iihs®
INDIAN INSTITUTE FOR HUMAN SETTLEMENTS

GLOBAL COMMISSION on the ECONOMICS OF WATER

URBANISATION, URBAN SYSTEMS AND WATER

IIHS WORKING PAPER

JULY 2024

INDIAN INSTITUTE FOR HUMAN SETTLEMENTS

GLOBAL COMMISSION on the ECONOMICS OF WATER

URBANISATION, URBAN SYSTEMS AND WATER

IIHS WORKING PAPER

JULY 2024

Citations

Beleyur, P., Revi, A. & Sami, N., 2024, Urbanisation, **Urban Systems, and Water**, Bangalore, India,
The Indian Institute for Human Settlements and the Global Commission for the Economics of Water.

Design & Layout: Nawaz Khan | Reviewed by Prachi Prabhu & Padma Venkataraman IIHS Communications & Design

ISBN: 9788198256843
DOI: https://doi.org/10.24943/9788198256843

First published in Bangalore, July 2024

This paper is part of a series of working papers commissioned by the Global Commission for the
Economics of Water (GCEW).

Introduction

More than 55 percent of the world's population now lives in urban regions, with urbanisation rapidly increasing in low- and middle-income countries in Asia and Africa (UN, 2018). As we move towards an increasingly urban planet, urban regions and their governments need to avoid getting locked into development pathways that put an increasing pressure on their natural and economic resources and may not be sustainable in the long run.

Most key urban Sustainable Development Goals (SDGs) assume the provision of some form of grid-based infrastructure to enable universal service provision in the areas of water and sanitation (SDG6), clean energy (SDG7) and sustainable mobility and ICT connections (SDG11). This is based on the 20th century experience of urbanisation in Europe, North America, Australia and parts of Latin America. This is neither true and may be unsustainable and unaffordable in parts of Asia, Africa and Latin America for the bulk of the incremental urbanisation of the 21st century, which will see an addition of 2.5 billion people to urban areas by 2050 (UN, 2018).

Cities and urban regions draw on natural resources, like water, from beyond their physical footprints. as well as create environmental and ecological impacts that extend beyond their administrative boundaries. The food-water-energy nexus is critical as resource and ecological constraints to urbanisation and urban expansion, in many regions. Urban regions are facing reduced availability and access to quality water. Urban water infrastructures are under threat from environmental degradation and land use change. They are simultaneously under severe pressure from changing climatic conditions such as irregular rainfall, a growing drought incidence, and rising temperatures, all of which are likely to be exacerbated by current development trajectories. As population densities and urban inequality increase, vulnerability and exposure to hazard risks also increase. All of these will have human well-being, public health, environmental health, and economic consequences.

Urban regions across the world therefore have populations that are increasingly vulnerable as the benefits of development are highly unequal across socio-economic classes. Access to water-related services and linked economic activity are deeply enmeshed with poverty, informality, sub-optimal technical arrangements and high relative costs. Nevertheless, there is widespread innovation that blends hyperlocal, local, and innovative services provision with a range of institutional and governance arrangements. Emerging planning and governing processes for urban regions need to begin to innovate urgently to respond to water and climate risks, while simultaneously building resilience.

The paper provides an overview of the current and emerging challenges that cities and urban regions face in the context of water stress, rapid environmental change, and social and political transitions. Drawing on case studies from key regions across the Global North and South, it points to some examples of ways forward.

Urban water

Urban settlements are marked by the diverse uses of water at differing scales as it includes: the household scale of domestic use, a larger quantum of use in economic and industrial uses of water and water-linked ecosystem services water often at the scale of the urban region. Across these types of uses, urban water is often sourced from beyond the region through piped water infrastructure and more locally through groundwater aquifers. While many urban neighbourhoods are connected to gridded piped water infrastructure, there are several others that continue to stay outside the formal water system (Colenbrander, 2016). Communities outside the gridded water infrastructure rely heavily on groundwater directly (sourcing water from within the urban boundary) or indirectly (through tankers and water vendors who could extract surface or groundwater from beyond the urban boundary). The latter often is an unregulated water supply market where vendors charge costly premiums to customers (Beard & Mitlin, 2021). Urban residents are willing to pay premium prices for consistent water supply in the absence of a reliant formal water connection (Magnusson & Van Der Merwe, 2005). Access to water has deeper implications beyond the financial cost of the resource. It has interconnected implications on access to food and energy, access to infrastructures of health, sanitation, and education among others (Bharathi et al., 2022) . These interdependencies make urban settlements a crucial site for the integrated local implementation of the SDGs.

At the moment there is a dissonance between institutions that are responsible for water supply along the lines of use (domestic, industrial and ecosystem services), source (surface water, groundwater) and scale (municipal/local, regional and federal). This means that there is very little horizontal or vertical interaction between the institutions in charge on questions of urban water security (Gupta & Pahl-Wostl, 2013). This is a fundamental issue that is at the heart of water management and is a pivotal reason to use water as the organising principle. This is all the more important in the context of future urban transitions that will have a large water footprint not just in terms of domestic water consumption but in the process of creating the social and physical infrastructure that an urban settlement requires. Centering water and climate change at the heart of future developments is a necessity to ensure that we stay within the safe operating space of water use (Grafton et al., 2023).

Urban water use may not be comparable in terms of quantum as compared to other types of water use, especially irrigational use: 70% of freshwater goes into agricultural uses while only 12% of freshwater is utilised for domestic purposes (UN, 2024). However, the implications of urban water are far reaching. Urban water demand has impacts on water resources that are direct (e.g. through overuse of water, and pollution of sources) but also has embedded for food, energy and infrastructure. It is estimated that by 2030, there will be a global 40% freshwater shortage (Koop et al., 2017) which will have serious implications in the way urban transitions will occur. Additionally, latent challenges such as large gaps in data, poor capacity, lack of sufficient and consistent finance apart from the underlying fragmented institutional structure, make the urban water situation a complex one to unpack, in most regions. In the next section we aim to elucidate some of the major challenges around governing urban water and use case studies from the Global North and South to illustrate them.

Challenges with governing urban water

The challenges around governing water at the urban scale are unique due to the diverse types of water use vis-a-vis the quantum of water used and the fragmented governance of each use and type of water. In this section we address a few key challenges such as fragmented water demand, backward and forward linkages of urban water, financial and capacity constraints and finally the fragmented governance processes. We begin by describing the water crisis at the urban scale, particularly drawing attention to tangible and latent water consumption around urbanisation.

Scale of the problem

Urbanisation is a resource intensive process that is important not only at the subnational scale, but also globally. It is a complex process motivated by multiple factors, of which global politics and investments are important drivers. Decisions made around global trade and politics have deep implications at the local urban scale, particularly in the rapidly developing countries in the global south. Increasingly, investments towards industrial and economic growth are tied to urbanisation processes through mega projects like economic corridors (S. Anand & Sami, 2016). While economic prosperity that follows such developments in the form of increased GDP may improve access to utilities and services, it will be at the cost of depleting natural capital, in turn affecting marginalised and vulnerable populations (Grafton et al., 2023). Further, in the face of large-scale future urban transitions, trade-offs between natural resource management and conservation, dealing with urban environmental challenges, particularly climate change, as well as balancing the aims of balanced and just economic growth are critical to understanding and addressing the unique challenges and demands of urbanisation. An understanding of the deeply embedded nature of water in urbanisation processes is essential to enable sustainable urban futures.

Urbanisation is also not a uniform process and is influenced by particular histories that shape the realms of equity, access and demand with regard to urban resources in the contemporary period. The urban fabric therefore is heterogeneous, where urban neighbourhoods are diverse but also segregated along socio-economic markers. (Bharathi et al., 2022) illustrate an inverse relationship between urban segregation and availability of public services which is important to consider since the asymmetry in access to water is often not captured in administrative data collection processes. Balakrishnan & Anand (2015) refer to 'shadow areas' reflected in Master Plans, that are neighbourhoods with poor access to health and education. They use variables in the Indian context to show the correlation between access to water and sanitation to the socio-economic status and housing access of urban populations. Drawing from socio-economic data analysis in the context of Bengaluru, they argue that there are sub-cities marked by access to basic urban utilities. In this scenario, participatory bottom-up approaches towards gathering data and making policy decisions is necessary to understand the complexity of these issues and address them appropriately. Fragmented water demand makes it challenging to account for different water uses in urban settlements. In the next section we highlight a few important urban blue and green water uses while reflecting on the interconnected nature of the SDGs through them.

Fragmented water demand

Urban water use is particularly difficult to manage due to the diversity of water demand in a relatively dense region. It includes 12% that goes into domestic water use consumed at a household scale, 20% that is consumed for economic/commercial/industrial purposes at a much larger scale and the ecological and environmental flows in the urban region which are scattered across the urban region (UN, 2024). An added layer of complexity lies in the fact that each of these categories use water from different sources with a varying ratio that depends on access and tariff of water.

Water for these diverse uses is sourced from beyond the urban region through piped water infrastructure and more locally through groundwater aquifers and is supplied through diverse mechanisms raising questions of equity and access. There is also a dissonance between institutions that govern water according to use (domestic, industrial and ecosystem services), according to source (surface water, groundwater) and according to scale (municipal/local, regional and federal). While this paper only concerns itself with the use of blue and green water, an equally important point to note is the production of grey and black water[1] from these above-mentioned spaces that need to be included in the holistic governance of urban water. We look below at different components of urban water demand and their implications for sustainable water management in urban regions

Domestic consumption

At the domestic scale, universal access to piped water supplied via a network is lacking in most urbanising areas of the global south. Gridded water infrastructure in the form of piped water supply is uneven in urban areas due to embedded historical inequalities that have been reproduced across time (N. Anand, 2017). More often than not this has resulted in marginalised communities having to pay premiums to access water from private vendors since they are not connected to formal water infrastructure. Water connections in urban settlements are closely linked to property and tenure rights of residents, in the absence of formal documents to acknowledge these rights residents' access to urban resources is further weakened. Balakrishnan & Anand (2015) show a correlation between socioeconomic status and access to housing, to access to water and sanitation infrastructure. Increasing urbanisation, especially in cities of the Global South, will exacerbate urban water equity and access concerns (Amankwaa et al., 2022)particularly in off-grid and low-income neighbourhoods in the Global South. Digital water infrastructure such as water ATMs (automated standpipes. Additionally, weaker access to safe infrastructures of water and sanitation is linked to health and wellbeing of urban residents. In the larger context

1 See 'IIHS Working Paper: Transitioning Urban WASH' for a more detailed analysis of urban grey and black water management.

of implementing the SDGs, concerns around access to water should be extended to access to social infrastructures. SDG 6 (clean water and sanitation) must be read and implemented in coordination with SDG 10 (reduced inequalities), SDG 11 (sustainable cities and communities) and SDG 3 (good health and well-being). These issues however, cannot be addressed only with a top-down approach and require participatory processes to understand the heterogeneity of these challenges across the urban fabric.

Economic demand

A second use of urban water is as an economic resource/input, has been growing with increasing urbanisation. Currently 20% of the global freshwater reserves are used for industrial purposes, estimated to rise to 24% by 2025 (UN, 2011, 2024). Currently, availability of water does not guide economic planning in urban areas, leading to unplanned extensions and extraction of water. While environmental regulations around water pollution and treatment are stringent in most countries, the supply side of the equation is not addressed with the same meticulous forethought. High commercial tariff is a common regulatory tool that plays a role in the consumption of blue and green water. However, users often bypass this method of federal monitoring by accessing off-grid water through borewells, tankers etc. (Tomer et al., 2021). This is crucial to consider particularly because the lack of affordable water could become a severe constraint to economic growth and incremental development in brownfield settlements.

A World Bank report states that economic growth rates are forecasted to decrease by up to 6% in certain regions by 2050 due to the effects of water shortages (World Bank, 2016). Alternate solutions to local water scarcity may prove to be too expensive, making drought prone and water scarce regions unsuitable for economic development. It is equally important to move away from a regulatory framework that is highly dependent on the tariff gradient since this disproportionately affects smaller economic/industrial enterprises in urban areas. Urbanisation, economic development and industrialisation are closely tied phenomena and have been driven by conceptions of mega infrastructure projects. In the last few decades, the resource-intensive infrastructure industry has boomed particularly around big urban centres.

Ecosystem services

Urban water systems provide critical ecosystem services such as facilitating drainage and stormwater management, hosting urban floral and faunal biodiversity, reducing evapotranspiration, replenishing groundwater tables, regulating micro climate, mitigating urban floods, and in the larger maintenance of the water cycle (Garcia et al., 2016; J. Li et al., 2020; Lundy & Wade, 2011; MEA, 2005). A unique feature of urban areas is the confluence of grey, blue and green infrastructures that have a significant impact on the microclimate. The issue of scarcity ("too less") is often highlighted as a failure to meet urban water demands, however, the complementary issue of urban flooding ("too much") is an equally pressing matter. Urban flooding due to the lack of appropriate and sufficient drainage systems is an overwhelming issue caused by multiple factors. Understanding drainage patterns and water systems in addition to monitoring rainfall, is crucial to create an urban environment that is resilient to risks like floods. Integrating these pools of data with urban planning methodology is crucial to allow a more compatible practice of city building. In many urban settlements, the increasing erasure of wetlands and water basins has contributed to the poor drainage that leads to floods (Ranganathan, 2015).

Conservation of water resources and wetlands such as lakes, tanks, groundwater aquifers contribute to the larger percolation and drainage of excess water (Alikhani et al., 2021). Creating innovative solutions at the urban region scale by implementing nature-based solutions through the integration of blue, green and grey infrastructures is the need of the hour (Kabisch et al., 2017). This is particularly important since urban water consumption does not occur in isolation and has many backward and forward implications as we highlight in the coming section.

Backward and forward linkages of urban water

The water consumed in urban settlements has consequences that extend well beyond the confines of the city. Cities are not self-sufficient entities and require resources from surrounding regions, this includes natural resources like water. In this section we focus on backward and forward linkages of urban water use to illustrate the impacts of considering the entire water supply chain. We refer to backward linkages as impacts of sourcing water before the supply to urban settlements. This includes ecological impacts on watersheds, biodiversity and non-urban communities. We refer to forward linkages as impacts post the usage of water in an urban area. This includes tracing the path of wastewater and its consequences on settlements downstream an urban area.

Gridded piped water infrastructures rely heavily on large water sources like rivers and reservoirs to fulfil urban water demands. Large scale and consistent extraction from these water bodies can have long lasting impacts on water levels which would in turn impact the biodiversity and hydrology of the waterbody. Additionally, groundwater extraction in aquifers outside the urban jurisdiction has dire effects on communities who rely on them for domestic household use. In rural jurisdictions where agriculture is a major economy, the water diversion to urban areas has severe impacts on the levels of groundwater. The unchecked use of groundwater within and beyond urban landscapes have long term impacts on the resilience of aquifers. Changes to aquifers and watersheds in turn impact the larger ecosystem they belong to, starting with soil biodiversity, a keystone in agricultural economies.

Subsequently, water post use, in the forms of grey and black water, is disposed outside the urban regions it is generated in. Globally, 80% of wastewater is disposed of into the environment (UN, 2018). A combination of treated and untreated wastewater joining a flowing water body like a river adversely impacts communities that are downstream. The contaminants also affect the biochemical properties of the flowing water that impacts life under water. The safe disposal of waste water is embedded not only in SDG 6 (clean water and sanitation) but also in SDG 3 (good health and wellbeing) and SDG 14 (life below water). However, in order to implement coordinated and integrated actions in the future, we must have a clear understanding of the current situation. Creating evidence-based decisions is possible only with accurate granular data that is periodically collected at granular levels as we highlight below.

Poor monitoring of the urban water crisis

A big gap in the way urban water is governed is the lack of accurate timely data around consumption of water. Considering that 80% of global gross domestic product (GDP) is generated in urban settlements, the monitoring of urban resource consumption is key to finding more sustainable ways to develop (Hodson et al., 2012). With regard to water use and consumption, it is critical to collect and record data regarding 1) natural water systems including groundwater consumption, aquifer percolation rates, water quality, drainage patterns, rainfall patterns etc; 2.) consumption data from gridded infrastructures - such as the piped water network; and 3.) consumption data from off-grid sources of water - that are often primary sources of water for marginalised urban residents. These are also key parameters in understanding the relationship of water to other social indicators such as access to health and sanitation as we will show further in this section.

Data collection and monitoring has advanced significantly with the development of new technology that allows for sensitive and real-time data collection and processing. State of the art Internet-of-Things (IoT) technologies allow capturing data such as contamination detection, pipe leakage detection, flood forecasting among several others(Fu et al., 2022). While data around water consumption and treatment is important for urban water management, it also plays a critical role in addressing urban inequality. Using water data in coherence with data around social security indicators such as access to healthcare, education, housing, sanitation etc would enable a more integrated approach to addressing inequality in urban settlements. As Balakrishnan & Anand (2015) and

Bharathi et al. (2022) illustrate in the case of Bengaluru, there is a correlation between access to public services like water and sanitation facilities, to the socio-economic status and housing access of urban residents. Data around urban inequality must be used to fulfil particular needs of marginalised communities outside the gridded infrastructure. In the larger goal to implement SDGs, data around water can be used intersectionally to create infrastructure, governance mechanisms and policies that are context specific and data driven.

In the absence of a holistic data availability, projections around urban water demand have been inflated in large cities such as Mumbai as illustrated by (Tiwale, 2021). Ironically, the increased water demand and supply has not necessarily meant equal access to the resource within the city. Marginalised groups and residents in urban slums still do not have access to safe water. Furthermore, the narrative of scarcity in Mumbai has led to redirecting water from other urban settlements and villages (ibid). At a larger scale, the demand for piped water has led to larger investments in dam projects, interfering with irrigational infrastructures and justifying the diversion of water from the hinterland.

An important point to consider while discussing problems around data and technologies that can capture and record real-time sensitive data is the monetary and human resource investment necessary for them. Countries in the global south often are not able to invest financially in these expensive technologies which not only require expertise to manage but also timely maintenance. Underinvestment in water infrastructure is an existing issue, which we illustrate in the coming section, that will extend to modern technologies without a serious amendment to the status quo.

Underinvestment in urban water systems

Many instances of infrastructure failure have been traced to insufficient re-investment in archaic hydraulic infrastructures and the poor capacity development of staff in the responsible institutions. Underinvestment in water infrastructure has led to high levels of Non-Revenue Water and leakages along the system, which impacts the financial sustainability of water utilities and supply institutions. This can also lead to a shortage of piped water infrastructure as urban boundaries expand (N. Anand, 2015). When the repair and maintenance of piped water infrastructure is not accounted for, it further exacerbates constraints in accessing safe water and its associated health benefits. Paradoxically, increased investment in large water infrastructure like dams has only increased the pressure on old piped urban water infrastructures due to the lack of periodical maintenance (Adams et al., 2020; Barkin, 2011; Hordijk et al., 2014).

Related to the low investment in maintenance and repair of water infrastructure is the trend of water privatisation. Private players entering the water delivery space has commodified water use leading to intensified inequalities across urban settlements. The pressure to increase return on the investment, often drives up the cost of water that many urban residents cannot afford. This system inevitably reproduces patterns of inequity that are manifested spatially across the urban fabric. Despite the focus on price, privatisation in the water sector has not been successful in many countries. After a brief rise in the 1990s, private participation in the sector has significantly decreased (MEA, 2005) resulting in the remunicipalisation of water without appropriate investment in the upskilling of state actors or upgradation of technology (McDonald, 2018).

Capacity challenges

An associated issue is the poor staff capacity around technological and governance upgradation. Investment in capacity training and strengthening is often not part of reform initiatives, creating a gap in the deployment of new technologies and management practices, by governmental system. Water unavailability is often addressed by modernising and upgrading engineering systems without enabling the appropriate knowledge transfer to local stakeholders. (Empinotti et al., 2018). Capacity building challenges however are not restricted to state actors. They can extend to non-state actors who play vital roles in participatory governance. Efforts to enable a larger support system to maintain urban water infrastructures that include non-state actors will allow a more diverse decision-making process. Investing in the training and upgradation of all actors involved in decision making and monitoring and evaluation to bridge knowledge gap, is important. However, the upskilling of state actors on new technologies must be integrated with tacit knowledge on the urban water systems. Magnusson and Van Der Merwe (2005) illustrate the importance of creating context specific policies around urban water use using the case study of Windhoek in Namibia (see Box 2). The Namibian case study highlights the importance of addressing unsustainable water use as well as issues of access to safe water through a participatory governance mechanism that includes non-state actors such as private water vendors in the larger discussions around urban water security. We also use the case of Mexico (see Box 2) where water reforms did not include elements of capacity building and timely flow of finance to local governments, leading to an overall poor governance mechanism. This brings us to the underlying challenge of fragmented governance across sectors and across multiple scales and jurisdictions. The subsequent section delves into issues around fragmented governance and its impact on the siloed practice of urban planning.

Box 1: Water Demand Management in Windhoek, Namibia

Magnusson and Van Der Merwe (2005) describe the water demand management in the city of Windhoek, Namibia through the lens of water justice resulting in a context specific policy architecture. Water managers of Windhoek have to tackle a dual challenge of increasing urbanisation along with unsustainable urban water use across a city that is segregated along serviced and unserviced neighbourhoods. Serviced neighbourhoods are connected to the formal piped water infrastructure while those unserviced by the gridded infrastructure buy water from private water vendors who charge them a costly premium. The result is an urban water management system that can be interpreted and adjusted to the specific characteristics of the neighbourhood's context. In serviced neighbourhoods, water managers chose to increase awareness campaigns around decreasing water use and used a block tariff to incentivise efficient water consumption. Whereas in the unserviced neighbourhoods, water managers chose to include private water vendors into the regulatory framework while they regulated and supervise the water distribution system which increased access to safe and affordable water, without extra investment into infrastructure. This is an effective example of how the demand and need for water are both considered important issues to be addressed by water managers who are instrumental in facilitating and calibrating water management tools.

Box 2: Regulatory challenges in Mexico

Barkin (2011) illustrates the weakness of the Mexican regulatory system despite devolving important responsibilities such as water distribution to local governments, due to lack of timely support. Water distribution in Mexico is the responsibility of local governments following a mandate from the 1983 Constitutional amendment. This was a step to devolve responsibilities from the Federal government to regional and local government. However, many local governments do not have the institutional capacity or financial resources to procure, construct and maintain water infrastructure. Therefore, they are increasingly dependent on federal funds for operations and investment. Adding to this issue is the fact that much water consumption is not measured and many users are not registered in the system, causing heavy revenue losses and weak regulation. Local agencies are often not supervised and do not have a way to address grievances and demand accountability, creating an overall weak regulatory framework.

Fragmented governance structures

The most striking challenge in the governance of urban water is the existing fragmentation of governance and planning institutions across sectors reflected at many scales beginning with the global, sub-national and below. Several scholars have observed that the fragmented nature of governance within countries presents obstacles to effectively coordinating water management and planning with economic and urban development (Cook, 2014; Gupta et al., 2013; Hordijk et al., 2013; Pahl-Wostl & Knieper, 2014). The dissonance arises from the perception of water as an economic resource by institutions focusing on economic development, as a natural resource by those overseeing land use, agriculture, forests, and biodiversity, as a public good by consumers, and as a resource imbued with cultural significance by other stakeholders. Further, long legacies of institutions working with limited purviews and fixed responsibilities has cemented the respective values of water in the way it is governed. This makes it additionally challenging to change fundamental structural patterns even when new integrative policies are introduced. In the case of Botswana illustrated in Box. 3, the disjunct between urban planning and urban water planning has led to an overall poor governance of urban water.

Box 3: Urban water planning in Botswana

Botswana's urban planning and land-use planning has been codified through Development Plans since 1997, after years of haphazard and reactive urban expansion. The practice of urban planning in the country, is a highly centralised process, reflected in administrative structure where local agencies are highly dependent on the central government. The urban planning process involves surveys and data collection around land use patterns, health and education infrastructure, economic activities and employment patterns and housing. However, water demand assessment is addressed only by calibrating the water supply infrastructure. Urban water planning is fragmented across institutions that are in charge of urban planning and water planning and is not practised as an integrated process. This results in a myopic understanding of how urban water must be managed, reducing it to issues of supply and demand rather than a more holistic approach including conservation and management.
(E. Toteng, 2002).

Associated with fragmented urban institutions is the fragmented manner of urban planning praxis. The spatial and financial bias in the planning process, results in the inadequate consideration of natural resources in the urbanisation process. It does not consider perspectives of political ecology and ecosystem services, and minimises issues of water to that of insufficient engineering (Mehta et al., 2014). The benefit of implementing a participatory governance mechanism is the easy inculcation of a participatory planning mechanism. A just urban planning praxis is a crucial to tackle issues of inaccessibility and inequality. By ignoring elements of the urban environment and climate change, cities are facing multiple simultaneous extreme water events. With growing urbanisation and water scarcity, it is critical to unpack such disjuncts and work towards creating a more sustainable and integrated governance and planning framework.

An instance of poor coordination between urban planning and urban wetland conservation can be observed in Bengaluru, India. Bengaluru's urban hydrology depends heavily on the man-made water tanks (a.k.a lakes) built as a network infrastructure across the city over the last two centuries (Unnikrishnan et al., 2017). It was designed to ensure smooth drainage and percolation of surface water to rejuvenate underground aquifers. Periodical encroachment of the water bodies to create urban land has resulted in a rapid decrease in groundwater reserves. Furthermore, dense urbanisation in the city over the three decades has created a more intensive freshwater use in the city, adding pressure on the groundwater supply (Unnikrishnan et al., 2021) . At the moment, the scattered governance of the lakes, in addition to a spatially motivated urban planning practice has resulted in a governance framework that relies on short-term solutions that do not account for natural resource flows.

Another instance of poor urban water management having dire consequences on urban land is that of land subsidence in coastal cities such as New York, Jakarta and Mumbai (Abidin et al., 2011; Nalakurthi & Behera, 2022). A NASA-led study has reported that there have been variations in the land elevation of the New York metropolitan area. They suggest that land use practices are among the reasons for the land subsidence, making it more vulnerable to flood risks (Younger, 2023). Severe groundwater extraction has been attributed to being a major factor in occurrence of land subsidence, making the link between land and water management a critical one.

Opportunities/solutions

Thus far, we have discussed challenges in creating a holistic urban planning system, in the next two sections we explore a few ways in which it can be done. Water sensitive planning, for cities in particular, has been implemented in cities in Australia and China. We look at a few key elements essential in addressing challenges that we have identified above.

Developing water-sensitive plans for cities

A foundational principle while making water sensitive plans is the integration of water and urban planning. Currently urban land use, economic development, transport planning, and water planning are usually parallel processes with different line departments in charge of each process. The spatial and financially biased land-use planning practice should be integrated with the hydraulic practice of water planning. Further, water planning itself must plan for water of all kinds, moving away from the understanding that water security can only be measured through the quantum of water in the gridded piped water supply. Water planning must include blue, green, grey and black waters in the urban settlement since governance of these types of water is intrinsically linked to urban land management. The prior mentioned elements of data around water use could then be seamlessly integrated while making decisions around the urban area in question. Additionally, with a more democratic, egalitarian and participatory planning and governing mechanism, tacit and traditional knowledge around urban water systems can be used to create small scale solutions organically developed with local communities (Sen & Nagendra, 2022). We look at two different approaches to creating water sensitive planning in China and Australia (see Boxes 4 and 5 respectively). Water Sensitive planning includes planning for future infrastructure aligned with the local hydrology. Infrastructure in the urban settlements has focussed dominantly on availability of land and finance. As a result, dimensions of the urban environment are ignored which in turn produce environmental risks such as urban flooding, heat risks etc that are costly to address. When water is considered as the organising principle, the local hydrology becomes central to the way urban settlements are envisioned. Retaining and integrating natural drainage systems with modern sewerage infrastructure for instance would ensure lower backflow. Sustaining and maintaining urban wetlands would increase percolation and recharge of the groundwater, conserving urban biodiversity. (Sridharan et al., 2023).

Box 4: China's Sponge City initiative

China's Sponge City initiative is an active attempt at creating sustainable urban water management through the use of nature-based solutions and usage of tacit knowledge directed at preserving water security and ecological restoration. (X. Li et al., 2016; Yao & Bell, 2022). Innovative building practices such as Water Sensitive Urban Design (WSUD), Sustainable Urban Design System (SUDS), and Low Impact Urban Design and Development (LIUDD) have been implemented in select Chinese cities after 2015. The initiative includes vital actions such as urban natural ecological protection of green spaces and wetland as well as ecological restoration which includes repair and maintenance of ecological infrastructure that were damaged in the process of urban development. In some instances, it has involved planning at a larger regional scale, by connecting surrounding water bodies through human-made channels to increase surface water storage which also improves flood resilience. Small-scale solutions have involved replacing older plumbing systems with new ones to prevent the mixing of stormwater with polluted water which is collected in separate tanks for future natural infiltration into groundwater. (X. Li et al., 2016).

Box 5: Water sensitive planning in Australia

The Australian government's mandate to plan cities using Water Sensitive Urban Design (WSUD) began with its initial focus to manage stormwater appropriately which informed a larger more comprehensive framework to form a sustainable urban water management system (Wong, 2006). The framework considered institutional fragmentation, which used innovative governance arrangements that included local, regional and state department actors. It also considers community participation and engagement by involving them in understanding water problems as well as finding suitable strategies to overcome them. The inclusion of diverse non-state actors has resulted in small scale solutions. The separate collection of household grey water and rainwater and their delivery to tertiary treatment plans, has been successful. Further, the use of recycled wastewater and rooftop harvested water for non-potable purposes reduced the use of freshwater by 80 percent. (Brown et al., 2009; Fogarty et al., 2021; E. Toteng, 2002; E. N. Toteng, 2008; Wong & Brown, 2009).

Addressing fragmentation in governance structures

A closely related element in the pathway to attain better governance of urban water is addressing the fragmentation between governance institutions that are directly and indirectly responsible for water. While this seems simplistic, to have an effective governance mechanism in the long term, the governance process must be a result of an integrated planning and governance system. Agencies and institutions in charge of these processes must work in a coordinated manner even in the absence of a conflict. The disjunct between institutions is a glaring issue that is reflected at many scales beginning with the global, sub-national and below.

Intergovernmental water treaties and agreements have proved to be ineffective in most subnational jurisdictions because sub-national governments have limited mandates, resources and agency in dealing with transboundary issues. A serious recalibration of institutional processes and structures is necessary to address underlying fragmentation of urban and urban governance, to create more holistic governance and institutional arrangements for the future. (Gupta & Pahl-Wostl, 2013).

At the sub-national scale and below, a critical move towards having a robust governance system is by integrating institutional processes across line departments. Fragmentation across ministries and departments in countries is a well-studied concern across the globe (OECD, 2011). A New Culture of Water and Integrated Water Resources Management (IWRM), are suggested responses to the fundamental disconnect between different state and non-state stakeholders (Barkin, 2011; Biswas, 2013). A reconciliation of how water is valued and viewed by different institutional stakeholders is key to establishing an integrated process. This arises from the perception of water as an economic resource by institutions focusing on economic development, as a natural resource by those overseeing land use, agriculture, forests, and biodiversity, as a public good by consumers, and as a resource imbued with cultural significance by other stakeholders. Building a pragmatic regional consensus on the values of water could play an important role in adjusting the goals, mandates and responsibilities of institutions, which is a critical first step in coordination and integration of their functions. (Hubendick & Hebart-Coleman, 2023).

Moving further, the recalibration of institutional processes must include meaningful implementation of participatory processes, without which elements of water justice and equity will not be complete. Participatory processes do exist in most countries in some form, however the main critique of this method of seeking public participation is that it works at hyperlocal or local scales and is challenging to scale up. Community engagement is also challenging across metropolitan and urban regions as most communities are not homogenous and do not have equal power and agency. Despite these valid criticisms, it is important to have participatory processes to include non-state stakeholders, with varying levels of mandate and agency. We use the example from Accra, Ghana (see Box 6) to illustrate the value of participatory processes in creating an adaptive governance system. Water governance is an intrinsically political endeavour and should include stakeholders from all strata to create an equitable system of governance. (Adams et al., 2020; Batchelor, 2007).

Box 6: Participatory processes in urban water governance in Accra, Ghana

Morinville and Harris (2014) illustrate successes and challenges with participatory processes around urban water in Accra, Ghana. They focus on public participation through Local Water Boards (LWB), established by elected representatives from local communities with the help of Ghana Water Company Limited (GWCL), the municipal water supply company. The establishment of LWBs was an attempt to create an adaptive governance system and increase local participation. According to the local context and requirement, LWBs have also taken up additional responsibilities such as being in charge of delivering water to the community by managing water tankers and kiosks among other administrative tasks. LWBs have proven to be beneficial in extending water access to underserved urban communities, the reduction of non-revenue water, in managing water prices and payment processes as well as contributing to infrastructure development at the local scale. However, LWBs depend on voluntary time and effort of individual members without compensation, highlighting the burden of devolution and participatory governance on local community members. They also report that LWBs are not effective in all the communities they have been established in, impacting the overall adaptive governance of the city. This example highlights the complexities of participatory urban governance strategies. Public participation poses numerous challenges, among which the social power and clout of individuals to influence processes stand out as significant (Pahl-Wostl, 2009).

Lastly, the inculcation of traditional/tacit knowledge of water systems into the larger political and technocratic process of water governance is important to create a sustainable and equitable urban governance system. Modern water infrastructures rely heavily on gridded piped water supply is the major water source. This has proved to be insufficient in many cities and towns of the global south, resulting in large fractions of urban consumers relying on supplementary sources of water. Rejuvenation of traditional decentralised water infrastructures could help conserve groundwater and revive urban wetlands. The integration of modern scientific methods with traditional technology is vital to ensure urban water security and conservation of the urban environment. Conservation of urban wetlands and green infrastructures with modern technology is still challenging. We use the case study of Jodhpur (see Box 7) to highlight how an incomplete integration of traditional water systems with the grid-based piped water system exacerbated environmental risks (Mehltretter et al., 2023; van de Meene et al., 2011).

Box 7: Use of traditional water knowledge in Rajasthan, India

The water scarce Indian state of Rajasthan has many traditional water conserving technologies that have enabled efficient collection of sparse rainfall. Over the last century, these water bodies and auxiliary drainage infrastructure have gone to disuse. In an attempt to conserve water, the city of Jodhpur rejuvenated a few stepwells, *Jhalras*, that have significantly increased the groundwater table. However, as the city's piped water infrastructure is the major source of water, the dependence on traditional water harvesting systems has reduced considerably. The rejuvenation of the *Jhalras* along with dependence on piped water supply has led to a situation where a rising groundwater table has become a peril. The rejuvenation of the water bodies in addition to excess wastewater has contributed to shallow groundwater that inundates buildings and causes property damage. The combined volume of water also causes backflow of sewers and water logging. The case study highlights the importance of integrating technologies appropriately, in a given context, where traditional tacit knowledge and modern scientific method must be implemented in synergy. (Sridharan et al., 2023).

References

Abidin, H. Z., Andreas, H., Gumilar, I., Fukuda, Y., Pohan, Y. E., & Deguchi, T. (2011). Land subsidence of Jakarta (Indonesia) and its relation with urban development. Natural Hazards, 59(3), 1753–1771. https://doi.org/10.1007/s11069-011-9866-9

Adams, E. A., Zulu, L., & Ouellette-Kray, Q. (2020). Community water governance for urban water security in the Global South: Status, lessons, and prospects. Wiley Interdisciplinary Reviews: Water, 7(5), e1466.

Alikhani, S., Nummi, P., & Ojala, A. (2021). Urban wetlands: A review on ecological and cultural values. Water, 13(22), 3301.

Amankwaa, G., Heeks, R., & Browne, A. (2022). Water ATMs and Access to Water: Digitalisation of Off-Grid Water Infrastructure in Peri-Urban Ghana. Water Alternatives, 15, 733–753.

Anand, N. (2015). Leaky states: Water audits, ignorance, and the politics of infrastructure. Public Culture, 27(2), 305–330.

Anand, N. (2017). Hydraulic City: Water and the Infrastructures of Citizenship in Mumbai. Duke University Press. https://doi.org/10.1215/9780822373599

Anand, S., & Sami, N. (2016). Scaling Up, Scaling Down: State Rescaling along the Delhi—Mumbai Industrial Corridor. Economic and Political Weekly, 50–58.

Balakrishnan, K., & Anand, S. (2015). Sub-cities of Bengaluru: Urban Heterogeneity through Empirical Typologies. Economic and Political Weekly, 50(22), 63–72.

Barkin, D. (2011). The governance crisis in urban water management in Mexico. In Water resources in Mexico: Scarcity, degradation, stress, conflicts, management, and policy (pp. 379–393). Springer.

Batchelor, C. (2007). Water governance literature assessment. International Institute for Environment and Development, 2523.

Beard, V. A., & Mitlin, D. (2021). Water access in global South cities: The challenges of intermittency and affordability. World Development, 147, 105625. https://doi.org/10.1016/j.worlddev.2021.105625

Bharathi, N., Malghan, D., Mishra, S., & Rahman, A. (2022). Residential segregation and public services in urban India. In Urban Studies (Vol. 59, Issue 14, pp. 2912–2932).

Biswas, A. K. (2013). Integrated water resources management: Is it working? In Integrated Water Resources Management in Latin America (pp. 5–22). Routledge.

Brown, R. R., Keath, N., & Wong, T. H. F. (2009). Urban water management in cities: Historical, current and future regimes. Water Science and Technology, 59(5), 847–855. https://doi.org/10.2166/wst.2009.029

Colenbrander, S. (2016). Cities as engines of economic growth: The case for providing basic infrastructure and services in urban areas. IIED. https://www.iied.org/10801iied

Cook, C. (2014). Governing jurisdictional fragmentation: Tracing patterns of water governance in Ontario, Canada. Geoforum, 56, 192–200. https://doi.org/10.1016/j.geoforum.2014.07.012

Empinotti, V. L., Gontijo, W. C., & De Oliveira, V. E. (2018). Federalism, water, and (de)centralization in Brazil: The case of the São Francisco River water diversion. Regional Environmental Change, 18(6), 1655–1666. https://doi.org/10.1007/s10113-018-1371-1

Fogarty, J., van Bueren, M., & Iftekhar, M. S. (2021). Making waves: Creating water sensitive cities in Australia. Water Research, 202, 117456.

Fu, G., Jin, Y., Sun, S., Yuan, Z., & Butler, D. (2022). The role of deep learning in urban water management: A critical review. Water Research, 223, 118973. https://doi.org/10.1016/j.watres.2022.118973

Garcia, X., Barceló, D., Comas, J., Corominas, L., Hadjimichael, A., Page, T. J., & Acuña, V. (2016). Placing ecosystem services at the heart of urban water systems management. Science of the Total Environment, 563, 1078–1085.

Grafton, Q., Gupta, J., Revi, A., Mazzucato, M., Okonjo-Iewala, N., Rockström, J., Shanmugaratnam, T., Aki-Sawyerr, Y., Barcena Ibarra, A., Cantrell, L., Espinosa, M. F., Ghosh, A., Ishii, N., Jintiach, J. C., Qui, B., Ramphele, M., Urrego, M. R., Serageldin, I., Damania, R., … Reale, I. (2023). The What, Why and How of the World Water Crisis: Global Commission on the Economics of Water Phase 1 Review and Findings Issue. DOI 10.25911/GC7J-QM22. https://openresearchrepository. anu. edu. au/handle ….

Gupta, J., Akhmouch, A., Cosgrove, W., Hurwitz, Z., Maestu, J., & Ünver, O. (2013). Policymakers' reflections on water governance issues. Ecology and Society, 18(1).

Gupta, J., & Pahl-Wostl, C. (2013). Global water governance in the context of global and multilevel governance: Its need, form, and challenges. Ecology and Society, 18(4).

Hodson, M., Marvin, S., Robinson, B., & Swilling, M. (2012). Reshaping urban infrastructure: Material flow analysis and transitions analysis in an urban context. Journal of Industrial Ecology, 16(6), 789–800.

Hordijk, M., Miranda Sara, L., Sutherland, C., Sydenstricker-Neto, J., Jo Noles, A., & Rodrigues Batata, A. G. (2013). Water governance in times of uncertainty: Complexity, fragmentation, innovation.

Hordijk, M., Sara, L. M., & Sutherland, C. (2014). Resilience, transition or transformation? A comparative analysis of changing water governance systems in four southern cities. Environment and Urbanization, 26(1), 130–146.

Hubendick, L., & Hebart-Coleman, D. (2023). Water Governance Processes: Cases from Cambodia, Laos, Jordan and Bosnia and Herzegovina. Stockholm International Water Institute, SIWI. https://siwi.org/wp-content/uploads/2023/05/water-governance-processes.pdf

Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (2017). Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice. Springer Nature.

Koop, S. H. A., Koetsier, L., Doornhof, A., Reinstra, O., Van Leeuwen, C. J., Brouwer, S., Dieperink, C., & Driessen, P. P. J. (2017). Assessing the governance capacity of cities to address challenges of water, waste, and climate change. Water Resources Management, 31, 3427–3443.

Li, J., Wang, Y., Ni, Z., Chen, S., & Xia, B. (2020). An integrated strategy to improve the microclimate regulation of green-blue-grey infrastructures in specific urban forms. Journal of Cleaner Production, 271, 122555. https://doi.org/10.1016/j.jclepro.2020.122555

Li, X., Li, J., Fang, X., Gong, Y., & Wang, W. (2016). Case studies of the sponge city program in China. World Environmental and Water Resources Congress 2016, 295–308.

Lundy, L., & Wade, R. (2011). Integrating sciences to sustain urban ecosystem services. Progress in Physical Geography, 35(5), 653–669.

Magnusson, T. S., & Van Der Merwe, B. (2005). Context driven policy design in urban water management. A case study of Windhoek, Namibia. Urban Water Journal, 2(3), 151–160. https://doi.org/10.1080/15730620500236468

McDonald, D. A. (2018). Remunicipalization: The future of water services? Geoforum, 91, 47–56.

MEA. (2005). Millennium Assessment Reports: Freshwater Ecosystem Services (Millenium Ecosystem Assessment). United Nations. https://www.millenniumassessment.org/documents/document.312.aspx.pdf

Mehltretter, S., Longboat, S., Luby, B., & Bradford, A. (2023). Indigenous and Western knowledge: Bringing diverse understandings of water together in practice. Technical Report), Global Commission on the Economics of Water, Paris.

Mehta, V. K., Goswami, R., Kemp-Benedict, E., Muddu, S., & Malghan, D. (2014). Metabolic urbanism and environmental justice: The water conundrum in Bangalore, India. Environmental Justice, 7(5), 130–137.

Morinville, C., & Harris, L. M. (2014). Participation, politics, and panaceas: Exploring the possibilities and limits of participatory urban water governance in Accra, Ghana. Ecology and Society, 19(3). https://www.jstor.org/stable/26269615

Nalakurthi, N. V. S. R. N., & Behera, M. R. (2022). Detection of Land Subsidence using Sentinel-1 interferometer and its relationship with Sea-Level-Rise, Groundwater, and Inundation: A case study along Mumbai Coastal city. https://doi.org/10.21203/rs.3.rs-1392714/v1

OECD. (2011). Water Governance in OECD Countries. https://www.oecd-ilibrary.org/content/publication/9789264119284-en

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change, 19(3), 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Pahl-Wostl, C., & Knieper, C. (2014). The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes. Global Environmental Change, 29, 139–154. https://doi.org/10.1016/j.gloenvcha.2014.09.003

Ranganathan, M. (2015). Storm drains as assemblages: The political ecology of flood risk in post-colonial Bangalore. Antipode, 47(5), 1300–1320.

Sen, A., & Nagendra, H. (2022). Rethinking inclusivity and justice agendas in restoration of urban ecological commons: A case study of Bangalore lakes. In Lakes & Reservoirs: Science, Policy and Management for Sustainable Use (Vol. 27, Issue 4, p. e12408). https://onlinelibrary.wiley.com/doi/abs/10.1111/lre.12408

Sridharan, N., Pandey, R. U., & Berger, T. (2023). Co-production through tacit knowledge for water resilience. Land Use Policy, 126, 106446. https://doi.org/10.1016/j.landusepol.2022.106446

Tiwale, S. (2021). Number Narratives of Water Shortages: Delinking Water Resources Development from Water Distribution in Mumbai, India. Water Altern, 14, 841–865.

Tomer, S. K., Sekhar, M., Balakrishnan, K., Malghan, D., Thiyaku, S., Gautam, M., & Mehta, V. K. (2021). A model-based estimate of the groundwater budget and associated uncertainties in Bengaluru, India. Urban Water Journal, 18(1), 1–11.

Toteng, E. (2002). Understanding the disjunction between urban planning and water planning and management in Botswana: A challenge for urban planners. International Development Planning Review - INT DEV PLAN REV, 24, 271–298. https://doi.org/10.3828/idpr.24.3.3

Toteng, E. N. (2008). The effects of the water management framework and the role of domestic consumers on urban water conservation in Botswana. Water International, 33(4), 475–487.

UN. (2011). Water and Industry in the Green Economy (Information Briefs). UNW-DPAC.

UN. (2018). World urbanization prospects: The 2018 revision. United Nations, Department of Economic and Social Affairs, Population Division. https://www.un-ilibrary.org/content/books/9789210043144

UN. (2024). The United Nations World Water Development Report 2024: Water for prosperityand peace. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000388952/PDF/388952eng.pdf.multi

Unnikrishnan, H., B., M., Nagendra, H., & Castán Broto, V. (2021). Water governance and the colonial urban project: The Dharmambudhi lake in Bengaluru, India. Urban Geography, 42(3), 263–288. https://doi.org/10.1080/02723638.2019.1709756

Unnikrishnan, H., Mundoli, S., & Nagendra, H. (2017). Making water flow in Bengaluru: Planning for the resilience of water supply in a semi-arid city. 2(1), 1–11.

van de Meene, S. J., Brown, R. R., & Farrelly, M. A. (2011). Towards understanding governance for sustainable urban water management. Symposium on Social Theory and the Environment in the New World (Dis)Order, 21(3), 1117–1127. https://doi.org/10.1016/j.gloenvcha.2011.04.003

Wong, T. H., & Brown, R. R. (2009). The water sensitive city: Principles for practice. Water Science and Technology, 60(3), 673–682.

World Bank. (2016). High and Dry: Climate Change, Water, and the Economy [Text/HTML]. World Bank. https://www.worldbank.org/en/topic/water/publication/high-and-dry-climate-change-water-and-the-economy

Yao, Z., & Bell, S. (2022). Tacit knowledge in water management: A case study of Sponge City. UCL Open Environment, 4.

Younger, S. (2023, September). NASA-Led Study Pinpoints Areas of New York City Sinking, Rising. NASA. https://climate.nasa.gov/news/3285/nasa-led-study-pinpoints-areas-of-new-york-city-sinking-rising

iihs®
INDIAN INSTITUTE FOR
HUMAN SETTLEMENTS

IIHS BENGALURU CITY CAMPUS
197/36, 2nd Main Road, Sadashivanagar, Bengaluru
560080, India
T +91 80 6760 6666 | F +91 80 2361 6814

IIHS CHENNAI
Floor 7A, Chaitanya Exotica, 24/51 Venkatnarayana
Road, T Nagar, Chennai 600 017, India
T +91 44 6630 5500 / 6555 6590

IIHS DELHI
803, Suriya Kiran, 19, Kasturba Gandhi Marg,
New Delhi 110 001, India
T +91 11 4360 2798 | F +91 11 2332 0477

IIHS MUMBAI
Flat No.2, Purnima Building, Patel Compound, 20-C,
Napean Sea Road, Mumbai, 400 006, India
T +91 22 6525 3874