General Article

Leveraging Chennai's Complex Governance Network for Addressing the City's Water Woes

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Abstract

Chennai's governance network plays a critical role in shaping the city's waterscape. Through an urban political ecology (UPE) lens, this article investigates the intersection between water as part of nature and water as shaped by social context, with a focus on existing governance networks. Using a combination of social network analysis and thematic analysis, the article studies data gathered from in-depth semi-structured interviews, workshop discussions with stakeholders, and extensive literature and policy reviews. The analysis reveals a need to reconfigure the urban governance network and the relationships therein to work towards a sustainable future for Chennai's water system. The article concludes by offering policy recommendations to leverage the strengths and weaknesses of the complex inter-agency relations that shape Chennai's current waterscape.

Keywords

Water governance, urban political ecology, social network analysis, Chennai

Introduction

The water situation in Chennai has been described as being a constant struggle, with either too little or too much water—in reference to the frequent and cyclic occurrence of droughts and floods (Resilient Chennai, 2019). Within the past 7–8 years, Chennai experienced one of the worst floods in several decades in 2015, followed by one of the worst droughts in 30 years in 2018–2019 (Narasimhan, 2015; *The Economic Times*, 2019).

Beyond these extreme occurrences, which received much attention in popular media, policy discussions and the political realm, Chennai's water experience is characterised by yearly flooding

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during the monsoons and chronic water stress during the summers. Chennai's water supply is at ~104 litres per capita per day (lpcd),[1] which is lower than the national supply benchmark of 135 lpcd (*The Hindu*, 2022a). The limited water supply—despite the arguably sufficient seasonal rainfall—has necessitated groundwater extraction by the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), households, commercial institutions and private water companies. This has led to over-extraction, groundwater depletion and salt intrusion (Roumeau et al., 2015). In the drier seasons and during periods of water stress, groundwater aquifers are further strained. For instance, in June 2019, groundwater levels in parts of the city had reduced by 9 m (Lakshmi, 2019a).

Climate change, which is already manifesting in the form of extreme precipitation events and increasing temperatures, has exacerbated Chennai's existing water challenges: on 30 December 2021, parts of the city recorded up to 175 mm of rain, with 20 mm falling in the span of two 15-minute intervals (*The Hindu Bureau*, 2021). A few months later, in March 2022, the city recorded the hottest days of the year thus far, at 38 °C, for the second time in the past decade.

A critical factor shaping Chennai's waterscape has been the rapid and somewhat unplanned urbanisation of the city. (See Figure 1 for changes in land use and land cover in the city.) Between 1988 and 2014 alone, Chennai's built-up area increased by 24 per cent, rapidly engulfing peri-urban agricultural land, open land and waterbodies to accommodate the increasing population and urban infrastructure demand (Roy et al., 2018a).

The Chennai region has three major rivers—Kosasthalaiyar, Adyar and Cooum—and a network of canals, including the Buckingham Canal. In addition, Chennai and its surrounding districts are dotted with an intricate network of *erys* (lakes), several of which were created as early as 4th–5th century AD by the

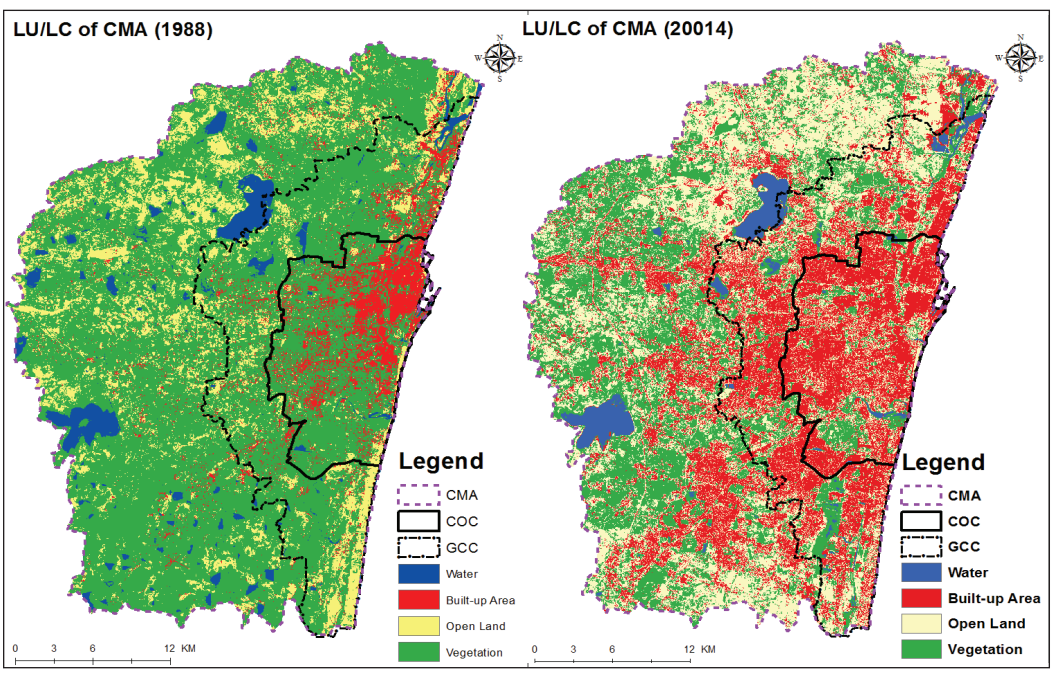

Figure 1. Land Use and Land Cover Change in the Chennai Metropolitan Area of 1,189 km^2.

Source: Roy et al. (2018a).

erstwhile Tamil rulers and maintained collectively by the surrounding communities (Vaidyanathan, 2001). The *ery* system typically constitutes a series of cascading tanks, supplying water for agricultural and domestic purposes while also mitigating the risks of flooding and drought (Jameson & Baud, 2016; Mukundan, 2005; Vaidyanathan, 2001). The Tamil Nadu Public Works Department (PWD) estimates that there were 2,100 major tanks and 2,200 minor tanks in the region historically (interview with PWD, 2021).

However, as Chennai urbanised, the value attached to these tanks as a source of water for irrigation and household consumption lost ground among urban dwellers who relied on piped water supply and/or private wells (Graft et al., 2018). Combined with the need for more infrastructure, housing, transportation and industrial developments began encroaching upon waterbodies and their connecting channels, disrupting the ability of the *erys* to fulfil their mitigatory functions (Jameson & Baud, 2016; Roumeau et al., 2015).

While colonial urbanisation slowly and steadily fragmented Chennai's waterscape, recent urban growth has been far more aggressive. Examples include the Tamil Nadu Housing Board's 'Ery Scheme' to build houses by filling up dry lakebeds in the 1970s and 1980s (Resilient Chennai, 2019); the development of resettlement colonies in Semmancheri and Perumbakkam; and the IT corridor in the early 2000s that encroached upon the Pallikaranai marshland, which has shrunk from 6,000 hectares to just about 695 hectares over the past several decades (Bremner, 2020; Kennedy et al., 2014). Informal encroachments have equally contributed to the disruption and deterioration of Chennai's waterways and lakes, along with formal developments.

Experts from the government, academia and media increasingly attribute the precarious state of Chennai having 'too little or too much water' to years of mismanagement of the city's resources, particularly its land and water (Arabindoo, 2016; Jameson & Baud, 2016; Janakarajan et al., 2007; Roumeau et al., 2015; Roy et al., 2018a). As a 2019 newspaper article notes, 'Chennai's crisis is of governance, not water' (Devasahayam, 2019).

In this article, we delve deep into the city's governance crisis to understand the roles and relationships between different stakeholders in the water system. We argue that the genesis of water mismanagement in Chennai is in the lack of coordination among these stakeholders and in the absence of an integrated and holistic approach to urban land use, water planning and policymaking. We also highlight certain leverages within the complex governance ecosystem that can be useful for transforming the current scenario. In order to answer the larger question of how governance processes and networks shape Chennai's water management, the following issues are scrutinised:

1. Who are the various stakeholders and agencies involved? How do they interact with each other?
2. What are the interests and priorities of these stakeholders? Are these interests and priorities conflicting or similar?
3. What are the power relations among these different groups? How do their interactions influence the Chennai's urban water system?

The article adopts an urban political ecology (UPE) framework to unravel Chennai's governance complexities. A UPE framework helps recognise that: (a) water is simultaneously natural and social, shaped by both the biophysical and human relationships through which it is produced and enacted (Bakker, 2002; Coelho, 2018; Swyngedouw, 2004) and (b) multistakeholder-driven governance processes are characterised by unequal power relations that ultimately shape the waterscape in terms of its biophysical character and its social implications (Cornea et al., 2016a; Drew, 2020; Monstadt, 2009; Swyngedouw & Heynen, 2003). Staying within this framework, we interpret the act of governing environmental resources as 'the ensemble of organizations, institutional frameworks, norms and practices, operating across multiple

spatial scales, through which such governing occurs' (McCarthy & Prudham, 2004; Perreault, 2014, p. 236). Thus, governance goes beyond formal, administrative or technical management of resources, and includes the formal and the informal, state and non-state actors, and processes and networks that shape socio-natures.[2] In this article, we focus on the broader governance network. However, given the key role played by government agencies in implementing and maintaining water infrastructure in their respective jurisdictions, a substantial part of the discussion is around the management of water as enacted by these agencies. In addition, the article also traces the transformation of Chitlapakkam Lake in Chennai to highlight the role of 'everyday governance', that is, the interplay of different stakeholder interests at a specific time and place (Cornea et al., 2016a, p. 397; Le Meur & Lund, 2001). Using social network analysis (SNA) and thematic analysis, we have assessed data from in-depth semi-structured interviews, workshop discussions with stakeholders from public, private, academic and civic realms, and extensive literature and policy reviews (Bodin & Crona, 2009; Bodin et al., 2006; Braun & Clarke, 2006, 2019; Ernston et al., 2010) to present the implications of Chennai's water governance ecosystem on its water woes.

Theoretical Framework: An Urban Political Ecology Approach to Water Governance

There is increasing recognition that society and nature are intrinsically linked and interdependent (Perreault, 2014; Swyngedouw, 2007; Zimmer et al., 2020; Zwarteveen et al., 2017). What we consider to be the natural environment is often a socio-physical hybrid construction that is shaped by context-specific historical, sociocultural, economic, political and institutional conditions (Latour, 1993; Swyngedouw, 1997, 1999). Following arguments presented by Harvey (1996) and Heynen (2014), Coelho (2018, p. 19) explains, 'Whether in avenue trees or city parks, canals or drains or even in marshlands, lakes, and rivers, the natural is inextricably enmeshed with the social production of urban landscapes. There is clearly nothing primordial or pristine in these forms of urban nature'. She further argues that we should not take the urban landscape at its face value, as if it is devoid of history and politics, and contends that UPE can 'educate the urban eyes' to understand the city's landscape as co-produced socio-nature that embeds complex socio-natural relations, discriminatory effects and differential values (Coelho, 2018, p. 28).

Urban political ecologists, in particular, highlight how urban environmental conditions are a result of 'metabolic circulation' of resources, including capital, nature, discourses and social processes (Coelho, 2018; Cooke & Lewis, 2010; Heynen et al., 2006a). This often involves exploitation of ecological resources, which is 'orchestrated through policies and interventions' defined by a few, usually powerful, people (Broto & Bulkeley, 2013). This leads to the production of 'enabling and disabling' socio-environments in cities. For the elite and the powerful, these environments can be enabling, while for marginalised communities, they are disabling. In the long run, these processes can be destabilising for both groups due to their negative impact on the ecology and the socio-economic environment (Monstadt, 2009, p. 10).

Given the importance of planning and policymaking in shaping urban nature, human perceptions, priorities, decision-making and power play remain central to unpacking the production of the urban environment and its social and ecological impact. Hence, the UPE lens has often been used to examine governance processes related to various aspects of the urban environment, such as climate change interventions (Broto & Bulkeley, 2013), production of unequal urban green cover (Heynen et al., 2006b), urban waste management (Cornea et al., 2016b), planning of urban waterfronts (Bunce & Desfor, 2007), water supply and access (Ranganathan & Balazs, 2015), restoration of waterbodies (Drew, 2020) and

management of the urban water cycle (Swyngedouw et al., 2002). Water is a particularly essential natural resource, key to human survival and development, and, hence, often implicated in conflict and inequalities. Thus, it has drawn considerable attention within UPE literature and in the burgeoning work on India's waterscape (Cornea et al., 2016a; Drew, 2020; Zimmer et al., 2020).

There has been increasing political attention to water stress and the need to conserve or restore waterbodies in India (GoTN, 2017; NDMA, n.d.). Researchers have highlighted the role of environmental and developmental imaginaries in shaping the process of 'uncommoning' urban lakes in Navsari, Gujarat (Zimmer et al., 2020); discussed the complex interaction of multiple interests and authorities shaping everyday governance and access to local waterbodies in Bardhaman, West Bengal (Cornea et al., 2016a); and underlined the resource inequity implications in the efforts to expand urban water catchments in New Delhi (Drew, 2020). In these discussions, it is evident that while the transformation of waterscapes causes, in many ways, broader sociopolitical inequalities, one should not think of this as a linear state-driven or elite-driven process. Rather, it involves complex 'power-infused' struggles (Cornea et al.,

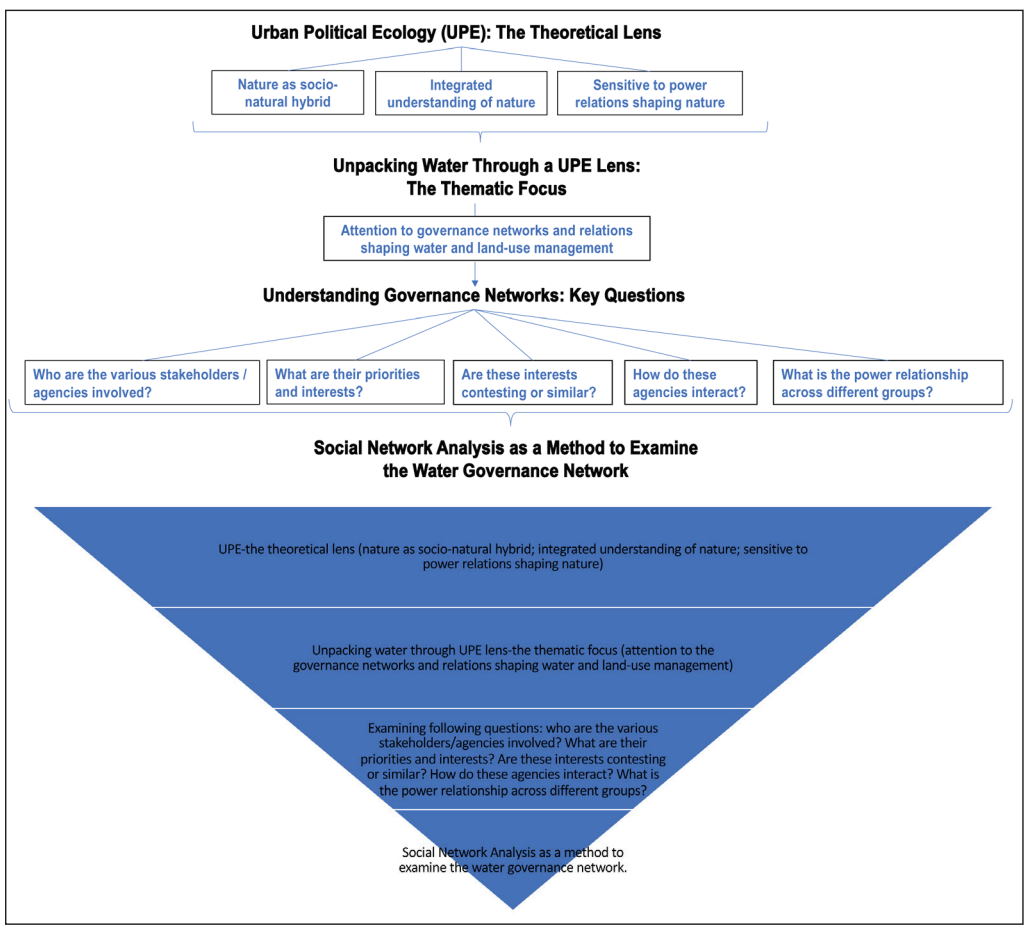

Figure 2. Urban Political Ecology: The Theoretical Lens to Study Chennai's Water Governance.

Source: The authors.

2016a, p. 406), sometimes leading to overt conflicts (Arabindoo, 2011; D'Souza & Nagendra, 2011). Even in the absence of overt conflicts, the agency, interest and authority of multiple stakeholders (including that of non-state and non-elite actors) may be pursued, challenged and co-opted in the shaping of urban waterscapes (Ahlers et al., 2014; Cornea et al., 2016a; Zimmer et al., 2020). These overt and covert power struggles ultimately remain linked to social, cultural and economic inequalities, political calculations, and development imaginaries and agendas (Drew, 2020).

UPE particularly emphasises sociopolitical power relations to tease out who gains from environmental changes and processes and who pays for them (Heynen et al., 2006a; Monstadt, 2009; Smith, 2001). As such, in analysing water governance, UPE helps unpack power play within governance networks and among various actors that shape a city's water system. It raises questions about who influences urban water policy and how the knowledge, vision and imaginaries of different stakeholders shape decision-making (Heynen et al., 2006a; Hommes et al., 2019; Swyngedouw, 1999). Figure 2 shows how the theoretical lens of UPE guides the scope and methodology of this article.

While UPE provides a conceptual framework to interpret data, we use a combination of SNA and thematic analysis to organise the data collected into identifiable patterns and visuals that help unpack the internal workings of Chennai's water governance ecosystem. These methods are discussed in detail in the next section.

Methodology: Unpacking Water Governance Ecosystem Through Social Network Analysis and Thematic Analysis

In order to examine the nature of water governance and its implications for Chennai's water woes, we carried out an extensive secondary review of academic literature and policy documents. We examined the websites of government and non-governmental agencies that have influence over water governance, including aspects of decision-making, supply and use. We also interviewed agency representatives to better understand their role and involvement in governing Chennai's water system. Between September 2017 and March 2019, in-depth semi-structured interviews were conducted with 30 individuals (Longhurst, 2016). Additionally, eight full-day workshops were organised, of which six were with government agencies, one with civic and academic organisations, and one with industry representatives. During these workshops, agency representatives were asked to identify their roles and elaborate on their relationships and interactions with other agencies that they believed were relevant to Chennai's water governance.

An interesting revelation emerged during the initial stages of fieldwork. While the concept of governance usually entails a tripartite horizontal assemblage of public, private and civic actors and their roles and relations that shape city-making processes (Swyngedouw, 2005), the literature review (Arabindoo, 2011, 2016; Esther & Devadas, 2016; Janakarajan et al., 2007; Kennedy et al., 2014; Srinivasan et al., 2010) and interviews indicate that non-governmental agencies play a weaker role in urban water governance. This is why we chose to conduct more workshops with public and parastatal agencies.

The information gathered through these various methods was assessed using a combination of social network and thematic analyses. An increasing body of scholarly work on natural resource management and governance highlights the role of socio-institutional networks and the applicability of SNA to examine these networks (Bodin & Crona, 2009; Bodin et al., 2006; Ernston et al., 2008, 2010; Stein et al., 2011). SNA has also been used in urban water governance. For instance, Narayan et al. (2020) utilise SNA as a diagnostic tool for planning inclusive citywide sanitation in Chennai, and Stein et al.

Table 1. Description of Parameters.

Agency	Description
Type	Nature of the agency: Government, non-government, parastatal or civic
Mandate	Main goal of the agency: Water supply, land use planning, solid waste management, financing, environmental protection, industrial promotion or housing provision
Jurisdiction	Geographic scale at which the agency works: Greater Chennai Corporation (GCC) limit, Chennai Metropolitan Area limit or Tamil Nadu state limit
Vision/World View	Overall focus or priority: Economic growth oriented, environmental sustainability driven, social equity focused or envisioning a world-class city
Dependencies	Defined in terms of policymaking power and approvals or funding that determines which agencies are in control or have greater power and influence
Collaborations	Primarily defined in terms of knowledge exchange

Source: The authors.

(2011) use it to map social networks between actors that influence water flows in the Mkindo catchment in Tanzania. SNA can serve multiple purposes: It can be used to map the flow of funds, exchange of information or influence wielded by various agents (Bodin & Crona, 2009). In addition to mapping existing socio-institutional landscapes, SNA can be crucial to identifying network strengths and weaknesses that are important leverage points for bringing about desired transformation (for instance, towards becoming a more collaborative governance network; Caniato et al., 2014).

In this article, we rely on SNA to understand and visualise the complex socio-institutional urban waterscape of Chennai by mapping institutional actors, particularly public and parastatal agencies, and their networks and relations. Data gathered on various stakeholders was collated under the following heads for SNA: agency type, agency mandate, agency jurisdiction, agency vision or world view, agency dependency and agency collaboration. Table 1 presents a brief description of each of these parameters.

We use quantitative and qualitative approaches to examine the nature of the urban environmental governance ecosystem in the Chennai Metropolitan Area. Quantitative SNA involves charting whole networks and comprehensively identifying nodes, links and indicators with the help of software that uses standard statistical tests. We specifically used indicators of network density and degree centrality.

Network density is used as a measure of general group cohesion. It measures the number of realised ties (i.e., 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 & Faust, 1994). Bodin and Crona (2009) suggest that higher network density presents greater potential for collective action due to increased chances of communication, reciprocity and trust. Empirically, scholars have shown this hypothesis to be true. In Northern Sweden, Sandstrom (2008) observes the positive effect of network density on collective action and specifically argues that relational ties among different kinds of actors (such as recreational fishermen and government officials) are particularly useful for collective action and knowledge development.

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, and the higher their ability to influence the overall network and access valuable resources (Burt, 2004). In the case of directed graphs of SNA, as in this article, the higher the number of incident arrows on an actor, the greater their degree of influence, and hence the greater their capacity to shape the overall network of actors.

While quantitative SNA provides a good understanding of the overall structure of a socio-institutional governance ecosystem, it can sometimes fail to represent complex relational attributes, which tend to lose visibility and significance when quantified. Therefore, this article also uses qualitative SNA that engages in a descriptive analysis of network diagrams using theoretical concepts of network research,

such as around the overall topology of the network. The topology is commonly classified into different types, such as individualistic, hierarchical and co-managerial. Sandstrom and Rova (2010) explain that some topologies are better suited for adaptive capacity (for instance, towards supporting more integrated planning). They identify the following three types of networks:

- *Individualistic network* has few links between nodes, and individual action prevails without much dependency or collaboration with others.
- *Hierarchical network* has one leader dominating the decision-making.
- *Co-managerial network* has multiple actors involved in varying degrees as opposed to centralised top-down management.

Parallel to SNA, we thematically assess the data gathered on inter- and intra-agency relations (Braun & Clarke, 2006, 2013). This data offers rich accounts of how different agencies understand their own roles and those of other agencies, define priorities, and describe and view interactions. Thematic analysis allows us to organise and interpret this data to reveal deeper inequalities and tensions among various actors. This method entails the identification and analysis of patterns of themes. It is particularly useful for examining experiences, interactions and perceptions (Braun & Clarke, 2013; Herzog, 2019). Coding forms the base of thematic analysis (Herzog et al., 2019). We transcribed all interviews and workshop discussions and coded the text. The coding process itself involves analysis (Cope, 2010) wherein relations, patterns, connections and gaps are identified by going beyond the description of what research participants are saying and making sense of it within the broader context.

We interpret the information gathered from various stakeholders both deductively, that is, guided by our reading of existing literature, and inductively, that is, based specifically on the reading of the

Table 2. Key Government Agencies Involved in Water Management in Chennai.

Organisation	Role
Chennai Metropolitan Development Authority (CMDA)	CMDA is the urban planning body for the Chennai Metropolitan Area. Its functions include preparation of the Master Plan and other development plans, and approval of larger building projects within its jurisdiction.
Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)	CMWSSB provides water supply and sanitation services to Chennai city and certain areas in the Chennai Metropolitan Area.
Chennai Rivers Restoration Trust (CRRT)	CRRT was created to plan, fund, monitor and coordinate among various agencies to restore water bodies and waterways other than those managed by the GCC and the PWD.
Greater Chennai Corporation (GCC)	GCC is the civic body that governs Chennai city—an area of 426 km^2, divided into 15 zones and 200 wards. Its functional areas include roads, parks, storm water drainage, solid waste management, healthcare and education.
Public Works Department (PWD)	The Water Resources Organisation of the PWD manages and restores major water bodies and waterways in Tamil Nadu, primarily for irrigation purposes. Its objectives include regulation of reservoirs, development and upkeep of water infrastructure, flood control and management, and coastal protection.
Tamil Nadu Water Supply and Drainage Board (TWAD)	TWAD is responsible for providing water supply and sanitation services to urban local bodies (ULBs) in Tamil Nadu, excluding GCC area.

Source: The authors.

transcribed text (Braun & Clarke, 2006, 2013, 2019). While coding, a combination of descriptive/in-vivo codes (that emerge from a reading of the data) and analytic codes (that are developed based on deeper contextual understanding) were used (Cope, 2010). This enables us to go beyond the description or spoken words and interpret underlying meanings and implications of how different agencies described their roles, positions and relations within the governance network.

Chennai Urban Water Governance Ecosystem

In order to define the boundaries of Chennai's urban water governance, we interacted with a wide range of public and non-governmental agencies working in the domains of water, urban land use planning, and other social and environmental concerns (see Table 2). Interviews with such agencies revealed that while many reputed non-governmental organisations are active in Chennai, they seem to play a limited role in policymaking. This is the case possibly for two reasons: first, institutional mechanisms of broad stakeholder participation are largely missing in Tamil Nadu (Coelho et al., 2013); second, few public agencies recognised NGOs, academic institutions and community groups as important partners in the decision-making process. Instead, these groups were often described as disruptive forces. The lack of trust between public agencies, who are mandated to create policies that meet citizens' needs, and non-governmental/civic groups, driven by social and environmental advocacy, is thus evident.

This inter-stakeholder group tension can be better understood by analysing their differing visions and priorities. A thematic analysis of the data gathered from interviews, workshop discussions, and literature and policy reviews offers some insight into this.

A thorough reading of the state's Vision Tamil Nadu 2023 document, the CMDA Second Master Plan and the GCC City Development Plan, coupled with analyses of the city budget and state-level policies and programmes, revealed that while public agencies discursively recognise the need for environmental sustainability and equitable socio-economic development, their actions indicate that the goal is to develop Chennai into a 'world-class city', a prime metropolis with key focus on economic growth. This vision of a world-class city urges investment in big infrastructure, smart technology and beautification projects (Roy et al., 2018a).

One would assume that the industrial sector would follow suit. However, our interactions revealed that this group is becoming increasingly aware of the repercussions of unfavourable environmental conditions on business. Hence, Chennai industries now aim to make responsible investment decisions that balance economic success and environmental accountability, which we call a 'responsible economic growth vision'.

In contrast to both these stakeholders, NGOs, academic institutions and community-based organisations have an alternate vision of development. While overall emphasis depends on the specific agency's scope of work, a general inclination towards envisioning development as a process of social empowerment and environmental conservation is evident within the non-profit and academic spheres. These agencies remain critical of attempts at creating world-class cities at the expense of the marginalised. For instance, they interpret eco-restoration projects as 'sites of enormous human tragedy' due to the exclusion and disruption of livelihoods that these projects cause (Arabindoo, 2011; Coelho, 2018, p. 24). In addition to this contentious collective vision, the fact that non-government/civic agencies collaborate as technical knowledge partners with the government further strains their relations. It is not surprising that Chennai's urban water governance ecosystem is dominated by public agencies, while the presence of NGOs, academic institutions and civil society organisations remains tokenistic. This is also evident from the SNA diagram in Figure 3.

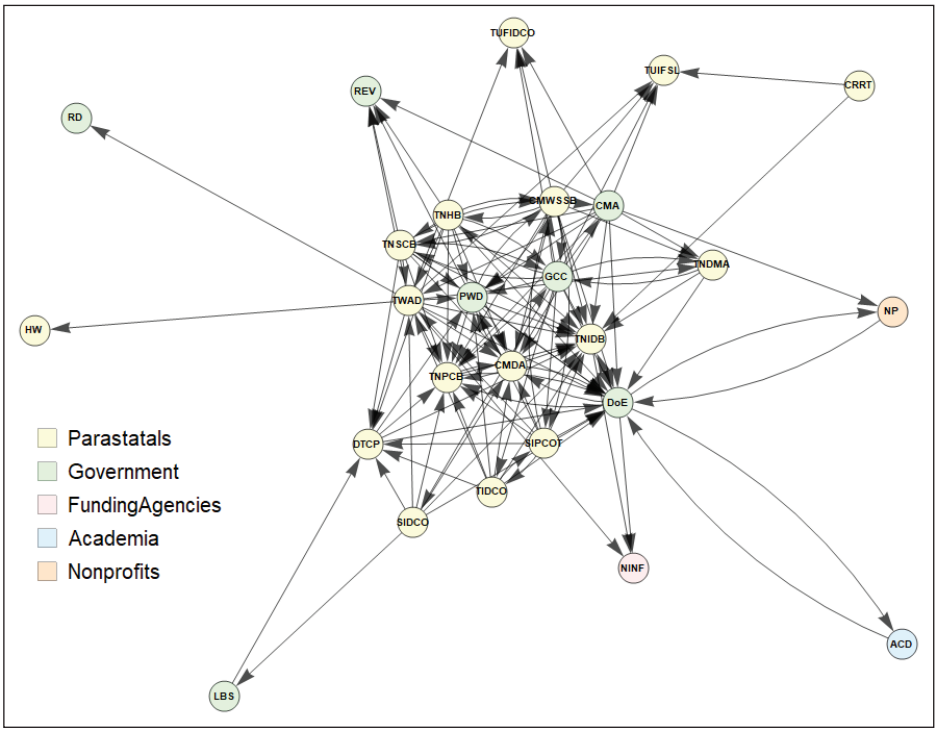

Figure 3. Functional Dependency Map for Chennai Metropolitan Area's Urban Environmental Governance Ecosystem (as Perceived by Governance Actors).

Source: The authors.

An initial assessment of the various agencies and their mandates further reveals some of the inherent problems in Chennai's urban water governance. First, parastatal agencies dominate the overall governance landscape with limiting implications for the empowerment of local-level governance structures. This is because specific acts were passed to create these agencies for specific municipal functions, such as providing water supply and sewerage services (Chennai Metro Water Supply and Drainage Act, 1977) or planning (Tamil Nadu Town and Country Planning Act, 1971), which are not answerable to local constituencies. This is despite the emphasis on empowering ULBs under the 74th Amendment to the Indian Constitution. Therefore, important decisions regarding the urban water supply lack transparency. During interviews and workshops, few agencies recognised ULBs as important actors, highlighting their lack of power or influence on urban water-related decision-making. This also becomes apparent in the SNA presented later.

Tensions and dependencies also arise from overlaps in jurisdictional rights and mandates. For instance, while the PWD owns Chennai's macro drainage and reservoirs, the CMWSSB is mandated to supply water from some of these reservoirs. However, it does not have the authority for maintenance and is dependent on the PWD for dredging, desilting and other activities. Since the PWD remains focused on irrigation, its attention has been diverted away from urban waterbodies that have lost their irrigation function. As such, lack of collaborative support from the PWD on regular maintenance of reservoirs can and often does limit the CMWSSB's ability to fulfil its mandate effectively (Roy et al., 2018b).

Similarly, the GCC is responsible for storm water drains in the city, while the CMWSSB is responsible for supplying water to all Chennai city residents. As such, the CMWSSB remains the primary agency in-charge of groundwater and rainwater harvesting infrastructure. The GCC can help immensely with recharging aquifers and rainwater harvesting by improving the management of storm water drains. Instead, it has been primarily interested in draining excess storm water into the sea to avoid flooding and has not delved into issues of groundwater recharge until recently.[3] These are some examples of 'functional fragmentation' or lack of integration that Coelho et al. (2011) insist enhances the challenges associated with effective resource allocation, personnel management and insufficient coordination and cooperation across the governance ecosystem. This also reflects how different agencies value water differently. For instance, the PWD primarily views water as an irrigation resource, the CMWSSB views it as a source of drinking water, while for the GCC, water is primarily a problem that needs to be fixed. Such differential imaginaries and associated narratives also shape action, often leading to dispossession of water resources that are interpreted as less valuable (Zimmer et al., 2020).

A Social Network Analysis of Water Governance Agencies

Using SNA, we attempt to chart two types of relational flows among the various agencies working within Chennai's governance ecosystem: functional dependency flow and data/knowledge collaborative flow.

Functional dependency flow refers to the linkages that represent an agency's dependency or influence on others for proper functioning, either funding-related dependencies or process approval dependencies. For example, the Tamil Nadu Housing Board and the Tamil Nadu Slum Clearance Board depend on the Directorate of Town and Country Planning to get planning and building permits for constructions outside the Chennai Metropolitan Area. Similarly, the Department of Environment (DoE)[4] provides funds to other government departments based on environmental project proposals submitted by them. These dependency flows, therefore, signify power relations, highlighting who is in control.

Data/knowledge collaborative flow indicates the communication pathways for knowledge sharing, including informal exchange of knowledge between actors. For example, the CMDA gathers data from multiple agencies such as GCC, DoE and PWD to prepare a Master Plan. SNA based on knowledge flow, therefore, highlights the collaborative power and coordination level among various agencies in the network.

Figure 3 presents actors (nodes) and networks (links) in the Chennai Metropolitan Area water governance ecosystem, primarily reflecting functional dependency flows (see Appendix 1 for the data, available online as supplementary files). It shows that CMDA, Tamil Nadu Pollution Control Board (TNPCB), Tamil Nadu

Box 1. Network Density for Chennai Metropolitan Area Governance Network.

Network density is the ratio of 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 Figure 3 is $262/650 = 0.4$.

Source: The authors.

Infrastructure Development Board (TNIDB) and DoE are the agencies with the highest level of functional dependency, that is, several other departments are dependent on these for different aspects of planning.

Further, Figure 3 sheds light on the relations that define the land–water policy realm in Chennai. The network density of the governance ecosystem presented here seems average, at 0.4 (see Box 1), indicating limited scope for collaboration and/or interorganisational coordination.[5] This corroborates the frustration among government stakeholders regarding the lack of communication across departments, which was mentioned during workshop engagements and interviews. To achieve more integrated governance, it will be crucial to improve this density or, in other words, build such interactions across actors in this network.

Complementing this quantitative measure of network density, a qualitative analysis of the overall topology of the network reveals that the Chennai urban water governance ecosystem is not a co-managerial network. While there are enough number of linkages that the network cannot be described as individualistic, the small number of links between government and other type of agencies (like NGOs or academic institutions) suggests that it is not a co-managerial network. Stakeholder groups with varying opinions and visions do not deliberatively engage in decision-making in such a network. Drawing on earlier reflections on agency visions, we can say that the civil society, with its alternative vision focused on environment and equity, therefore, get limited opportunity to influence the public vision of creating a world-class city. Having pointed out the limitations of a moderately hierarchical network density, we acknowledge that (a) a handful of powerful agencies can be critical in bringing positive change, as evident from the recent shift in public discourse and practice around waterbody restoration and climate adaptation, and (b) as presented through the story of Chitlapakkam Lake in the discussion section, non-state actors can still play a critical role in influencing everyday governance.

Figure 4 presents the degree centrality of agencies in Chennai's governance network, highlighting which are the central actors in the network. DoE, GCC, TWAD, CMWSSB, TNIDB, CMDA, PWD and TNPCB are the key actors, with more than 15 linkages, compared to the 22 total network linkages of any one agency.

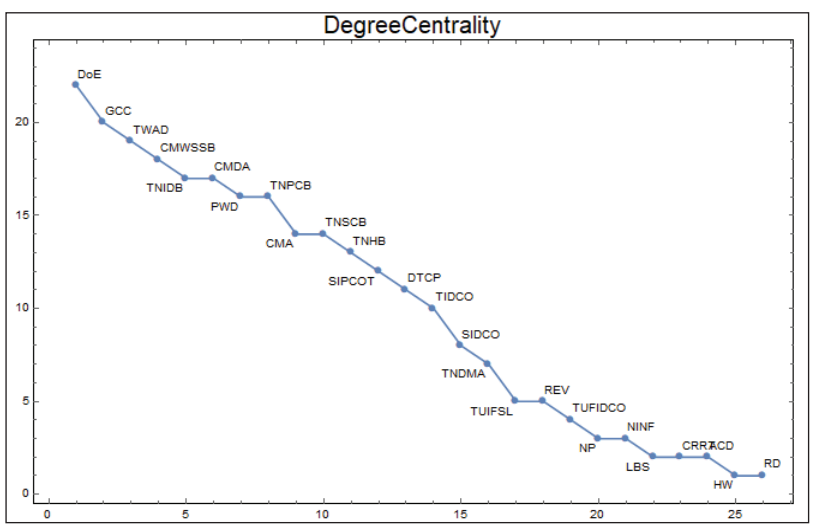

Figure 4. Degree Centrality: Key Actors in Chennai Governance.

Source: The authors.

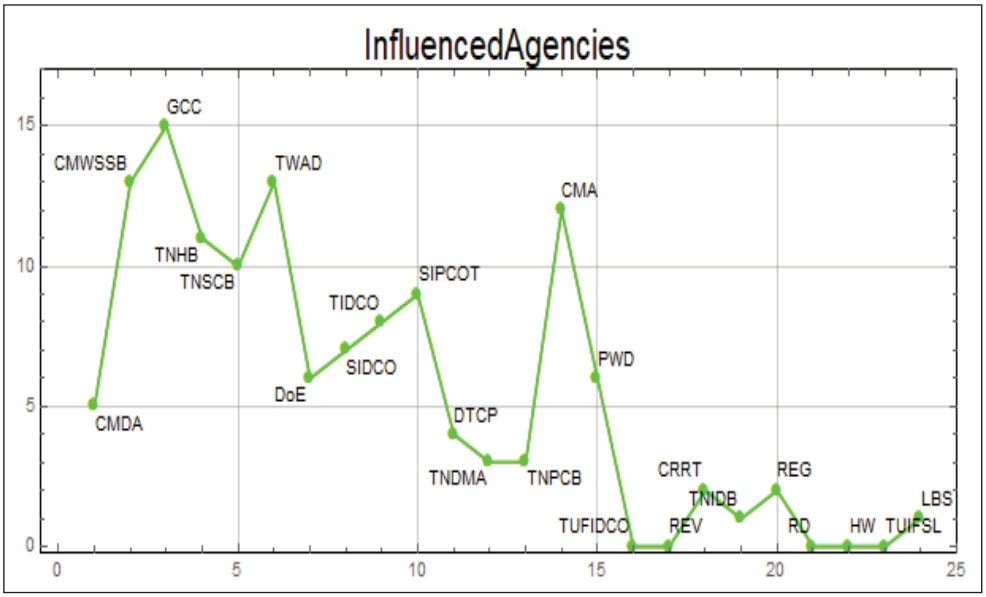

Figure 5. Actors Who Are Highly Influenced in the Governance Network.

Source: The authors.

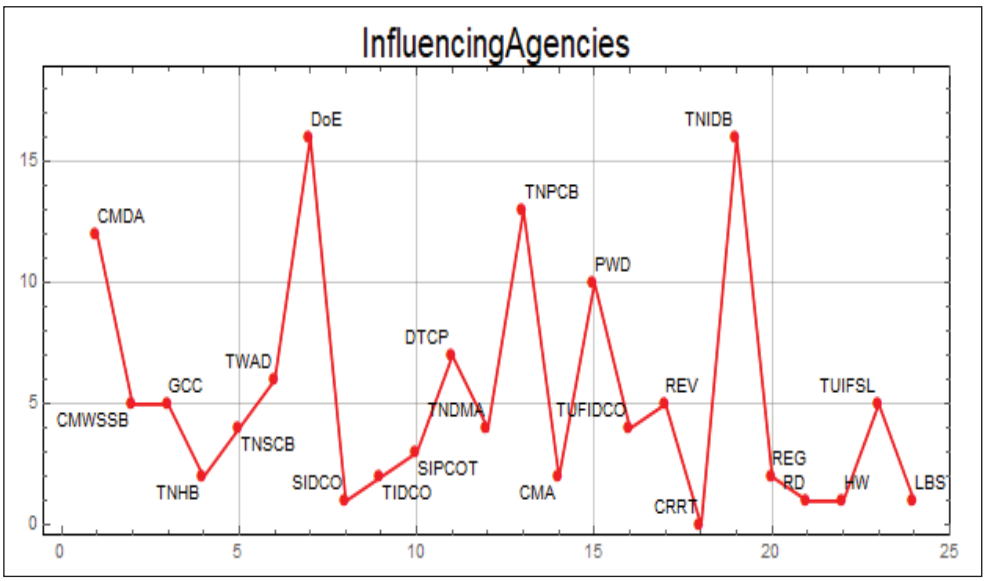

Figure 6. Actors Who Highly Influence Others in the Governance Network.

Source: The authors.

However, it is important to differentiate between those agencies where several links originate and those where several links end. Accordingly, Figure 5 ranks agencies based on vertex-out measure, which indicates to what extent agencies depend on or are influenced by other agencies. Figure 6 ranks agencies based on vertex-in measure, which indicates to what extent agencies influence others.

The ones where the links are incidental include those agencies that remain primarily responsible for defining rules and policies, and overseeing their implementation. This includes CMDA, DoE, TNPCB, PWD and TNIDB. Note that three of these five key agencies—CMDA, TNIDB and TNPCB—are parastatal agencies. Any infrastructure development in the Chennai Metropolitan Area, whether industrial, water or waste treatment related, must, as a first step, secure planning and building permits from the CMDA (or the GCC or other local bodies, depending on the scale and nature of the project). It is also responsible for preparing the Master Plan and for laying out development control regulations. As a result, most organisations tend to depend on and interact with the CMDA to gain planning permissions. Next, the DoE and TNPCB must be approached to secure Environmental Impact Assessment (EIA) clearance. If the development project is close to waterbodies, a No Objection Certificate (NOC) from the PWD must be obtained. As such, the PWD remains right behind the above-mentioned four agencies in terms of incident linkages.

In addition to the DoE and TNPCB, planning permit-granting authorities such as CMDA, GCC and other ULBs are critical for development regulation. Depending on the nature and size of development projects, these agencies remain in charge of gauging environmental risks and directing developers to the appropriate authorities for NOCs or pollution certificates. Overall, the CMDA remains particularly powerful as it controls major developments with greater social and environmental implications. Finally, TNIDB emerges as a key actor because it remains a major player in terms of funding all kinds of infrastructure projects initiated by other agencies in Tamil Nadu and Chennai's governance ecosystem.

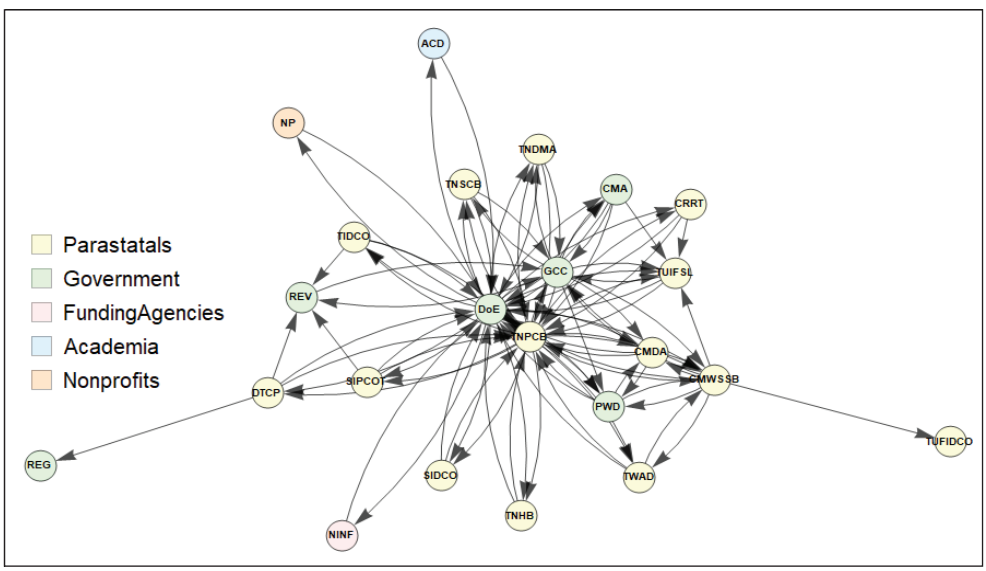

Figure 7. Knowledge Flow Map for Chennai Metropolitan Area's Urban Environmental Governance Ecosystem.
Source: The authors.

Organisations such as GCC, CMWSSB and TWAD are also key players, more so because linkages originate from these nodes. In other words, as implementing agencies, they are responsible for infrastructure and service delivery and remain dependent to different degrees on the former set of agencies with respect to rules, funds and approvals that collectively shape their ability to fulfil their functions.

Based on the above analysis, the overall topology of the Chennai governance network is moderately hierarchical, with not one but a handful of agencies playing important roles. While a strongly hierarchical network is more likely to be authoritarian and insensitive to broader societal interests, a moderately hierarchical network indicates the involvement of a number of agencies who can potentially maintain checks and balances on each other and address multiple needs. However, the fact that most of the agencies across the entire system, including many of the key actors, are parastatal agencies with no transparency in governance processes has strong implications for accountability in water governance. Since these parastatal agencies are not answerable to local constituencies, they are more likely to take decisions which may not accommodate the visions of local communities.

Within such a fragmented and complex network, collaboration, specifically in terms of knowledge sharing, is extremely crucial for efficient functioning. Most government agencies who participated in this study claimed to have two-way interaction with substantial knowledge sharing across departments (see Figure 7). For instance, the CMDA requires that other departments share data in order to prepare the Master Plan for the Chennai Metropolitan Area. This Master Plan then becomes (or at least in principle should become) the basis for other departments to develop their own plans (e.g., the CMWSSB 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 is one of the few public agencies that heavily interact 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, at 0.4, which is similar to the functional dependency map. Further qualitative thematic analysis of the nature of these interactions and networks offers interesting revelations.

Specifically, knowledge sharing among public agency departments seems problematic on many counts. CMDA collects data and feedback from disparate departments to prepare the Master Plan and presents it for public review. However, interviews with other government agencies revealed dissatisfaction regarding communication and the level of engagement by the CMDA. For instance, one point of contention between the PWD and the CMDA was that the latter'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 are maintained by the PWD. While it is debatable whether the PWD shared this data or the CMDA failed to incorporate it into the plan, this certainly highlights a gap in effective communication and collaboration.

Similarly, CMDA land reclassification exercises and related data sometimes impede CMWSSB operations. The CMWSSB Master Plan is essentially derived from land use classifications defined by the CMDA in its initial Master Plan iteration. However, continued land reclassification processes by the CMDA demand a complete overhaul of CMWSSB's priorities if they are to meet water supply requirements for the newly classified areas. 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. Lack of timely consultation and data sharing regarding such reclassification exercise between the two organisations indicates the challenges faced within a network that is defined by limited cross-departmental communication.

Knowledge and data sharing are even more problematic between public agencies and civil society groups. During interviews, several NGOs recollected their experiences on accessing public data. Concerned

about industrial development along the Ennore Creek, an ecologically sensitive area, the Coastal Research Center (CRC) filed a Right to Information (RTI) application to access the Coastal Regulation Zone (CRZ) maps used to approve the development. The Ennore Creek area had been declared a no-development zone in 1996, but over the years it was systematically reclaimed and eventually marked off as a special hazardous zone by the CMDA Master Plan. This has had a major negative impact on the local environment and community by exposing the area to rapid industrial development, pollution, loss of ecological functionality and livelihood, and greater risk of flooding. Despite CRC's efforts to know more and intervene to restrict such development by filing an RTI application, it was refused on account of unavailable information. Several such accounts of failure by academic and civic agencies to access public data reveal the weak nature of the knowledge-sharing network across these groups.

Overall, limited data and knowledge sharing point to the challenges of advancing the cause of evidence-based policymaking and collaborative governance for Chennai's water system.

Discussion: Chennai's Water Woes as a Crisis of Governance

Our study reveals that Chennai's water governance is intricately connected and primarily managed by a handful of public agencies. It is interesting that agencies such as TNIDB and PWD, while not directly responsible for the provision and management of water supply, play a critical role in the governance system due to their roles in managing funding for projects and a part of the water infrastructure, respectively.

We also find that the role of non-governmental agencies remains weak, with limited communication and knowledge sharing between the two sectors. This accounts for a governance scenario that is not conducive to collaborative action, wherein the visions of different stakeholder groups can collectively drive policymaking and implementation. Rather, the world-class city vision of market-centric state agencies has greater control over the city's water management, as seen in other cities in the global South (Broto & Bulkeley, 2013; Goldman & Narayan, 2019).

The relationship between public agencies within the governance ecosystem is also tenuous, as only a few agencies seem to control the system. Even among the key players, a smaller subset garners more power as approving agencies, rule setters, and permit and fund providers such as CMDA, DoE, TNPCB, PWD and TNIDB. In contrast, while CMWSSB and TWAD are key players, they operate primarily as implementing agencies who depend on the former agencies. For instance, CMWSSB depends on PWD for management, operations and maintenance of water reservoirs. It is mandated by the CMDA to provide 24/7 water supply to the IT corridor, despite the fact that this is beyond their jurisdiction and current capacity. Understandably, CMWSSB has failed to meet this mandate, and IT industries have been largely dependent on private water tankers to meet their needs.

Interestingly, while the CMDA yields considerable power for being in charge of planning and regulating developments, it has failed to garner much influence over other public agencies through the Second Master Plan, which is meant to be a legally binding document. Defying the CMDA Second Master Plan, which is valid for a period of 20 years, the CMWSSB has created its own Master Plan for a 30-year period, with a different starting point. This highlights the lack of a unified development vision which integrates growth aspirations and basic water and sanitation infrastructure requirements and capacities.

Furthermore, the dominance of parastatal agencies like CMDA in the overall governance landscape has created significant challenges for effective devolution of powers to lower-level local bodies (Coelho et al., 2011). In turn, this is indicative of the limited influence that local constituencies may garner within the governance network through ULBs.

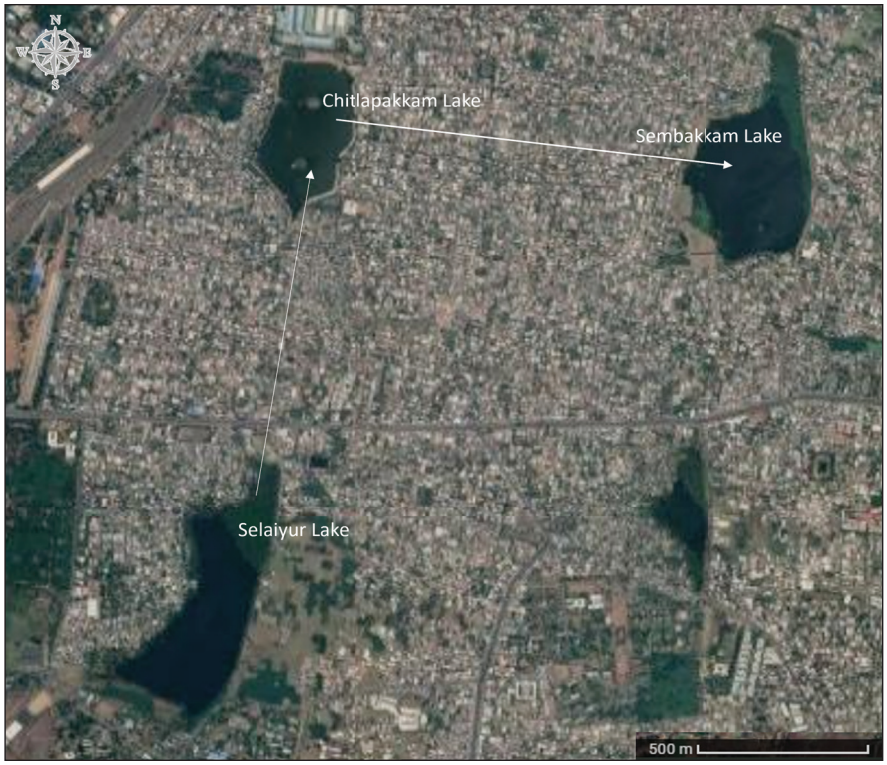

Figure 8. Chitlapakkam, Selaiyur and Sembakkam Lakes.
Source: Google Maps.

Overall, we may describe the Chennai urban water governance ecosystem as a moderately hierarchical network, which is not particularly suitable for effective co-management of city resources. However, we would like to acknowledge the complexities of everyday governance as manifested within Chennai's lakescape.[6] Using the transformation of the Chitlapakkam Lake as an example, we highlight how new relations and strategies are being forged to co-produce local waterbodies in Chennai as part of the city's lake restoration efforts.

Chitlapakkam Lake: A Microcosm of Chennai's Lakescape

The story of Chitlapakkam Lake in Tambaram taluk, Chennai, in many ways reflects the trajectory of development of many lakes in the city. We use this story to highlight how the everyday governance of Chitlapakkam has evolved with changing roles, strategies and imaginaries of multiple actors shaped by and eventually shaping the biophysical characteristics of the lake itself. As part of the age-old *ery* system, Chitlapakkam is connected to Sembakkam Lake on its east and Selaiyur Lake on the southern side. Historically, excess water from Selaiyur Lake flowed into Chitlapakkam, while excess water from Chitlapakkam flowed into Sembakkam (see Figure 8). However, due to urban development, the linking

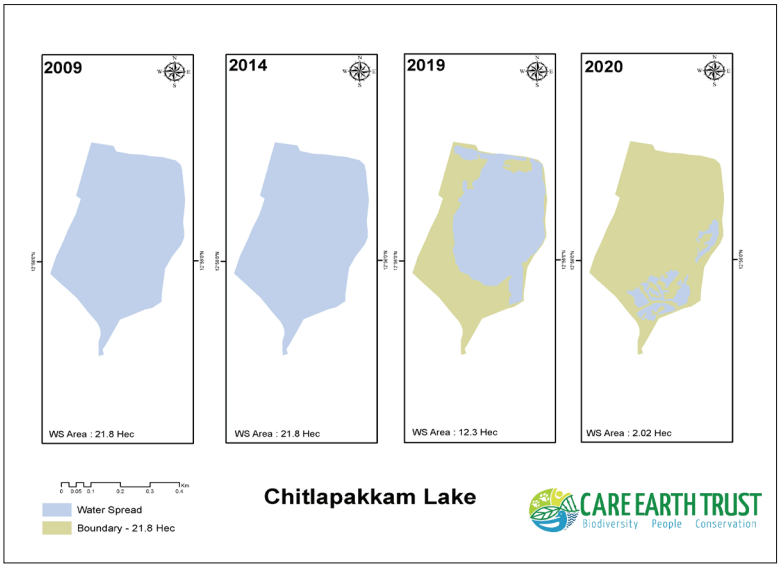

Figure 9. Map of Temporal Change in Chitlapakkam Lake Area.
Source: Care Earth Trust.

drainage channels, and hence the lakes' traditional water management, flood mitigation, and water distribution/harvesting functions have been compromised.

The water spread area of Chitlapakkam has also reduced from 202 hectares to 2.02 hectares over the years due to formal developments and encroachments (see Figure 9). The capacity of the lake, which was 7.02 million cubic feet, has reduced by 24 per cent due to lack of maintenance and desilting and resulting sedimentation over three decades (Lakshmi, 2019b). Such neglect is attributed to the PWD's overall attitude towards 'urban lakes' that are no longer valued for their irrigation function. The compromised catchment area and sedimented lakebed have thus reduced the lake's water recharging capacity immensely. Consequently, residents report sinking borewells as deep as 200–300 ft to access groundwater (Sofia Juliet, 2019).

Over the years, the lake has been illegally used for dumping solid waste, transforming the imaginary of the lake from a local asset to an eyesore. In the absence of a piped sewage system, the lake has also acted as the sink for sewage from the locality, further deteriorating the condition of the lake. As such, activities of various agencies, including CMDA (permitting unplanned development), Tambaram Municipal Corporation (permitting development, allowing illegal dumping, inability to provide proper sewage infrastructure), PWD (lack of maintenance) and the local community (encroaching, dumping waste, turning a blind-eye until recently) showcase how their sense of value for the lake and immediate priorities/mandates guided them in the everyday governance of Chitlapakkam for years, deteriorating the biophysical nature of the lake (see Figure 10).

However, during the 2015 floods, when a large part of the neighbourhood was submerged under nearly 9 ft of water, a local community group called Chitlapakkam Rising decided to intervene. By mobilising the community for cleaning up the lake and drawing public and media attention to its condition, the group managed to involve the government to take up a ₹250 million worth restoration effort in 2019. This formal restoration work, which is part of PWD's Climate Adaptive Restoration and Rehabilitation effort, includes clearing the landfill on the northern side of the lake, desilting and deepening of the lake to increase groundwater percolation and mitigate floods, strengthening the bund for 960 m with concrete blocks to

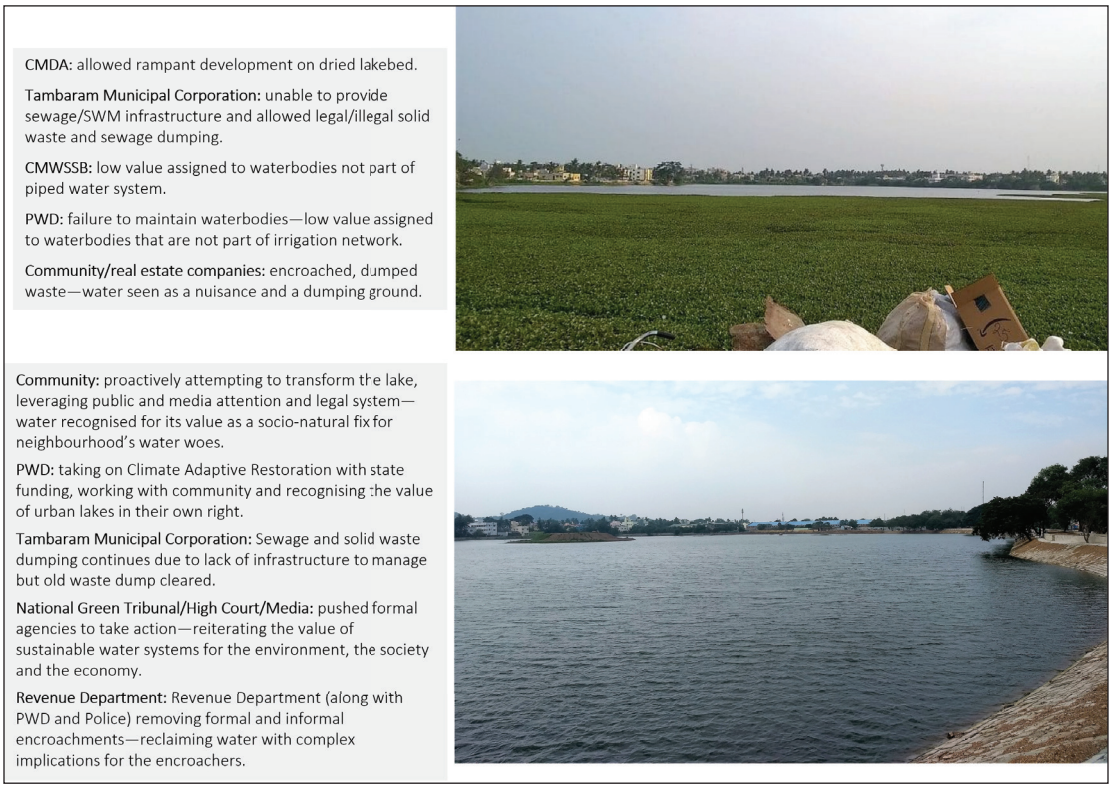

Figure 10. Key Stakeholders and Their Role in (Re)Shaping Chitlapakkam Lake's Social and Natural Characteristics.

Source: The authors.

effectively hold water when the lake is at full capacity, construction of a surplus weir for flood mitigation and laying a footpath on the lake bund. Construction of a cut and cover drain linking Chitlapakkam and Sembakkam Lakes, which began in 2018, is also included as part of the lake restoration activities.

While removal of encroachments remains a sensitive issue, constant petitioning by the local community has compelled the National Green Tribunal (NGT) and Madras High Court to intervene, resulting in the removal of several encroachments. For instance, in January 2022, PWD and Revenue Department removed encroachments of houses to reclaim 20 acres of the lake (*The Hindu*, 2022b).

The 2015 floods were an important turning point when local residents realised the consequences of the current state of the lake and the role it could play in improving the neighbourhood's experience of floods and chronic water stress. Efforts initiated by the community, pressure from the NGT and High Court, and news and social media pushed formal agencies to take action. The Chitlapakkam story thus showcases (a) a microcosm of what has been happening within the city's lakescape in the recent years; (b) the role that non-state actors can play and strategies they can use in the context of everyday governance to align community and state/dominant interests; (c) the potential of leveraging changing imaginaries/values attached to urban lakes to transform them into more sustainable resources; and (d) how within a moderately hierarchical governance network different stakeholder groups can maintain checks and balances.

Conclusion: Leveraging Network Complexities for Interactive Governance

Using the UPE lens, this article unpacks Chennai's water system as a hybrid social–natural construct and highlights its challenges. As a moderately hierarchical governance network, this system is characterised by weak interactions between various agents, such as public departments, parastatal agencies, ULBs and civil society groups. However, unlike a strongly hierarchical network, it is also less authoritarian in nature, as the involvement of these different stakeholders ensures that they maintain checks and balances on each other. We argue that such a network presents opportunities for fostering more interactive governance (Ansell & Gash, 2017; Ansell & Torfing 2014; Sorensen, 2013).

Growing literature on interactive governance highlights the potential of innovative platforms, networks and partnerships formed by constellations of public, private and civic actors who come together for specific tasks (such as ensuring safety, sustainable urban development, service delivery and so forth; Edelenbos & van Meerkerk, 2016; Kooiman, 2003; Torfing et al., 2012). These networks are appreciated for their efficiency, as they can realign and bring together dispersed resources (such as finance, workforce and data), build trust among different agencies and offer new democratic spaces for collective decision-making (Edelenbos & van Meerkerk, 2016; Sorensen & Torfing, 2019). While these arenas rarely have formal authority, they can shape governance outcomes considerably through soft forms of institutionalisation, incentive structures, routinised practices and logics of appropriateness (Kooiman, 2003; Sorensen, 2013).

In the case of Chennai's lakescape, prolonged neglect by formal managerial agencies has pushed civil society organisations to become more proactive. As such, everyday governance arrangements around lake restoration efforts, like that of Chitlapakkam, are forging new kinds of partnerships indicative of the possibility for more interactive water governance in the city. In most cases, these restoration efforts involve loosely defined and temporary networks that bring multiple government agencies and civic stakeholders together, gradually developing a working relationship and building trust among them. Taking advantage of this, neighbourhood-level 'lake councils' can be formed with representation from the local community, resident welfare associations and NGOs to establish regular and sustainable channels of communication with government agencies. These networks can not only leverage civil society's counter-weight on business-as-usual governance but also act as eyes on the ground, reduce the burden of long-term maintenance and support government agencies by taking ownership of activities such as reporting encroachments and waste dumping, organising monthly clean-up drives, building awareness and fundraising.

These lake councils can report to a 'Chennai Water Council'. This article has shown how the fragmentation of management functions across multiple departments ignores natural linkages within the city's hydrology. While changing departmental mandates is difficult, the formation of a city-level water council can integrate the entire water sector. Such a platform will ensure regular interaction and knowledge sharing across all departments handling different aspects of water, such as water supply, waste water, flood control and waterbody maintenance, among others. Over a period of time, these activities will help build trust and highlight how each department can function more efficiently by supporting each other's mandates instead of working in silos or at cross-purposes.

Our discussions also highlighted CMDA's central role as a planning and regulating authority and the need for the organisation to work closely with other agencies in order to ensure better water governance and earn greater accountability within the network. As such, bringing together the CMDA with other public departments, parastatals and ULBs working in different sectors, such as land, water and waste, relevant for holistic urban and water management can be particularly beneficial. The State Planning Commission (SPC) may act as the facilitating agency organising regular meetings, curating and facilitating discussions and knowledge sharing.

While concerns of democratic accountability of such forums cannot be denied (Benz & Papadopoulas, 2006; Bevir, 2010; Young, 2000), a range of measures can support greater exchange of ideas/plans and collaborative planning. For instance, a common and open data repository can be created to allow different agencies including CMDA to exchange information and relay their plans, and achieve higher transparency and efficiency.

There is growing interest among government agencies to explore how urban simulations and agent-based-modelling (ABM) can support integrated decision-making in the city. For instance, post the 2015 floods, the SPC recognised the interlinkages between floods, land use planning and city's waste management, and funded a project to build an ABM to help various departments handling these sectors to work together more efficiently (Roy et al., 2019). While these are new techniques, they are gaining traction in evidence-based and integrated urban planning efforts (Portugali, 2011; Verrebes, 2014). Utilising such novel methods and tools to support government agencies to work better as a collective can also be extremely useful.

Since 2015, the cyclical experience of floods and droughts has transformed the way city leaders and common citizens have been thinking about and acting upon Chennai's water system. We are at an opportune moment where we can tap into emerging transformations in values and imaginaries of water and the emerging partnerships between formal and informal, state and non-state actors, for more holistic and interactive governance of Chennai's water. Some of the pathways to build interactive governance arenas discussed here suggest how we may begin to transform the current disadvantages associated with Chennai's fragmented water governance network into opportunities.

Abbreviations List for Figures 3 to 7

ACD: Academia
CMA: Chennai Metropolitan Area
CMDA: Chennai Metropolitan Development Authority
CMWSSB: Chennai Metropolitan Water Supply and Sewerage Board
CRRT: Chennai Rivers Restoration Trust
DoE: Department of Environment
DTCP: Directorate of Town and Country Planning
GCC: Greater Chennai Corporation
HW: State Highways
LBS: Local Bodies
NINF: National and International Funding Agencies
NP: Non-Profits
PWD: Public Works Department
RD: Tamil Nadu Road Development Company
REG: Registration Department
REV: Revenue Department
SIDCO: (Tamil Nadu) Small Industries Development Corporation
SIPCOT: State Industries Promotion Corporation of Tamil Nadu
TIDCO: Tamil Nadu Industrial Development Corporation
TNDMA: Tamil Nadu Disaster Management Authority
TNHB: Tamil Nadu Housing Board
TNIDB: Tamil Nadu Infrastructure and Development Board
TNPCB: Tamil Nadu Pollution Control Board
TNSCB: Tamil Nadu Slum Clearance Board
TNUIFSL: Tamil Nadu Urban Infrastructure and Financial Services Ltd.
TUFIDCO: Tamil Nadu Urban Finance and Infrastructure Development Corporation Ltd.
TWAD: Tamil Nadu Water Supply and Drainage Board

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Notes

1. This figure was calculated assuming water supply of 935 million litres per day (mld; as on 22 April 2022) and an estimated population of 9 million according to the UN.
2. This is in line with Cornea et al. (2016b), where the authors distinguish between the management of solid waste in formal technological-organisational terms versus governance of solid waste in terms of formal and informal politics between various state and non-state actors.
3. Through the Integrated Storm Water Drain Project, GCC is now attempting to construct recharge wells and connect storm water drains to temple tanks wherever possible to allow for groundwater recharge.
4. The Department of Environment (DoE) has been renamed Department of Environment, Climate Change and Forests.
5. Here, we have used the density figure of an undirected graph instead of a directed graph because, in the context of urban environmental governance, a connection between two agencies, even if it is not a two-way connection, is relevant for communication and/or collaboration. Typically, a directed graph density is half the density of an undirected graph with the same number of nodes. So if we consider the former measure, then the network density of the Chennai Metropolitan Area's governance ecosystem would be even lower (0.20), implying greater constraints with respect to collaboration and/or coordination.
6. This term is inspired by the reference to 'pondscape' by Cornea et al (2016a).

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