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POLICY BRIEF

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Enhancing Urban Water Resilience: Science-based Approaches and Strategies for Asian Megacities

Shokhrukh-Mirzo Jalilov, Yoshifumi Masago, Junko Nishikawa, Xuemei Bai, Thomas Elmqvist, Kazuhiko Takeuchi, and Kensuke Fukushi

Highlights

In Asia, urban water security garners much greater attention than any other water-related issue. This is largely because of deteriorating infrastructure, rising demand for water and sanitation, water pollution, floods, and ineffective decision-making, all of which threaten city residents' safety and security. This policy brief presents several science-based concepts and frameworks that could be applied to Asian urban water issues and contribute to achieving water-related Sustainable Development Goals (SDGs):

- Utilize the multifunctional nature of urban water systems — integrate city planning with the urban water environment to consider synergies and tradeoffs, and create win-win situations
- Adapt principles of the circular economy for cities' water management, to result in an increase of economic benefits
- Introduce small-scale, decentralized, modern water-quality technologies vital to solving emerging urban water challenges
- Most importantly, central governments should foster supportive environments for innovative science-based solutions to build urban water resilience

Water and Resilience in Asian Megacities

While cities are home to more than half of the world's population and account for approximately 80% of global GDP, at present they are rapidly depleting scarce resources (such as food, water, and energy) and face numerous challenges such as increasing population density and environmental degradation. Urban water management is among the most pressing challenges. There is a rapidly growing demand for water as a result of rapid urbanization, an expanding urban middle class, insufficient budget allocations for declining and aging infrastructure, and degradation of urban ecosystems.

As of 2015, the world had 30 megacities (metropolitan areas with populations of 10 million or more), of which 17 were in Asia. By 2025, it is expected that 21 of the world's 37 megacities will be located in the region (UN DESA 2015). Cities in the region's developing countries are greatly suffering from natural disasters due to insufficient preparedness, geographical characteristics (such as susceptibility to seasonal monsoons and El Nino), and development patterns. This, coupled with the necessity to make urban water management more resilient in the face of current and future shocks such as climate change, requires a shift to science-based approaches and innovations to enhance urban resilience in Asian megacities.

Despite the proliferation of the term "resilience" in both academic and policy discourse, it still lacks a "single, universally accepted definition" (Sharifi and Yamagata 2014). Among the various ways in which resilience is understood, the key attributes are time and uncertainty, and it is seen as encompassing complex interactions between technical, social, economic, political, and environmental systems. This policy brief considers the city as a dynamic socioecological system (Chen and Graham 2011) that is undergoing a constant process of change and adaptation. It takes urban water resilience to refer to the capacity of urban water infrastructure to cope in the short term, and adapt and develop in the long term in the face of unforeseen changes such as major system failures, acute water infrastructure degradation, inadequate drinking water and wastewater infrastructure, and/or natural disasters.

Similarly, the term "science-based" has grown in use recently, but few people understand exactly what it means in practice. When invoking science as the basis for one's positions, it is important to be clear and consistent about how science can be part of the decision-making process. The need for science-based approaches and strategies reflects the foundational role that science has to play in policymaking that is based on empirical evidence.

Advancing Science for Resilient Urban Water Management

In response to the growing demand for sustainable schemes for urban water management, in recent years, there has been a gradual shift from the "control by construction" model to "stewardship and dynamic/adaptive management" for balancing environmental concerns and the economic benefits of water resources development (Petts et al. 2006). Likewise, the adoption of the 2030 Agenda for Sustainable Development has brought renewed energy and international commitment for addressing water-related challenges (SDGs 6, 11, and 14). By putting water at the center of the global goals, researchers, practitioners, and policymakers are being encouraged to find solutions to these challenges. This presents opportunities for the water sector to develop innovative solutions and scale up best practices that will make cities more livable, resilient, and sustainable.

Asian megacities should take immediate steps to increase their preparedness to confront current and emerging challenges, protect their populations from natural disasters, and enhance their resilience overall. There is little doubt that science and technology should play a leading role in designing the solutions to meet such challenges. Of the many ideas that exist on how new strategies and innovations would bring benefits to cities and make them more resilient and sustainable in terms of society, economy, and environment, some deserve special attention in the context of Asian megacities.

Policy Recommendations

1. Utilize the Multifunctional Nature of Urban Water Systems — Integrate City Planning with Urban Water Environments by Considering Synergies and Tradeoffs to Create Win-win Situations

If properly managed, urban water has the potential to provide functions beyond the provision of drinking water and sanitation. The pre-eminent function should be the provision of environmental services: offering habitats for wildlife and a desirable landscape for people. There are also many other functions for urban water: irrigation; urban livelihoods and economic vitality; micro-weather stabilization; cultural heritage and identity; and religious, spiritual, and aesthetic values. Many cities invest significantly in creating new infrastructure such as buildings, roads, water, and energy systems to meet the needs of their inhabitants. However, such infrastructure in many cases is developed at the expense of natural ecosystems through deforestation — drying up rivers, lakes, and wetlands, and levelling natural hills, among others, thus making cities less liveable places. The two examples below illustrate how multifunctionality can be put to work in an urban context.

Combining Land, Wind, and (Waste-) Water
Through proper placement of urban parks and canals to cool and filter air, nature can mitigate the urban heat island (UHI) effect, benefitting millions of people in urban areas. For example, the city of Tokyo uses a land and sea breeze system connected through a network of canals. The main water source (90%) is treated wastewater, which also forms an ecological network and allows for recreational activities.

Sponge Cities
In an effort to address the impacts of extreme weather events such as flooding, the President of the People's Republic of China, Xi Jinping, announced in 2013 that cities should act like "sponges". Developing a "sponge city" is a new engineering solution in city planning, which refers to design that allows the city to retain all of the surface water runoff that occurs within its confines, so that it can be reused at a later date. This creates an urban environment that absorbs water and then releases it when required—in a similar manner to a sponge. This idea of "sponge cities" was supported with substantial funding for cities to experiment on ways of absorbing precipitation through permeable

pavements, rain gardens, and wetlands; or reusing water locally for irrigation, parks, or even for drinking.

2. Adapt Principles of the Circular Economy for Cities' Water Management to Increase Economic Benefits

The focus of the circular economy is on reducing waste by reusing materials and resources. While the conventional economy related to water management generally is based on an "obtain, treat, delivery, and dispose" model, the circular economy emphasizes a "reduce, reuse, and retention" model which could reduce water use, prevent water pollution, and increase overall water use efficiency. The principles of the circular economy are based on the systems approach for achieving sustainable social, economic, and environmental goals in cities. However, integrating city water management requires effective and enforceable legislation, and a multi-stakeholder coordination mechanism across central, regional, and city governments. Collaborative approaches should involve all stakeholders (including local communities) in setting priorities, taking action, and assuming responsibility. This requires optimal operation of water-related infrastructure in a city; it pursues economic efficiency in water use, without which water operations cannot be sustainable.

While the circular economy — which aims to reduce, reuse and retain water — cannot fully eliminate water shortages, it can help to reduce them. For example, the circular economy has become an alternative for desalination plants that come at high social and environmental costs. The reduce, reuse, recycle (3R) concept has already been successfully used to recharge and store water in aquifers and for the drinking water supply. Such water can be used to irrigate city parks and gardens, and water from rain harvesting can be stored in city lakes and wetlands for further use. The circular economy could also open new opportunities in efficient urban water management, sustainable water use, treatment, and recycling. For example, wastewater treatment alone could bring such benefits as biological nutrients (primarily nitrogen and phosphorus) that could be used in agriculture, energy that could be consumed, and a substantial reduction of carbon emissions.

3. Introduce Small-scale, Decentralized, Modern Water-quality Technologies Vital to Solving Emerging Urban Water Challenges

With large-scale infrastructure-related technologies out of reach for most developing countries due to budget constraints, community-managed and low-cost technologies related to water and wastewater treatment and sewerage infrastructure development are practical alternatives. These include small-scale wastewater treatment plants, inexpensive water pumps, provision of low-cost latrines, and septic sewer systems. "Smart," data-driven, science-based solutions also present opportunities to improve urban wastewater systems. They allow operators to detect infiltration and inflow, prioritise actions, quickly respond to system failures, and apply predicative modeling. For instance, four U.S. cities are already preventing harmful sewage overflows through data technologies (SWAN 2016).

The ability to effectively manage problems associated with water networks, both at the source and at the distribution level, is related to detection capabilities. Contamination events such as the Flint water crisis in Michigan have drawn global attention to water quality issues in developed and developing countries. Utilities can proactively manage and avoid potential threats through real-time water quality monitoring.

Authorities in Asian megacities should shift towards smart wastewater solutions, place increased emphasis on the need for real-time water quality monitoring solutions to ensure water network security, and introduce small-scale water technologies in areas that are remote or cannot afford large-scale infrastructure development projects.

4. Most Importantly, Central Governments Should Foster Supportive Environments for Application of Innovative Science-based Solutions for Urban Water Resilience

In areas well beyond water management, many developed and developing countries are inventing and introducing modern, innovative solutions and approaches that potentially apply to challenges facing cities all around the world. For example, the solutions sought in Japan for natural disaster risk management are highly relevant for most other Asian megacities (WPDMJ 2015). These include disaster prevention management solutions to support local authorities and agencies in responding to multiple simultaneous incidents, as well as those for post-event recovery. As another example, in early 2016, India's Ministry of Urban Development launched the "Smart Cities Mission", a competitive process for cities to receive funding for urban transformation projects. The 27 selected cities will launch projects to transform existing areas (retrofit and redevelop), including slums, into better planned ones, thereby improving the liveability of the whole city. New areas (greenfields) will be developed around cities to accommodate the expanding populations of urban areas. Such smart solutions use technology, information, and data to improve infrastructure and services. Yet governments

must accelerate the introduction of the necessary regulatory frameworks and funding mechanisms. Overall, the authorities of megacities should aim to improve governance, promote equitable growth and access to services, and ensure public participation in urban development, resulting in enhanced quality of life for city residents.

In terms of water resources management, such recommendations will not solve existing problems without real institutional reforms in relevant cities. A holistic and integrated approach to enhancing urban water resilience will require considerable effort from national and local governments. This should be one of the top priorities of all national development agendas. Local government capacity should be enhanced through training and improving scientific and technical expertise. Foreign governments, international donors, and non-governmental organizations should play a significant role in promoting capacity development for local government agencies dealing with water quality issues. Foreign development assistance is a catalyst for change in the developing world and should support these countries' efforts to adopt better standards in water quality management through capacity building and knowledge and technology transfer.

Conclusion

Science is often recognized as the solution to urban water management problems, yet most decisions to date, by necessity, have been based primarily on existing knowledge and previous experience. There is no doubt that science should play a significant role in realizing and advancing solutions to current and future challenges of urban water management. Improving and enhancing the capacities of cities to withstand, mitigate, and adapt to shocks and stresses requires further development of science-based technologies and the ability of decision-makers to work hand-in-hand with the academic community in implementing science-based approaches, strategies, and innovations for a city's water management needs. In turn, these science-based approaches and strategies should reflect the latest developments and innovations and be integrative, adaptive to changing conditions, technologically sound, and financially feasible.

Note

Recommendations 1 and 2 are based on expert discussion at a UNU-IAS special event held as part of the HABITAT III conference in Quito, Ecuador on 17–20 October 2016.

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