Towards water sensitive cities in Asia: an interdisciplinary journey

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ABSTRACT

Rapid urbanisation, population growth and the effects of climate change drive the need for sustainable urban water management (SUWM) in Asian cities. The complexity of this challenge calls for the integration of knowledge from different disciplines and collaborative approaches. This paper identifies key issues and sets the stage for interdisciplinary research on SUWM in Asia. It reports on the initial stages of a SUWM research programme being undertaken at Monash University, Australia, and proposes a framework to guide the process of interdisciplinary research in urban water management. Three key themes are identified: (1) Technology and Innovation, (2) Urban Planning and Design, and (3) Governance and Society. Within these themes 12 research projects are being undertaken across Indonesia, China, India and Bangladesh. This outward-looking, interdisciplinary approach guides our research in an effort to transgress single-discipline solutions and contribute on-ground impact to SUWM practices in Asia.

Key words | developing cities, integrated water management, sustainable development, sustainable urban water management

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INTRODUCTION

Rapid urbanisation as a worldwide phenomenon is most prominent in Asia. With Asia accounting for 65% of global urban expansion since the start of the century, the 21st century is shaping up to be the 'Asian Urban Century' (UN-Habitat 2013). This transformation exerts tremendous pressure on urban water systems, which is further aggravated by the effects of global climate change. Many Asian cities are ill-equipped to respond to these pressures, as they face a host of social, institutional, technological and economic barriers to establishing 'sustainable urban water management' (SUWM) practices (UNW-DPAC 2010). Examples of such barriers include resistance to change, poverty and marginalisation, fragmented responsibilities, lack of institutional capacity and legislative mandate, insufficient engineering standards and guidelines, uncertainties in performance and cost of potential solutions, and lack of funding and effective market incentives (Roy *et al.* 2008; Goff & Crow 2014).

SUWM is advocated by an increasing number of scholars as an alternative paradigm to traditional water infrastructure and approaches, which can address the complex challenges facing urban water management (Pahl-Wostl *et al.* 2008; Brown *et al.* 2009; Crow-Miller *et al.* 2016). SUWM is an umbrella concept which encapsulates the concepts of 'integrated urban water management' and 'water sensitive urban design' (WSUD) (Mitchell 2006; Fletcher *et al.* 2015). A 'water sensitive city' (WSC) integrates normative SUWM values of environmental protection, equity, rehabilitation and sustainability with essential water services, including supply security, flood control, and public health, but also additional benefits such as food security, energy savings, amenity and resilience of cities to

doi: 10.2166/wst.2017.287

climate change (Wong & Brown 2009). Furthermore, it has acquired diverse, adaptive, multi-functional technologies and infrastructure, with urban design features that reinforce water sensitive behaviours and practices, underpinned by a flexible institutional regime (Brown *et al.* 2009).

Theoretically, a WSC state can be achieved, in part, through cumulative change in socio-political drivers and service delivery functions that fully operationalise the principles of SUWM (Brown *et al.* 2009). Figure 1 shows the urban water transitions framework which can be used to demonstrate the continuum 'states' a developed city may pass through towards a WSC state. An emerging line of inquiry in urban water transitions research is whether developing countries can 'leapfrog' this traditional pathway and directly execute SUWM (Binz *et al.* 2012).

Stemming from earlier work in transitions and systems innovation, Binz *et al.* (2012) define leapfrogging as 'a situation in which a newly industrialised country learns from the mistakes of developed countries and directly implements more sustainable systems of production and consumption, based on innovative and ecologically more efficient technology' (p.156). In short, leapfrogging theory proposes that developing countries may be able to leapfrog older versions of technology and avoid developed countries' path to industrialisation with its environmentally degrading legacy. By leapfrogging straight to a cleaner (sustainable) production, developing countries may also be able to avoid the socio-technical 'lock-in' that many industrialised economies are currently experiencing (Unruh & Carrillo-Hermosilla 2006; Maassen 2012). This difference in socio-technical contexts (between industrialised and developing) is an important element in the process of leapfrogging. The focus is not on how existing methods of production can be transferred from industrialised countries, but instead what solutions are available that meet the contextual conditions and allow the normative goals of sustainability to be achieved. Taken together, this presents an opportunity for developing cities to 'leapfrog' towards a WSC state.

The United Nations (UN) recently released 17 'sustainable development goals' (UN 2015), of which Goal 6 – Clean water and sanitation, Goal 9 – Industry, innovation and infrastructure, and Goal 11 – Sustainable cities and communities align closely with the concept of WSCs. Each of these goals relates future prosperity to the provision of clean water, sanitation, community engagement, smart infrastructure and technological innovation. While these goals are specifically related, SUWM relates to most of the other goals, such as ending poverty, ending hunger, equity and protection of ecosystems. Because of these complex interdependencies, uncertainty of future drivers and lack of consensus on solutions, the obstacles related to SUWM can be classified as 'wicked problems' (Rittel & Webber 1973). It is this 'wicked' nature of SUWM that calls for an interdisciplinary approach, as solutions from any one discipline are not fit to address this complexity (Brown *et al.* 2015; Larson *et al.* 2015).

In our research programme, researchers from different disciplines are working together to address complex

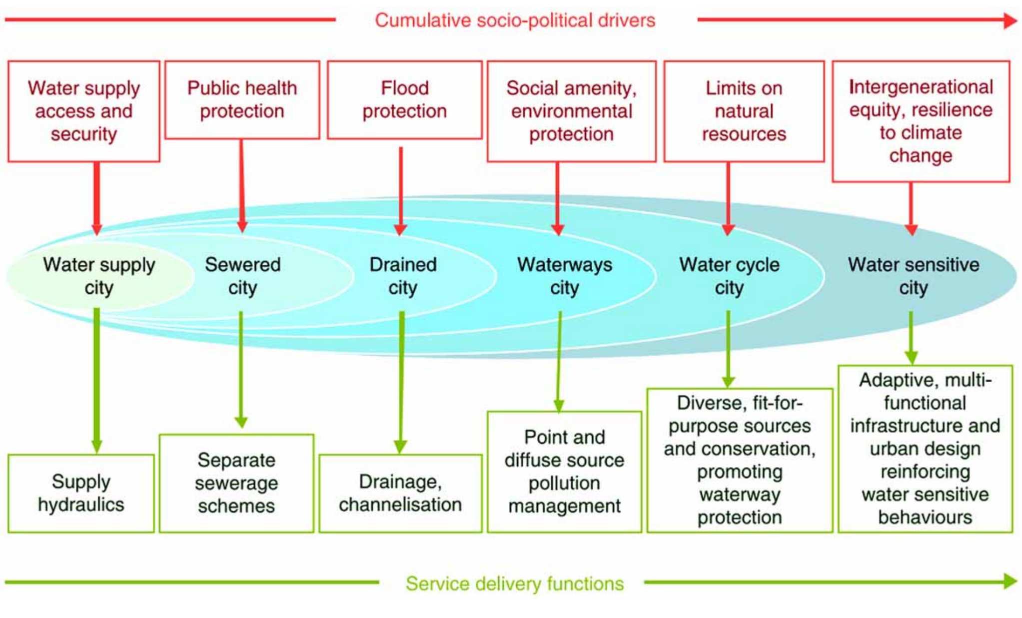

Figure 1 | Urban water transitions framework (Brown *et al.* 2009, p. 850).

SUWM challenges from both a biophysical and social perspective. Each researcher employs their own discipline-specific base (Rosenfield 1992), but also actively shares and synthesises their knowledge across the single disciplinary silos in order to develop a holistic understanding of SUWM in developing Asian cities. Although complexity poses a challenge, there is a range of opportunities to achieve research impact and facilitate real-world transformation in this space. First and foremost, our approach seeks to create impact through interdisciplinary research that defines emerging urban water problems and advances novel SUWM solutions in Asian cities – a context where such a research programme is, to date, yet to transpire.

While it is not at the core of our approach, the involvement of a variety of stakeholders beyond the academic actors (Massey *et al.* 2006), or the so-called transdisciplinary approach, serves as an important background to many of the research activities. We envisage that our research activities will create opportunities for bridging the interface between academic theory, policy-making and application. This paper is primarily focussed on the journey the researchers are undertaking as part of the interdisciplinary team. We will discuss the role of interdisciplinary researchers in bridging research, policy, and practice, where suitable (Brown *et al.* 2015).

MATERIAL AND METHODS

Traditionally urban water management solutions and innovations emerge from, and are sought after, within strictly separated disciplinary silos, most prominently social sciences and natural sciences/engineering. An interdisciplinary approach requires breaking down the barriers between these silos. Therefore, our research integrates the knowledge and expertise from both civil engineering and social science. Collaboration is the backbone to this approach. An integral but not core part of our research is engagement with industry, governments and non-governmental organisations (NGOs) in the process. Again, collaboration is the underpinning theme in our research programme, both between academics from different disciplines and between academia, decision-makers and implementing stakeholders.

Brown *et al.* (2015) identify five fundamental principles for interdisciplinary research in SUWM: (1) a shared mission, (2) 'T-shaped' researchers, (3) constructive dialogue, (4) institutional support and (5) bridging research, policy and practice. Following these principles, 12 researchers from five continents and diverse cultural backgrounds are working together at Monash University to tackle the complexity of SUWM in Asian cities. While six of these researchers are based in the Department of Civil Engineering and six from the School of Social Sciences, educational training and professional expertise included civil engineering, environmental engineering, environmental science, sustainability, international relations, international development, economics, geography, resource management, psychology, religious studies and landscape architecture.

RESULTS AND DISCUSSION

Research framework and outcomes

We developed a research framework that breaks down the disciplinary boundaries (see Figure 2). Three key themes or 'angles' are identified to cover a broad spectrum of the issues identified when implementing SUWM in a developing Asian context. The framework serves as a heuristic model, and boundaries between the angles are necessarily porous. As discussed below, these angles are: (1) Technology and Innovation, (2) Urban Planning and Design, and (3) Governance and Society.

The outcomes of this interdisciplinary programme span the spectrum of urban water management, from technological innovation (low level, focussing on local implementation) up to vision and strategy (high level, focussing on metropolitan strategies) (see Figure 2). These outcomes emerge on the interface of the three research angles. All outcomes are based on a fundamental knowledge and understanding of the urban water system in the broadest sense. In order for this knowledge and understanding to have the anticipated impact in the real world – a transition towards SUWM – it must be operationalised. This operationalisation is achieved through the development of a diverse set of 'tools', which should empower policy makers, urban planners, developers and civil society to drive the envisioned transition.

As shown in Figure 2, these tools are broadly categorised into four groups:

1. The development and testing of technological innovations in infrastructure design, to effectively capture, treat, control and monitor urban runoff, both stormwater and wastewater. These technologies are designed in the context of developing Asian cities, to generate multiple

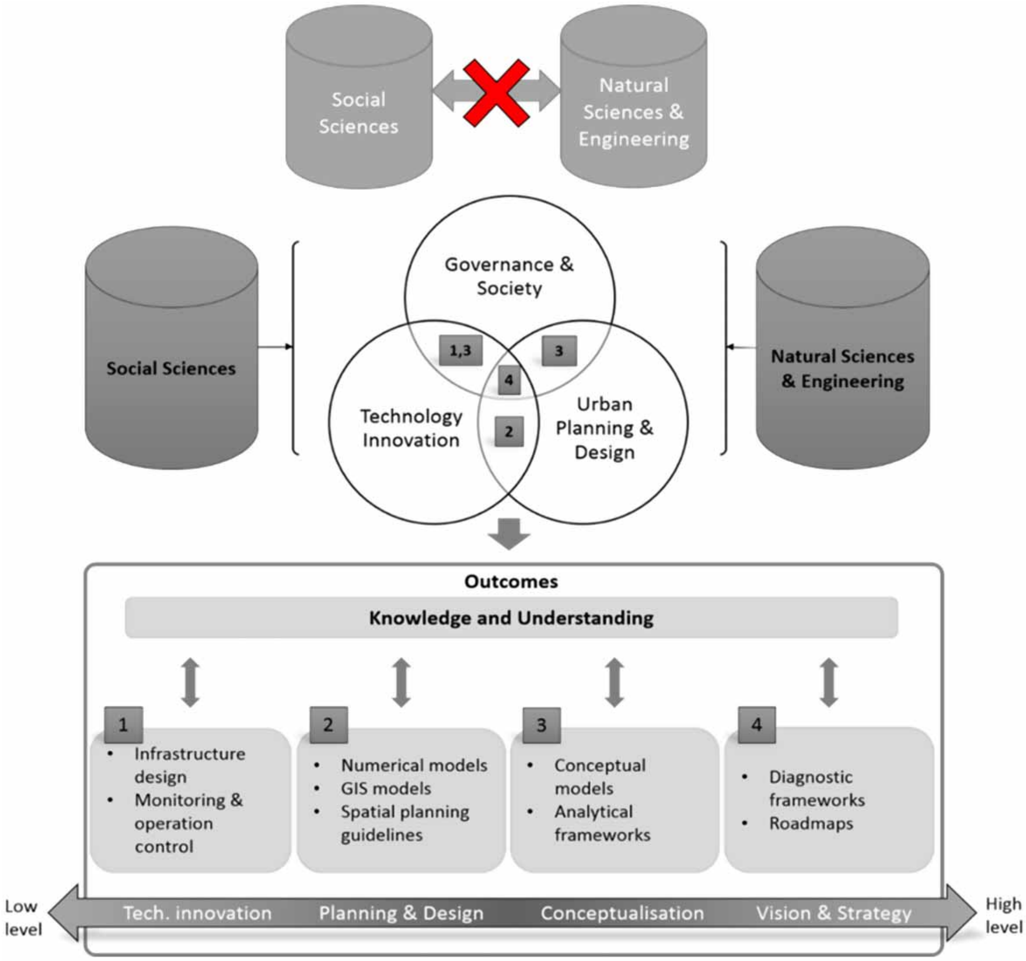

Figure 2 | Breaking the wall between disciplinary silos in urban water management: our interdisciplinary research model and its outcomes.

benefits, such as water treatment, fit-for-purpose water supply, flood mitigation, food production and the provision of green space in dense cities.

2. The development of computer tools and models which can simulate different scenarios of urbanisation, calculate impacts and optimise the localisation of SUWM measures. These tools support the implementation of distributed, local-scale technological innovations, in combination with centralised water infrastructure. This combination is important as careful urban planning and design is required to ensure sustained operation and maximisation of acquired benefits.
3. The development of conceptual models and analytical frameworks that describe systems of stakeholders and their roles, capacities and relations with respect to urban water and sanitation. These frameworks and models inform and enable good governance practices and support urban planning and design, which needs to be based on solid concepts of socio-technical urban water systems.
4. Overarching visions and strategies are required to inspire and enable change. We support these visions and strategies by developing diagnostic frameworks and roadmaps towards water sensitivity. Tools in this group promote adaptive governance and identify strategies for cities to leapfrog to more effective, sustainable and just urban water management.

Technology and Innovation

There are genuine opportunities for sustainable technologies to be adopted in developing Asian cities, as urban water infrastructure has yet to be formalised. While centralised systems for water supply and wastewater treatment, along with large underground drainage networks for stormwater management, are associated with a number of benefits (e.g. securing a clean water supply, improvements in health through the disposal of contaminated wastewater and mitigating flood impacts), they also come with a number of costs (Brown *et al.* 2009). These include but are not limited to locked-in technology that is expensive to maintain, centralised systems that are difficult to upgrade, environmental degradation of local waterways due to discharging of polluted wastewater, impacts on the hydrological cycle and system vulnerability to climate change. Consequently, alternatives are being sought, including technology that is adaptable, multi-functional, cheaper and greener (Wong & Brown 2009).

Four researchers work primarily within the Technology and Innovation theme and have identified the following research topics: (1) the design of small-scale green technology for the on-site management of stormwater and greywater, (2) development of a stormwater biofiltration system for the simultaneous treatment of stormwater and irrigation of urban agriculture, (3) the control and optimisation of WSUD systems to allow real-time adaptation to different operational conditions, and (4) exploring the emergence and uptake of innovations in sanitation and how to leverage this at the community scale. These topics are explored in two different contexts: Indonesia and China (see Figure 3). Conducting studies in two different contexts will allow us to compare and contrast the success of novel technology (e.g. adaptions required in design due to climate) and community engagement in the uptake of innovation.

Urban Planning and Design

Rigorous planning and functional design of the urban landscape are instrumental to facilitating growth and adapting to climate change. Planning and design is foundational to the physical exponent of the WSC. It requires a deep understanding of the local spatial, demographic and social context (Bach *et al.* 2015). In this angle, this understanding is combined with innovative green technologies such as raingardens, ponds and wetlands, which are aimed at stormwater retention, treatment and harvesting.

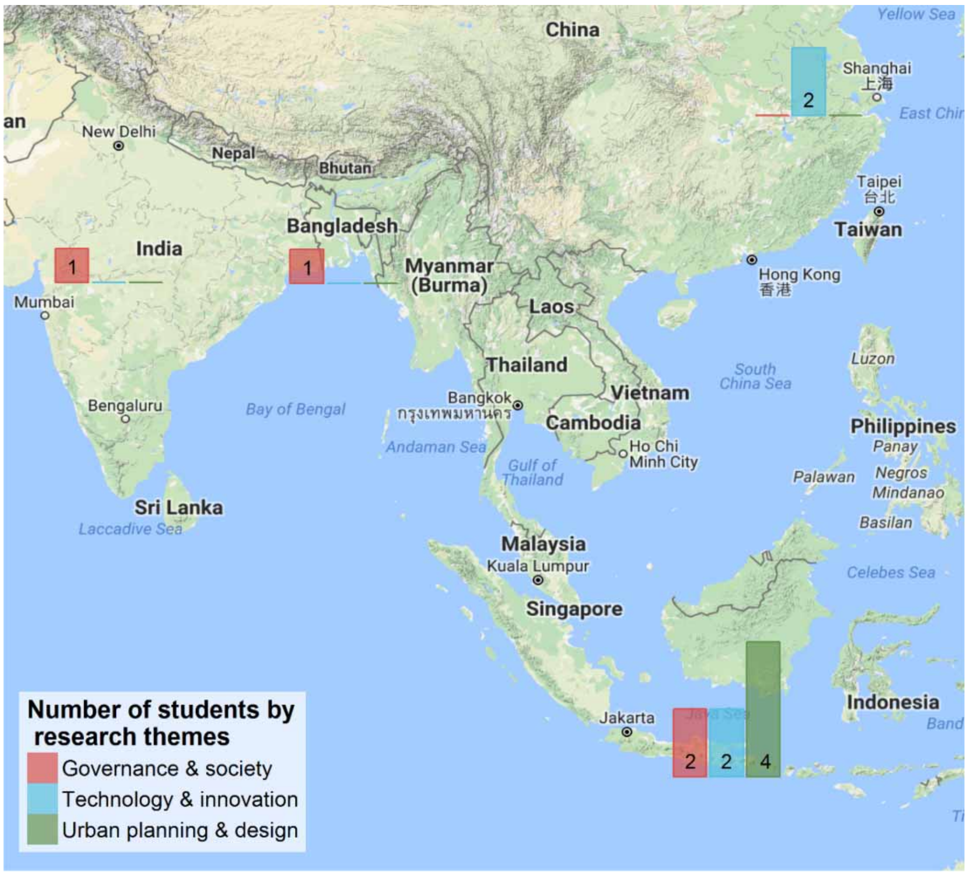

Figure 3 | Map of SUWM research projects across Asia (Google Base Map 2016).

Four researchers work primarily within the Urban Planning and Design theme and have identified the following research topics: (1) developing an integrated urban water modelling tool to investigate the multiple benefits of WSUD elements, (2) the development of a spatial suitability assessment method and computer application for the placement of WSUD elements, (3) modelling the impact of different policies on the transition from traditional infrastructure to green infrastructure adoption, and (4) assessing the influence of the physical built environment on sustainability transitions to inform strategic action towards SUWM. These topics are explored in Indonesia (see Figure 3). Conducting all these studies in Indonesia allows for comprehensive data gathering (e.g. topography, existing water infrastructure), which is required to inform the models and assessments.

Governance and Society

We begin with a hypothesis that governance strategies are needed to facilitate progressive policies and institutional change for implementing SUWM in developing contexts. When faced with uncertainty and complex choices, conventional water institutions tend to go into inertia which sustains less-than-effective governance structures and societal processes, such as organisational fragmentation, poor political processes, lack of accountability, bureaucratic complexity, ad hoc decision-making, entrenched inequality, and risk-averse attitude, among others (Brown 2005). In contrast, studies have shown that new governance attributes (e.g. adaptive learning and experimentations, multi-stakeholder decision-making, accountable and transparent process, just and equitable outcomes) need to be introduced in order to facilitate complex societal transformations as required by SUWM (Van de Meene *et al.* 2011; Finewood & Holifield 2015).

Four researchers work primarily within the Governance and Society theme and have identified the following research topics: (1) identifying socio-political drivers and the enabling contexts for leapfrogging towards SUWM, (2) diagnosing capacity for strategic action to accelerate SUWM adoption, (3) assessing adaptive capacity to overcome institutional barriers for SUWM, and (4) developing a justice framework to empower marginalised communities towards SUWM. These topics are explored in three different contexts: Indonesia, Bangladesh and India (see Figure 3). Conducting studies in three different contexts will allow us to compare and contrast governmental structures and alternative practices, which promote or hinder the implementation of SUWM in a developing context.

Interconnections

While each researcher sits within one of the above mentioned research angles it is important to note that as a cohort we span the spectrum from pure engineering to social science research, with a number of researchers also working on individual interdisciplinary projects. Of the 12 projects, this roughly equates to: two pure engineering projects, one each from Technology and Innovation and Urban Planning and Design; two pure social science projects, both from Governance and Society; and eight interdisciplinary projects, two from Society and Governance, three from Technology and Innovation and three from Urban Planning and Design. Regular meetings, conversations and presentations are organised to facilitate dialogue and ideas among the group.

Linkages

As stated previously, while not at the core of our programme, the involvement of a variety of stakeholders beyond academic actors serves as an important background to our research activities. In all four countries various professionals from the government involved in the water and sanitation sector will be interviewed as they play a key role in the decision-making, implementation and enforcement of SUWM. For example, in Indonesia, individuals from the Department of Planning, Environmental Agency and Department of Public Works will be engaged via interviews and focus groups. The results of these encounters are expected to provide us with insights on current water management approaches and their receptiveness towards SUWM. Additionally, these interactions will allow us to understand the various current government structures, their workings and effectiveness in delivering current water management goals and hence their ability to move towards SUWM.

In addition to governmental organisations and agencies, NGOs will also be involved. These NGOs may be industry partners or charities involved in the water sector, such as WorldVision. Their involvement is essential as it recognises the influence that NGOs have in engaging with the community and their role in various community-led movements, particularly in the areas of sanitation and ensuring equitable urban water development. In contrast to governmental agencies and private organisations, NGOs are more involved in bottom-up instead of top-down approaches. They provide a different perspective that can be used to inform the development of SUWM initiatives, such as consideration to the needs and wants of communities and the contextual suitability of projects. Additionally, there will be other industry partners, such as consultants and developers, involved in the design, construction and implementation of water systems who will be engaged through interviews. They play an important role in determining the capacity for the implementation and adoption of SUWM.

While governmental and NGOs play a large role in decision-making and the implementation of various strategies, there is a need to include the community whose lives are impacted by these approaches and their social and environmental outcomes. This is particularly the case for WSUD elements delivered as part of SUWM, where placement is within the vicinity of local communities. SUWM is also a relatively new concept in developing countries and will give rise to different perceived risks and uncertainty. As such, it is intended that select local communities in all four countries will be involved through surveys and focus group discussions to obtain their insights on the current water system, their understanding of SUWM and their receptiveness to this approach.

Finally, in developing cities where there is underdeveloped infrastructure and institutional capacity, there is a need to look at the role and strategies used in alternative practices emerging outside formal institutions (Bauler *et al.* 2017). Among these are social innovations and social entrepreneurship, which are gaining tangible traction for their ability to tackle complex and persistent social and environmental problems while contributing to environmental sustainability and socio-economic development of poor and marginalised citizens (Bonifacio 2014). Therefore, social entrepreneurs in the water and sanitation realm will also be engaged as part of our research programme.

Interdisciplinary research: initial thoughts

Interdisciplinary research has a more holistic view in solving complex problems in comparison to traditional silo research; however, it comes with both rewards and challenges. The biggest challenge we have found to date is that it requires more time, more patience, more effort, more support and more money, than traditional projects we have worked on. The biggest incentive of interdisciplinary research is that approaching problems from different angles and thinking about them through different disciplinary lenses can result in non-conventional ideas and solutions. Besides this advantage, the process of doing interdisciplinary research has several personal rewards. In the journey so far, it has provided a good opportunity for individual researchers to gain or improve communication and team work skills. It has enabled and facilitated learning about other disciplines. Through the increased communication with each other, we have learnt to understand the lexicon of other disciplines, conversing across academic boundaries and beginning to speak a common language. With time this should lead to T-shaped professionals who can quickly collaborate across different disciplines, even in entirely new teams and contexts for future projects (Brown *et al.* 2015). Arguably, T-shaped professionals possess transferable skills and capacity to effectively bridge communication and collaboration across various stakeholders (beyond the academic actors). After all, the task of tackling complex challenges cannot be delivered only through the ivory tower of research academia. Nonetheless, we contend that by starting the journey early and intently, interdisciplinary researchers can complement the broader transdisciplinary agenda to bridge research with policy and practice more effectively.

CONCLUSIONS

SUWM is facing complex challenges in developing cities, such as rapid urbanisation, population growth and climate change. However, there are also substantive opportunities to promote SUWM in this context, with urban water systems yet to be formalised and minimal lock-in to conventional approaches. Utilising an interdisciplinary approach and bridging the interface between the biophysical and social science disciplines, researchers are working together to aid 'leapfrogging' of Asian cities to WSC futures. Three key research angles have been identified in this process; (1) Technology and Innovation, (2) Urban Planning and Design, and (3) Governance and Society. Within these research angles 12 research projects are being undertaken across Indonesia, China, India and Bangladesh. This outward-looking, interdisciplinary approach guides our research in an effort to transgress single-discipline solutions and contribute on-ground impact to SUWM practices in Asia.

ACKNOWLEDGEMENTS

We acknowledge the guidance and assistance of the supervisory team of this research programme: Peter Bach, Annette Bos, Megan Farrelly, Belinda Hatt, David McCarthy, Sayed Iftekhar, Diego Ramirez-Lovering, Briony Rogers and Christian Urich. Thank you for your support and patience.

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First received 19 February 2017; accepted in revised form 3 May 2017. Available online 19 May 2017