State of Knowledge and Research for Urban River Management in India

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Abstract

Urban river management is an emerging paradigm in India. Much of the previous endeavours in this domain has been in the area of pollution control. While this is unquestionably important, there has been burgeoning evidence that holistic urban river management requires a systems approach that caters to multiple sectors and corresponding stakeholders. Only then will it be possible to achieve holistic and wholesome management of urban rivers that is not only able to address current challenges but is able to effectively respond to imminent threats and issues. The objective of the paper is two-fold. First, to collate and report existing work on urban river management in India. Second, to identify and highlight key research needs in this domain where emphasis must be placed on current times in order to ensure healthy rivers in the future as well.

Key words: Climate Change, Environment Planning, Floodplain, Master Plans, River Management, Urban Rivers

Introduction

River management is a complex process. The complexity stems from the fact that there are multiple issues that need to be addressed. Likewise, there are multiple stakeholders, often with conflicting agendas, and dynamics between these stakeholders keep changing rapidly. As Moore (2021) points out 'among the many difficult problems in environmental governance, cooperatively managing a shared river basin is one of the most complex—and elusive'. The need for this cooperative management is vital to ensure a holistic response to the planning objectives and paradigms. The complexity of river management is more pronounced in urban settings compared

to their rural counterparts for a number of reasons. First, the competing users of the river, and more importantly of the river zone, are larger in number. Second, very often these users have contrasting mandates. For example, the stakeholders concerned with tourism typically focus on the economic value of the river without much thought of the environmental aspects. Contrarily, the government agencies tasked with environment protection by and large oppose any kind of development in the river zone.

Urban rivers, as one of the most important urban ecological corridors, supply diverse and critical ecosystem services, including provisioning, regulating, cultural, recreational, and aesthetic services (Guo et al., 2021). The competition for urban rivers and the river zone is, therefore, understandable. However, it is vital that this competition does not result in a condition where: (a) urban rivers are exploited beyond their carrying capacity, or (b) the rivers are underutilised and are prevented from providing their full range of ecosystem services. Avoiding this condition is a matter of arriving at optimal solutions as opposed to perfect solutions, which accentuates the importance of holistic and inter-disciplinary urban river management.

Urban river management is an emerging paradigm in India. For far too long, the ambit of urban river management has solely focused on pollution control. This skewed approach is also found in scientific literature with several recent studies focusing on it (e.g. Bao et al., 2022; Tramoy et al., 2022; Kuwimba et al., 2021; Yin et al., 2021, Thiebault et al., 2017 etc.). To be fair, there are examples in literature that view urban river management from a lens other than that related to pollution. For example, in 2010, Zander et al. (2010) carried out a study to compare and contrast the willingness of urban Australians to pay for the sustenance of three aspects of urban rivers—river development, river culture, and river conservation. More recently, Guo et al. (2022) have focused on the demand for recreational services for sustainable urban river management. Through this work, they have proposed a comprehensive framework for supply-demand analysis of urban river recreation and apply this framework to the Jinjiang River. Likewise, Vian et al. (2021) studied the recreational interface between rivers and cities and classified urban riverfront parks and walks vis-à-vis seven Spanish urban rivers. However, such examples are few and far in between.

Human kind is already facing threats from multiple quarters—pandemics, climate change, loss of biodiversity, food insecurity, among others. Healthy urban rivers have the potential to alleviate these threats significantly, and make cities more livable for their inhabitants, while at the same time contributing to reversing debilitating trends. However, achieving the goal of making rivers healthy will require more than mere pollution control. The knowledge in this domain is still evolving, especially in terms of what is needed to continue to maintain healthy rivers in the light of anticipated drivers of change. The objective of the paper is two-fold. First, to collate and report existing work on urban river management in India. Second, to identify and highlight key research needs in this domain, where emphasis must be placed on current times in order to ensure healthy rivers in the future as well.

Relevance of Healthy Urban Rivers in National and International Development Agenda

Urban rivers have a central role to play in the overall socio-economic development of a city. This has been directly and indirectly alluded to in the global as well national narrative for sustainable development. In 2015, the member states of the United Nations adopted the 2030 Sustainable Development Agenda that required all countries to take actions against 17 Sustainable Development Goals, commonly called SDGs. The SDGs are a universal call to action to end poverty, protect the planet, and improve the lives and prospects of everyone, everywhere. Interestingly, many of these SDGs are intrinsically related to healthy rivers, and achieving the targets under these SDGs will require taking action to maintain the health of rivers. For example, target 6.6 of SDG-6 directs all nations to "protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes", which is directly related to healthy rivers. Likewise, SDG-11 emphasises "making cities and human settlements inclusive, safe, resilient and sustainable". Notice the words "resilient" and "sustainable" in this statement. As already stated, healthy rivers provide a wide range of ecosystem services to a city. Among these, services such as erosion control, flood mitigation, carbon storage, and climate regulation all improve a city's resilience. Similarly, healthy rivers are an important avenue for provisioning services like drinking water, food, and transport of timber, which are vital from a sustainability point of view.

The link between healthy rivers and SDG-6 and SDG-11 is quite direct. The link may not be as direct for some other SDGs but is equally relevant and significant. For example, SDG-1 talks about "ending poverty in all its forms, everywhere". Healthy rivers provide tangible and useful avenues for supporting livelihoods of people that depend upon them, and help mitigate poverty. Another example is SDG-13, which is centered on "taking urgent action to combat climate change and its impacts". Contemporary research suggests that a vital component of any climate change adaptation strategy is social cohesion. This is based on the notion that when things become really critical, people will have to rely on other people for help. In such times, technology may not be so helpful, neither will finances. What will actually help people deal with crises and shocks is their interaction with other people. Unfortunately, society is losing that personal connection between one another in this digital age. Healthy rivers provide an avenue for people to socialise and get together, and in the process, help re-establish that personal connection that is so important for climate change adaptation.

Healthy rivers are also directly relevant to the New Urban Agenda (UN Habitat, 2016) that was endorsed at the 68th Plenary Meeting of the 71st Session of the General Assembly of the United Nations held in December 2016. The New Urban Agenda called for the development of cities that "protect, conserve, restore and promote their ecosystems, water, natural habitats, and biodiversity, minimize their environmental impact and change to sustainable consumption and production patterns". It is quite clear therefore that healthy rivers have a vital role in implementing the New Urban Agenda.

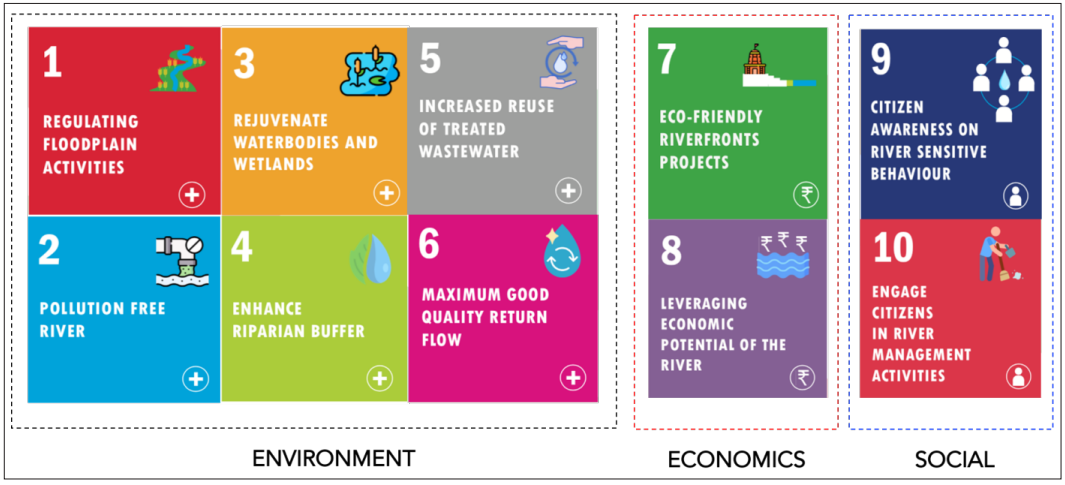
Current Ecosystem of Knowledge on Urban River Management in India

As already indicated in the previous section, the work in urban river management is relatively new in India. Most of the work in this domain has been carried out by the National Institute of Urban Affairs (NIUA) (affiliated with India's Ministry of Housing and Urban Affairs) and the National Mission for Clean Ganga (NMCG) (affiliated with India's Ministry of Jal Shakti). The two organisations have taken several initiatives to promulgate river-sensitive development in Indian cities.

Urban River Management Plan (URMP) Framework

In 2020, NIUA and NMCG launched a framework for managing urban river stretches, called "Urban River Management Plan" (URMP). The purpose of the URMP is to provide a decision support system for river cities in India to systematically and holistically plan for interventions required to revive and maintain the rivers within their limits in a sustainable manner. The URMP is embedded in the central idea that maintaining healthy rivers is crucial to enhance livability and productivity in the cities. At the heart of the framework is a ten-point agenda (Figure 1) that every river city would need to adopt in order to prepare their city-specific URMPs.

Figure 1: 10-Point Agenda of the Urban River Management Plan Framework



These agenda items are grounded in the principles of sustainable development, and advocate interventions under the environment—economic, and social categories. The URMP framework has been developed for all river cities in India and hence the framework is generic enough for it to be relevant to all these cities. However, all the cities are not the same. They have different characteristics, different needs, and different aspirations. Therefore, while the agenda items are the same for all river cities, they have the flexibility to choose the specific actions/interventions under each agenda item in line with their context and priorities. For example, objective 8 of

the framework leverages the economic potential of the river. As an intervention to achieve this objective, one city may decide to run a river cruise, while another may decide to create provisions for water sports. Yet another may opt for a river market. A city can choose what it thinks is best for its context and needs.

Strategic Guidelines for Making River-Sensitive Master Plans

Another initiative taken by NIUA and NMCG was to develop strategic guidelines for making river-sensitive Master Plans (NIUA and NMCG, 2021). The need for this document stemmed from the fact that a number of interventions required for rejuvenating urban rivers cannot be achieved by infrastructural projects and engineering solutions alone. A typical case in point is regulating, and if required, restricting development activities in the flood plains of rivers to ensure 'room for the river'. Likewise, conservation of water bodies and wetlands, which are deeply interlinked to the river anyway, requires a different management approach. A large number of these 'softer' solutions can be incorporated through sound city planning, i.e. through a city's Master Plan. The purpose of this guidance document is to help city planners across the country at large understand how to integrate river-sensitive thinking into a Master Plan. It seeks to leverage on the legal sanctity of the Master Plan to ensure a harmonious relationship between cities and rivers. The document highlights a set of planning instruments and tools that planners can use to plan for and manage different river-related aspects in the city. These include:

- *Localising national policies and instruments:* a number of national policies (e.g. National Water Policy 2012; National Policy on Faecal Sludge and Septage Management, 2017; The Water (Prevention and Control of Pollution) Act 1974; National Tourism Policy 2002; River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016; among others) have provided key river-related directions for cities to adopt. It is important for the Master Plan to acknowledge and incorporate these.

- *Developing city-specific sectoral strategies:* elaborates on specific key strategies (e.g. for riparian buffer development; for relocating encroachments in the river zone, among others) that are required in the city for sustainable management of the river.

- *Land use assignment:* includes the appropriate land use categories; use zones; use premise; and associated permissible/non-permissible activities in the flood plain as well in areas in other parts of the city that have a bearing on river management.

- *Development control regulations:* manages the FAR; and ground cover and height restriction in the relevant areas.

- *Norms and standards:* such as set-back distances; buffers; width of no development zones; discharge standards; among others, that are required to conserve and protect rivers and their associated elements.

- *Recommendations and directions:* to influence aspects that the Master Plan cannot directly control (e.g. citizen engagement in river management; CSR activities for river rejuvenation; among others).

- *Special projects:* for key big-ticket iconic endeavours that a city should undertake in order to enhance the river-city relationship (e.g. riverfront development project; reviving historic water bodies; developing a constructed wetland; among others).

Guidelines for Management of Urban Wetlands/Water Bodies: A Toolkit for Local Stakeholders

This toolkit is developed by the School of Planning and Architecture, Delhi, and NMCG (SPA, Delhi and NMCG, 2021). The main objectives of the toolkit are to: (a) protect the ecological processes that sustain water resources in urban settings; (b) mainstream protection of water bodies in the urban planning process; and (c) provide a step by step approach to identify, prioritise and prepare an action plan for protection of water bodies in urban areas.

The toolkit advocates a two-stage process for management of the urban wetlands/water bodies. The first stage focuses on identification of these features for conservation. It begins by requiring cities to prepare a detailed documentation of city-level information of natural resources such as temperature, humidity, soil, hydro-geology, ground water level, land use and land cover, which together provide a better insight into the water regime of wetland/water bodies. Next, cities are required to prepare interactive Geographic Information System (GIS) maps identifying and mapping of urban water bodies at city scale. This may also include the peri-urban areas. This part will not only cover the demarcation of urban wetlands, but also the zone of influence and the catchment area. This is done collectively from a primary survey and with the help of local stakeholders and Urban Local Bodies (ULBs). Next, the toolkit provides a simplified approach for identifying the ecosystem services of urban wetlands/water bodies. The ecosystem services include provisioning services, regulating services, cultural services and supporting services. The fourth step is to make a scientific assessment of the groundwater resources, estimation of ground water draft, estimation of ground water recharges during monsoon and non-monsoon seasons. This is to be followed by a land suitability analysis for ground water recharge based on whether the situation is semi-critical, critical or over-exploited. The last step of this stage is to identify drivers of changes in the hydrological regime of wetlands/water bodies. Assessment of impact is carried out at the level of zone of influence of wetlands/water bodies, catchment of wetlands/water bodies and within a 200 meter buffer area of wetlands/water bodies. The assessment will provide a basis for formulating synergy between wetlands/water bodies and urban development within the city.

The second stage of the process begins by developing an action plan for identified urban wetlands and water bodies. The plan should include a comprehensive listing of activities required to be implemented. These include boundary mapping and delineation, removal of encroachment at site level, afforestation activities, selective dredging and desilting, diversion and treatment of point sources of pollution, maintenance of breeding and spawning grounds for key species, management of invasive species, setting regulatory regimes, and development of a monitoring and evaluation

system at institutional level. This is followed by developing a management plan that defines all the indicative actions, core and non-core activities to be undertaken, along with a complete costing (activity wise) for the entire tenure of the plan using the existing norms of the state and central government, as may be the case.

Guidance Note for Environmentally Sensitive, Climate Adaptive and Socially Inclusive Urban Riverfront Planning and Development

This document is developed by the World Resources Institute (WRI) and NMCG, 2021. Riverfront planning and development in India is heavily skewed towards the built environment (construction, landscaping and beautification) and the potential economic benefits that can be derived from these projects. However, it is equally important that these projects give due consideration to their social, hydrological, environmental and ecological impacts as well as impacts on the project itself caused by erratic climatic events like flood and droughts. Failure to acknowledge and account for these aspects will only lead to failed outcomes, hydrological/ecological/ environmental stresses and disasters like floods with loss of life and property. This guidance note has been developed to help riverfront planners and developers help integrate water, ecology, environment and climate resilience related considerations within the existing framework of urban riverfront planning and development.

The document covers three broad objectives. The first is as an appraisal tool to support decision-making on urban riverfront development based on environmental and social indicators. The second is to inform project proponents and decision makers and other stakeholders about environmentally sensitive, climate adaptive and socially inclusive riverfront development. The third is to provide guidance to various service providers on design and planning and implementation of ecological riverfront development projects.

Research Needs for Urban River Management in India

Floodplain Protection in Dense Settlements

Even in ordinary circumstances, floodplain protection in rapidly urbanising cities is a challenge, given that the urban sprawl typically engulfs such government-owned vacant areas. The problem becomes particularly challenging when this results in informal unauthorised dense settlements that typically have very limited waste management and sanitation facilities. The preferred option in India to deal with such challenges is to carry out a court-backed eviction drive from time to time. However, such measures are counter-productive in the long run. They merely transfer the problem to some other part of the city, and since the river is a system of interconnected elements across the city, this will eventually have a cascading and detrimental effect on the river itself.

On the one hand, solving such problems requires dedicated research to understand the social and economic dynamics in the floodplain, and the kind of effect it will have on the river when the dynamics is disturbed. For example, what are the social ramifications of forced evictions? What should an empathetic and sensitive relocation strategy for informal settlements be comprised of? On the other hand, it is vital to carry out research on design transformation solutions that may take time to implement but are grounded in the pursuit of long-term sustainability. One

area of specific research is how to mainstream floodplain protection into a city's long-term plan (e.g. Master Plan or City Development Plan) through the intelligent use of planning instruments? Likewise, it would be worthwhile to explore economic models to incentivise floodplain protection so as the optimise the ecosystem services returns from the river.

Naturalising Existing Channelised Rivers and Concretised Riverfronts

It has been established that channelling river banks causes a disconnection between city dwellers and rivers (Che et al., 2012). However, for much of the nineteenth century, channelising river banks was seen as the norm, mostly to ensure quick removal of floodwater to a downstream location. While this was successful in mitigating the flood threat, it had quite the opposite effect on the aquatic biodiversity and the ecosystem at large. As environmental awareness started to grow in the 1970s, it became quite apparent that channelising river banks was detrimental to the overall health of the river. Likewise, with advances in scientific knowledge, it emerged that concretised riverfronts impede the river from performing its natural functions such as groundwater recharge, flood regulation, micro-climate regulation, among others. As a result, a number of cities like Singapore, Amsterdam and Los Angeles took up initiatives to naturalise their riverfronts through demolition and redevelopment activities. However, these have been cost- and resource-intensive endeavours.

Based on physical observations by the authors, a number of Indian cities like Agartala, Ahmedabad, Jaipur, Lucknow and Patna have also channelised their river banks and pushed for concretised riverfronts. While there is growing awareness among the cities about the benefits of naturalised features, the costs for transformation are quite significant, particularly since heavy investments were made in the first place.

There is need for urgent research on how Indian cities can naturalise existing channelised rivers and concretised riverfronts in a cost-effective way. This includes research on developing new technologies, innovative business models, and flexible governance mechanisms to support the transformation.

Estimating the Optimal Return Flow that a City should provide a River

One of the most important requirements in river management is ensuring the required environmental flow. Poff and Zimmerman (2010) defined environmental flows as one approach to setting science-informed water management goals, by quantifying the hydrological regime necessary to support aquatic ecosystems. Recognising that in-stream habitat requires more than a simple minimum level of flow they suggested that environmental flows incorporate a more comprehensive view of the magnitude, timing, variability and quality of streamflow.

In India, environmental flow is typically dictated by releases from dams and barrages that are built of rivers, and may not necessarily lie within the administrative jurisdiction of a city. In such cases, the onus is on the city to earmark an appropriate return flow into the river to ensure its environmental flow is not comprised. Ensuring this return flow is far easier in the monsoon where the stormwater drainage system carries the runoff from the city into the river. However, providing

this return flow is far more challenging in the non-monsoon months, especially in the dry season when the river requires the environmental flow the most. The only option, it would appear, is to earmark a portion of the treated wastewater as return flow. However, given the current thrust on wastewater reuse (some cities are even targeting 100% reuse), how does a city juggle between the two? More importantly, how does a city arrive at an optimal return flow value? These are very real and practical research questions that need to be answered in order to provide cities with a systematic and clear plan to make a contribution to the environmental flow of the river that passes through or beside it.

Linking Valuation of Urban River-Related Ecosystems to River Management

As highlighted in the introduction section, urban river management is never about perfect solutions but rather about optimal solutions, given the range of competing users and use sectors. Urban river managers are, therefore, forced to make choices and trade-offs about river ecosystems on a continuous basis. These imply valuations. The concept of evaluation of ecosystem services, introduced in the 1990s, has seen significant scientific traction in subsequent years. It involves assigning a monetary value to natural ecosystems (in context of this paper, river and its associated elements) and the services provided by the ecosystem.

Literature is abound with examples of the different modalities of valuation of riverine ecosystems in India. For example, Sinclair et al., (2018) developed an economical valuation tool using crowd-sourced data to: (a) map nature-based recreation patterns; (b) create value recreational ecosystem services; and (c) investigate how recreational benefits are affected by changes in ecosystem quality. They applied this model to the Vembanad Lake in the state of Kerala. Similarly, Sannigrahi et al. (2020) estimated the ecosystem service value of six eco-regions of the Sundarbans biosphere reserve.

The translation of scientific research findings into practice has, however, been very limited. One possible explanation could be lack of awareness among decision makers about the philosophy of ecosystem valuation and its application. However, a more plausible reason is that ecosystem valuation is treated as a theoretical subject matter with limited practical implications. Action research is needed to change this narrative. There is a need for more evidence-based studies that provide tangible avenues and channels to mainstream ecosystem valuation in decision making.

Sustainable Models for Enhancing River-Related Economy

Rivers have an intrinsic economic value. Throughout history, civilisations have flourished along the banks of rivers. For such civilisations, rivers were the main avenues for economic and social activities. To not tap into the economic potential of rivers will essentially be a lost opportunity. The challenge, however, is to do so without breaching the threshold of disturbance that the river can handle naturally.

Research is needed to identify quantity and explain this threshold of disturbance. This is closely related to the much touted term 'carrying capacity', which was originally an index of physical mechanics, describing the maximum load that an object can sustain without damage. Gradually over time, the philosophy of carrying capacity found application in natural resource management and land ecological protection to help define the extent of permissible socio-economic development (Hu et al., 2022).

There are good references in literature where the concept of carrying capacity has been applied in the water sector. For example, Hu et al., (2022) used water supply-demand analysis and temporal threshold analysis to estimate the regional water resource carrying capacity in Inner Mongolia of China. Sun et al. (2022) propose a marine ecological carrying capacity framework that uses the AHP-entropy based TOPSIS method to carry out a multi-angle evaluation of marine ecological carrying capacity, and applied this framework to the Shandong province of China. Likewise, Khorsandi et al. (2022) employed an earth observation method to develop an analytical tool to estimate the water resources carrying capacity for Iran.

The aforementioned studies and a number of others may be referred to to establish a methodology to estimate the carrying capacity of rivers under different development pathways, and identify means to boost this capacity through technological, economic and institutional mechanisms.

Addressing the Impacts of Climate Change

Climate change is easily among the greatest challenges for sustainable development. Water is the primary medium through which the impacts of climate change are manifested, which makes it all the more important to account for climate change in river management strategies of the future. Already across the globe, rivers are beginning to exhibit the impacts of climate change. Rivaes et al. (2022) carried out an assessment of climate change effects on the instream biota of the Lima River in Peru. Their results revealed that climate change-driven flow regimes will influence river hydraulics because of which all the assessed biological groups are prone to potential drastic changes. Likewise, studies have quantified the impacts of climate change on: (a) sediment load in rivers (e.g. Muto et al., 2022); (b) flow in rivers (e.g. Du Plessis and Kalima, 2021); (c) riverine aquatic species (e.g. Rivaes et al., 2022) sustainability of ecosystem services (Ashrafi et al., 2022), among others.

There is a need for research on how to integrate climate change in decision making for urban river management, linking climate-related considerations to planning strategies and management options. Some key research questions that need to be answered include: 1) How to address the variation in streamflow in light of climate change? 2) What kind of planning and management provisions should be made to account for large deviations in the course of rivers resulting from climate-induced change? 3) How to protect native aquatic and riverine species from the impacts of climate change?

Most importantly, however, is the question of how to keep rivers healthy in the face of climate change. This is a crucial aspect because already cities across the globe are bearing the brunt of climate change through increasing instances of floods, droughts, water-related pandemics, loss of

biodiversity, and other detrimental impacts. Healthy rivers are excellent avenues to help mitigate these impacts. For example, rivers with well-defined and well-maintained riparian buffers can reduce the threat of fluvial flooding significantly. Likewise, effective floodplain management can augment depleting groundwater levels, and subsequently enhance the overall water security in the city. The range of ecosystem services that a river provides—i.e. provisioning, regulating, supporting and cultural—are unparallel. However, many of these ecosystem services are likely to be compromised in light of climate change. Effective and sustainable management of healthy rivers is, therefore, a vital cog in the wheel of sustainable development in the context of climate change.

Conclusion

It is now well established that healthy rivers have a significant role to play in the overall livability and development of cities. It, therefore, is vital that cities invest their resources and time in maintaining healthy rivers. However, the management needs of the current times may be very different from those of the future. This accentuates the need for a dedicated stream of research on urban water management in the country, particularly because this domain is relatively new. The research required is more from an 'action' standpoint, where the emphasis has to be on creating a 'solution space' for addressing imminent and anticipated challenges.

The paper highlights a few areas of research that can be taken up in the near future. However, this list is not exhaustive. As the knowledge on urban river management improves, it will lead to both newer and deeper areas of research. The conventional cycle of research-to-publication-to-recommendation may have worked in the past. However, the current urgency to address the impacts of climate change demands embedded approaches to research that accompany the pursuit of massively scaled-up climate action. This calls for solution- and action-oriented research that is integrated into practice: from problem definition to solution implementation, from programme design to evaluation.

Conflict of Interest

Authors has no conflict of interest to declare.

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