CHENNAI: EMERGING TENSIONS IN LAND, WATER AND WASTE GOVERNANCE

A PLATFORM FOR INTEGRATED WATER GOVERNANCE IN METROPOLITAN CHENNAI: DEVELOPING FUTURE SCENARIOS AND STRATEGIES THROUGH PARTICIPATORY SIMULATIONS

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Tamil Nadu State Land Use Research Board

The State Planning Commission established TN SLURB as a permanent body in 2011. TN SLURB evolves formal interactions with various stakeholders and arrives at various policy options besides enabling the State Planning Commission to host seminars/workshops and to commission studies on sustainable land water resource management. The objectives of TN SLURB range from assessing land resources and assigning priorities for land-use changes to building databases and utilizing such databases for improved integration.

Cholamandalam Finance

Cholamandalam Finance has been carrying out CSR through AMM Charities Trust (renamed AMM Foundation). Over the decades, the foundation has been extensively engaged in public health and education initiatives in the communities of its operational presence. The foundation now manages four schools, a polytechnic college and four hospitals. They further support initiatives in eco-conservation and environmental protection through afforestation, soil conservation and promoting rain water harvesting. The organization's continued investments in clean practices and processes that often go beyond statutory requirements reflect its commitment to the environment.

Tata Trusts

The Tata Trusts are among India's oldest philanthropic organizations. The trusts own two-thirds of the stock holding of Tata Sons, the apex company of the Tata group of companies. The wealth that accrues from this asset has enabled the trusts to play a pioneering role in transforming traditional ideas of charity and introducing the concept of philanthropy to make a real difference to communities. Through grant-making, direct implementation and co-partnership strategies, Tata Trusts support and drive innovation in the areas of natural resources management; education; healthcare and nutrition; rural livelihoods; enhancing civil society and governance; media, arts, crafts and culture; and diversified employment. The trusts engage with competent individuals and government bodies, international agencies and like-minded private-sector organizations to nurture a self-sustaining ecosystem that collectively works across all these areas.

Technical Partners

Okapi Research & Advisory

Okapi is an IIT Madras-incubated research and consulting group focused on strategies for addressing the institutional voids that handicap collaboration and innovation in delivering sustainable development. It works with government, corporate, philanthropic and community-based clients, primarily but not exclusively in India, to help them reach environmental and human development goals. Its current work focuses largely on infrastructure and service governance, in sectors ranging from energy to urban infrastructure and at scales from social enterprise development to national policy. It also has a growing portfolio of projects focused on developing scenarios as a tool for anticipating, preparing for and influencing the future; including adoption of new technologies and science-based approaches across sectors.

Fields of View

Fields of View is a Bangalore-based non-profit organization that uses simulations and games as visual representations to engage specific groups or diverse stakeholders on a wide range of issues from framing and defining vague but pressing policies to solving "wicked problems". Tools such as Agent-Based Models enable policymakers to explore multidimensional implications of their decisions prior to implementation. The visualization process broadly functions as a means to deepen participation in social, economic and environmental problems that require solutions through involving multiple actors including the general public. The interdisciplinary team works with academia, civil society and the government around complex public policy problems ranging from urban poverty to waste management.

The Indian Institute of Technology, Madras/Centre for Urbanization, Buildings and Environment (CUBE)

CUBE, a centre of excellence being raised as a society in IITM, is an applied research centre founded to address the practical challenges being faced by urban built environment through development and deployment of innovative technology and policy-based solutions in partnership with academia, government and the private sector. Its mission is to innovate and translate academic research into actionable solutions. Its primary focus is on housing and construction, smart cities, urban planning, transportation and environmental sustainability.

EXECUTIVE SUMMARY

With an aim to foster more integrated thinking and planning for addressing Chennai's water woes, this report focuses on examining the institutional relationships within Chennai Metropolitan Area's land, water, and waste governance ecosystem. This is one of the policy-oriented reports prepared as part of the project, "A Platform for Integrated Water Governance in Metropolitan Chennai: Developing Future Scenarios and Strategies through Participatory Simulations", which also aims to develop an agent-based model to help assess implications of specific land, water and waste-related decisions on the Chennai Metropolitan Area (CMA)'s water vulnerability scenario. Through direct engagement with stakeholders relevant within CMA's policymaking realm and a review of existing knowledge, the strengths and challenges of managing water and closely related issues like encroachment and solid waste are highlighted in this report.

First, the report presents an overview of the decision-making ecosystem around land, waste and water using socio-institutional network analysis (SNA). The key finding from this analysis highlight the following points:

- Urban land and water is governed primarily by a handful of public agencies with limited linkages between them, particularly across public and non-governmental stakeholder groups.
- The ecosystem is moderately hierarchical in character, which is not particularly suitable for effective co-management of city resources. Substantial effort in trust-building will be required for the system to become more collaborative.
- Amongst the multiple key actors some e.g. the CMDA, DoE, TNPCB, TNIDB and PWD are approving agencies, permission or fund givers and rule setters, while others like the GCC, TWAD and CMWSSB operate primarily as implementing agencies who depend on the former agencies.
- The CMDA occupies a particularly important role since developers often approach the DoE, TNPCB or PWD for NOCs or permissions only when the CMDA with power to provide planning or building permits, especially for bigger developments, ask them to.
- The GCC in particular appears to be an important linking agency because it connects several other agencies who do not interact directly with each other. Therefore, the GCC has the potential to act as an important bridge in helping spread sustainable and transformative changes across the network.
- Parastatal agencies dominate the overall governance landscape with obvious implications for empowerment of local-level governance structures.

Next, the report delves deeper into three specific tension areas identified as particularly challenging by government officials and policy-makers. These include dealing with encroachment, managing solid waste and addressing water supply-demand mismatch. While discussing the challenges related to these themes in the context of CMA, the report unpacks the involved actors' roles, relationships, processes and gaps in order to identify what needs to change or improve for better governance of these areas of concern.

In conclusion, based on the above-mentioned in-depth engagement, the report presents a number of scenarios around each of the three tension areas (see table below). These scenarios are intended to provide ideas for policy makers to decide on desirable and sustainable futures and think about related short, medium, and long term strategies.

Encroachment Scenarios	SWM Scenarios	Water supply-demand mismatch scenarios
Developing a holistic policy approach to addressing encroachment (through affordable housing and transportation policies, effective skilling programs)	Enforcing source segregation	Complete dependence on desalination
Streamlining and coordinating the eviction and relocation process (through a rule book that defines roles and responsibilities clearly)	Scientific closure of existing landfills, development of sanitary landfills and waste to energy plants inside landfills	Revival of waterbodies and no desalination
Securing more resources to address encroachment challenges (data, funds, dedicated officials)	Decentralised waste processing and treatment	Revival of waterbodies and increased desalination capacity
Awareness and capacity building on ecological impact of infrastructural projects and EIA process	Enhanced role of private sector in SWM	All industries and commercial establishments reuse waste water
Higher resource/power allocation to the SEAC		Domestic dependence on rain water harvesting
Stringent checks and balances on EIA process and actors		Combination of all the above

In the next phase of the project, "A Platform for Integrated Water Governance in Metropolitan Chennai: Developing Future Scenarios and Strategies through Participatory Simulations", this work will form the foundation for developing an agent-based model and a strategic blueprint to guide policy and action towards making Chennai more resilient with respect to its water needs and threats.

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LIST OF ABBREVIATIONS

AIADMK	All India Anna Dravida Munnetra Kazhagam
CAG	Civic Action Group (CAG)
CMA	Chennai Metropolitan Area
CMDA	Chennai Metropolitan Development Authority
CMWSSB	Chennai Metro Water Supply and Sewerage Board
CoC	Corporation of Chennai
CPCL	Chennai Petroleum Corporation Limited
CRC	Coastal Research Center
CRZ	Coastal Regulation Zone
CTE	Consent to Establish
CTO	Consent to Operate
DMK	Dravida Munnetra Kazhagam
DoE	Department of Environment
DTCP	Directorate of Town and Country Planning
EAC	Expert Appraisal Authority
EC	Environmental Clearance
EIA	Environmental Impact Assessment
GCC	Greater Chennai Corporation
GIS	Geographic Information System
HUD	Housing and Urban Development
IT	Information Technology
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KL	Kilolitre
MAWS	Municipal Administration and Water Supply
MoEF	Ministry of Environment and Forestry
MoEFCC	Ministry of Environment, Forestry and Climate Change
NGO	Non-Governmental Organisation
NoC	No Objection Certificate
NRW	Non-Revenue Water
O&M	Operation and Maintenance
Ppm	Parts Per Million

PWD	Public Works Department
RFD	Refuse Derived Fuel
RTI	Right to Information
RWH	Rain Water Harvesting
SEAC	State Environmental Assessment Committee
SEIA	State Environment Impact Assessment Authority
SEIAA	State/ UT Environment Impact Assessment Authority
SEZ	Special Economic Zones
SIDCO	Small Industries Development Corporation Limited
SIPCOT	State Industries Promotion Corporation of Tamil Nadu Limited
SNA	Social Network Analysis
SWM	Solid Waste Management
Sq. km	Square Kilometre
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TIDCO	Tamil Nadu Industrial Development Corporation Limited
TNEB	Tamil Nadu Electricity Board
TNHB	Tamil Nadu Housing Board
TNIDB	Tamil Nadu Infrastructure Development Board
TNPCB	Tamil Nadu Pollution Control Board
TNSCB	Tamil Nadu Slum Clearance Board
TP	Town Panchayat
TUFIDCO	Tamilnadu Urban Finance & Infrastructure Development Company
TWAD	Tamil Nadu Water Supply and Drainage Board
ULB	Urban Local Bodies
UPE	Urban Political Ecology
WTE	Waste to Energy
WTERT	Waste toEnergy Research and Technology Council

FOREWORD

Chennai, the fourth largest city in India, on the one hand aspires to sustain its growth and development and, on the other is increasingly facing environmental limitations in multiple forms (water scarcity, floods, droughts, sea-level rise and loss of greenery, wetlands and other natural resources/ habitats). Okapi Research & Advisory, the Center for Urbanization, Buildings & Environment (CUBE) at IIT Madras and Fields of View, funded by Tamil Nadu State Land Use Research Board, Cholamandalam Investment and Finance Company Limited, and Tata Trusts, have initiated a project titled, "A Platform for Integrated Water Governance in Metropolitan Chennai: Developing Future Scenarios and Strategies through Participatory Simulations". This project is an attempt to **develop a process of planning and decision-making** that can help integrate concerns and actions around urban growth and environmental management, particularly with respect to water-related vulnerabilities, so that Chennai may develop as a sustainable and resilient city.

This process of *integrated planning and decision-making* encompasses a three-step methodology:

I. **Context Development:** This involves using primary and secondary research to gather background information on current trends of the city's development, its state of water and emerging tensions, particularly with respect to institutional and governance-related challenges.

II. **Scenario and Tool Development:** This involves agent-based model development to present multiple scenarios based on varied decisions and actions undertaken by different public, private and civic agencies.

III. **Strategy Development:** Finally, scenarios and games will be used to enable multiple actors to design strategies that can help address current challenges characterizing the city's development and its intersection with water-related risks.

The specific outcomes of this work will include:

1. **Five policy-oriented reports**

a. *Chennai: Urban Visions* – A report on the city's socio-economic drivers, their visions and the overall trajectory of development.

b. *Chennai: State of Water* – A report on the current state of water and associated risks.

c. *Chennai: Emerging Tensions in Land, Water and Waste Governance* – A report on institutional and decision-making challenges related to how land, water and waste is dealt with in the context of rapid urban development and need for greater water resilience.

d. *Building an Integrated Governance Platform* – Drawing on grounded experience, a report on challenges and good practices around data collection, workshop facilitation and project design to facilitate replication of similar scenario-based integrated governance platforms.

e. *Shaping Public, Private, Community Actions for Transformative Change* – A comprehensive, grounded, tactical strategic blueprint to guide, public, private and civil society actions to transform the system.

2. An agent-based model to help assess implications of specific land, water and waste-related decisions on the Chennai Metropolitan Area (CMA)'s water vulnerability scenario.

The reports and the agent-based model will offer the essential integrated/ interdisciplinary knowledge and practical tool and guidance for planners and policy makers to make informed decisions for a more sustainable water resilient Chennai. The first phase of work has synthesized existing data and collected some primary data to set the stage for stakeholder engagement and deliberation in the following two steps of the integrated planning process, namely, the scenario and strategy development phases. This work is presented in the first three reports: *1. Chennai: Urban Visions; 2: Chennai: State of Water; and 3: Chennai: Emerging Tensions in Land, Water and Waste Governance.* The overarching thought that binds the three reports is grounded in Urban Political Ecological (UPE) scholarship rooted in the work of David Harvey (2000; 1996; 1989; 1973) and Neil Smith (1996; 1984; 1980 with Keefe).

Since our core purpose in this project is to develop a process of integrated and participatory planning that can make Chennai more resilient towards water-related risks, a common question is whether such integrated planning falls within the scope of urban planning or environmental planning? We often think of urban/human issues and environmental/natural issues as distinct, and hence tend to differentiate urban planning and governance from environmental planning and governance. However, UPE scholars contend that our cities and the state of their resources including land, water, vegetation, air, etc., are a result of the complex interaction between existing environmental conditions and human processes. For instance, flooding in Chennai in 2015 was not simply a natural disaster. Rather, as one activist described, "it was in the making since 1990s". Land-use change due to fast urbanization and economic development lead by human decisions and actions across CMA, interacted with the hydrological and climatological dynamics, leading to the city to come to a stand-still in December that year.

The UPE approach can be summarized in terms of its three core tenets. Each of these tenets provides a theoretical and analytical basis for examining our cities and its environment.

Tenet 1: Understanding city and its environment as a manifestation of the dialectic interaction of social and environmental processes.

Counter-intuitive to the traditional and popular expectation of finding nature outside the city's boundaries (Keil, 2003) and necessarily contentious understanding of "pristine nature" vs. "destructive humanity" (Braun, 2002), the UPE approach focuses on the dialectic/two-way and symbiotic relation between nature and society (Swyngedouw, 1996; Swyengedouw and Kaika 2000; Cronon, 1991; Keil and Graham, 1998). It enables us to think of the urban environment as a product of interaction between human elements of planning decisions, policies, infrastructure funding, investment and ownership practices, public engagement, local politics, etc. and nature (Kaika 2005; Swyngedouw and Heynen, 2003; Braun and Castree, 1998). As such, in our effort to present an understanding of the current state of waterbodies in Chennai, we pay attention not only to the physical/environmental aspects of rainfall, local topography and drainage patterns, but also engage with social aspects of urbanization and planning and policies around water and waste management to highlight the complex two-way society-nature interaction (see the State of Water report). This dialectic interaction is evident, for instance, inthe extent to whichrapid

encroachment on waterbodies impacts the quality and quantity of water while this state of water itself poses threats to future development of the region in absence of sustainable solutions.

Tenet 2: Excavating socio-political power play in production of city environment.

UPE recognizes the existence of the deeply uneven power relations through which the contemporary city environment is produced (Heynen et al., 2006). Harvey explains that urbanization is a process of contestation for achieving control over society's scarce resources. In this struggle, it is usually those with relatively more socio-economic power who win, letting the marginalized fall further back in the struggle. This explains the continued inequality in distribution of resources like drinking water, which are scarce to start with in a city like Chennai (Janakarajan,2013; Srinivasan et al., 2010). However, this power play is not only driven by economic power but also by social, political and institutional power, which plays an equally important role in determining who benefits from and who is threatened by the state of the socio-natural condition of a city. As such, uncovering these intricate power relations remains an extremely important part of our three reports as we attempt to explain the process of peripheralization of the water problem in Chennai (in the State of Water report), the limited incorporation of citizens' inputs, especially those of marginalized ones, in urban planning and policy-making (in the Urban Visions report) and the interaction between various government agencies with differential power and jurisdiction, divided responsibilities across sectors and geographies and blurred accountability shaping urban-water governance ecosystem in Chennai (in the Emerging Tensions report).

Tenet 3: Understanding the present through a historical-geographic perspective.

The UPE framework highlights that a proper understanding of the present state and plans to modify the future towards sustainability requires a historical geographic perspective. In other words, to understand the present and predict and/or modify the future, we need to look at the past trajectory. Similarly, for a complete picture, it is essential to pay attention to social and ecological processes interactively shaping our cities at various geographic scales/spaces. As such, in our analysis of the present state of urban development, water resources and governance we have time and again highlighted how past events have shaped or have been transformed by current trends. In the Urban Visions report, for instance, we describe the historical trajectory of development of Chennai as the fourth largest city in India, underlying political-economic shifts and implications for the city's environment. Similarly, in examining the role and relation of agencies involved in governing Chennai, we have paid particular attention to how these agencies work at various scales and with what implications, specifically in the Emerging Tensions report. As such, each of the three reports in the Context Development phase of our work emphasizes on different aspects of the human-environment interaction process that ultimately shape Chennai and its waterscape (see Figure 1).

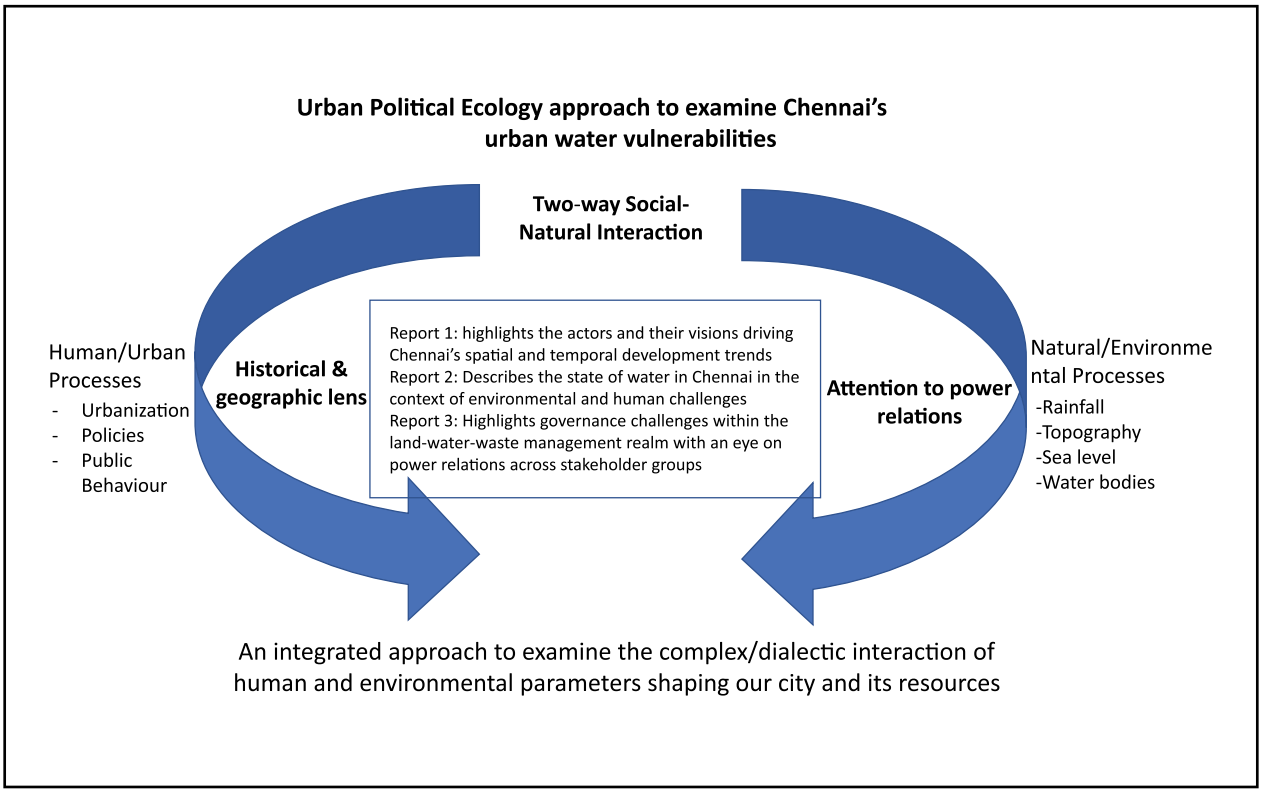

Figure 1: Urban Political Ecology Approach

Counter-intuitive to the traditional and popular expectation of finding nature outside the city's boundaries and necessarily contentious understanding of "pristine nature" vs. "destructive humanity" the UPE approach focuses on the dialectic/two-way and symbiotic relation between nature and society.

The following report, Chennai: Emerging Tensions in Land, Water and Waste Governance is one of the three reports that present the context development work. In addition to the findings of the two other reports, this report draws on primary (direct engagement with stakeholders through interviews and workshops) and secondary (review of existing literature, reports, newspaper articles, etc.) research. This report attempts to highlight the institutional relationship within the policymaking realm through a) an overview of the decisionmaking ecosystem around land, waste and water using a socio-institutional network analysis and b) a number of case studies that unpack the roles, relationships, processes and gaps around specific tension areas including encroachment, managing solid waste and addressing water supply-demand mismatch. These case studies were selected on the basis of how stakeholders themselves defined and prioritized tension areas relevant to managing city development and water resources.

CHAPTER 1

INTRODUCTION: EVOLUTION OF URBAN AND ENVIRONMENTAL GOVERNANCE IN CHENNAI

CHAPTER 1: INTRODUCTION: EVOLUTION OF URBAN AND ENVIRONMENTAL GOVERNANCE IN CHENNAI

The historical trajectory of Chennai city from an urban and environmental governance perspective reveals path-defining developments, decisions and policies made over many decades. These have ultimately shaped the current state of Chennai city's land, water and waste. This chapter describes the ways in which decisionmaking and institutional processes around land, water and waste have evolved over time, emphasizing two critical points: First, while urban land and water was historically used and managed collaboratively, with higher degrees of environmental consideration, this trend has changed drastically since colonial times and with the rising pressure of population and economic development. Second, an 'entangled history of centralization and decentralization' has shaped the complex urban and environmental decision-making realm that is currently characterized by multiple agencies (often parastatals), with overlapping responsibilities and jurisdictions, and, as a result, tensions.

As described in the Urban Visions report, land during the pre-colonial period (2nd Century A.D. to 1639) was perceived as a collective resource. It was typically managed by villages and communities which pooled together resources and managed them as 'commons' that were accessible to all for varying purposes. A land use and segmentation system known as 'poromboke' implied that areas such as grasslands, groves and forests were designated as 'shared spaces' for communal use (Jayaraman, 2016). Land was not typically segmented according to economic terms (viz. public and private land). Furthermore, it is interesting to note that human settlement considered prevailing topographical and hydrological constraints, with most communities settling in elevated areas – and thereby sidestepping flood risk and revealing a regard for the environment. However, this 'consciousness' dwindled over time, with serious ramifications for land, water and eventually waste management in the Chennai region.

Around the same time an intricate system of (sometimes isolated and sometimes interconnected) water tanks, also known as 'erys', were built and maintained to meet local water demand and to address the disparities in annual monsoon cycle (Arabindoo, 2011). These local resources were primarily meant for irrigation but they also played a critical role in conservation, aquifer recharge and flood mitigation (Manohar and Muthaiah, 2016; Baud et al., 2016). Local village communities saw value in these resources and took up the responsibility to manage and raise funds for maintaining the 'erys' (Mukundan, 2005).

With the advent of the seventeenth century, and the foray of the East India Trading Company into the Madras region, the Corporation of Madras was born in 1688. This gradually led to the evolution of new systems of administration, with a focus on systems of municipal governance aimed at suburbanisation and the development of local areas through

the construction of infrastructure such as schools, jails and townhalls, which were funded through taxation. This trend was further encouraged through the development of road and railway networks (Kanchanamal and Sekar, 2011). Between 1850 and 1900, the then Madras region began to experience urbanization and commercialization at a far greater rate than the surrounding area, driven in part by a growth in agriculture, and also by a growth in transportation and migration for employment (Vijayabaskar et al., 2011).

Gradually, these Madras region developments meant changes in the system of land and water management. Land began to be perceived in economic terms and many of the poromboke areas such as wetlands ended up being demarcated as wastelands (Manohar and Muthaiah, 2016; Jayaraman, 2016). Such classifications and new land use patterns, driven by the planning process, began to shape the development trajectory of the region in less scrupulous or accountable ways, especially with regard to the environment. Water management through the ery system too began to be neglected, with the focus now shifting to managing the growth and development of the city and catering to the needs of an ever-increasing population. This is perhaps best exemplified by the development of the Royapuram Railway Station in a low-lying area, which meant that the railway path now skirted sensitive ecological zones (such as swamplands in Perambur) and settlements began to spring up along these transportation networks, irrespective of their location on low-lying regions of the city. Many of the erys and tanks which 'stood in the way' of the now-favoured pattern of growth and development gradually fell into disuse and were filled up or became hotbeds for diseases such as malaria on account of a lack of maintenance or recognition of their ecological function (Baud et al., 2016).

The colonial period also remained particularly eventful in terms of the various institutional experiments in the realm of governance (Coelho et al., 2011). Since the creation of the Corporation of Madras in 1688, the growth of Chennai into its current metropolitan manifestation has been shaped by a long and tangled history of decentralization and re-centralization (Coehlo et al., 2011). For example, while in its first iteration, there was a level of representativeness and localization of functions, as imperial ambitions expanded, revenue raising and decision-making powers were slowly shifted to provincial officials. There was push-back to these moves via means ranging from litigation to internal protests, whereby the processes occasionally led to some transfer of roles and prerogatives (Ibid; Arabindoo, 2008).

With the establishment of the Corporation of Madras in 1688, various forms of local governance were experimented with. This experimentation centred around, for example, the level of functional autonomy given to local bodies, finance sourcing and the manner of selecting local body members. The charter that established the Corporation of Madras in 1688 encouraged all people (irrespective of nation and faith) to take part in municipal governance. The revenue generated by the corporation through taxes was used to improve basic infrastructural facilities consistent with the functions of a municipality, such as lighting, roads, drainage, schools and a town hall. Subsequent charters provided greater statutory footing to municipal administration. The Madras Town Improvement Act of 1865 went on to place the administration of Municipalities under District Commissioners, who in turn appointed office bearers, thus empowering the municipalities to levy various types of taxes and usethem to improve infrastructure. Following

this, the city was reorganized in 1867 and divided into 8 wards – a move that could be viewed as a juncture when devolution of authority gradually began to spread. In the decades leading up to India's independence in 1947, a Royal Commission on Decentralization was set up in 1908 to address issues in power sharing between the various levels of Government. The Madras Municipal Corporation Act of 1919 and the Madras District Municipalities act of 1920 sought to empower councils and boards to conduct their own internal elections for the post of the Chairman, create budgets and limit undue influence from external parties. The Government of India Act of 1935 continued the trend to give more powers to local bodies with regard to electoral policies at the municipal level (for a detailed description see Coehlo et al., 2011).

Post-independence, the democratic basis of the Corporation persisted for a couple of decades and a level of autonomy over drafting plans for city growth was retained. However, with the influx of patronage politics at a time when a growing population needed more urban amenities, particularly around water, better sanitation and housing, pressure increased to enhance the efficacy of urban governance (Arabindoo, 2011, 2008).

From a planning perspective, the Tamil Nadu government responded to this pressure by constituting the Chennai Metropolitan Development Authority (CMDA) in 1973 that would draft a master plan to determine the metropolitan area growth trajectory and land use demarcations (CMDA, 2012). The officials of this body were state-appointed. The evolution of the CMDA coincided with the "Emergency" period in India. This served as an impetus tohalting the democratic functioning of the Corporation, which in any case had been superseded by the CMDA (Coehlo et al., 2011).

Furthermore, the World Bank's intervention into India's urban space during the same period was characterised by investment offers subject to reforms that would further corporatize urban bodies and create guardrails against politicization (MIDS, 2012). To meet the conditions at a time when the state was desperate for funding, agencies such as the Tamil Nadu Slum Clearance Board (TNSCB) and the Tamil Nadu Housing Board (TNHB) were constituted as professionalized, state-appointed bodies. Parallel to the establishment of these state-appointed bodies (sometimes referred to as parastatal agencies), the World Bank entered the realm of urban governance in Tamil Nadu. Through the funding of projects, mostly revolving around housing, the World Bank placed a strong emphasis on the financial efficacy of these projects primarily in terms of cost-recovery (Coelho et al., 2011)

While the World Bank's early role provided an initial shift to a more economically competitive governance, economic reforms at the national level in 1991 created an institutional environment that catalysed state level governments to more proactively target private investors, both locally and internationally (Arabindoo, 2008). The way cities were viewed by state governments changed during this time from loci of regionalism through cultural expression to lucrative centres for capital formation and economic growth (Ibid). The latter iteration was also rooted in a growing appreciation among international investors of the importance of regional governments in economic development in a liberalized framework (Cuadrado-Ruda, 2008). It is therefore telling that in Tamil Nadu's State Vision 2023 document, Chennai is projected as a "World Class" city without acknowledging any other Indian counterparts (Kennedy et al., 2014).

The intense competition to attract urban investments was also emerging

in the context of national reforms expressed in India's 74th constitutional amendment that called for devolution of powers, responsibilities and fund-raising capabilities to the local level (MIDS, 2012). At the time the Centre also initiated the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), an INR 500 Crore national urban investment scheme that would be operational from 2005 to 2012 (Ministry of Urban Development, 2012). Funding here was further tied to conditions that included a combination of mandatory and voluntary reforms that would ensure the implementation of the 74th Constitutional Amendment.

To the extent that mandatory reforms are concerned, the Tamil Nadu Government reportedly transferred 17 out of 18 services to the local level, with the exception of fire services. The requirement to set up a Metropolitan Planning Committee via legislative process, however, has not yet been completed (The CMDA was created by the state).

In terms of the directive on engaging urban local bodies (ULBs) for city planning function,changes are unclear. While the official response is that a chunk of the responsibilities has been transferred to ULBs, the CMDA appears to retain a number of its prerogatives. The Corporation Commissioner is a board member, thus serving to potentially reconcile differences.

In any case, the unfettered development patterns reflected in large scale megaprojects and household-level encroachment on land that development regulations actually forbid shows weak enforcement capacity and continued state-level presence in urban decision making on a significant scale. Chennai's present governance system is symbolic of the historical trajectory and political and administrative inclinations, alongside other developments. This has shaped the city governance in the post-independence period in a manner that pride the higher role of the state in facilitating economic growth and development, as opposed to a comprehensive devolution of responsibilities to lower levels of governance (Kennedy et al., 2014).

This reality is also exhibited in the ambiguous position of the Chennai Metropolitan Development Authority (CMDA), a parastatal body that is responsible for planning and development activities within Chennai city. While the approvals process for development and buildings has been partially devolved to the City Corporation, this is limited to small-scale, household level projects. Approvals for multi-sectoral endeavours remain under the ambit of the CMDA (Coehlo et al., 2011). On the one hand, unabated household-level developments, particularly in the peripheral and ecologically vulnerable areas, reflect the Corporation's limited enforcement capacity notwithstanding the additional powers afforded to the body. On the other hand, the strategic segmentation of responsibilities between the CMDA and the Corporation buttresses the claim that the government is indeed retaining its power over some of the most lucrative elements associated with the city's urban and economic development. As such, one may argue that state and parastatal agencies continue to yield greater power over governance processes in and around Chennai city, with relatively limited consideration of inputs from lower levels of governance.

Furthermore, an emphasis on economic and infrastructure development has also raised important concerns for social and spatial equity in peri-urban areas around the city. These spaces are increasingly being highlighted as sites that are heavily polluted or where excessive resource extraction occurs. A study in two such peri-urban areas in Tamil Nadu

revealed a paucity of analysis and documentation of patterns and intensities of vulnerabilities in peri-urban areas of Chennai city (Janakarajan et al., 2007). The consideration of rural, peri-urban and urban issues in isolation rather than through an "integrated livelihood and ecosystem" approach (Janakarajan et al.,2007) has rendered most urban governance initiatives futile in terms of meeting the needs of diverse citizen groups. Janakarajan thus contends that "a fragmented approach would only bring about rural/urban and peri-urban/urban divides, besides contributing to the destruction of ecology, environment and livelihood options in the rural and peri-urban areas" (Janakarajan, 2013). As such, with rapid urbanization and an associated increase in the amount of waste created, many peri-urban area waterbodies have come to be used as urban waste dumping yards (Janakarajan, 2013). Similarly, a practice of locating disposal areas and landfills in lower income areas, specifically on the outskirts of the city, has raised environmental and social justiceconcerns among vulnerable communities, civil society and academia (Srinivasan, 2006). Furthermore, studies have raised the issue of excessive water resource extractionin peri-urban areas to meet city demands. This is deemed responsible for negative externalities in those regions. As noted by one expert "The main reason for conflicts in the peri-urban areas of Chennai is that urban stress is transferred to peri-urban areas, leading to a drain on natural resources such as land and water" (Jankarajan et al., 2007, pg. 59).

It is therefore evident that, while the ecological functions of land and water determined where people settled and other aspects of development during the pre-colonial era, the colonial and post-colonial times ushered in an era of 'development' that placed a greater emphasis on infrastructure and economic growth, with less consideration given to other important factors revolving around ecological balance, social equity and local empowerment. In particular, the post-liberalization period of the 1990s and early 2000s was characterized by the rapid infrastructure development of Chennai's IT corridor along and on top of Chennai's Pallikaranai marsh. Also, considerable development occurred in the Ennore creek vicinity, despite it being declared a no-development zone in 1996 (Special Correspondent, The Hindu, 2017) (see Figure 2 for a graphical representation of the evolution of Chennai's urban environmental governance).

Chennai city experienced heavy flooding in 2015 and this brought with it a new awakening and awareness among the population and city authorities about the dangers and implications of development that fails to consider the environment or the larger ecological functions of land and waterbodies. As a result of this new awareness, several government efforts are being formulated with the goal of making future development more sustainable. However, our engagement with stakeholders during workshops and interviews revealed that such efforts frequently occur in silos; that they need to be better coordinated in order to acutally receive sustained results. For instance, lake restoration efforts are carried out in good faith by government and/or civic agencies but are then sometimes undermined by other agencies' continued disposal of sewage water into those restored waterbodies, which renders ineffective any restoration effort.

As such, it is evident that the government's growing awareness and resulting efforts need to be supported by a thorough understanding of the various governance challenges or limitations as well as opportunities that multiple agencies working at the intersection of land-water-waste management present. This will provide the necessary support to these agencies to work

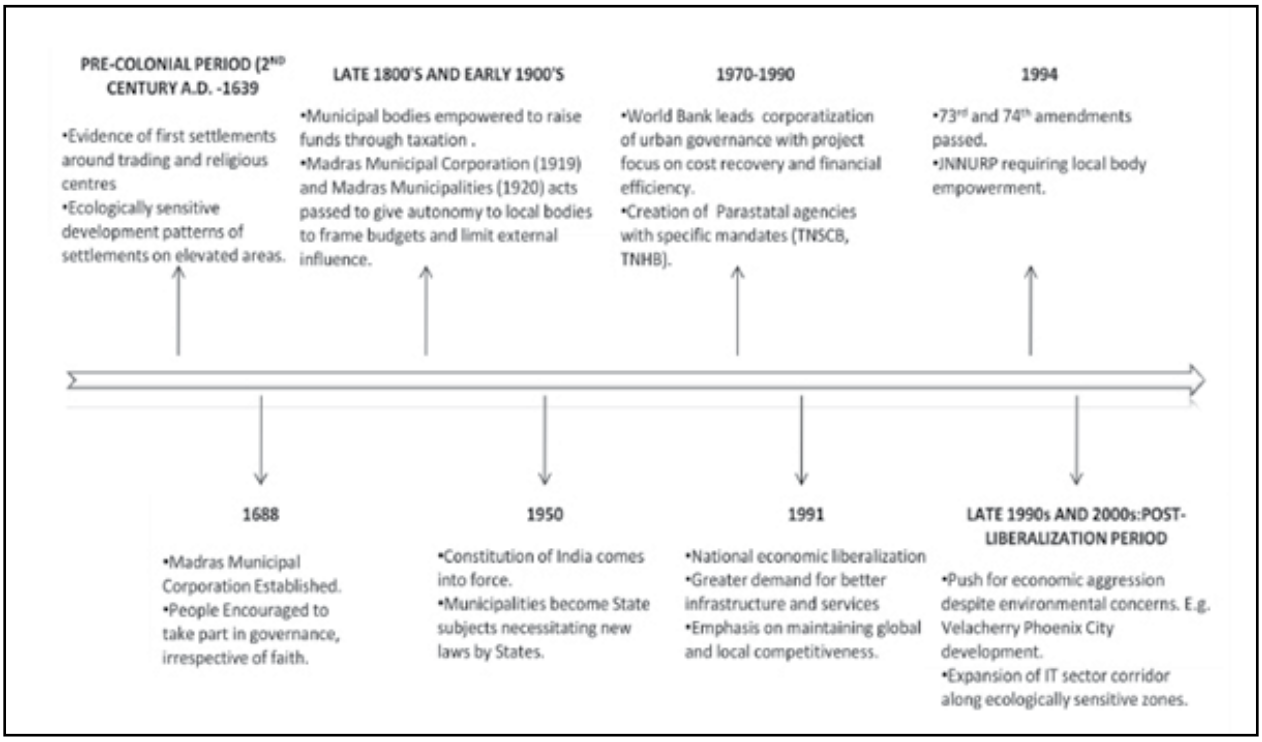

Figure 2 : A timeline for changing trends in urban and environmental governance

better together.

Therefore, in the first section of this report we attempt to map Chennai's governance ecosystem around land, water and waste, this being the first step to facilitating more integrated forms of decision-making by myriad agencies across sectors. Specifically, we examine how various agencies interact with one another in order to understand the inter-agency relationship using a Social Network Analysis (SNA) methodology. This analysis primarily involves government agencies who remain at the core of policy-making processes while incorporating selective non-governmental, private and academic agencies mentioned by the government stakeholders as relatively important actors. The socio-institutional network approach enables us to identify who are the key actors, why, to what extent they depend on/collaborate with one another and who might act as important linking agencies to enable sustainable transformations in the governance system.

The second section of the report presents the ways in which various government agencies are responsible for regulating development, supplying/managing water and managing waste in the Chennai Metropolitan Area (CMA) and identifies and describes a) emerging tensions at the intersection of land-water-waste management (such as encroachment) and b) governance related challenges associated with fulfilling their duties with respect to addressing such tensions (limited funds, personnel, data to address encroachment). As such, in chapter 3 we first list all the tension areas and associated governance challenges discussed by government agencies over several workshop engagements. This broad overview is then followed by a more in-depth analysis of three specific tension areas that were voted as highly critical tension areas that need to be addressed for Chennai to become more resilient with respect to water risks. These are encroachment

(chapter 4), solid waste management (chapter 5) and water demand-supply mismatch (chapter 6). These three chapters take an institutional approach to unpacking the inter-agency/stakeholder relationship, related strengths and gaps or governance challenges. Finally, we conclude by pointing out a set of future scenarios based on our examination of the three prioritized areas of tension. The highlight of this report is the analytical work presenting the institutional environment within which urban-water governance unfolds (see Table 1 for an overview of the report's organizational framework). This will be a critical input in the agent-based model that will be developed in the next phase of our work on this project. It also helps identify where and what sort of coordination is needed between which agencies in order to achieve more effective and sustainable results.

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<tr><td>Section I: Chapter 2</td><td colspan="4"></td></tr>
<tr><td rowspan="4">Examining institutional environment using Social Network Analysis</td><td>Chapter 3:</td><td>Overview of tensions areas and governance challenges as identified by stakeholders</td><td>Examples of tension areas at the intersection of land-water-waste. For example, encroachment or solid waste management</td><td>Examples of governance challenges that agencies face when dealing with tension areas such as encroachment. For example, funding or personnel</td></tr>
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Table 1: Organizational framework of this report

CHAPTER 2

CHENNAI'S GOVERNANCE SCENE UNPACKING INTER-INSTITUTIONAL RELATIONS

Section I

CHAPTER 2: CHENNAI'S GOVERNANCE SCENE – UNPACKING INTER–INSTITUTIONAL RELATIONS

The accompanying Chennai: Urban Visions report includes stakeholder analysis that indicates how public agencies play a key role in planning and policy-making around land use and economic development, as well as water and waste management. Alternative development and sustainability visions emerging primarily from civil society, academia and marginalized communities (and also reflected in theory within planning documents) tend to fail to shape actual decision-making, largely because avenues of broad stakeholder participation remain missing in the governance realm. During stakeholder mapping exercises, few key participating public agencies recognized or even mentioned non-governmental organizations (NGOs), academic institutions or community groups as important partners in decision-making. Instead, these groups were described largely as disruptive forces. Government representatives emphasized a need for improved citizen responsibility for better management of city's water and waste – rather than citizen right to participate in decision-making around these issues. This is in sync with popular and academic literature that mentions the overall failure of the State of Tamil Nadu to respond to the 74th Amendment of the Constitution, best showcased through the historical opposition of the two dominant political parties, the Dravida Munnetra Kazhagam (DMK) and the All India Anna Dravida Munnetra Kazhagam (AIADMK) to the 73rd and 74th amendments. As one writer points out, a few states, including Tamil Nadu"... have woeful records on urban decentralization. Indeed, they present (along with a few other States), contrasting styles of how to marginalize local governments while pretending to abide by constitutional mandates" (Raghunandan, 2013). In this chapter our institutional mapping exercise also reveals that Chennai's urban and environmental governance scene remain limited and primarily dominated by government actors, specifically state, parastatal and other higher-order government actors.

Social (Institutional) Network Analysis: a viable method to unpack the complex networks/ relations between multiple actors involved in using, managing and making decisions about natural resources (Stein et al., 2011)

In order to better understand the inter-organizational relationship between these government agencies and the few NGOs they perceive as part of Chennai's governance scene, this chapter resorts to an SNA approach. An increasing body of scholarly work on natural resource management highlights the role of socio-institutional networks (Bodin et al., 2006; Bodin and Crona 2009; Ernstson et al., 2008, 2010; Stein et al., 2011). This work recognizes the importance and uncertainties associated with complex networks of actors and their involvement in using, managing and making decisions about such resources and hence emphasize the need to unpack such networks and the relations embedded therein. Stein et al. (2011), for instance, demonstrates the applicability of SNA as a viable method to describe and analyze the socio-institutional complexity underpinning water resource governance in Tanzania.

SNA provides a means to unpacking complex socio-institutional landscapes by mapping the institutional actors (organizations, individuals, interest groups) and their linkages or networks (socio-institutional relationships). SNA can serve multiple purposes. For instance, it can be used to map flows of funds, exchange of information or influence posed by multiple agents/ institutions. It can also help provide an understanding of actors' world view, their problem framings and associated decision framing, which can be synergistic or competing. In addition to mapping existing socio-institutional landscapes, SNA can also be crucial to identifying network strengths and weaknesses that are important leverage points for bringing desired transformation (for instance, towards becoming a more collaborative governance network). As such, SNA involves initial visualization of actors and their linkages, followed by interpretation and analysis of this diagram which can be done quantitatively and/or qualitatively.

Both methods have pros and cons. Quantitative SNA usually tends to chart whole networks and comprehensively identifies nodes and links, as well as measures indicators such as network density and centrality, with the help of software using standard statistical tests. While such rigorous quantitative analysis provides a thorough understanding of the overall structure of a socio-institutional governance ecosystem, it can fail to represent the complex relational attributes which tend to lose visibility and/ or significance when quantified. In contrast, qualitative SNA engages in a descriptive analysis of network diagram using various theoretical concepts of network research, such as those around the topology of the network, and highlight the nuances of relations amongst agents. In this report we resort to a mixed method, using both quantitative and qualitative approaches to examine the nature of urban environmental governance ecosystem in the CMA. SNA (particularly qualitative SNA) is sometimes critiqued for being ego-centric, representing one actor's or a few actors' perceptions. However, a participatory SNA or one where multiple means of data collection and validation is used, can address this problem. In this case, while we have relied particularly on data collected through participatory workshops, interviews (see Appendix 1) and secondary research have also been used to validate the information used in the analysis. Therefore, relations included in the analysis have been either identified repeatedly or by both agencies involved and those that the stakeholders identified as particularly important interactions.

Since most contemporary governance systems represent clusters of agencies working at multiple scales and within various sectors, substantial coordination, particularly through knowledge transfer, is essential for integrated management and cross-sectoral planning. Furthermore, strong functional dependencies or funding-related dependencies on one or few actors can pose restrictions or offer strong incentives for the larger network to work towards a goal of more integrated planning. As such, in this report we attempt to chart two types of relational flows between multiple agencies working within Chennai's governance ecosystem: first, functional dependency flows; and second, data/knowledge flows.

Functional dependency flow

Functional dependency flow marks the linkages that represent agencies' dependency or influence on others for proper functioning, either through funding-related dependencies or process-approval dependencies (for

example, TNHB or TNSCB depending on Directorate of Town and Country Planning (DTCP) to get planning and building permission beyond the CMA boundaries, or Department of Environment (DOE) providing funds to various other government departments based on project proposals submitted by them).

Data/knowledge flow: marks the communication pathways for data or knowledge-sharing between actors (for example, the CMDA gathering data from multiple agencies like Greater Chennai Corporation (GCC), Department of Environment (DoE) or the Public Works Department (PWD) to prepare a master plan). Figure 3 represents a visualization of the actors (nodes) and networks (links) that represent the CMA governance ecosystem reflecting primarily the functional dependency flows (see Appendix 2 for the SNA data). We analyse this socio-institutional network drawing on a set of measures and concepts commonly used in SNA analysis (see Box 1).

1. The overall topology or the structure of the governance network is commonly classified into different types, such as individualistic, hierarchical or co-managerial. Sandstrom and Rova (2010) explain that some topologies are better suited for adaptive capacity (for instance, towards supporting more integrated planning).

   Individualistic network: has few links between nodes; individual action prevails without much dependency and also possibly collaboration with others. Hierarchical network: network with a leader dominating decision- making, Co-managerial network: multiple actors involved in varying degrees as opposed to centralized top-down management.

2. Network density is used as a measure of general group cohesion. It measures the number of realized ties (that is, the number of existing ties divided by the number of possible ties) to highlight the extent to which all actors are tied to each other in the network (Wasserman and Faust, 1994). Bodin and Crona (2009) suggest that higher network density presents greater potential for collective action due to increased chances of better communication, reciprocity and trust. Empirically, scholars have shown this hypothesis to be true. In Northern Sweden, Sandstrom (2008) observed the positive effect of network density on collective action and specifically argued that relational ties among different kinds of actors (such as recreational fisherman and government officials) was particularly useful for greater collective action and also knowledge development.

3. Central actors based on degree centrality: Degree centrality is a measure of the total number of linkages maintained by an actor with other actors. The higher the number of linkages, the more central the position of an actor in the network with higher ability to influence the overall network and to access valuable resources (Burt, 2004). In case of directed graphs of SNA (as in this report), the higher the number of incident arrows on an actor/group, the greater the degree of influence that it enjoys, and hence the greater the capacity to change/shape the overall network of actors.

4. Bridging actors based on betweenness centrality: Another common measure of actor centrality is betweenness centrality, which is based on the number of shortest paths that pass through it. An actor who sits between many other actors and therefore indirectly connects them is said to have a high betweenness centrality. High betweenness centrality implies that the actor could act as a bridge between other actors and also grants it the ability to influence the flow of resources and interactions between others (Bodinet al., 2009). In other words, such actors are crucial for effective knowledge flow and collaboration.

Box 1: SNA concepts/measures

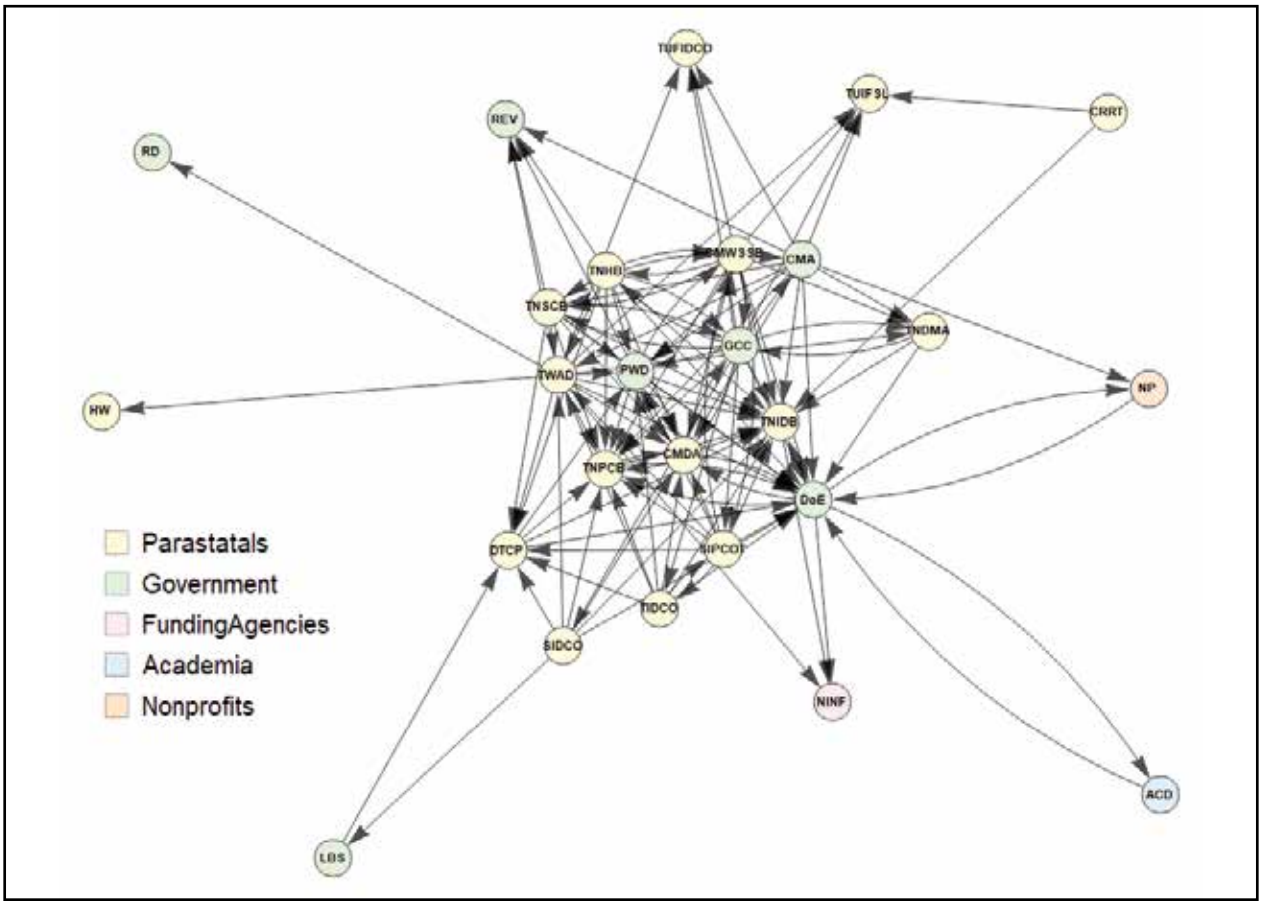

Figure 3: Functional dependency map for Chennai Metropolitan Area's urban-environmental governance ecosystem (as perceived by governance actors)

The above diagram is a visualization of the actors/agencies and relations that according to the government stakeholders we engaged with define the core of land-water-waste decision-making/policy realm. Analysis of this visual representation of the network of organizations/groups involved to different degrees in CMA's governance presents some interesting points. First, the network density of the governance ecosystem presented here seems average at 0.4 (see Box 2), indicating limited scope for collaboration and/or interorganizational coordination. This corroborates the frustration among government stakeholders around a lack of communication across departments mentioned during workshop engagements and interviews. To achieve more integrated governance, it will be crucial to improve this density, in other words build such interactions across actors in this network. However, the nature of the current network suggests that substantial time and dedicated effort will be needed to build trust and to develop a culture of more interactive governance. One limitation of network density measure is, however, that it fails to differentiate between variable nature/size/scope of agencies and uses the possibility of linkages between all types of agencies as a benchmark. Also, we should be wary that excessively high network density could lead to homogenization of information and less efficient resource use and reduced capacity to adapt to changes (Bodin and Norberg, 2005).

Network density provides a ratio between the existing number of linkages between nodes in a graph to the maximum number of possible linkages. Therefore, if a graph contains m linkages and n nodes the graph density is 2m/[n(n-1)]. Therefore, network density for fig. is: 262/650=.40

Box 2: Network Density for Chennai Metropolitan Area Governance Network

Figure 4 below presents the degree centrality of the agencies in CMA governance network highlighting which are the key or central actors in the network. From this graph it is evident that DoE, GCC, Tamil Nadu Water Supply and Drainage Board (TWAD), Tamil Nadu Infrastructure Development Board (TNIDB), CMDA, Chennai Metro Water Supply and Sewerage Board (CMWSSB), PWD and Tamil Nadu Pollution Control Board (TNPCB) are the key actors with higher number of linkages (above 15 compared 22 which is the total network linkages that any one agency has). However, it is important to differentiate between those agencies where several links originateand those where they are incident. Accordingly, Figure 5 ranks agencies based on vertex-out measure, that indicates to what extent agencies depend on or are influenced by other agencies and Figure 6 ranks agencies based on vertex-in measure, that indicates to what extent agencies influence others.

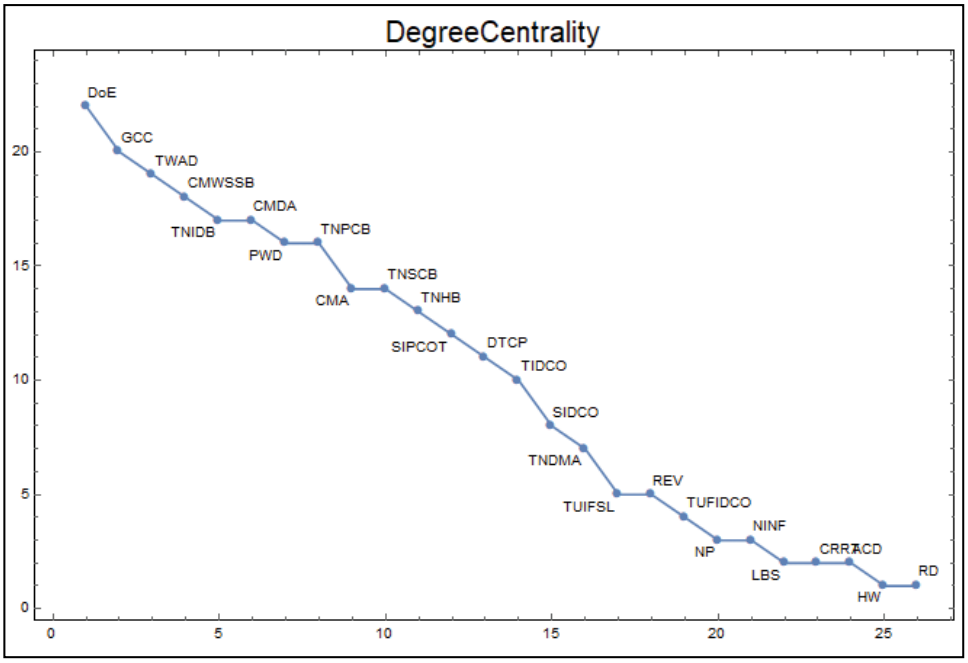

Figure 4: Degree Centrality: who are the key actors in CMA governance?

The ones where the links are incident include those agencies that remain primarily responsible for defining policies, rules and approving or overseeing that these rules are implemented properly. This includes the CMDA, DoE, TNPCB, PWD and TNIDB. Any infrastructure development in the CMA, whether industrial, water or waste treatment related must as a first step secure planning permission and building permits from the CMDA (or the GCC or other local bodies, depending on the scale and nature of the project). The CMDA is also responsible for preparing CMDA master plans and for laying out development control regulations. As a result, most organizations tend to depend on and interact with the CMDA to gain planning permissions. As a next step, they also have to secure environmental impact assessment (EIA) clearance which means approaching the DoE and the TNPCB. If development is close to waterbodies a No Objection Certificate (NoC) from the PWD must be obtained. As such, the PWD remain right behind the above-mentioned four agencies in terms of incident linkages.

Smaller developments, whether residential or commercial, do not readily require oversight by the DoE or the TNPCB – unless the planning-permission-granting authority (CMDA, GCC or other local bodies)

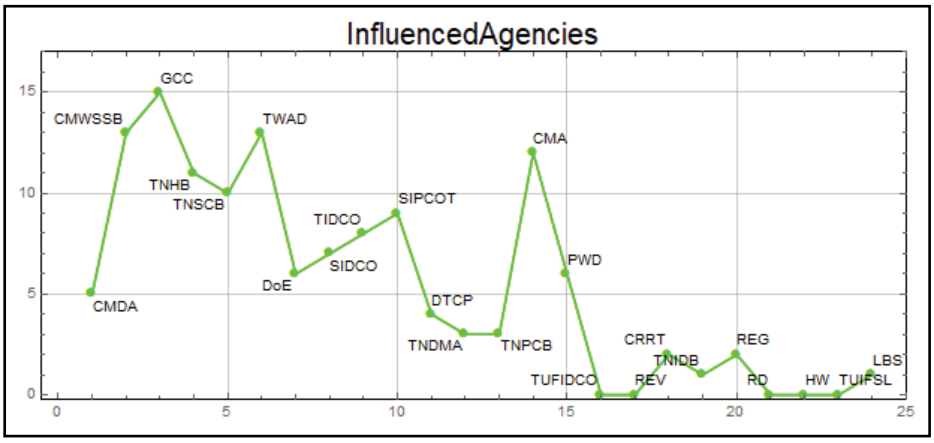

Figure 5: Key actors who are highly influenced in the governance network

gauge some degree of environmental or other risks and direct such developments to arrange for NoCs or pollution certificates from the DoE, PWD or TNPCB. As such, the CMDA, GCC and other local bodies play a more important role in regulating and monitoring smaller developments than do the DoE or TNPCB.

Finally, TNIDB emerges as a key actor because it remains a major player in terms of fulfilling Tamil Nadu's Vision 2023; it funds all kinds of infrastructure projects initiated by other agencies in Tamil Nadu and the CMA governance ecosystem.

On the other hand, organizations such as the GCC, CMWSSB and TWAD are also key players – but more so because linkages originate from these nodes. In other words, as implementing agencies they are responsible for infrastructure and service delivery (water, waste, etc.) and remain dependant to different degrees on the former set of agencies with respect to following rules, providing funds and approvals that collectively shape their ability to fulfil their functions.

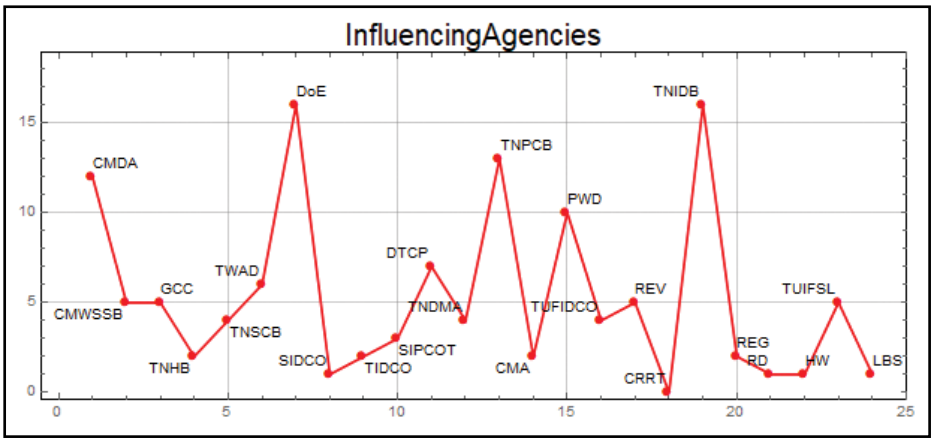

Figure 6: Key actors who highly influence others in the governance network

The betweenness centrality measure, on the other hand, helps us identify the GCC as a key agency that sits between or connects several of the other actors in the network (see Figure 7). As such, it has the potential to access resources from multiple agencies, initiate and facilitate exchange of knowledge and resources between such agencies, and therefore play the critical role of a bridge in the network. With respect to triggering any change, for instance in terms of introducing a more integrated or participatory decision-making process, the GCC could be the critical leverage point in the CMA's governance scene.

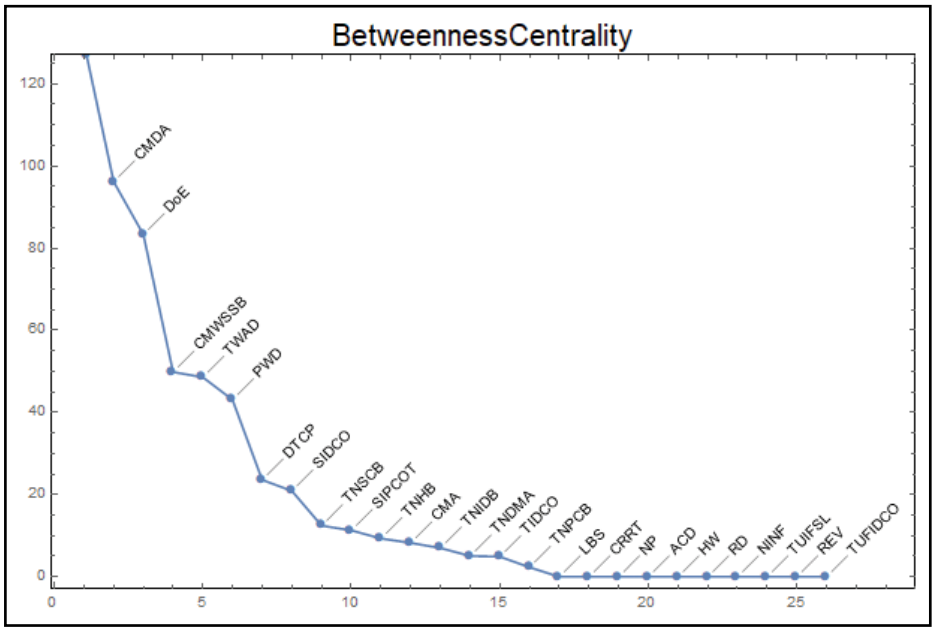

Figure 7: Who can mediate across multiple agencies in the CMA's governance network?

Based on this graph we can also suggest that the overall structure presents a moderately hierarchical network with not onebut a handful of agencies playing a central role. While there are a sufficient enough number of linkages that the network cannot be described as individualistic, the small number of links between government and other type of agencies (for example, NGOs or academia) suggests that it is not a co-managerial network. While a strongly hierarchical network is more likely to be authoritarian and insensitive to broader societal interests, a moderately hierarchical network indicates involvement of a number of agencies who can potentially maintain checks and balances on each other and address multiple needs. However, the colour coding in Figure 3 reflects that most of the agencies across the entire system, including many of the key actors playing a stronger role in the governance network, are parastatal agencies, such as CMDA, CMWSSB, TNPCB, TNIDB.

The birth of many Chennai parastatal agencies can be traced back to the 1970s, when specific acts were passed to create state-level bodies that were tasked with specific municipal functions such as providing water and drainage (TN Water and Drainage Act, 1971), sanitation (Chennai Metro Water Supply and Drainage Act, 1977), housing (TN Housing Board Act, 1961 and TN Slum Clearance Board Act, 1971) or planning (Town and Country Planning Act, 1971). Despite the passage of the 74th amendment which aimed to provide greater planning authority and decision-making powers to ULBs, planning aspects of the city have nonetheless been captured by specialized parastatal agencies such as the CMDA and the DTCP. As a consequence, planning has remained primarily under the aegis of experts and bureaucrats who are primarily accountable to the State Government. The functioning of these bodies has created significant challenges to the effective devolution of powers to lower level local bodies (Coelho et al., 2011). The lack of linkages assigned to local bodies by key actors in the governance network also suggests the limited role and power these agencies exercise.

Furthermore, the multiplicity of agencies performing various sectoral functions (such as water, sanitation, housing or drainage), also suggests the issue of 'functional fragmentation' (Coelho et al., 2011). Associated problems relating to resource allocation, personnel management and insufficient coordination among these agencies have been identified as major challenges to effective governance (Coelho et al., 2011; Datta and Chakravarty, 1981).

Knowledge flows network

Most government agencies who participated in the SNA exercise claimed to have two-way interaction with substantial data sharing across departments (see Figure 8). For instance, the CMDA requires that other departments (such as the CMWSSB, GCC and PWD) share datain order to prepare master plans. These master plans then become(or at least in principal should become) the basis for other departments to develop their own plans (for example, the CMWSSB's master plan). In particular, the DoE and TNPCB appear to have a higher number of linkages, possibly because, along with interacting with other government agencies, the DoE in particular is one of the few public agencies that heavily interacts with academic institutions and NGOs for technical support. While government stakeholders themselves claim to interact through knowledge and data exchange, the overall density of the network is average (.4), which is similar to the functional dependency map. Further analysis of the nature of these interactions and networks offer interesting revelations.

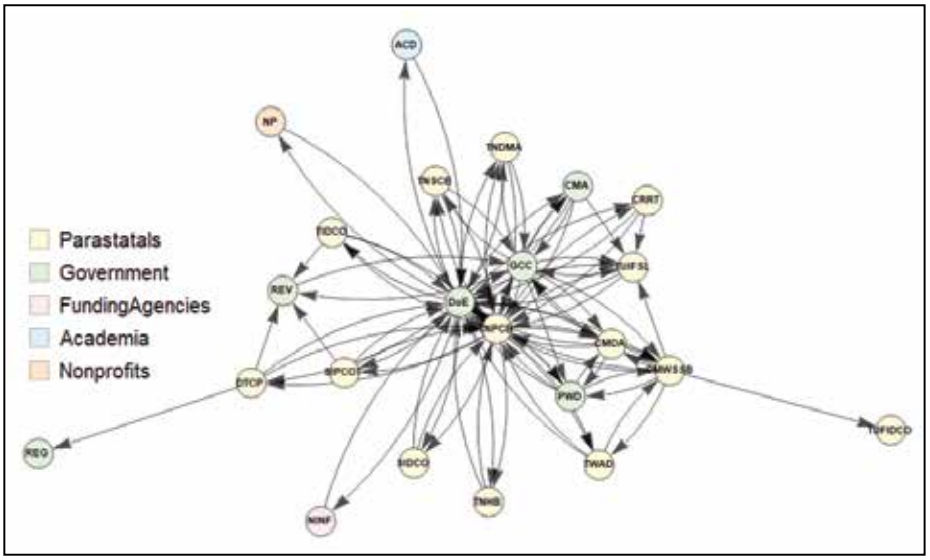

Figure 8: Knowledge flow map for Chennai Metropolitan Area's urban-environmental governance ecosystem (as perceived by governance actors)

In particular, exchange of information between public agency departments seems problematic on many counts. Here we engage with just one instance, which isc entred around the CMDA – a key actor in CMA governance ecosystem (see Figure 9).

In principle, the CMDA does share knowledge and data, and communicates with multiple agencies in the network. For instance, the CMDA collects data and feedback from disparate departments to prepare its master plans and by presenting this plan for public review. However, interviews revealed

dissatisfaction among several agency representatives around the level of engagement and continuous communication here. One point of contention is evident between the PWD (responsible for maintaining macro drainage in Tamil Nadu) and the CMDA (responsible for preparing the master plan). The CMDA's Master Plan Report identifies substantial sections of natural drainage channels as residential and commercial land-use, which opens these spaces up for development. On the other hand, detailed old village maps on all drainage channels, which are maintained by the PWD, were not, until recently referred to during the master plan development process. However, the two organizations have begun to work together more closely since the 2015 floods and a growing recognition of the intricate relation between land-use classification, development and water vulnerabilities in Chennai.

Similarly, CMDA land reclassification exercises sometimes impede CMWSSB operations. The CMWSSB's master plan is essentially derived from land use classifications defined by CMDA in its initial master plan iteration. However, CMDA's continuing land reclassification processes demand a complete overhaul of CMWSSB's priorities if they are to meet the water supply requirements for the newly classified area. A land parcel classified as agricultural, for example, may be reclassified for residential or industrial use, with potentially significant water demand and sewage infrastructure implications for the CMWSSB. This is just one instance indicating the challenges faced within a network that is defined by limited cross departmental communication.

Furthermore, NGO experience makes it evident that, while data is available, it is not easily accessible. Interviews with the Coastal Research Center (CRC) revealed this limitation. Concerned about industrial development along the Ennore Creek region, the CRC filed for Right to Information (RTI) to access the Coastal Regulation Zone (CRZ) maps used to approve the development. However, the RTI was refused on account of unavailable information. The Ennore Creek area had been declared a no development zone in 1996 but over the years was systematically reclaimed with government intervention assisted by the CMDA, who finally declared ita special hazardous zone. At the same time, local fishing communities agitated against what they said was neglect as a result of the Master Plan Report having marked off the areas they use for fishing as unused – and thereby opening them for development. This was evidenced by government plans to construct an elevated expressway between Besant Nagar and Kottivakkam on coastal lands that were classified as unused.

Today, as a result of continuous CRC and local fishing community efforts, data sharing gaps are being bridged and channels of communication with the CMDA are being opened. Locally developed land use maps are being shared with CMDA, and the next Master Plan and CRZ Plan iterations will incorporate that data.

Other NGOs report similar difficulties in accessing data. For example, Civic Action Group (CAG), whose work includes a focus on inclusive data driven governance, had its RTI request to access Master Plan mapsdenied. The reason cited was data unavailability.

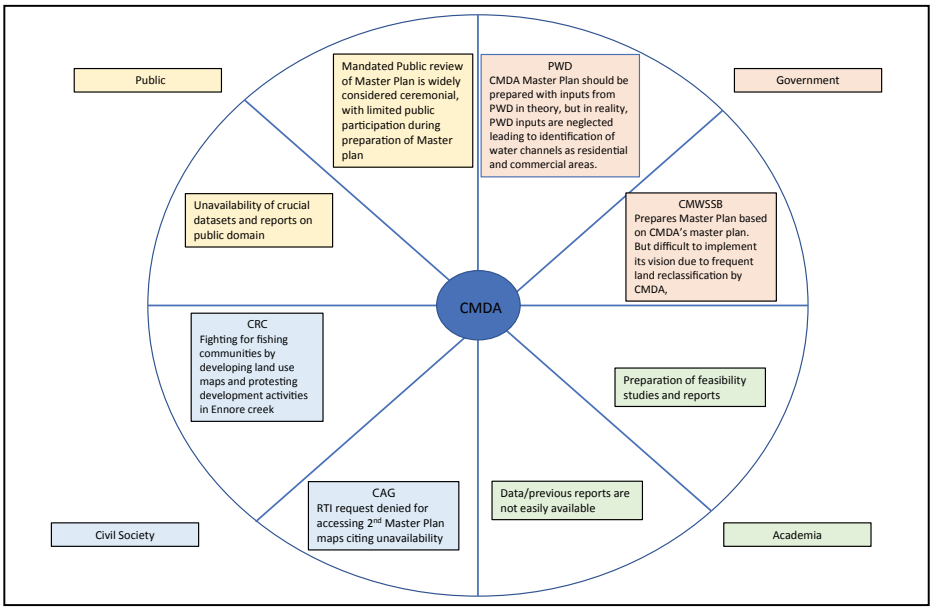

Figure 9: Various areas of contention around data/knowledge sharing and communication

In general, useful data sets are maintained and studies commissioned by multiple public agencies but these are not readily available to the general public or to civic, academic or other public agencies. For example, studies related to encroachment were carried out by the TNSCB. Also, the GCC commissioned a study on hydrology and topography which ws carried out by Aarve associates. Further, the CMDA commissioned the Rain Centre to conduct an audit of Chennai's rain water harvesting effort. The results of all of these were unavailable to us. Overall, an absence of data and data sharing, as well as a lack of easy access to data repositories points to the challenges of advancing the cause of evidence-based policy making in the realm of urban environmental governance.

The above discussion indicates that, while there is some degree of recognition among stakeholders to collaborate better around knowledge, there is substantial scope for improvement in inter-departmental communication among public agencies, as well as for intra-organizational communication across public, private and civic agencies. Perhaps one issue that seems to hinder more effective government-civil society knowledge sharing isthe fact most civic agencies in Chennai's governance scene are advocacy groups and government agencies feel insecure about sharing data with them for fear that the data will be used to highlight what is not going right. This sentiment was evident among public officials during the workshops organized as part of this project. A few organizations do, however, maintain closer linkages with government agencies. For example, Care Earth, an organization that provides technical knowledge and assistance to public agencies (for instance related to strategies for scientific tree planting or effective wetland restoration methods), specifically collaborate closely with agencies such as the Department of Forestry.

The above analysis provides us with the following key findings regarding the nature of the CMA governance ecosystem:

1. Urban land and water is governed primarily by a handful of public agencies with limited linkages between them, particularly across public and non-governmental stakeholder groups.

2. The ecosystem is moderately hierarchical in character, which is not particularly suitable for effective co-management of city resources. Substantial effort in trust-building will be required for the system to become more collaborative.

3. Within the system, the DoE, GCC, TWAD, TNIDB, CMDA, CMWSSB, PWD and TNPCB appear as key actors, but each for different reasons: the CMDA, DoE, TNPCB, TNIDB and PWD are approving agencies, permission or fund givers and rule setters, while the GCC, TWAD and CMWSSB operate primarily as implementing agencies who depend on the former agencies. Interestingly, the CMDA occupies a particularly important role since developers often approach the DoE, TNPCB or PWD for NOCs or permissions only when the CMDA or other local bodies with power to provide planning or building permits ask them to.

4. The GCC in particular appears to be an important linking agency because it connects several other agencies who do not interact directly with each other. Therefore, the GCC has the potential to act as an important bridge in helping spread sustainable and transformative changes across the network.

5. Parastatal agencies dominate the overall governance landscape with obvious implications for empowerment of local-level governance structures. Very few agencies in the network recognized local bodies as important actors, highlighting their lack of power or influence.

The SNA analysis in this report provides an overview of Chennai's governance ecosystem. The data and knowledge gathered for this exercise will be used at a more granular level in the model development phase of our work. For instance, functional dependency linkages will be disaggregated into several types of relations such as administrative, policy-related, implementation-related and financial to understand each agency's institutional interactions in more depth (see Figure 10 for a glimpse of what such institutional mapping is likely to look like). These institutional maps will become important inputs for the model to simulate the sort of inter-agency interactions that would need to happen in order for certain scenarios to materialize.

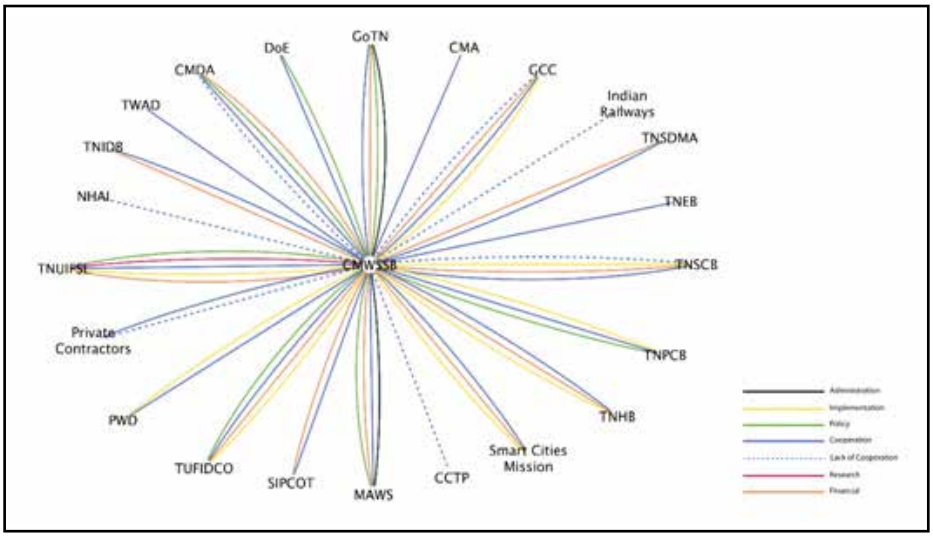

Figure 10: Institutional mapping for CMA governance model development in the next phase

CHAPTER 3

EMERGING TENSIONS AND ASSOCIATED GOVERNANCE CHALLENGES IDENTIFIED BY GOVERNMENT STAKEHOLDERS

CHAPTER 3: EMERGING TENSIONS AND ASSOCIATED GOVERNANCE CHALLENGES IDENTIFIED BY GOVERNMENT STAKEHOLDERS

As a part of our research, we organised a series of workshops with stakeholders from various government departments. During two of these workshops the stakeholders were asked to identify the emerging tensions at the intersection of land, water and waste management that were relevant for them. Discussions among agencies during these workshops focused exclusively on the tensions arising on account of Chennai's burgeoning development, their implications for land, water and waste in the city and its peripheries, and the issues of sustainability and citizen welfare arising as a consequence. Participating agencies first chose a set of tension areas that they thought were particularly problematic with respect to more sustainable development pathways (see Table 2).

This list reflects the problem areas prioritized by each participating agency. An interesting aspect of this exercise relates to the difference in the nature of the problems discussed and prioritized by the two stakeholder groups during the two workshops. For the sake of better management and facilitation of the workshops, we had primarily invited agencies with a focus on the broader urban development agenda for the city of Chennai on one day (for example,the CMDA, GCC, Small Industries Development Corporation Limited (SIDCO) and TNHB). We invited all those tasked with the responsibility of providing ecological services, managing natural resources and scrutinizing ecological ramifications of policy decisions and actions taken, on another day (for example, the PWD, DoE, TWAD and TNPCB). Interestingly, the former group's discussion revolved largely around institutional and coordination related challenges while the second group's discussion remained anchored more into technical challenges.

ACTORS (URBAN DEVELOPMENT FOCUS)	EMERGING TENSIONS AT LAND-WATER-WASTE INTERSECTION	ACTORS (ENVIRONMENT FOCUS)	EMERGING TENSIONS AT LAND-WATER-WASTE INTERSECTION
TNSCB	Encroachment on government land and water resources. Resettlement and relocation of slum residents and lack of affordable rental housing. Unavailability of storm water drains in resettlement colonies.	TNUIFSL	No specific law for water conservation. Lack of inter-departmental coordination. Encroachment on government land and water resources.
TNHB	Encroachment on government land and water resources. Resettlement and relocation of slum residents and lack of affordable rental housing. Unavailability of storm water drains in resettlement colonies.	CRRT	No specific law for water conservation. Lack of inter-departmental coordination. Encroachment on Government land and water resources.
DTCP	Encroachment on government land and water resources. Poor enforcement of regulations and monitoring practices of urban local bodies.	PWD	Rapid urbanization and defunct land-use patterns. No specific law for water conservation. Lack of inter-departmental coordination.
SIDCO	Encroachment on government land and water resources. Lack of regular water supply for industries. Lack of basic amenities (waste removal, sewage management, etc.) for industries inside industrial estates.	TNPCB	Lack of solid waste segration at source. Lack of awareness of waste disposal among general public. Rapid increase in generation of solid waste due to population growth. Lack of awareness of role of trees in water conservation.
SIPCOT	Lack of regular water supply for industries. Lack of basic amenities (waste removal, sewage management etc.) for industries inside industrial estates.	DOE	Lack of segregation of solid waste at source. Lack of awareness of waste disposal among general public. Rapid increase in generation of solid waste due to population growth. Lack of awareness of role of trees in water conservation.
TIDCO	Lack of regular water supply for industries. Lack of basic amenities (waste removal, sewage management, etc.) for industries inside industrial estates.	CMWSSB	Water supply-demand mismatch. Ageing infrastructure and obsolete technology.
TNIDB	Encroachment on government land and water resources.	TWAD	Water supply-demand mismatch. Lack of perennial sources of water supply.
GCC	Poor uptake of rainwater harvesting practices. Lack of enforcement of efficient solid waste management practices, as defined in the SWM Rules of 2016 (source segregation, composting,etc.). Lack of maintenance of storm water drains network due to lack of inter-departmental coordination.	CMA	Lack of land availability for waste disposal. Lack of segregation of solid waste at source.
CMDA	Encroachment on watercourses. Poor enforcement of regulations and monitoring practices of urban local bodies. Lack of maintenance of storm water drains network due to lack of inter-departmental coordination.		

Table 2: Stakeholder Problem Mapping Exercise

Following this initial problem and tension identification and prioritization phase, each agency was asked to pick the most relevant and critical problem area and elaborate on the specific challenges they face on the ground in addressing these problems from the perspective of their departments. At this stage, they highlighted the various governance related challenges, i.e. challenges they face in making and implementing decisions around their mandates, which we have categorized into the following heads.

- Institutional-coordination related challenges
- Resource constraints
- Policy and legal issues
- Human resource management and personnel issues

We discuss these challenges in some detail here.

Inter-departmental and inter-stakeholder coordination related challenges

Workshop participants noted a lack of coordination among government agencies, in particular with respect to tackling illegal encroachments and settlements, water supply and demand issues and infrastructural development projects. In the case of encroachments on public land, for instance, there is, at times, a need for proper coordination between revenue officials, the police authorities and the government body tasked with removing illegal encroachments. However, as a SIDCO official explained, coordination between these departments is not always forthcoming.

> "Increased coordination between the police department and revenue department is absolutely necessary for the removal of encroachments in industrial estates. The police need to provide bundobust protection, while the revenue officials need to mark boundaries to identify encroachments and remove them" - Government Official from SIDCO

Similar coordination challenges were also highlighted with respect to the process government bodies need to go through in order to secure approvals from other nodal agencies. Such processes may involve, for instance, securing environmental clearances for new projects or procuring requisite approvals for water pipeline projects from other stakeholders such as railways. Agencies often face difficulties due to the multiple clearances required at various levels. For example, delays in securing NOCs from government bodies often lead to an escalation of project costs. This has resulted in ULBs having to invest significant funds from their own budgets in order to compete the project. Workshop participants specifically recognized that the lack of digitization of this process has also resulted in tremendous delays in project implementation.

> "There are often issues arising that lead to delays in obtaining permissions/ clearances of projects, from concerned departments (such as PWD, revenue, railways or TNPCB), due to challenges encountered in the course of land acquisition, delays in obtaining NOCs, etc. This leads to cost escalation and trouble in procuring further funds for the project to be completed. Perhaps

giving ULBs more power to make decisions, and digitization of processes (such as NOC from TNPCB) and addressing current technological inadequacies, can help ameliorate some of these challenges" - Government Official from Commissionerate of Municipal Administration

Similarly, according to some participants, a lack of communication across multiple agencies was also the reason the Second Master Plan did not accommodate ecological concerns related to development to the extent it should have. A Municipal Administration and Water Supply (MAWS) official pointed this out. Also, a PWD official expressed concern during an interview about the process of master planning, which, according to him, did not meaningfully involve or engage with agencies such as the PWD which have a deeper understanding of the area's water ecosystem.

"Planners (CMDA and DTCP) are not abreast of the implications of lack of proper drainage in their pursuit of providing housing for the people. Master planning is not done with ecological aspects in mind. We do not know if we are compromising natural drains and flood plains through permissions that are provided, and this has assumed greater significance in the aftermath of the 2015 floods necessitating additional scrutiny" - Government Official from MAWS.

In the case of illegal encroachment ong overnment land and along waterways, many participants pointed out that providing documentary support from other departments (such as ration cards, electricity bills or land pattas) or 'infrastructure' support (in the form electricity or lighting, for example) to the illegal encroachments, defeats the mandate of various government bodies involved in removing the encroachments. Furthermore, the issue of stay orders by the judiciary without due consideration of the larger developmental and ecological scenario causes hurdles in the eviction of illegal encroachers by the concerned government departments. Political interference in the process was further identified as an obstacle to fulfilling anti-encroachment initiatives. Here, too, we see the need for multiple agencies to understand and address the issue of encroachment collectively with improved coordination.

Coordination issues around water management, specifically across government bodies and civil society, was also identified as a major challenge by workshop participants. The lack of real-time information on groundwater extraction, combined with ambiguity in rules around the practice, has led to crises in water supply and groundwater exploitation. Individuals and farmers from peripheral regions of the city continue to extract groundwater for short term benefit, putting themselves and the entire city at risk of an unsustainable future.

"There is no mechanism to estimate ground water potential in exploited/ over used areas, in order to set up recharge structures. Individuals sell ground water at the time of crisis leading to over exploitation of ground water potential" - Government Official from TWAD.

The large number of agencies involved in water management also plays a role in sustaining poor water management practices in Chennai. For instance, while the PWD is responsible for the maintenance of tanks in and around the city, the CMWSSB supplies water. Many workshop participants pointed to best practices in countries such as Australia, where a single nodal agency

was empowered to carry out both responsibilities. Another example of the challenges arising from poor coordination between agencies, especially in times of stress and crisis, was an incident that occurred during the course of the 2015 floods in Chennai. A decision to open the gates of an overflowing Chembarabakkam reservoir at that time was fraught with many allegations of failure to share information among relevant authorities (such as the PWD, the police, Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) andthe GCC) and citizens in a timely manner. Many argue this incident led to significant distress and loss to citizens in the affected areas (Ravishankar, The Wire, 2015).

Infrastructural and resource constraints

Another major hurdle mentioned is infrastructural inadequacies and a lack of modern software and technologies. These are cited as impediments to discharging various government agency mandates, particularly those involved in urban environmental governance. Water inundation and flooding, as well as the impacts that result, are particularly challenging because culverts and storm water drains are poorly maintained, and because of a lack of equipment such as desilting machines or equipment to clear water-logging. Similar challenges of removing blockages and debris have been noted, especially with regard to sewage and garbage accumulation issues. Furthermore, many of these activities of sewage and garbage clearance and other cleaning processes are still carried out manually; a push towards mechanization here is seen to be necessary.

Workshop participants further indicated that a shortage of funds meant an inability to capitalize on newer technologies, equipment or software. Notable mentions in this regard included the use of Geographic Information System (GIS) technology to analyze land use patterns and the use of WATER GEM software to gain more insights intowater supply and use. Also, the use of GIS to study contour levels was seen as a promising endeavour, currently lacking in application.

> "Government funding is essential to meet the infrastructure development targets. A proper revenue model is needed in order to maintain the entire system, with efficient and accurate water metering systems being essential to tackle the issue of non revenue water (NRW). There are however many 'infrastructural inadequacies'. As prevailing systems are more than 30 years old, there is a need to upgrade this. Advanced piping systems with Double wall corrugated piping, dual piping, water demand management through GIS technology and replacing mechanical meters with electromagnetic meters that are periodically monitored, are the need of the hour." - Government Official from CMWSSB

In the case of public encroachments on government land, some stakeholders noted a lack of proper fencing to deter encroachers. Workshop participants also suggested the use of technologies such as burglar alarms to alert government officials of unauthorized use of public property. Further to this, many participants pointed to the lack of adequate resources earmarked to protect government land and waterways.

Policy and legal issues

Many workshop participants indicated two problem areas in terms of

existing rules and regulations: the time lapsed since the last review and update of rules and regulations, and the lack of awareness among personnel across government departments on the nuances of these rules. For example, the Town and Country planning Act and the TNHB rules have not been reviewed in a long time. In the case of illegal encroachments on public land, many participants pointed to the lack of a clear specification or rules on the complexities of coordination between various departments, and the lack of prescribed time limits on eviction processes.

> "There is a need to form a committee to study the present rules and acts: DCR, DR, Town and Country Planning Act and TNHB Acts and rules. Furthermore, rules and regulations specifying time limits for the removal of encroachments ought to be enshrined in these rules themselves, along with direction on the various agencies that will need to collaborate, in the case of removal illegal settlements for instance." - Government Officials from TNSCB, TNHB and DTCP

Many participants looked at various challenges from a macro socio-economic perspective and revealed that the lack of adequate housing and rental policies for the urban poor was driving the rise in illegal encroachments. A mismatch between supply and demand in housing for this group was identified as a major issue since this has a parallel impact on employment and livelihoods.

> "There is a huge mismatch between the demand and supply of affordable housing for the urban poor. Furthermore, there is a lack of a policy to provide them with rental housing, and the absence of a separate institutional agreement to provide affordable rental housing." –Government Officials from TNHB, TNSCB

Many evictions from encroached areas result in households being forced to shift to the peripheries of the city, to as far as 40 kms away from their original homes. This has serious consequences in terms of livelihoods, as well as education opportunities for children. Also, skills initiatives that target illegal encroachers with the aim of making them relevant to the workforce, have not gone as planned. Despite the large number of evictions and resettlements occurring every year, skilling programmes have occurred at a relatively slow pace. The 2015-16 year alone saw just 1,790 beneficiaries of the employment-oriented training and youth development programmes (Policy Note, TNSCB, 2016-17). As such, better coordination and collective effort by concerned departments such as TNSCB, TNHB and the Ministry of Labour and Skills development, in realizing the full potential of these skilling programmes was recognized in the course of consultations with representatives from various agencies.

Human resource management, training and personnel issues

A shortage of trained and adequate staff to deal with challenges such as encroachment on public land and maintenance of storm water drain networks was raised as a major concern by workshop participants. A mismatch between present staff strength and sanctioned strength was noted as a key issue.

"At present, there are senior personnel such as branch managers and assistant engineers who are safeguarding the grounds (lands, roads, open space reservation, vacant plots, etc.) from encroachments. Therefore, existing vacancies need to be filled and adequate staff strength maintained in order to improve the efficiency and quality of work." - Government Officials from SIDCO

While a large number of vacancies across relevant government departments was described as a bottleneck to effective governance, the lack of qualified candidates to fill these positions was also noted. Stakeholders pointed out that managers and technical officers were sometimes assigned to address encroachment on the government lands on or near which they worked.

Insufficient training is also an issue. In terms of encroachment on public land, for instance, government personnel are not adequately trained to recognize an illegal encroachment when they see one. Workshop participants further noted that outsourcing such tasks to external agencies or firms has not been effective.

Furthermore, many stakeholders pointed to a lack of motivation among staff across various government departments. This was said to be the result of delays in promotions, transfers or lack of periodic and systematic training and refresher courses.

"There is a lack of proper adherence to the norms specified for the sanction of personnel. Furthermore, at present there is a lack of manpower and an absence of adequate training policies for personnel, and disparities in their pay/ emoluments." - Government Officials from PWD

Stakeholders also pointed to a lack of welfare measures for government employees, such as availability of housing loans and canteen and hospital facilities within easy access. They further noted that a majority of current workforce is moving towards retirement, but there appears to be no systematic plan to bring in or recruit new and well-qualified personnel.

"Transfer and posting ought to be according to staff requirements and staff welfare should be improved through the provision of facilities such as canteen, provision of housing loans, promotions irrespective of vacancies, etc. This can positively impact staff satisfaction. Periodical training ought to be given to staff, sometimes by sending them to other countries to learn best practices and also keep up to date as per the latest technological developments." - Government Officials from SIDCO

Manpower shortages were also cited in the realm of garbage collection and water inundation and addressing related problems. These shortages hinder the normal functioning of the various government departments.

While the above discussion provides a broad understanding of the challenges that government agencies often have to deal with in their work, in the next three chapters we pick three specific areas of tension voted by these agencies as critical. These are examined in-depth. We focus specifically on the actors, processes and gaps associated with each problem area relevant for building Chennai's resilience towards water risks: encroachment, solid waste management and water supply-demand mismatch.

CHAPTER 4

ENCROACHMENT AND ASSOCIATED GOVERNANCE CHALLENGES

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The heavy rainfall that occurred across South India during the months of November and December, 2015, resulted in widespread waterlogging in Chennai city and surrounding areas (see Figure 11). The Political and state machinery subsequently referred to these events as unprecedented, implying that theresulting damages were inevitable (Press Trust of India, 2015). However, Chennai media and academia have critiqued that response as an attempt to seek refuge in the 'inevitability' argument (Arabindoo, 2016). A Parliamentary panel also expressed scepticism about the inevitability argument (Press Trust of India,2016). Primary reasons for the flooding are now widely understood to involve ineffective planning and implementation of regulations. In particular, (Esther and Devadas, 2016):

- Illegal encroachments that impede the natural flow of water and cause water logging
- Poor maintenance of drainage and conveyance systems
- Loss of marshlands, wetlands, waterbodies and other areas serving natural storage, recharge and drainage functions.

Figure 11: The swollen water bodies and the settlements on the banksof the water bodies being inundated in the 2015 floods

As mentioned earlier in this report, the issue of encroachment on land (often close to waterbodies) and water was widely lamented by workshop participants. These stakeholders unanimously voted encroachment as a major tension area posing multiple challenges to land, water, and wastegovernance in Chennai.

Satellite imagery from different sections of Chennai city and its outskirts indicate rapid industrialization and development, particularly in areas that are on or near to waterbodies (Jayaraman, 2015). These include: Uthandi, Chembarabakkam, Oragadam, Kovalam creek, Thuraipakkam, SIruseri, Velachery and Sholinganallur (see Figure 12).

Figure 12: Satellite imagery depictsextent of development that occurred on the shoulder of waterbody in Okkiyam Thuraipakkam, on the eastern banks of the Pallikaranai marshland, Old Mahabhalipuram road, between 2002 and 2015

Table 3 presents the many estimates that multiple sources have come up with on extent of encroachment on waterbodies in Chennai, highlighting the seriousness of the problem.

SOURCE(S)	TIME PERIOD OF STUDY/ANALYSIS	AREA/SITE OF STUDY	FINDINGS
IIT MADRAS, NATIONAL INSTITUTE OF DISASTER MANAGEMENT, CITED BY ARABINDOO (2017)	LAST THREE DECADES	CHENNAI CITY REGION	OF THE MORE THAN 600 WATERBODIES IN THE 1980'S (AS DETAILED BY AN IIT-M STUDY) ONLY ABOUT 27 REMAIN TODAY (AS DETAILED BY NIDM)
DEPARTMENT OF GEOLOGY, ANNA UNIVERSITY, CHENNAI	1893 -2017	CHENNAI CITY REGION AND SUBURBS	AREA OF WATERBODIES REDUCED FROM 12.6 SQKM IN 1893 TO 3.2 SQ KM IN 2017
CARE EARTH TRUST	1900-PRESENT	PALLIKARANAI MARSH	AREA OF PALLIKARANAI MARSH REDUCED FROM 6000 HECTARES TO 593 HECTARES
PUBLIC WORKS DEPARTMENT (PWD), TAMIL NADU	2017	AREA WITHIN 25 KM RADIUS OF CHENNAI CITY	NEARLY ALL 70 WATERBODIES STUDIED WERE ENCROACHED UPON
PWD REPLY TO RTI QUERY	2017	PALLAVARAM TALUK AND PALLAVARAM LAKE	30% OF EIGHT WATERBODIES ENCROACHED UPON IN PALLAVARAM TALUK. PALLAVARAM LAKE AREA REDUCED FROM 80.54 HECTARES TO 34.96 HECTARES
ARAPPOR IYAKKAM	1972-PRESENT	SIDCO NAGAR, VILLIVAKKAM	WATERBODY COMPRISING AN AREA OF 250 ACRES REDUCED TO 20 ACRES
WATER RESOURCES DEPARTMENT (WRD)	HISTORIC RECORDS (DATE UNSPECIFIED)	CHENNAI CITY REGION	AREA OF 19 MAJOR LAKES HAS REDUCED FROM 1130 HECTARES TO 45 HECTARES
PUBLIC WORKS DEPARTMENT (PWD), TAMIL NADU	2008	CHENNAI CITY REGION	50% OF 19 MAJOR LAKES ENCROACHED WITH NEARLY 20,000 ILLEGAL STRUCTURES IN THIS VICINITY

Table 3: Estimates for extent of encroachment on Chennai waterbodies

Encroachments on waterbodies is a complex problem and increases the chances of flooding by obstructing water runoff and overflow, and also contributes to water pollution. The fact that many encroachers have been in the encroached spaces for long periods (20-25 years in some cases), further complicates the eviction process, especially in the absence of clear alternatives such as adequate housing or enforced housing policies for the affected citizens.

Historically, the construction of settlements along waterbodies has been common. Reports point to the state machinery 'going soft' on encroachers along waterbodies in the 1990s. Over the years, this trend continued, in part due to an 'officer-politician-builder/contractor nexus' that benefitted from the encroachers either monetarily or as a vote bank category (Radhakrishnan, 2015). Regularisation schemes for settlements and structures, irrespective of their legality, were common across the city during the 1990s, and, to a large extent, the entire state. Development on vulnerable and ecologically sensitive areas in and around the city bears testament to the challenges faced in dealing not just with encroachments by way of slums and informal settlements, but also with the expansion of major industries and private and public housing complexes. A few examples of such 'aggressive' development that fails to consider environmental consequences occurred in areas such as the Ennore creek and Pallikaranai marshland areas, which experienced heavy industrial growth during the last two decades. Critical waterbodies were dramatically reduced in size. For example, the Pallavaram Lake, which once covered a 200 acre currently covers 50 acres as a result of unchecked industrialization, encroachment and waste dumping (Manikandan,2012). Furthermore, government initiatives have been found to be flouting environmental impact assessment (EIA) norms, by running projects without securing the necessary environmental clearances (Rohit, 2018). This highlights the seriousness of the problem.

In the following discussion we attempt to describe encroachment as a governance problem. We present the perspectives of multiple actors, their actions and the challenges they face in dealing with this issue and the related processes. The discussion is largely drawn from primary data collected during interviews and workshop engagements.

Relocation and resettlement of slum dwellers encroaching on waterbodies

Historically, the state of Tamil Nadu government response to encroachment has been to evict families living on risky, low lying areas. Evictions come with a promise for resettlement into housing or resettlement colonies, which are typically situated in peripheral parts of the city (Housing and Land Rights Network, 2017). Major eviction campaigns occurred following the 2004 tsunami and the 2008 and 2015 flooding events. The state government has also resorted to resettling vast numbers of families living along the coast in fishing hamlets, as well as from along the banks of city waterbodies. These latter eviction movements occur frequently, in particular as waterbodies are eco-restored (for example, during the course of restoring the Cooum river), and/or due to safety concerns for those living too close to rivers and lakes (Chaitanya,2015).

The Tamil Nadu Slum Clearance Board (TNSCB) implements either resettlement or in-situ development projects to tackle encroachment issues.

The 'in-situ' or "as is where is" projects aims to make existing areas habitable through the development of infrastructure facilities and granting tenure rights to dwellers. Tenure rights are granted for the areas occupied. If these are unsuitable, tenements are approved and constructed in alternative areas (Rehabilitation and Resettlement Schemes). Some such resettlement colonies and in-situ development projects are in Nochikuppam (in-situ) Ezhil Nagar, Perambakkam, Semmencherri, and Kannagi Nagar (see Figure 13).

Figure 13: Resettlement tenements constructed at Ezhil Nagar (left) and Perumbakkam (right)
Source: TNSCB

Anti-encroachment and resettlement programs are justified by government agencies as necessary for dealing with waterbody encroachment problems. However, they are viewed less favorably from the environmental and disaster-reduction points of view. Also, from the perspective of vulnerable communities, anti-encroachment drives are often seen as a relegation further from their "right to the city" (Prabhakar, 2018). Opposition to these projects are grounded in the questionable location of new residences, 'ghettoisation' of the communities and the quality of the new settlements (Aditi, 2017). The 'ghettoisation' of communities by shifting them en-masse to peripheral areas of the city where access to basic amenities such as adequate housing, water, food, livelihoods and santitation is limited is, according to some, a human rights violation. The fact that many of the resettlements are at a great distance from their original livelihood sources has led to informal settlements springing up closer to the prior locations. As such, unless alternative housing options also accompany livelihood options in the resettlement location, the problem of encroachments and illegal settlements is likely to repeat itself in the years to come (Citizen Consumer and Civic Action Group, 2016). This was also corroborated by residents of Semmancheri during interviews.

Other critical issues around resettlement processes include the 'misinformation' provided by authorities to families and the dilapidated conditions that qualify many older settlements (see Figure 14). These are said to not have been adequately addressed by the TNHB (Ravi, 2016). Furthermore, a report of the Comptroller and Auditor General of India depicts the design of tenements as more densely populated than initially planned, as pushed forward by the Tamil Nadu government (CAG, 2015).

Figure 14: Dilapidated state of TNHB tenements
Source: CAG "TN Slum Clearance Board and its projects through the lens of CAG's audit report," Ravi P., 2016

Particularly problematic is the questionable location of some resettlement colonies. This has received increasing attention from the media and academia. Numerous reports reveal that the construction of the tenements earmarked for the families to be resettled in the name of ecological restoration and risk reduction, were actually constructed on lake-beds and low- lying areas (Radhakrishnan, 2015).

In the 1970s and the 1980s the TNHB and CMDA resorted to making use of what they deemed to be 'defunct' areas that were in fact 'erys' and 'peramboke' (unassessed) land for constructing infrastructure. During the 2000s when rapid urban development occurred, many slum resettlement tenements were built in areas such as Kannagi Nagar, Ezhil Nagar (on the Pallikaranai marshland) and on lake beds in Perumbakkam and Semmencherri (Housing and Land Rights Network, 2017). Areas like Semmancherri then became badly affected when flooding occurred in 2015 (see Figure 15) (BBC News, 2015). This illustrates the lack of informed and comprehensive planning typified by many Chennai resettlement initiatives.

Figure 15: A flood-affected housing complex in Semmancherri
Source: Chennai Floods, BBC News, 2015

While media and academic reports discuss the many problems with encroachment and related resettlement initiatives from a vulnerable communities' perspective, our engagement with government stakeholders during workshops revealed the challenges they face when carrying out their duties as they address encroachment.

This process of dealing with encroachments and evictions is complex and multi-layered, requiring coordination between various departments (see Figure 16). At each stage, agencies face different types of hurdles, including data, personnel and regulation-related limitations, as explained in the following discussion.

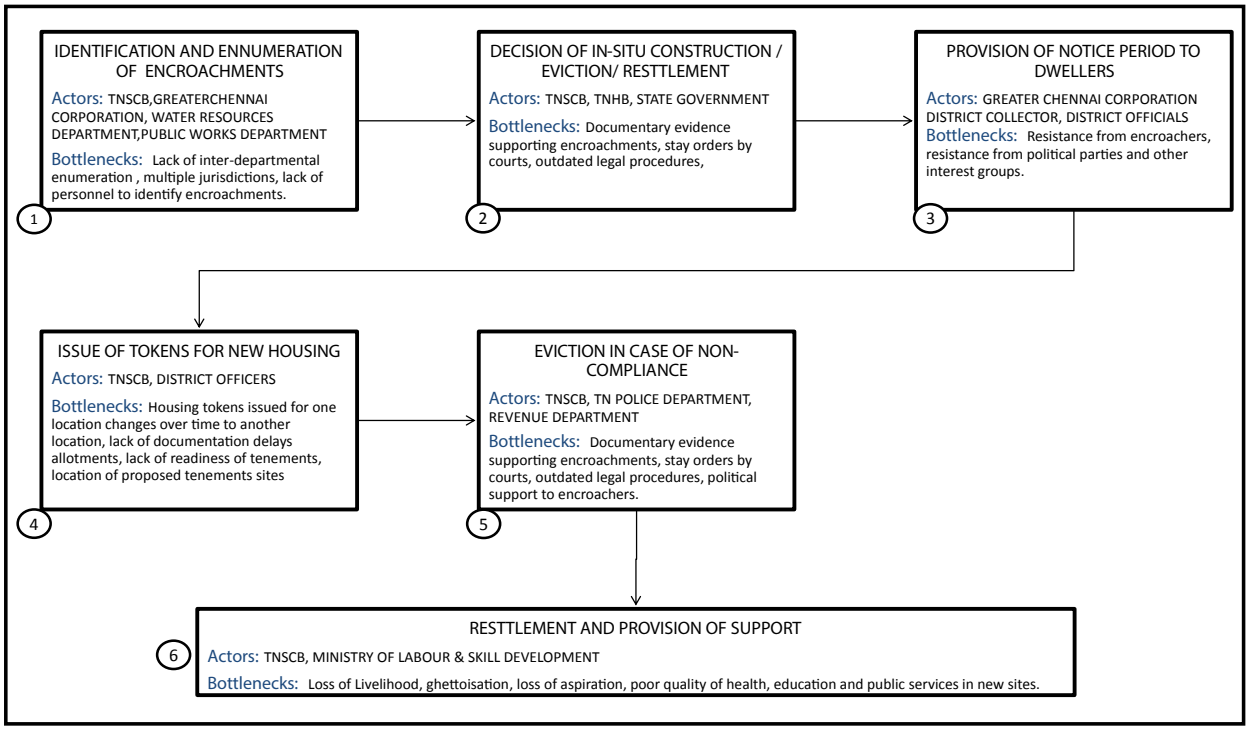

Figure 16: Process of resettlement

Data-related challenges: At the outset it must be mentioned that encroachments occur on a range of different property types, each falling under the jurisdiction of different authorities. Organizations within industrial estates such as Small Industries Development Corporation Limited (SIDCO) and State Industries Promotion Corporation of Tamil Nadu Limited (SIPCOT) report encroachments on their premises, while the Water Resources Department (WRD) and the PWD periodically report encroachments on properties under their jurisdiction across the city. Discussions with representatives from various departments revealed an urgent need for an inter-departmental enumeration of all encroachments. Newspaper reports indicate that the last time this was carried out at a high level was in November, 2016. Workshop participants expressed a need for such enumeration exercises to occur with greater frequency and pro-activeness.

Personnel-related challenges: The PWD, industrial estates (SIDCO and SIPCOT) and the WRD all encounter various types of encroachments on their respective properties. Interactions with stakeholders from these institutions revealed that, more often than not, a lack of a designated officer to deal with encroachments within their own organizations inhibits the process of identifying encroachments.

Political challenges: The politics of patronage have historically played a role in encroachment, with some of it being supported by the ruling state and political machinery. Workshop participants hinted

that this trend continues. Many contended that it was challenging to identify encroachments and proceed with eviction processes because of opposition from political groups who view encroachers as a valuable vote-bank to leverage, often helping them to avoid eviction.

Legislation and regulation-related challenges: Representatives from various departments such as the PWD, TNSCB and TNHB pointed out during workshops that official familiarity with current legislation around encroachment and evictions is generally poor. They also mentioned an urgent need to review these policies, many of which are outdated and not reflective of the present scenario. The TNSCB and the TNHB cited the 'implicit' support given to encroachers as a major hurdle to executing their mandate. This support comes in the form of documentation, favourable judicial stay orders and extension of infrastructure and utilities (such as roads and electricity) to encroached-upon lands. A key point to emerge was the lack of affordable rental housing policy, which drives many citizens to resort to cheaper housing options, which in turn are often situated on encroached land orin illegal settlements. This implies that the issue of encroachment will continue to be problematic unless its root causes are addressed.

Skilling and employment related challenges: From a macro perspective many stakeholders recognize that resettlement often implies changes in livelihood and employment opportunities. Many families who live in illegal settlements are often from lower income and educational backgrounds. Therefore, there is an urgent need to keep resettlers relevant to the labour market and provide them with training and skills development opportunities. While the TNSCB conducts such training for youth at a limited scale, there is room to improve their efficacy through collaboration across departments such as the TNHB and Ministry of Labour and Skill Development.

Implementation challenges related to eviction procedures: Another critical issue relates to the hurdles officials encounter during the actual process of eviction. Many officials, particularly those from the TNSCB and the other relevant departments, mentioned that families who were asked to evict produced stay orders from the courts entitling them to continue living where they were. The case for the encroachers was further bolstered with documentary proof such as utility bills and land pattas that were provided to them over the years. In light of such 'legal' documentation, many stakeholders felt that there was insufficient coordination between various city authority arms. Many encroachers were also provided with infrastructure and utility support, such as roads, street lights and telephone connections. This, according to some, needs to be curtailed immediately. Workshop participants also indicated that opposition to the process of eviction from various sides rendered formidable the task required of the TNSCB, Revenue Department and Police officials. Many participants were of the opinion that the rules regarding encroachment ought to be reframed so as to include a clause calling for compulsory inter-departmental coordination, while spelling out the roles and responsibilities of specific departments in such instances. Newspaper reports support this concern and opinion (The Hindu, 2017).

Regulation of public and private housing and industrial developments encroaching waterbodies

Just as illegal slum developments on or near waterbodies exemplify the issue of encroachment, the development of industries and housing on such vulnerable areas pose similar threats. In fact, during the 1970s and 80s, public housing was often constructed by the TNSCB and TNHB on dry lake beds and 'unused' natural water tanks were filled in for various infrastructure and housing development programmes (Coelho, 2016). However, the Environmental Impact Assessment (EIA) Notification was legalized in 1994, with the objective of making development more environmentally and socially responsible. Accordingly, the 1994 EIA notification and the revised 2006 notification made it mandatory for all projects and development activities above a certain threshold (of size of operation and capacity) to procure an Environmental Clearance (EC) before the project could begin (Environmental Impact Assessment Notification, 2006). Clearance is granted based on potential environmental and social impact. This should have controlled the degree to which waterbodies were encroached upon. However, the analysis we present in the accompanying State of Water report, which focuses on whether ECs are granted close to waterbodies and on ecologically vulnerable areas, reveals that several projects across Tamil Nadu state continue to be constructed on flood plain areas. In fact, ten projects that received clearance in 2016 were found to have been less than one km away from a waterbody.

Several studies and reports reveal it's not just the private players, developers or industries who fail to comply with established EIA norms; but government bodies too. These bodies are found not to always abide by stipulated rules and procedures when sanctioning or implementing megaprojects.Secondary literature also reveals that state government authorities such as the TNSCB who are involved in construction opted to go ahead and begin implementing four projects prior to receving the required EC. The TNHB also proceeded with constructing 606 residential complex units in Padi village without procuring ECs. In response to these 'blatant' violations of the 2006 MoEF Act, a directive was issued by the State Environmental Assessment Committee (SEAC) that a 'no consent to operate' / 'no occupancy' certificate is to be issued while EC is in process of being aqcuired (Rohit, T.K., The Hindu, 2018).

TNSCB and TNHB officials cited a lack of knowledge about the EIA process (Rohit, 2018). This clearly points to a lacuna that needs to be filled: every arm of the state and city authorities need to be in tune with the mandated EIA processes as they apply to both government and private entities.

Another instance of a clear violation of environment-related legislation is the case of Ennore creek. Here private and government bodies alike have constructed on what was officially declared a 'protected tidal body' (Jagannath,2017). Interviews with resource persons from the Coastal Resource Centre (CRC) reveal that vast development occurred on and around the creek area, including thermal plants and a port, despite a 1996 declaration that 8000 acres were a 'no development zone.' These violations were blatant and completely hidden from both authorities and the public until 2017 when an RTI query revealed that the creek had disappeared from official maps. Several allegations have been made as a result, with the Department of Environment (DoE) seen as complicit. In addition to development, an alarming level of pollutants are periodically dumped into the creek by government agencies (see Figure 17) (Raman, 2017).

Figure 17: The Ennore creek area, with fly ash dumped into it by TANGEDCO
Source: The Hindu, 2017

It is therefore important to understand the entire Environmental Impact Assessment (EIA) process, including the potential loopholes and fault zones that can be addressed to improve compliance and accountability, and ensure improved coordination among the regulators and other parties involved in the process.

Actor, process, and challenge mapping:

The EIA notification mandated that all projects or activities (including building and construction, oil and gas exploration, common effluent treatment plants, common municipal solid waste management facility and airports) require prior permission from the central government in the Ministry of Environment and Forestry (MoEF). This applies to Schedule I projects, which include expansion and modernisation of existing projects and change in product mix. The latest amendment to the notification in 2006 pushed for more power to states, with several of these projects going to the state for clearance depending on their size, capacity and area through a State Environment Impact Assessment Authority (SEIA) in consultation with an SEAC (State Environment Appraisal Committee).

Projects and activities are classified into Category A and Category B, based on their potential impact on human health, natural resources and man-made resources. In the case of the former, the clearance sought has to be acquired from the Central Government (MoEF) on the advice of the Expert Appraisal Authority (EAC) constituted by the Central Government for this purpose. In the case of Category B projects or activities, the clearance sought has to be acquired from the concerned State Government or Union Territory through its Environment Impact Assessment Authority (SEIAA), based on the appraisal by the State Expert Appraisal Committee (SEAC). Furthermore, a Consent to Establish (CTE) must be sought from the Tamil Nadu State Pollution Control Board (TNPCB), and this comprises the adherence of the entity being established, to the Water (Prevention and Control of Pollution) Act of 1974 and the Air (Prevention and Control of Pollution) Act of 1981. Clearance is granted based on potential environmental and social impact. For example, changes in soil, water and air quality, impact on wild life habitats, settlement patterns, water consumption levels, aesthetic values (views, socio-cultural systems, etc.).

The following diagram (see Figure 18) and discussion explains the process, the actors involved and the possible challenges associated with the various steps of the EIA process, ultimately leading to the provision or the rejection of the Environmental Clearance for various projects.

Step 1: Project conceptualization

The process begins with project conceptualization (either residential or industrial) and at the outset is fraught with challenges, the primary one being a lack of awareness on the part of some developers around the existing rules and regulations aboutthe EC process, as well as the sanctity of designated ecologically and environmentally sensitive zones.

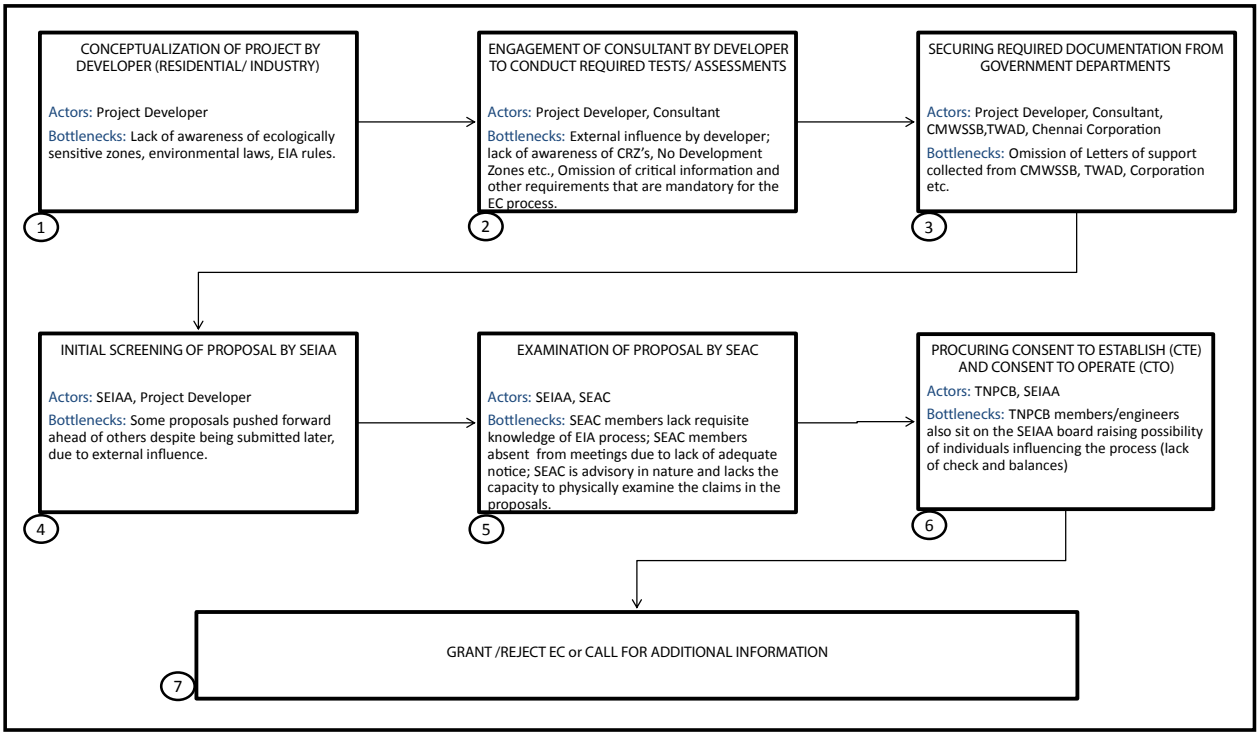

Figure 18: EIA Actor-process mapping: finding the weak links

Step 2: Engagement of consultants to assess parameters

The next step in the process of obtaining an environmental clearance is to engage a consultant to conduct required tests and assessments on the proposed project site. A major loophole identified at this stage is the fact that the consultant is open to external influence from the developer and may not be as well versed in aspects of the proposed site, particularly around CRZs, no development zones, etc. This also results in critical information frequently being left out of prepared documents or test reports. An often-quoted omission relates to the failure of the developer and consultant to procurethe individual department clearances required from various nodal agencies (such as the CMWSSB, TWAD and GCC).

Step 3: Uploading the poroposal and initial appraisal

Once required documentation has been procured, it is compiled and uploaded onto the SEIAA website, which, following the initial appraisal, forwards the proposal to the SEAC. Our interviews with stakeholders indicated that these proposals are often pushed forward to the SEAC before their due date of hearing as a result of influence. This points to developers' ability to push forward their

proposals with the SEIAA and obtain faster clearances.

Step 4: SEAC assessment and report

At this point, the SEAC, which comprises various sectoral experts (including planners, geographers, environmental experts and engineers) enters the EC process, making note of the proposal content and providing its own independent assessment. Often the meetings at which proposals are heard and discussed are fixed with very short notice given to SEAC members, meaning that many members don't turn up. Since the SEAC is a multi-disciplinary body comprising experts from diverse fields and backgrounds members' failure to participate can mean a comprehensive evaluation of proposed projects is compromised. Also, one SEAC committee member we spoke with was of the opinion that nominated committee experts, while accomplished experts in their respective fields, aren't always properly familiar with the EIA process, the rationale behind it and the various links and gaps in the EIA process. The member was of the opinion that a training programme ought to be conducted for all those experts nominated to the SEAC, thereby ensuring that all the members are fully acquainted with the expectations. Most importantly, while SEAC provides its own independent report, these are merely advisory in nature. The final decision of granting or rejecting clearance by SEIAA thereby raises concerns of transparency and accountability.

Step 5: Obtaining CTO and CTE

The next step in the process is for the TNPCB to provide two critical approvals viz. Consent to Establish (CTE) and post-establishment, Consent to Operate (CTO). The fact that many members of the TNPCB also form part of the SEIAA, who now are responsible for the final decision of granting or rejecting the EC or requesting for additional information, raises serious questions of conflict of interest.

Step 6: Grant/Rejection of EC

The SEIAA finally takes the call on whether to grant or reject the EC or they might send the proposal back to the SEAC for re-examination or call for additional documentation as the case may be. As mentioned earlier the fact that TNPCB members who form a vital part of the process in so far as the granting of the CTO and CTE are concerned, also make the final decision to approve or reject a project, is a cause for concern as espoused by stakeholders interviewed.

Some experts have pointed to the information asymmetry that exists between all relevant stakeholders in the development and environmental process and the community, project developers and government. Furthermore, the inability of the apprising committee to personally verify the proposals and claims coming before them through site-visits and the limited time available renders the exercise less meaningful than it could be. Also, the lack of safeguard mechanisms to 'insulate' decisionmakers from undue pressures (whether internal or external) in the process opens the door to subterfuge noble efforts made to ensure the sustainability of the environment (Ghosh, 2013). These expert reflections match what we find in

the secondary literature, which points to a culture of 'casual' compliance, lack of management commitment and lack of understanding of regulations – as well as low resources for regulators – as inhibiting factors to the proper flow of the process (Sinha, 2016). In this context, despite a well-defined policy, flawed implementation and monitoring limit the policy's ability to support sustainable forms of development. Identifying the various stakeholders, their roles and the challenges they face in order to enhance the coherence, accountability and co-ordination of the entire process thus seem central to ensuring that the EIA and EC processes meet their desired outcome in practice.

CHAPTER 5

SOLID WASTE MANAGEMENT AND ASSOCIATED GOVERNANCE CHALLENGES

CHAPTER 5: SOLID WASTE MANAGEMENT AND ASSOCIATED GOVERNANCE CHALLENGES

In the immediate aftermath of the December 2015 floods, much criticism was levied against the poor co-ordination between urban planning and Chennai's hydrology infrastructure. However, as the flood water receded, the city was confronted with its menacing solid waste problem and its role in exacerbating the impact of the floods. According to the GCC, 1.32 lakh tonnes of garbage was cleared from the city post-floods (Chandrababu, 2015 a). To put that in perspective, the city generates around 5,200 tonnes of garbage per day, which essentially implies that the city was grappling with 25 days' worth of waste during the flood recoveryperiod (GCC, 2018).

In the absence of efficient solid waste management (SWM) practices, uncollected garbage often finds its way into empty water ways. The once vibrant Adyar and Cooum rivers have consequently been reduced to mere garbage dumps. During the series of high intensity rainfalls in December, the rivers rose with the rains and, in addition to washing away the settlements in their vicinity, also ended up spreading garbage all over the city. Many experts believe that the Chennai flooding event was in fact a large-scale water inundation due to the clogging of open water ways and chocking of storm water drainage as a result of poor solid waste management (see Figure 19) (Narasimhanet al., 2015).

Figure 19: Solid waste pollution in storm water drains
Source: Times of India, 2017

Further, workshop participants indicated the issue of solid waste management as one of Chennai's primary urban governance challenges. Stakeholders from the GCC, TNSCB, TNHB, SIDCO, Tamil Nadu Industrial Development Corporation Limited (TIDCO) and SIPCOT all indicated this as a top challenge. Their concerns included non-segregation of waste at source, quantum of waste generated, availability of land for waste disposal, clogging of storm water drains with waste and contamination of groundwater and waterbodies. This corroborates the magnitude and the pervasive nature of the problem, which, if unresolved, will have far-reaching impact on the city's ecology and long-term environmental sustainability.

Passage of waste

Unsegregated waste is collected from 200 wards across 15 city zones. The city generates around 5200 tonnes of garbage every day. The collection of garbage is two-phased. The primary phase involves door to door source collection, collection from community bins and street sweeping. The garbage collected in this phase is transported and unloaded in the eight transfer stations in the city.

Zone	Location	TentativeStorage Capacity (MTs)
IV	Basinbridge	1200
V	Pulianthope	1200
VI	Otteri	1500
VII	Athipattu	2000
VIII	Pulianthope	1500
IX	Karaneeswara , Pagoda street	2000
X	Valluvarkottam	2500
XIII	Alandur Road,Saidapet	1500
Total		**13400**

Table 4: Garbage transfer stations

In the second phase, the garbage is transported from transfer stations to landfills. The city has two major landfills, situated on the city outskirts: Perungudi in the south and Kodungaiyur in the north. SWM is handled by the GCC in 12 of the 15 zones, and is privatised in three zones (9,10 and 13). In both the cases, the process is pretty much restricted to collecting, transferring and dumping waste into landfills. There is little emphasis on source segregation or scientific disposal.

SWM Policy and Stakeholders

The Solid Waste Management Rules, 2016, is the primary legally binding document for municipal solid waste management, replacing the Municipal Solid Wastes (Management and Handling) Rules, 2000 (MoEF, 2016). These rules, which were notified by the Ministry of Environment, Forests and Climate Change (MoEFCC) are applicable to areas even beyond municipal boundaries and include outgrowths in urban agglomerations, census towns, notified industrial townships.

While the 2016 Rules were notified by the MoEFCC at a national level, they prescribe duties to local authorities for managing waste (see Figure 20). Each state is required to prepare a state policy and solid waste management strategy' in consultation with key stakeholders based on the Rules. However, as of now, there is no policy in Tamil Nadu.

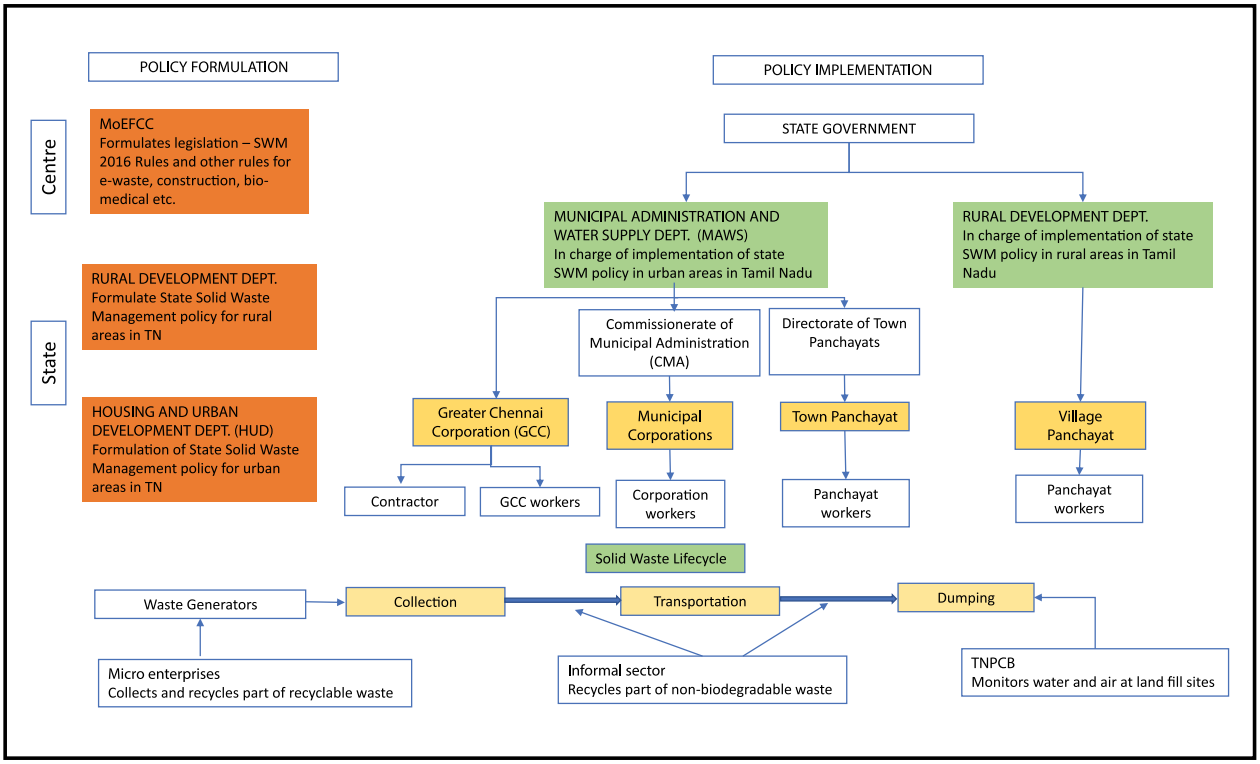

Figure 20: SWM Stakeholder Mapping

The 2016 Rules also specify that ULBs are responsible for managing solid waste, including operating and implementing SWM projects, scientific waste processing, treatment and disposal and identification of land for the same. In Tamil Nadu, ULBs could be Municipal Corporations or Town Panchayats in urban areas or Village Panchayats in rural areas. While Municipal Corporations and Town Panchayats are housed within the framework of the MAWS, the latter fall under the purview of the Rural Development Department (CMA, 2008). It is interesting to note that the 2016 Rules mandate the Urban and Rural Development Departments of each State (in this case – The Housing and Urban Development (HUD) and the Rural Development Departments respectively) to prepare the State Solid Waste Management Policy, while actual implementation of the policy lies with the MAWS department in urban areas and the rural development department in rural areas. The role of the Pollution Control Board is to ensure that prescribed standards related to water, air, leachate, noise with respect to all solid waste processing and disposal facilities are adhered to and norms are updated as and when required.

In Chennai city, the ULB in charge of SWM is the GCC. This means that the GCC is responsible for collection, transportation, processing, treatment and disposal for all 15 zones in Chennai City. The private sector also plays a key role in waste management in Chennai city. For 3 zones (Adyar, Kodambakkam and Teynampet), the GCC has contracted Municipal SWM to a private firm, Ramky Enviro from 2012 to 2018.

Chennai was one of the first cities in India to formally contract private firms, including NGOs and for-profit firms, to manage municipal waste through a public-private partnership (PPP) model. Since 2000, three contractors, CES Onyx (2000 to 2007), Neel Metal Fanalca (2007 – 2011) and Ramky Enviro (2012 – 2018), have been responsible for SWM in 3-4 zones including Adyar, Kodambakkam and Triplicane

(Subramanian, 2007; Lopez, 2012). The waste generators hardly have any incentive (positive or negative) to reduce waste generation and play a negligible role in managing the waste – merely dumping waste into the nearest public bin. Solid waste in the remaining wards is managed directly by the GCC. In these GCC-operated areas, a door-to-door collection system exists.

Microenterprises are also emerging as important players in Chennai's SWM. Several start-ups, including Paperman, Kuppathotti.com and Kabbadiwala connect have sprung up in the past 7-8 years. They primarily deal with door-to-door collection of segregated inorganic waste, selling it to the informal recycling market. These organisations either have employees collecting waste from customers or directly connect customers to the local informal recycling shops that have been in operation for many years. They cater to a relatively small market consisting of informed and environmentally aware individuals who realise the implications of the waste they generate and wish to do something about it. It remains to be seen if such effortscan sustain in the long run, after their initial funding period expires and without government support or recognition.

While Paperman, Kuppathotti.com and Kabbadiwala connect are formal organisations, a large unorganised and informal sector comprising of waste pickers and recyclers also plays a critical yet unrecognised role in the SWM process in Chennai. The informal sector has been in existence for decades, especially recycling paper and plastic of different grades (cardboard, soiled cardboard, white paper, soiled paper, pet bottles, etc.), glass and e-waste. They divert several tonnes of waste from landfills.

Conflicts and challenges in solid waste management

Outsourcing conservancy operations

The practice of collaborating with the private sector for SWM started in 1989 when the Corporation of Chennai (CoC) began partnering with Exnora International, a Chennai-based NGO. Exnora worked with community organizations and informal waste workers to collect solid waste from households and deposit it in neighbourhood bins that were provided by the CoC, which was then collected and taken to the dumpsite by the CoC. When the CoC took the pioneering effort to privatise conservancy operations by contracting a private company (CES Onyx), Exnora could not resume its operations; the modernisation of garbage clearance practices warranted no fee from the residents, thus sidelining Exnora's role (Sridhar, 2013). However, Exnora's volunteers continue to carry out campaigns on the importance of cleanliness and waste segregation at source (Chandrababu, 2015 b).

Although CES Onyx's work was commended, the company did not comply with the Municipal Solid Waste (MSW) Rules 2000 provisions on segregation (Subramanian, 2007). These had not been specified in its contract (which predated the law) so the lack of segregation was not technically a violation of contract.

Neel Metal Fanalca, the second contractor, received legal notices from the CoC for irregular waste collection, failing to provide adequate dustbins and failing to execute door-to-door waste collection (Radhakrishnan, 2012). Neel Metal Fanalca also faced a shortage of manpower (because of attrition problems) and machinery -- to the extent that the Corporation had to take

over wards that were previously assigned to Neel Metal Fanalca (Times of India, 2013).

Ramky Enviro Engineers Pvt. Ltd., the third contractor, faced similar issues, especially with hiring and retaining personnel, most of whom demanded higher salaries (The Hindu, 2012). In fact, a section of workers even went on a flash strike demanding a salary hike, which seriously affected collection operations in some zones of the city (Ramakrishnan, 2012). Ramky was unable to step up its night conservancy operations by adding more workers to its operations. The CoC expressed its dissatisfaction over the performance by taking over some of the divisions under Ramky Enviro.

Further, in the entire process, the highly significant and critical role of the informal sector, including waste pickers and small-scale recyclers has been largely ignored. The SWM process followed by the GCC over the years indicates that they seem to prefer large scale, capital intensive, engineering and technological options over decentralised approaches that are often better suited to manage a diverse range of waste generated by households. The tradeoff between modern waste management techniques and providing a livelihood for waste pickers is a complicated issue which needs to be addressed. The 2016 SWM Rules attempted to achieve this by mandating that state policies acknowledge the informal sector and provide guidelines for their integration into the formal system. However, in the absence of a state SWM policy, that integration is unlikely.

Going forward, the GCC plans to privatise the conservancy operations in all 15 Chennai city zones, a move that has been met with severe opposition from GCC's conservancy workers and from resident welfare associations (Deccan Chronicle, 2017). Private sector participation in solid waste management activities has some potential advantages, due to the extra latitude private providers often have in management, technology access and financial structuring. But in the absence of an effective monitoring mechanism, which has encouraged the private operators to mix construction debris with domestic waste, and poorly written conservancy contracts, which does not offer flexibilities for adaptation in a changing policy environment, GCC's move is poised to increase the garbage menace.

Landfill management

Chennai city has two major landfills: Perungudi in the south and Kodungaiyur in the north. In addition, two smaller landfills exist, in Athipattu and Pallikaranai. These landfills have been the subject of ongoing debate, specifically around the environment problems they pose. For instance, waste leaches into wetlands and pollutes groundwater. Also, emissions from burning trash and decomposing organic matter contribute to local air pollution. These issues are starting to matter for politics as well, as air and water pollution get more attention in the media.

There is little knowledge around why these sites were chosen as landfills. One can only assume that, at the time of choosing, these areas were considered to be on the fringe of the city. However, rapid urbanisation and the development of an Information Technology (IT) corridor has stretched the core of the city and moved development into city outskirts. Inexplicably, real estate development and planning permissions have placed many residents dangerously close to landfills. These sites are often plagued

with increasingly frequent fires, affecting residents, polluting the air and groundwater and threatening ecological sites such as Pallikaranai marsh (Janardhanan, 2012; The Hindu, 2014; Kumar, 2017; and The Hindu, 2017).

There are several ongoing efforts, both community driven and government led, to scientifically shut down the landfills. But closing landfills would require shifting them to a new location which is difficult because land within the city is largely unavailable, and also because proposed new locations are protested by residents and environmentalists. For example, two solid waste processing facilities were proposed at Minjur and Kuthambakkam. However, local residents protested, and environmentalists and scientists condemned the proposed plant in Kuthambakkam for having been constructed within the Chembarambakkam lake catchment area, which contains a major water source for Chennai city. They argued that the plant would pollute the water source, leading to a water shortage crisis (The Hindu, 2010). An EIA by the TNPCB found that the project would indeed pollute the lake if completed. Curiously, TNPCB gave an NOC for the proposal despite the recommendations of the environmental expert assessment committee (TNPCB, 2008). Eventually, the projects were shelved and, instead, waste to energy plants have been proposed in the existing dump yards at Kudangaiyur and Perungudi (TNPCB, 2008).

Community engagement

Much of the blame around solid waste management is often placed on the government, while the role of waste generators is conspicuously overlooked. In many ways, SWM woes stem from the irresponsible manner in which the city's residents handle their waste. At 5200 tonnes per day, Chennai is one of the leading waste generators in the country.

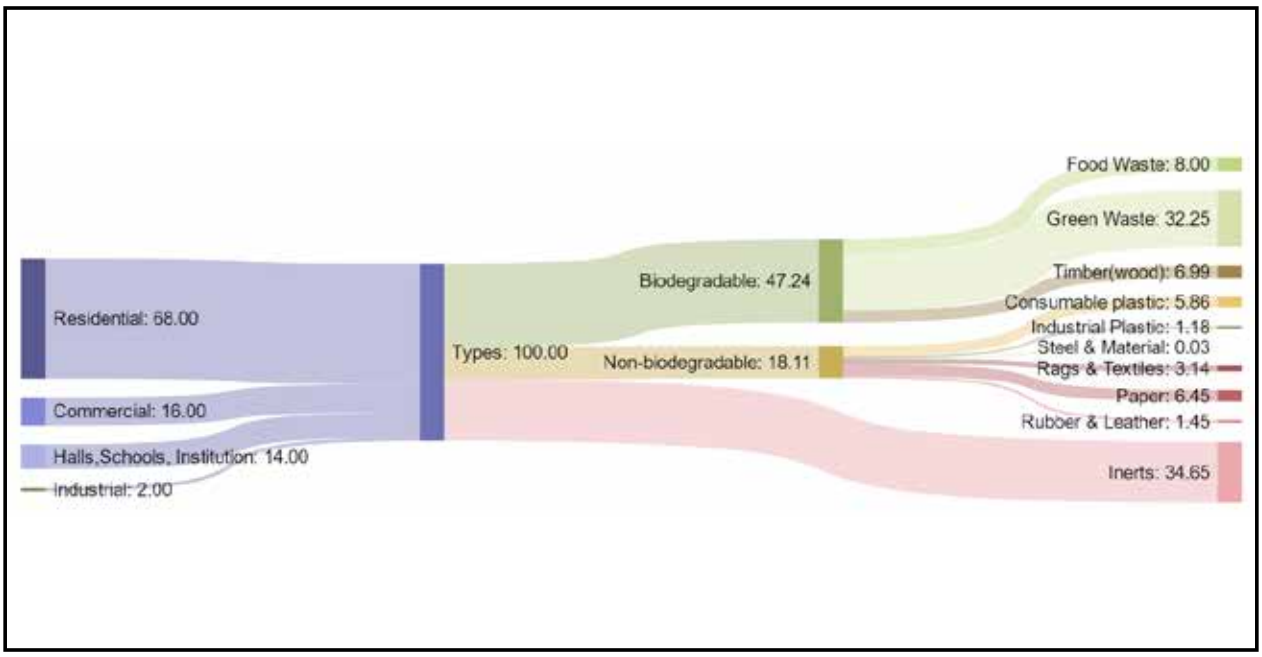

Figure 21: Solid waste composition
**Note: The numbers in the figure are in percentage*
Source: GCC Website

Municipal solid waste typically consists of household waste, debris from construction and street waste. With rapid urbanization, the amount of waste generated per capita in the city has increased from 300 grams per day in 1971 to 760.6 grams per day in 2016. According to the Chennai Corporation (see Figure 21), residential waste contributes 68% of municipal waste generated, followed by commercial waste, which contributes 16%, institutional waste, which contributes 14% and industrial waste, which contributes 2%. Of the total waste generated, bio-degradable and inert waste make up 47.24% and 34.65%. If segregated at source and reused, these can significantly reduce the amount of waste that goes into landfills.

While the state of city landfills is abysmal, it is important to be mindful of the fact that the government cannot always be scrambling to find new locations for landfills. At its current pace, the GCC will have no further option but to use incinerators (despite their environmental and health implications) to reduce the mountains of garbage and reclaim the land currently occupied by landfills.

Despite the mandate for source segregation in both iterations of SWM rules, this has not really taken off in the city. The success stories of Exnora, Hand in Hand and Resident Welfare Associations are fragmented, and get lost in the prevailing SWM practices, which are often inept. In addition to reducing the waste that reaches landfills, source segregation has the potential to support the growth of several business opportunities for start-ups and industries in the waste to energy value chain including collection, segregation, recycling, transportation and energy recovery.

The above discussion on SWM gives a much-needed insight into the systemic gaps that are entrenched in Chennai's SWM practices. The problem is manifold and an effective intervention needs concerted cooperation from governmental and non-governmental stakeholders alike. The consequences of a bourgeoning population, in addition to unbridled urbanisation and the associated consumerism is bound to increase the amount of waste generated. Addressing the SWM problem must be the starting point in the GCC's quest to develop Chennai as a Smart City.

CHAPTER 6

WATER SUPPLY–DEMAND MISMATCH AND ASSOCIATED GOVERNANCE CHALLENGES

CHAPTER 6: WATER SUPPLY–DEMAND MISMATCH AND ASSOCIATED GOVERNANCE CHALLENGES

The issue of water supply is currently a key political debate in Chennai city as well as the state of Tamil Nadu. Decades of mismanagement of water resources by government and non-governmental actors, including private individuals, as well as growing demand, have made water supply a sensitive and contentious issue with severe political implications. Water supply and demand mismatch was also identified as a critical issue during the stakeholder workshops and interviews we conducted.

In this chapter, we present the existing debate on water supply and demand by identifying current opinions on the issue and discussing potential solutions for bridging the gap, including their advantages and disadvantages – as identified by key stakeholders. We also identify important actors involved in water supply and demand management, their respective roles and responsibilities and the challenges they face in managing water, drawing primarily from our State of Water report, stakeholder interviews and workshops.

Water supply and demand in the CMA

As mentioned in the State of Water report, water supply in Chennai is characterised by three distinct systems: a) piped and "mobile" (tankers) supply from Chennai Metro Water Supply and Sewage Board (CMWSSB), which is sourced from reservoirs and desalination plants; b) self-provision through privately dug bore wells and c) a private market consisting of water tankers and packaged water. Piped supply from CMWSSB is highly intermittent and supplied only for a few hours a day irrespective of rainfall levels. As a result of their intermittency and other issues such as poor water quality, illegal connections, theft and low water pressure at the end of pipelines, consumers are often forced to depend on other sources to meet their needs. These sources include digging their own bore wells and relying on informal actors such as water tankers and packaged drinking water producers. Undoubtedly, prices and water quality on the informal market are not regulated and consumers sometimes have no choice but to rely on non-potable water at high prices. The following figure, taken from our State of Water report provides a succinct illustration of water supply and demand in the city (see Figure 22).

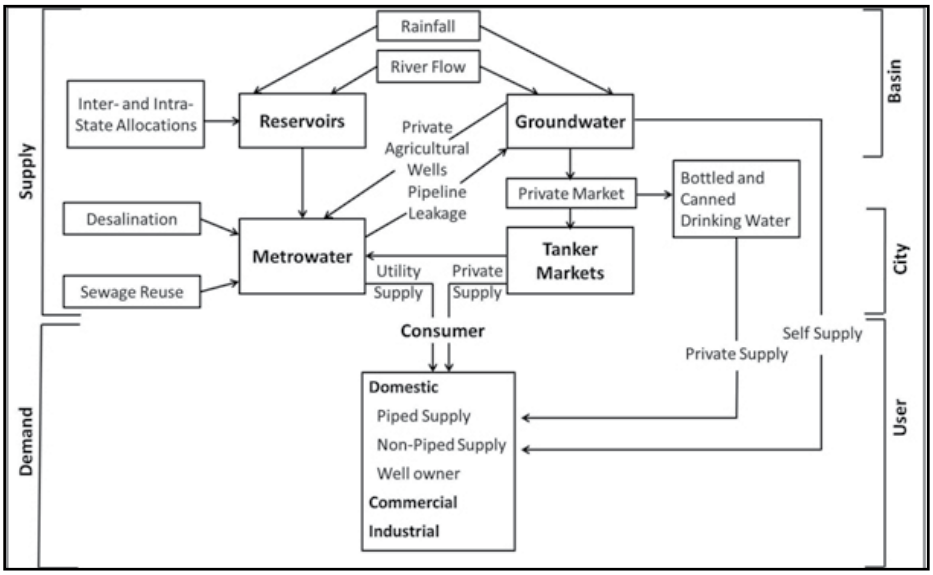

Figure 22: Water supply and demand in Chennai; Adapted from Srinivasan et al. 2010b

Is there a water supply–demand mismatch? Who thinks what?

Existing water supply practices indicate that there is a mismatch between water supply and demand in the CMA. The extent of the mismatch varies temporally and seasonally, with an obvious high during drought years and summer months. However, record rains during the 2015 northeast monsoon that entirely filled reservoirs and tanks provided supply for just a year; the quantity of piped supply had to be reduced following a less than normal 2016 northeastmonsoon.

There are varied views on whether Chennai water supply and demand equate. We interviewed several experts to understand their take on this issue. One of them was Professor Janakarajan, president ofthe South Asia Consortium for Interdisciplinary Water Resources Studies SaciWATERs and former professor at Madras Institute of Development Studies (MIDS). Professor Janakarajan believes that the mismatch is artificially created and the actual problem lies in poor storage infrastructure. Another advocate of this view is Sunita Narain, of the Centre for Science and Environment, who argues that the city should move towards protecting its vast number of lakes and ponds and use them as its primary source of water supply (Narain, 2015). Other experts maintain that in most Indian cities including Chennai, intermittency is caused not by lack of sufficient water resources but as a result of poor management, pipeline leakage and excess demand spurred by low tariffs and metering (McIntosh, 2003; WSP, 2003). On the whole, this group believes that there is enough water to serve Chennai needs, but it is not well managed – and hence the mismatch between supply and demand.

On the other hand, the Chennai Metro Water Supply and Sewage Board (CMWSSB) seems to think differently, addressing water supply-demand mismatch as a function of natural water shortage. This is evident in increasing government investments in desalination technology to augment existing water sources (rather than focusing energy and resources on

storage capacity building). Two desalination plants – Nemmeli and Minjur – each with a capacity of 100 MLD, currently supply water to the city; Nemmeli to southern parts of the city and Minjur to northern areas. There are plans to increase capacity to 750 MLD by adding at least two more plants in the near future: another plant in Nemmeli with a capacity to treat 150 MLD and a fourth plant at Perur, beside Nemmeli, with a capacity of 400 MLD (Lakshmi, 2018b). The medium-term plan is to source at least 50% of total piped supply from desalination plants. The Tamil Nadu Water Supply and Drainage Board (TWAD) has also commissioned 17 additional plants outside the CMA area.

CMWSSB also agrees that water is mismanaged, specifically as evidenced in Chennai's high percentage of Non Revenue Water (NRW). NRW is defined as water lost as a result of pipeline leakage, theft and illegal connections. A senior CMWSSB official we interviewed cited NRW as the Board's biggest concern (CMWSSB, personal communication, 2018). While NRW has been reduced over the years, the fact that water is not metered like electricity creates disparity in availability and usage patterns. Therefore, one of the CMWSSB's next steps, according to the same official, is to implement water metering and pricing. CMWSSB sees NRW as an 'infrastructural inadequacy' that needs to be addressed, he stated. However, the issue of NRW and water pricing is not an easy one to solve, and most Indian water utilities struggle with it. Residential connections are mostly not metered but utilities often face stiff resistance from consumers when attempting to introduce water meters through pilot projects (HPEC, 2011). In the case of Chennai, current pricing, which is INR 50 per month per household for residences, is extremely low and non-reflective of demand; introducing meters would mean households paying significantly more for water, and based on their usage (Times of India, 2018b; Lakshmi and Lopez, 2018). Their resistance to metering is therefore not surprising.

Current views on feasible solutions

1. Rain water harvesting (RWH): The RWH scheme, launched in 2001, made it mandatory for all new buildings in Chennai to install RWH structures. Also, in 2003, after two successive years of severe continuous drought, an ordinance was passed making it mandatory for all buildings throughout the state. RWH was and still is considered one of the most environmentally friendly methods of augmenting water supply at the local and decentralised levels. A household survey conducted by the Centre for Science and Environment in 2004-2005 found that 92% of the surveyed households reported having installed RWH systems, of which 86% were installed after the ordinance (Narain, 2015). Further, a groundwater study by CMWSSB in 2007 found that the groundwater table had gone up by almost 50% between November, 2004 and November, 2007 (Ibid).

A strong advocate for RWH, Mr. Shekhar Rahgavan of the Rain Centre, believes that Chennai city's water demand can be met with efficient and widespread implementation of RWH. He argues that the rushed implementation of RWH in residential buildings resulted in construction of poor and malfunctioning harvesting systems. Further, a 2015 audit conducted by the Rain Centre revealed that only 50% of the RWH systems are functional.

The Sustainable Water Security Mission was born out of the RWH audit report. It aims to protect and restore Chennai's waterbodies and to meet Chennai's growing drinking water needs by implementing various projects that include plans to expand and strengthen RWH across the city. It seeks to do this by deepening existing structures through a campus RWH scheme in government buildings, universities and other campuses, and by means of storm water harvesting to "collect, store and utilize it for recharging the groundwater table" (Sustainable Water Security Mission website, accessed on June 12, 2018).

While it is evident that rooftop RWH does contribute to aquifer recharge and can possibly reduce demand for CMWSSB piped supply, it is less clear if this option alone is adequate to meet Chennai drinking water needs in the long run. A study by Srinivasan et al. in Chennai found that "benefits from rainwater harvesting arise entirely from the increased availability of groundwater that can be used during droughts and is a cost-effective option. However, viability of the rainwater harvesting option depends critically on the level of recharge. A combination of efficiency improvements and rain water harvesting would be an optimal solution" (2010a, pg. 7). Also, in a much broader sense, RWH is not confined to the rooftop scale but also includes RWH through lakes and ponds. Professor Janakarajan, president of SaciWATERs and former professor at MIDS firmly believes that rooftop RWH can only complement the latter and not substitute for it.

2. Revival of existing tanks and ponds: Many experts believe that the way forward in water supply management is to revive the lakes and ponds which once served as a primary water source for Chennai and its surrounding areas. There are varying estimates on the number of such waterbodies. According to one, the region has almost 320 reservoirs, tanks and lakes, all fed primarily by rain water (Narain, 2015). Others indicate that Chennai had more than 600 waterbodies in the 1980s, only a fraction of which remain today (Arabindoo, 2016). Some estimates even place the number as high as 4100 (Janakarajan, 2017). However, all agree that the role of these tanks is not just water storage but also groundwater recharge, creating a micro climate and maintaining biodiversity (ibid and personal communication, Janakarajan, S., 2018). These waterbodies also serve as important tools in mitigating floods impact. Historically, before the colonial era, a traditional ery (tank or reservoir) system served the areas around present-day Chennai. "This system is more suited to the city's topography and was designed to capture slow and gradual movement of water across the landscape through a series of interconnected bunds. The system also served a dual purpose of groundwater recharge and flood management" (Arabindoo, 2016, pg. 808).

Despite experts' faith in the value of reviving this traditional storage and flood mitigation system, CMWSSB has a different opinion. Although officials here agree that, in principal traditional lakes, ponds and tanks have been a formidable asset in the history of the city, times have now changed. Numerous factors, they argue, prevent returning to this system to fulfil current water needs – the most significant being unreliability in rainfall (Personal communication, CMWSSB, 2017). Their opinion is not wholly unfounded. In 2017, despite surplus rainfall of nearly 25% during the northeast monsoon, reservoirs were only half full. This was because the four reservoir catchment areas did not receive as much rain as the city (Times of India, 2017a; The Hindu, 2017 and Shivakumar, 2017).

Other important factors that prevent large-scale lake restoration are pollution, high transportation costs and encroachments. Earlier, lakes and other waterbodies were linked to one another though a cascading system, where excess water from one lake would be carried into another through interconnecting channels. Today, however, encroachments and pollution mean these linkage points have been choked. Further, CMWSSB view tanks to be a far riskier proposition since they would be dry during drought years, and the costs of treatment and transportation could be quite high. However, CMWSSB does contend that tanks could feasibly provide some respite to water woes in a highly local manner and there are some rare instances where such types of waterbodies have been rejuvenated and reused to service nearby areas, for example in Ponneri. This is not and can not be, according to CMWSSB, a largescale measure. In fact, CMWSSB has established a committee to investigate which tanks can be rejuvenated for this purpose. Encroachment is a significant obstacle,which requires considerable political will to tackle and therefore raises questions on whether the tanks and ponds can be restored to the extent that would have a significant enough impact on Chennai's drinking water supply (Personal communication, CMWSSB, 2017).

From both sets of arguments, the primary issue appears to be a question of the type of governance model that best suits Chennai water supply: one that is centralised or decentralised. The essence of a tank revival system follows a decentralised approach that gives more power to users to manage their own water supply. The state government has been all in favour of such schemes for smaller towns and villages by actively promoting and allocating funds (for example, the Kudimaramathu scheme). However, in a metropolitan area such as Chennai, which is expected to expand to as much as 8878 sq. km in the near future, it would require a complete overhaul of a management system that was founded by the British in the 1800s. This would drastically impact CMWSSB operations and their primary mandate to provide clean drinking water and sewage connections to city residents.

3. Desalination: It has already been established that the state government is spending heavily on desalination technology as a reliable water source (Gopalakrishnan, 2017). However, there is a strong case to be made against this technology on the grounds of its environmental and financial implications and high energy requirements. On the environmental front, highly saline brine discharge from the Nemmeli plant is impacting local fisherman from nearby Sulerikattukuppam village. These effluents are being discharged directly onto the beach, contaminating groundwater, increasing total dissolved solids (TDS), a pollution marker,and threatening marine life such as turtles, shrimp and fish (Dasgupta, 2016). This view is corroborated by CMWSSB and TWAD officials (Personal communication, CMWSSB and TWAD, 2017).

On the financial front, capital cost alone for the Nemmeli plant was INR 533.38 crores, an amount that is suggested to be four times what was originally quoted (Personal communication, Tamil Nadu Urban Finance & Infrastructure Development Company (TUFIDCO), 2017). The new Nemmeli plant is anticipated to cost INR 1371.86 crore, while the Perur plant, initially costing INR 4070.67 crore was then revised to INR 5300 crore in 2017 (Municipal Administration and Water Supply Department, 2016 and Press Trust of India, 2017). Added to this are the high production costs dominated by energy requirements. It is estimated that CMWSSB pays a private SPV (in-

charge of running the Minjur plant) INR 54/KL as opposed to a maximum of INR 10.5 /KL for conventional sources (Dasgupta, 2016) (Hingorani, 2011).

However, CMWSSB officials argue that the high costs are worthwhile, since desalination provides a reliable water source that can supply at least 50% of future requirements in the event of zero rain (Personal communication, CMWSSB, 2017). They also contend that, from a long term perspective, the cost of desalination is actually lower than the likely cost of tank revival. Further, they downplay financial costs particularly in terms of price per kilolitre (KL). As such, one CMWSSB official was quoted saying, "(C)osts are nothing compared to bottled water. It costs 6 paise a litre, INR 60 for 1000 litres against INR 15 for a litre of bottled water. Even a tanker, you pay 15 paise and you don't know how safe that water is" (Narayanan, 2016).

4. Wastewater reuse: This option has been widely discussed by the government and concerned stakeholders. However, discussions have not been translated into large-scale projects. Existing projects cater to a few industries, which then treat water further before consuming it. Experts such as Professor Janakarajan are of the opinion that sewage recycling and reuse are feasible for Chennai but that government is not actively pursuing them (personal communication, Janakarajan, S., 2018). CMWSSB currently supplies 28.67 MLD of treated waste water to Chennai Petroleum Corporation Limited (CPCL), Madras Fertilizers and Manali Petro Products (MAWS, 2016).

Experience from Indian cities, including Chennai, reveal that perhaps the biggest constraint to large-scale wastewater reuse is cost. According to Hingorani (2011), since fresh water supply is highly subsidized across most Indian cities; the per liter cost of supplying fresh water, even when new conventional sources are added, is cheaper than supplying treated sewage. For instance, CMWSSB reports that sewage collection and treatment (using a secondary treatment process) across all its plants costs INR 8.9 per KL, excluding capital costs. By comparison, the cost of fresh water supply from surface water is much lower and ranges from INR 5 to INR 10.5 per KL. This estimate includes capital costs through addition of new sources other than desalinated water (ibid). Treating water through a tertiary treatment process, which is required to meet drinking water standards, will only add to production costs. However, recycling and reusing sewage waste water might still be more cost effective than desalination, which has a production cost of approximately INR 54 per KL (Dasgupta, 2016).

The role of wastewater recycling in CMWSSB's future water supply framework is uncertain. With respect to industry, as mentioned above, CMWSSB already supplies treated sewage to three industries in North Chennai. It plans to increase its Sewage Treatment Plants (STP) capacity by setting up two new plants, each with 45 MLD capacity, at Koyambedu and Kodungaiyur to provide water for nearby industries with the purpose of "overcoming water scarcity in Chennai" (MAWS 2016). Further, our State of Water report finds that future water demand projections for commercial and industrial establishments will fall over the years, up until 2050. This suggests that CMWSSB is relatively certain of supplying using some other source (possibly recycled waste water) other than fresh water to meet industrial demand. Certainly, these projections are subject to modification as a result of CMA expansion plans. Nevertheless, whether these systemic changes would impact water demand is questionable because a) the

capacity of new plants is small, meaning they can only cater to a limited number of industries and b) a majority of industries do not depend on CMWSSB for supply, but instead draw groundwater from their own wells. Therefore, CMWSSB's push for using treater sewage water in industries should include increasing the capacity of the STP's to cater to the insustry requirement and reducing the price of treated sewage water.

In terms of residential demand, the uncertainty seems to be starker. As of now, CMWSSB does not supply treated wastewater to residences. On April 21, 2017, the organization issued a press release stating that it "will not provide new water and sewage connections to special and multistoried buildings which do not have facility to separate toilet waste water (black) from other waste water (grey)." The press release also stated that this was mandatory since 2002, but compliance was low and that it expects 15% of the city's future demand to be met by recycled wastewater. The latter is merely a supply target that the CMWSSB has set for itself (with no firm deadline) that can be modified when necessary. Further, future fresh water supply demand projections going up to 2050 seem to contradict this move. Unlike the industrial and commercial sectors whose fresh water supply is projected to reduce, CMWSSB's domestic water demand projections for fresh water supply up to 2050 are increasing.

Identification of actors, their roles and responsibilities

So far, we have provided a discussion of the water supply-demand debate and several views on possible solutions to bridge the gap. In the next section we discuss the roles and responsibilities of government and non-governmental actors involved in water supply, through which we attempt to identify challenges related to their activities that would account for the present state of water management in the CMA.

Government actors

I. State government: According to India's constitution, water supply is a state responsibility, making the role of the state government and the local water utility extremely important. Actual operations and maintenance of water supply systems are managed by the local water authority. The role of the state government is to facilitate financial support for these authorities through budgetary allocations and external aid, as well as formulation of state wide policy in consultation with appropriate departments. However, a brief analysis of budget speeches for the past 5 years (2013-14 to 2017-18) reveals that the largest allocation has been for school education and not water infrastructure, indicating the priority of the state government.

II. Municipal Administration and Water Supply (MAWS): At the state level, the MAWS governs local water supply authorities, for example the CMWSSB and TWAD. According to the MAWS website, their primary objective is to provide a clean urban environment and maintain public health in urban areas by providing infrastructure including water supply and sanitation, roads and buildings, storm water drains and so on. The department is also responsible for formulating policies, implementing schemes through its subdepartments, and mobilising financial resources for water and sewage

schemes.

III. CMWSSB: CMWSSB's primary role is to supply adequate and safe drinking water and safe disposal of sewage to residential, commercial and industrial users in the CMA. Other functions include preparing long term plans to meet future water supply and sewage requirements, undertaking development activities to meet future requirements, water quality monitoring at site, at source and various distribution points, and operating and maintaining existing water supply systems.

CMWSSB has not been able to provide adequate or safe drinking water to all its users. Piped water is supplied only for a few hours a day, irrespective of rainfall levels – as is the case in most Indian cities forcing consumers to depend on other sources such as ground water and water tankers to fill the gap between demand and supply. Additionally, while piped water covers approximately 100% of core city areas, those that were added in later years, specifically those added in 2011, still do not have 100% coverage. Several pockets of the IT corridor are yet to get a piped water or sewage connection; residential, commercial and institutional consumers here rely on water tankers to meet demand. In response, CMWSSB supplies drinking water using its own tankers. However, a limited number of vehicles making a limited number of trips mean long waiting periods for this supply, making consumers opt for private water tanker water, even if it means paying a higher price (The New Indian Express, 2017).

With regard to safe drinking water, the State of Water report finds that CMWSSB treats its water at source and monitors water quality on a 24 hour basis in various distribution points across the city. GCC officials also occasionally participate in the sampling. However, despite these measures, 'minor' differences in quality arise between water quality at source and water sampled at distribution centres, possibly because of leaks in pipe lines that run near sewage lines.

Another CMWSSB role is to monitor groundwater withdrawals through judicious grants of permission for private individuals to extract groundwater. The Chennai Metropolitan Area Groundwater (Regulation) Act, 1987, was enacted to control extraction and encourage recharge in Chennai and surrounding villages in Kancheepuram and Thiruvallur district. The Act also restricts the capacity of pumps to draw groundwater and entrusts the CMWSSB with granting licenses in Chennai city and Collector of Chengalpattu in the rest of the CMA. However, the Act largely remains a law on paper, with no proper implementation in the CMA. In an interview, a senior CMWSSB official stated that no one comes to CMWSSB to get permission,and that flats and even individual households often have more than one bore well. Further, while CMWSSB does have groundwater monitoring stations across the city, hardly any analysis has been done on this data.

IV. Public Works Department (PWD): The PWD is one of the oldest government departments; it has existed for over 153 years. The primary role of the PWD lies in irrigation: maintaining reservoirs, irrigation canals, etc. In addition, the PWD maintains major rivers (personal communication, PWD, 2017). Their website lists other functions, including flood control and management, artificial groundwater recharge, coastal protection and

interlinking of rivers within the state, but evidently their primary focus is on irrigation.

With respect to the PWD's role in the CMA, they "own" reservoirs and a network of smaller tanks that store water for Chennai. PWD is also officially responsible for maintaining and managing Chennai's reservoirs: opening and closing valves, desilting and maintaining water channels, including the removal of encroachments (personal communication, TUFIDCO, 2017). CMWSSB's role, meanwhile, is restricted to extracting, treating and distributing the water released by the PWD. This arrangement gives rise to considerable tensions between the two departments regarding water discharge and maintenance. The PWD's role in maintaining these reservoirs – whose end use has changed from water supply for agriculture to water supply for drinking water - is not wholly justified and the overlapping jurisdictions between CMWSSB and PWD has resulted in operational incapacity. PWD's ineptitude in maintaining water bodies has choked the quantity of water available to CMWSSB for distribution, thus constraining their efforts to meet the required water supply.

V. Local Town Panchayats (TPs) are responsible for providing water supply and sewage connections in their jurisdictions. However, the majority of these TPs are severely under financed, and lack necessary human resources to set up large centralised systems. Residents are therefore forced to rely on self-financed groundwater resources such as bore and tube wells. However, many TPs, for example Sriperumbudur, are slowly increasing the capacity of their existing sewage and piped drinking water network to include all villages.

Non-governmental actors

I. Private water tankers and packaged drinking water producers: Together, private tankers and packaged drinking water producers make up a large informal market that supply drinking water to Chennai (see Figure 23). The role of these actors is to supply water to customers whenever there is limited CMWSSB piped supply or when groundwater (as extracted from own bore wells) is limited. There are more than 400 registered bottled (including cans) companies in the state, of which 220 are located in and around Chennai (Janakarajan et al., 2007) and about 300 tankers serve customers just along the Old Mahabalipuram Road and Adyar (The Hindu, 2017) – indicating the size of the market. Srinivasan et al. (2010c) found that, between January, 2002 and March, 2006, residential tanker demand emerged mainly during drought periods, was non-existent during wet periods, and that changes in demand were driven by fluctuations in the regional groundwater table and piped water supply. Water tanker demand by large commercial consumers such as hotels, however, is determined by aquifer capacity and piped water supply. These consumers are virtually dependent on private tanker water at all times.

Being an informal market, both water tankers and packaged drinking water producers remain unregulated in terms of price and quality; they are not governed by the Food Safety and Standards Act 2006 nor do they conform to Bureau of Indian Standards. This also renders them inaccessible to the poorer residents of the city.

Figure 23: Water tankers in Chennai
Source: Govindarjan, 2017

Munian (2010) finds that tanker water is typically untreated and not fit for human consumption. A water quality test by the GCC and the Food Safety Department revealed that water transported through 90 tankers across the city did not have the minimum chlorine level of 0.2 parts per million (ppm) as per relevant specifications (Lakshmi, 2012). Further, there have been several raids and random water quality tests of water supplied through bubbletop cans over the past few years that also reveal inconsistencies. In 2013, the TNPCB and the State Food Safety and Drug Administration Department conducted tests in 85 units in and around Chennai and found that 34 of them did not conform to prescribed standards and contained aerobic microorganisms and higher residual chlorine than allowed (Mariappani, 2013). In 2017, officials from the Food and Safety Drug Department found that several water cans being distributed in the city were unlabelled, soiled or damaged (Times of India, 2018c).

With respect to pricing, the wholesale rate for 20 litre drinking water bubbletop cans vary between INR 5 and INR 7 but, when they reached consumers, the price range increases to INR 30 to INR 40, with major brands priced up to INR 80 (Lakshmi, 2017a). The price of water tankers (as already established) varies with season. Many residents across the city had to pay as much as INR 2,800 for a 12,000 litre tanker in July, 2017 due to high demand (Lakshmi, 2017b). Similarly, residents and commercial establishments on the IT corridor, where private borewells are not giving the yield and quality they once did, are relying on water tankers during dry and wet seasons, despite high prices and poor quality. Here, residences pay anywhere between INR 800 and INR 1600 per 12,000 litre tanker (Citizen Matters, 2017). By comparison, CMWSSB charges either INR 670 or INR 850 for a 10,000 litre tanker, depending on customer type (domestic, commercial or institutional), irrespective of the season. The primary reason for such high private tanker pricing is the distance from which water is drawn, primarily from agriculture wells.

Ironically, the extent and size of the informal tanker market have made regional tanker associations a powerful force to reckon with. In 2017, around 1200 lorries from the South Chennai Private Water Lorry Owners

Association went on strike when the Revenue Department started levying fines and seized lorries for indiscriminate groundwater withdrawals from periurban agricultural wells. The government claims it was trying to regularise groundwater extraction by asking tanker operators to get prior permission. The strike was finally called off after three days, not because of agreements with the government but because of public inconvenience (Govindarajan, 2017; Times of India, 2017b).

II. Periurban farmers: the CMWSSB has entered into contracts with several farmers in periurban areas of Chennai to tap the groundwater that was traditionally used for agriculture. Ruet et al. (2007) found that, in the early 2000s, nearly 200 farmers in Thiruvallur district had entered into a tripartite agreement with the CMWSSB and Tamil Nadu Electricity Board (TNEB). This enabled the CMWSSB to buy water from private agricultural wells and pay INR 26 per hour for electricity. Apart from this formal agreement, which forms a relatively smaller share of the tanker market, several private tanker owners have their own arrangements with farmers and/or illegally extract groundwater from periurban agricultural wells leading to severe ground water exploitation (Govindarajan, 2017; Nurullahl, 2017).

The impacts of such unregulated groundwater extraction on, for example, agriculture has far reaching consequences for farmers. The CMWSSB's practices in periurban areas and implications for both the farmers who supplied water to CMWSSB and those who did not are well documented (Janakarajan et al., 2007). The most direct impact on both groups relates to depleted groundwater levels and, in many instances, drying up of aquifers. Consequently, farmers' livelihoods have been affected and unemployment rates are high due to a drastic decline in incomes (dominated by agriculture) and employment opportunities. This has also forced farmers into heavy debt because of large investments in developing well irrigation without adequate returns. Even the former group that supplied water to CMWSSB are affected due to cancellation of their contracts. While there is not enough data on the impacts of private water tankers' groundwater withdrawal on farmers, it is likely they are similar.

III. Consumers: Domestic, commercial and industrial consumers are the driving force for all the water supply practices described so far in this chapter. Perhaps the role of the consumer ends in demanding for water. However, their responsibilities go beyond this. Ideally, consumers should be responsible for the quantities of water they use. However, this is not the case in most of urban India, including Chennai, where consumption-based water tariffs are not levied. Indeed, the existing water tariff for piped water for residential consumers (combined with a sewage tax) is very low: INR 50 per month per unit. Commercial and industrial consumers are charged more. Further, the high rate of NRW indicates that consumers are not penalised for illegal connections.

The issue of water management in Chennai is highly complex and multilayered, further aggravated by the multiplicity of formal actors and unregulated informal actors. In addition, domestic customers' unmonitored consumption patterns are only exacerbated by a policy environment that provides neither incentive nor penalty mechanism for water conservation unlike other state supplied commodities such as electricity.

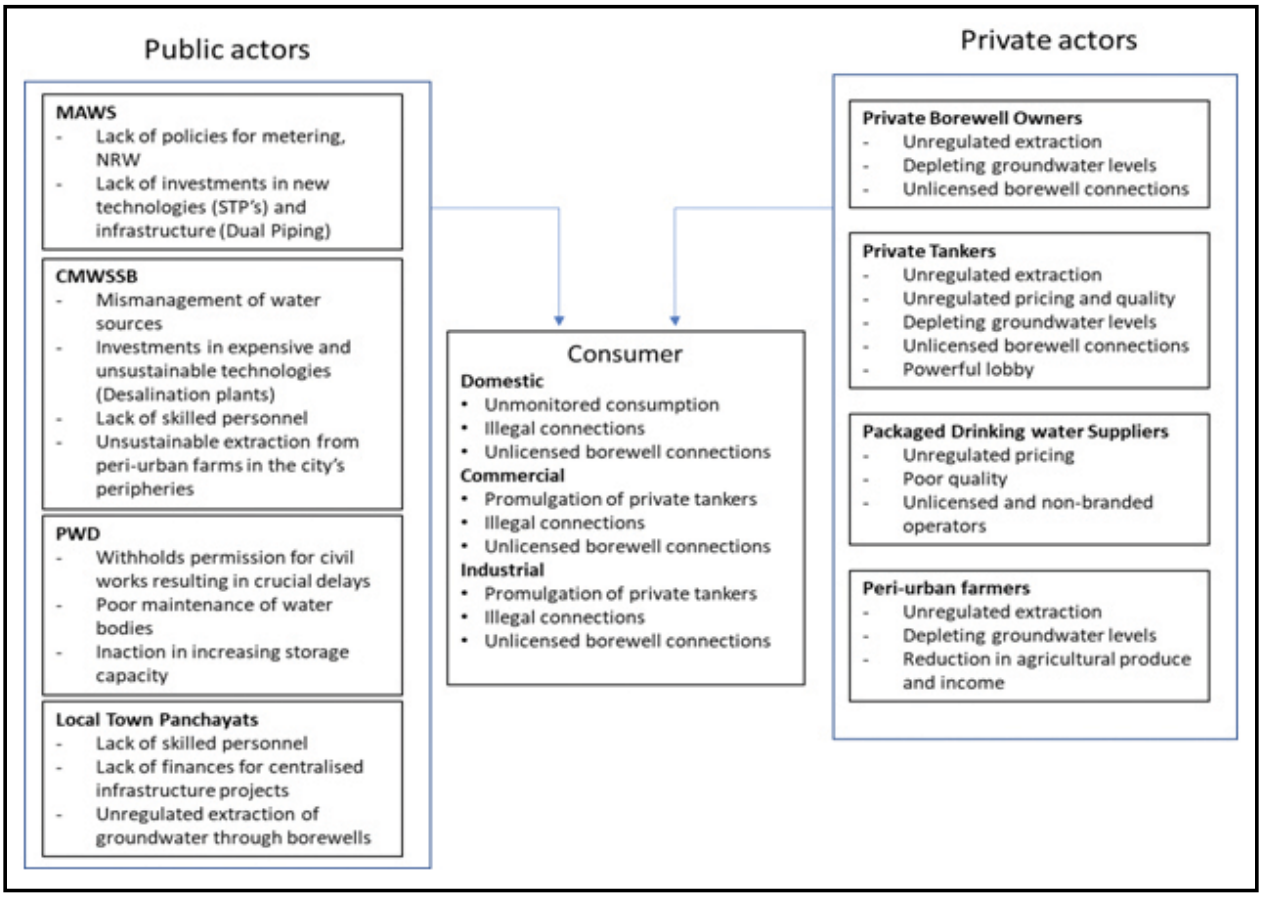

Figure 24: Actor Process Challenge mapping

The actor-process challenge mapping (see Figure 24) shows that the operational inefficiencies, incoherent policies and poor infrastructure and management of water resources by formal actors has bloated the influence and market share of informal actors (private tankers). Without a comprehensive nodal agency, metering policies orimprovement in infrastructure, this trend is poised to continue leading to undesirable outcomes for the city's natural resources and its residents.

CHAPTER 7

CONCLUSION: LOOKING AHEAD

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Chapters 4, 5 and 6 in this report focus on three specific tension areas that lie at the core of integrated urban water governance. They are encroachment, solid waste management and water demand-supply mismatch. Based on these discussions, this concluding chapter presents a set of future scenarios around each tension area. These scenarios vary from one another. Some of them relate to financial sources and arrangements, some relate to institutional relations and processes, while others are regulatory or technological in nature. Some relate to short term interventions, while others require longer term efforts. Similarly, some of these scenarios may readily seem to be desirable scenarios for a more sustainable future, while others may not. In the end, collectively, these scenarios present strategic ideas for achieving a more sustainable and resilient future for CMA with respect to its water, waste and land governance.

Future of encroachment

In chapter 4 we discussed the challenges encountered in the course of addressing the issue of encroachments, including illegal settlements, evictions and resettlements in and around the city. We also pointed out that encroachments often involve public and private developments on vulnerable land and waterbodies due to an ineffective EIA process implementation. If we allow these processes to continue as is, the likely future scenario would be one where current problems associated with encroachments are worse.

"As is" scenario: Given the current conditions in terms of a) the way encroachment is dealt with through resettlement efforts and EIA mechanisms and b) future population (rural-to-urban migration) and economic trends (growth of jobs that do not match the skills of the increasing urban populace), a maintained status quo will mean that current challenges continue to rise. It has already been estimated that the area of waterbodies in Chennai city and its suburbs reduced from nearly 12.6 sq. km in 1893 to around 3.2 sq. km in 2017 (Lakshmi, 2018). Continuing loss of such waterbodies will aggravate the risk of floods in Chennai, while jeopardizing the lives and livelihoods of many. More and more families migrating into the city will continue to encroach on cheap but unsafe river and waterbody banks, in the absence of better, affordable options. Periodically, government agencies such as the TNHB and TNSCB will relocate these encroachers to alternate sites within their limited means based on the resources available to them. The lower income citizens who are resettled or evicted will continue to face the same challenges and drawbacks they currently encounter, ranging from the poor quality of the new tenements, lack of facilities, distance of new settlements from the city, poor law and order situation, loss of livelihoods, etc. In the absence of a comprehensive and well coordinated plan, the very cycle of encroachment will in due course be perpetuated as one group is moved out while another moves in. As such, many non-governmental organizations, citizen welfare groups and scholars have identified critical issues and corrective measures that need to be addressed immediately to

ensure that 1) ongoing efforts have sustainable or long lasting influence to keep waterbodies and land close to waterbodies encroachment free and 2) that encroachers are not penalized or left out in the course of addressing the issue of encroachment to ensure a 'slum-free' and/or 'world-class' city. Similarly, the number of cases of non-compliance with the EIA mandate by public and private developments alike indicate the inherent ineffectiveness of this process. In an "as is" scenario this would boil down to continued encroachments on environmentally vulnerable land and associated human-instigated so-called natural disasters like the one experienced during the 2015 floods.

However, a number of alternative future scenarios could emerge by re-imagining the processes in place. Some such scenarios are as follows (see Table 5 for a summary of various encroachment scenarios).

1) Developing a holistic policy approach to addressing encroachment:

This scenario recognizes the complexities of addressing the resettlement process in a comprehensive and multidimensional manner. Given the relatively lower levels of income and education prevalent among resettled/ affected communities, there is a definite need to keep this section of the population relevant to the economy and to current market trends. Due to the resettlement process, which often places families at great distances from their original city residence, it is critical that the deprivation of employment and livelihoods caused by this process be addressed. Through this scenario, it is envisaged that greater emphasis is placed on skilling and training programmes conducted by the TNSCB, and their efforts coordinated to a higher degree with other departments such as the TNHB and the Ministry of Labour and Skills Development to yield greater impact. Creation of additional links with potential employers and NGOs involved in this space will help catalyse the impact.

Citizens' attempts to find affordable housing options in the city is the primary cause for illegal encroachments. Hence, a policy ensuring affordable rental housing for the urban poor, either through legal provisions made by the government or through public private partnerships would help minimize illegal encroachments.

In lieu of the location of many of the new resettlement tenements on the outskirts of the city, several kms away from where the affected families work or send their children to school, better connectivity to the city at affordable prices also seem essential for these families' normal functioning. In absence of this, many are forced to stay back in the city during the week, finding cheap, often illegal accommodation options close to vulnerable areas such as flood plains or waterbodies, thereby continuing to aggravate the issue of encroachment.

2) Streamlining and coordinating the eviction and relocation processes:

This scenario envisages a complete overhaul of the eviction and resettlement process in a manner that renders it a well coordinated process with clearly defined roles and responsibilities for involved actors. In this scenario, the various stakeholders (including the TNSCB, police, Revenue Department and

Registration Department) liaise and work together during eviction drives orresettlement processes, and their respective roles and responsibilities are clearly stated, leaving no room for flexibility in interpretation or ambiguity in enforcement. This would streamline the process of identifying and dealing with encroachments, evictions and resettlement and leave no unaddressed concerns in the process.

3) Securing more resources (funds, personnel, data) to address encroachment challenges:

This scenario envisages a concerted effort to address vacancies and funding shortfalls across government departments in a bid to ensure the required personnel is availble to identify encroachments on government lands, and the funds to aqequalty deal with violations. This scenario is especially applicable to industrial estates (such as SIDCO, SIPCOT and TIDCO) and the PWD since they own vast tracts of land but are currently understaffed and lose valuable staff time and monetary resources in the course of addressing encroachments on their properties.

Furthermore, the presence of various jurisdictions means that different departments have their own 'list' of encroachments on their respective properties (including land and waterbodies). Given that government departments historically don't coordinate when addressing encroachments, a process that pools together all the available data on illegal encroachments from various departments on a common platform can help eliminate any discrepancies or duplications and progressively address the issue. As one popular motto in governance goes, 'What gets measured gets done'.

4) Building awareness and knowledge on the ecological impact of infrastructural projects and the EIA process:

This scenario attempts to address the lack of awareness or knowledge about ecological terminologies (including CRZs and No Development Zones) and what they entail, the larger and long-term impacts of development projects on the environment and the procedures that must be fulfilled to obtain the requisite environmental clearances and documents by both public and private developers. Creating training modules andconducting awareness programmes on the rationale of ECs and EIAs could help generate a greater level of awareness among project developers (at the conceptualization stage), consultants (at the testing stage) and regulators (at the assessment stage). This could ensure a higher degree of responsibility among these key players towards environmental sustainability.

5) Higher resource/power allocation to the SEAC:

This scenario accords a greater degree of importance to the SEAC, both in theory and practice. Besides incorporating periodic training for SEAC members on their role when evaluating development proposals, small steps can go along way in ensuring the sanctity of the EIA process, including providing adequate notice to SEAC members prior to meetings and allowing them the time and capacity to individually or as a group verify the assessments conducted by the consultants acting on behalf of developers. Making appropriate financial allocations for this purpose is also a requisite. Given that the findings by the SEAC are advisory and not binding in nature, perhaps a method to accord greater recognition to unanimous SEAC findings (for example, a majority of members arriving at the same finding) could help bolster the SEAC's role.

6) Stringent checks and balances on EIA process and actors:

This scenario envisages a comprehensive review of both the process itself and the role of various stakeholders at every stage of the EIA process, with the goal of ensuring its sanctity and a system of checks and balances. These arecurrently found lacking. Another loophole that needs to be addressed is that around the lack of an independent SEAC assessment, and the fact that consultant findings are indisputable and taken as given – particularly since contultatns are contracted by developers. Furthermore, despite the digitization of the process of submitting proposals to the SEIAA, the fact that some proposals are brought forward earlier than their predecessors point to the possibility of vested interests among state authorities, who may be aligned with project developers. Finally, the presence of the same stakeholders in multiple (decisionmaking) stages of the process points to a conflict of interest that needs to be stemmed at once (for instance, TNPCB members who are part of the SEIAA are also responsible for granting CTOs and CTEs).

Encroachment Scenarios	
"As is" scenario	Aggravated rates of encroachment posing further social, ecological and economic threats
Developing a holistic policy approach to addressing encroachment	Rental/affordable housing policy for lower income groups Effective skilling programs Affordable transportation policy connecting city and its peripheries
Streamlining and coordinating the eviction and relocation process	Rule book clearly laying down roles and responsibilities No scope for ambiguity in eviction process No department/stakeholder (utility, political group or judiciary) should act counterproductively to the mandate to remove encroachments
Securing more resources to address encroachment challenges	More funding Dedicated officials Well managed data
Awareness and capacitybuilding on ecological impact of infrastructural projects and EIA process	Training modules and awareness building for developers, government officers and SEAC members
Higher resource/power allocation to the SEAC	Resource support SEAC decision should have greater influence on SEIAA decision
Stringent checks and balances on EIA process and actors	Possibility of external or internal manipulation in the process must be removed Cross checking of all assessments by multiple and independent parties is needed

Table 5: Encroachment scenarios

Future of SWM

In chapter 5 we highlighted the challenges associated with current SWM policy (or lack thereof) and practice. Against this background, it is not too difficult to fathom the unsustainable future we are heading towards in absence of effective interventions.

"Asis" scenario: Chennai is a leading generator of waste in the country, with the amount generated having increased exponentially over the years. This number doubled from 2616 tonnes in 2000 to 5200 tonnes in 2018. If the status quo persists, Chennai's two landfills will go far beyond their saturation point and small land parcels inside the city or in the envisaged expanded CMA will be used for dumping the waste. As evidenced in the existing dump yards, unscientific disposal of waste in open land parcels will have a severe impact on groundwater quality. The health hazards associated with waste incineration and dumping close to human settlements will only intensify.

The recent estimates by WasteToEnergy Research and Technology Council (WTERT) place the quantity of waste ending up in drains at 30% of the total amount generated. This leads to widespread clogging of storm water drains and pollution of waterbodies, which will result in extensive inundation in the city during even moderate rainfalls. Further, efforts to restore waterbodies will prove to be unsustainable due to inevitable pollution, thus crippling the city's water supply situation. Thus, if the status quo persists, it will have far reaching and long-term impacts on the city's ecology, water supply and quality of life.

Our discussions around the challenges relating to the SWM policy and process, the stakeholders' role and the nature of waste all indicate a number of opportunities for improving current practices. As such, drawing on that discussion we may etch out several alternative scenarios wherein solid waste is managed with long term environmental, public health and water quality related concerns in mind. Following are some possibilities (see Table 6 for a summary of various SWM scenarios):

1) Enforcing source segregation

80% of the waste generated in Chennai can be recycled or reused. Enforcing source segragation so as to enable this will be a crucial step in decreasing the quantity of waste that goes to the landfill. Experts estimate effective source segregation will reduce the quantity of waste going to the landfill to 1000 tonnes per day (reduction of 80%) (Merigala, 2017). While there are clearly defined rules for source segregation the CoC has had a hard time implementing them. Further, the private operators in charge of the conservancy operations in three zones are not contractually obligated to collect segregated garbage.

In this scenario, a comprehensive SWM plan for the city is prepared by HUD and the GCC takes drastic efforts to implement city-wide source segregation, which includes individual dwelling units. The actions comprise an incentive mechanism for source segregation and heavy penalties including non-collection of unsegregated waste, in order to bring about a behavioural change in waste management. Further, the private conservancy contracts, which will expire in 2018, will have a mandatory source segregation clause in its next iteration.

2) Scientific closure of existing landfills, development of sanitary landfills and implementation of waste to energy plants inside landfills

During the stakeholder workshops and interviews, much of the concern with SWM revolved around land unavailability for storing and disposing garbage. At 485 hectares, Chennai already has the largest parcel of land demarcated for waste disposal in the country. The predicted urbanization trends will only make it difficult for the government to use contiguous tracts of land for waste disposal in the future. Further, the strides made in source segregation will have no effect if there is an absence of waste management plan in the landfills.

In this scenario, the GCC constructs waste to energy (WTE) plants inside landfills, which will be used for power generation, in addition to reclaiming the land. The waste generated in Chennai has the highest calorific value (10.9 MJ/kg) in the country and has a power production potential of 149 MW (Annepu, 2012). The WTE is a large-scale technology and the GCC currently has issued tenders to construct one WTE plant in its dump yards. Each of these planned WTE will be equipped to handle up to 5000 tonnes of wastes per day. This scenario, in conjunction with source segregation, will largely reduce the quantity of waste present in the two dump yards, which will eventually pave the way for their closure. Further, the development of new landfills will adhere to the rules established in SWM Rules 2016, ensuring that the chosen area does not have waterbodies or human settlements within 100 metres and 500 metres respectively.

3) Decentralised waste processing and treatment

This scenario envisages biodegradable waste to be processed, treated and disposed of through composting and biomethanation inside gated communities and large scale dwelling units. Further, the GCC will set up localised waste processing facilities, encouraging decentralised solid waste management practices. The private sector, especially Special Economic Zones (SEZ), Industrial Estates and Industrial Parks will earmark space for waste processing inside their premises, as defined in the SWM Rules 2016.

4) Enhanced role of the private sector in SWM:

Under this scenario, the conservancy operations will be privatised in all 15 zones and the contracts will include the rules, regulations and provisions mentioned in SWM Rules 2016 for waste handling and waste processing. Despite mixed reviews on the effectiveness and efficiency of private operators in Chennai, the technology and financial resources available with private sector outweigh the GCC's operational capacity. The GCC's weak budget allocation for SWM over the years further illustrates this lack of resources for SWM at the GCC. The private sector, under an effective monitoring set up, therefore takes over the conservancy operations in the city. The support from the GCC will include access to personnel talent pool through formalising and training of existing informal garbage collectors.

Apart from conservancy operations, the private sector will be encouraged to use the compost and fertilizers derived from waste processing and Refuse Derived Fuel (RDF) from WTE plants as established in the SWM Rules 2016. Further, this scenario, through incentive mechanisms, will promulgate innovation and research in manufacturing of biodegradable products by

the private sector to eventually replace non-biodegradable products like plastic.

SWM Scenarios	
"As is" scenario	Exponential rise in waste produced Increased pollution of waterbodies Severe groundwater contamination Unavailability of land for disposing waste
Enforcing source segregation	Reusing and recycling reduces quantity of waste going to landfills Penalties for failure to comply Behavioural change towards consumption and waste management
Scientific closure of existing landfills, development of sanitary landfills and waste to energy plants inside landfills	Land reclamation Waste to energy plants: sustainable way to remove garbage Strict development regulations around existing landfills and location of new landfills
Decentralised waste processing and treatment	Community ownership and responsibility Localised waste handling processes
Enhanced role of private sector in SWM	Regulated private sector takes over the conservancy operations in all the zones GCC provides training for informal workers and integrates them Policy mechanisms that promulgate the manufacturing of biodegradable and environmentally sustainable products

Table 6: SWM scenarios

While the abovediscussed scenarios have their individual merits, their effectiveness will be dwarfed if they are not implemented simultaneously. Desirable and long-term solutions in SWM can only be achieved through concerted implementation of all these scenarios. The basis for most of the scenarios is the SWM Rules 2016, which, when released were acclaimed around the world for their audacious stance on managing solid waste. But, two years since its ratification, the policy exists only on paper and the garbage woes have only intensified in Chennai and most other metropolitan cities in India.

Future of water supply-demand mismatch

Chapter 6 discussed in detail the existing debate around water supply and demand in the CMA area and potential solutions to bridge gaps. While it seems clear that a supply-demand gap does exist, there are varied views on what factors cause the gap: mismanagement, unpredictable rainfall, lack of storage or a combination of these. Consequently, there are also different views on the best possible solution, from centralised technological introductions such as desalination to more local measures like rainwater harvesting. We also find that several governmental and non-governmental

actors form an intrinsic part of the water management framework in the CMA. The latter group, including informal water tankers, play a key role in supplying water to consumers who are looking to bridge the gap between their demand and supply, especially during periods of water stress. Based on the discussion, the current trends and an "as is" scenario seem to present immense uncertainties.

"As is" scenario: Most environmental experts believe that the CMWSSB's emphasis on desalination plants over waterbody restoration to be unsustainable in the long run. The envisaged plants will take more than10 years to reach full operation, by which time the city's water demand will have increased considerably. The CMA expansion will give jurisdiction for CMWSSB to tap into agricultural lands in the expanded area, which will further deplete groundwater levels and affect water availability for agriculture. Without water metering or solving NRW problems, the CMWSSB will experience a severe financial crunch, crippling their operation and maintenance and RWH efforts. The unregulated and unmonitored informal water supply ecosystem will become mainstream and residents will have no option but to foot the bill for expensive private water tankers for their primary water source. This will further diminish poor people's capacity to meet their basic water requirements. Furthermore, without CMWSSB's support to restore and better manage existing waterbodies, they are likely to meet a fate already experienced by several affected and polluted waterbodies in the CMA that have already been categorised as unrestorable.

Alarmed by this possibility, different stakeholders may resort to different strategies to fill the water supply and demand gap leading to alternative scenarios redefining the water governance mechanisms in the CMA (see Table 7 for a summary of water supply-demand scenarios).

1) Complete dependence on desalination:

This would deepen the financial burden on CMWSSB, making the situation unsustainable in the long run. Desalination plants require large capital and operations and maintenance (O&M) investments. Much of these are driven by highly intensive energy requirements which have a high carbon foot print. The impact of discharge from the plants on aquatic life is also significant. Further, climate change predictions indicate Chennai is vulnerable to sea level rise (Department of Environment, 2015), meaning any infrastructure (including desalination plants) on the coast is also vulnerable to sea level rise and storm surges. Regardless, desalination in Chennai has proven to be a fairly reliable source in periods of water stress.

2) Revival of waterbodies and no desalination:

This scenario would entail a complete cleanup of all lakes and waterbodies in and around the CMA, such that they can store rainwater to maximum capacity. This would also include clearing encroachments (by non-government and government actors), plugging illegal discharge and revivingthe channels connecting waterbodies. It would also require large investments to modify existing water supply networks to support this system, and large investments in maintenance and monitoring of waterbodies. One consideration is that there is not enough scientific evidence to show that revived waterbodies could meet current and/or future water demand (especially in light of increased climate variability) and whether this system

could be relied upon during drought periods.

3) Revival of waterbodies and increased desalination capacity:

In order for this scenario to work, large financial and human resource investments are required from the government and other stakeholders. In particular, funds would be needed to monitor waterbodies and keep them free from pollution and encroachments. The advantages are that risks are diversified and, during dry seasons, higher dependence can be placed on desalination plants. One caveat is that optimal use of desalination plants requires that they run on full capacity throughout the year.

4) All industries and commercial establishments reuse waste water:

Waste water reuse would significantly reduce groundwater extraction and dependence on fresh water. Some industries already reuse sewage water for their operations. Complete industrial dependence on wastewater would require a substantial increase in sewage treatment plant (STPs)_ capacity by setting up new plants near industrial estates. There are currently more than 40 industrial estates in Chennai, Kanchipuram and Thiruvallur districts. In terms of commercial establishments, specifically hotels and educational institutions, STPs and grey water recycling plants would provide necessary water for all purposes including drinking. In addition to capacity increases, treatment processes need to be upgraded to tertiary treatment, and extensive awareness campaigns will be needed to reassure users on the quality of treated water for drinking and cooking. Further, CMWSSB could make it mandatory for industries to only use treated water and provide necessary support. It would also have to strengthen monitoring mechanisms to ensure industries reuse waste water.

5) Domestic dependence on rain water harvesting:

This scenario would significantly reduce dependence on piped water, groundwater and water tankers. In some cases, it would also lead to improved aquifer recharge. However, it is likely that rain water harvesting alone cannot meet domestic need and some other source is required to fill the gap, especially during dry periods.

6) Combination of all the above:

This scenario would involve building supply capacity through desalination and revival of lakes while simultaneously reducing demand on fresh water through mandatory RWH and waste water reuse. It would also involve multiple actors at different levels for different solutions that would all be integrated to reduce impact on natural environment and water systems.

Water supply-demand mismatch scenarios	
"As is" scenario	Overdependency on desalination plants No metering policy or efforts to reduce NRW Poor investments in O&M or new technology due to lack of funds Aggravated water scarcity due to encroachment, poor maintenance and non-revival of waterbodies
Complete dependence on desalination	Effective source during droughts Financially unviable due to high capital expenditure Environmental degradation
Revival of waterbodies and no desalination	Revival of channels Removal of encroachments and illegal connections Improved storage capacity during monsoons High investments to monitor revived waterbodies Difficulty in removing encroachments due to political over-reach Uncertainty of time and resource required for removing encroachments
Revival of waterbodies and increased desalination capacity	High investments for monitoring revived waterbodies and high capital expenditure for developing desalination plants Diversification of source by part dependence ondesalination and revived waterbodies
All industries and commercial establishments reuse waste water	Lowers dependency on fresh water and groundwater High investment costs in STPs Awareness and incentives to use treated water
Domestic dependence on rain water harvesting	Improve aquifer recharge Decrease dependency on groundwater and piped water High risk in the event of drought
Combination of all the above	Reduce risks through diversification of source Less strain on the environment and ecology

Table 7: Water supply-demand mismatch scenarios

Our analysis of existing data and direct engagement with varied stakeholders during the course of this project has therefore enabled us a) to present a comprehensive understanding of the urban water governance ecosystem, its actors, their roles and the weak links within the ecosystem and b) to etch out various alternative future scenarios, some more desirable or favourable than others with respect to Chennai's sustainability. These scenarios also highlight multiple possibilities that may prove particularly helpful to drive Chennai's development trajectory on a more resilient path. In the next phase of this project we will draw on this work to build a model and also to identify short, medium and long term interventions along various axes, including financial, technological, personnel and regulatory. The final outcome of this ongoing work will include:

1. An agent-based model to help assess implications of specific land, water and waste related decisions on CMA water vulnerability and

2. A comprehensive and strategic blueprint to guide policy and action towards making Chennai more resilient with respect to its water needs and threats.

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APPENDIX 1

List of organizations /groups interviewed	Nature	Number of interviews
Chennai Metropolitan Development Authority	Government	2
Chennai Metro Water Supply and Sewerage Board	Government	1
Greater Chennai Corporation	Government	1
Public Works Department	Government	2
Tamil Nadu Water Investment Company	Private	1
Tamil Nadu Urban Infrastructure and Financial Services, Ltd.	PPP	1
Tamil Nadu Urban Finance and Infrastructure Development Corporation Limited	PPP	1
Urban Workshop	Private	1
Coastal Research Centre	NGO	1
Care Earth	NGO	1
Civic Action Group	NGO	1
Indo German Centre for Sustainability	Think tank	1
Rain Centre	NGO	1
MIDS	Academia	1
SaciWATERs	NGO	1
MCCI	Industry	1
IIT Madras	Academia	1
Semmancheri Residents	Vulnerable Communities	2 groups (10 in each)

APPENDIX 2

FUNCTIONAL DEPENDENCIES

	CMDA (a)	CMWSSB (b)	GCC (c)	TNHB (d)	TNSCB (e)	TWAD (f)	DoE (g)	SIDCO (h)	TIDCO (i)	SIPCOT (j)
CMDA (a)	NA	(a) gives permits for infrastructure development; (b) is expected to develop its plans based on (a)'s Master Plan; (b) is expected to meet the needs of development approved by (a) in CMA. (b) → (a)	(c) need permit from (a) for infrastructure development; (c) is expected to develop its plans based on (a)'s Master Plan; (c) → (a)	(d) may need permit from (a) for their projects; (d) is expected to follow (a)'s Master Plan (d) → (a)	(e) may need permit from (a) for their projects; (e) is expected to follow (a)'s Master Plan (e) → (a)	(f) may need permit from (a) for infrastructure development: (f) must follow (a)'s Master Plan (f) → (a)	(g) depends on (a) to direct development in vulnerable areas or posing environmental threat to (g) for getting environmental clearance (g) → (a)	(h) need permit from (a) for their development (h) → (a)	(i) need permit from (a) for their development (i) → (a)	(j) need permit from (a) for their development (j) → (a)
CMWSSB (b)	(b) is expected to devlop its Master Plan following (a)'s Master Plan; (b) is required to supply water, sewerage services to developments approved by (a). (b) → (a)	NA	(c) funds for reconstruction of roads once (b)'s work is over: (b) needs permission for construction of infrastructure from (c). (b) → (c)	(d) pays (b) for water and sewerage infrastructure work (b → d)	(e) pays (b) for water and sewerage infrastructure work (b) → (e)		(g) provides environmental clearance for (b)'s infrastructure work. (b) → (g)			(j) funds infrastructure in (j) estate and can pressurize to complete infratsructure projects; (b)'s TTRO Water Scheme supplies water to (j) Industries. (j) ↔ (b)
GCC (c)	(a) giving funds for infrastructure dev; (a) and (c) collaborate on projects and can initiate or hinder projects (c) (a)	(b) funds for water service provision; (c) depends on (b) for watersupply (c) → (b)	NA	(d) provide funds for infrastructure development within housing board facility; (d) depend on (c) to complete infrastructure work on time (c) (d)	(e) provides funds for infrastructure development within the slums and relocation sites; (e) depend on (c) to complete infrastructure work on time (c) ↔ (e)		(c) needs to get EIA clearance from (g) for various projects (c) → (g)	(h) provide funds to (c) for infrastructure development within the SIDCO area (c) → (h)	(i) provide funds to (c) for infrastructure development within the TIDCO area (c) → (i)	(j) provide funds to (c) for infrastructure development within the SIPCOT area (c) → (j)
TNHB (d)	(a) provides permission for planning and building layout within metropolitan area (d) → (a)	(b) installs sewer system within housing board developments (d) → (b)	(d) would need permission from (c) for development within corporation area (d) → (c)	NA	(e) nodal office getting funds from central government (Pradhan Mantri Awas Yajona). (d) ties up with TNSCB for building houses for the economically weeker section. (d) → (e)	(f) provides water lines for housing beyond corporation area (d) → (f)	(d) need to get EIA clearance from (g) (d) → (g)			
TNSCB (e)	(a) provides permission to (e) for planning and building layout within metropolitan area (e) → (a)	(b) instal sewer system within housing board developments (e) → (b)	(e) would need permission from (c) for development within corporation area (e) → (c)	(e) nodal office getting funds from central government (Pradhan Mantri Awas Yajona). (d) ties up with (e) for building houses for the economically weeker section. (d) → (e)	NA	(f) provides water lines for housing beyond corporation area (e) → (f)	(e) need to get EIA clearance from (g) (e) → (g)			
TWAD (f)				(f) provides water and sewage connections for (d) outside of metropolitan area (d) → (f)	(f) provides water and sewage connections for (e) outside of metropolitan area (e) → (f)	NA	(f) needs to follow CRZ rules and get approvals for projects from (g) (f) → (g)	(f) provides water and sewage connections to (h) (h) → (f)	(f) provides water and sewage connections to (i) (i) → (f)	(f) provides water and sewage connections to (j) (j) → (f)

DTCP (k)	TNSDMA (l)	(TNPCB) (m)	CMA (n)	PWD (o)	TUFIDCO (p)	Revenue Dept. (q)	CRRT (r)	Academic Org. (aa)	National & International Funding Org.(bb)	Civic Org. (cc)	OTHERS
		(a) can direct certain development to (m) before giving permits (m) → (a)	(n) may need permit from (a) for developments (n) → (a)	For infrastructure development (o) needs permit from (a); to monitor development near waterbodies, (o) depends on (a) to direct such developments to them for NoC (o) → (a)							
	(l) give funds for relief work to (b). (b) → (l)	(b) depends on (m) for project clearance. (b) → (m)	(n) funds water works in areas beyond GCC area (b) → (n)	For different water work they collaborate (b) ↔ (o)	(p) funds (b) for projects (b) → (p)						
	Funds for relief work needs to be shared; Both decide together on what needs to be prioritized at times of disasters (c) ↔ (l)	(c) may need to obtain clearance or NOC for certain developments ((c) → (m)	(n) provides funds for infrastructure development in municipalities beyond old Chennai Corp. to (c). (c) → (n)	(o) provides funds for Lake restoration to (c). (c) → (o)	(p) offers grants/loans to (c). (c) → (p)						
Permission for planning and building layout for (d) (beyond CMA area) comes from (k) (d) → (k)		(d) May need to get NOC from (m) incase (a or k) express concern or insist (d) → (m)		(a or k) can insist that NOC be obtained from (o) in case development is close to waterbody. Also, (o) rules and regulations about floating tenders have to be followed by (d) (d) → (o)		(d) goes to (q) to get land (d) → (q)					
Permission for planning and building layout for TN (beyond CMA area) comes from (e) (e) → (k)		(e) May need to get NOC from (m) incase (a or k) express concern or insist (e) → (m)		(a or k) can insist that NOC be obtained from (o) in case development is close to waterbody. Also, (o) rules and regulations about floating tenders to be followed by (e) (e) → (o)		(e) goes to (q) to get land (e) → (q)					
	(l) requires (f) to have a plan for disaster (f) → (l)	(f) needs to get permision from (m) for discharging sewage water into water bodies (f) → (m)	?	(f) needs their permission for extracting water and sand from lakes/tanks from (o) (f) → (o)	(p) provide funds for infrastructure development to (f) (f) → (p)	(q) has the land-so (f) goes to them for land ((f) → (q)			(bb)-provide funds to (f) (f) → (bb)		1. Rural Development (dd)-provide funds for infrastructure dev. To (f) 2. Highways (ee) (National, State): (f) needs to get permission for laying pipelines under the roads (f,dd)+((f,ee))

FUNCTIONAL DEPENDENCIES

	CMDA (a)	CMWSSB (b)	GCC (c)	TNHB (d)	TNSCB (e)	TWAD (f)	DoE (g)	SIDCO (h)	TIDCO (i)	SIPCOT (j)
DoE (g)	Based on proposals submitted by individual departments funds are allocated by (g). (g) must provide environmental clearance (a) → (g)	Based on proposals submitted by individual departments funds are allocated to (b). (g) must provide environmental clearance (b) → (g)	Based on proposals submitted by individual departments funds are allocated +DoE must provide environmental clearance (c) → (g)	Based on proposals submitted by individual departments funds are allocated to (d). (g) must provide environmental clearance (d) → (g)	Based on proposals submitted by individual departments funds are allocated to (e). (g) must provide environmental clearance (e) → (g))	Based on proposals submitted by individual departments funds are allocated to (f) (g) must provide environmental clearance (f) → (g)	NA	Based on proposals submitted by individual departments funds are allocated to (h). (g) must provide environmental clearance (h) → (g)	Based on proposals submitted by individual departments funds are allocated to (i) (g) must provide environmental clearance (i) → (g)	Based on proposals submitted by individual departments funds are allocated to (j). (g) must provide environmental clearance (j) → (g)
TIDCO (i)	(i) must get approvals for their estates within metropolitan area from (a) (i) → (a)		(i) provide funds to (c) for infrastructure development within the (i) area (c) → (i)			(f) provides water and sanitation to (i) (i) → (f)	If (i) estates border forest land then they need approval from (g) (i) → (g)"			Collaborate on project (e.g. Sriperumbudur) (j) provided land to (i) (i) ↔ (j)
SIPCOT (j)	(j) needs approvals from (a) (j) → (a)	through TTRO Water Scheme, (b) supplies water to (j) (j) → (b)		↔		(f) Implement Schemes for industrial projects in (j) (j) → (f)	(j) needs Environmental clearance from (g) (j) → (g)		Collaborate: Aerospace Park being developed jointly (j) ↔ (i)	
DTCP (k)				(k) approves building layout, planning permission for (k) (d) → (k)	(k) approves building layout, planning permission for (e) (e) → (k)	Developments approved by (k), (f) has to supply water and sewerage (f,) → (k)	CRZ rules, NoC, Pollution certificate provided by (g) to (k) (k) → (g)	(k) approves building layout, planning permission for (h) (h) → (k)		(k) approves building layout, planning permission for (j) (j) → (k)
TNPCB (m)	(m) provides NOC and Pollution certificates on projects to (a) (a) → (m)	(m) provides NOC and Pollution certificates on projects to (b) (b) → (m)	(m) provides NOC and Pollution certificates on projects to (c) (c) → (m)	(m) provides NOC and Pollution certificates on projects to (d) (d) → (m)	(m) provides NOC and Pollution certificates on projects to (e) (e) → (m)	(m) provides NOC and Pollution certificates on projects to (f) (f) → (m)	(m) provides NOC and Pollution certificates on projects to (g). (g) → (m)	(m) provides NOC and Pollution certificates on projects to (h). (h) → (m)	(m) provides NOC and Pollution certificates on projects to (i) (i) → (m)	(m) provides NOC and Pollution certificates on projects to (j) (j) → (m)
CMA (n)	8 municipalities of (n) need approval for projects above 10 lakhs from (a) (n) → (a)"				PMAY: Commissionarate provides list for (n) and (e) implements (n) → (e)	(f) Implements water supply and sewerage projects for (n) (n) → (f)	(g) Gives (n) funds for certain projects (plastic roads) (n) → g)			

DTCP (k)	TNSDMA (l)	(TNPCB) (m)	CMA (n)	PWD (o)	TUFIDCO (p)	Revenue Dept. (q)	CRRT (r)	Academic Org. (aa)	National & International Funding Org.(bb)	Civic Org. (cc)	OTHERS
Based on proposals submitted by individual departments funds are allocated to (k) (g) must provide environmental clearance (k) → (g)	Based on proposals submitted by individual departments funds are allocated to (l). (g) must provide environmental clearance (l) → (g)	Based on proposals submitted by individual departments funds are allocated to (m) +DoE must provide environmental clearance (m) → (g)	Based on proposals submitted by individual departments funds are allocated to (n) (g) must provide environmental clearance (n) → (g)	Based on proposals submitted by individual departments funds are allocated to (o) (g) must provide environmental clearance (o) → (g)				Anna University, IITM: (g) funds projects to be carried out by (aa)+technical assistance from (aa) to (g) (aa) ⟷ (g)	(bb) funds (g) based on proposals and tenders (g,bb)	Care Earth: (g) funds projects to be carried out by (cc)+ technical assistance from (cc) to (g) (cc) ⟷ (g)	
(i) need approvals for their estates outside CMA from (k) (i) → (k)		(i) Need NOC from (m) for certain developments (i) → (m)		If there is any waterbody within or closeby, ((i) will need NOC from (o) They are also required to maintain 10% OSA. In case of a waterbody, this should be conserved withn this. (i)→(o)							
(k) Approves layout plans of (j) (j) → (k)		(m) Gives environmental clearance for development to (j) (j) → (m)	→	(o) Give NoCs; Also operate water supply schemes for (j) (j) → (o)							
NA		NoCs provided by (m) to (k). (k) → (m)		NoC for construction in vulnerable areas provided by (o) to (k) (k) → (o)							Local Bodies (v) approach DTCP (k) for development approvals (v) → (k)
(m) provides NOC and Pollution certificates on projects to (k) (k) → (m)		NA	(m) provides NOC and Pollution certificates on projects to (n) (n) → (m)	(m) provides NOC and Pollution certificates on projects to (o) ((o) → (m)							
	(L)Gives funds for disaster management (water supply, roadworks) and mitigation projects to (n) (n) → (l)	(m) must give NOC to (n) for consent to establish (gassifier/ crematorium, biomethane plant/operate projects (SWM, Sewerage)) (n) → (m)	?	(n) must get NoC from (o) for source augmentation -river, coasts, dam site (n) → (o)	(p) gives loans for market, shopping complex, road development to (n) (n) → (p)	(q) Provides land for water and sewerage projects to (n) ((n) → (q)				Hindu Religious and Cultural Groups (cc): Hold and alienate a lot of land, (n) buys from them for projects- (n) → (cc)	

FUNCTIONAL DEPENDENCIES

	CMDA (a)	CMWSSB (b)	GCC (c)	TNHB (d)	TNSCB (e)	TWAD (f)	DoE (g)	SIDCO (h)	TIDCO (i)	SIPCOT (j)
PWD (o)	(a) need to get approval from (o) for development projects if these are close to waterbodies (a) ⟶ (o)	(o) gives partial funding to (b) projects (b) ⟶ (o)	(o) gives partial funding for infrastructure development. +(o) provides NOC's for © initiated projects close to waterbodies (c) ⟶ (o)	(o) may need to provide permission to (d) in case development is close to Waterbodies (d) ⟶ (o)	(o) may need to provide permission to (e) in case development is close to Waterbodies (e) ⟶ (o)		(g) provides environmental certificates, NoC for (o) projects (o) ⟶ (g)			
TNIDB (s)	(s) Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (a) ⟶ (s)	(s) Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (b) ⟶ (s)"	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (c) ⟶ (s)"	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals. (d) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (e) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (f) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (g) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (h) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (i) ⟶ (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (j) ⟶ (s)
TNUIFSL (u)		(u) gives funds for implementation of projects +(u) offers technical assistance to (b). (b) ⟶ (u)	(u) gives grants and loans +(u) offers technical assistance to (c) . (c) ⟶ (u)							
SIDCO	(h) need permit from (a) for their development (h) ⟶ (a)		(h) provide funds to (c) for infrastructure development within the SIDCO area (c) ⟶ (h)			(f) provides water and sewage connections to (h) (h) ⟶ (f)	Based on proposals submitted by individual departments funds are allocated to (h). (g) must provide environmental clearance (h) ⟶ (g)			

DTCP (k)	TNSDMA (l)	(TNPCB) (m)	CMA (n)	PWD (o)	TUFIDCO (p)	Revenue Dept. (q)	CRRT (r)	Academic Org. (aa)	National & International Funding Org.(bb)	Civic Org. (cc)	OTHERS
			(n) must get NoC from (o) for source augmentation -river, coasts, dam site (n) → (o)	NA		Enter upon the land permission field map"" boundary by (q) forms the basis of (o) drawings (o) → (q)					
(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (k) → (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (l) → (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (m) → (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (n) → (s)	(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (o) → (s)			(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (r) → (s)		(s)Provide funds; any project above 500 Crores & PPP above 10 crores need (s)'s approval; Permanent Body created to fulfill Vision 2023 goals (s) → (bb)		
			(u) gives grants for DPRs +(u) offers technical assistance to (n) (n) → (u)				(u) offers technical assistance to ®. (r) → (u)				
(k) aproves building layout, planning permission for (h) (h) → (k)		(m) provides NOC and Pollution certificates on projects to (h). (h) → (m)									(h) depends on (v) for services (h) → (v)

KNOWLEDGE DEPENDENCIES

	CMDA (a)	CMWSSB (b)	GCC (c)	TNHB (d)	TNSCB (e)	TWAD (f)	DoE (g)	SIDCO (h)	TIDCO (i)	SIPCOT (j)	DTCP (k)	TNSDMA (l)
CMDA (a)												
CMWSSB (b)	both share data for preparation of reports (b) ↔ (a)		both share data for preparation of reports (b) ↔ (c)			information is shared between both (b) ↔ (f)	information is shared between both (b) ↔ (g)					
GCC (c)	Exchange information during Master Plan preparation ca;ac (c) ↔ (a)	During plan preparation they share data (c) ↔ (b)			Getting slum related info from them. GCC shares info on land availability for relocation. (c) ↔ (e)		Studies are conducted and data shared both ways (c) ↔ (g)					Data sharing for disaster management /relief work (c) ↔ (l)
TNHB (d)	did not recognize any knowledge-based interaction as crucial or regular											
TNSCB (e)												
TWAD (f)		share information and policy both way (f) ↔ (b)										
DoE (g)	Information flow both way (g) ↔ (a)	Informtion flow both way (g) ↔ (b)	Information flow both way (g) ↔ (c)	Information flow both way (g) ↔ (d)	Information flow both way (g) ↔ (e)	Information flow both way (g) ↔ (f)		Information flow both way (g) ↔ (h)	Information flow both way (g) ↔ (i)	Information flow both way (g) ↔ (j)	Information flow both way (g) ↔ (k)	Information flow both way (g) ↔ (l)
SIDCO (h)	no knowledge interaction mentioned											
TIDCO (i)												
SIPCOT (j)												

TNPCB (m)	CMA (n)	PWD (o)	TUFIDCO (p)	Revenue Dept. (q)	CRRT (r)	TNIDB (s)	Regis-tration Depart-ment (t)	TNUIFSL (u)	Academic Org.	Interna-tional Funding Org.	Civic Org.	OTHERS
		Both share information (b) ◄► (o)	CMWSSB shares information (b) ◄► (p)									
Data is shared for preparing for Govt. Reports. (c) ◄► (m)	Preparation of reports (c) ◄► (n)	PWD shares land-based data: who owns etc (c) ◄► (o)		Land related info shared by Rev. Dept GCC shares population/ socio-eco-nomic info. (c) ◄► (q)				GCC providing data for report preparation and technical knowledge shared with GCC through completed reports (c) ◄► (u)				
did not recognize any knowledge-based interaction as crucial or regular												
Information flow both way (g) ◄► (m)	Information flow both way (g) ◄► (n)	Information flow both way (g) ◄► (o)			Information flow both way (g) ◄► (r)			Information flow both way (g) ◄► (u)	share data for preparing studies and provide each other technical sistance. (Anna Uni-versity, IITM) (g)◄►(aa)	Two-way interaction for preparing and com-missioning studies (GIZ, WorldBank) (g)◄►(bb)	"share data for preparing studies and provide technical assstance (g) ◄► (cc)	
no knowledge interaction mentioned												
				information on land availability, ownership is shared by Revenue Dept (i) ⟶ (q)								
				Info for identification of Land (j) (q)								

KNOWLEDGE DEPENDENCIES

	CMDA (a)	CMWSSB (b)	GCC (c)	TNHB (d)	TNSCB (e)	TWAD (f)	DoE (g)	SIDCO (h)	TIDCO (i)	SIPCOT (j)	DTCP (k)	TNSDMA (l)
DTCP (k)										SIPCOT brings all the plans, layout etc to DTCP (k) ← (j)		
TNPCB (m)	Information flow both way (m) ↔ (a)	Information flow both way (m) ↔ (b)	Information flow both way (m) ↔ (c)	Information flow both way (m) ↔ (d)	Information flow both way (m) ↔ (e)	Information flow both way (m) ↔ (f)	Information flow both way (m) ↔ (g)	Information flow both way (m) ↔ (h)	Information flow both way (m) ↔ (i)	Information flow both way (m) ↔ (j)	Information flow both way (m) ↔ (k)	Information flow both way (m) ↔ (l)
CMA (n)	did not specify knowledge exchange											
PWD (o)	Both share data for drafting Master plans, reports (o) ↔ (a)	enquire about water demand, supply, reservoirs (o) ↔ (b)										
TUFIDCO (p)												
Revenue Dept. (q)												
CRRT (r)												
TNIDB (s)	NO knowledge interaction mentioned											
Registra-tion Depart-ment (t)	no knowledge interaction mentioned											
TNUIFSL (u)		TNUIFSL of-fers technical assistance: STPs and Water Supply related studies (u) → (b)	TNUIFSL of-fers technical Assistance: Sewerage Master Plan Dev. (u) → (c)									

TNPCB (m)	CMA (n)	PWD (o)	TUFIDCO (p)	Revenue Dept. (q)	CRRT (r)	TNIDB (s)	Regis-tration Depart-ment (t)	TNUIFSL (u)	Academic Org.	Interna-tional Funding Org.	Civic Org.	OTHERS
				land ownership data, master plan records, pattas, Field Measure-ment Book (FMBC) is available through Revenue Dept. (k) → (q)			Need infor-mation to give planning permits, preparing Master plans; Encumbrance Certificate; Sale Deed. (k) → (t)					
NA	Information flow both way (m) ↔ (n)	Information flow both way (m) ↔ (o)			Information flow both way (m) ↔ (r)			Information flow both way (m) ↔ (u)				
did not specify knowledge exchange												
NO knowledge interaction mentioned												
no knowledge interaction mentioned												
	TNUIFSL offers info/ technical assistance (u) ← (n)				TNUIFSL of-fers technical assistance: develop Master Plans, DPR (u) ← (r)