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What makes a successful Sponge City project? Expert perceptions of critical factors in integrated urban water management in the Asia-Pacific

Sustainable Cities and Society, 2021; 75:103317-1-103317-17

Final publication at: http://dx.doi.org/10.1016/j.scs.2021.103317

What Makes a Successful Sponge City Project? Expert perceptions of critical factors in integrated urban water management in the Asia-pacific

Abstract

Sponge City (SC) projects aim to replicate natural water cycles within urban settings, providing sustainable solutions to urban water management. However, there is a lack of understanding on the relative importance and performance of the significant factors that contribute to the success of SC projects. To address this, we conducted a survey of urban water experts from the two distinctive cultures of Australia and China, to generate insights on ‘what makes a successful Sponge City project?’. We also explored the relationships between success factors using importance performance analysis and structural equation modelling. Our findings demonstrate that whilst professionals think that the water management objectives have been dealt with in a satisfactory way, they also find that economic, socio-cultural and design factors are addressed in an insufficient or fragmented way. Our research highlights both similarities and differences in the importance and performance of SC factors in two countries. In China greater attention to economic factors is required, while in Australia policy and governance factors require greater focus. Both China and Australia would benefit from further research on undervalued socio-cultural factors. Most importantly we find that SC projects require greater integration of substantive and procedural factors to address urban water challenges.

Keywords: project management, WSUD, Low Impact Development, Nature-based solutions, water quality, long-term monitoring

1. Introduction: Integrated urban water management, an unfinished project

Urban water management is one of humanity’s grand challenges, as recognised by complementary global policies such as the Sustainable Development Goals (SDGs) (UN. ESCAP, 2019) and New Urban Agenda (UN Habitat, 2017). Freshwater ecosystems, drinking water treatment plants, distribution networks, urban stormwater catchments, urban water bodies, sewer systems and wastewater treatment plants form complex and fragmented socio-technical systems. Despite a range of global policies, water systems within cities are generally not well integrated, due to siloing of knowledge, fragmentation of decision making and a lack of ambitious, transdisciplinary targets (Porse, 2018).

Integrated urban water management is an emerging approach to address a wide range of water related problems in cities. It is holistic in its synthetic approach and relies on a range of factors to address complex urban water problems. A global body of knowledge focuses on innovation in this area, but a valuable diversity of experience also captures local challenges and cultural difference (Ureta *et al.*, 2021). Although different societies have learnt from each other (Kumar *et al.*, 2021), specialised programs focus on national challenges. There are multiple current approaches to better manage the different elements of urban water systems, including Sponge Cities (Li *et al.*, 2017), Water Sensitive Urban Design (Morison and Brown, 2011), Low Impact Development (Liao *et al.*, 2018), Sustainable Urban Drainage Systems (Lashford *et al.*, 2019), Nature Based Solutions (Langergraber *et al.*, 2020), and Blue-Green Infrastructure (BGI) or Blue-Green Systems (BGs) (Deletic *et al.*, 2020). As Fletcher *et al.* (2015) argue, although a 'uniform set of terminology' may aid communication and knowledge transfer, the variety of terms also reflect 'locally shared understanding'. As this paper focuses on both different cultural and historical stages of Sponge City development, we use the more generic term 'integrated urban water development' to refer to global or cross-cultural factors; the more imaginative 'Sponge Cities' to refer to Chinese cases; and 'water sensitive urban design' (WSUD) for Australian contexts.

Urban water management is exposed to a diverse range of political, economic, social, technological, legal and environmental (PESTLE) influences (Henriques *et al.*, 2015;Ulubeyli and Kazanci, 2018). These systems and their interactions are complex; therefore, failures of Sponge City BGI are commonly found, not just due to technical problems, but also economic, and legal issues (Blecken *et al.*, 2017;Li *et al.*, 2017). Thus, urban water management schemes require ongoing innovation and calibration to a diverse range of problems and local conditions to achieve positive outcomes (Brown *et al.*, 2009;He *et al.*, 2019). There is an awareness amongst both Australian (Wong *et al.*, 2020) and Chinese (Jiang *et al.*, 2017) practitioners, that current Sponge City approaches require improvement to achieve better sustainability outcomes and associated programs such as the SDG goals and the New Urban Agenda. Nevertheless, it is challenging to understand where to invest resources to improve future urban water management projects. Previous studies on success factors in Sponge City projects have identified challenges and opportunities through field examinations and questionnaire (Li *et al.*, 2017) but such research was mainly limited to general assessments (Li *et al.*, 2020) or to local cases in China (Zhai *et al.*, 2021). It therefore lacks transferrable insights and cross-cultural robustness that makes findings relevant to Sponge City projects in diverse geographic areas and diverse development stages. Previous studies of Sponge Cities have focused on a range of factors such as flooding (Yuan *et al.*, 2017;Zhang *et al.*, 2018a), ecosystems (Zhao *et al.*, 2018;Yang *et al.*, 2019;Wang *et al.*, 2021a) planning and design (Du *et al.*, 2019;Liu *et al.*, 2021;She *et al.*, 2021), community engagement (Chen *et al.*, 2019) and policy (Dai *et al.*, 2018;He *et al.*, 2018;Qiao *et al.*, 2019;Wihlborg *et al.*, 2019). But as Brown et al (2018) suggests, there is a need for integrated urban water management research across all PESTLE aspects, so as to achieve greater live ability, sustainability and resilience.

The overall aim of this study was to investigate what critical factors contribute to the success of Sponge City projects. To do this we interviewed a diverse range of urban water experts in two countries that are at very different Sponge City developmental stages - China (which has started its program more recently) and Australia (which has experimented with such programs for three decades) - to gain cross cultural insights into the current shortcomings and gaps in Sponge City and integrated urban water management projects. Specifically, we gauged the satisfaction of participants in the successful fulfilment of a range of factors identified as being significant for sponge city success through a combination of literature review and focus group feedback. Research has shown that stakeholder satisfaction is an effective way to gauge the success of projects in relation to the fulfillment of specific project values, goals and factors (Leung *et al.*, 2005;Kärnä *et al.*, 2013). In this study we measured both the perceived importance and performance of a range of factors to achieving successful sponge city outcomes. The specific aims and objectives of this study include:

- Systematically assessing the importance and performance of a wide range of integrated water management factors across all PESTLE aspects, based on a questionnaire across (i) two countries, and (ii) multiple professional stakeholder groups.
- Understanding the relationships between the factors using structural equation modelling.

This innovative and distinctive cross-cultural approach makes the research relevant to different cities and urban cultures at different stages of their water sensitive journey. We note this is the first time such a systematic exploratory study has been completed between countries in the Asia-Pacific. We address and deliver new insights in relation to two major challenges and research questions: firstly, what factors make a successful Sponge City project? Secondly, how can current projects' shortcomings be addressed? By synthesising current expert knowledge on urban water management, to address the above question, we aim to increase the success of future Sponge City projects. This approach, which seeks to both identify and prioritise critical factors, is important for improving the delivery of Sponge Cities, as a lack of resources such as space, knowledge, time, has severely hampered the implementation of these projects (Qiao *et al.*, 2020). Further better understanding of the relationships between critical success factors can help leverage the synergies between factors; link them through new strategies; and better fulfil the unfinished project of "integration" in Sponge Cities (Qiao *et al.*, 2020).

2. Background: Identifying critical factors from current research

To develop a comprehensive range of factors relevant to achieving success in Sponge City projects we conducted both literature review and a series of two workshops in Sydney and Shanghai. The literature review was guided by the PESTLE analytic approach in which Sponge City literature was evaluated across political, economic, social, technical, legal, and environmental areas. This search and analysis were in turn refined by focus groups in the two workshops and a final series of factors was developed to use in the study questionnaire. Focus groups were each made up of 20 participants from professional backgrounds spanning engineering, landscape architecture, architecture, urban design, construction, planning, project management and policy. Focus groups endeavoured to identify key factors of importance for the past and future success of Sponge City projects. A range of factors emerged from the PESTLE structured literature review and non-structured discussions in the two focus groups. These are as follows:

- Water management factors (WMF)
- Ecological factors (ECOF)
- Socio-cultural factors (SCF)
- Policy and governance factors (PGF)
- Economic factors (ECONF)
- Project design factors (PDF)
- Project implementation factors (PIF)
- Project management factors (PMF)

The following background based on both the literature review and discussion is structured according to the resulting list. As Sponge and Water Sensitive Cities are piloted and evaluated, new research has addresses a broader range of criteria for success including environmental outcomes such as urban cooling, and cultural dimensions such as swimming and recreation (Liu *et al.*, 2018;He *et al.*, 2019;Yu *et al.*, 2019;She *et al.*, 2021). For instance, Ren *et al.* (2017) propose 'water system 3.0', a framework to guide the development of integrated water supply systems, decentralised sewage systems, green and grey Sponge City infrastructure and near-natural ecological zones.

The United Nations and World Bank High Level Panel on Water (HLPW) developed an Action Plan (HLPW, 2018) setting out a range of challenges to be considered when implementing water sensitive cities, including diverse hydrological, ecological, cultural, institutional, financial, social and political management systems. The HLPW list captures this expanding focus of integrated water management research and acknowledges that water is a cross-cutting thematic that touches on a wide range of factors. Different factors are of varying significance when it comes to different cultural and policy contexts such as those that exist within China and Australia (Wong et al., 2020).

The literature and focus groups identified that flooding has been a significant factor in driving Sponge City policy in China. Rapid urbanisation in China has resulted in severe pluvial flooding (Jiang *et al.*, 2017;Zhang *et al.*, 2018b), thus flood control has shaped integrated urban water management there. In contrast, Australia has focused on both water management factors (WMF) and ecological factors (ECOF) with policy and project focused on managing runoff and stormwater quality (Wong, 2006;Sharma *et al.*, 2016;Shi *et al.*, 2019). In recent years a broader range of water management factors or concerns has arisen, including stormwater recycling and reuse (Hatt *et al.*, 2006), drought resilience (Broadbent *et al.*, 2018), and ground water level maintenance and control (Zhang and Chui, 2020). Although the Sponge City program's focus on flooding aimed to reduce risk, the overly technical approach has seen stakeholders reluctant and unsure of the economic returns of improved sponge city infrastructure (Anderson and Renaud, 2021;Wang *et al.*, 2021b).

In contrast literature and the focus group clearly indicated that ecological protection of urban waterways has driven Australian water management approaches. It is important to note however, that research has focused more directly on receiving waters and the design and conservation of robust, biodiverse shorelines (He *et al.*, 2018) than a comprehensive consideration of the ecological elements of such drainage and stream systems (Bolleter, 2017). BGI such as bioretention swales have enhanced urban biodiversity compared to conventional green spaces (Kazemi *et al.*, 2011). Direct enhancement of biodiversity and landscape systems is often identified as an outcome of integrated water management but has not been fully achieved and is often seen as secondary to hydrological water management factors (Lahde *et al.*, 2019). Fragmentation across disciplines and cultures (Jiang *et al.*, 2018) makes it difficult to gain insights into the stages of local program development or to learn from best practices.

In both China and Australia there is an emerging cognisance of the wide social and community based cultural benefits, or what we call here Socio-cultural factors (SCF), of integrated urban water management (Bowen and Lynch, 2017), these have often been limited by health risks and concerns around chemical and microbial contaminants (Ahmed *et al.*, 2019). In recent years urban water management approaches have been seen as one of the key ways to mitigate against heatwaves through modifying urban microclimates (Timm *et al.*, 2020). Quantification of the microclimate benefits has also been performed (Zhang *et al.*, 2020). Increasing the interaction of urban people with urban water management projects (Schirmer and Dyer, 2018) is therefore a focus of future research and design, along with enhancing attachment to place, sense of belonging and aesthetic enhancement (Dobbie, 2013). Mental, social and physical well-being have all been linked to BGI, and there is a growing literature that seeks to understand how to develop and deliver these diverse health and socio-cultural benefits through blue-infrastructure (BGI) (Albert *et al.*, 2019). Further integrated urban water management is now key to the delivery of the Sustainable Development Goals with its complex socio-cultural considerations of liveability and inclusivity (Cumming *et al.*, 2017;Vörösmarty *et al.*, 2018;UN. ESCAP, 2019).

To deliver better ecological and socio-cultural outcomes, decentralisation is now acknowledged as significant (Jiang *et al.*, 2017;Jiang *et al.*, 2018;Zevenbergen *et al.*, 2018). For example, van de Meene *et al.* (2011) has emphasised that "Shifting from traditional, large, centralised infrastructure to alternative, distributed technologies are widely accepted as essential for enabling sustainable water management.". Whilst such approaches have increasingly gained acceptance the take up of such decentralised and circular approaches remains slow. One of the main reasons for this is that transforming and coordinating cross-sector governance and collaboration (Pettit *et al.*, 2019) between urban agencies within the same city can be difficult. A range of research focused on such "policy and governance factors" (PGF) seeks to build visibility of such radical collaborative approaches, and to contribute step changes to governance by documenting landmark case studies (Dai *et al.*, 2018), government budgeting (Wang *et al.*, 2020), citizen government relationships (Barclay and Klotz, 2019) and government environmental management (Zuniga-Teran *et al.*, 2020).

Within focus group discussions and also throughout key literature we found that beyond the radical transformation of social, technical and technical systems, integrated urban water management is often underpinned by pragmatic economic considerations (ECONF) (Alves *et al.*, 2018). BGI has been shown to positively influence property values (Hoover *et al.*, 2020), generate greater tourism amenity (Cook *et al.*, 2019;Whiteoak, 2019), and promote the circular economy (Langergraber *et al.*, 2020). However, by far the largest economic value is generated by avoiding disasters and overload of water infrastructure (Cook *et al.*, 2019). Economic considerations prioritise risk minimisation over issues such as amenity. Citizens have also demonstrated a willingness to pay for such services (Wang *et al.*, 2020) although public acceptance and trust of Sponge City and related approaches is still evolving (Zhao *et al.*, 2020;Anderson and Renaud, 2021). A range of new research seeks to demonstrate the economic value of Sponge City and related approaches to local communities and governments alike (Koc *et al.*, 2021;Kumar *et al.*, 2021;Shen *et al.*, 2021;Xu *et al.*, 2021;Zhao *et al.*, 2021).

Climate change has had an important influence on such economic considerations and in the future the health risks associated with heat waves may dramatically transform integrated urban water management, requiring decentralised cooling approaches, and BGI (Coutts *et al.*, 2013;Broadbent *et al.*, 2018). However, in contexts like Australia, urban water management systems have failed to fully operationalise environmental and circular economic benefits due to market mechanisms which protect major water agencies' revenue (Johnston, 2019), even during water security emergencies (Johnston, 2019).

A recurring theme throughout focus group discussions was that project design factors (PDF), project implementation factors (PIF) and project management factors (PMF) seem to be marginalised in favour of more technical considerations (Bolleter, 2017;Dyca *et al.*, 2020;Cook and Larsen, 2021). This focus on the technical over socio-cultural and design considerations has some negative outcomes. For example, once BGIs are installed, they are often not maintained due to insufficient communication, unclear responsibilities, lack of knowledge, financial barriers, and divided governance (Singh and Kandasamy, 2009;Blecken *et al.*, 2017;Liang *et al.*, 2020). Sponge City design has typically been approached from an engineering perspective, with urban water literature dominated by engineering publications, despite landscape architects, planners and architects shaping the urban precincts into which water technologies must be integrated (Zhai *et al.*, 2021). There are exceptions, such as the influential work by Saunders and Yu (2012) but it is notable that *Journal of Urban Design* has published only two significant papers on water sensitive urban design (Bolleter, 2017;Palazzo, 2019). Integrated urban water management approaches such as WSUD and Sponge Cities are typically approached from a technocratic perspective, despite the clear economic, social and ecological value of open space (Brander and Koetse, 2011) and urban design's role in shaping and making it (Carmona, 2019). Urban design and landscape mechanisms have demonstrated their effectiveness in making space for water sensitive and sponge city infrastructure (Dyca *et al.*, 2020) but this is still often marginal to technical considerations (Palazzo, 2019).

According to Liu *et al.* (2018), project planning and project management factors (PMF) of integrated urban water management also require innovation, facing challenges like space and cost constraints and inter-sectorial and stakeholder collaboration. Major barriers to integrated urban water management exist in the planning sector due to 'a lack of communication between regulators and planners, and the absence of consistent financial evaluation methods' (Furlong *et al.*, 2016a). Significantly dominant water management frameworks are visualised as if planning processes are rational and objective, overlooking the reality that water management and planning systems are shaped by social and political dimensions (Furlong *et al.*, 2016b). Smaniotto Costa *et al.* (2015) argue that "integrating practices is seldom problem free due to a limited culture of cooperation between stormwater managers". This is perhaps a side effect of the dominance of STEM disciplines and a lack of design and social science disciplines within water sensitive city research. Further the focus groups noted that fragmentation across disciplines and cultures (Jiang *et al.*, 2018) makes it difficult to gain insights into the stages of local program development or to learn from best practices. Critical historical and sociological inquiry is essential for better understanding the evolution of integrated urban water management in different national contexts. Research is needed to orientate future urban water innovation within different national contexts as well as facilitating knowledge exchange across the Asia-Pacific region (Gain *et al.*, 2016). Our research addresses this knowledge gap.

Despite integrated urban water development being a focus of research over many decades in Australia and other cultures, there was agreement within the focus groups that water projects were often integrated in name only with fragmentation resulting in poor water management decisions and outcomes, and ecological aspects often sidelined for more visible engineered works (Jiang *et al.*, 2017). Although integrated urban water development programs have delivered many early, positive outcomes (Chan *et al.*, 2018) there was agreement that shortcomings across a range of factors from ecological factors, to project management factors to policy factors for example, needed better acknowledgement and investment in future. Our research therefore aims to deliver on this knowledge gap to better balance and calibrate investment in the diverse factors and areas that essential for successful Sponge City projects. Further for practitioners in the focus group, working across both

China and Australia, there was a curiosity and uncertainty as to which factors to prioritise, which factors were critical to both cultures, and which were transferable across such cultural context. Within the focus groups there was also agreement that Sponge City Projects could achieve greater success if locally important factors were better considered. As a result, we decided to evaluate the satisfaction of professionals in China, in Australia and across both of these Asia Pacific based cultures too. We considered that such an approach could provide insight into locally significant success factors (Jin *et al.*, 2021) and also Asia-Pacific significant success factors.

3. Methods

3.1 Research Design

Our research was based on three major steps including: 1) research design and data collection, 2) analysis and production of results and 3) synthesis of results, discussion and production of policy implications and takeaways (Figure 1).

We selected critical success factors and developed questions based on the above literature review and a series of two expert workshops held in Sydney and Shanghai, in June and July of 2018, involving two cross-cultural focus groups. These focus groups integrated government, professional and academic participants from both China and Australia as well as participants from Germany working in China. Participants included a range of disciplinary backgrounds that reflected the target sample of the study participants, *i.e.*, landscape architects, architects, planners, engineers, local government etc. In each instance focus groups consisted of twenty participants. The focus groups evaluated our literature review and selected the set of critical success factors based upon discussions in the workshops.

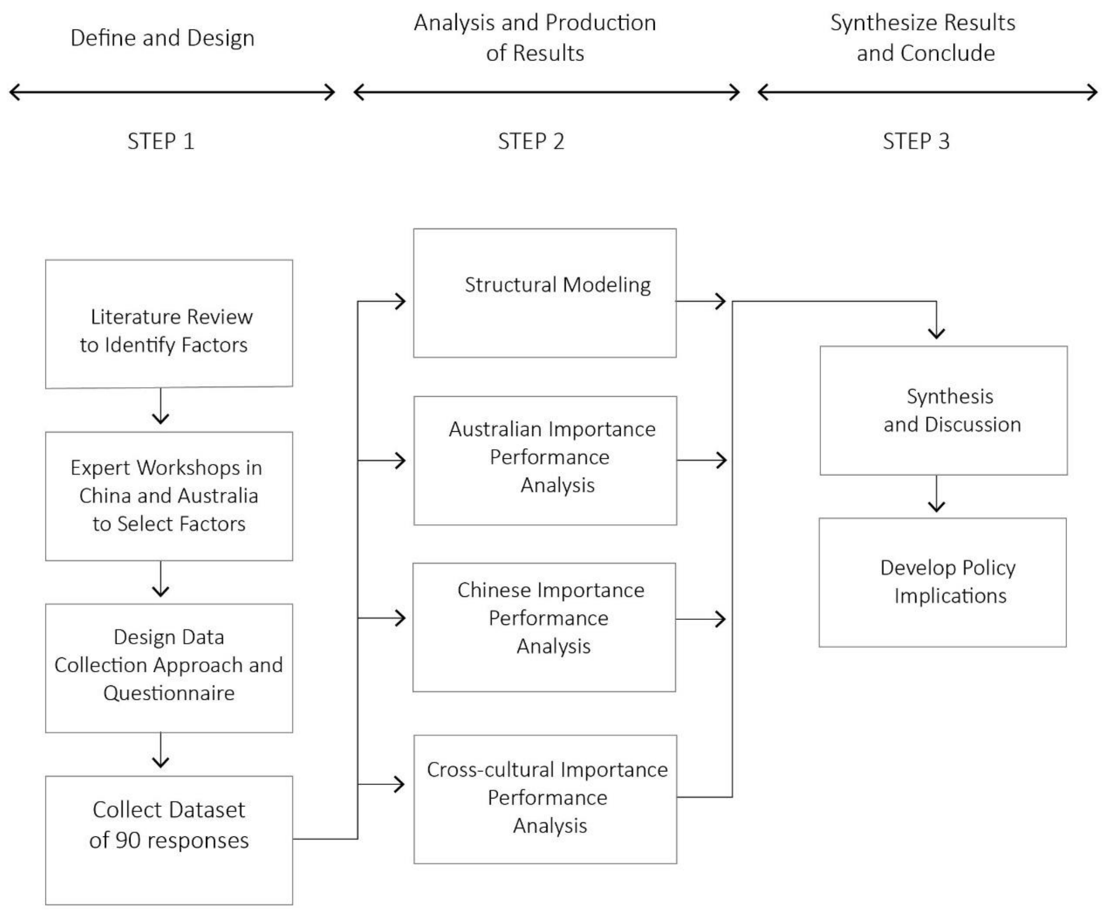


Figure 1. *Steps of the Research Design.*

Thereafter, we designed a questionnaire, available in English and Chinese, around a set of 40 factors across eight categories (Table 1; the original questionnaire is included as Supplementary Material and was available in English and Chinese). The questionnaire comprised three parts: Part A (A1-A7) identified the experts' backgrounds, Part B (B1-B6) captured participants' familiarity with sustainable urban water management terms; those not familiar with any terms were excluded from analysis. Part C (C1-C9) evaluated linkages in the success factors of Sponge City projects from eight major aspects. Participants were asked to rate the degree of (1) importance of each aspect and (2) the satisfaction level towards the achievements of each aspect based on their experience. This was based on a five-point Likert Scale with description was used to measure the degree of importance (*1 = Not at all important, 2 = Slightly important, 3 = Neutral, 4 = Important and 5 = Of utmost important*) and performance/satisfactory (*1 = Completely dissatisfied, 2 = Dissatisfied, 3 = Neutral, 4 = Satisfied, 5 = Completely satisfied*). The eight aspects C1-C8, each had their sub-aspects, and an open-ended response to collect additional explanatory information. In question C9, the participant was requested to make an overall rating of the importance and their satisfaction regarding current performance of the eight major aspects identified.

We targeted experts working in various areas of Sponge City development (with experience on real-world projects), e.g., policy marking, research, planning, engineering, etc, thus allowing us to have a broad understanding of the views from different disciplines. We then used two analytic methods, the importance performance approach (IPA) (Prajogo and McDermott, 2011;Sepasgozar *et al.*, 2021) and structural equation modelling (Hoyle, 1995;Yaghoubi *et al.*, 2017), to understand expert perceptions. We then used the results to generate a set of industry implications and takeaways for action.

Table 1. *Summary of the questionnaire's eight key aspects' links to successful Sponge City projects*

Major aspects		Sub-aspects	
C1	**Water management factors (WMF)**	C1.1	• Stormwater quantity control (*e.g.* Reduced runoff volume, control of road surface ponding and local pluvial flooding)
		C1.2	• Stormwater quality control (*e.g.* pollution reduction, improved water quality in urban streams/rivers, reduced combined sewer overflow discharge, decreased black and odour water body)
		C1.3	• Stormwater recycling and reuse (*e.g.* reduced water demand for urban landscapes)
		C1.4	• Drought resilience (*e.g.* Decreasing the risk of water scarcity for water use in urban areas)
		C1.5	• Ground water level control
		C1.6	• Other indicators, please specify
C2	**Ecological factors (ECOF)**	C2.1	• Urban biodiversity-protection and enhancement
		C2.2	• Urban Landscape improvement (*e.g.* well fitted to local existing landscapes)
		C2.3	• Ecological protection of urban streams/rivers (*e.g.* shoreline protection)
		C2.4	• Improved local microclimate (*e.g.* cooler surrounding temperatures)
		C2.5	• Other indicators, please specify
C3	**Socio-cultural factors (SCF)**	C3.1	• Increased the interaction of people to the urban areas with WSUD projects
		C3.2	• Attachment to place and sense of belonging (e.g. cultural and symbolic value)
		C3.3	• Increased the liveability of the place and the city
		C3.4	• Enhanced attractiveness of city
		C3.5	• Improved social well-being (*e.g.* more Sponge City parks)
		C3.6	• Improved mental well-being (e.g. happiness and satisfaction when seeing the multifunctional, natural green water treatment green systems)
		C3.7	• Improved Physical well-being (*e.g.* increased opportunities for physical practices around your life)
		C3.8	• Other indicators, please specify
C4	**Policy and governance factors (PGF)**	C4.1	• Made positive impact on government environmental management
		C4.2	• Positive impact on policy as a landmark case study
		C4.3	• Positive impact on government budgeting
		C4.4	• Positive impact on citizen-government relationship
		C4.5	• Other indicators, please specify
C5	**Economic factors (ECONF)**	C5.1	• Increased property values
		C5.2	• Enhanced tourism value
		C5.3	• Enhanced local or district economies
		C5.4	• Value of reduced water consumption and resource costs in project
		C5.5	• Value of disaster avoidance costs
		C5.6	• Other indicators, please specify
C6	**Project design factors (PDF)**	C6.1	• The initial issues solved through the strategic design vision (e.g. reduced flooding, reduced amount of drinking water for irrigation)
		C6.2	• A visionary and landmark project that has strong demonstration potential, and achieved widespread attention
		C6.3	• Integration of different professional and scientific knowledge in design vision
		C6.4	• Communication of the urban water cycle through design approaches
		C6.5	• Innovative detailed design and resolution of water cycle challenges
		C6.6	• Other indicators, please specify
C7	**Project implementation factors (PIF)**	C7.1	• Clear urban design framework and project delivery responsibilities
		C7.2	• Adequate financing of project
		C7.3	• Success of water cycle integration in Sponge City projects
		C7.4	• Quality of construction and initial maintenance
		C7.5	• Other indicators, please specify
C8	**Project management factors (PMF)**	C8.1	• Stakeholder engagement with project including community
		C8.2	• Long term care of constructed ecologies and gardens
		C8.3	• Long term monitoring
		C8.4	• Supportive private management of project (e.g. effective management during design and construction)
		C8.5	• Supportive public governance of project
		C8.6	• Other indicators, please specify
C9	**Overall rating**	C9	• Overall rating of the C1 – C8 factors

3.2 Data Collection

The questionnaires were distributed between the period of December 2018 and May 2020, seeking to establish the viewpoints and values of the research population, *i.e.*, experienced professional practitioners and stakeholders in the built environment. In Australia, the survey was initially distributed to relevant institutions focused on water sensitive approaches (those were suggested by the focus groups in the Sydney Workshop): (i) the members of Stormwater NSW, a non-profit association whose membership covers a range of stormwater industry stakeholders, including consultancy and local government, (ii) the Georges Riverkeeper, a non-for-profit organisation that supports eight local Sydney Councils, and (iii) network of Cooperative Research Centre for Water Sensitive Cities, an Australian national research centre that brings interdisciplinary responses to urban water problems. The questionnaires were sent to the participants via email containing a questionnaire file, an invitation letter, and the participant information sheet and consent form. In China, a web search across grey literature was done to identify initial lists of professionals working in Sponge Cities project, including many of the pilot sponge cities (including Xi'an, Beijing, Shanghai and Shenzhen). Following these invitations, the respondents were asked to email the questionnaire to qualified colleagues. This type of snowball sampling approach was utilised to disseminate the survey to a wide variety of experts across diverse disciplines and cultural contexts such as planning, designing and management of urban renewal projects involving WSUD approaches in Australia and Sponge City approaches in China. The effectiveness of snowball sampling is acknowledged as being a purposeful technique to access diverse and specialist communities (Valerio *et al.*, 2016;Ghaljaie *et al.*, 2017). In a snowball approach, initial participants are "seeded" and these then contact their networks to reach a specialised and hard to reach sample. As results are influenced by the networks of the initial "seed" participants it is necessary to ensure initial participants are located in the various representative institutions or participant groups the study seeks to engage with (Brunet, 2012;Ghaljaie *et al.*, 2017). In both the Chinese and Australian contexts responses were returned to the researchers via email.

In qualitative research questions of sample size, are not as important as they are in quantitative research. Rather, as Thompson (1999) makes clear it is the "fitness for purpose—or quality—of the sample" that is of significance. We have tested and measured the spread of participants across the required professional and industry sectors and have substantial representation across all sectors. Some concentration exists in planning and design professional expertise and in the landscape architecture and environmental engineering industry sector.

3.3 Analytical Approach

There were two major parts to our analytic approach. The first involved analysing the questionnaire data using an importance-performance approach. The importance-performance approach (IPA) has been widely adopted as an accepted analytical technique for its effectiveness in assessing the perspectives of participants on different "indicators" or "factors" for a given area of knowledge (Prajogo and McDermott, 2011;Sepasgozar *et al.*, 2021). The IPA is used in this study to identify the differences between the desired outcomes and the actual performance of selected Sponge City factors (Table 1). In this method, the mean score of each factor is plotted in four quadrants so that they can be visually assessed in relation to each other (visualised in Figure 2): **Zone 1** – high performance and importance (high priority, maintain current investment level), **Zone 3 -** low performance and low importance (low priority but potentially unrecognised value), **Zone 4 -** low importance and high performance (low priority, reflect on current investment level), and **Zone 2 -** high importance and low performance (high priority, investment and focus needed). The IPA plot provides Sponge City managers and water professionals with a visualisation of expert perspectives on the various factors that contribute to Sponge City success. The Importance axes therefore assess the perceived criticality of Sponge City factors by the interviewed experts.

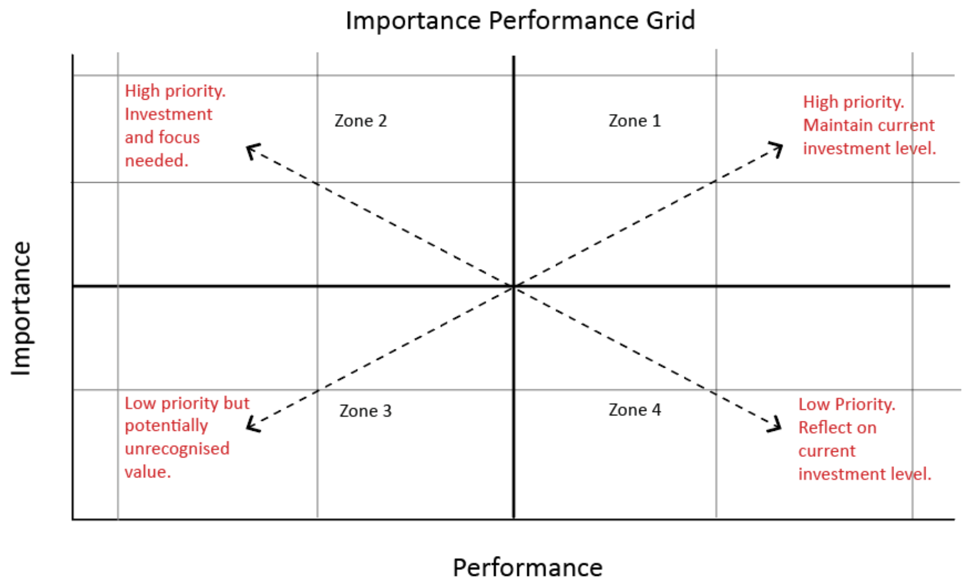


Figure 2. *Schematic of importance and performance approach (IPA) plot*

The second analytic technique used was the structural equation modelling method. Literature such as Yaghoubi *et al.* (2017) recommend the structural equation method for identifying the impact of constructs and variables. In this study this method was used for measuring the contribution of certain factors to the successful implementation of the sponge cities. Most helpful is the way it provides a systematic visualisation of the relationship between factors. It is acknowledged as a an effective and useful approach for assessing the relationships between critical factors (Hoyle, 1995). In our paper the structural modelling measures the contribution of Sponge City factors to successful project outcomes including the path between constructs and the path-coefficients (Johnson and Wichern, 2007). Path coefficients refers to a causal analysis which helps to explore the correlations within the developed model including a set of constructs (in this case, the factors in Table 1). Hair Jr *et al.* (2016), suggested this approach for studies which intend to develop theories or predictive models. The structural modelling approach is used to quantify the relationships between factors and test the robustness of the resulting structural model. A multivariate statistical technique was used to compute different constructs in a way to minimise residual variance of the model (Rahman *et al.*, 2017). This technique was used because it can examine relationships among multiple measures of the constructs included in the model at the same time (Johnson and Wichern, 2007). In order to identify the significance of paths, a bias-corrected and accelerated bootstrapping of 5000 sub-samples was computed in this study (Puth *et al.*, 2015). The literature suggests the use of bootstrapping because it is a direct approach to compute the estimations of standard errors and confidence intervals (Tibshirani and Efron, 1993).

4. Results

4.1 Characteristics of Survey Respondents

In total 90 valid responses were collected, 49 from China and 41 from Australia. This sample size is comparable with other surveys of environmental management experts (Ulubeyli and Kazanci, 2018;Shih *et al.*, 2020). Respondent demographic profiles are presented in Figure 3. As expected, respondents come from a variety of industry sectors: landscape architecture (23%), environmental engineering (22%), urban ecology (12%) and infrastructure (12%). Their professional expertise spans planning and design (44%), integrated water management (19%), engineering (15%), research (10%), policy making (7%) and capacity building (5%). Almost half of participants (46%) have worked in the area for more than ten years, especially among respondents from Australia, where WSUD has been practiced for longer than in China (Xiang *et al.*, 2018). Generally, respondents are familiar with terms for sustainable urban water management around the world, with an average of 76.6% of participants knowing all five terms, while 100% know at least one term.

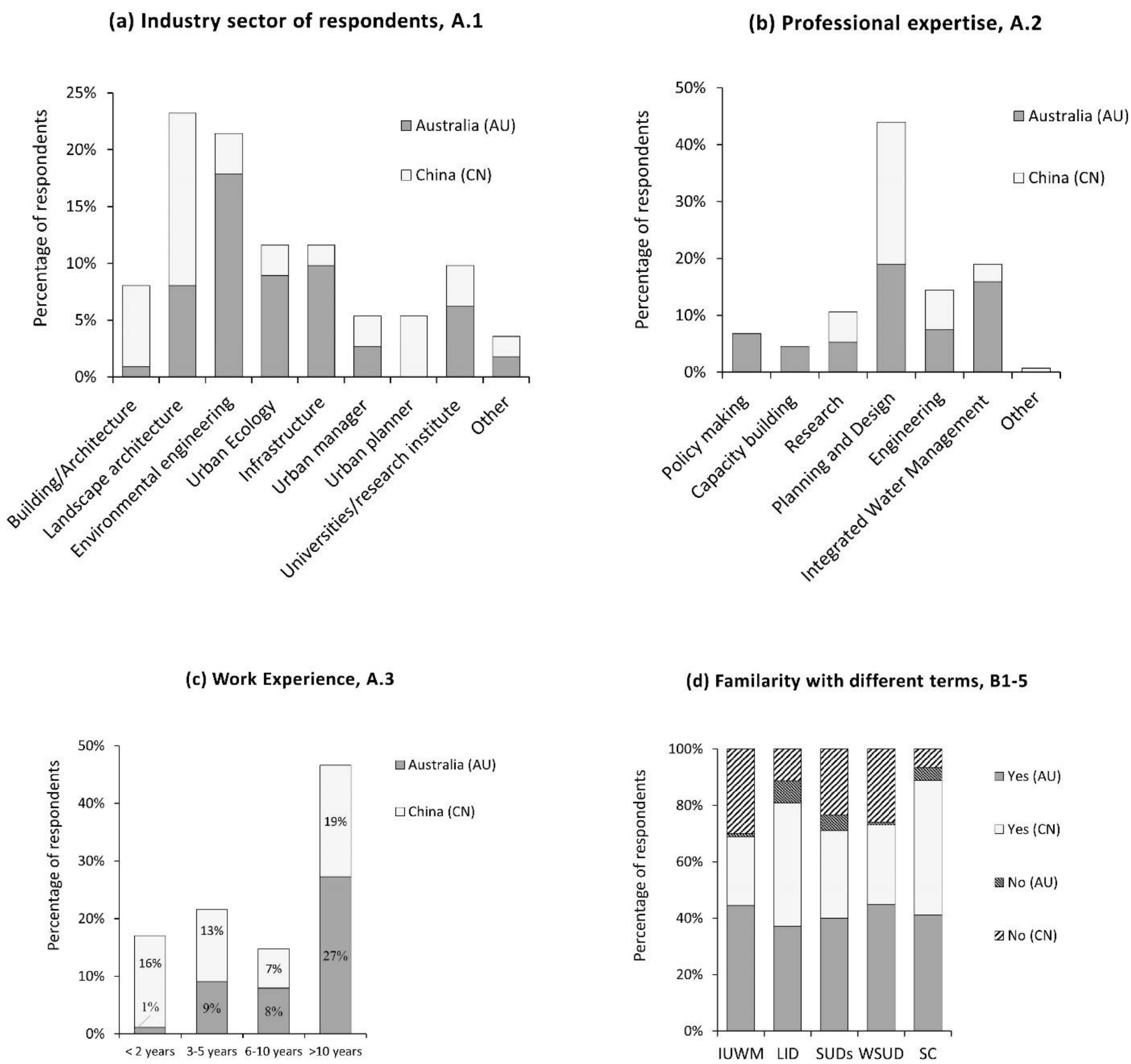


Figure 3. *Profiles of respondents' background and experience*

4.2 Importance and Performance of the Factors

Respondents rated importance and satisfaction with the factors linked to the success of Sponge City projects. Zone 1 indicates high importance and high performance. Factors across All (Figure 4), AU (Figure 5) and CN (Figure 6) datasets include *Stormwater quantity control* (C1.1), *Increased the liveability of the place and the city* (C3.3) and *The initial issues solved through the strategic design vision* (C6.1), *Stormwater quality control* (C1.2) was important in both countries, but good performance was only found in Australia.

In Zone 2, strong similarities are identified across All, AU and CN datasets regarding the factors classified as 'important but low performance'. Particularly, *Long term care and monitoring* (C8.2, C8.3) and *quality of construction and initial maintenance* (C7.4) often have low satisfaction scores in both countries, while *Stormwater recycling and reuse* (C1.3) did not achieve high satisfaction in China or Australia.

Included in Zone 2, there are also factors relating to project implementation and management (e.g., C8.1 *Stakeholder engagement*, C8.4 *Effective management*, and C8.5 *Supportive public governance* in China, and C7.2 *Adequate financing* and C8.5 S*upportive public governance* in Australia). In addition, there is also lower performance in Australia with regards to the factors of *Drought resilience* (C1.4) and *Made positive impact on government environmental management* (C4.1).

In Zone 3, low performance and low importance, fewer factors were identified from the Australia dataset (Fig 5) than the China dataset (Fig 6). Only one factor (*Ground water level control*, C5.1) featured in this zone in both countries. Other factors identified from Australia datasets include *Positive impact on government budgeting* (C4.3), *Supportive private management of project* (C8.4), *Positive impact on citizen-government relationship* (C4.4) and *Value of disaster avoidance costs* (C5.5). In China datasets, the factors are mainly from the social-cultural (C3) and economic (C5) categories.

Factors in Zone 4 are characterised as less important but with high performance. Only one factor was observed in this zone from China datasets (*A visionary and landmark project*, C6.2). Within the Australian dataset three economic factors (i.e., C5.1 *Increased property value,* C5.2 *Enhanced tourism value,* and C5.3 *Enhanced local or district economics*), and one social-cultural factor (i.e., C3.7 *Improved physical well-being*), were included.

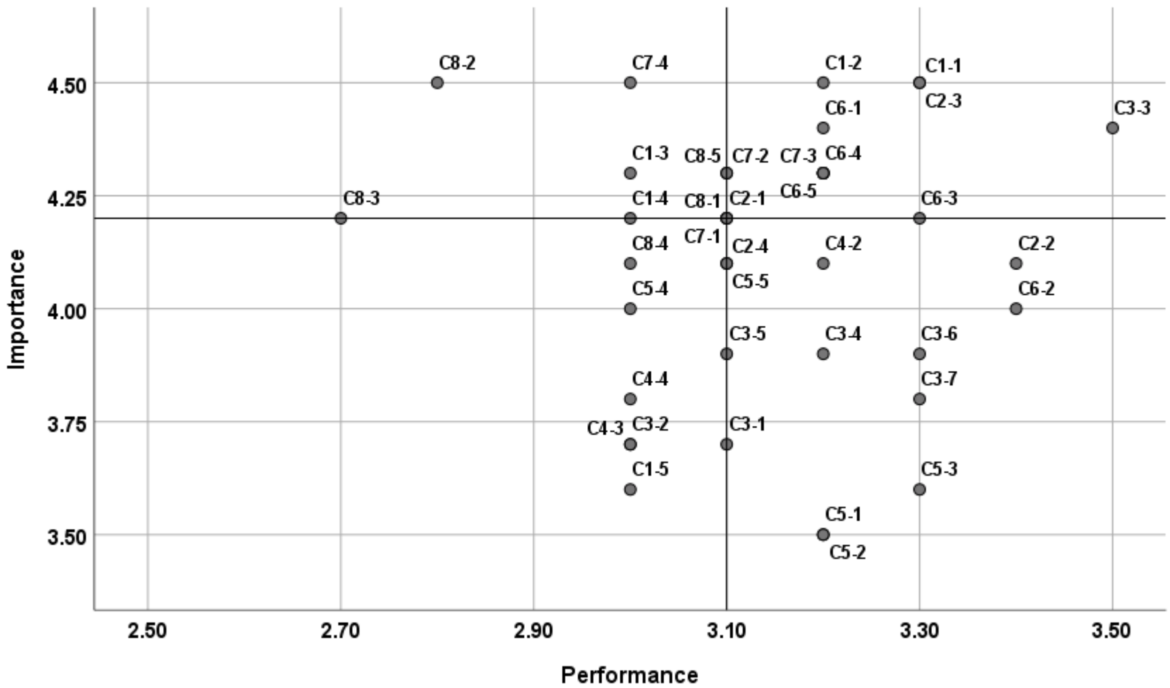


Figure 4. *Plots of importance and performance of the sub-aspects impacting the success of Sponge City projects, analysed based on all data (i.e., AU and CN data combined).*

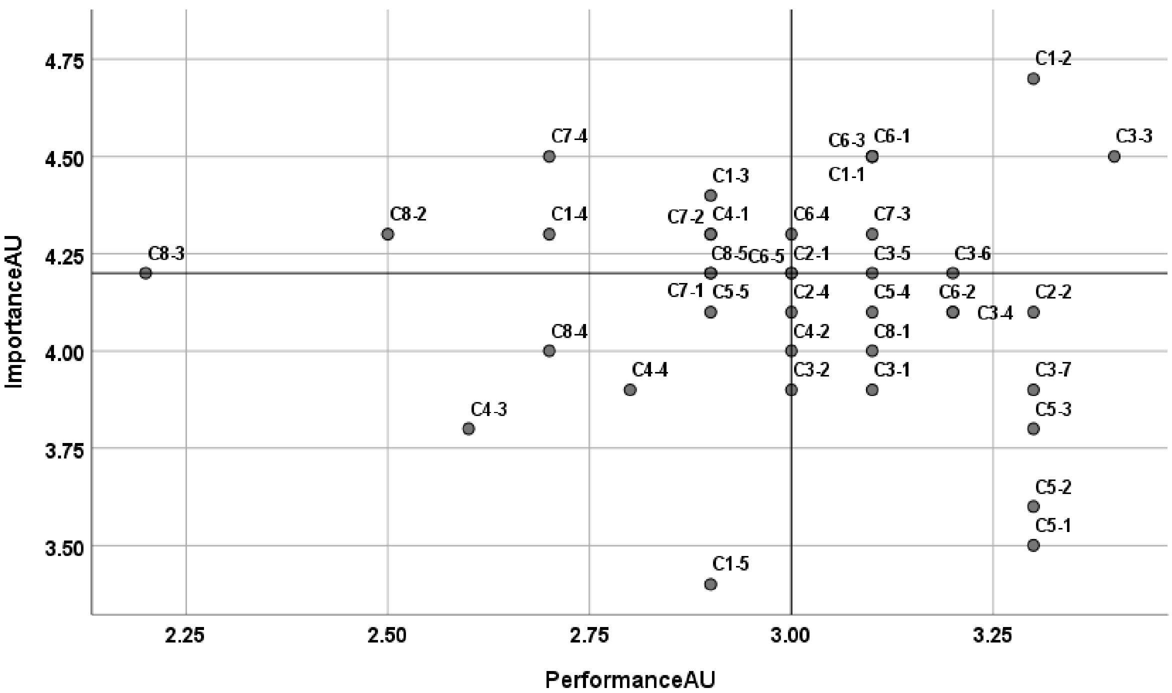


Figure 5. *Plots of importance and performance of the sub-aspects impacting the success of Sponge City, analysed based on Australia (AU) dataset.*

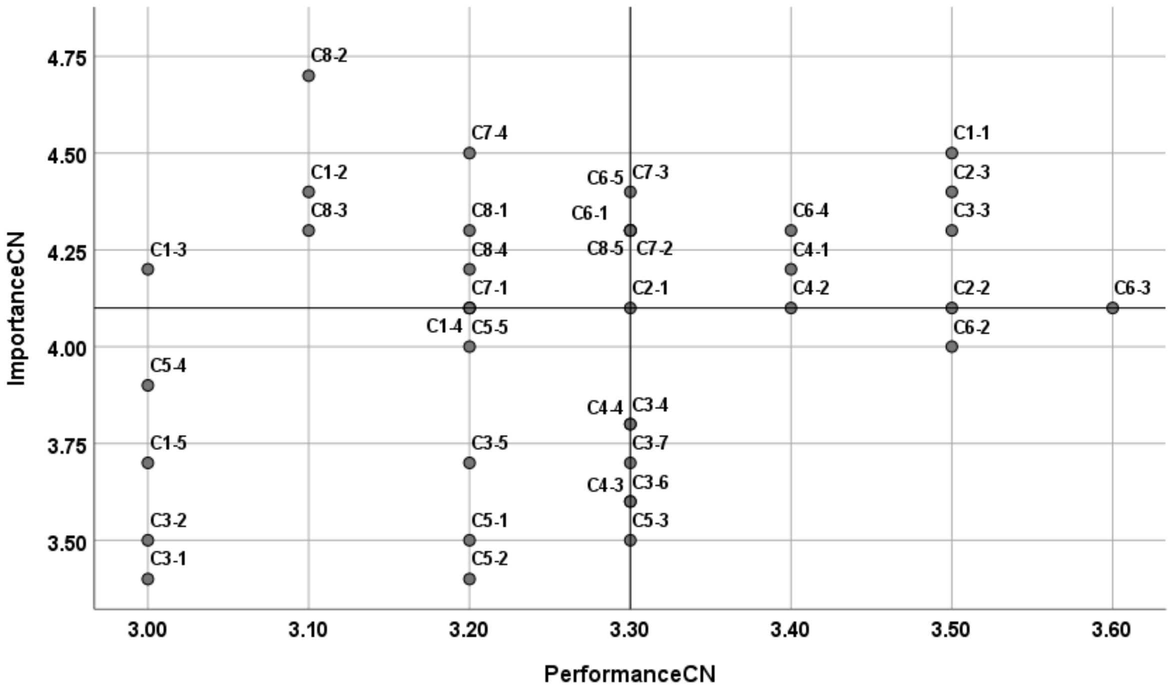


Figure 6. *Plots of importance and performance of the sub-aspects impacting the success of Sponge City projects, analysed based on China (CN) dataset.*

Overall, the water management factors (C1) and ecological factors (C2) had the highest importance across all eight categories with average ranking of 2.2 and 2.5 (out of 8) for C1 and C2, respectively. Social-culture factors ranked lowest (average rank = 6.5) for Chinese respondents, while Australian respondents considered the economic factors least important (average rank = 5.9). Figure 7 further communicates these results.

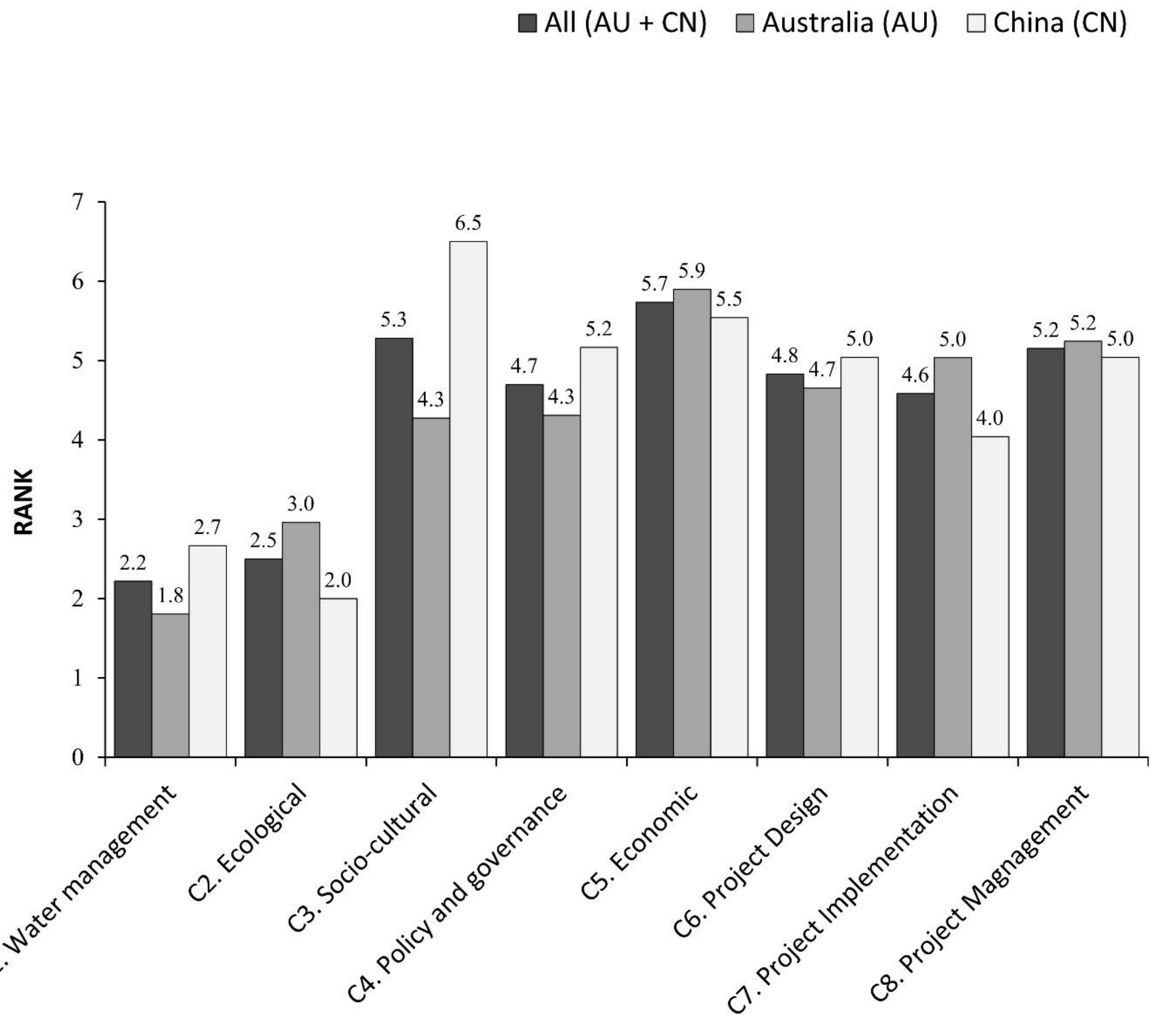
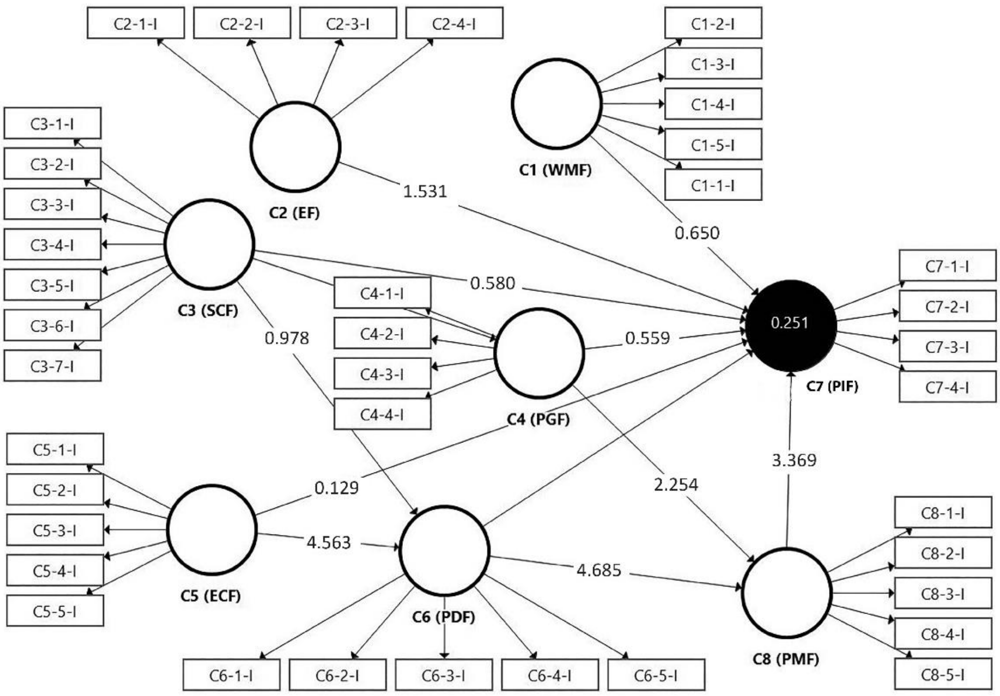


Figure 7 *Importance rankings of the eight categories of factors from C9 of the questionnaire. Rank ranges from highest (1) to lowest (7) performance and importance.*

4.3 Relationships between factors : Structural Equation Modelling.

Figure 8 shows the resulting structured model including path coefficients. The values on the arrows connecting factors refer to the original estimate of path coefficients computed by running the bootstrap resampling routine. The result of the structural modelling statistics from the bootstrap is shown in Table 2. R Square values are all above 0.228 and the R Square adjusted is above 0.210. In particular, the R square adjusted is 0.48 and 0.36 for C7 and C8 respectively. Since C7 and C8 are the key constructs of the model, these are good results for the exploratory study. Table 2 also shows that the Average Variance Extracted (AVE) of each latent variable is greater than 0.5 or very close to it such as C1 and C8 as suggested by Fornell and Larcker (1981) and Larcker (1981). Thus, the AVE was met and reached the expected convergent validity and both Cronbach's Alpha and Composite Reliability are close to 0.6 and above, as are satisfied.



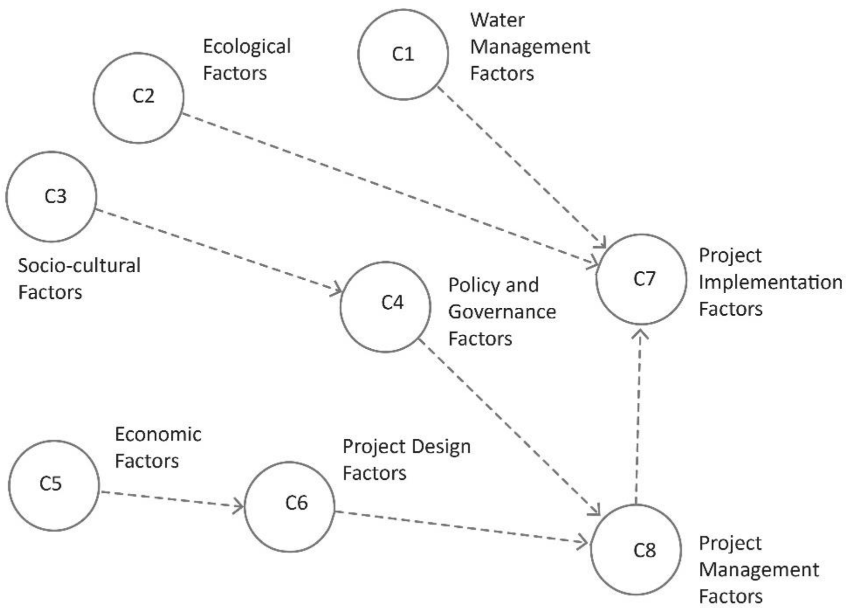


Figure 8. *Sponge City success factor model as derived through the structural equation modelling method. The top model includes the coefficients whilst the lower model represents a simplified representation of the results. This empirical model shows clustering of factors in two clear major groups which we term substantive (ecological factors and water management factors) and procedural*

(socio-cultural and policy and governance, economic factors, project design factors, project management factors).

Table 2. *Construct reliability and validity tests.*

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
C1 (WMF)	0.522	0.573	0.724	0.358
C2 (EF)	0.760	0.798	0.844	0.576
C3 (SCF)	0.879	0.889	0.906	0.579
C4 (PGF)	0.777	0.816	0.853	0.594
C5 (ECF)	0.701	0.683	0.796	0.440
C6 (PDF)	0.758	0.771	0.838	0.513
C7 (PIF)	0.759	0.766	0.847	0.581
C8 (PMF)	0.734	0.755	0.824	0.488

The model's discriminant validity was also computed to distinct that similar concepts of constructs are distinct (Hair Jr *et al.*, 2016). This indicates that the correlations of the constructs are more substantial than the correlations between each construct with others ranging from 0.559 to 0.771 (all are almost 0.6 and above; Table 3), and the constructs are independent (Fornell and Larcker, 1981;Hair Jr *et al.*, 2016). The strong cross-loading between contracts satisfies the model the condition of discriminant validity of the model (Chin, 1998).

Table 3. *Discriminant validity of C1 to CB based on Fornell-Larcker criteria.*

	C1 (WMF)	C2 (ECOF)	C3 (SCF)	C4 (PGF)	C5 (ECONF)	C6 (PDF)	C7 (PIF)	C8 (PMF)
C1 (WMF)	0.599							
C2 (ECOF)	0.469	0.759						
C3 (SCF)	0.373	0.688	0.761					
C4 (PGF)	0.312	0.554	0.527	0.771				
C5 (ECONF)	0.377	0.444	0.537	0.448	0.664			
C6 (PDF)	0.460	0.496	0.329	0.445	0.468	0.717		
C7 (PIF)	0.416	0.564	0.327	0.443	0.342	0.543	0.762	
C8 (PMF)	0.432	0.582	0.319	0.483	0.387	0.555	0.664	0.699

All the inner Collinearity Statistics (such as variance inflation factors or VIF which detect multicollinearity in regression analysis) are well below 5, ranging from 1.110 to 2.586, showing that the collinearity is not a problem in this analysis. For the relationships, hypotheses testing based on two-tailed t-test, Table 4 shows that five hypotheses C3 (SCF) to C4 (PGF), C4 (PGF) to C8 (PMF), C5 (ECF) to C6 (PDF), C6 (PDF) to C8 (PMF), and C8 (PMF) to C7 (PIF) are supported; remaining hypotheses are not supported. This means that while water management (C1) and ecological factors (C2) scored well in terms of significance and importance, they were not well-connected to the other factors. In contrast, socio-cultural factors (C3) were well-connected to policy and design factors (C4) and project management factors (C6) (but C4 and C6 were not well connected). Equally economic factors (C5) were well-connected to project design factors (C6) and subsequently to project management and then project implementation (C7).

Table 4. *Summary of the model statistics including estimated path coefficients with T-value.*

Proposed path including relationships	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
C1 (WMF) -> C7 (PIF)	0.064	0.089	0.098	0.650	**0.516**
C2 (EF) -> C7 (PIF)	0.231	0.232	0.151	1.531	**0.126**
C3 (SCF) -> C4 (PGF)	0.527	0.545	0.089	5.895	**0.000**
C3 (SCF) -> C6 (PDF)	0.110	0.116	0.112	0.978	**0.328**
C3 (SCF) -> C7 (PIF)	-0.068	-0.068	0.118	0.580	**0.562**
C4 (PGF) -> C7 (PIF)	0.067	0.068	0.120	0.559	**0.576**
C4 (PGF) -> C8 (PMF)	0.295	0.280	0.131	2.254	**0.024**
C5 (ECF) -> C6 (PDF)	0.409	0.434	0.090	4.563	**0.000**
C5 (ECF) -> C7 (PIF)	-0.016	-0.005	0.123	0.129	**0.897**
C6 (PDF) -> C7 (PIF)	0.178	0.164	0.115	1.549	**0.121**
C6 (PDF) -> C8 (PMF)	0.424	0.434	0.090	4.685	**0.000**
C8 (PMF) -> C7 (PIF)	0.400	0.399	0.119	3.369	**0.001**

We can therefore identify two major factor clusters. The first consisted of socio-cultural (C3) and policy governance (C4); and economic (C5) and project design (C6) factors. These in turn were linked to project management (C8) and project implementation (C7). The two remaining factors, that of water management (C1) and ecological factors (C2) were directly linked to project implementation (C7) forming a second, clear major cluster.

5. Discussion

Our major finding, demonstrated by the structural modelling, is that among water focused urban professions there is a lack of understanding around the linked socio-ecological system that exists around water sensitive and Sponge City projects. Our secondary finding, demonstrated by our importance performance analysis, indicate that a number of factors have been either overlooked or are not well addressed in current praxis. Our findings have implications for better understanding the challenges at different stages of the water sensitive cities evolution as outlined by Brown *et al.* (2009) and discussed by Wong *et al.* (2020). Further, they highlight the importance of a networked or systematic understanding of integrated urban water management as a socio-ecological system as suggested by Flynn and Davidson (2016). Our findings also suggest the effectiveness of, but also serious problems with, singular metric based hydrological targets that have been used to incentivise and guide integrated urban water management in cultures such as Australia and China. The structured model developed from the questionnaire results (Figure 7) demonstrates the relatively narrow professional prioritisation of substantive ecological and hydrological factors over softer procedural factors (such as cultural, policy, governance, economic, design, and management factors), which form separate clusters and are applied to project implementation outcomes directly rather than in an integrated way. For example, there is a clear break between substantive factors such as ecological factors (C2) and water management factors (C1) and as policy and governance (C4) and project design factors (C6) (Figure 8). This presents a challenge for future integration and innovation in the Sponge Cities. These overarching findings demonstrated by our structured model (Figure 7) are important for acknowledging that there are common challenges in integrating factors that exist across cultures. Our more granular investigation of individual factors in the two cultural contexts also demonstrates that within China and Australia there are distinct differences in what factors are perceived as important and contributes to successful Sponge City Projects, as detailed in Table 5.

Table 5. *Summary of the importance and performance of critical Sponge City factors in Australian and Chinese contexts (based on Figure 5&6: for Importance, 'High' refers to the factors in Zone 1 and Zone 2, while 'Low' refers to the factors in Zone 3 and Zone 4; for Performance, 'High' refers to the factors in Zone 1 and Zone 4, while 'Low' refers to the factors in Zone 2 and Zone 3; 'median' refers to the points on the median lines).*

Aspects		**Australia**		**China**	
		Importance	Performance	Importance	Performance
C1Water management factors (WMF)					
C1.1	• Stormwater quantity control	**High**	**High**	**High**	**High**
C1.2	• Stormwater quality control	**High**	**High**	**High**	*Low*
C1.3	• Stormwater recycling and reuse	**High**	*Low*	**High**	*Low*
C1.4	• Drought resilience	**High**	*Low*	Median[1)]	*low*
C1.5	• Ground water level control	*Low*	*Low*	*Low*	*Low*
C2 Ecological factors (ECOF)					
C2.1	• Urban biodiversity-protection and enhancement	median	median	median	median
C2.2	• Urban Landscape improvement	*Low*	**High**	Median	**High**
C2.3	• Ecological protection of urban streams/rivers	median	median	**High**	**High**
C2.4	• Improved local microclimate	*Low*	**High**	Median	**High**
C3 Socio-cultural factors (SCF)					
C3.1	• Increased the interaction of people to the urban areas	*Low*	**High**	*Low*	*Low*
C3.2	• Attachment to place and sense of belonging	*Low*	**High**	*Low*	*Low*
C3.3	• Increased the liveability of the place and the city	**High**	**High**	**High**	**High**
C3.4	• Enhanced attractiveness of city	*Low*	**High**	*Low*	median
C3.5	• Improved social well-being	Median	**High**	*Low*	*Low*
C3.6	• Improved mental well-being	Median	**High**	*Low*	median
C3.7	• Improved Physical well-being	*Low*	**High**	*Low*	median
C4 Policy and governance factors (PGF)					
C4.1	• Made positive impact on gov environmental management	*Low*	*Low*	**High**	**High**
C4.2	• Made positive impact on policy as a landmark case study	*Low*	**High**	Median	**High**
C4.3	• Made positive impact on government budgeting	*Low*	*Low*	*Low*	median
C4.4	• Made positive impact on citizen-government relationship	*Low*	*Low*	*Low*	median
C5 Economic factors (ECONF)					
C5.1	• Increased property values	*Low*	**High**	*Low*	*Low*
C5.2	• Enhanced tourism value	*Low*	**High**	*Low*	*Low*
C5.3	• Enhanced local or district economies	*Low*	**High**	*Low*	median
C5.4	• Value of reduced water consumption and resource costs	*Low*	**High**	*Low*	*Low*
C5.5	• Value of disaster avoidance costs	*Low*	*Low*	*Low*	*Low*
C6 Project design factors (PDF)					
C6.1	• The initial issues solved through the strategic design vision	**High**	**High**	**High**	Median
C6.2	• A visionary and landmark project that has strong demonstration potential, and achieved widespread attention	Median	**High**	*Low*	**High**
C6.3	• Integration of different professional and scientific knowledge in design vision	**High**	**High**	Median	**High**
C6.4	• Communication of the urban water cycle through design approaches	**High**	Median	**High**	**High**
C6.5	• Innovative detailed design and resolution of water cycle challenges	Median	Median	**High**	Median
C7 Project implementation factors (PIF)					
C7.1	• Clear urban design framework and project delivery responsibilities	Median	*Low*	Median	*low*
C7.2	• Adequate financing of project	**High**	*Low*	**High**	Median
C7.3	• Success of water cycle integration in Sponge City projects	**High**	**High**	**High**	Median
C7.4	• Quality of construction and initial maintenance	**High**	*Low*	**High**	*Low*
C8 Project management factors (PMF)					
C8.1	• Stakeholder engagement with project including community	*Low*	**High**	**High**	*Low*
C8.2	• Long term care of constructed ecologies and gardens	**High**	*Low*	**High**	*Low*
C8.3	• Long term monitoring	Median	*Low*	**High**	*Low*
C8.4	• Supportive private management of project	*Low*	*Low*	**High**	*Low*
C8.5	• Supportive public governance of project	Median	*Low*	**High**	Median

There is a strong consensus amongst urban water professionals that the hydrological and ecological factors incentivised through metrics (WMF, ECOF) in both China and Australia, are being well addressed through current approaches. *Water quality* and *Environmental benefits* have high importance and high satisfaction rates in both countries (Table 5). This is not surprising; these are usually critical factors in WSUD (Fletcher *et al.*, 2015;Li *et al.*, 2017) and are the most researched (Eggimann *et al.*, 2017;Zhang *et al.*, 2021), hence water quality guidelines are often available to guide physical and environmental aspects of WSUD systems.

Indeed, the original objective of WSUD in Australia was water quality management (Fletcher *et al.*, 2015), while in China urban flooding has been the major driver of Sponge City development (Li *et al.*, 2017) with lesser requirements for water quality improvement (Wang *et al.*, 2020). Both China and Australia regarded stormwater quality control as important, but only in Australia did it have satisfactory water treatment performance as a result of integrated urban water management systems. This is probably due to the fact that Australia has embraced Sponge City concepts for three decades whilst in China it remains a relatively new concept. Previous studies have shown considerable investment in designing the stormwater control measures (SCMs), however, once installed, they always suffer from lack of maintenance or even outright neglect (Blecken *et al.*, 2017), making these systems more problematic.

China's relatively new Sponge Cities program puts more emphasis on flooding mitigation than reuse, so it was unsurprising that experts there were not currently satisfied with reuse (Table 5). More surprisingly, however, Australian experts are not satisfied with the performance of this factor, despite a long practice of stormwater recycling (Wong *et al.*, 2020). This may be partly due to the fact that after the millennium drought (2001-2009), the uptake of stormwater recycling declined (Parliament of Australia, 2015); also innovations surrounding the circular economy remain limited due to current finance models and policy (Moore, 2019) which are necessary to stimulate WSUD and the circular economy (Langergraber *et al.*, 2020). Our results clearly highlight the need for a much greater investment in developing the capacity of Sponge Cities to both endure and ameliorate drought through more effective circular resource use and management. This drought related shortcoming remains despite Sponge Cities specifically tasked with targeting this issue (Zevenbergen *et al.*, 2018).

When it comes to socio-cultural (SCF) factors, they were not regarded as quite important (i.e., mostly low - medium importance, Table 5). On the other hand, high performance was found in Australia, while only low-medium performance was suggested in China. Our research strongly suggests that socio-cultural aspects such as community relationships are undervalued and underperforming in China but are undervalued and performing well in Australia. This is likely due to still early stage of Sponge City development in China, so the social-cultural benefits have just started to show.

Despite literature suggesting that policy and governance factors (PGF) are key to the envisioning, delivering, and managing projects and relationships with communities (Furlong *et al.*, 2016b;Jiang *et al.*, 2017;Porse, 2018;Qiao *et al.*, 2019), this area is lacking in performance and recognition within the professional community, especially in Australia, *i.e.*, none of the PGF factors were regarded as important, nor they had good performance (except C4.2, Table 5). Whereas in China, as the Sponge City is very much driven by central and local governments, the performance was median to high, with varied importance to different sub-aspects (Table 5). Often there is a lack of ownership of such local, decentralised systems that sit in the public domain (John and Phillip;Byrne *et al.*, 2019). Greater development of community management initiatives could help link them with local water infrastructures and also help develop economic and cultural values associated with strong place attachment (Coyne *et al.*, 2020;Hawken *et al.*, 2021). Communities have a role to play in managing these assets in the long term. There is a clear lack of education here, but also a need for design (PDF) and governance (PGF) approaches to help link communities with their water landscapes and engender a sense of ownership. It is worth noting that communities are almost never included in system design – if such water systems were treated more like community gardens, this situation could improve dramatically (Qiao *et al.*, 2019).

Within our results, economic factors (ECONF) seem to be less important but show good 'satisfaction' (for which Australia has a higher performance than China, Table 5). This highlights the need for a great deal more research to demonstrate the economic benefits of Sponge City and Water Sensitive

City systems as a significant metric when investing and planning in urban water management. Current research suggests as much with both Bai *et al.* (2019) and Bowen and Lynch (2017) arguing that whilst a substantial body of evidence shows BGI is highly beneficial for human health, this has not been adequately quantified through economic research. The lack of weight given to economic factors contrasts with the critical perspectives on project financing which although viewed as important in both China and Australia have not been sufficiently financed according to our sample (Table 5 see PIF), thereby affecting project implementation (PIF, e.g., C7.2 Adequate financing of project).

Nevertheless, economic benefits are hard to quantify with hedonic pricing lacking in relation to water infrastructures. While some studies have evaluated property price change when nearby WSUD system is implemented, listing up to 6% price increase in urban Sydney, Australia (Polyakov *et al.*, 2015), it is not clear how to evaluate this effect on a wider scale, across fully implemented water sensitive precincts. Another issue is that there is usually a disparity between communities, who receive most of the benefits, and governments, who invest into Sponge City projects. There is a need for socio-economic research in this complex area so that new Sponge City funding schemes integrate communities into the design and management of future water schemes. Part of this challenge involves better consideration of the political economy when implementing Sponge City projects.

When it comes to other procedural factors (i.e., PIF, PDF and PMP), they were mostly regarded as important, but the performance varied across the different sub-aspects in both countries (Table 5). In particular, it is evident that long-term Sponge City maintenance is lacking, in both Australia and China. This may be due to a lack of policies clarifying responsibilities for maintenance and long-term management. More pragmatic dimensions such as a lack of appropriate guidelines for Sponge City maintenance are also at play, with technical staff unsure how to maintain the living, dynamic and constructed ecologies at the heart of such systems. Such systems are still largely treated with a 'set and forget' mindset, rather than nurtured through continual and repeated care. Furthermore, a lack of designated funding for such specialised infrastructures leads to a lack of long-term maintenance of open space (Cousins, 2018;Hopkins *et al.*, 2018;Qiao *et al.*, 2019). Funding for continuous maintenance is critical to ecological values such as biodiversity. In bioretention swales and wetland systems there is a problem in achieving biodiverse systems, with planting selections often mismanaged and weeds or monocultures coming to dominate (Bansal *et al.*, 2019). As previously discussed, experts regarded political factors as less important and also of low performance. However, political factors play a fundamental role in enabling and encouraging the advancement of Sponge City projects and ensuring they have broad community support. Without suitable policies such projects would cease to exist (Moore, 2019). Our findings point to the fact that professionals need to do better at advocating for Sponge City projects in the political realm. Such political recognition may help the poor long term project management and monitoring (PMF) of projects that is common to both China and Australia. Significantly there is better recognition of the importance of long-term perspectives in China than Australia despite the longer time Australia's program has been running for.

6. Conclusion

In our study we have addressed two major questions or challenges, that is: "what makes a successful integrated urban water development project?" And secondly, "how can current projects' shortcomings be addressed?"

This research has developed a comprehensive evaluation of the concerns, hopes and satisfaction of a range of urban water factors as they relate to success. The many practitioners interviewed present hard-won practical insights, gained from decades of collective experience. The deep experience and diversity of the study's 90 participants give us confidence in the insights generated. In answer to the first question, our systematic, exploratory approach affirms that projects have generally been successful in addressing the initial objectives of projects in Chinese and Australian contexts but have not dealt with the broader more complex objectives of such programs as they have evolved over time. Our findings suggest professionals believe that core objectives to do with drainage and water quality have been dealt with in a satisfactory way but there is a patchy and fragmented satisfaction amongst other factors. For example, there is a clear break between substantive service delivery functions such as ecological factors (C2) and water management factors (C1) and more procedural factors such as socio-cultural factors (C3), policy and governance (C4) and project design factors (C6). Our structural modelling suggests that socio-cultural and economic factors are currently embedded as a subset of project design and governance factors. This presents a challenge for future integration and innovation in Sponge Cities as a wicked problem where multiple dynamic factors need to be addressed together simultaneously for high quality, successful outcomes. This finding, in some ways also points towards what needs to be done to address the second questions regarding how best to "address current shortcomings" and ensure success in current and future sponge cities. The insights generated in this study also confirm expected successes in hydrology and ecology while highlighting how far we have to go when it comes to the social and cultural and economic dimensions of water sensitive cities. Although greater emphasis and integration of the design professions and social sciences will help address such shortcomings, ultimately there is a requirement for a much firmer commitment to collaboration and knowledge sharing. Indeed, global governance structures like the SDGs focus on generating network synergies and cross-sector benefits whilst avoiding negative cross-system impacts and externalities.

Further work could focus on those undervalued or underperforming factors identified or test the study's findings in relation to specific Sponge City case studies. Most importantly the links between the factors, as visualised in our structured model, need further research. This includes the significant contribution of design to economic factors and the successful management of projects. Likewise, research around socio-cultural dimensions of water projects and their linkages to governance, finance, and management, and ultimately implementation, need closer consideration. Further, our research suggests that such linkages and connections are often robust across cultures, providing scope for knowledge sharing and exchange.

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