Creating Water-Secure Futures in Megacities: A Comparative Case Study of "Day Zero" Cities - Bangalore and Chennai

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ABSTRACT

As urban water security is increasingly prioritized on the global agenda, this article focuses on two Indian cities, Bangalore and Chennai, which are moving towards a "Day Zero" scenario. We begin by contextualizing urban water security in Bangalore and Chennai through an analysis of their water resource and consumption profiles. This article identifies and compares the issues faced by the two cities in ensuring urban water security by systematically exploring stakeholder roles, efforts, and collaborations. Rapid, unregulated urbanization and a population explosion are posing challenges to Bangalore and Chennai in creating water-secure futures. Furthermore, the expansive presence of quasi-legal water economies and the colonial legacy of high modern water management practices impact water resources and their distribution, exacerbated by the unpredictable effects of climate change. This has created a fragmented stakeholder landscape, resulting in suboptimal, disjointed efforts to achieve urban water security that do not reflect the realities on the ground. The incorporation of the Integrated Water Resources Management framework into water management is an important first step and greater collaboration between stakeholders, particularly community-level actors, is critical to avoid "Day Zero" scenarios and build water-secure futures in Bangalore and Chennai.

Keywords: *Urban water security, water management and governance, climate change, urban planning, Integrated Water Resources Management, community initiatives*

INTRODUCTION

Urban water security is a crisis that is looming over many mega-cities. As two-thirds of the world's population is expected to live in urban areas by 2050, states and municipalities have unique challenges ahead of them (UN, 2019). India is projected to have the highest population increase between 2020 and 2050, overtaking China to become the world's most populous country by around 2027 (UN, 2019). Massive amounts of water are required to hydrate, feed, protect, and power India's growth, and the country is already the world's largest user of groundwater (World Bank, 2020). However, as a perceptive reporter for *The Economist* (2019) points out, Indian cities have a management problem, not a water problem.

At the national level, water has been on the political agenda since the 1980s, with the Federal Ministry of Water Resources actively circulating bills for the regulation and control of the development

and management of groundwater resources (BBMP, 2011). Arguably, the two most relevant pieces of legislation concerning water security at the federal level are the National Water Policy (1987, 2002, and 2012) and the model bill to regulate and control the development of groundwater (1992, 1996, 2005, and 2011). Both measures are formulated by the Ministry of Water Resources and the Government of India to govern the planning, development, and utilization of water resources (Ministry of Water Resources, 2002). The National Water Policy was the first of its kind, dating back to 1987. The policy was reviewed and updated in 2002 and later in 2012. The 2012 National Water Policy attracted criticism for its emphasis on treating water as an economic good, which the Ministry of Water Resources claims is necessary to promote its efficient use and conservation through an IWRM framework (Ministry of Water Resources, 2012).

Furthermore, the policy advocates for a demand-driven approach to water efficiency and states that "recycling and reuse of water should be the general norm and water pricing should ensure its efficient use, and reward conservation" (GCC, 2019, p. 42). Demand management, as opposed to source augmentation, is a key theme throughout the 2012 policy (GCC, 2019), which explains the focus on water efficiency and conservation measures, including setting water tariffs (Visakha, 2019). Many states adopted the national policy which demonstrates the recognition of the importance of federal legislation concerning water management at the state level, as the federal government has no power to make laws for states, except as provided in articles 249 and 250 of the Constitution (Government of India, 1974). This would otherwise make it challenging to collaboratively address a cross-border issue, like water, if state governments are lacking in political will. The second important piece of legislation at the federal level is the Groundwater Model Bill, put forward for the first time in 1992 in response to the tremendous increase in groundwater use in the late 20th century, aimed at giving greater attention in law and policy terms to groundwater use and protection (Cullet, 2012). It provides a basis for rethinking groundwater regulation and is framed as a model bill, which is a set of guidelines for states to use to develop their own groundwater acts. As such, the model bill needs to be tailored to the contexts in which it would be applied, which suits the devolved nature of the federal government and the legislative competence states hold for regulating water (Cullet, 2012).

From within this context, there are several challenges that act as obstacles to the achievement of urban water security. Across India's mega-cities, unplanned and unregulated urbanization expands city limits, destroys wetlands, contaminates water resources, and increases the proportion of impervious surfaces, thereby hindering the absorption of monsoon rains, on which many cities depend heavily, into the groundwater table. As municipal water authorities are racing to keep up with the skyrocketing demand, they are forced to extensively extract groundwater, which is then supplied, albeit intermittently, through deteriorating colonial-era infrastructure to households or resorting to high modern practices of source augmentation. The intermittent supply forces the more well-off households to resort to supplementing their supply with private water tankers, operating in the informal water economy, which are profiting off poor management and governance practices in both cities. These issues, unless effectively addressed through improvements in water management and governance practices, have been and will continue to be exacerbated in the context of uncertainty created by climate change.

This article begins with a contextualization of both cities through a detailed water use profile. It will then lay out the key challenges and exacerbating factors in ensuring urban water security in both cities, followed by a comparative stakeholder analysis at the international, state, municipal, and community levels. This sets the stage for an engaging discussion into IWRM and the role of community-level stakeholders in ensuring urban water security. The article concludes by finding that the achievement of urban water security in Bangalore and Chennai is possible though conditional upon sufficient political will to implement context-appropriate solutions to avoid "Day Zero" scenarios.

BACKGROUND

Bangalore

Bangalore, the capital city of Karnataka, is one of the fastest growing cities in India. With a population of over 11 million (11,440,000) (UN, 2018), it is India's fifth most populated urban city. It is located in southern India, on the Deccan Plateau at an elevation of over 900 meters (3000 ft) above sea level, which is the highest among India's major cities. The topology of Bangalore is flat except the western parts, which are slightly hilly. Most of the city lies in the Bangalore Urban district of Karnataka and the surrounding rural areas are a part of the Bangalore Rural district. Bangalore is sometimes referred to as the "Silicon Valley of India" because of its role as the nation's leading information technology exporter.

Chennai

Chennai, the capital city of Tamil Nadu, is located on the Coromandel Coast off the Bay of Bengal. With a population of over 10 million (10,456,000), it is India's sixth most populated urban city (UN, 2018). It is located on the southeastern coast of India on a flat coastal plain with an average elevation of around 6.7 meters (22 ft) above sea level. The city together with the adjoining regions constitutes the Chennai Metropolitan Area. With more than one-third of India's automobile industry being based in the city, it is referred to as "Detroit of India." Chennai is prone to floods due to its proximity to the Bay of Bengal, heavy rainfall during monsoon, heavy precipitation, and low elevation above sea level.

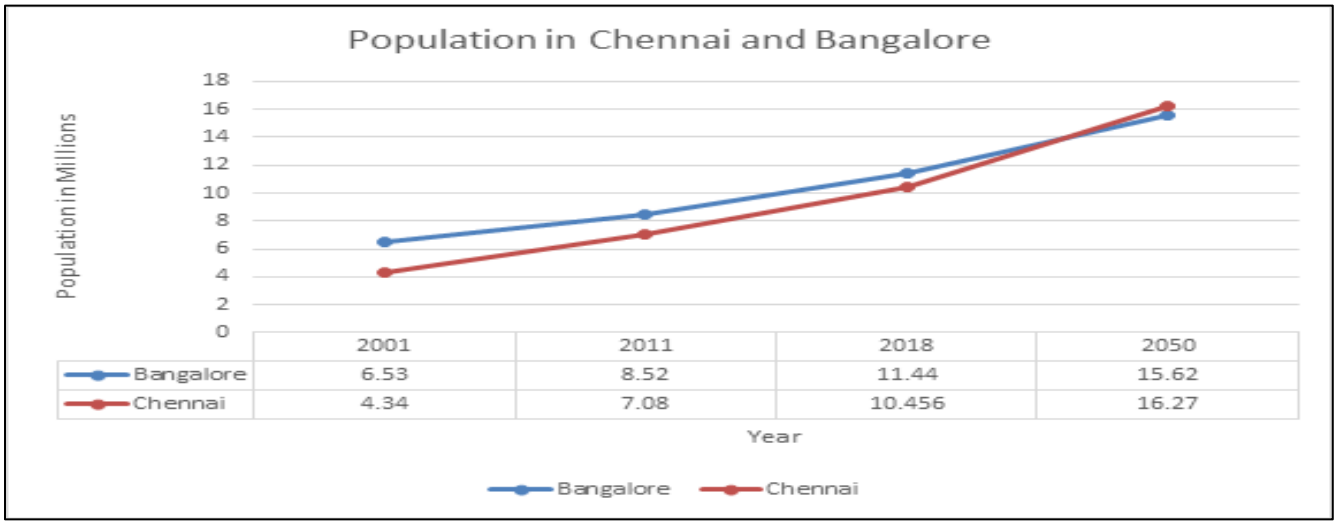

Figure 1 Source: Census 2001 and 2011, Hoornweg and Pope, 2014 and UN, 2016

Water Supply and Resources

Bangalore

Precipitation averages 905 mm per year in Bangalore with most of it falling during the June-September monsoon season. However, 55 percent of urban water supply comes from the Cauvery River, located 100 km to the south of the city. Pumping an estimated one million cubic meters per day roughly 500 meters uphill over this considerable distance, according to Joshi (2019), makes Bangalore's water the costliest in Asia. The remaining 45 percent is obtained from groundwater resources and the Thippagondanahalli and Hesaraghatta reservoirs of the Arkavathi River (a tributary of the Cauvery located 60 km northwest of the main city). With an annual population growth of approximately four percent, the city will be unable to sustain the rising demand of water. Bangalore Water Supply and Sewerage Board (BWSSB) supplies approximately 900 million liters of water to the city per day despite a municipal demand of 1.3 billion liters. The water demand per person in Bangalore is between 150 to 200 liters per capita per day but average consumption is about 65 liters per capita per day (BWSSB, 2014). Many households supplement the water supplied by the BWSSB with groundwater, which is either extracted from a private borewell or purchased from private tanker companies. In terms of wastewater treatment, there are three main sewage treatment plants located in Vrishabavathy, Koramangala-Chellaghatta and Hebbal Valleys; in addition, two mini-plants have been constructed near Madiwala and Kempambudi (BWSSB, 2017).

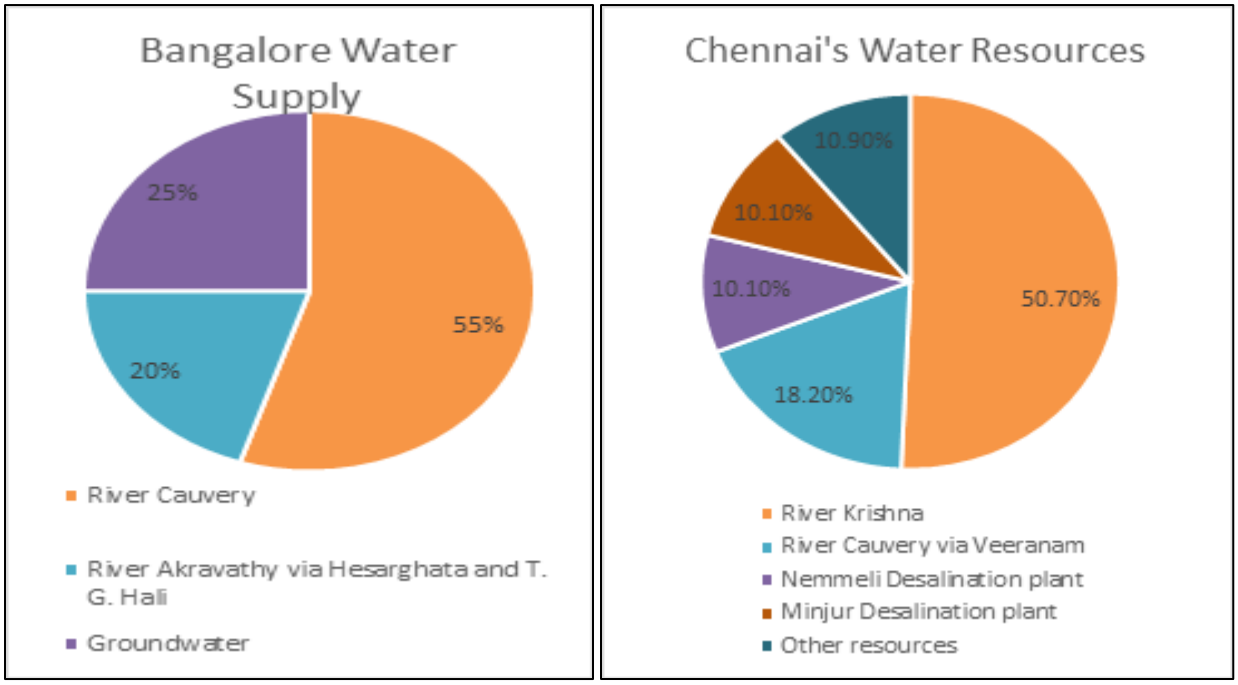

Figure 2 Source: Ramchandra (2016), BWSSB, 2017 and CMWSSB, 2016

Chennai

The average annual rainfall is 1541 mm per year in Chennai. Three major rivers flow through the city: the Cooum, Adyar and Kosasthalaiyar rivers, all of which are heavily polluted with effluents and waste from domestic and commercial sources. The city's water supply and sewage treatment are managed by

the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) which draws water from the Red Hills and Chembarambakkam Lakes (primary water reservoirs of the city). Like Bangalore, Chennai is also expected to see a huge deficit in the water demanded as compared to water supplied. The city receives about 985 million liters per day, as seen in Figure 2, against the estimated required amount of 1.2 billion liters per day. The city receives 530 million liters of water per day from Krishna River through Telugu Ganga Project. The remaining water comes from desalination plants, due to its proximity to the coast, and the Cauvery River and its tributaries from the Veeranam Lake. Groundwater extraction is common in Chennai, though not as frequently practiced as it is in Bangalore due to the proximal supply of seawater (CMWSSB, 2016). Water treatment plants are located at Kilpauk (270 mld), Puzhal (300 mld), Vadakuthu (Veeranam Lake source) (180 mld), and Chembarambakkam (530 mld) (CMWA, 2017).

Cauvery River

Bangalore and Chennai both depend on the Cauvery River for part of their water supply, albeit to varying degrees. The Cauvery River is an interstate river with an unique characteristic geographical layout in that its upper hilly catchment lying in the Karnataka and Kerala states is influenced by the dependable south-west monsoon during the months June to September, while its lower part lies in the plains of the Tamil Nadu State served by the less dependable north-east monsoon from October to December (Cauvery Water Disputes Tribunal, 2007). The Cauvery River has been a source of conflict between Karnataka and Tamil Nadu for many years, which is discussed in a later section.

Water Use Profile

Several factors such as climate, culture, food habits, work and working conditions, level and type of development and physiology determine the requirement of water. As per the Bureau of Indian Standards, IS: 1172-1993, a minimum water supply of 200 liters per capita per day should be provided for domestic consumption in cities with full flushing systems. Besides domestic requirements, water is also demanded for commercial, agricultural, and industrial uses.

The water consumption patterns of Chennai and Bangalore are similar. Domestic water use includes bathing, drinking, cooking, flushing, and washing. The Center for Climate Change (2018) conducted a study on water resource depletion in Chennai and concluded that road construction, predominantly highways and flyovers, airports, and high rises, were responsible. Similarly, in Bangalore, the construction of the city metro line and high-rise buildings have drained water resources. The two urban cities face similar problems of unregulated urbanization combined with massive population growth resulting in a heavy reliance on groundwater resources, and the presence of expansive quasi-legal water economies as households struggle to meet their daily water requirement through intermittent, colonial-era municipal piped water connections. As the cities are rapidly urbanizing, the demand for water will continue to rise in the context of environmental uncertainty (Choi, 2019).

CHALLENGES

Rapid Unplanned and Unregulated Urbanization

The dire predicaments of Bangalore and Chennai depict various issues and challenges that are the indicators of the broader water mismanagement within the urban water metabolism framework in India. Both cities have witnessed a population explosion in recent years, leading to the destructive expansion of unplanned, unregulated urbanization. Rapid, unplanned urbanization poses serious challenges, bringing with it a plethora of socio-ecological issues, such as changes in the micro-climate (the "heat island effect") and the depletion of groundwater resources through a massive increase in impervious surfaces (Ramachandra & Bharath, 2017). The Greater Chennai Corporation, Chennai's municipal government, permits building over filled-in ponds and canals and other reclaimed water bodies, which further hinders the ability of water to be absorbed into the ground (Dutta, 2019). The unprecedented rapid urbanization and sprawl in the last few decades has resulted from a mismanaged concentrated developmental path from both state and municipal governments, as both cities strive for booming economic activity (Sudhira & Nagendra, 2013). The economic opportunities in Bangalore and Chennai entice migrants with the possibility of better jobs and an improved quality of life in big cities (Sudhira & Nagendra, 2013).

Surface and Groundwater Contamination

The rapid urbanization in Bangalore and Chennai has led to massive increases in surface and groundwater contamination from industrial effluent and sewage (Ramachandra et al., 2019). One of the consequences of the unplanned urbanization in Bangalore and Chennai is increased levels of toxic waste which, without adequate infrastructure to treat contamination, then seeps into surface and groundwater resources (Ramachandra et al., 2019). A report in late 2019 gathered nearly 400 samples of tap water and groundwater from across Bangalore and reported dangerous levels of water contamination that posed a threat to public health, including heavy metals, nitrate, and phosphorus (Kulkarni, 2019). Similarly, at least 30 percent of the drinking water samples tested by the Greater Chennai Corporation from January to late November 2019 have failed quality tests, with about one in every five samples having some contamination from minerals, metals, salts, and organic compounds from sewage (Times of India, 2019). Few regulations are in place to ensure toxic wastewater from industrial effluent and sewage is minimized. Activists note that many industries dump toxic waste into rivers and lakes at night despite the presence of the Karnataka and Tamil Nadu Pollution Control Boards that are intended to monitor whether industries located near water bodies comply with effluent regulations (Joshi, 2019). Critically, neither state government has implemented a clear-cut policy for effluent treatment and release (Joshi, 2019). Moreover, the infrastructure of water treatment facilities cannot keep pace with the large-scale generation of wastewater, which has resulted in the sustained inflow of untreated or partially treated sewage to surface and groundwater resources (Ramachandra et al., 2019). Many households in both cities have noted the effects of the harmful consumption of toxic waste on their families and livelihoods. This is particularly concerning due to the heavy reliance on groundwater in both states to meet the increasing demand.

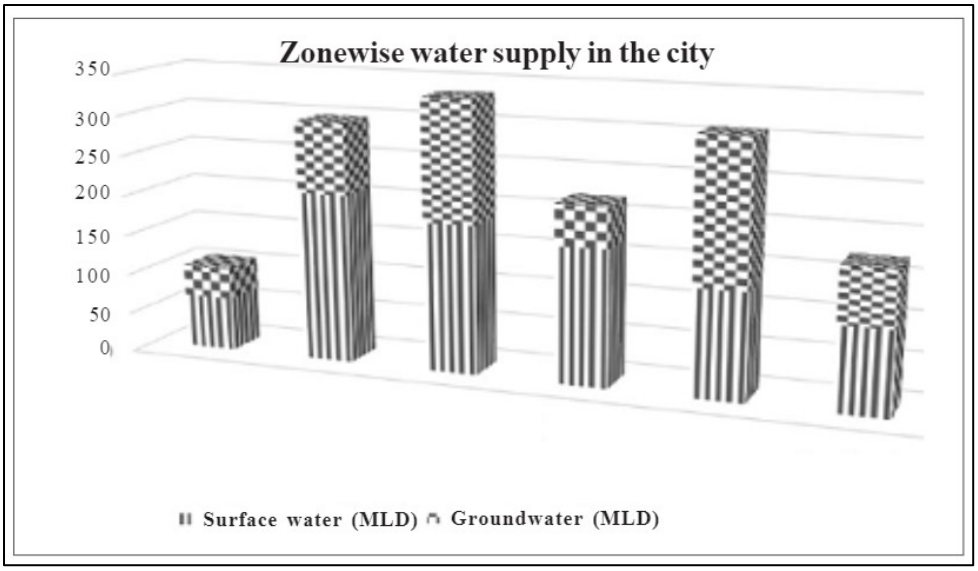

Figure 3 – Water usage in Bangalore (piped water supply and groundwater resources)
Source: Ramachandra et al., 2019

Heavy Reliance on Groundwater and Remote Resources

Over 80 percent of the rural and urban domestic water supplies in India are served by groundwater (World Bank, 2020), with the states of Karnataka and Tamil Nadu becoming heavily reliant on groundwater to supplement their supplies (Dhillon, 2019). Part of the reason for the heavy reliance on groundwater is caused by the expansive urbanization that is taking place around the country, including in Bangalore and Chennai. As the population increases in both cities, the demand for water increases, which cannot be met by the historical modes of water storage, including tanks, wells, and lakes which hold water from monsoon rains to sustain their populations' typical consumption for the year (Sudhira & Nagendra, 2013). In Bangalore, the number of tanks and lakes have dwindled due to urban development and encroachment (Narasimhachar, 2018). Rapid changes in land use have taken place around lakes and wetland areas as water bodies have been encroached upon to be converted to urban land use, resulting in the conversion of many open, "soft" surfaces to impervious ones (Sudhira & Nagendra, 2013). This has also led to Bangalore's reliance on pumped water from the Cauvery River. Through the Cauvery Water Supply Scheme (CWSS), the BWSSB supplies treated river water, pumped from 100km away, to the core area and urban local bodies through four progressive stages (Visakha, 2019). This excludes the 110 villages on the periphery of the urban area, though a fifth stage of the CWSS is in progress to supply municipal water to these households (Visakha, 2019). Due to the insufficient water supply from the Cauvery River, a significant number of households (39 percent) rely on groundwater to meet their water needs (Ramachandra et al., 2019). Likewise, Chennai's urban growth has increased the pressure on the water sources of the city (Arunprakash et al., 2014), which are increasingly being met by high-modern source augmentation practices including desalination and damming. After a devastating flood and monsoon season in 2015, officials authorized the systematic destruction of waterbodies in and around the city, as this was thought to be an effective method of preventing floods as part of their overarching plan of mastering control of their water supply (Allan, 2003; Lakshmi & Radhakrishnan, 2019). Thamaraikeni Lake,

for instance, recently shrunk in size from 152 acres to 26 acres as land was reclaimed to continue the urban sprawl and reduce the proportion of water bodies in the city (The Hindu, 2019b). In both cities, the municipal piped water supply does not meet the demand for water, due to the extensive urbanization over the last few decades, and as a result, many parts of the cities depend on remote water resources, like the Cauvery, and on groundwater extracted from borewells by households and private tanker companies as the municipal water supply systems cannot keep pace with the increasing demand (Sudhira & Nagendra, 2013; Sahu, 2016).

Presence of Expansive Quasi-Legal Water Economies

The increasing water demand in Bangalore and Chennai has left many households scrambling to meet their daily water requirements as municipal water delivery systems are inadequate (Visakha, 2019). This has forced a reliance on private water tankers and, as a result, the perpetuation of quasi-regulated water economies. Lacking access to formal housing and/or a municipal piped connection, many residents are forced to rely on private vendors, neighborhood sources or illegal networks of accessing municipal water to meet their daily demand (Sudhira & Nagendra, 2013; Visakha, 2019). In fact, it is estimated that 60 percent of households in Bangalore use water either supplied by private tankers or from private borewells and more than 50 percent of households in Chennai supplement their intermittent municipal water supply that is available just a few hours each day irrespective of the season with private tankers (GCC, 2019; Visakha, 2019). Municipal water authorities are responsible for issuing licenses to private tanker companies who can then legally supply water to households, however, relatively few licenses have been granted recently in either city (Government of Karnataka, 2011; GCC, 2019; George, 2019). As the government is unable to effectively oversee the private tanker business through licensing, they cannot guarantee water quality standards nor can they regulate groundwater extraction from borewells, which hinders the recharge ability of the water table (Shah & von Koppen, 2016; Visakha, 2019). Nevertheless, there are licensed private tankers that operate in both cities, which makes the water economy quasi-legal, as some standards are upheld by a few companies yet illegal activity by other actors is still present. The current municipal water systems in both cities is not conducive to growing populations and current source augmentation practices are not addressing the root causes of the situation.

High Modern Water Management Practices

Long before colonialism took hold in India, cities used relatively interconnected, community-managed systems of tanks and wells (Broto et al., 2018). However, the colonial era left a legacy of complicated, poorly planned, high-modern infrastructure that does not adequately meet the needs of citizens. More specifically, the "progressive industrial modernity" promoted by the West assumed that Nature could be controlled by man (Allan, 2003, p. 6). The lasting legacy of this practice is demonstrated through the promotion of high-modern, technological solutions to water management through source augmentation. For instance, by 1885, Bangalore's water supply was already running low and the colonial government responded by setting up piped infrastructure to bring water from sources 30km away to meet the rising demand (Broto et al., 2018). In both cities, civil engineers realized the fixed size of tanks and wells was insufficient in the face of population growth and, as a result, rivers were tapped and water was brought into urban areas through pipes (Gronwell, 2008). Both Bangalore and Chennai, to a lesser extent, still rely on the colonial-era pipes that are in dire need of upgrading as seen through the average of 20

percent of water that is wasted in Indian cities due to leaky pipes (Broto et al., 2018; CMDA, n.d.; Kumar-Rao, 2019). Presently, authorities in both cities are exploring other possibilities to ensure water security through large-scale, technocratic proposals costing billions of dollars (Broto et al., 2018), pursuing a hydraulic mission that emphasizes ownership and management of water resources This is a clear example of the high-modernist legacy left by colonialism that is imprinted in India's water management practices.

Climate Change as an Exacerbating Effect

Climate change has made effective water management challenging due to the distortion of the quantity and frequency of rainfall. Much of India, including Bangalore and Chennai, are reliant on monsoon rains to fill reservoirs, tanks, and rivers; however, the rains have become more erratic because of climate change and monsoon seasons are increasingly unpredictable (Earth Observatory, 2019). In fact, the India Meteorological Department announced that the 2019 monsoon, which started late in June, was the most delayed withdrawal in history, ending in late October (Earth Observatory, 2019). As Bangalore and Chennai do not have adequate infrastructure in place to manage excessive rainfall, their water security is challenged by the uncertainty and unusuality of monsoon seasons. Furthermore, extreme heat waves in both cities are compounded by expansive urbanization which has decimated green spaces, which have a moderating effect on air temperatures. Climate change has different effects on Bangalore and Chennai, owing to the different topographic and climatic systems. As exemplified in Figure 4, climate change has further compounded the water security issue in both cities by drying up reservoirs, lakes, and other water sources in the catchments of the important river basins (Raj, 2013).

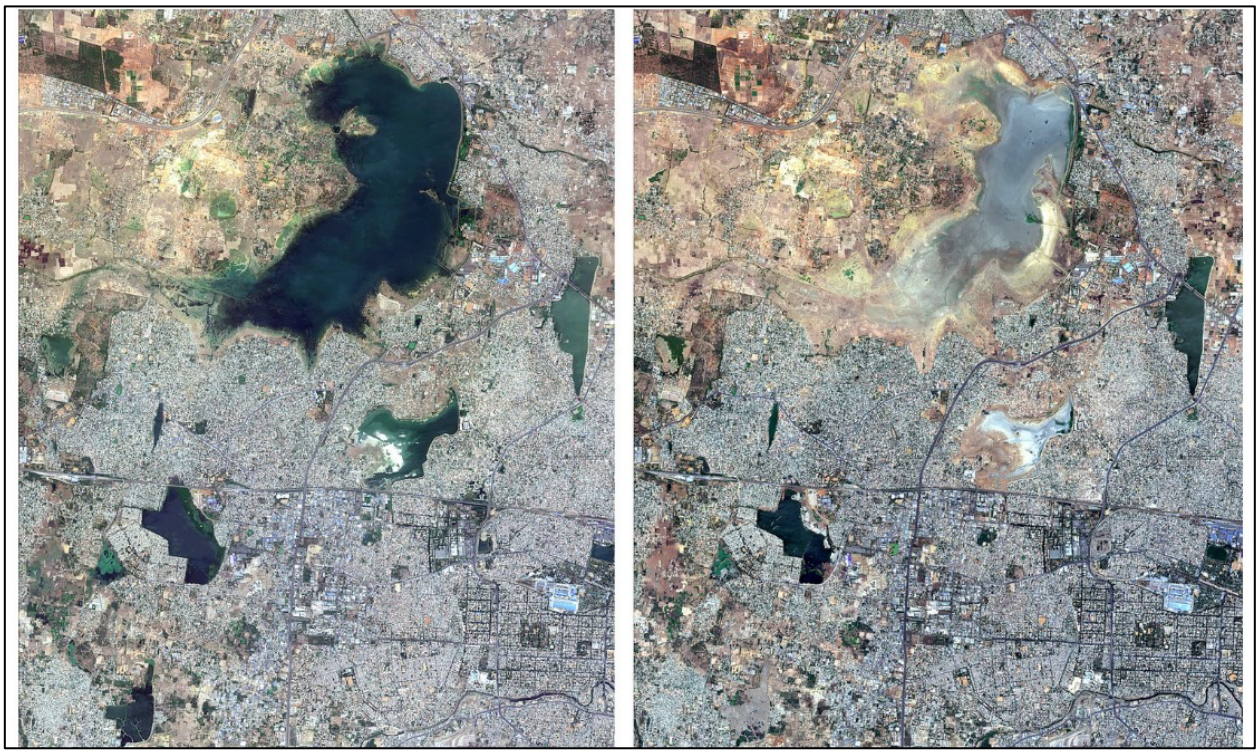

Figure 4 – Satellite images from June 15, 2018 (left) and June 15, 2019 (right) show the diminishing size of the Puzhal Lake reservoir in Chennai Source: Pathak, 2019

The mechanism behind this are decreased levels of rainfall and increased temperatures in conjunction with the rapid unplanned, unregulated urbanization and exploitative groundwater extraction. In Chennai, climate change has made the city extremely vulnerable through its dependence on variable precipitation from October to December (Gopakumar, 2009). A considerable amount of rain falls in the span of a few months; however, the inadequate water storage infrastructure, in open wells and reservoirs, and a massive increase in impervious surfaces in the city has greatly decreased the amount of water that can recharge groundwater tables and thus be harnessed for use at another point in the year (Lakshmi & Radhakrishnan, 2019). So, both cities face challenges in ensuring urban water security, which is exacerbated by the unpredictable effects of climate change. Such an intense reliance on unpredictable rainfall to quench growing cities' thirst will only result in more cracked mud puddles and massive floods unless concerted collaboration between stakeholders occurs.

STAKEHOLDERS

International Actors

The exponential growth in groundwater extraction in Karnataka and Tamil Nadu has gained the attention of the international community. International actors' efforts have focused on improving groundwater management at the federal and state level, as this is expected to contribute to creating sustainable water security within the two states. The interventions tend to be compartmental and focus on just one aspect of water security. For instance, the Tamil Nadu government often seeks external support for the aversion of flood and cyclone impacts on the city (Roul, 2019), preferring instead to "flood-proof" their cities, as opposed to adapting to the new reality (GCC, 2019). The World Bank and the Asian Development Bank (ADB), most notably, fund projects in both Karnataka and Tamil Nadu. The former signed a 450-million-dollar loan with the federal government to support initiatives in groundwater-dependent states that aim to halt depleting groundwater levels and strengthening groundwater institutions under the National Groundwater Management Improvement Scheme (World Bank, 2020). Community-led management measures have emerged to make users aware of consumption patterns and create the conditions necessary to introduce economic measures that will reduce groundwater consumption (World Bank, 2020). The World Bank, in conjunction with the German Development Bank, also runs a second project in Tamil Nadu wherein the two entities are funding stormwater drains and massive underground drain projects in certain river basins as flood mitigation measures (Roul, 2019). The ADB (2019), on the other hand, also operates in Karnataka and Tamil Nadu. A loan from the ADB (2019) in Karnataka aims to improve water availability through the implementation of the Karnataka Integrated Sustainable Water Resources Management and Investment Program – a program that aims to incorporate integrated water resources management (IWRM) into the state-level water resources mandate (Water Resources Department, 2020). In Tamil Nadu, the ADB is funding stormwater drain projects while also supporting water supply and sewerage system improvement under a state-wide urban development project (Roul, 2019). While the results of these projects remain to be seen, it is not absolute that external agencies will be able to provide much-needed water security to Bangalore and Chennai.

State Governments

Both Karnataka and Tamil Nadu recognize the pressing need to improve water development and management. Shortly after the implementation of the first National Water Policy in 1987, the Tamil Nadu government and its Water Resources Department implemented the Chennai Metropolitan Area Groundwater (Regulation) Act, which is an act to regulate and control the extraction, use and transport of groundwater with the overarching objective of increasing conservation (Government of Tamil Nadu, 1987). This piece of state legislation came into fruition after the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) reported that all other possibilities of augmenting water supply to the city were being exhausted and that it was therefore necessary to regulate and control the extraction and use of groundwater (Government of Tamil Nadu, 1987). Just over a decade later, the Karnataka government and its Water Resources Department enacted the Karnataka Ground Water (Regulation for the Protection of Sources of Drinking Water) Act, 1999 to give priority for drinking water and its sources in the state (Government of Karnataka, 2011). This act, however, did not expand on the pivotal role of groundwater in the state. As such, in 2003, both Karnataka and Tamil Nadu enacted groundwater acts that were based on the national Groundwater Model Bill (Government of Tamil Nadu, 2003; Government of Karnataka, 2011). The Tamil Nadu government repealed their Groundwater Act in 2013, as it was found to not be sufficiently "workable" due to a variety of reasons, including poorly defined terms (Ramakrishnan, 2016). In essence, the rapid urbanization in the state led to an exploitation of groundwater by various players that was not adequately regulated by the ordinance. In 2011, the Karnataka government passed another act, the Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011 which, most notably, established the Karnataka Groundwater Authority (Government of Karnataka, 2011). This Authority then became the body responsible for upholding the aforementioned act and ensuring indiscriminatory exploitation of groundwater in the state is monitored and controlled (Government of Karnataka, 2011). As will be discussed in the following section, there is an overlap in responsibilities at the state and municipal levels, which has created confusion as to the appropriate authority to monitor, regulate, and enforce water use. This has facilitated the illegal extraction of groundwater across Karnataka and Tamil Nadu alike and in both states, there appears to be lacking political will to comprehensively address the problem (Brunner et al., 2014). In the case of both states, plummeting groundwater levels continue with little effort made at the state level to intervene. For instance, the Tamil Nadu government has been criticized by the Madras High Court for its inaction, accused of waiting passively for the arrival of monsoon season instead of proactively handling the water crisis (Dhillon, 2019), perhaps in part due to fixation on interstate water conflicts, such as the Cauvery River.

The sharing of the water of the Cauvery River has been the source of conflict between Karnataka and Tamil Nadu since the 1890's (Cauvery River Disputes Tribunal, 2007), driven by a perceived scarcity of the resource (Ghosh et al., 2018). The importance of the river arises from its course through traditional rain-fed agriculture areas in the plateau and delta regions of Karnataka (Ghosh et al., 2018). Decades of negotiations between the two parties were fruitless until the federal government constituted a tribunal in 1990 to look into the matter (Cauvery River Disputes Tribunal, 2007). Karnataka, the upstream state, had been planning various projects, including the construction of dams across tributaries of the Cauvery, and had not obtained prior consent from the Tamil Nadu government, the downstream state, for any of the projects, particularly a dam in Mysore (Cauvery Water Disputes Tribunal, 2007). As the Cauvery is the only major river in Tamil Nadu, contributing nearly 50 percent of the state's surface water use, the verdict

from the tribunal in February of 2007 was such that Karnataka was obligated to release water from its reservoirs so as to ensure approximately 5.8 billion cubic meters of water would be available in Tamil reservoirs from June to May (Cauvery Water Disputes Tribunal, 2007). The tribunal remarked that the right to use of the flowing water is *publici juris* and common to all riparian proprietors and, as such, they do not have an absolute and exclusive right to all the water flowing within their borders (Cauvery Water Disputes Tribunal, 2007). The verdict opened up opportunities for setting up an appropriate river basin organization as a base for integrated governance (Ghosh et al., 2018). However, the dispute did not end there, with parties deciding to file petitions seeking clarifications and a possible renegotiation of the order (Supreme Court of India, 2018). The final verdict from the Supreme Court in February 2018 reduced the allocation of water for Tamil Nadu from 5.4 billion cubic meters to 5 billion cubic meters and increased Karnataka's allocation by 417 million cubic meters, potentially paving the way for a sustainable resolution of the interstate water dispute (Ghosh et al., 2018; Supreme Court of India, 2018).

Municipal Governments

Water provision in Bangalore and Chennai is the responsibility of municipal bodies: the Bangalore Water Supply and Sewerage Board (BWSSB) and the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), respectively. The BWSSB provides water and sewage services on a "no-profit, no-loss" basis to the core area and urban local bodies (Visakha, 2019). Through the Cauvery Water Supply Scheme, the BWSSB spends approximately 65 percent of its total revenue on power charges to raise the water approximately 500 meters, then pump it to the city (Narasimhachar, 2018; Visakha, 2019). Stakeholders in Bangalore are aware of the city's heavy dependence on the Cauvery, a river that is shared between two other states. Due to the intermittent nature of the water supply during the dry season and unreliable piped connections, households often supplement their BWSSB supply with water purchased from private tankers at fluctuating rates (George, 2019). These tankers in Bangalore are largely unregulated and unlicensed (Deepika, 2017), despite requiring a permit or license to dig wells and extract groundwater. Both the municipal government, the Bruhat Bengaluru Mahanagara Palike (BBMP), and the Karnataka Groundwater Authority are responsible for issuing licenses (Government of Karnataka, 2011). This has resulted in the ineffective implementation of licensing procedures and, as a result, poor monitoring and evaluation, thereby facilitating the illegal extraction of groundwater. As one observer pointed out, if you have a borewell, you just need to buy trucks and hire drivers to start a tanker business (George, 2019).

The situation is much the same in Chennai, albeit with different external issues placing pressure upon water supplies, as discussed in a preceding section. Under the Greater Chennai Corporation, the municipal government, the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) is the body responsible for water supply and sewerage functions within city limits (Brunner et al., 2014). While Chennai is not reliant on a distant water source, the city relies on monsoon rains, from October to December, to fill reservoirs (Natarajan & Kalloikar, 2017). As reservoirs are not being adequately filled during the rainy season, the CMWSSB is forced to draw on groundwater to meet the demand for water (Brunner et al., 2014). As with the case of Bangalore, uncertainty of supply means that people who have the means buy water at inflated prices from private tanker companies (Dhillon, 2019). Unlike in Bangalore, wherein authorities at both the state and the municipal levels have the power to issue licenses or permits to extract groundwater, the authority in Chennai is the CMWSSB under the 1987 Groundwater Regulation

Act (GCC, 2019). The CMWSSB attempted to crack down on unlicensed tankers in the summer of 2019; however, the Tamil Nadu Water Lorry Owners' Association planned to go on an indefinite strike, effectively stripping individuals who depended on the tanker water of a supply (The Hindu, 2019a). Allegedly, the strike was called off because government authorities promised to help the tankers legally source water (The Hindu, 2019). Since then, monitoring and enforcement has been poor and, as in Bangalore, illegal groundwater extractors face practically no consequences (GCC, 2019).

The extensive groundwater extraction from both legal and illegal actors in both cities has resulted in inadequate opportunities for groundwater recharge (Visakha, 2019). While there is emphasis at the state level to find sources of water as an alternative to groundwater, there are a number of promising demand management initiatives at the municipal and community levels that hold potential to achieve urban water security in both cities. This is discussed in more detail below.

As mentioned previously, the legal framework of Chennai, and Tamil Nadu more generally, creates a favorable platform from which to launch urban water security initiatives. The city has proposed a draft climate action plan in February 2020, with 199 planned activities across seven key sectors, prepared in sync with Nationally Determined Contribution which India submitted under the 2015 Paris Agreement (Chaitanya, 2020). In contrast, Bangalore does not have a municipal level climate action plan, though a state-level plan exists with gaping holes that, most notably, did not encourage climate action to be the crux of development planning (Shah, 2018). Moreover, following the disastrous 2015 floods in Chennai, more attention is being paid to restoring and protecting water bodies as a means to enhancing future water supply, as demonstrated through the CMWSSB's 'Sustainable Water Security Mission' (GCC, 2019). This mission aims to meet the future demand for water not only through restoring water bodies in and around the city, but also through expanding and strengthening rainwater harvesting and the recycling and reuse of wastewater (Roul, 2019). With the Sustainable Water Security Mission in mind, the future priority of the CMWSSB is to figure out how to create a water resource matrix that includes surface, ground, and reclaimed waste waters (CMDA, n.d.). Rainwater harvesting has the highest social acceptance and the least opposition amongst stakeholders, likely due to court judgments supporting the practice as well as it being mandatory on rooftops since 2001 (Brunner et al., 2014; Metro Water, 2018a). Reservoirs are also seen as relatively uncontroversial and the city plans to enlarge existing ones, as this is seen as the most economical solution to securing a dependable water supply (Brunner et al., 2014; Natarajan & Kalloikar, 2017). Desalination, however, appears to have caught the attention of officials due to the proximity of Chennai to the coast. There is great skepticism among citizens, as the plants are one of the costliest options, both financially and environmentally, to secure drinking water (Brunner et al., 2014)[1]. However, this infrastructure does present an immediate solution to the present water scarcity (GCC, 2019). From a demand management perspective, metering to measure water consumption and effective pricing in the

[1] While the costs of desalinated water are decreasing as the technology evolves, the cost of a plant depends on source water, location, and treatment process, among others. Research suggests that, as of 2017, cost trends vary between three to nine dollars per thousand gallons (Advisian, 2017). Desalination requires a great deal of energy and greenhouse gas emissions created by the power needed, especially where fossil fuels generate electricity, are significant contributors to global warming. The ecological impacts of desalination range from depleting the ocean of oxygen (it takes two gallons of sea water to make one gallon of freshwater) while leaving behind brine waste, to the killing of organisms through the sucking in of seawater for processing. Ultimately, there are a lot of unknowns on the impacts on sea life (Jones et al., 2019; Robbins, 2019).

form of a water tax are the most direct ways to manage demand and encourage users to conserve water (GCC, 2019). Chennai's water tax is set at a rate of 7 percent of the annual rental value, which is a fixed rate set by the municipal government (Metro Water, 2018b). Consumption is measured through meters which are, unfortunately, present in just 10 percent of households across the city (GCC, 2019), thereby making consumption-based pricing next to impossible.

Bangalore's transition to a water-secure future has not received the same attention as that of Chennai. The city has adopted rainwater harvesting, pricing, and metering, much like Chennai and, to its credit, it has achieved better consumption-based pricing outcomes. Whereas Chennai has a fixed rate for its water tax, Bangalore's tariffs increase depending on the amount consumed or water consumption slabs, as is referred to by BWSSB (2014). For example, a household will pay seven rupees for 1000 liters if between 0 to 8,000 liters are consumed. They will pay 11 rupees per 1000 liters if between 8,000 to 25,000 liters of water is consumed (BWSSB, 2014). Moreover, Bangalore followed the example of Chennai and has made rainwater harvesting structures mandatory on existing and proposed buildings (Menezes, 2018). This legislation was made possible by collaborative efforts at the state and municipal level between the Karnataka Groundwater Authority, the BBMP, and the BWSSB. First, the Groundwater Authority identifies recharge-worthy areas in the state for rainwater harvesting (Government of Karnataka, 2011; Central Ground Water Board, 2012). The BBMP and the BWSSB then both operationalize the Groundwater Authority's findings through a bylaw (2003) and an Amendment Act (2009 and 2011) and Regulation (2015), respectively (Biome Environmental, 2016). The BBMP bylaw applies to all properties coming under its jurisdiction and the BWSSB Act applies to all properties that have a BWSSB connection (i.e. the core urban area) (Biome Environmental, 2016). This has ensured that the many buildings in Bangalore have rainwater harvesting systems in place to supply water in times of shortage, though the enforcement of the legislation is poor and system maintenance is lacking (Biome Environmental, 2016). In addition to rainwater harvesting to meet households' water needs, the city and its citizens, as is discussed in the proceeding section, have also undertaken lake rejuvenation projects just as Chennai is doing, which includes dredging and desilting work, followed by the filling of the water body with freshwater (Akshatha, 2019). This will assist in groundwater recharge and facilitate the efficient management of available water sources. Both examples provide a fascinating glimpse into the potential such small-scale options hold for harnessing and storing water (Broto et al., 2018).

Community Initiatives

As Bangalore and Chennai are rapidly urbanizing, the number of businesses and industries is increasing dramatically. Such expansion has repercussions on the hydrological cycle, as impervious surfaces become the norm, groundwater levels drop as water demand spikes, and water contamination becomes the harsh reality, hitting communities the hardest. Collaboration between the different levels of government has not resulted in sufficient improvements in urban water security in Bangalore and Chennai. This has resulted in an increase in community initiatives that engage and mobilize citizens to work towards achieving urban water security (Kumar-Rao, 2019). Certain organizations work on the macro level, including *Isha Outreach*, and are making progress on achieving a water-secure future at the municipal, state, and national levels. *Isha Outreach* is the foundation of a well-known Indian spiritual leader, Isha Sadhguru, and it works across southern India, implementing several large-scale human service projects to

support individual growth, revitalize human spirit, rebuild communities and restore the environment (Isha Foundation, 2017). The organization has two ongoing initiatives, *Cauvery Calling* and *Rally for Rivers*, both of which are concerned with the Cauvery River. *Cauvery Calling* is a first of its kind campaign, setting the standard for how India's rivers can be revitalized (Isha Foundation, 2017). Through this initiative, the organization supports farmers to plant 2.42 billion trees in Cauvery basin (Isha Foundation, 2017). This will have a triple benefit effect of improving soil health by replenishing organic content in soil, reviving the river and groundwater levels by increasing water retention in Cauvery basin, and augmenting farmer income through agroforestry. *Rally for Rivers*, on the other hand, is a movement to save India's rivers. Supported by over 162 million people, it is the world's largest ecological movement today, focusing on local-level actions. It was launched in September 2017 to raise awareness about river depletion (Isha Foundation, 2017) while simultaneously generating potential to instigate government action. River depletion is a pressing issue in India wherein many urban areas, including Bangalore and Chennai, are dependent on rivers and their tributaries, as a source of water to sustain livelihoods, both in urban and rural areas. On the micro scale, within Bangalore and Chennai, community groups are working towards meeting their daily water requirement under the broader objective of achieving urban water security. In Bangalore, community-level approaches to creating water security are taking place throughout the city, raising awareness about the importance of the issue. Some citizen groups are mapping groundwater levels with the intention of influencing user behaviour that enables better groundwater management (Desai, 2017). Others are working to protect and rejuvenate old tanks and open wells that held the city's water supply prior to the mid-20th century which can then be used to store water for household consumption or irrigation (Broto et al., 2018), effectively acknowledging the traditional water practices in region. In both cities, lake rejuvenation is increasingly being prioritized on the municipal agenda, demonstrated by the efforts made by citizens to ensure lakes are brimming with water throughout the year (Desai, 2017). Lakes are also an integral component of proposed solutions to industrial effluent and untreated wastewater in water bodies. The issue is being approached through micro level bioremediation efforts to treat wastewater for reuse through an integrated wetlands system, including an algal pond integrated with a lake (Ramachandra et al., 2019). The treatment of polluted waters in natural systems such as constructed wetlands is being practiced across developing countries, as it is a simple and economically-viable method of managing wastewater (Ramachandra et al., 2019). As such, community initiatives are an integral part of addressing the water crisis in Bangalore and Chennai by ensuring that local concerns are voiced on a macro scale to governments through large organizations like *Isha Foundation* and community-level, context-appropriate practices are adopted through small-scale citizens' groups.

DISCUSSION

As a rapidly urbanizing country experiencing a population explosion, water is high on the national political agenda in India due to its essentiality to life and economic and social development. The population explosion especially in the urban centers has increased the demand for water, which adds to the existing challenges that Bangalore and Chennai are currently facing. As such, water issues mobilize stakeholders at all levels, from the national government to small-scale, community groups. In India, the national government takes on the role of overseeing water at a high-level, with its legislation prioritizing the state of India's water through the various iterations of the National Water Policy (2012). State governments then have the choice to either incorporate or reject national legislation into state-level

policy, as water is under the legislative competence of states (Cullet, 2012) and, in the case of Karnataka and Tamil Nadu, both have accepted the responsibility to manage water affairs within their boundaries predominantly through their Water Resources Departments. Municipal governments are accountable for supplying water to households in their jurisdictions through their water authority boards. Notably, the water regimes in Bangalore and Chennai differ significantly in terms of, inter alia, infrastructure, policies, as well as the influence and participation of stakeholders. Therefore, the responsibility of carrying out the oversight, management, and supply of water cannot be the responsibility of governments alone. Put differently, while the central government can oversee the policies through official regulations, the state and municipal governments would have more significant impacts on implementing and managing the system, while acknowledging the political, regional, and social contexts. The Supreme Court ruling on the Cauvery Water dispute has set a precedent for incorporating IWRM thinking into water issues by recognizing the multidimensionality of the basin system and the interdisciplinarity of stakeholders involved therein (Ghosh et al., 2018). This ruling offers an important opportunity to better align IWRM thinking with action.

In essence, the concept of integrated water resources management provides ideas to assist in considering how social choices can be made with water allocation and access in mind, as well as the sustainability of water resources and the infrastructure used to manage them (Giordano & Shah, 2014). However, the traditional IWRM framework that is employed in the 2012 National Water Policy does not adequately address the social dimensions of water. This is demonstrated through the national and state governments' approaches to IWRM as a "one-size-fits-all" empirical framework that promotes apolitical, nongeographic solutions to water issues (Giordano & Shah, 2014; Shah & von Koppen, 2016). Many think tanks and international organizations, including the Asian Development Bank, embrace the IWRM discourse and recommend actions to be taken in alignment with the framework (Shah & von Koppen, 2016). Consumption-based water pricing, for instance, is a textbook solution to improving water efficiency in the IWRM framework (Giordano & Shah, 2014). However, water pricing is not compatible with the realities on the ground in India, as efforts to rationalize pricing were met with resistance by citizens who were accustomed to paying extremely low tariffs for water and, perhaps more importantly, water meters are faulty and poorly regulated in Bangalore and Chennai which makes consumption-based pricing next to impossible in most households (Giordano & Shah, 2014; GCC, 2019). This exemplifies the futility of implementing a solution that is suboptimal and disjointed with realities on the ground.

Despite the association of IWRM with apolitical, nongeographic approaches, IWRM in Indian cities has the potential to foster a bottom-up governance structure and a participatory democratic approach that reflects the contextual realities (Ghosh et al., 2018; Goyal et al., 2020). Community-level groups and other civil society organizations play a vital role in ensuring proper implementation and adoption of sustainable water practices through an incorporation of the social dimensions of water (Linton & Budds, 2014). Otherwise stated, macro thinking at the government level is important, but it must be linked to local needs and practices. "Local IWRM" is emerging as a promising alternative to the traditional IWRM framework that emphasizes stakeholder-inclusive, community-level processes (Goyal et al., 2020). This effectively incorporates macro scale thinking through IWRM while tailoring it to a local context. So, rather than aspiring to the full framework of IWRM, localized IWRM offers greater attention to a variety of entry points to enable the participation of local initiatives in promoting coordinated water management while

encouraging greater cooperation from local users (Goyal et al., 2020). The mobilization and engagement of community-level actors bolsters context-appropriate responses to water management by incorporating the flows and uses of water into discussions.

Community-level initiatives are diverse in Bangalore and Chennai, with some operating at the micro level as individuals or small groups, and others operating on the macro scale with great potential to lobby governments, like *Isha Outreach*. Both are useful, albeit in different ways, as they hold potential for harnessing, storing, and supplying water in the face of rapidly-changing environments (Broto et al., 2018). As part of an effective water management strategy, initiatives operating at both scales require community participation (Gupta & Ahmad, 2019). Strong community participation and engagement builds social capital as well as trust with governments by ensuring local voices are reflected in discussions. While water falls under municipal jurisdiction, many citizens feel disconnected from the issue (Gupta & Ahmad, 2019). A strategy that has seen great success in rural India has been to create *paani panchayats*, or local water governance councils, for citizens and officials to discuss water management issues (Gupta & Ahmad, 2019). Such a strategy holds potential for urban India as part of an effective water management strategy for three reasons. First, it fosters social ties between locals within neighborhoods which is key for building trust within communities. Second, the council acts as a channel of communication between government and communities and, third, it promotes localized responses to urban water security and includes discussions about the social dimensions of the issue.

As such, a community-focused *paani panchayat* fits within the localized IWRM strategy that will more effectively address urban India's water security woes than the dominant top-down framework. Due to the local nature of the water governance council, it holds great potential to implement small-scale initiatives, like rainwater harvesting (RWH), which are increasingly seen as an integral part of an effective water management strategy in India (Gupta & Ahmad, 2019). The practice of holding water in small structures including tanks, wells, and ponds to serve a community is a traditional water supply option in south India, thereby aligning with local practices and capabilities, and has been supported by court judgments (Brunner et al., 2014). By storing rainwater from monsoons, households and communities are able to complement their municipal water supply to ensure a predictable source of water year-round (Vivek, 2016; Metro Water, 2018a). Governments and civil society recognize the benefits of these local, small scale structures and both are actively promoting them in both Bangalore and Chennai. Both cities have adopted laws mandating RWH infrastructure on buildings since the early 2000's and while the municipal enforcement rate has been low, citizens are aware of the benefits of the practice thanks to civil society's active engagement in promoting RWH (Brunner et al., 2014; Holland-Stergar, 2018). For instance, an educational center in Chennai, *Rain Center*, has been offering programming to communities on the benefits of RWH. A study even suggests that these efforts have played a part in increasing well levels by 30 percent and groundwater levels by an average of four meters across the city (Holland-Stergar, 2018). The key takeaway from this initiative is that a strategy must be tailored to the local context, which fosters community buy-in, and backed by sufficient political will and commitment to the issue rather than working in opposition to citizens' efforts. The creation of *paani panchayats* across urban India is a promising approach that can facilitate the engagement between citizens and governments, fostering greater collaboration between stakeholders, which is crucial to capture the realities on the ground. While India's

approach to IWRM is a good start, there must be greater recognition that a prescriptive approach for governing water resources is not the best system in a country that is as diverse as the world.

CONCLUSION

To conclude, given the current situations in Bangalore and Chennai, neither city is likely to achieve urban water security, assuming business-as-usual trajectory of development. However, there is a possibility to work towards ensuring urban water security and, as a result, avoiding "Day Zero" scenarios, but this is conditional upon sufficient political will from governments to address water issues. There needs to be increased regulation and enforcement of urbanization and groundwater extraction policies that are relevant to the contexts, in addition to greater community involvement in conservation efforts to reflect the realities on the ground. As India is an incredibly diverse country, national-level efforts to ensure urban water security are futile. A solution that works in a southern Indian context, for instance, might not be appropriate in northern India due to the variability in cultures and infrastructure. For this reason, the federal government must oversee efforts from a high level while state and municipal governments engage in managing and supplying water, respectively, to ensure context-appropriate solutions are adopted. Active community engagement and participation is crucial to pressure governments to act. The efforts made by the stakeholders needs to be aligned with each other instead of limiting the efforts of community efforts. Political will can be further fostered through the mobilization of influencers who are individuals whose opinions are held in high regard in India and South Asia, more generally, as Indian society is strongly motivated by social ties and human connection (Thussu, 2016). The strong potential of influencers in the environmental sphere, which can be extrapolated into water security, will enable key figures in Indian society to raise awareness of the issues and call for larger, people-centric, future-oriented approaches to water management and governance that embrace the entire city and its citizens (GCC, 2019). The connecting and interdependent nature of water provides us with a window of opportunity that we cannot ignore: water can be used to both meet basic needs and fuel impactful and catalytic change in the world's mega-cities.

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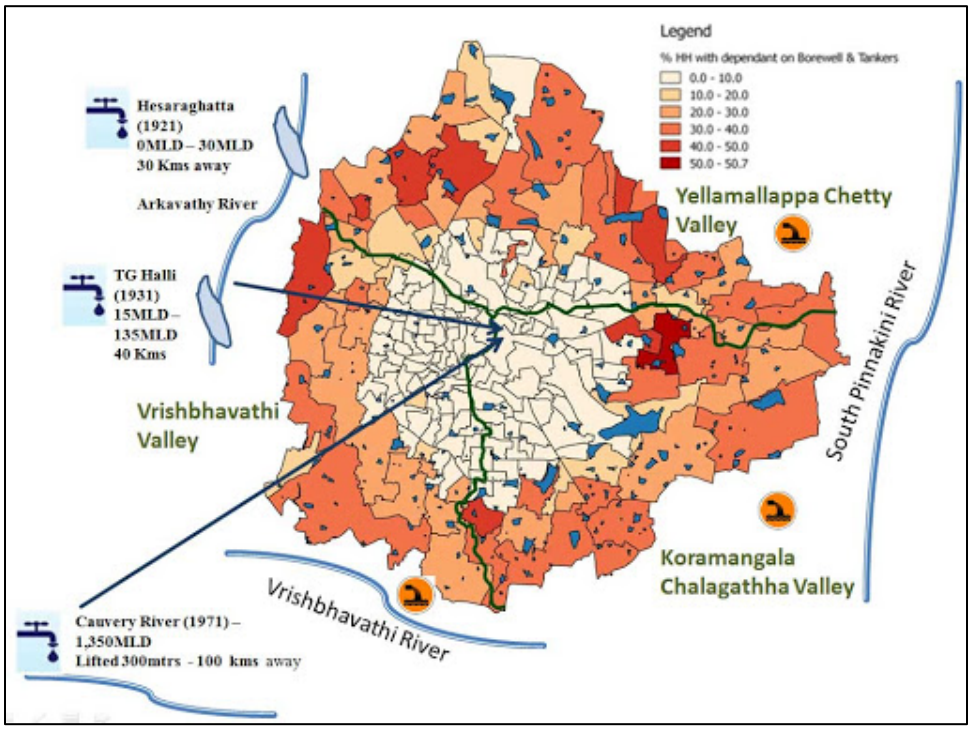
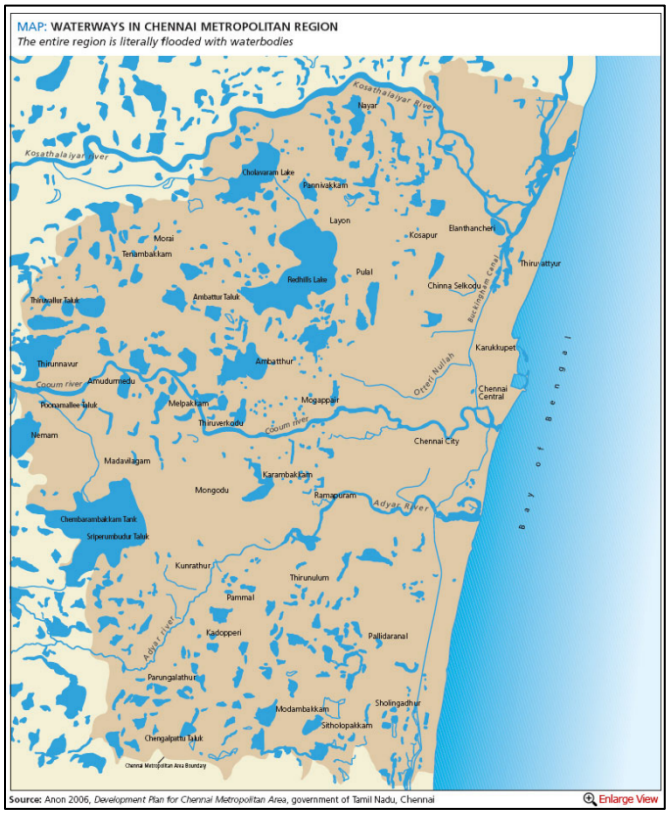
APPENDIX A



Source: Kiran Consultants, 2016

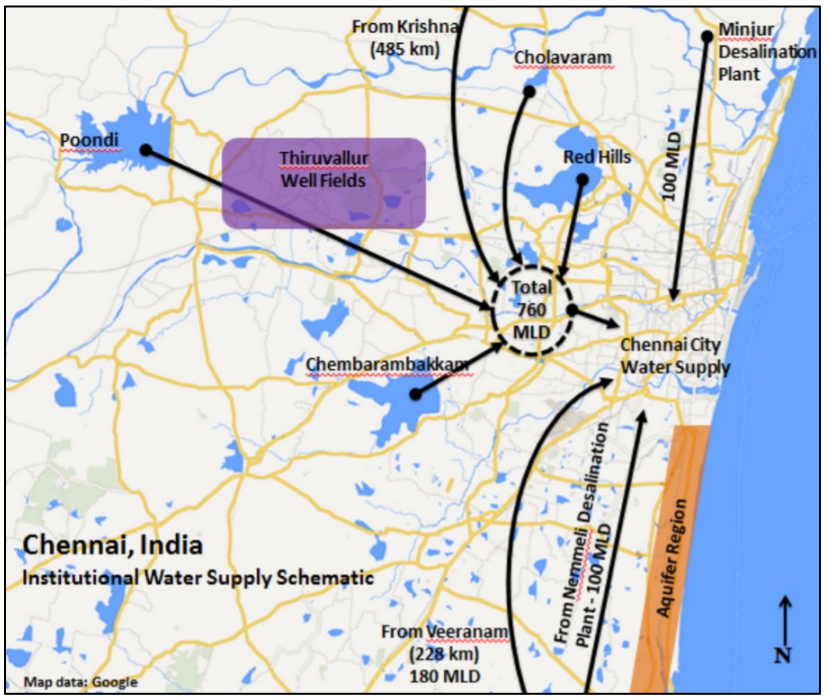
This is a map of greater Bangalore that depicts the proportion of households that are dependent on borewells and tankers as opposed to the municipal water supply from the BWSSB.

APPENDIX B



This map depicts the lakes, rivers, and tributaries in and around the Chennai Metropolitan Area. The Cauvery River is not on this map due to its distance from Chennai. It is current as of 2015.

Source: Narain, 2015



This map highlights, as of 2015, the total volume of water that Chennai receives from various sources. Again, the Cauvery River is not directly depicted on this map as it does not significantly contribute to Chennai's water supply.

Source: Ramesh, 2015