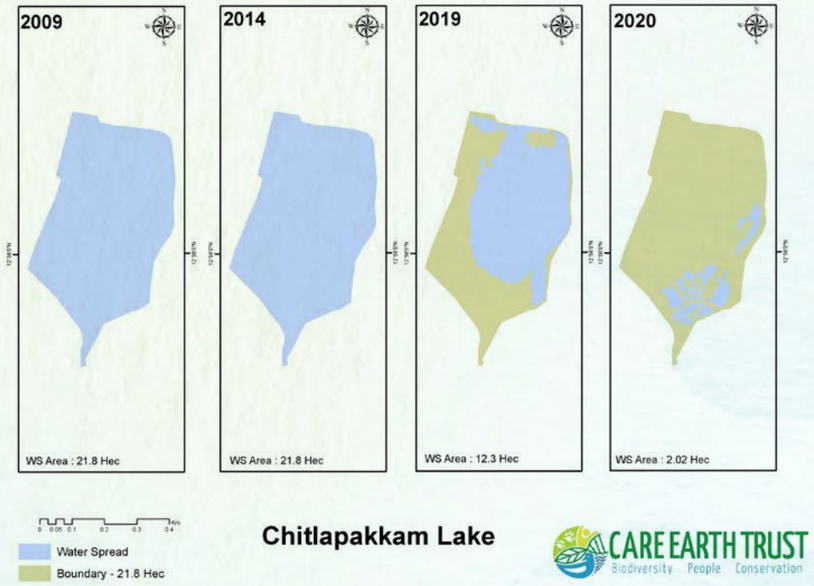
Figure 29: Chitlapakkam, Sembakkam and Selaiyur Lakes

Source: Google Maps

Like many other lakes in the region, Chitlapakkam lake had not been desilted for several decades. It was also used to dump solid waste and let out sewage from the surrounding communities due to the absence of piped sewage system. Chitlapakkam is currently facing severe water scarcity: Borewells that are 300 and 400 feet deep have gone completely dry and water suppliers are unable to meet the large water demand (see Fig. 30 for temporal change in the wetland area).

In 2013, a group of like-minded individuals from the Chitlapakkam residential community came together with the intent of creating a cleaner and hygienic neighbourhood. The group began conducting several street cleaning activities, removing posters from walls and painting them instead. Popularly known as Chitlapakkam Rising with the tagline 'if not you, who? If not now, when?', the group has expanded significantly as they seek to question and monitor services performed by the government. It now has around 10,000 followers on social media, of which anywhere between 50 and 200 people volunteer their time for various group efforts.

Figure 30: Map showing temporal change in wetland area



Source: Care Earth Trust, 2020

The 2015 flooding was a wake-up call for the group. During the floods, the lake overflowed and several houses in the south side of Chitlapakkam were completely inundated with up to nine feet of water. This hastened the need for action. With constant petitioning by the community, in 2017, several encroachments- three temples, a portion of a church, a portion of a mosque, and one marriage hall were demolished to get back the lake's original water spread area.

In June 2019, Chitlapakkam Rising began restoration activities. They sought permission from the government, specifically PWD to conduct cleaning activities and held a lake cleaning event for which there was a large turnout of 2000 people. It was an unprecedented outcome, but one which caught the attention of the government through the hyped media coverage where several questions were raised by the public.

In fact, despite the anger and frustration directed towards the government, the PWD officials stated they were deeply impressed by the manner of the agitation and decided to support the group. As a result, through the Environment Protection and Renewable Energy Development Fund, managed locally by the Department of Environment, PWD was granted a budget of ₹25 crores to restore the lake. Additionally, the organisation received ₹7 lakhs as public donations towards lake restoration. A one-year contract was drawn in November 2019 by the WRD to restore the lake and a comprehensive plan was formed.

Evidently, without the constant campaigning by Chitlapakkam Rising and extensive media coverage of their efforts in the news and social media, the lake would not have got the resources and attention from the government that it has received. This highlights the critical role and strength of collective action to protect common resources.

The government restoration project consists of several components that are underway: Clearing the landfill on the northern side of the lake – which is almost 70% complete (Fig. 31), desilting and deepening of the lake to increase groundwater percolation and mitigate floods, strengthening the bund for 960 m with concrete blocks to effectively hold water when the lake is at full capacity (Fig. 32), construction of a surplus weir for flood mitigation and laying a footpath on the tank bund. Construction of a cut and cover drain, which began in 2018 is also included as part of the lake restoration activities. This drain will link Chitlapakkam lake to Sembakkam lake and transport excess water during monsoons. Further, sewage entering the lake is being diverted into one of the channels which lead to Sembakkam lake.

Figure 31: The landfill in 2017 and being cleared in 2020

Source: Chitlapakam Rising

Figure 32: Concrete block acting as a bund, constructed around the lake

Source: Okapi Research and Advisory 2020

Chitlapakkam Rising has also put forth their demands to the government which focus on two island hills for bird nesting (part of the silt excavated from the lakebed was used for the islands), granite slab seating for people to enjoy the lake view, an STP for treating incoming sewage and an increase in greening and lighting. These demands were integrated into a 2000-page report prepared by the PWD, but the work is yet to start (Interview with Chitlapakkam Rising, 2020). The one-year contract has been extended to 2021, as progress of work was halted due to COVID-19 and monsoons. Care Earth Trust has been roped in for planting activities.

Chitlapakkam Rising group has also decided to monitor the lake and ensure that restoration efforts are sustained over the long run (Fig. 33). The monitoring does not include specific restoration parameters such as water quality, rather is more of an informal, but systematic process that aims to oversee if the restoration work is being conducted as per the plan. The group maintains elaborate activity charts and graphs which track the various work components and the percentage of completion.

Figure 33: Snapshot of the activity progress chart maintained by Chitlapakkam Rising

Source: Chitlapakkam Rising Facebook Page, n.d.

A monitoring team has been formed comprising of local residents who visit the lake every day to document activities and take pictures which are then uploaded to the Chitlapakkam Rising Facebook page. The group uses Facebook to great effect to garner support for the lake and in monitoring the progress of the restoration work. It helps that some of these people have the necessary technical skills to ascertain gaps in the ongoing activities and present practical solutions to the government. With time and constant engagement, the PWD and Chitlapakkam Rising have been able to trust each other and work together. In the long run, the group plans on continuing this monitoring system to ensure that all the efforts are not in vain. As a representative of Chitlapakkam Rising says, “all the good work will be lost unless we maintain it”.

CASE STUDY 3: MADIPAKKAM LAKE RESTORATION: MORE THAN 20-YEARS JOURNEY TO PROTECT AND RESTORE A LOCAL RESOURCE

Figure 34: A glimpse of the lake from the southern end in Nov 2020

Source: Okapi Research & Advisory, 2020

Madipakkam lake is a 52-acre lake in Velmurugan Colony, Madipakkam, Chennai, which has reduced from its original spread of over 62 acres, as per the Sabari Green Foundation, a non-profit leading current restoration efforts at the lake. **The restoration efforts at Madipakkam lake began in 1998 when the Revenue Department wanted to reclassify the lake into a commercial hub. A group of residents (supported by the NGO Exnora) protested and approached the ‘Green Bench’ which passed an order against the land conversion. However, the lake came under stress again when the land mafia started creating parcels of land in the lake of 5 cents each to be sold. This time the PWD was approached and they worked with the local administration to remove these encroachments.** Since then, intermittent activities are being undertaken, spearheaded by resident groups and Sabari Green Foundation.

Currently, the lake is surrounded by several eateries. Garbage is dumped by these eateries and their patrons, contributing greatly to the deterioration of the water body. Sewage inflow

and encroachments further exacerbate this state and result in the spread of invasive plant species and algae in and around the lake. The most pressing issue is the inflow of untreated sewage coming into the lake through eight inlets. The experience of Madipakkam is an appropriate example to understand how rapid and rampant urbanisation typically alters water bodies.

In 2017, Greater Chennai Corporation (GCC) and Sabari Green Foundation officially took up restoration work at the lake. The first of three phases of restoration took one and half years to complete and involved the following activities: removal of garbage and strengthening of lake bunds, information boards were put up to discourage residents from waste disposal, a fence was erected around the lake and several dustbins were set up around the lake to dissuade the public from dumping garbage into the lake.

The second phase involved the desilting and deepening of the lake and the creation of three nesting islands for birds (Fig. 35). It also involved planting vegetation such as wild Neem (Kaatu Veppam) and Indian Beech (Poonga Maram) along the bank of the lake to further strengthen it and construct a 2.7km walking path with benches around the lake for recreational activities. Tree guards were placed around the vegetation planted to prevent uprooting by cows and dogs and GCC is routinely removing invasive plant species in and around the lake. The community also plays a crucial role in sustaining the restoration efforts. They have formed a Madipakkam Lake Walkers Club which promotes water conservation and restoration and spreads awareness about related activities such as safe garbage disposal.

Figure 35: Islands for birds to rest

Source: Okapi Research & Advisory, 2020

The third phase of restoration of the Madipakkam lake, which was suspended due to the COVID-19 pandemic, will involve installing a regulator for the inlets to monitor and control the sewage entering the lake. So far, the restoration effort has been unable to halt the sewage inflow that comes in from both, the immediate neighbourhood surrounding the lake and neighbouring town panchayats, and there is no STP near the lake where the sewage can be diverted (Fig. 36). This is even though the neighbourhoods surrounding the lake have been incorporated within GCC limits since 2011 and by now should have underground piped sewage networks. (Interview with Sabari Green Foundation 2020)

Figure 36: Sewage being let into the lake

Source: Okapi Research & Advisory, 2020

The first two phases of restoration have had a very positive impact on the biodiversity surrounding the lake. It is now common to spot at least 25-50 birds at the Madipakkam wetland. Pelicans, White Ibis', Darters, and Ducks are often seen frequenting the wetland and the 2020 monsoon showers have filled the Madipakkam lake and truly rejuvenated it (Fig. 37).

While formal restoration was initiated in 2017, the fight to protect the lake has been an ongoing process for over 20 years and is likely to continue well into the future, and beyond the formal restoration which is scheduled to end in 2021. The case of Madipakkam lake highlights the need to think about lake restoration not just as a one-time effort but a journey that needs to be sustained over time.

Figure 37: Madipakkam Lake post-monsoon (Nov 2020)

Source: Ibid.

CASE STUDY 4: SEMBAKKAM LAKE RESTORATION: AN INTERDISCIPLINARY/ MULTI-STAKEHOLDER TEAM ATTEMPTING A SCIENTIFIC AND HOLISTIC PROCESS

Figure 38: Aerial view of Sembakkam Lake from the North

Source: TNC

Sembakkam Lake is a 100-acre lake located in the South-Western part of Chennai. It is part of a system of 54 lakes that drain into the Pallikaranai marshland. The lake is surrounded by three municipalities, Sembakkam municipality, Pallavaram municipality, and Tambaram municipality, and the inlets that are in the wetland fall within the jurisdiction of these three municipalities, making the governance of the lake, a challenge. The inlets travel through the jurisdiction of these three municipalities but are controlled by the PWD. Historically, wetlands in Chennai tend to have two or three inlets and one outlet. However, with the construction of stormwater drains, several inlets and channels are now connected to the city's wetland. Currently, Sembakkam lake has 16 channels and 22 inlets (Interview with Dr. Jayshree Vencatesan, 2020). The lake is also linked to Chitlapakkam lake on the west, from where excess water used to flow into Sembakkam. PWD has recently constructed a new cut and covers stormwater drain that connects Chitlapakkam and Sembakkam lake and other lakes upstream (Fig. 39).

Figure 39: Cut and cover drains constructed between Chitlapakkam and Sembakkam

Source: Radhakrishnan (2020)

The lake is surrounded by several residential colonies, and this has led to its deterioration over the years. Nearly 7 million litres of sewage flow into the lake daily and solid waste is dumped regularly resulting in a landfill on the bund. Further, several invasive species have also taken over the lake (Fig. 40). Due to severe groundwater extraction in the entire region, the lake also attracts private water tanker operators who utilise the lake as a water source. Other issues faced are the presence of fishing activities in the contaminated areas.

Figure 40: Aquatic weed being removed from the lake

Source: TNC

Recognising these issues, the PWD was keen on restoring the lake and connected with an NGO - TNC to take up restoration activities in the lake. TNC is working with the Indian Institute of Technology Madras (IITM), CET, PWD, Tamil Nadu Pollution Control Board (TNPCB), and the Tamil Nadu Forest Department to restore the lake holistically and scientifically.

TNC serves as the coordinator and facilitator between the organisations. PWD's contribution as the owner of the tank involves providing technical advice and the necessary clearances.

IIT Madras was involved in an initial survey of Sembakkam lake to prepare a comprehensive plan to scientifically restore the lake and CET took care of dredging and engaged with the local community to understand their expectations from restoration activities.

This is a rare occasion where an initial scientific assessment was conducted to characterise a lake and its watershed in order to develop a holistic understanding of the lake and suggest the most optimal restoration plan. This process involved identifying inlets, quantifying water flow through these inlets and testing the water quality by measuring parameters like dissolved oxygen, biochemical oxygen demand (BOD), total suspended solids (TSS), nitrate, phosphate and ammonia. Chlorophyll content was also measured when there were algal blooms. Water inflows were monitored weekly to understand variations for a year and ground water levels and quality were also measured at different points around the lake including near the dump site.

Due to the presence of the solid waste landfill, the team also decided to conduct a heavy metal test on the water and studied the soil profile. A boat was taken to a few zones of the lake and bore holes were drilled to extract samples. A Bathymetric survey was conducted to identify the soil profile below the lakebed and identify where siltation began, in order to desilt the lake at the correct depth.

An issue with wetland restoration in general is that desilting is often carried out without any scientific basis, resulting in desilting either too much or too little without prior tests to identify where silt deposition has started taking place (Fig. 41). Apart from these tests, the team had the landfill on the banks cleared. The goal is to bring the lake to the Central Pollution Control Board's Category D standard which is fit for wildlife and fisheries propagation.

Therefore, it plans on monitoring progress by measuring turbidity, TDS, nutrients and heavy metals during and post-restoration.

Figure 41: Silt being removed from the lake

Source: TNC

Based on the initial assessment, the team has developed a comprehensive plan to tackle water contamination in the lake. Three different treatment systems have been proposed depending on the level of contamination: sedimentation tanks, aeration, and anaerobic treatment. This is a DEWATS (decentralised wastewater treatment system). A constructed wetland would be the final polishing step.

Plants belonging to the species Phragmites will be employed for filtering the grey water. Their treatment plan also requires that the lake be divided into three different zones: A Contaminated zone (where active treatment takes place), a Buffer zone, and a Clean zone (where fishing and tanker activities can take place). While the restoration team does not recommend the use of the lake water for direct human usage, they recognised that the community was using the lake and will continue to use the lake for certain purposes like fishing. Therefore, the lake has been demarcated into these three zones so that these activities remain limited to the clean zone.

Plans include sufficiently deepening the lake, constructing a walkway along the foreshore bund, and adding a gardening activity to further community livelihood, and giving the community a source of income (Interview with IIT Madras team, 2020). The restoration activities are likely to be

completed within the next eight to ten months and the team is planning on developing a Lake Protection Committee with representation from government, community, private stakeholders to better manage and sustain the outcomes of the restoration process in the long run.

As such, the Sembakkam effort, although underway, seems to present a good example where all the key phases of a holistic and scientific restoration process are being followed: beginning with research, planning, and development of a customised restoration plan by an interdisciplinary and multi-stakeholder team, followed by implementation and continued monitoring, and culminating into a long-term management plan involving multiple partners, especially community representatives.

CASE STUDY 5: VANDALUR LAKE RESTORATION: MOBILISING VOLUNTEER STRENGTH FOR LAKE CLEAN-UPS AND NEIGHBOURHOOD ACTION

For several years, the Environmentalist Foundation of India (EFI) has been involved in restoring lakes not only in Chennai but also across other districts within Tamil Nadu and other states. According to their website, EFI has worked on 129 water bodies in total, of which nearly 75 are in and around Chennai including Madambakkam, Vandalur, Arasanazhani, and Sholinganallur lakes. As an NGO, EFI is heavily dependent on its volunteers (not necessarily from the local community) to carry out any restoration activity. They work with support from the government and engage the community in the restoration of water bodies such as lakes, ponds, reservoirs, and canals through activities that include clean-ups (removal of solid waste), planting native species around the bund, wall painting, street theatre and so on. EFI is keen on sensitising children and young people on the importance of the environment and has tied up with several schools through their 'Science Badge' programme to engage students in restoration efforts.

Vandalur is situated alongside the Vandalur-Oragadam state highway, just off National Highway 32, and is spread across 76 acres. The lake is part of a system where excess water from Otteri lake in the Southeast feeds into Vandalur and excess water from Vandalur feeds into Mudichur lake in the Northwest which is connected to the Adyar river (Figs. 42 & 43). During the 2017-19 drought in Chennai, the water body had dried up due to inadequate rainfall.

Figure 42: Vandalur Lake

Figure 43: Map showing Vandalur and other connected lakes

Source: Google maps

The lake faces similar problems as other urbanised lakes such as indiscriminate solid waste and sewage disposal, open defecation, and encroachments resulting in increased nutrient load and presence of invasive species (Fig. 44). The presence of two highways – one of which is on the foreshore bund (Interview with PWD) has exacerbated the situation as it provides easy access to the lake.

Figure 44: Growth of invasive species

Okapi Research and Advisory 2021

EFI, with support from PWD and Astra Zeneca began restoring the lake in June 2020. According to the PWD, the lake had an NGT order which mandated the ULB to remove solid waste dumped into the lake and this became the first activity (interview with PWD).

PWD, EFI, and their band of volunteers from across the city helped clear the garbage and while doing so EFI found that soil was contaminated from leachate. To prevent more garbage dumping, EFI has erected a ten feet fence of barbed wire and chain link around the lake. EFI has also introduced a few earthen islands to attract bird species with plantations of Neem and Acacia (a native plant species) and conducted community activities such as two plantation activities, a lake walk, a lake clean-up, and a wall painting event. These activities are carried out periodically to "sensitise the community" regarding the importance of the lake (according to EFI), and to help keep the momentum of activities going around the lake (interview with EFI 2020).

EFI's strength is its very large volunteering base. Almost every weekend EFI organises community activities such as lake clean-ups and wall painting in and around Chennai which attract quite large crowds and through which they can instil in citizens, a sense of responsibility towards protecting and conserving natural resources. In cities that are rapidly urbanising and where the younger generation is increasingly becoming disconnected from nature, mobilisation of this kind can help revive interest in nature and nurture community cohesion and civic responsibility towards natural resources.

BIBLIOGRAPHY

EFI. (2020, Jul 24). Vandalur-an unknown water paradise. EFI Blog. https://efiblog.org/2020/07/24/vandalur-an-unknown-water-paradise/

Juliet, S. (2019, Jun 1). Chitlapakkam Rising asked to spearhead efforts to restore lake. The Hindu. https://www.thehindu.com/news/cities/chennai/chitlapakkam-rising-asked-to-spearhead-efforts-to-restore-lake/article27400216.ece

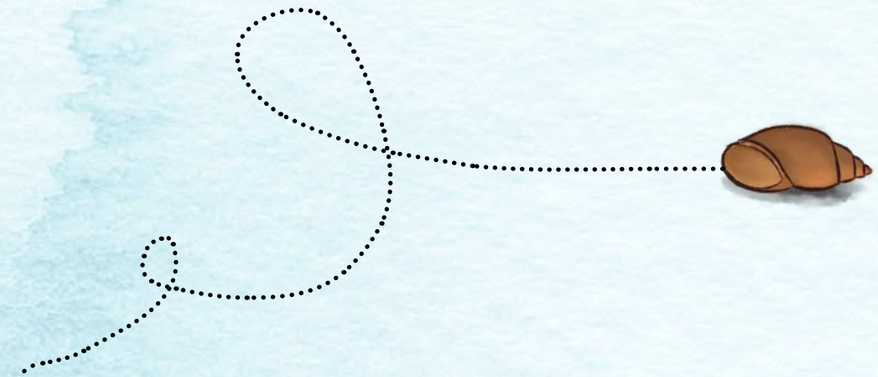
Lakshmi, K. (2019, Nov 15). Work on Chitlapakkam lake to begin by end of November. The Hindu. https://www.thehindu.com/news/cities/chennai/work-on-chitlapakkam-lake-to-begin-by-november-end/article29976300.ece

Special correspondent (2020, Aug 2). Rejuvenation project at Sembakkam lake under way. The Hindu. https://www.thehindu.com/news/cities/chennai/rejuvenation-project-at-sembakkam-lake-under-way/article32250553.ece

Swaminathan, A. (2020, Nov 21). 'Resume restoration of Madipakkam lake'. The Hindu. https://www.thehindu.com/news/cities/chennai/resume-restoration-of-madipakkam-lake/article33148550.ece

Mallick, D. (2019, Aug 5). Greater Chennai Corporation saves lake at Madipakkam. The New Indian Express. https://www.newindianexpress.com/cities/chennai/2019/aug/05/corporation-saves-lake-at-madipakkam-2014221.html

Chitlapakkam Rising Facebook Page. https://www.facebook.com/groups/chitlapakkam.rising/permalink/3407128455987487



CHAPTER 8
CONCLUSIONS

From a quick overview of restoration efforts in the CMA, a few key points emerge, which are:

A. There is increasing interest in protecting water bodies by multiple stakeholders (community-based, NGOs, government, corporates).

B. Despite resource constraints, government agencies like PWD are getting actively involved in water body restoration efforts as an essential step towards climate change adaptation.

C. Communities/ community-based organisations are increasingly playing a key role in initiating many of the efforts by mobilising collective action and awareness building, public interest litigations, media attention, and other means. One of the key resources that NGOs heavily depend on is their volunteer base.

D. Some of the most common challenges that must be addressed for restoration efforts: solid waste and sewage disposal, encroachment, anti-social activities around the lake.

E. The most common strategies to address these challenges include steps such as removing solid waste, erecting tall fences to prevent solid waste dumping, planting native species along the lake bund, building walkways and benches to encourage public use, etc. While these are relatively easier steps to take on, dealing with issues of inflow of sewage and encroachments remains much more challenging. Most restoration efforts have been unable to deal with sewage inflow and to some extent encroachments as these issues are linked to the lack of safe and adequate sewerage systems in the neighbourhood and planning process that needs to be challenged in court and need serious multi-departmental government intervention.

F. Lake restoration efforts often work with limited resources and therefore find it difficult to engage in pre-restoration planning and or continued/long-term monitoring. Much of the government and international funding go directly into large scale infrastructural rehabilitation measures rather than “soft” infrastructural measures such as in-depth research and planning, or long-term monitoring and management.

G. In most cases, sustainability of the outcomes depends on the presence of informal mechanisms like RWAs organising activities, or forming forums or committees to visit, and monitor developments/changes in and around lakes and informing government agencies and raising alarm when needed.

H. All of these efforts highlight the critical role of public-private-partnership (PPPs) for a variety of lake restoration activities such as funding, planning, and research, getting in volunteers, long-term engagement, and sustainable management.

Over the past few decades, Chennai has been experiencing increased frequency and intensity of floods and droughts typically occurring in cycles and associated with climate change. The wetlands restoration has emerged as an important climate change adaptation strategy to tackle these changes because of the crucial role wetlands play in the water cycle and in providing various types of ecosystem services. The 2015 floods proved to be the turning point for Chennai with interest and efforts from the government, private companies, NGOs, academics, and civil society, to clean, rejuvenate and restore wetlands picking up significantly. While these efforts are commendable there is an urgent need for integrating research, monitoring, and sustainable management practices in these efforts, especially those that involve the local communities.

Regular monitoring that extends beyond the project period is essential to understand if the restoration activity has resulted in positive changes to social and ecological parameters, while building-in participatory management processes into the project cycle will ensure that positive actions and outcomes are sustainable (ecologically, socially, and economically) over time.

ANNEXURES

ANNEXURE I: CLASSIFICATION OF WETLANDS

WETTCODE*	LEVEL I	LEVEL II	LEVEL III
1000	Inland Wetlands		
1100		Natural	
1101			Lakes
1102			Ox-Bow Lakes/ Cut-Off Meande
1103			High altitude Wetlands
1104			Riverine Wetlands
1105			Waterlogged
1106			River/stream
1200		Man-made	
1201			Reservoirs/ Barrages
1202			Tanks/ Ponds
1203			Waterlogged
1204			Salt pans
2000	Coastal Wetlands		
2100		Natural	
2101			Lagoons
2102			Creeks
2103			Sand/Beach
2104			Intertidal mud flats
2105			Salt Marsh
2106			Mangrooves
2107			Coral Reefs
2200		Man-made	
2201			Salt pans
2202			Aquaculture ponds

** Wetland type code*

Source: Space Applications Centre (SAC) (2010). National Wetland Atlas: Tamil Nadu, SAC/RESA/AFEG/NWIA/ATLAS/22/2010, Indian Space Research Organisation, https://vedas.sac.gov.in/vedas/downloads/atlas/Wetlands/NWIA_Tamilnadu_Atlas.pdf