ENSURING WATER SECURITY

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White Paper.

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Ensuring Water Security

White Paper

United Cities and Local Governments

C40 CITIES

Ministry of Housing and Urban Affairs
Government of India

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Abbreviations

BOT	Build-Operate-Transfer
DESC	Dorset Environmental Science Centre
EDS	Event Detection System
EPC	Engineering-Procurement-Contracts
EU	European Union
G20	Group of Twenty
GHG	Greenhouse gas
HAM	Hybrid Annuity Model
ICT	Information and Communications Technology
IEC	Information, Education, and Communication
IUWM	Integrated urban water management
RCA	River Cities Alliance
SDG	Sustainable Development Goal
U20	Urban 20
UN	United Nations
URMP	Urban River Management Plan
WSUD	Water Sensitive Urban Design

01/ Introduction

" काल करे सो आज कर,
आज करे सो अब
पल में परलय होएगी,
बहुरि करेगा कब "

(What you can do tomorrow do it today, what you can do today, do it now. There is no time like the present)

Kabir, Indian mystic poet and saint

In so many ways, this 15th century Indian saying, resonates aptly with the urgency required in the present times to take actions for water security on multiple fronts.

First, already about two billion people worldwide do not have access to safe drinking water[1], and roughly half of the world's population is experiencing severe water scarcity for at least part of the year.[2] These numbers are expected to increase, exacerbated by climate change and population growth[3]. Second, globally, 44% of household wastewater is not safely treated[4]. Given that water quality data is not collected routinely in a majority of countries means that over 3 billion people are at risk because their exposure to environmental faecal contamination increases their already stressed health vulnerabilities. Third, around 74% of natural disasters between 2001 and 2018 were water-related and during the past 20 years, floods and droughts affected over 3 billion people, and caused economic damage of almost US$700 billion[5]. Alarmingly, since 2000, flood-related disasters have increased by 134%[6]. Inevitably, all of these impacts the poor and disadvantaged disproportionally in all global economies.

Achieving water security is inherently central to human security. A case in point is the synergy of the Sustainable Development Goal for water (SDG-6) with almost all other SDGs **(Figure 1)**. A study[7] of the influence of good water management on the 169 targets of the 17 SDGs revealed that it directly influences 50 of these targets and indirectly influences a further 34. The interconnections between the goals, however, may manifest differently in contexts of developed as compared to developing countries.

Ironically, for a resource that is undeniably vital for humankind's survival, water is itself under threat due to anthropogenic activities. The concerns with water security are not new. Approximately four decades ago, Malin Fredrika Sofia Sundberg-Falkenmark, through a seminal work[8], introduced the Falkenmark Index to link per capita availability of water with sustainable exploitation of water resources. Since then, while the knowledge on the subject matter has improved rapidly, its application into on-the-ground action has been relatively slower.

One of the reasons for this gap between knowledge and implementation is that water security is perceived differently by different disciplines[9]. This means, for example, that while on one hand agricultural stakeholders equate water security as an input for food security; on the other hand, public health practitioners view water security

1 UN Water (2021). Summary Progress Update 2021: SDG 6 – water and sanitation for all. Accessed 01 June 2023 from website https://www.unwater.org/publications/summary-progress-update-2021-sdg-6-water-and-sanitation-all
2 IPCC (2021). Sixth Assessment Report: Working Group II - Impacts, Adaptation and Vulnerability
3 World Meteorological Organisation (2021) State of Climate Services
4 UN Water (2021). Summary Progress Update 2021: SDG 6 – water and sanitation for all. Accessed 01 June 2023 from website https://www.unwater.org/publications/summary-progress-update-2021-sdg-6-water-and-sanitation-all
5 UN Water (2020). World Water Development Report 2020: Water and Climate Change
6 World Meteorological Organisation (2021) State of Climate Services
7 Wong, T.H.F (2016). Human Settlements - A Framing Paper for the High-Level Panel on Water, Australian Water Partnership, ISBN 978-1-921543-20-3, 15pp. https://waterpartnership.org.au/wp-content/uploads/2016/08/HLPW-Human-Settlements.pdf
8 Falkenmark M. (1986). Fresh water: Time for a modified approach. Ambio,15:192-200.
9 Cook, C. and Bakker, K. (2012). Water security: Debating an emerging paradigm. Global Environmental Change, 22(1): 94-102.

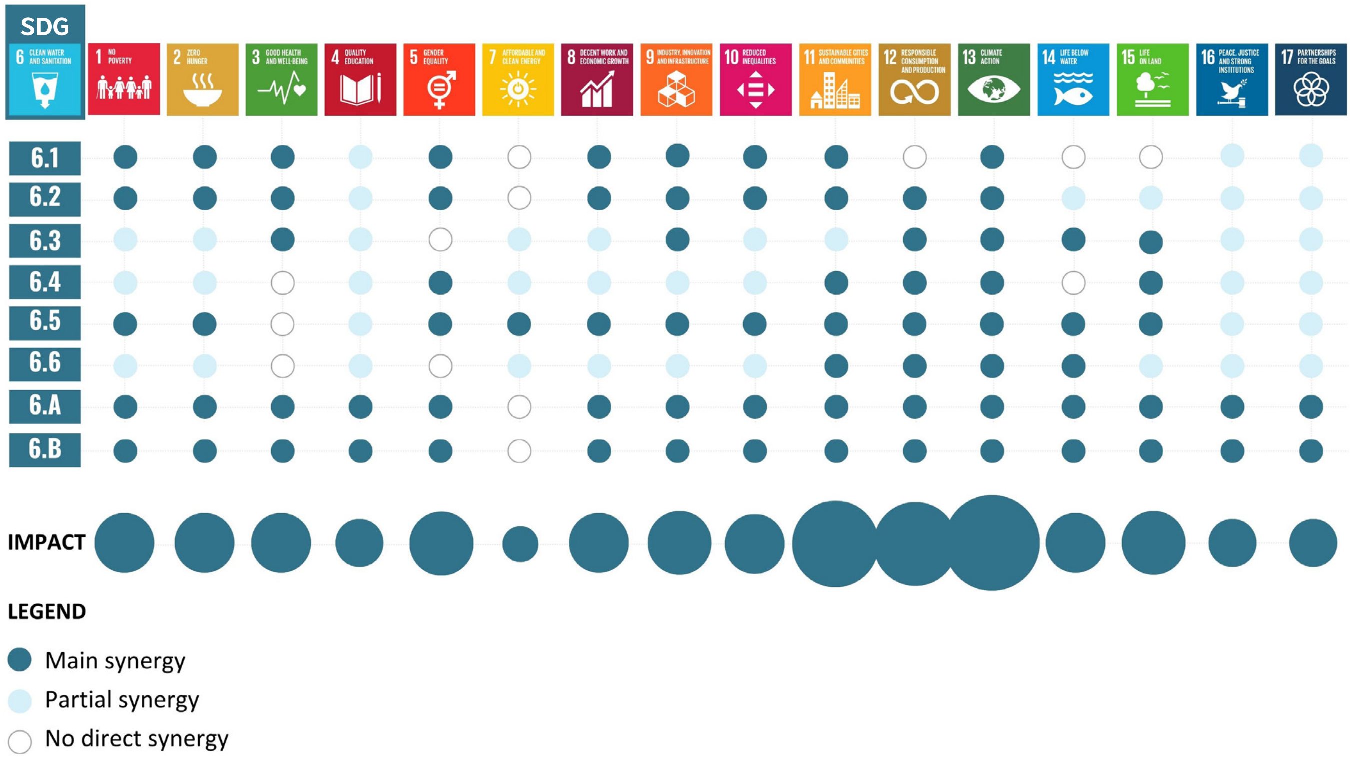

Figure 1: Synergies of SDG 6 with other SDGs
Source: Authors' depiction

through the lens of supply security and prevention of contamination in the water. It was only in 2013 that UN Water proposed a universal definition for water security as *"the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability"*, which is widely accepted today.

This notion of water security clearly extends beyond the physical availability of water and suggests a multi-faceted framing of the definition of water security that must address different dimensions. Most countries in the world are exposed to any combinations of these dimensions at different times and the relative significance of each one is determined by site-specific institutional, biophysical and climatic context.

That water security is multi-dimensional automatically calls for a coordinated management approach to achieve it in a holistic manner. The need for such an approach for water management is even more crucial in urban areas, given that urbanisation is a core driving element of demographic and water mega-trends[10]. According to the World Bank,[11] approximately 56% of the world's population i.e., 4.4 billion inhabitants live in cities. This trend is expected to continue, with the urban population more than doubling its current size by 2050, at which point nearly 7 of 10 people will live in cities. This will invariably lead to increased demands on water resources. Statistics suggest that between 2000 and 2021 the number of city inhabitants lacking safely managed drinking water nearly doubled[12]. With global water demand projected to increase by 20-30% by 2050[13], the situation will only exacerbate unless corrective action is urgently taken.

The scope of urban water management generally involves four aspects–(a) protecting water sources and ecosystems and harnessing them sustainably, (b) providing good quality and reliable water supply to the residents, (c) collecting, treating, and safely disposing the used water (also referred to as wastewater) that is generated within the city, and (d) drainage and flood management including management of storm-water runoff as a resource and for protection of the receiving water environment.

10 Chapagain, K., Aboelnga, H.T., Babel, M.S., Ribbe, L., Shinde, V.R., Sharma, D. and Dang, N.M. (2022). Urban water security: A comparative assessment and policy analysis of five cities in diverse developing countries of Asia. Environmental Development, Volume 43:100713.
11 World Bank (2023).
12 UN Water (2021). Summary Progress Update 2021: SDG 6 – water and sanitation for all. Accessed 01 June 2023 from website https://www.unwater.org/publications/summary-progress-update-2021-sdg-6-water-and-sanitation-all
13 UN (2018). World Water Development Report 2018.

At its core, contemporary integrated management of the urban water sector is a social-technical endeavour in harnessing science and technology, while cognisant of the social and institutional drivers underpinning urban water governance. Furthermore, there are environmental stewardship, natural capital regenerative, ecological landscapes and ecosystem services, and urban liveability dimensions that communities are now demanding.

Within an urban setting, there are multiple sources of water that could be use on a fit-for-purpose basis, i.e. for consumptive and non-consumptive purposes. Key to managing and harnessing these resources is identifying and strengthening the management synergies among the water sources while reducing trade-off in terms of infrastructure investments and environmental impacts **(Figure 2)**. Such a synergistic relationship will help make the transition from linear management of water resources to circular and integrated management through the widely acclaimed Reduce-Recycle-Reuse-Restore-Recharge principles[14].

Overall, integrated management of the water sector can change the 'business as usual' approach towards water management and carve out space for application of non-conventional solutions. For example, several of these solutions help reduce the demand for freshwater (demand management), which is increasingly becoming difficult to harness in many parts of the world. Likewise, some solutions involve integrating infrastructure planning, spatial land use planning and urban design that not only help in alleviating flood risks but also augment availability of usable water, and other multiple environmental and urban liveability benefits.

This white paper is an earnest endeavour to facilitate a change in the current water management practices in cities that are typically engineering-driven, carried out in 'silos', and rely on grey infrastructural interventions. It seeks to do so by proposing tangible recommendations for strengthening integrated water management in cities– under the ambit of the Urban 20 (U20) priority area

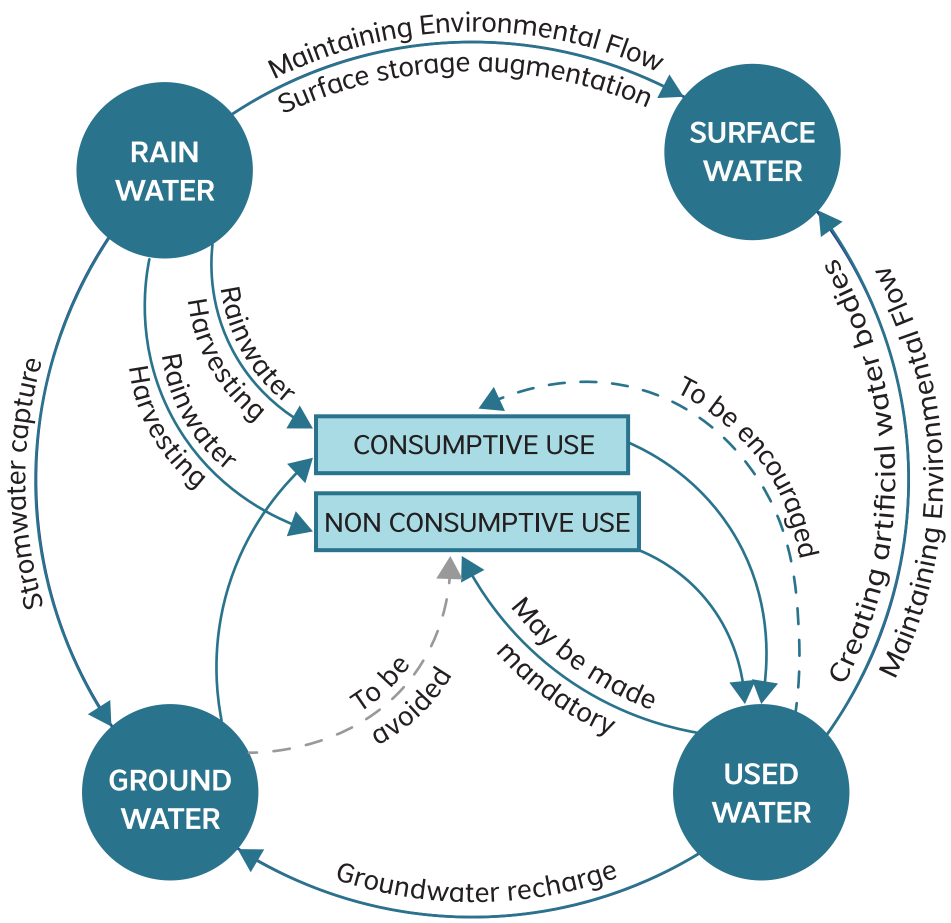

Figure 2 : Synergistic circular interactions among the elements of the urban water sector
(Authors' depiction)

14 Kulkarni, H. and Shah, M. (2015). Urban water systems in India: Typologies and Hypotheses. Economic and Political Weekly, 50:30.

"Ensuring Water Security", as part of the sixth cycle of the U20 under India's G20 Presidency.

The white paper canvasses actions to operationalise contemporary global initiatives and narratives for urban water security by adaptation to local institution and biophysical context. The SDG 6 Global Acceleration Framework, for example, is one such initiative where one of the key thrust areas is to make SDG 6 everyone's business by fostering collaboration across sectors, which is at the heart of integrated water management.

02/

Water Security : Key Challenges

Currently, the progress that countries make against the indicators of SDG 6 is considered, in some way, to be a measure of the status of water security. However, as highlighted in the previous section, the gamut of water security is far more than what is captured in the SDG 6 indicators (Refer annexure). Moreover, these indicators are measured at a national level that includes both urban and rural areas and may mask issues at city-scale. For intra-country analysis of urban water security, it would be prudent for nations to design evaluation systems that capture the management interactions among the four dimensions of integrated water management–water resources and ecosystems, water supply, used water, and drainage and flood management. There are several examples of such evaluation systems[15 16 17], that may be used for this purpose.

An assessment[18] of G20 countries on various parameters of water security using the SDG indicators brings out some interesting findings. From the standpoint of urban population access to safe drinking water, nine out of the twenty countries claim 100% coverage. All other countries report more than 95% coverage on this indicator. Likewise, all countries report more than 80% coverage against the indicator pertaining to urban population access to basic and safely managed sanitation. In contrast, only seven out of the twenty countries have reported that 80% or more of their urban household wastewater is safely treated. The progress in the remaining countries is substantially lower.

A major area of concern is the significantly low reuse of treated used water in almost all G20 countries despite the fact that a significant percentage of used water is treated in most countries. There are countries such as France, Italy, China, Germany and the UK that treat more than 95% of used water and yet the reuse percentage ranges from only 2-3% in Italy and Germany to only 17-18% in China and France with the UK in the middle at only 8%. In a few countries, while the percentage of reuse is high, the volume of water actually reused is quite low as the percentage of used water treated is very low. Given that used water is a significant resource and instances of water shortages have been on the rise in the G20 nations, there has to be a concerted effort both towards treatment of used water as well as the reuse of treated used water.

In terms of water related disasters, numerous studies[19 20], suggest that all G20 nations are vulnerable to extreme events, especially floods. China, India, Indonesia and Japan have the highest proportion of the population vulnerable to flooding. In case of the first three, the absolute number of people at risk is extremely high as the total population of China, India and Indonesia is also significantly high. Eleven countries–Argentina, Australia, Brazil, Canada, France, Mexico, Japan, Republic of Korea, Saudi Arabia, USA, and the UK have more than 80% of the population living in urban areas, with a number of cities densely populated. Hence, it is the urban populace that is most at risk in these countries, pointing towards the need for developing urban flood management strategies as part of the integrated water management framework.

15 Babel, M.S, Shinde, V.R., Sharma, D. and Dang, N.M. (2020). Measuring urban water security: A vital step for climate change adaptation. Environmental Research, 185, https://doi.org/10.1016/j.envres.2020.109400.
16 Chang, Y. and Zhu, D. (2020). Urban water security of China's municipalities: Comparison, features and challenges. Journal of Hydrology, Volume 587, 125023
17 Krueger, E., Rao, P.S.C., and Borchardt ((2019). Quantifying urban water supply security under global change. Global Environmental Change, 56: 66-74
18 SDG Tracker accessed on 5 June 2023 from website https://hlpf.un.org/tools/sdg-tracker
19 Rentschler, J., Salhab, M. and Jafino, B.A. (2022). Flood exposure and poverty in 188 countries. Nature Communications, Volume 13, Article, 3527.
20 Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H. and Kanae, S. (2013). Global flood risk under climate change. Nature Climate Change, 3: 816-821

With climate change already beginning to manifest its effects, the challenges for water management in cities are becoming more pronounced. Hence, the conventional management protocols practiced thus far may not necessarily be appropriate for addressing new and emerging issues. Cities and countries that have performed well on water management in the past will also need to be agile in terms of adapting their systems to respond to such changes.

Since the turn of the century, the advocacy for an integrated approach for water management in cities has been louder and stronger resulting in different variants of this approach, e.g., water-sensitive cities in Australia[21], sponge cities in China[22], and urban river management plans in India[23], among others. Adoption of these concepts/ philosophies, and others shows that some initial traction has begun for cities across the world to adopt integrated management of water. This will have to be progressively enhanced in the future and ideally, become a norm. While there are sporadic examples of integrated urban water management in G20 countries, many cities have been unable to adopt it enthusiastically for several reasons.

First, the interface between urban and rural is consistently becoming blurred. The omnipresent peri-urban context of expanding urban spaces makes it challenging to demarcate the necessary 'boundary conditions' for management. Not only does this have implications on sustainable use of available water sources, the ambiguity of jurisdiction affects the 'formal' or legal provision of water supply to such areas.

Second, rapid urbanisation results in a perpetual 'catch-up' game for city officials to augment supplies that are invariably falling short of a growing demand, leaving them with very little scope and bandwidth to attempt new and creative approaches.

Third, there is a genuine lack of awareness and knowledge about the need and benefits of integrated water management in cities, especially in smaller cities. The focus is predominantly on the 'engineering' water-supply related aspects of water management. The lack of a broader perspective offers little to enable water managers and city officials to challenge the 'business as usual' scenario. Very few cities and countries have undertaken expansion of the capacities of the 'water departments', for example, in terms of expertise required with new technology or for assessing/ monitoring the socio-economic and environmental impacts of adopting any solution.

Fourth, water managers are not equipped well enough to handle contentious tradeoffs. This is particularly relevant when dealing with aspects of economic development vs environmental protection. In the absence of skills and institutional capacity to judiciously maneuver through such tradeoffs, invariably economic development takes priority over ecological considerations instead of the two being complementary to each other.

Fifth, the institutional inertia and silos within the government set-up makes it challenging to coordinate and work together towards implementation of integrated water management strategies[24]. Fragmentation in the functioning and prioritisation of projects in isolation by different organisations often lead to competing projects that counter weigh the co-benefits.

Additionally, the following aspects also limit a city's capacity or vision to implement integrated water management strategies:

a. paucity of financial resources
b. lack of spatially disaggregated data required for informed decision making
c. piecemeal approach/ knee-jerk reactions towards addressing problems in part, not considering the inter-connectedness of the elements of the urban water cycle.

How the G20 nations approach the pursuit of integrated water management will have far reaching implications not only within the G20 community but beyond. This will be central to action plans for addressing the glaring gaps in the sustainable and efficient management of water resources that averts humanitarian, economic and developmental challenges.

21 Wong, T.H.F., Rogers, B. and Brown, R. (2020). Transforming cities through water sensitive principles and practices, Perspective OneEarth, 3(4): 436-447
22 Jiang, Y., Zevenbergen, C. and Ma. Y. (2018). Urban pluvial flooding and stormwater management: A contemporary review of China's challenges and "sponge cities" strategy, Environmental Science and Policy, Volume 80: 132-143
23 NIUA and NMCG (2020). Urban River Management Plan: Components and Guidance Note. Accessed 15 March 2023 from website https://niua.in/waterandenvironment/wp-content/uploads/2022/03/URMP-Framework-pdf
24 Bassi, N. and Kumar, M.D. (2012). Addressing the civic challenges: perspective on institutional change for sustainable urban water management in India. Environment and Urbanisation Asia, 3(1), pp.165-183.

03/ Recommendations for Strengthening Integrated Water Management in Cities

Integrated water management is a process and not an outcome. This is because the water management needs in cities, and related responses, are very dynamic, and change as a city grows and expands. Additionally, there are many challenges faced by the water sector today (e.g., climate change, pandemics, depleting resources) that were not so relevant in the past. Hence, contemporary urban water management models will need to be flexible to address not just current but future needs as well. Cities will, therefore, need to adopt a progressive approach for implementing integrated water management, aspiring to continuously improve on the existing condition, while at the same time account for new and emerging needs and contexts.

Additionally, it is becoming increasingly evident that integrated water management is a transdisciplinary subject that requires water managers to work on aspects that are beyond their core domain of expertise. This includes the indirect, yet critical, inter-linkages of water with gender equity, poverty alleviation, livelihoods and other social dimensions. Similarly, protection and regeneration of forests, soils, wetlands etc., contributes towards water availability and water quality, and strengthens the resilience of watersheds, thus complementing investments in physical infrastructure and disaster preparedness.[25]

In order to facilitate this paradigm shift in the pursuit of enhanced integrated water management, this paper proposes an eight-point agenda for cities to consider and adopt.

1. Re-imagine the role of water managers
2. Leverage urban planning instruments to promote integrated urban water management
3. Strengthen the data ecosystem within cities
4. Integrate nature-based solutions in urban water management
5. Transition from mono-functional to multi-functional infrastructure
6. Invest in social and human capital
7. Explore non-traditional financing sources
8. Encourage city partnerships and networks

3.1 Re-imagine the role of water managers

Integrated water management requires a transdisciplinary approach for implementation, which essentially means water managers of the future will need to have knowledge about different disciplines and the ability to apply that knowledge to address the management agenda comprehensively. For example; in addition to engineering knowledge about hydrology, hydraulics and catchment dynamics; designing a storm water management system will also require knowledge about ecology (to manage the ecosystem within the buffers), urban design (to integrate features like bioswales and rain-gardens in the larger stormwater management plan), sociology (to influence behavioural change for maintenance of the system), landscape architecture (to ensure seamless integration into the city profile), among others.

This is starkly different from what is commonly practiced today, where the focus of water managers is disproportionately skewed in favour of engineering solutions. Engineers conceptualise, plan and implement most of the water management agenda for the city, which invariably results in largely hard infrastructural solutions. Cities must invest in building capacities at different levels of governance in transdisciplinary thinking and application. Engineers and managers of the future should be trained in systems thinking.

Even with improved capacities, a key impediment for water managers is the lack of coordination and cooperation amongst different water-related agencies. This is less

25 https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-6

challenging in cities like Singapore where the water sector is being managed by an apex agency. Such a model may work in cities where the scale of operations is manageable. However, in larger cities there will invariably be more than one agency responsible for managing the different elements of the water sector. In such cities, it is vital to have a coordinated effort among all these agencies in order to achieve the outcomes of integrated water management. Hence, while the agencies may continue to operate independently, the horizontal channels of communication among the agencies must be kept open and ideally a common database. This is to ensure that an agency is aware of the plans and initiatives of the others, which will aid inter-sectoral decision making. Melbourne is a good example of this model, where water-related agencies meet in a workshop-like format every six months to share information about their plans and projects. The city also has an overarching agency encompassing environment, water, land planning, and climate change to foster greater collaboration and accountability for integrated water management.

3.2 Leverage urban planning instruments to promote integrated urban water management

Growth in cities, especially in the developing nations of the G20, is inevitable. There is compelling evidence that until recently the sole objective of this growth was the pursuit of economic development, which unfortunately came at the cost of depleting natural resources including water. With improved awareness that sustainable economic development cannot be achieved without environmental considerations, the last two decades have seen a paradigm shift in the way city growth is planned and conceptualised. Increasingly, city planning instruments like Master Plans and Development Plans are mainstreaming concepts such as resource optimisation, liveable cities etc.

Traditionally, such Plans have been solely concerned with land-use planning. However, in recent years these Plans have emerged as a strategic enabler to influence the direction cities will take to make them more vibrant, liveable and productive[26]. For example, one of the targets of the Plan Melbourne (2050) is to reduce its greenhouse gas emissions to net zero by 2050 as a means to combat climate change. Similarly, Los Angeles' General Plan (2035) has marked Significant Ecological Areas to conserve genetic and physical diversity within the LA county by designating biological resource areas that are capable of sustaining themselves.

Integrated water management is a transformational approach that requires a departure from the normal and doing things differently. An ideal avenue for facilitating such transformational thinking in a city is at the planning stage, e.g., through planning instruments like the Master Plan. A key characteristic of such instruments is that they are

Box 1: Salient features of the integrated water management provisions in the Draft Master Plan for Delhi (2041)

The draft Master Plan for Delhi (2041) has adopted the integrated water management approach that aims to manage all water-linked (i.e., water supply, wastewater, and storm water) infrastructure together. The Plan recognises that new sources of water are difficult to harness, and therefore, Delhi will need to adopt a demand management strategy. Accordingly, the emphasis is on reducing the reliance on the groundwater and freshwater resources and move towards non-conventional water sources such as treated wastewater to meet almost 50% of the freshwater demand. Rooftop rainwater harvesting is already mandatory for plot sizes above 100 square meters in the city. The Plan proposes both macro and micro-level interventions ranging from plot level, neighbourhood level, to city-region level.

The Master Plan has also stipulated forward looking water-sensitive planning norms for large-scale regeneration and greenfield development in the city. For example, the Plan calls for mandatory installation of decentralised wastewater treatment plants, dual piping, water efficient plumbing fixtures, etc. in these areas. Furthermore, the Plan has also provided avenues for implementation of Water Sensitive Urban Design (WSUD) features such as bio-swales, retention ponds, and bio-drainage in low-lying areas, roads, parks, etc. to reduce water logging incidents and recharge the groundwater aquifers.

The rejuvenation of water bodies through treated used water is also an important thrust area of the draft MPD-41 targeted towards groundwater recharge and improving the health of water bodies in the city.

26 Shinde, V.R. and Sharma, L. (2021). Conservation, protection and management of urban groundwater through city Master Plans: A case of Indian cities in UNESCO and UNESCO i-WSSM. The Role of Sound Groundwater Resources Management and Governance to Achieve Water Security (Series III). Global Water Security Issues (GWSI) Series - No.3, UNESCO Publishing, Paris.

legally binding documents. Hence, cities should leverage these to create an enabling environment for the scaling up of integrated water management approaches across the city. **Box 1** presents an example of the how the draft Master Plan for Delhi (2041) has promoted integrated water management in the city.

3.3 Strengthen the data ecosystem within cities

The importance of good quality data for decision making cannot be overemphasised. In the context of integrated urban water management, the need for this data is even more significant to understand and account for the interactions and interdependence among the different elements as well as agencies of the urban water sector –water resources and ecosystems, water supply, used water, and stormwater. Cities must invest in collecting and collating all the relevant data required for decision making and host it on a common platform that is accessible to all concerned stakeholders.

The quality and resolution of the data is often a deciding factor in determining the level of planning ambition. The data attributes critical for integrated water management planning are existing land use maps; sources of water; water users by categories; water demand and wastewater infrastructure; drainage network and infrastructure; green cover; spatial spread of water bodies; water quality of sources; river ecosystem health; inter alia. The availability of a GIS-based centralised database of spatially disaggregated water-related information is fast becoming a necessity rather than an option. This can ensure regular updating of water data, uniformity in data usage, and reduced duplication of similar efforts.

The need for integrated data collation and management becomes all the more crucial to create an enabling environment for the absorption of disruptive technologies like artificial intelligence, which is already showing good promise in diverse areas of water management. **Box 2** presents an example of the use of artificial intelligence in the UK for detecting and predicting pipe bursts and leaks.

A study[28] suggests that improved landscapes and views of waterways can increase property values in the UK between 6-8%. This can translate into additional property tax revenue for the city government.

Investing in the health of natural ecosystems can also generate additional revenue for cities. For example, healthy rivers boost real-estate values, as riverside properties generally attract the highest prices. services are broadly

Box 2: Application of Artificial Intelligence for Leakage Prediction[27]

In the UK, the water supply is privately managed by water companies but regulated by a government body–Water Services Regulation Authority in England and Wales, and in Scotland, Water Industry Commission. Since 2015, a large company has been using a tool called Event Detection System (EDS) to detect and predict leakages in the water supply system. EDS uses artificial neural networks to establish a relationship between pressure and flow with failure events (i.e., leakages or pipe bursts). Hence, the system collects real time data from over seven thousand pressure and flow sensors every fifteen minutes and compares those with incoming observations to collect different forms of evidence about the failure event taking place. The evidence is processed using Bayesian Networks to estimate the likelihood of the occurrence of the failure event in order to raise an alarm. Hence, EDS effectively learns from historical bursts and other events to predict the future ones, which helps water managers take appropriate preventive action.

3.4 Integrate nature-based solutions in urban water management

Natural ecosystems have the unique ability to impart provisioning, regulating, cultural and supporting services for urban water management [27] .Ecosystems such as urban forests, wetlands, water bodies, rivers, and streams, if in a healthy state, can provide several vital inputs for implementing integrated urban water management. For example, the ecosystem services provided urban rivers include water provisioning, recycling and nutrient cycling, and flood attenuation, among others. Similarly, in coastal cities the benefits of mangrove swamps include regulating flood, storm surges and erosion control, prevention of salt water intrusion, and a habitat to support greater biodiversity.

Activities directed at conserving natural capital and building infrastructure that incorporate or harness these ecosystem

27 International Water Association (2020). Digital Water: Artificial Intelligence Solutions for the Water Sector. Accessed 09 May 2023 from website https://iwa-network.org/wp-content/uploads/2020/08/IWA_2020_Artificial_Intelligence_SCREEN.pdf

Box 3: India's Urban River Management Plan framework[29]

In 2021, India's Ministry of Housing and Urban Affairs and the Ministry of Jal Shakti launched the Urban River Management Plan (URMP) framework with the objective to provide river cities in India a common agenda for managing the urban river stretches so as to improve overall water security of the city. At the heart of the URMP framework are ten items against which each city must take action. These include (a) regulating activities in the floodplain, (b) preventing the flow of pollution into the river and water bodies, (c) rejuvenating and reviving urban lakes and ponds, (d) enhancing the riparian vegetation along the river edge, (e) increasing the reuse of treated used water, (f) maintaining the environmental flow in the river, (g) developing eco-friendly riverfronts, (h) leveraging the economic value of the river in a sustainable manner, (i) inculcate river-sensitive behavior among citizens, and (j) involve citizens in the river management.

Several Indian cities such as Ayodhya, Chattrapati Sambhajinagar (formerly Aurangabad), Bareilly, Kanpur, and Moradabad have already used this framework to prepare city-wide urban river management strategies linked to the overall water management plan.

referred to as nature-based solutions. Cities must mainstream such solutions within their larger integrated urban water management strategy to reap multi-faceted benefits. A good starting point would be to institutionalise the adoption of such thinking into national/city level policy. **Box 3** presents an example of India's Urban River Management Plan framework that requires river cities in India to take actions for the protection and sustainable management these natural assets.

3.5 Transition from mono-functional to multi-functional infrastructure

Among all infrastructural investments that a city makes, investment in water infrastructure is one of the most capital-intensive. Cities in G20 nations like Argentina, Brazil, China, Mexico, India, and Turkey are poised for making massive infrastructural investments to enhance water security. For example, the Atal Mission for Rejuvenation and Urban Transformation in India launched in 2021 is a USD 37 Billion initiative for creating 500+ water-secure cities, with significant investments being made in new infrastructure and infrastructural upgradation.

As cities begin to plan for infrastructural investment, there is a unique opportunity to expand the horizon and re-imagine infrastructure to provide multiple benefits, water-related or otherwise. For example, projects of storm water drains may be conceptualised with green buffers that allow for recreational use. Likewise, rejuvenation of a water body (e.g., a lake) can be planned in such a way that it offers multiple benefits–flood control, groundwater recharge, habitat for biodiversity, creation of recreational spaces, among others. This means that city managers and planners need to have an understanding of the type of ecosystem services that a particular type of multi-functional infrastructural solution could provide. This will equip them with a range of possible opportunities to design interventions around specific problems, and to identify the most appropriate locations for the implementation of these interventions.

Multi-functional infrastructure is not only restricted to ecosystem services but encompasses a include a range of conventional urban services such as transport, drainage and flood mitigation, open space, power etc. For example, key transport connectors, waterways (drainage) and open space corridors within a city have a particular strategic role in fostering multifunctional infrastructure.

A subset of multi-functional infrastructure that has been widely propagated in the recent past is green infrastructure. This is particularly important from the climate change standpoint, which undoubtedly is one of the greatest challenges facing humankind in the present times. Green infrastructure offers cities greater possibilities to address the threat of climate change through both mitigation and adaptation avenues. For example, from a climate change mitigation perspective, a water body with a green buffer can help reduce GHG emissions as well improve the micro-climate by reducing the urban heat island effect. From an adaptation viewpoint, the same water body can provide flood control and groundwater recharge benefits. Countries like Canada, Denmark, Germany, Japan, Netherlands, and Sweden have already created an enabling environment for proliferating green infrastructure through relevant policies. This can serve as a useful reference for developing countries of the G20 group to help institutionalise the mandate of multi-functional infrastructure [29]. **Box 4** presents an example of the European Union's directive for promoting green infrastructure.

Land is already a precious commodity in several G20 cities, given the space crunch, cities cannot afford the luxury

28 RESTORE (2013). Rivers by design: Rethinking development and river restoration. Accessed on 15 June 2023 from website https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297315/LIT8146_7024a9.pdf

29 Cruz Ayala, M. B., Tortajada, C. (2023). Managed aquifer recharge in Mexico: Proposals for an improved legal framework and public policies. Water International 48(1), 165-183.

Box 4: EU Green Infrastructural Strategy[31]

The EU Green Infrastructure Strategy, officially titled, 'Green Infrastructure: Enhancing Europe's Natural Capital' is the European Union's key policy document for green infrastructure development. Adopted in 2013, its overall vision is to develop strategically planned networks of natural and semi-natural areas, and connect them, to support the maintenance of ecosystem services, thereby promoting multifunctional landscapes.[32]

The Strategy promotes the development of green infrastructure across the EU to deliver multiple benefits and contribute to sustainable growth. It guides its implementation at EU, regional, national and local levels. Integration of green infrastructure in spatial planning is also encouraged whenever it offers an alternative to, or complements grey infrastructure. The other actions under the Strategy include improving the knowledge base and promoting green innovation and evaluating opportunities for developing a trans-European green infrastructure network, similar to the existing networks for transport, energy and ICT.

of having mono-functional infrastructure for different ecosystem services. Given its ability to provide land use optimisation benefits, multi-functional infrastructure has to be the way forward.

3.6 Invest in social and human capital

The water sector in a city embodies a system, a system of interconnected elements and related stakeholders. For effective implementation of integrated water management in cities, each of these stakeholders has a different role to play. Citizens are a primary stakeholder whose cooperation and support is vital for the fulfilment of any integrated water management plan. This support becomes far easier to solicit when they are aware of the issues at hand, and the role they could play to address those. There is compelling evidence to suggest that several projects and initiatives have failed because the citizens were not sufficiently engaged in the project planning and implementation stages.

A number of core integrated water management practices are very challenging to implement without full support from citizens. Some of these include installing and maintaining rainwater harvesting systems, adopting water efficient fixtures, proper waste segregation to, mitigate pollution and flooding, embracing used water for non-potable purposes[30], and willingness to pay for full-cost recovery of water services.

Cities must invest in dedicated citizen engagement initiatives to nurture a brand of water-sensitive communities and citizens. These initiatives must not stop at the typical IEC (Information, Education, and Communication) campaigns that are usually a one-way communication medium. Instead, these initiatives should seek to pro-actively engage citizens in co-management of the urban water sector through various modalitie[31] This is important to make that shift from 'citizens as spectators' to 'citizens as actors'. This also sends out the message that integrated water management cannot be the government's mandate alone. Citizens will need to step up and share the onus of action. There are notable examples[32] within the G20 community where such proactive citizen engagement has been achieved. **Box 5** presents the case of a citizen science initiative in Ontario, Canada.

Box 5: Lake Partners' Programme (LPP) in Ontario, Canada[33]

The Lake Partners' Program involves volunteer-based water-quality monitoring. It is coordinated by the Ontario Ministry of Environment, Conservation and Parks from the Dorset Environmental Science Centre (DESC). Each year, more than 600 volunteers collect water samples of ~550 lakes from over 800 sampling locations and send them, postage paid, to the DESC where parameters such as total phosphorus, calcium and water clarity are analysed. The data, published every January on the LPP webpage is used by government agencies, members of the public, NGOs, academic researchers and private consultants to assess and report on water quality in lakes across Ontario.

30 Tortajada, C. (2020). Contributions of recycled wastewater to clean water and sanitation Sustainable Development Goals. npj Clean Water 3(22)..
31 Taylor, J., Graham, M., Louw, A., Lepheana, A., Madikizela, B., Dickens, C., Chapman, D.V. and Warner, S. (2021). Social change innovations, citizen science, miniSASS and the SDGs. Water Policy (2022) 24 (5): 708-717.
32 Taylor, J., Graham, M., Louw, A., Lepheana, A., Madikizela, B., Dickens, C., Chapman, D.V. and Warner, S. (2021). Social change innovations, citizen science, miniSASS and the SDGs. Water Policy (2022) 24 (5): 708-717.
33 Government of Ontario (2020). Ontario Lake Partners Programme. Accessed on 5 May 2023 from website https://open.canada.ca/data/en/dataset/7ce06d85-7cc3-4ae3-a5c3-37d7c8d55b08

3.7 Explore non-traditional financing sources

One of the biggest barriers to water security enhancement in cities is the lack of financial resources. Some water infrastructure required for IUWM is typically capital intensive, long-lived with high sunk costs. It requires a high initial investment followed by a very long payback period. Many of the benefits accrued from these cannot be easily monetised, undermining the potential revenue flows and the "risk-return" balance for potential investors. The availability of finance, in many ways, is key to determining the level of ambition that a city can target for integrated water management.

Some degree of traditional financing can be secured from earmarked budgets within federal- or state -funded schemes, or even from a city's own resources. However, because the financing requirement are significant, cities in G20 nations must start exploring non-traditional avenues of securing these funds such as Viability Gap Funding (where the government makes a seed funding of up to about 20% of the project cost and invites a private entity to meet the remaining requirement, and in return allows the entity to develop, operate and earn revenue from the project for a fixed number of year); Value Captured Finance (where cities earn revenue through special taxes imposed in the vicinity of key infrastructural projects whose land value has increased because of the projects); Municipal bonds, etc. A city's financial status, and its financial acumen in generating these financial resources, will go a long way in determining its integrated water management trajectory. **Box 6** presents the innovative Hybrid Annuity Model used in India to fund major sewage infrastructure projects.

Box 6: India's Hybrid Annuity Model for financing infrastructure[34]

Since 2016, India's National Mission for Clean Ganga has been using the Hybrid Annuity Model (HAM) for encouraging the private sector to invest in sewage infrastructure projects. HAM is a combination of the Build-Operate-Transfer (BOT) annuity and Engineering-Procurement-Contracts (EPC). A private entity undertakes design, construction, commissioning, operations & maintenance of the used water treatment plant for a period of fifteen years from the date of commissioning of the project. The project assets are transferred back to the city at the end of the concession term.

Only 40% of the capital cost is paid to the developers upon completion of construction, while the remaining 60% of the cost is be paid over the life of the project as annuities, along with operations & maintenance expenses. Further, the interest rate risk and inflation risk are covered by the government through additional payment of interest on the reducing balance of 60% capital cost at the rate of 3% over State Bank of India's Marginal Cost of funds-based Lending Rate. In other words, the private partner bears the construction and maintenance risk, while the government bears all the revenue and inflation risk.

A key highlight of the HAM is that the annuity and O&M payments are linked to the performance of the treatment plants. This ensures that the assets created are well-maintained for the intended design span.

3.8 Encourage city partnerships and networks

The SDG 17 recognises that the SDGs can only be realised with strong global partnerships and cooperation. Strong national and local partnerships are therefore useful avenues to realise the overall vision of achieving water security through capacity building, peer-to-peer learning between cities as well as forge partnerships and long-term relationships.

The role of partnerships and networks becomes even more significant for scaling up the idea of integrated water management. This is because as cities take actions towards changing the 'business as usual', they can learn valuable lessons from each other's experiences—both good and bad.

Given their convening power and authority, federal/central governments may need to take the lead in creating such networks and partnerships. However, their role should be limited to facilitation, allowing the network to draw up its own agenda. This will ensure autonomy of the network whilst still anchored in the national machinery. **Box 7** presents an example of a recently established network of river cities in India.

34 World Bank (2017). IFC Helps Structure India's First Hybrid-Annuity PPP For Sewage Treatment, Boosts National Clean Ganga Mission. Accessed 08 May 2023 from website https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=18262

Box 7: India's River Cities Alliance[35]

In 2021, India's Ministry of Housing and Urban Affairs and the Ministry of Jalshakti set up the River Alliance as a platform for river cities to discuss and exchange information on aspects that are vital for sustainable management of urban rivers. The Alliance is a city-led movement for promulgating river-sensitive planning and development. Hence, the agenda and operations for RCA is determined by the member cities. However, to allow member cities enough time to set up their own structure for managing the Alliance, the National Institute of Urban Affairs, is serving as the Secretariat for a period of 3 years. Currently 119 Indian cities are part of the River Cities Alliance. Each city is represented by the administrative head–the Municipal Commissioner or Executive Officer.

The main activities of the Alliance include organising an annual summit for the Alliance members to showcase the work done in their cities and have discussions with peers for new and emerging ideas. Additionally, the Secretariat organises periodic training programmes (once every two months) on various niche topics for different categories of officials from the member cities. Member cities are also encouraged to have independent bilateral visits to learn from each other.

The River Cities Alliance was acknowledged as a unique and forward looking initiative at the 2023 UN Water Conference and by the Department of Economic and Social Affairs on its website.[36]

35 NIUA and NMCG (2021). River Cities Alliance. https://niua.in/rca/

36 https://sdgs.un.org/partnerships/river-cities-alliance-partnership-developing-international-river-sensitive-cities

04/ Conclusion

Addressing and enhancing urban water security is a global aspiration. Hence, the actions that cities take today will play a deciding role in defining the contours of the global response to this aspiration. In view of burgeoning development pressures in cities, integrated water management is our best option to pursue holistic water security. Going forward, actions for the urban water sector must be anchored in systems thinking and adopt a transdisciplinary approach to planning, design and implementation. The paper has proposed an eight-point agenda for enhancing integrated water management in cities as follows:

1. Re-imagine the role of water managers to address current and emerging needs and contexts.
2. Leverage urban planning instruments to create a long-term recourse for sustained actions for integrated urban water management.
3. Strengthen the city data ecosystem to create a sound premise for evidence-based decision making.
4. Integrate nature-based solutions to complement traditional infrastructure for the overall management of the urban water sector.
5. Transition from mono-functional to multi-functional infrastructure to reap multiple benefits from the same investment.
6. Invest in social and human capital as a means to encourage citizens to take some onus of action required for managing the urban water sector.
7. Explore non-traditional financing sources to help expand the ambition for integrated water resources implementation.
8. Encourage city partnerships and networks to facilitate the exchange of practical knowledge and ideas for proliferating integrated water management.

Adopting and actioning these agenda items will require a paradigm shift in thinking and a marked departure from 'business as usual'. It must start with building capacities of elected representatives, which is particularly important for two reasons. First, they comprise part of the 'decision-making' body who have the mandate and the authority to translate aspirations into reality. Second, because of their inherent association with the general citizens, integrated water management can truly become a people's movement.

It is vital to understand, and appreciate, that water needs and requirements of cities are different, which would be reflected in their integrated water management models. These models will, and should, differ from place to place. Hence, each city will need to discover its own model based on the local context and aspirations.

The onus of action is, of course, on individual members of the G20 community to devise context-specific strategies and plans to implement the eight-point agenda. However, as a collective body, there is much that the G20 can do to facilitate the uptake of this agenda.

First, would be to set up a **Urban Water Security Task Force** under the G20 mechanism comprising apex urban water agencies from cities of the member countries. The primary objective of the Task Force would be to propose a bi-annual/annual action plan based on the eight-point agenda for member cities to follow. For example, the priority for the first two year could be to propose a generic template for strengthening urban water database. The Task Force could convene periodically to catalyse partnerships and collaboration for improved knowledge management for decisions and actions around the eight point agenda listed above.

Second, would be to create a dedicated **Urban Water Security Corner** on the G20 Water Platform[37] to foreground that urgent action is required on the urban water security front. Currently, the G20 Water Platform has only limited coverage on "urban" water aspects. The dedicated Urban Water Security Corner would enable creation and sharing of an online repository of data, knowledge, success stories and other related information about actions taken by member cities against the eight-point agenda. Such a repository will not only help in enhancing awareness on integrated urban water management initiatives; it will also inspire member cities to take ambitious and progressive actions as the online platform would offer them high visibility.

37 https://g20waterplatform.org.sa/en/Pages/default.aspx

Third, would be to introduce **Outstanding Water Management Awards** for cities performing very well against the eight-point agenda using different performance indicators. The opportunity to receive global recognition may incentivise cities to push the envelope further.

The G20 has the influencing power to help transcend the boundaries of conventional thinking and create water-secure cities that thrive in harmony with nature, promote social equity, harness the power of technology, and engage all stakeholders. The time for action is now. The G20 has been known as a body of world economic leaders thus far. It is time for G20 leadership to take on the role of global water stewards.

> "यथा चित्तं तथा वाचो यथा वाचस्तथा क्रिया ।
> चित्ते वाचि क्रियायां च साधूनामेकरूपता ॥"

(As is the mind, so is the speech; as is the speech so is the action.
In all good entities, there is uniformity in mind, speech and action.)

05/

Annexure

SDG 6: Ensure availability and sustainable management of water and sanitation for all			
Targets		**Indicators**	
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all	**6.1.1**	Proportion of population using safely managed drinking water services
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	**6.2.1**	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	**6.3.1**	Proportion of domestic and industrial wastewater flows safely treated
		6.3.2	Proportion of bodies of water with good ambient water quality
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	**6.4.1**	Change in water-use efficiency over time
		6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	**6.5.1**	Degree of integrated water resources management
		6.5.2	Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	**6.6.1**	Change in the extent of water-related ecosystems over time
6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	**6.a.1**	Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.b	Support and strengthen the participation of local communities in improving water and sanitation management	**6.b.1**	Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

(Source: https://sdgs.un.org/goals)