UCL Institute for Environmental Design and Engineering

Communication of tacit knowledge in integrated urban water management:

The structural, cognitive, and relational dimensions in China's Sponge City programme

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Declaration

I, Zeyu Yao, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

In China, water and environmental problems along with rapid urbanisation and climate change have prompted urgent efforts to improve the urban water infrastructure systems as well as sustainable urban development. The complexity of the urban environment and urban development demands the consideration of different facets of urban systems and their relationships. However, it is known that the inter-disciplinary and inter-sectoral collaboration, communication, and learning are vital for sustainable urban water management, and yet are challenging to attain satisfactory results due to the tacit nature of the messages communicated, as well as the complexity of the network dynamics. With a mix-method approach, this study aims to improve understanding of the use and communication of tacit knowledge by the individual actors as well as by the network, and the multi-layered conditions that enable access and mobilisation of social resources which lead to the return of knowledge.

The quantitative study (survey N_raw=536, N_valid = 387) investigated actors' acquisition and use of different types of relevant knowledge. It revealed that the actors' professional background influences the channels they use for learning. Furthermore, different professions should need resources and materials that target their specific need for learning, because results showed that the actors identified varying degrees of knowledge gaps for different types of knowledge. The findings from the qualitative study (38 semi-structured interviews) suggested that the access to social capital can be facilitated by sharing of space, where actors in close proximities can treat each other by focusing on commonalities and disregarding distinct individual identities. It can create a sense of cohesion among actors, which encourages the sharing of knowledge, though successful learning by individuals relies on the level of contact and redundancy as well. There is a lack of connectivity and meaningful interactions between some professions, and urban planners have the potential to bridge the connectivity between unconnected professions and help ensure that the flow of knowledge access is bi-directional between upstream and downstream of the project.

Despite having access, social capital cannot be adequately mobilised unless some preconditions are met. First, the findings showed that trust is a crucial determinant of mobilisation of social capital, and the forms of trust, as well as the sense of meeting obligations, are influenced by collective assets such as the historical and cultural backgrounds of the society. One should be more aware of one's habits and biases, and respect the social rules to find solutions in the social context. Second, the acquisition and use of tacit knowledges are hindered when there are difficulties with understanding perspectives, concepts and jargons, or when actors are unaware of the gap in knowledge. In response to this obstacle, training on delivering messages and engaging in dialogues with clarity should be incorporated in education, as well as training on increasing alertness to gaps of knowledge.

Research Impact Statement

Integrated urban water management depends upon the collaboration of multiple disciplines and professions, which is contingent on excellent communication and effective knowledge transfer across disciplinary and professional boundaries. This PhD research steers researchers on China's Sponge City to a new direction and addresses this pressing and persisting issue of collaboration and knowledge transfer.

Impacts on research area and methodology

This research used sociological tools to study how Sponge City professionals can communicate and transfer tacit knowledge effectively. It is one of the few pieces of research on China's Sponge City that employs a mixed-methods approach, using survey and semi-structured interview methods. In 2017, the progress of the research was presented at the 14th International Conference on Urban Drainage. The panel expressed that the focus on the transfer of tacit knowledge in this research signified the "maturation of Sponge City research". The research also draws a link between urban water management research and education research. Pedagogical research can be conducted in the future to extend the theoretical findings to research on educational practice.

Impacts on professional practice and policy nationally and internationally

The insights from this research are relevant for Sponge City as well as integrated urban water management at large. The study considered the interrelationship of knowledge transfer and urban water management in the social, economic, political, and cultural contexts of the society. A strategy map is developed to illustrate the interconnected of the influence of social-political constraints on network structure and configuration, the influence of societal rules on the relationships between individuals and communities, and the influence of complexity in urban water management on knowledge transfer between actors. It can inform practitioners and public policymakers the multifaceted nature of the constraints and their ramifications, as well as the connectedness of the solutions. The survey findings offered insights on how actors acquire different types of knowledge, and it has recommended distinguishing different categories of knowledge. Researchers, professionals, and policymakers may apply this information to adjust the media used for knowledge transfer between different fields and disciplines.

Acknowledgements

A journey of a thousand miles begins with a single step. I embarked on this journey four years ago as an adolescent filled with dreams and aspirations. A thousand miles later, my heart is bursting with gratitude when I reflect back on each step of this journey. It was a process of learning and growing. I grew as an independent researcher, a student, a teacher, a friend, and a daughter. I also learned to enquire, analyse, write, and moreover, I learned to be resilient.

My sincere thanks go to my supervisors and other researchers that contributed to my intellectual thinking. I am grateful for the support of Prof Sarah Bell through the moments of excitement, anxiety, confusion, and frustration, and I was able to learn so much from our conversations and your book recommendations. Dr Fangzhu Zhang has always been there for the "reality check", and this research relied so much on your expertise in China's urban planning. In addition, the intellectual inputs from Dr Priti Parikh, Dr Meri Duryan, and Prof Yvonne Rydin, have pushed me forward as a thinker and researcher. Needless to say, this research would have been possible without the cooperation of the professionals that participated in the interviews and survey.

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Abbreviations and Glossary

BMPs	Best Management Practices
CPC or CCP	Communist Party of China or Chinese Communist Party
DCPs	Detailed Construction Plans
DDCPs	Detailed Development Control Plans
FYP	Five-Year Plan
GI	Green Infrastructure
IUWM	Integrated Urban Water Management
IWA	International Water Association
LA	Learning Alliance (SWITCH)
LID	Low Impact Development
MOHURD	Ministry of Housing and Urban-Rural Development
EPA	Environmental Protection Agency (the United States)
PPP	Public-Private Partnership
SECI	Socialisation, Externalisation, Combination, Internalisation
SOE	State-Owned Enterprise
SPV	Special Purpose Vehicle
SUDS	Sustainable Urban Drainage Systems
SUWM	Sustainable Urban Water Management
SWITCH	Sustainable Water Management Improves Tomorrows Cities Health
UNCED	United Nations Conference on Environment and Development (The Earth Summit)
UNCHE	United Nations Conference on the Human Environment
UNEP	United National Environment Programme
WSUD	Water Sensitive Urban Design

General

Sponge City/Sponge City Initiative: an approach and a program originated in China launched in response to urban flooding impacts and other urban water and development problems

Water professionals: In this research, water professionals refer to professionals whose works are contributing to improving the water system.

Tacit Knowledge: Knowledge that is difficult to be clarified from one to another using only words both verbally and in writing.

Social capital: resources embedded within a network of relationships possessed by an individual or social unit, which can be accessed and/or mobilised through that network.

Actor categories (Sponge City)

An actor is placed in the category of **University** if she is researcher staff or student at a university; **Professional organisation** is she is working for an SOE or previously an SOE; and **Private sector** if she is working for a company or organisation that is not an SOE or previously an SOE.

Academic disciplinary background (Sponge City)

An actor's disciplinary background is self-reported, one can choose to identify with one or more disciplines.

The following are undergraduate/graduate courses as taught in Chinese universities: **Environmental Engineering, Water Resources Engineering, Landscape Architecture, Civil Engineering, Urban Planning, Architecture, Industrial design.**

The following can be either course taught as professional degrees or undergraduate/graduate degrees: **Building/subway Construction management, Construction Engineer, Project management**

Stages of participation (Sponge City)

Planning, Design, and **Construction** are the main stages of a Sponge City project.

Consulting, Technical support, Product development, and **Implementation management** are stages that can be parallel to one or all of the main stages

1 Introduction

1.1 Study context

1.1.1 Water and sustainability

Water is at the very core of sustainable urban development. A faulty system may present multi-faceted problems in society. They are economic problems – the maintenance and improvement of water supply, treatment, and transmission infrastructure require a financial investment. Industries and agriculture demand water and require treatment for the effluent. They are environmental problems because water pollution and significant and prolonged fluctuations in water volume due to human activities can have detrimental impacts on the ecosystem. They are social and health problems. Access to clean water and sanitation is among the UN's Sustainable Development Goals for 2030, and this is a baseline for most of other social and economic goals.

These problems are inter-dependent, so one must find solutions that are concurrently optimised for multiple objectives. Meanwhile, solving such problems requires an understanding of many disciplines, including engineering, ecology, architecture and urban planning. To approach these problems, one should recognise the coupling and feedbacks in the water cycle across the built, natural, and social systems (Reed and Kasprzyk, 2009).

It has long been recognised that traditional water management is not sufficient because it fails to coordinate the management of water supply, sanitation, stormwater, and urban ecosystem in concert, as well as connect to the urban planning processes (Global Water Partnership, 2011). Sustainable urban water management (SUWM) concepts were proposed as traditional management could no longer cope with the increasing social, economic, and environmental pressure on the water sector, in hope that the urban water cycle at all stages can be managed in an integrated way that produces more benefits than delivered using traditional approaches (Marlow et al., 2013).

To tackle the existing and potential problems in the urban water system due to the various social and environmental pressures, while balancing the need for growth and the risks from uncertainties, moving towards a more sustainable approach of urban water management has been a global concern since the 1970s. Modern cities are expected to provide infrastructure systems that ensure safe drinking water, flood protection, drainage and sanitation (Chocat et al., 2007). China, as a developing country, and one of the largest economies in the world, found herself in the middle of the tug of war between the social, environmental pressures, and the need for growth and uncertain risks. Emission pollutions have been damaging the air, soil, and water, consequently, environmental protection and pollution prevention and control are receiving higher than ever priorities (Khan and Chang, 2018). In particular, severe water problems in the forms of flooding, scarcity, and pollution, are damaging the urban environment and quality of life (Zevenbergen et al., 2018).

A review of literature on sustainable urban water management can reveal that urban water challenges are often described as socio-technical, socio-political, or socio-ecological. It recognises that solutions

to water infrastructure no longer lie in just technical, or political, or even ecological or environmental regimes. Instead, efforts should be linked across different regimes and embedded in the context of society. It is imperative to consider inter-organisational collaboration in order to address complex issues such as the management of urban water systems. (Gajda, 2004).

1.1.2 Integrated management of water

Under the umbrella concept of SUWM, there are various concepts that are adapted to different countries and problem setting, such as Integrated Urban Water Management (IUWM), Low Impact Development (LID), Sustainable Drainage System (SuDS), Water Sensitive Urban Design (WSUD), Sponge City (SC), etc. There is a number of commonalities between the concepts, such as the "naturalisation" of urban water cycle, diversification and decentralisation of water sources and infrastructure, consideration of water conservation and resource efficiency, and integration of water sub-sectors within cities and beyond, as well as engagement with other sectors and communities (Bell, 2018; Global Water Partnership, 2011; Marlow et al., 2013). Most of the objectives require constructive collaboration between people from different occupational contexts, which needs the building of relationships that are conducive to learning and sharing.

Previous research in IUWM have tested different strategies, measures, and frameworks to cope with the complexities and uncertainties in urban water management, for example, the Water-Wise Cities (IWA, 2016), City-Blueprint Framework (Koop and van Leeuwen, 2015), and Pathways for Melbourne's transition to a water sensitive city (Ferguson et al., 2013). Many of the case studies proposed structures, steps, and methods. However, outcomes are mixed, for some solutions worked well for specific locations or political or cultural contexts but not others. While sustainable urban water management has been practised in many developed countries, China differs drastically from these countries in terms of its environmental legislation and management. Furthermore, environmental governance and priorities in environmental management are changing rapidly to cope with the problems that arise as the country develops. The Chinese administrative system and some cultural characteristics (such as guanxi and mianzi[1]) are factors that must be considered when investigating knowledge transfer and inter-disciplinary, inter-sectoral collaboration.

Multi-disciplinary and cross-professional boundary communication and learning are usually proposed as the solution and at the same time, the culprit of the problems in delivering sustainable urban water management. The importance of being able to understand one another's language and experiences have long been identified among researchers and professionals in the realm of urban water management. Among others, some critical and persistent challenges to the implementation of sustainable urban water management include the lack of knowledge and expertise, lack of effective communication and collaboration, and lack of shared understanding and context. The challenges to a

[1] Guanxi, Mandarin, literally 'connection': (in China) the system of social networks and influential relationships which facilitate business and other dealings (Oxford Dictionary). Mianzi, Mandarin, literally 'face': "self-esteem somebody feels and the way they feel they are viewed by the groups they belong to(Warburton, n.d.).

great extent are due to the "tacitness" of the materials to be shared or communicated, which means they are adorned by a person's perspective and experience, and complicated by the social interaction and social network. The urban water network contains an immense amount of tacit resources that need to be accessed and mobilised across disciplinary and professional boundaries, which is enabled by the possession and use of social capital. This type of capital can be seen as a set of resources embedded in the relationships between individuals belonging to a network, as well as the network itself (Nahapiet and Ghoshal, 1998). The social capital theory is rooted in individual interactions and networking; it provides the theoretical framework that guides the research (Collins, 2013; Nonaka and Toyama, 2003; Polanyi, 1966).

1.1.3 China's urban water management

> **The key problem for the Chinese state has always been the same one. It's a problem of scale. The country is so vast, its climate so extreme, its needs so boundless, and its water course so immense, that nothing but engineering of epic proportions seems likely to make an impact. And if the preference for large-scale hydraulic engineering was surely ideological to some degree, it was also in tune with the orthodox view of river management worldwide in the immediate post-war decades. But the bigger the project, the bigger the challenges, and the greater the risk and cost of failure** (Ball, 2016: 226).

China, as one of the major growing economies, has become a protagonist in the adoption and reformulation of sustainable development (Olsson, 2009). In the past 20 years, China went through transitions in not only its economic and industrial structure but also transformations in its environmental management (Holdaway, 2017; Mol and Carter, 2007). This transition saw a gradual shift from command-and-control hierarchical environmental regulation to more hands-off environmental governance, but China still faces a unique set of challenges driven by its political, economic, and cultural contexts (Lo and Tang, 2007).

With the quickening pace of urbanisation, the increasing demands and vulnerability caused by extreme events are placing ever more stress on the urban infrastructure. Urban water systems in developing countries need special attention because while demand is increasing due to the massive population inflow, the urban water environment is in continuous decline. In China, urban areas are often troubled by severe drought and flood events, in addition to other problems, including water resources pollution and groundwater depletion (Xu, 2015). Solving China's urban water problems are compatible with the nation's ambition in economic growth and aligned with their goals to implement stricter management of water resources and improving the urban environment and life quality.

As urban water management becomes more integrated by adopting more collaborative, participatory, flexible, adaptive and inclusive processes, many different models and concepts have been developed and tried in developed countries. While attempts have been made to adopt the models and concepts in developing countries that require an improved urban water management approach, adapting to the local contexts has been one of the hurdles that are more difficult to cross. China as a developing

country who is balancing economic growth and environmental protection, in the past, has made many attempts to become more ecologically responsible by making policy changes at the national level, especially in its 5-Year Plans. However, the bold and ambitious national-level policies changes are often met with difficulties in implementation at the local level. While China's environmental governance continues to be associated with descriptions such as top-down, "authoritarian", and technocratic (de Jong et al., 2015; Lo, 2015), it is much more complex. In reality, the governing structure is very complex, and the local government is highly autonomous (Lo, 2015).

As a response to the quickly deteriorating urban water environment and more frequent extreme weather events culminating in life-threatening floods and droughts, the government of China decided to take action to tackle the various problems simultaneously (Qiu, 2015). The overall objective of the "Sponge City Initiative" is to introduce the concepts and requirements of sustainability into urbanisation so that economic growth can be in concert with environmental protection. The city as a "sponge" is adaptive and resilient to changes in the environment, especially during rain events (MOHURD, 2014). The foundation of this concept is quite similar to various urban drainage models and schemes in other countries such as LID and BMP in the United States, SUDS in the UK, and WSUD in Australia (Austrade, 2016). In order to achieve the multiple objectives set out by the central government, the projects need to take a systematic approach that addresses problems at both the institutional level and technical level. The fundamental principles are "(urban) planning leading", "ecology prioritised", "safety ensured", "context considered", and "constructions integrated" (MOHURD, 2014: 2–3). This endorses the significance of the role that urban planning must play in orienting and guiding the Sponge City projects in each city.

Since the beginning of the initiative, it has faced a variety of challenges in design and planning, implementation and construction, as well as in management and evaluation. As a project in its experimental stage, the project objectives and principles are revised and amended as information and feedback being collected. Therefore, it is vital for urban planners to establish good communication with actors at other stages so that their opinions and feedback can be incorporated in future updates of Sponge City plans, as well as Master Plans and other topic-related plans. Since the pilot cities are chosen to represent a wide range of social, economic, and environmental statuses, each city is anticipated to approach the projects with different perspectives and expectations. However, there are universal challenges experienced in most cities at various intensities that are usually a result of knowledge gap across different sectors and disciplines, which may lead to misinterpretation of objectives and requirements, over-simplification or complication of problems and solutions, as well as implementation gaps (Che and Zhang, 2016).

Cross-disciplinary and cross-sectoral collaboration can lead to exchanges of knowledge and expertise, and the realisation of such requires effective communication and understanding. In the context of urban water management, knowledge transfer is exceedingly challenging because actors come together with different worldviews and languages. Sometimes, such knowledge possessed by each actor is difficult to explain and is difficult for an unfamiliar person to understand. The integrated management

of urban water relies on a collective network of such tacit knowledge, and this study focuses on China's Sponge City initiative to investigate the factors that influence the access and mobilisation of the knowledge resources.

1.2 Research aim, question, and objectives

This study approaches Sponge City as a case study of inter-disciplinary and inter-sectoral collaboration in sustainable urban water management, from the perspective of knowledge sharing. It asks the question:

How do urban water professionals communicate across disciplines and professions to deliver integrated urban water management?

The objectives are:

a. To define the elements influencing preferences in the types, methods and sources of knowledge used and acquired in integrated urban water projects.
b. To characterise the factors influencing knowledge transfer between actors from different professional backgrounds
c. To evaluate the role of urban planning in urban water management in China and its impact on knowledge transfer

The research methodology is based on a pragmatic worldview and is employing a convergent parallel mixed methods research design where both quantitative and qualitative data are collected and analysed individually, and they are compared and interpreted collectively. The quantitative data are collected using an online survey. The survey instrument is designed to assess quantitatively the tendency to use and the learning strategies for each type of knowledge in various topics relevant to the Sponge City projects. The qualitative data are gathered and generated using semi-structured interviews. There are three parts to the open-ended questions: the interviewees' understanding and opinions of the objectives of the Sponge City and the role of planning in achieving the objectives, their experiences and difficulties on Sponge City projects, and the network of actors (at organisational level) that they interact and work with throughout the Sponge City projects.

1.3 Thesis structure

Chapter 1 (this chapter) provides a background to the study, by presenting the context and scope, and the research aims, question, and objectives. It begins with an introduction to the existing and potential problems associated with the current urban water systems and their management. The multifaceted urban water challenges demand integrated management, which depends on the collaboration and knowledge exchange among organisational and across the boundaries of sectors and disciplines. When placed in the context of China's social, cultural, economic, and political backgrounds, integrated urban

water management encounters obstacles and circumstances that are unique to China. It is, therefore justified to study urban water management challenges that are specific to China and seek solutions that have both local and broader implications.

Review

Chapter 2 reviews the development and application of the concept of sustainable urban water management (SUWM). It describes the historical challenges and progresses in water management, as illustrated in two conceptual frameworks. The section after described several principles and techniques developed to target a range of objectives in different countries, including Integrated Urban Water Management (IUWM), Water Sensitive City and Water Sensitive Urban Design (WSUD), Low Impact Development (LID), Green Infrastructure (GI), Sustainable Urban Drainage Systems (SUDS), and Best Management Practice (BMPs). The next section reviews sustainable urban water management in practice using the Sustainable Water Management Improves Tomorrows Cities Health (SWITCH) projects and Blue Water Green Cities initiative. The barriers and constraints in the application of SUWM principles are discussed, pointing to the complex demands for a competent water manager and the challenges in knowledge transfer between actors in water management.

Chapter 3 describes the theoretical framework rooted in the concept of tacit knowledge and the social capital theory. It begins with a review of the current perspectives on tacit knowledge, notably the theoretical positions of Polanyi, Collins, and Nonaka. The chapter then narrows the focus on the discussion of whether and how tacit knowledge can be made explicit, then presents the position of the research on this matter. Tacit knowledge that is transferred and exchanged between actors can be considered as a form of social resources, so the chapter moves onto the presentation of the social capital theory. The conceptualisations of social capital theory by Bourdieu, Coleman, Putnam, Nan Lin, as well as Nahapiet and Ghoshal are reviewed, which then led to the formulation of the theoretical position of this study.

Chapter 4 presents the analysis context of the study, providing background knowledge on China's environmental governance, urban planning and its role in addressing environmental concerns, and the state of urban water management in China prior to Sponge City. The focus is then shifted to the Sponge City initiative and the role of urban planning in it. It highlights the motivation and early progress since the pilot studies began in 2014, and also provides a comparison of the use of language presently and at the beginning of the initiative.

Analysis

Chapter 5 defines the main objectives of the investigation and describes the methodological framework for this research. It outlines the research paradigm, research approach and the rationale for using mixed methods research design. It is followed by details on data collection and analysis methods. It then explains the use of social capital theory and how it is used to guide the data collection and analyses. Finally, issues such as ethical considerations and the maintenance of quality are addressed.

Chapter 6 reports to the research *objective a,* Explicit and tacit knowledge differ in their methods of acquisition, use and transfer. With the assumption that explicit and tacit knowledge is learned and used differently, the survey instrument is designed to assess quantitatively the tendency to use and the learning strategies for each type of knowledge in various topics relevant to the Sponge City projects. The respondents (n=362) reported their work experience, education level, and self-identified profession(s). Descriptive statistics are used to analyse their knowledge of learning and using habits.

Chapter 7 responses to research *objective b and objective c.* It first provides a context to the actors interviewed, using descriptions of their professions, fields of study, and stages of participation in the Sponge City projects. It then describes the actors' perspectives on the objectives of Sponge City. Following the descriptions, it analyses the semi-structured interviews conducted with Sponge City actors, with the consideration of the context presented earlier, as well as the understanding established in the last chapter on actors' use of tacit knowledge. The analysis uses a social capital theoretical framework adapted from the works by Nahapiet and Ghoshal, and Lin. The results are presented in three sections: between actors (non-governmental), between the actors (non-governmental and authority figures), and between the urban planning profession and actors in Sponge City network. Each section analyses the actors' perspectives and relates the results to the theoretical concepts.

Synthesis

Chapter 8 connects the quantitative and qualitative findings to address the research question. It identifies different types of barriers to social capital access and mobilisation and provides recommendations for solutions that entail the development of several skills. It also discusses the meaning of tacit knowledge and how it should be interpreted in the context of urban water management. Finally, it maps the structural, cognitive, and relational strategies to improve knowledge communication between water professionals.

Chapter 9 summarises the solutions that correspond to each research objective. Furthermore, it reflects on the contributions of this research to theoretical, practical, and methodological knowledge surrounding knowledge, communication, and urban water. It then briefly discusses several suggestions for future development before concluding the entire thesis.

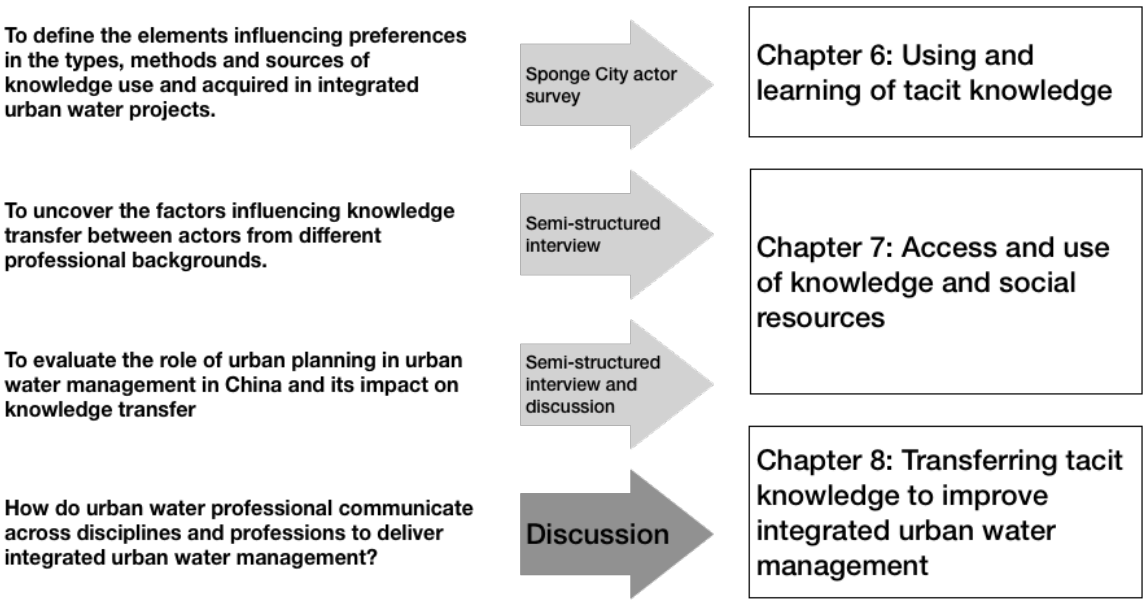

Figure 1-1 Overview of the research question and objectives in relation to thesis content

2 Sustainable urban water management

Urban water systems are socio-technical systems, which are made of not only technological development but also the social environment consisting of scientists, policymakers, cultural and user preferences (Schot and Geels, 2007). These technical and social groups form a network with mutual dependencies and require inter-group interaction and coordination (Grin et al., 2011). This chapter provides background information on urban water management, including the meaning, functions, and the importance of sustainable urban water management. It begins with defining the urban water system and its management, which is followed by the historical and current efforts in the sustainable management of urban water.

2.1 Overview of urban water management status quo and challenges

The urban water system consists of a network of components: drinking water and sanitation, control of infiltration and stormwater runoff, recreational parks, and maintenance of urban ecosystems, and the management of such system rely on proper planning, design, and operation of infrastructure (Loucks and van Beek, 2017). Historically, traditional centralised water management systems have adequately accommodated the urban populations' needs on water supply and sanitation, flood protection, and healthy water environment and ecosystems (Trommsdorff, 2015). However, people have recognised the limitations of the conventional systems, as the basic urban needs are complicated by high urban growth rates, ageing infrastructures, climate crisis, and the subsequent high complexities in environmental problems and uncertainties in long term planning and policy making (Cosgrove and Loucks, 2015; Larsen et al., 2016; Porse, 2013). The biggest challenge in management of water resources, especially in an urban setting, is the complexity caused by the diversity of opinions and values of different decision-makers and stakeholders, as well as the uniqueness of each system where any solution is likely to be embedded in the local context (Loucks and van Beek, 2017).

New paradigms of urban water management are receiving attention from scientists, engineers, and water management practitioners, and there exists a rich literature on the research and practices. Urban water management and governance problems are being recognised and becoming a subject of discussions nationally and globally. Historically, the urban water system went through many stages of transitions in development, which is well captured in the Urban Water Management Transition Framework Figure 2-1 introduced by Brown et al. (2009). The transition framework describes a nested continuum of shifts in socio-technical systems in response to accumulating socio-political drivers, where the transition from one stage to the next is a result of a distinct shift in the cognitive, regulative, and normative pillars of institutional practice(Brown et al., 2009). While from each stage to the next, the service delivery functions expand as a cognitive response to the normative and regulative shifts in institutional arrangements and regulatory frameworks (ibid), the first three historical stages experienced incremental expansion whereas the stages on the right-hand side require re-alignment of cognitive, regulative, and normative pillars (Fjalar J. De Haan et al., 2015). It should be recognised that although the framework is depicted as a linear progression, cities could move in both directions on the continuum or even leapfrog to a stage that is not the immediate next (Brown et al., 2008).

The International Water Association (IWA) has published 17 principles of action to guide city leaders on their journey towards "Water-Wise Cities" (IWA, 2016). Figure 2-3 illustrates the four increasing levels of actions, with each level building up to another. What these principles are trying to achieve is "to encourage collaborative action, underpinned by a shared vision, so that local governments, urban professionals, and individuals actively engage in addressing and finding solutions for managing all waters of the city (IWA, 2016b, 2)". It recognised that it takes a community to deliver sustainable urban water. It is built on having a shared vision that provides consistency to policies, framework and incentives for urban stakeholders, possession and sharing of knowledge, as well as the tools to initiate and implement action.

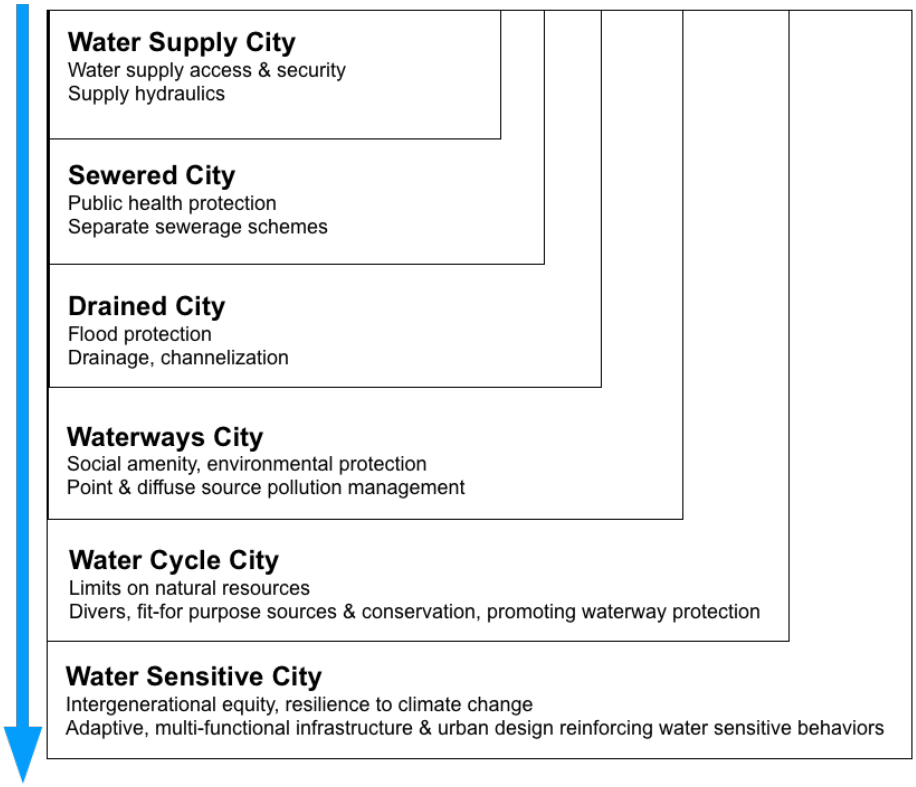

Figure 2-1 Urban water management transition framework, adapted from Brown et al. (2008)

Figures 2-1 and 2-2 captures the essence of the ideal trajectory envisioned by water professionals for the development of urban water management. The nested structure of the frameworks reflects the expansion of demand on the urban water system, as well as an increase in the number of boxes to check in order to fulfil these demands. Solutions encouraged by these new paradigm frameworks are drawing links between society and technology, organisational and institutional reforms and structural changes. The multifaceted goals (or problems) are calling for better integration between disciplines and professions, and better collaboration between professionals, practitioners, and communities.

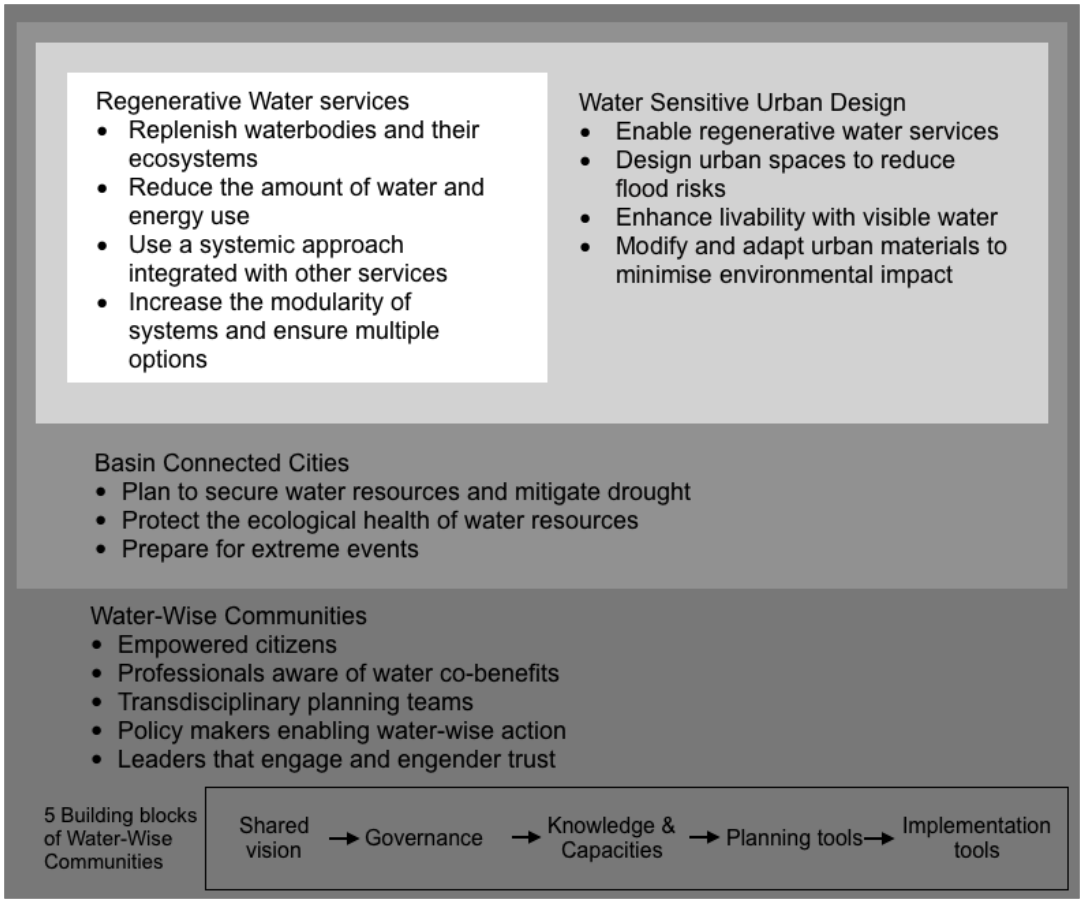

Figure 2-2 The IWA Principles of Water-Wise Cities, adapted from IWA (2016)

However, impacts on real water systems have been limited, as Larsen et al. (2016) have pointed out, because the technical expertise and professional cultures developed over decades of practice are not well aligned with planning discourses or government mission statements. As Cosgrove and Loucks (2015) put, water resources planning and managing are critical, and they will take place in a social or political environment (environment dominated by humans). The next section reviews the development of sustainable urban drainage concepts since Dublin Statement and Agenda 21, which will then be followed by a review of past projects incorporating these ideas and objectives.

2.2 Sustainable Urban Drainage Concepts in Practice: from broad principles to specific techniques

As cities are becoming increasingly crowded, urban development and redevelopment are now inseparable from water resources and water infrastructure (Whitler and Warner, 2014). What began as a vision about how water resources are best managed to serve the people without damaging the environment, gradually developed into more holistic approaches with innovative strategies (van der Steen et al., 2010). There are several milestones on the way to what we know today as the integrated approach to urban water management (IUWM).

In 1992, as a response to the increasing need for social and economic development without harming the environment, the Dublin Statement (from International Conference on Water and the Environment) and Agenda 21 (from UN Department for Sustainable Development) addressed integrated water management from both river basin and urban perspectives. The Dublin Statement principles addressed several criteria of best management, which include linking social and economic development with environmental protections within river basins, participatory approaches towards water development and management, acknowledging the role of women in water provision and protection, and the recognition of economic value of water (van der Steen et al., 2010). The Agenda 21 then built upon the Dublin Statement and highlighted the needs for holistic management of water resources to achieve environmentally sound management of water resources for urban use (van der Steen et al., 2010). However, Agenda 21's main objective is to eradicate poverty, and the aim for improving urban water management remains at satisfying the freshwater needs to development (UNEP, 2014).

The "Bellagio Statement" formulated by the Environmental Sanitation Working Group of the WSSCC (Water Supply and Sanitation Collaborative Council) in 2000, and the UNEP 3 Step Strategic Approach (Nhapi and Gijzen, 2005), went a step further and presented greater emphasis on prevention and recycling in the urban water system. The "Bellagio Statement" principles were meant to achieve universal access to safe environmental sanitation with respect for the economic value of wastes (EAWAG, 2000). According to the principles, good governance should include stakeholders at all levels in decision making to produce solutions that are responsive and accountable to the needs and demands in the local setting, as well as include holistic waste management and recycling to promote efficiency and reduce the spread of pollution (EAWAG, 2000).

To balance environmental protection and urbanisation, the UNEP 3 Step Strategic Approach shifted its focus from technology-centred end-of-pipe fixes to a three-step process for wastewater management – pollution prevention, treatment for reuse, and disposal with stimulation of self-purification capacity (Nhapi and Gijzen, 2005). Rather than improving the treatment processes while the consumption level remains the status quo, the three-step strategic approach starts with reducing water use, thereby minimising the wastewater generation and discharge. This concept is important because following the three-step strategies in chronological order requires a collaborative effort from industries, households, planners, and institutions, and produces specific solutions to specific situations (Nhapi and Gijzen, 2005).

As summarised by Mitchell (2006), IUWM describes a sustainable urban water system where all parts of the water cycle are planned, managed, and monitored as an integrated system to produce context-specific solutions in a process that engages stakeholders at all levels. In fact, IUWM is only one of the terms describing this concept, otherwise known as water sensitive cities, water sensitive urban design and low impact development. These different movements in urban water management have experimented with different frameworks and, while the processes involved and the theoretical basis may differ, the underlying objectives and the necessary measures to be taken are similar. Some

underlying principles or criteria of success that are present in all contexts include the need to address water infrastructure as a socio-technical rather than technical system, the need for coordinated decision making and water management, as well as diversified urban water infrastructure and service types (Brown et al., 2009; Mitchell, 2006; Wong and Brown, 2008).

Building on the sustainable urban water management principles, several conceptual schemes and terminologies ranging from broad principles to more specific techniques emerged to describe different objectives. Fletcher et al. (2015) used Figure 2-3 to illustrate the primary focus and specificity of different urban drainage terminologies. The different terminologies describe concepts, frameworks, or techniques based on similar principles and objectives as outlined in the previous section. This graph will be used here as a guide to discuss sustainable urban water management currently in practice and introduce the concept of Sponge City within the same framework.

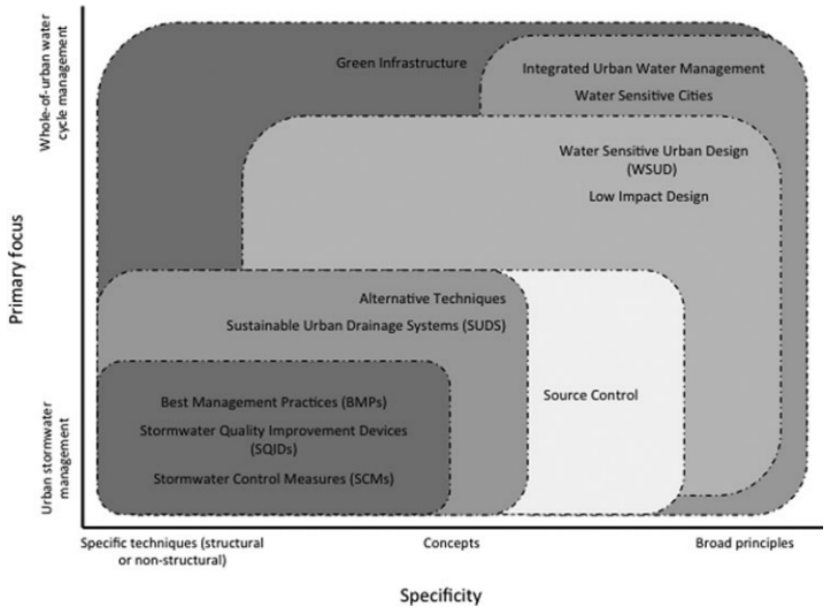

Figure 2-3 Possible Classification of Urban Drainage Terminology (Fletcher et al., 2015)

2.2.1 Integrated Urban Water Management and Water Sensitive Cities

To address the complexity in urban water management, a need for an approach that can address all parts of the water cycle and all requirements for water at different levels in an integrated and comprehensive manner is exigent. This forms the basis of the Integrated Urban Water Management (IUWM) principles. As mentioned previously, IUWM describes a shift in paradigm from traditional mono-disciplinary and –sector management of urban water, to a more holistic approach that considers supply, sanitation, drainage, and even solid waste as components of an integrated cycle (Closas et al., 2013; Mitchell et al., 2007).

Water Sensitive Urban Design (WSUD) was first used in Australia in the 1990', which is aiming to use urban planning and design approaches to minimise the hydrological impacts of urban development on the surrounding environment (Fletcher et al., 2015). The process of water sensitive urban design will eventually achieve the destination that is water sensitive cities (the process of WSUD is discussed in 2.2.3. Water sensitive city describes a vision of the Australian government where a city can provide a range of different water sources for multiple purposes, ecosystem services and a healthy natural environment, as well as knowledgeable citizens that desire to make wise choices about water (Fletcher et al., 2015; Wong et al., 2013). In other words, the cities of the future are envisioned to be resilient, liveable, productive, and sustainable (CRC for Water Sensitive Cities, 2016).

Both IUWM and Water Sensitive City are broad conceptual frameworks that outline the principles or set of criteria that a city should strive for in order to achieve a more sustainable urban water system and environment. And these set the groundwork for the design and adoption of approaches such as Low Impact Development (LID), Water Sensitive Urban Design (WSUD), as well as Sustainable Urban Drainage Systems (SUDS). In summary, this emerging regime or paradigm views the urban water systems with a holistic and integrated approach, and the solutions that enable the transition should be diverse, multifaceted achieved through an integrated, interactive, inter-disciplinary and cyclic process.

2.2.2 Low Impact Development (LID) and Green Infrastructure (GI)

Low Impact Development (LID) is a concept originated from North America to describe an urban drainage design that can achieve natural hydrology by use of site layout and integrated control measures (Fletcher et al., 2015). It is an alternative approach towards stormwater management, where the typical large end-of-pipe solutions are replaced by smaller-scale practices that use or mimic natural processes in order to reduce the impact of built areas and protect the natural movement of water in an ecosystem or watershed (EPA, 2016; Fletcher et al., 2015). Although the term was initially intended to describe specifically site design to minimise impervious areas, later it was expanded to become a mainstream term for alternative stormwater management approach being adopted in design manuals and guidelines (Fletcher et al., 2015). Some examples are LID techniques or features, strategies, elements are summarised in Table 2-1, and these are typical measures that can be adopted for quantity and quality control of stormwater runoff as an alternative to conventional grey stormwater management infrastructure.

Table 2-1 Examples of LID techniques/features/strategies/elements

LID techniques/features/strategies/elements	
Quantity Control	Quality Control
Rain garden Bioretention pond Bioswales Permeable Pavement Land conservation	
Rainwater Harvesting	
Green Roofs "Green Parking"	
Urban tree canopy "green street"	

The terminology of LID has since been widely adopted globally, and it is often interpreted as a set of principles that can draw close links between stormwater management and urban planning as well as land development, 'smart growth' and 'sustainable development' (EPA, 2016; Florida, 2016; Kirkland, 2016; LIDI, 2016).

Green Infrastructure (GI) is often used interchangeably with LID when discussed in the context of stormwater management, but this concept has a broader definition than LID that influences urban planning, human health, as well as social equity (Fletcher et al., 2015) Some examples of definitions include:

> **"Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation… Green infrastructure planning is a successfully tested tool to provide environmental, economic and social benefits through natural solutions and help reduce dependence on 'grey' infrastructure that is often more expensive to build and maintain (Landscape Insitute, 2013)."**
>
> **"The term green infrastructure is a description of what the land is, but also reflects what the land does… Green infrastructure is a phrase used to describe all green and blue spaces in and around our towns and cities. The term allows us to refer to – and consider the collective value of – all of these spaces at once** (Royal Town Planning Institute (RTPI), 2013: 1)**."**
>
> **"Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provide many community benefits. While single-purpose grey stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits (US Environmental Protection Agency, 2016b)."**

LID and GI are widely adopted concepts globally because they bridge well the broad integrated urban water management principles and specific technical design concepts and methods. Both LID and GI when placed in the context of stormwater control and urban water management, refer to the use of techniques or measures to control and treat stormwater at source to minimise impact of urban drainage

infrastructure on the natural areas, and restore some of the natural processes in water management (US Environmental Protection Agency, 2016b). In this sense, the IUWM principles can be realised or concretised through detailed description of design requirements and methods. On the other hand, the lack of 'water' or 'drainage' in both terms enable them to be adopted in an even broader context and allow for cooperation across disciplines (Fletcher et al., 2015). While the techniques prescribed in LID adhere to the concept of 'low impact', the keyword in this terminology is also 'development'. Similarly, GI is often associated with the improvement from an environmental, social, and economic perspective, as shown in the definitions provided above. It is therefore important to draw a closer link between the benefits of each specific technique and the overall benefits of implementation of such measures on wider scales.

2.2.3 Water Sensitive Urban Design (WSUD), Sustainable Urban Drainage Systems (SUDS) and Best Management Practice (BMPs)

Water Sensitive Urban Design (WSUD) is often used in parallel to Water Sensitive Cities. It is a 'water sensitive' approach towards stormwater management in the context of the whole urban water cycle. However, it should be made clear that the WSUD describes the techniques and measures that define the process to achieve the vision of a "Water Sensitive City" (Fletcher et al., 2015; Wong et al., 2013). As summarised in Table 2-2, the objectives of WSUD evolved from urban drainage to what it is now as a more holistic concept towards sustainable urban development that encompasses three different fields: urban water management, urban planning, and landscape/architectural design.

Table 2-2 Evolution of WSUD objectives

Water Sensitive Urban Design Objectives		
Whelans et al. (1994)	**Victorian Stormwater Committee (1999)**	**Current (Hoyer, J., Dickhaut, W., Kronawitter, L., & Weber, 2011; Wong et al., 2013)**
manage the water balance (considering groundwater and streamflow, along with flood damage and waterway erosion)	protection and enhancement of **natural water systems** in urban developments	Sustainable urban water management or integrated water cycle management Water supply Stormwater management Wastewater treatment/recycling Protect health of natural water systems
maintain and where possible **enhance water quality** (including sediment, protection of riparian vegetation, and minimise the export of pollutants to surface and groundwaters)	integration of **stormwater treatment** into the landscape by incorporating multiple-use corridors that maximise the visual and recreational amenity of developments	Urban Design/Urban Planning Consider ecological, economic, social, and cultural demands Landscape/architectural design
encourage **water conservation** (minimizing the import of potable water supply, through the harvesting of stormwater and the recycling of wastewater, and reductions in irrigation requirements)	protection of **water quality** draining from urban development	
Maintain water-related environmental and recreational opportunities".	reduction of **runoff and peak flows** from urban developments by employing local detention measures and minimising impervious areas	
	Adding value while minimising drainage infrastructure development costs.	

Sustainable Urban Drainage Systems (SUDS) is a stormwater management approach originated in the UK in the 1980s, which consists of a range of technologies and techniques for sustainable drainage of stormwater and surface water (Fletcher et al., 2015). A range of measures are available to form a management train in order to control both the quality and quantity of urban runoff, and it closely follows the principles behind LID (ibid).

Best Management Practices (BMPs) is first used in North America (the United States and Canada) to describe a range of practices for pollution prevention (Fletcher et al., 2015). In the United States, it became an important part of the National Pollutant Discharge Elimination System (NPDES) permitting process to prevent the release of toxic and hazardous chemicals (US Environmental Protection Agency, 1993). In October 2000, the US EPA released a menu of BMPs based on the stormwater Phase II rule's six minimum control measures, with the objectives of BMPs still being prevention of pollutants from entering waterway (US Environmental Protection Agency, 2016a). In Europe and other parts of the world, BMPs also describe a set of management practices that target either or both quantity and quality control of stormwater runoff (Fletcher et al., 2015).

2.3 Sustainable urban water management in practice

A selection of research projects on sustainable urban water management across the globe was reviewed to provide some insights into the application of IUWM knowledge on real-life situations. The emphasis on the SWITCH project is due to its inclusion of Chinese cities in this type of large-scale project that aims to target all aspects of the water cycle.

2.3.1 Sustainable Water Management Improves Tomorrows Cities Health (SWITCH, 2006-2011)

The SWITCH project is a research and development project funded by the European Union and 33 partners across the globe. Having researchers, practitioners, and stakeholders in cities work directly together across a range of different geographical, climate, cultural, and socio-economic settings, the project aims to develop a "SWITCH approach" to catalyse a switch towards sustainability in urban water management practices (Howe and Mitchell, 2011). To reach their goals, the project focuses on improving the scientific basis that informs decision making, as well as improving knowledge sharing to find new solutions to the future urban water systems that are robust, efficient, flexible, and adaptable to known and unknown changes (van der Steen et al., 2010).

There are in total of 12 projects in cities and megacities across the world, excluding North America and Australia. The project covers six main aspects of integrated urban water management: strategic planning and transitioning, stakeholder engagement, explorative research on water supply, stormwater, and wastewater, as well as decision-support tools. The Learning Alliances (LA) are a key mechanism of integration at the city-scale. It is a stakeholder platform to guide and support the implementation of research demonstration activities in each city, and it is designed to take into account local problems and needs. The third area of focus is social inclusion. As mentioned, LA is a key mechanism in this project because it enables and facilitates the integration and collaboration needed for social inclusion that empowers marginalised groups to contribute, as well as for institutional mapping that identifies key actors and institutions to get involved.

A successful Learning Alliance or any engagement of stakeholder requires strong leadership and effective facilitation. It also asks for trust and mutual respect between the stakeholders for meaningful interactions to happen. Equally important to the development and success of Learning Alliance is an in-depth analysis of power relations within the participating cities and research networks, as well as an analysis of the internal dynamics within a project team (Chlebek et al., 2011). However, these processes are usually slow and very dependent on the local context. For example, it was more difficult in Beijing to establish trust between stakeholders by holding frequent multi-stakeholder meetings for ideas exchange due to cultural reasons. The same cultural difference in China also prompted the change from multi-stakeholder meetings to more informal bilateral meetings with the universities served as 'honest brokers' (Chlebek et al., 2011).

SWITCH works with the LA in each city to implement a strategic planning process, which aims to prepare for the uncertainties in urban water system planning due to the on-going changes as well as future changes that remain unknown yet (van der Steen et al., 2010). The members of the LA come together to work on the different stages of strategic planning, which starts with the development with a shared vision of the future organisation of the urban water system (van der Steen et al., 2010). The goal of visioning is to help stakeholders to think beyond the current problems and set a medium to long term target that they deem achievable.

The second stage of strategic planning is scenario development. After the team has agreed on a common vision of the future, the LA works to generate different scenarios to account for a range of uncertain factors and risks. The goal is to have the stakeholders think imaginatively about what the most uncertain and relevant factors are in the future, bearing in mind that some things in the future can be unpredictably different than in the past (van der Steen et al., 2010).

In the last, strategy development phase, the LA works on different strategies that can lead to different outcomes for each scenario developed. A good strategy should be flexible and adaptable so that it can achieve the vision developed in the first phase in multiple scenarios developed. The strategy decides what types of measures should be implemented to achieve the vision, and the outcomes are assessed with long term indicators that are designed to reflect the changes in the state of the urban water system. Instead of measuring the impacts after the projects are completed, the SWITCH projects used "micro-scenarios" for each objective that the LA has decided to focus on, and compared the progress of improvement to the micro-scenarios each marked with distinguishing evaluative term.

The strategic planning process encourages the stakeholders to look beyond personal or institutional interests and focus on the priorities of the city. Nevertheless, the strategic planning is a long-term process that should take at least five years, while it allows for the building of trust among the stakeholders, the process could be troubled by the instability in the structure and composition of the Learning Alliances.

2.3.2 Blue Water Green Cities initiative (first phase, 2009-2012)

The Blue Water Green Cities initiative was funded by the Water Partnership Program, with an objective of exploring and developing the concept of IUWM through the implementation of a series of projects focused on different aspects of the IUWM in Latin America and the Caribbean (LCR), Europe and Central Asia (ECA), and sub-Saharan Africa (Closas, et al., 2012). The focus of this initiative was on the operationalisation of IUWM projects, which was realised by developing a conceptual framework and implementation guide for IUWM in LCR, formulating an IUWM strategy and Cost-Benefit Analysis strategy in ECA, as well as exploring alternative planning processes in sub-Saharan Africa (Closas et al., 2013). Instead of using IUWM as a basis to develop another set of approaches like SWITCH project did, the WPP projects under Blue Water-Green Cities aimed to

optimize the implementation of urban water projects using IUWM principles, and provide step-by-step guidance on the IUWM process involving developing IUWM strategies, identifying practices, and learning and prioritising investments (Michaud et al., 2012).

The first phase identified in this project was the engagement phase, which was also the entry point for countries with none or minimal experience of IUWM (Closas et al., 2013). This stage was where key stakeholder should be identified and stakeholder engagement plan created. Another outcome by the end of the initial stakeholder meetings and training was the creation of a plan of activities and capacity building. Much like the SWITCH approach, a crucial part of this phase was to identify an effective leader as well as a coordinator from the government representatives, also to identify the correct government level to be involved.

Much like the Strategic Planning process in the SWITCH approach, the stakeholders needed to agree on a set of objectives to be achieved, though this project started with the current issues instead of a future goal. At this stage, the aim was to identify the main issues in terms of the current urban water management and assess their importance and impacts both qualitatively and quantitatively. The stakeholders were expected to actively participate in the identification and prioritisation of the main problems and challenges, as well as in the evaluation of the economic cost of inaction. Similar to SWITCH, it was recommended to define urban scenarios in the future considering any risks and uncertainties.

Once the main issues were agreed upon, the stakeholders could work out the goals and the strategies to achieve them. A series of participatory meetings would take place to decide on the strategies for the issues that have already been prioritised, and consider both structural and non-structural, as well as further studies and research in the areas that have insufficient knowledge.

The Blue Water Green Cities project approach's last stage was monitoring, which was during and after the implementation of the projects according to the action plan developed in the previous stage. Both project approaches emphasise the importance of documentation of progress and adjustment according to evaluation results. While in the World Bank/WPP projects, the monitoring and evaluation should be iterative and participatory, the SWITCH approach makes it clear that the evaluation needs to be continuous throughout the entire process starting from the stakeholder engagement stage so that each evaluation can turn into an opportunity of learning and adjustment. A signature of the SWITCH project is that all the research areas are slightly overlapping and complementary. Although there is chronological order, the activities and processes under each research area should be carried out somewhat simultaneously. In fact, the ability to conduct stakeholder engagement, research, and strategic planning in parallel with constant monitoring in all processes give the SWITCH projects an upper hand. If done correctly, this can truly reflect the nature of the IUWM approach, which has better flexibility and faster responses to uncertainties.

2.3.3 Barriers and constraints

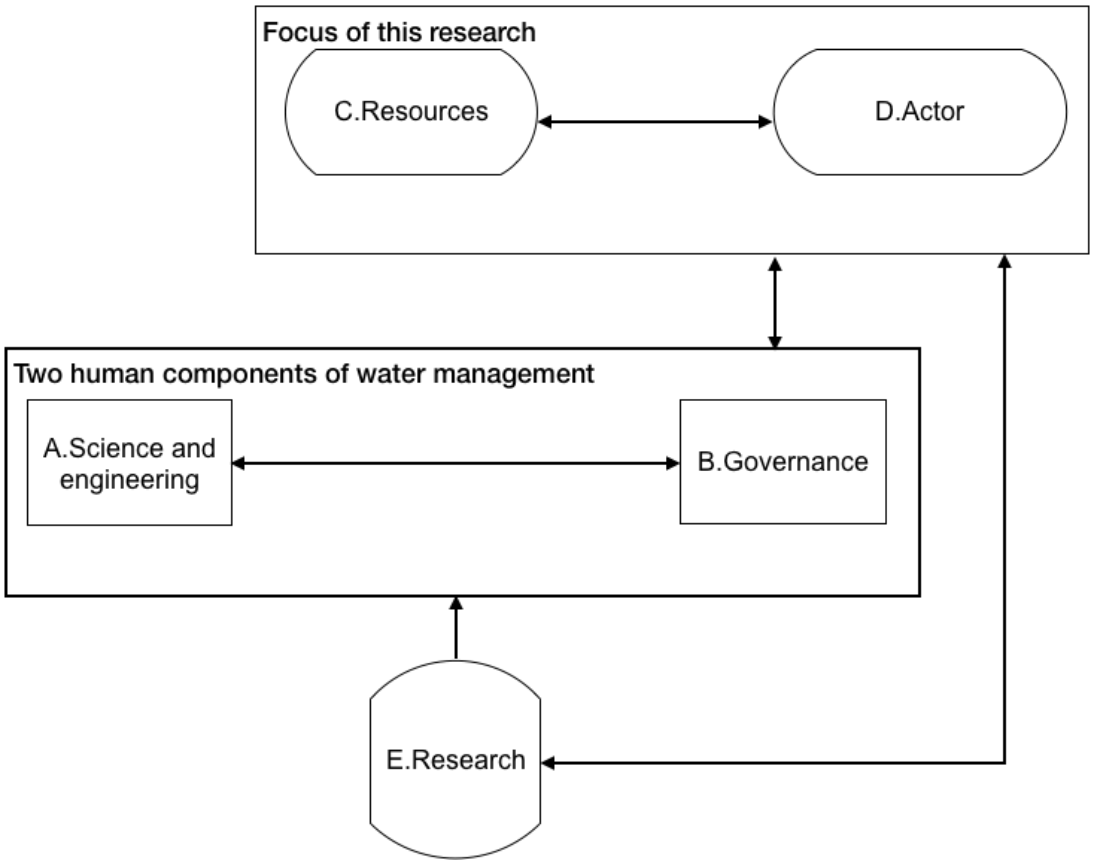

Figure 2-4 Mapping of barriers and constraints in urban water management

The management of urban water systems consists of two human components, the technical component and social component. From the technical aspect (**A**), innovative and creative solutions, as well as the diffusion and transfer of the technologies, are needed (Cosgrove and Loucks, 2015). While technological development has been rapid, the sustainable water management sector has not been receptive enough towards technical innovation because of the high risk with uncertain return, which despite the superiority of more sustainable and innovative solutions, large and expensive end-of-pipe physical interventions are still being favoured (Brown et al., 2006; Cosgrove and Loucks, 2015). Long-range and innovative technical solutions require government financing and support, but this can only be possible with changes made to governance and regulations, which in comparison to technical aspect will experience more gradual development in a prolonged period (Cosgrove and Loucks, 2015; Marlow et al., 2013).

The social component of urban water management is experiencing more gradual changes compared to technologies. Governance (**B**) can be improved to encourage the development and adoption of social, policy, planning and administrative interventions (Brown et al., 2006). Since more than a decade ago, Brown et al. (2006) already identified in the case studies on Australian sustainable stormwater management across 166 local government organisations, that the planning process was dominated by

engineering consultants, and implementers did not possess the expertise and mentality for working with non-technical communities. Years later, Cosgrove and Loucks (2015) reaffirmed this opinion by reflecting that it is vital to include all stakeholders in a framework for negotiations. Decision-making process at various levels should have clarity, and water managers should involve from the earliest planning stage so they can interact with other actors and managers from other sectors (ibid.).

A healthy relationship between the social and technical components should be mutually stimulating to pave the way for sustainability. However, governance and regulations are not encouraging a balanced interest in technical innovation. The costs and benefits, as well as the social, economic, and environmental values of the solutions, are not always reasonably conveyed, resulting in less technological and governance attention being paid to preventative and protective measures (Brown et al., 2006). On the other hand, the advancement in technologies does not always warrant warm reception among non-technical audiences such as actors in policy and administrative realms, especially when communication of knowledge is challenging. Existing structures and prevailing practices linger, for path dependency of any approach is "path-interdependent with economic, technical, and political decisions (Werbeloff and Brown, 2011: 2367).

While it is needless to say that innovative and creative solutions, products, and methodologies are needed in research, innovative research into institutional mechanisms shall not be neglected either (Cosgrove and Loucks, 2015). As pointed out in the technical aspect, physical interventions are dominating still, and in the governance aspect, the collective decision-making process that involves all stakeholders is a work in progress. It is urgent to address both concerns in research with equal interests. Research efforts (**E**) must be made towards innovation in social and technical aspects, which should endeavour to address simultaneously financial, social, and environmental challenges while considering the cultural and religious values of societies (ibid). Therefore, a multidisciplinary group of researchers, including engineers, social scientists, need to work collectively and collaboratively.

Research (E) is one factor that influences the dynamics of urban water management by injecting new thinking and new solutions. The actors (**D**), their capabilities, as well as their learning and sharing capacities, are another factor. More specifically, what is significant is the capacities to obtain, apply, and share knowledge and expertise. The multi-faceted problems and multiple objectives of urban water management are demanding actors to be "polymaths", just as described below.

> **Water managers today and those in the future will have to be familiar with a wide range of applicable disciplines and be able to interact with a variety of professionals, stakeholders and users. These managers and their agencies should have sufficient technical, economic, social, financial, and environmental skills to be able to engage in dialogue with the professionals and affected stakeholders in the regions where improved water management is needed. They should have the capacity to interact with politicians and inform them of the science behind any impact predictions. They need to understand policy makers' short-term political commitments, and be able to facilitate the conciliation of politicians' initiatives with long-term sustainable water resource policies** (Cosgrove and Loucks, 2015: 4835).

In other words, being a competent water manager to is to be able to communicate meaningfully with people from a wide range of disciplines, professions, which requires the possession of adequate skills and expertise in a variety of fields. A position with such description is not easy to be filled, especially when resources (**C**) are insufficient to enable capacity building. It is undeniably important to provide funding and opportunities for research activities, as well as providing the materials, experts, and platforms for capacity building (Cosgrove and Loucks, 2015; Qiao et al., 2018). While access to information and training opportunities off and on-line are essential, the abilities to interact and "engage in dialogue" with actors from different backgrounds may not be acquired so straightforwardly, for it requires one to access information that is socially available. There are two challenging elements in the process, one is the access to the knowledge possessed by other actors, and the other is the application of the knowledge, ensuring that the learning accomplished while doing can be translated again back to doing.

2.4 Summary

Sustainable urban water management is a model and a series of concepts that intends to use an integrated approach towards the management of urban water cycle from the perspectives of delivering safe, reliable, and secure water services, by mobilising and coordinating stakeholders from all relevant backgrounds, and at the same time enhancing the social, economic, and ecological sustainability. It is an ideal that people are trying to work towards, though the uncertainties from the climate perspective, the complexities in the urban systems, and the practical challenges emerged from cross-disciplinary communication, are adding to the difficulty levels of that journey.

In this chapter, the concept of sustainable urban water management and its application in some case studies are reviewed along the timeline of its development. Since the initial ideation of sustainable urban water management, the concepts have been adopted and implemented in cities of many countries, and have been attracting research efforts from international/national academic and professional bodies, and garnering attention from international, national, and local authorities. Challenges remain especially in the cognitive aspect due to lack of knowledge, lack of shared understanding, and lack of effective communication.

3 Tacit knowledge and social capital framework

The importance of being able to understand disciplinary language and experiences have long been identified among researchers and professionals in the realm of urban water management. Among others, some critical and persistent challenges to the implementation of sustainable urban water management include the lack of knowledge and expertise, lack of effective communication and collaboration, and lack of shared understanding and context.

Inevitably the conversation will lead to collaboration between different disciplines and professions, and the social factor in technical and economic challenges. This conversation brings the focus to the efficient use of knowledge that is possessed by different groups of people in the network. The chapter is divided into two sections. Section 3.1 examines the nature of tacit knowledge and the positions of several prominent theorists on the definition of tacit knowledge and its relationship with the explicit. Section 3.2 concerns the conceptualisations of social capital, as well as the development of the theoretical framework for this research.

3.1 Tacit and explicit knowledge

One must be able to comprehend what is being communicated in order to learn and collaborate. Some pieces of knowledge are easier to be codified and disseminated using the spoken and written language, and so it is explicit. However, there are other pieces of knowledge that are difficult to be made explicit. Tacit knowledge has many interpretations and theorisations. The next section explains the formulation of the conceptual framework of tacit knowledge in the context of this research, which draws on the perspectives of Polanyi and Collins. Other perspectives on tacit knowledge are also introduced in order to clarify the reason to place less emphasis on the theorisation of Nonaka and Takeuchi.

3.1.1 The positions of Michael Polanyi and Harry Collins

Polanyi argued in the book *The Tacit Dimension* (Polanyi, 1966: 4), that all knowledge relies on personal judgement, and more specifically that "we can know more than we can tell". While he invigorated the discussion on the role of personal experiences in sharing of scientific knowledge in the well-known book *Personal Knowledge Towards a Post-Critical Philosophy* (Polanyi, 1958), *t*he theoretical framework of this research is inspired mainly by his theoretical positions outlined in the book 'The Tacit Dimension'. He spoke of "knowing" – the "knowing what" and the "knowing how", to cover both theoretical and practical knowledge (Polanyi, 1966: 7). Knowledge is an activity that should be described as the process of knowing, and tacit knowing is a "tacit power", or "an act of integration" (Gourlay, 2002: 10). Polanyi further explained that we could communicate our knowledge provided we are given adequate means for expressing ourselves, whether it can be understood by others rely on other people's intelligent co-operation for catching the meaning of the "demonstration" (Polanyi, 1966: 5).

In describing the basic structure of tacit knowing, Polanyi elaborated on two terms of knowing, where we know the first term (the proximal term) only by relying on our awareness of it for attending to the second (the distal term). This perspective on knowledge or the process of knowing has drawn inspiration from the Gestalt school of psychology. According to which, we organise perceptual cues from the external world by perceiving the integrated image of distinct objects by grouping them using the principles of proximity, similarity, and a good figure [2]. He explained, "we know the second term (the electric shock) by attending to it, hence the subject is specifically known; we know the first term (shock producing particulars) only by relying on our own awareness of them for attending to something else, so our knowledge of them remains tacit" (Polanyi, 1966: 9–10). The significance of the relation of the two terms – the distal term signifies the approach of the proximal term – is composed of two aspects of tacit knowing, namely the functional and phenomenal aspects. The structural aspect explains how by attending to the achievement of joint purposes from the elementary movements we are unable to specify these elementary acts; while the phenomenal structure explains

[2] Gestalt's Principles or Gestalt laws. The Proximity principle states that "elements tend to be perceived as aggregated into groups if they are near each other; the similary principle states that "elements tend to be integrated into groups if they are similar to each other"; and the good [figure] principle states that "elements tend to be grouped together if they are parts of a pattern which is a good Gestalt, meaning as simily, orderly, balanced, unified, coherent, regular, etc as possible, given the input" (Todorovic, 2008).

that we are aware of the proximal term in the *appearance* of the distal term. This aspect that he defined as the semantic aspect, addresses how all meanings "tend to be displaced away from ourselves", or meaning is separated from that which has this meaning (Polanyi, 1966: 12–13). He further deduced a fourth aspect based on the functional, phenomenal, and semantic aspect, describing the way "we comprehend the entity by relying on our awareness of its particulars for attending to their joint meaning", and this is the ontological aspect of tacit knowing (Polanyi, 1966: 13).

Polanyi recognised that there is the knowledge that cannot be put into words, and as a result, we tend to know more than we can tell. This kind of knowledge is embedded within the personal abilities and experiences and thus is difficult to articulate to another person for them to replicate (Polanyi, 1966). He believed that we hold firmly to our opinions and understandings and resist to bring changes to them (Smith, 2003). The emphasis on knowledge being subjective and stems from personal values as well as context forms the basis for the analysis of the tacit dimension of urban water management in this research.

In Collins' view, "tacitness" is a continuous spectrum from "weak" to "strong", and its strength is determined by the extent to which the knowledge is programmable and have the use of knowledge reproduced in machines (Collins, 2013). Collins argued that although all tacit knowledge is obtained by humans through interacting in society, there are different ways to acquire it. When Polanyi described *tacit* as what we can know more than we can tell, Collins emphasised that tacit could be either "understood or implied without being expressed directly", or it could also be "cannot be explained".

One kind of tacit knowledge is somatic-limit tacit knowledge, where the biological limitations of the human brain and bodies can only process knowledge that has not yet been converted to explicit rules, for example, one can formalise the rules for balancing a bicycle, and yet one does not apply these rules when acting out the riding of a bicycle. Another kind is collective tacit knowledge, which one cannot make explicit because it is located in the human collectivities, so the only way to acquire it is to be embedded in a specific society (Collins, 2007). While Polanyi's example of riding a bicycle has become a typical example of tacit knowledge, Collins is positioned to focus on the collective or society level instead of individual or body level of tacit knowledge (Collins, 2013).

A third type described by Collins is relational tacit knowledge, a supposedly "weaker" type of tacit knowledge. These pieces of knowledge are on the borderline of explicit and tacit. They are categorised as "tacit" knowledge by Collins because they can be but are not made explicit for various reasons. It could be kept hidden and are, therefore, not made explicit to those who are excluded. It could be better explained by pointing to the artefact instead of describing it using words. Or, it could be made explicit but would become less efficient in its extraction and processing. Mismatched saliences cause some knowledge to remain tacit because the person explaining misjudges unintentionally the amount of knowledge that is already possessed by the receiving person, and therefore "skips" specific pieces of knowledge that prevent another person from understanding. Unrecognised knowledge refers to

things of which the person who possesses them is not aware, thus making it impossible to make explicit to another person.

By recognising the knowledge that is not readily expressible, comprehensible, and digestible, Polanyi laid out the foundation for the concept of tacit in the process of knowing. In relation to the subject of making knowledge explicit or explicable, Collins elaborated and expanded the notion of tacit into a spectrum where knowledge is divided into categories based on how difficult it is to understand and explain it. To acquire "specialist tacit knowledge" or obtain "specialist expertise", Collins (2016) explained that one must become "socially embedded in the appropriate groups of experts" and "[immerse] in the society of those who already possess it". He distinguished two categories of specialist tacit knowledge that one can achieve through socialisation among groups of experts. Contributory tacit knowledge is acquired by working in an expert domain, allows one to contribute to a domain of practice, and if possessed, could potentially enable that person to "apply for a job in the science in question or at least publish papers in the professional journals or perhaps be let loose in the laboratory" (Collins, 2014).

Interactional expertise can be acquired through "deep immersion in the linguistic discourse of the domain", and when possessed, one would be able to offer critical comments and convey scientific thoughts and activities of others with experts in a domain, and perhaps "anticipate a point, speeding the conversation along without needing detours where mutual understanding already exists" (Collins, 2014: 129, 2016: 3). He further argued that without interactional expertise, individuals would be isolated and bounded by things that they had practised themselves, making it less or impossible to cooperate and build common understandings (Collins, 2016). Collins and Evans (2014) claimed that interactional expertise could enable members from different social and disciplinary groups to coordinate their actions without first embedding in each other's experiences, thus making interdisciplinary collaboration more likely to succeed.

3.1.2 Nonaka and Takeuchi's position: transformation between tacit and explicit

Nonaka and Takeuchi (1996) differentiated two types of tacit knowledge, one is the "technical dimension", which is similar to the previously mentioned "know-how", or skills and crafts that are obtained through experiences but hard to pin down the principles behind them. The other is the "cognitive dimension", which consists of "mental models, beliefs, and perceptions" that are embedded in a person (Ibid).

Later, Nonaka and Toyama (2003) explained using Gidden's Structuration theory that the two types of knowledge are produced by the two main levels of consciousness in our daily lives: practical consciousness and discursive consciousness[3]. Moreover, explicit knowledge is produced by discursive consciousness because it is easier to consciously express such knowledge in formal and systematic

[3] practical consciousness refers routine and theory that we don't really think about in our daily lives, and discursive consciousness refers to the rationalizations of actions.

language, whereas tacit knowledge being produced by practical consciousness is much harder to communicate because it is highly subjective and personal (Nonaka et al., 2000).

An alternative way to understand explicit knowledge is that the user is fully conscious of how it is being used due to very recent or infrequent usages (Chilton and Bloodgood, 2007), and so it is implied that through frequent uses one could become more familiar with the knowledge and thus converting it to tacit. Although tacit knowledge can be transformed or elicited into a transmittable format, during this process some aspects such as the personal and subconscious experiences and abilities are bound to be reduced and remained tacit (Geldof et al. 2011).

Knowledge differs from information as it builds upon the information but anchored on the commitment and beliefs of its holder (Nonaka, 1994). Traditionally, especially in the western culture, an organisation is viewed as a passive and static system that processes information in the "input-process-output" sequence, but this paradigm is insufficient to explain the functions of organisations (Ibid). Organisations are made of people, and people interact actively and dynamically with their environment continuously. In a social-technical system such as the urban water system, knowledge is very much "context-dependent" rather than "absolute". It is embodied in the personal beliefs and values, and the experience of the individuals acquired in specific contexts. Thus, knowledge is created from the interaction between tacit and explicit knowledge (Nonaka et al., 2000).

Nonaka et al. (2000) explained that as tacit knowledge and explicit knowledge interact, "knowledge conversion" occurs and both types of knowledge increase in quality and quantity, in other words, new knowledge is created through this process. Although this process is used to illustrate organisational knowledge creation, the process of externalisation elucidates the conversion of tacit knowledge into explicit knowledge, which is a process that they argued is usually neglected in studies of organisational theory (Nonaka, I. and Takeuchi, 1995).

SECI (see Figure 3-1) is a framework proposed by Ikujiro Nonaka in the early 1990s. It is a two-by-two model of knowledge conversion between tacit and explicit. SECI refers to the four stages that knowledge expands through. **Socialisation** aims at sharing tacit knowledge among individuals. During this process, knowledge such as technical skills and mental models is transferred from one person to another directly without the use of language. They argued that it is difficult since having shared experience and context are the prerequisites for any individual to learn this type of knowledge. **Externalisation** aims at articulating tacit knowledge into explicit concepts, through the uses of "metaphors, analogies, concepts, hypotheses or models". They argued that tacit knowledge, to some extent, is expressible in the form of metaphors, which helps to understand something by conjuring up an image of another thing that is more familiar. **Combination** aims at combining different entities of explicit knowledge, via the use of media such as documents, meetings, and conversations, online and offline. **Internalisation** aims at embodying explicit knowledge into tacit knowledge, through the process of "learning by doing", as well as embedding it in the culture of the organisation or network.

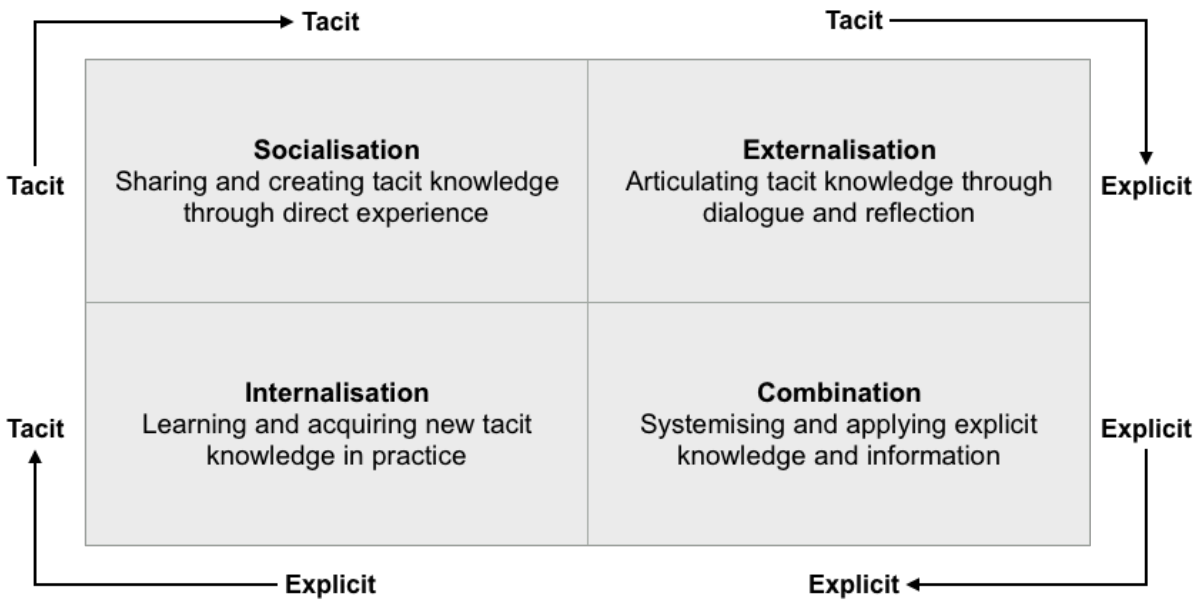

Figure 3-1 SECI process of knowledge conversion (Nonaka and Takeuchi, 1995)

The knowledge creation in an organisation is a "spiral process" that starts with tacit knowledge created and accumulated at the individual level and is mobilised and amplified by the organisation as tacit and explicit knowledge interacts through the cycle of knowledge conversion (Nonaka and Takeuchi, 1995).

Although Nonaka and his collaborators emphasised that tacit and explicit knowledge is on a continuum, their SECI process defines clear boundaries between two types of knowledge and how they can convert from one form to another. Nonaka et al. said that "it is difficult to communicate tacit knowledge to others", that is to assume that communication of knowledge can only be done through the media of "data, scientific formulae, specifications manuals and such like (Nonaka et al., 2000: 7)".

> **"Western epistemology has traditionally viewed knowledge as explicit. However, to understand the true nature of knowledge and knowledge creation, we need to recognise that tacit and explicit knowledge are complementary, and that both types of knowledge are essential to knowledge creation…Knowledge is created through interactions between tacit and explicit knowledge, rather than from tacit or explicit knowledge alone** (Nonaka et al., 2000: 8)**."**

The distinction Nonaka and Takeuchi (1996) made between the two types of knowledge can help with the understanding of the components of a piece of knowledge being used, but it does not contribute to the imparting and learning since the knowledge that is needed for increasing expertise and competency is rarely one type or the other. It would be helpful for teaching and learning if one can use their distinction between the two types of knowledge and provide transmission methods and resources accordingly.

Table 3-1 Theoretical positions on tacit knowledge

	Polanyi (1966)	Collins (2013)	Nonaka (Nonaka and Takeuchi, 1996; Nonaka and von Krogh, 2009)
What is knowledge?	Knowledge is highly personal, "our body is the ultimate instrument of all our external knowledge, whether intellectual or practical".	Relational tacit knowledge- "is a matter of how particular people relate to each other" Somatic tacit knowledge- "turns on the nature of the body." Collective tacit knowledge- "turns on the nature of the social	1.knowledge is justified true belief 2.knowledge is the actuality of skilful action and the potentiality of defining a situation to permit skilful action 3.knowledge is explicit and tacit along a continuum. The knowledge that is uttered, formulated in sentences, and captured in drawings and writing is explicit. knowledge tied to the sense, tactile experiences, movement skills, intuition, unarticulated mental models, or implicit rules of thumb is tacit
Can and how to make tacit explicit?	Tacit knowledge is not and cannot be made explicit	Relational- "can be formalised and transmitted by someone who possesses the relevant communication technology and technical capacity." Somatic- "can be expressed in terms of the 'scientific understanding of causal consequences. The uses of this knowledge can be reproduced in machines. Collective- "we can describe the circumstances under which it is acquired, but we cannot describe or explain the mechanism nor build machines that can mimic it."	Socialisation- sharing through direct experience Externalisation-articulating through dialogue and reflection
Where is tacit knowledge located?	A tacit dimension: our belief is anchored in ourselves, and to understand one must dwell in the tacit dimension	The terrain of tacit knowledge: "outer zone is relational tacit knowledge, an intermediate zone (harder to access but still attainable in principle) of somatic knowledge, and a central and currently inaccessible zone of collective tacit knowledge."	Technical dimension: "know-how", skills and crafts that are obtained through experiences but hard to pin down the principles behind them Cognitive dimension: "mental models, beliefs, and perceptions" that are embedded in a person

3.1.3 Position of this research

Urban water system comprises a variety of components that are responsible for all the functions supporting the urban life, from the treatment of water to different purposes to the draining of rainfall runoff from the urban streets. The difficulty of its management does not only reside in the structural and technical complexities; the social dynamics create layers of complications and uncertainties. It is a complex system made up by multiple disciplines and professions, each occupying a niche environment and commanding niche knowledge that is difficult to communicate with clarity.

Tacit and explicit knowledge are both constructed concepts. As demonstrated in Table 3-1, there are different takes on where tacit knowledge is located, whether/how/to what extent can it be externalised. Instead of trying to define what tacit knowledge is or is not, what is essential to this particular study is the communication of knowledge that is difficult to transmit from person to person. It is important because the aim of communicating knowledge is to transmit expertise, abilities, and competency.

Nonaka and Takeuchi described one of the processes to make tacit explicit; the SECI process is an effective pathway of knowledge conversion in a closed network where the knowledge is mostly bounded within the actors of an organisation. In response to controversies regarding the theory of knowledge creation and the knowledge conversion process, Nonaka and von Krogh (2009) gave more clarification on how knowledge conversion incorporates the dynamic interaction between tacit and explicit knowledge. They recognised that tacit and explicit knowledge is along a continuum while being able to "momentarily take on different forms". In their views, the ability to transform is significant because the explicit form of knowledge is more enriched, and the process of making it explicit articulates the tacit knowledge and expands one's boundary of understanding.

Nonaka and Takeuchi (1996) acknowledged that "the organisation cannot create knowledge on its own without the initiative of the individual and the interaction that takes place within the group" (p12). They further elaborated that "organisational knowledge creation, therefore, should be understood as a process that "organisationally" amplifies the knowledge created by individuals and crystallises it as a part of the knowledge network of the organisation (p59)." Nonaka's definition of knowledge is rooted in the traditional tripartite analysis (justified true belief, JTB), but treating knowledge as a resource/asset/capital may be more appropriate when the attention of analysis is on cross-organisational and cross-disciplinary communication of knowledge, rather than on organisational knowledge creation and accumulation. In a sense, by amplifying the knowledge through the organisation, the personal asset becomes the company/organisation's resources, and that interaction between individuals are the fundamental processes that enable the transformation of personal assets to network assets.

Regardless of how tacit and explicit knowledge are being defined to suit different theoretical frameworks, Michael Lynch's remark presents a good reminder for researchers focusing on this topic.

> **"[Tacit] knowledge (along with its close cousins incommunicable knowledge, craft knowledge, etc) is, first of all, a vernacular concept; a concept or theme that**

is used to do rhetorical work in concerted efforts to manage work and to resist such management (Lynch, 2013: 70)**."**

Two characteristics of knowledge are highlighted by Polanyi, that it relies on personal judgment, and we can know more than we can tell. In his articulation of the concept, all knowledge is either tacit or rooted in tacit knowledge, ruling out the possibility of drawing a clear boundary between "tacit" and "explicit" knowledge. The concept of tacit knowledge began with Polanyi as he placed scientific knowledge and rational thinking back into the environmental, social, cultural, and personal context surrounding the knowledge. His perspective on tacit knowledge and tacit knowing forms the philosophical basis of this research, while Collins' mapping of tacit knowledge provided a structural framework that categorised the concept of tacit based on the reason behind the inability to tell what one knows, as well as the mechanism that could enable tacit knowledge to be made explicit.

What is in common between Nonaka's position and Collins' position is the importance of socialisation, but Collins' terrain of tacit knowledge provides a broader framework of analysis that was based and expanded based on Polanyi's conceptualisation of tacit knowledge. All of the above theorists treated socialisation as a lengthy and sustainable process, where when the knowledge and insights embedded within an individual are accessed and mobilised by an individual or a group, they become socially shared and collective resources for the member(s). It is, therefore, on the conditions that affect the access of resources from the individuals and the use or mobilisation of the resources within the network that this research will be focusing.

3.2 Social capital theory

Unlike other forms of capitals (economic, human), social capital exists between actors instead of being attributed to anyone actor (Sato, 2013). At the core of social capital theory is the social network or the relationships between and among the members of a network. Though, because there is a mixture of definition and scope of the theory, studies of or using social capital theory may not be referring to comparable measurements (Tzanakis, 2013). The various definitions of social capital differ in terms of their scope, the goals and utilities of actors (Sato, 2013), categorisation of social capitals, and the level of analysis. "Divorced from its roots in individual interactions and networking, social capital becomes merely another trendy term to employ or deploy in the broad context of improving or building social integration and solidarity (Lin, 2017)." It is, therefore, necessary to declare the theoretical stance to support the analysis for this research. The next section addresses the foundation of the concept of social capital as well as the theoretical positions of prominent sociologists who have contributed significantly to the progression of the social capital theory.

3.2.1 Influential conceptualisations of social capital

Pierre Bourdieu introduced the term *social capital* as he discussed the three basic kinds of capital occurring in a society, along with economic and cultural capitals (Bourdieu, 1986; Häuberer, 2011). With the intention to extend the definition of capital beyond economic theory, Bourdieu distinguished social capital as "the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition (Bourdieu and Wacquant, 1992: 119)". He explained that social capital resides in the network of relationships that is defined by the complex clusters of actors' positions in the social space, and under certain conditions can be converted into economic capital and institutionalised (Bourdieu, 1986). An important concept Bourdieu introduced was the symbolic capital, which is "the form that the various species of capital assume when they are perceived and recognised as legitimate"(Bourdieu, 1985: 724). He argued that, for example, money alone does not have value until it has been recognised as a legitimate form of exchanges for goods, the relationships (friendships or kinship ties) can only be valuable when they are being recognised, or their legitimacy is being acknowledged in exchanges.

James Coleman, another early theorist of social capital, derived his definition from the theory of rational action, and identified that as a "variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors, whether persons or corporate actors-within the structure (Coleman, 1990: S98). He contended that social capital cannot exist if no link between at least two individuals is established, in other words, it only exists in relations (Coleman, 1990). He further argued that for the forms of social capital to function well, it is essential to maintain closure in a network, where all members are connected. The closure of a social structure is a precondition for the network to provide collective sanction on members' actions

and effective norms to emerge. The collective sanction also would create and ensure trustworthiness in a social structure, as well as ensure that obligations are met, and reputation can be established.

Robert Putnam's concept of social capital consists of three elements: trust, networks of civic engagement, and norms of reciprocity, he believes that the existence of social networks, and the norms of reciprocity and trustworthiness, allow people to work more effectively towards collective goals (Häuberer, 2011). Like Coleman, he referred to these characteristics as "social capital". He recognised that social capital differs from both physical capital and human capital, for the latter two refer to physical objects and the properties of individuals, respectively, while social capital refers to the *connections* among individuals, which means isolated individuals would not be rich in social capital even if they are rich in other forms of capitals. He argued that social capital is able to reduce transaction costs and lubricate social relations, and this function can be either bridging or bonding (Tzanakis, 2013). Bridging social capital is what directed to the outside of a group and bridges people of different social classes. While bonding social capital is directed to the inside of the group, which tends to reinforce homogenous groups, which adheres to Bourdieu's concept of social capital, increasing the exclusivity of a network. He focused on formal social networks for it is easier to gather data on association, unlike Bourdieu and Coleman (Putnam, 2001). He also differed from Bourdieu in that he did not recognise the fact that trust is not equally distributed in a network, for this he has been criticised for his a priori assumption that trust has pro-social consequences (Tzanakis, 2013).

3.2.2 Construction of social capital models

Bourdieu, Coleman, and Putnam laid down the foundation for the formulation of social capital concept. Although based on different ideologies, a commonality that they share is their emphasis on relational resources in social structures and networks (Tzanakis, 2013). Bourdieu recognised social capital in two layers: the connections and networks an actor builds, and the resources she and her network wield (Häuberer, 2011). Bourdieu's definition of social capital is placed in the context of social and economic inequalities, which can be a powerful and yet limited perspective (Gauntlett, 2011). Meanwhile, there are several controversies around Coleman's conceptualisation, and subsequently, Putnam's because of their commonalities in theoretical basis (ibid). One of criticisms is that in Coleman's argument, social capital is defined by its function, and it appears to be circular or tautological for social capital only seems to be acknowledged when and if it produces positive effects (Lin, 2017; Tzanakis, 2013). Another surrounds the fact that they described assets such as obligations, trust, norms, as forms of social capital. However, Lin (2017: 10) argued that they are collective assets which include the relational, and while they may "promote the relations and networks and enhance the utility of embedded resources, or vice versa", they are not alternative forms of capitals.

Nan Lin's definition of social capital consists of three ingredients: resources embedded in a social structure (embeddedness); accessibility to such social resources by individuals (accessibility); and use or mobilisation of such social resources by individuals in purposive actions (use). The access and use of social resources are determined by the positions in the hierarchical structure as well as the use of

weak ties (Lin, 2017). He emphasised the meaning of *capital*, which is characterised by investment and its return, where social capital is the "investment in social relations by individuals through which they gain access to embedded resources to enhance expected returns of instrumental or expressive actions[4] (Lin, 1999: 39)". Moreover, he argued that social capital is not suitable to be studied as a collective asset, an asset that everyone possesses, because members within a network may not have equal access and use of the assets(Lin, 2004). He also considered that closure and density are not necessarily a requirement for social capital - denser networks may have an advantage for preserving or maintaining sources (expressive actions), while the significance of bridges, structural holes or weaker ties may be more prominent for searching for and obtaining resources (instrumental actions) (Häuberer, 2011).

In an attempt to integrate the diverse perspectives and approaches towards the conceptualisation of social capital, Lin proposed a model for theorising social capital that is composed of three blocks of variables in causal sequences (Figure 3-2) (Lin, 2004, 2017). The first block represents the investment in social capital, or the preconditions that facilitate or constrain investment in social capital.

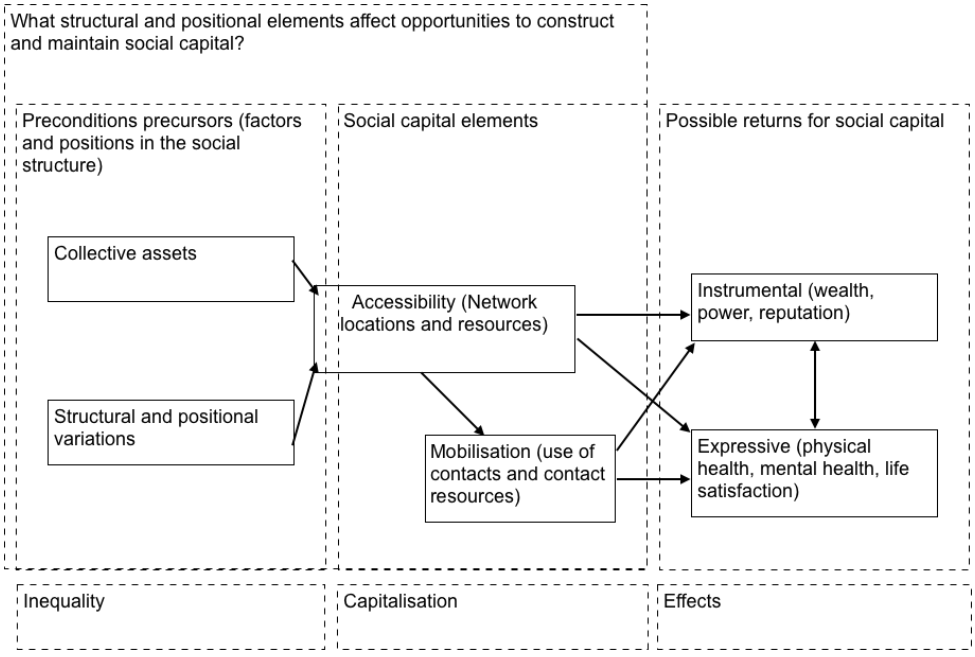

Figure 3-2 Nan Lin's conceptualisation of social capital, adapted from Lin (2004)

What determines the accessibility of social resources are factors of social structure including collective assets and each individual's position in the structure. The collective assets here are referring to economic productivity, level of technology, level of education, social/political/cultural participation[5], and these factors are characterising the social structure to which the individual belongs. Within a structure, an individual could occupy different positions. The variations in the social factors and the

[4] Lin described two types of return, instrumental (wealth, power, reputation), and expressive (physical health, mental health, and life satisfaction).
[5] In an earlier version of this model, Lin (2004) defined collective assets as norms, trust, etc., which were not included in the updated model anymore.

positions occupied in the social structure may contribute to the unequal distribution of access to social capital.

The second block concerns the process of mobilisation of social capital, which is a process that links the access to and the use of social resources. The process of capitalisation takes place to convert social resources into capital, which is used to perform specific actions. Lin postulates that better accessible embedded resources should lead to more embedded resources being mobilised in purposive actions by an individual. However, the same level of accessible embedded resources can result in different levels of resources mobilisation by different individuals, and this may be influenced by the network location as well as the

The third block of Lin's conceptualisation represents the returns of social capital. Instrumental actions are taken to obtain resources not possessed by the actors already, and the returns could be economic, political, or social, which could be in the forms of wealth, power, and reputation (opinions about an individual in a social network). Expressive actions are taken to access and mobilise those actors who share interest and control of resources, in order to pool and share for the sake of preservation of existing resources. The returns to the actor could be in the forms of physical health, mental health, and life satisfaction. Instrumental and expressive returns could have reciprocal effects on one another, but the factors that benefit each type of return are different. Instrumental returns are enabled by open networks, whereas expressive returns can benefit more from a denser network with reciprocal relations among members.

3.2.3 From community bond and network resources to knowledge transfer

Nahapiet and Ghoshal (1998)'s definition of social capital is adopted from the views of Bourdieu, Putnam, and Burt, "social capital is the sum of the actual and potential **resources embedded** within, available through, and **derived from the network of relationships** possessed by an individual or social unit. Social capital thus comprises both the **network** and the **assets** that may be **mobilised** through that network". Their framework focused on the influence of social capital on what they defined as intellectual capital, which is the "knowledge and knowing capability of a social collectivity" that is a social artefact and is embedded in a social context.

In order to use social capital theory to better explain the accumulation and transfer of knowledge in organisations, they defined social capital in terms of three dimensions: structural, cognitive, and relational.

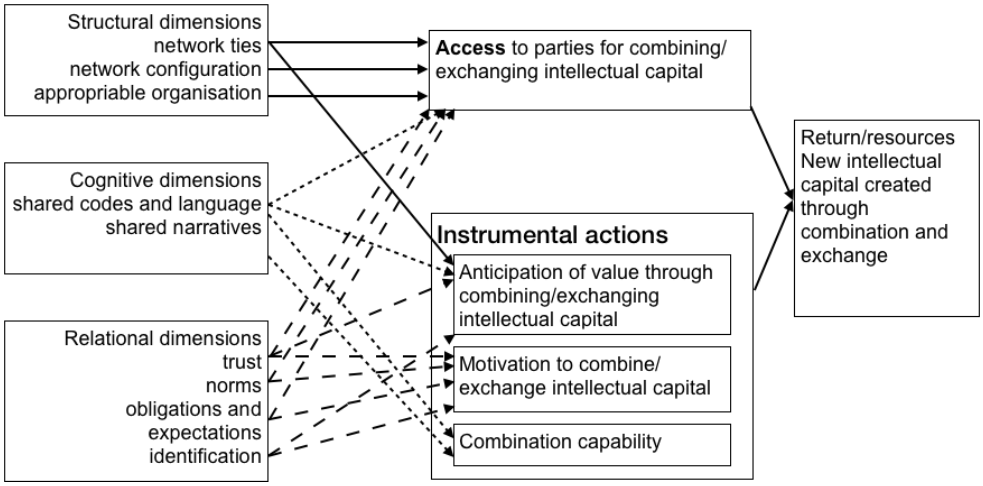

Figure 3-3 Nahapiet & Ghoshal's conceptualisation of social capital, adapted from Nahapiet and Ghoshal *(Nahapiet and Ghoshal, 1998)*

Structural social capital dimension relates to the properties of the social system and of the network of relations as a whole (Nahapiet and Ghoshal 1998). It describes the tangible dimension of social capital, which is the impersonal configuration of linkages between people or units, whom one reaches and how one reaches them (ibid). Important aspects of the structural dimension are network ties which consider the access to resources, network configuration which describes density, connectivity, and hierarchy, as well as appropriable organisations that describe the roles, rules, precedents, and procedures (Claridge, 2018; Nahapiet and Ghoshal, 1998). Since the structural dimension describes the physical properties of the network relationships (density, connectivity, hierarchy and appropriability), instead of the quality of the relationships (relational dimension), the network approach is usually used to study the tie strength and centrality, network stability and size (Claridge, 2018).

The relational dimension relates to the quality of the relationships formed in a network, where the key aspects are trust, norms, obligations and expectations, as well as identification (Nahapiet and Ghoshal, 1998). The nature and quality of the relationships are developed over time, shaped by distinct bonds formed and dynamics of the interactions between two individuals. This dimension is intangible and highly subjective as well, for aspects such as trust and trustworthiness, and norms of interaction are based on observation, perception, and opinion that may be different for individuals in different contexts (Claridge, 2018; Muniady et al., 2015).

When the actors spoke about the relationships they have with other governmental actors as well as non-governmental actors, the two common discussion foci that emerged are trust and trustworthiness, as well as the norms and identification of a group of actors. Trust is a critical factor that is widely discussed in network-wide knowledge transfer and social capital literatures (Bonfim et al., 2017; Goh, 2002; Inkpen and Tsang, 2005; Kang et al., 2014; Masiello et al., 2015; Steinmo and Rasmussen, 2018). The increase in trust contributes to improvement in cooperation and knowledge transfer between actors in a network because it induces an elevated willingness to experiment with combining different

information and sense of confidence in the outcome of knowledge transfer and creation, especially in situations of considerable uncertainty and complexity (Nahapiet and Ghoshal, 1998).

Other facets include norms, obligations and expectations, and identification. As Coleman (1990) pointed out, unlike physical and human capitals, the person or persons usually invested only experience a subset of the benefits while all those who are part of the social structure may also benefit from the person or persons' investment. Norm represents "a degree of consensus in the social system" where the control of action is held by others instead of the actors themselves. Obligations and expectations are a commitment or duty to undertake some activity in the future, as expected within particular personal relationships. And identification is described here as a process where actors see themselves as one with another person or group of people as a result of being members of a group or taking the values or standards of the group/individuals as a comparative frame of reference. These attributes occupy the same function as trust, which urges and motivates individuals to engage in knowledge exchange and positive collaboration. Just as one would be willing to share knowledge due to strong inter-personal trust, one could also show such willingness to conform to a norm, respond to an obligation, and contribute to a group with whom the individual identifies.

Nahapiet and Ghoshal (1998: 244) described the cognitive dimension as resources that provide "shared representations, interpretations, and system of meaning among parties". This is an intangible dimension that related to the interpretation of shared reality, or a sharing of context between parties (Claridge, 2018; Nahapiet and Ghoshal, 1998). Other descriptions of the cognitive dimension also include shared goal and vision, shared paradigm, or shared culture, which is often manifested in the use of a shared language or codes that have different meanings inside versus outside the group (ibid).

First, what do language and narrative mean in their literal sense? Language, "a system of phonemic and grammatical differentiation", is constructed of linguistic signs that are surrounded by their semantic fields, which are partly governed by a social code and partly individualised by the unique features of the "utterer" or "interpreter" (Scholes, 1980: 206). The interpretant (a sign, or a word, to explain another sign or word, Charles S. Peirce) generated by each interpreter is distinct, and is generated as a function of the semantic fields developed by the interpreter for that particular sign in terms of its previous appearances in other utterances (speech act) (ibid). Scholes (1980) then defines narration (the act of narrating) as "a word that implicates its object in its meaning (209)", and he further elucidates that it is "the symbolic presentation of a sequence of events connected by subject matter and related by time (209)". In this sense, a language consists of signs that are incomplete when being independent from the user's individual interpretations and social environment, and a narrative is a string of events as they happen through time.

Nahapiet and Ghoshal (1998) explained that the sharing of context that is needed for the exchange and combination of knowledge comes in two main ways: through the existence of shared language and code, and the sharing of collective narratives. They described three layers of influence of sharing language and code. First, language and code are how people can discuss and exchange information,

and sharing common language and code allows better access to people and their information. Second, language and code also influence people's perception and frame of reference when observing and interpreting the environment, so sharing common language and code provides a common conceptual apparatus for evaluating the value of events. Third, having an overlap of knowledge is often manifested in the existence of shared vocabulary, which enables the combining of information. In addition to the combining of information, having shared a collective narrative, i.e. tales, stories, metaphors, enables the combination of different forms of knowledge, including those that are tacit in nature such as interpretations of events, and such shared narrative helps create and transfer new interpretations of events (ibid).

Nahapiet and Ghoshal explained that their study was focused on the independent effects these dimensions, but they recognised that the dimensions and the multiple facets of social capital are likely to be interrelated in complex ways that may mutually reinforce or interfere their effects.

3.2.4 Research using social capital theory on knowledge transfer between organisations

Since social capital theory has a number of definitions and schools of interpretations, studies may adopt different definitions and propositions. This section looks at the conceptualisation of social capital theory and the theoretical frameworks adopted in selected studies. Several studies have based their theoretical frameworks on the work of Nahapiet and Ghoshal, but the number of dimensions and the elements within included in the studies could vary.

In the study by Inkpen and Tsang (2005), they examined the social capital dimensions embedded in three different types of networks and the social capital conditions that affect knowledge transfer for each type of network. They adopted a definition of social capital that is similar to that of Nahapiet and Ghoshal (1998), which is "the aggregate of resources embedded within, available through, and derived from the network of relationships possessed by an individual or organisation", as well as adopted in their analyses the three dimensions of social capital: structural, cognitive, and relational.

In the structural dimension, the facets included in the analysis are network ties, network configuration, network stability. The two facets included in the cognitive dimension are shared goals, which refers to shared understanding and approach to goals and outcomes, and shared culture, which refers to the norms of behaviour that govern relationships within a network. The relational dimension that the authors of this study decided to focus on was trust, because they thought it was "critical factor affecting interfirm knowledge transfer and creation" as well as due to "space limitation". They added that these facets were included because they were deemed to be most relevant to knowledge transfer between network members.

Chang and Chuang (2011) conducted a quantitative study that measured the knowledge sharing behaviour and interactive relationships between participants in virtual communities. The definition of social capital adopted was "the sum of the assets or resources embedded in the networks of

relationships between individuals, communities, networks, or societies, [which] exists through interpersonal relationships among individuals". Their conceptualisation also adopted the three-dimensional framework of Nahapiet and Ghoshal.

The structural dimension contains the variable of social interaction, where a network of high social interaction has strong connections and direct ties between members. In the relational dimension, they included variables of identification, trust, and reciprocity, where identification is the members' sense of belonging to a group, trust is a set of values, norms, and principles followed by the members, and reciprocity refers to a sense of fairness. Cognitive dimension is represented by shared language, which encourages mutual understanding between members.

In addition, they recognised that knowledge belongs to individuals, therefore also included two individual motivation factors: reputation, and altruism, as well as participant involvement which they believed, was a moderator of the individual factors.

Steinmo and Rasmussen (2018) conducted a longitudinal case study to investigate how prior experience influences the development of social capital in university-industry collaborations. This study established their theoretical framework based on the works of Nahapiet and Ghoshal (1998) and Inkpen and Tsang (2005), and the definition of social capital given in Nahapiet and Ghoshal's study was adopted. They chose to focus on the cognitive and relational dimensions and excluded structural dimension in their study because they considered that structural dimension refers to patterns of connections instead of the development of relationships and interactions.

In this study, the cognitive dimension of social capital is measured by the firm's general collaboration experience with universities and academic expertise, which can take the forms of shared interpretation and systems of meanings, common languages and codes, as well as shared narratives among parties. The relational dimension of social capital is measured by prior relationships and collaboration experience between the specific partners, which can take the form of reciprocity, which is an aspect of trust.

Rhoes, Lok, Hung and Fang (2008) conducted a correlational field study to examine the relative impact of social capital and organisational learning on knowledge transfer. They adapted their definition for social capital based on Inkpen and Tsang (2005), "a jointly owned set of resources that accrue to an individual or group by virtue of their social connections."

Their theoretical framework is based on the views of Nahapiet and Ghoshal (1998) and another study, and there are six variables adopted. In the structural dimension, the variables are core knowledge players and network connection. The relational dimension includes relationship strength and relation quality. The cognitive dimension is being referred to as the cognition dimension in this study, and the variables are shared value and common norms.

Table 3-2 Conceptualisation of selected studies using social capital theory

	Inkpen and Tsang (2005)	**Rhodes, Lok, Hung and Fang (2008)**	**Chang and Chuang (2011)**	**Steinmo and Rasmussen (2018)**
Structural dimension	network ties network configuration network stability	core knowledge players network connection	social interaction	-
Cognitive dimension	shared goals shared culture	(Cognition dimension) shared value common norms	shared language	shared interpretation and system of meanings common languages and codes shared narratives among parties
Relational dimension	trust	relationship strength relation quality	identification trust reciprocity	reciprocity, which is an aspect of trust
Other factors			individual motivation (reputation and altruism) participant involvement	

As Table 3-2 summarised, the three-dimensional social capital framework of Nahapiet and Ghoshal (1998) is a popular theoretical framework among studies on social capital and knowledge transfer or network learning. Though researchers usually made modifications to the facets under each dimension. The results mostly pointed to the importance of the interplay of all the dimension (variables), as well as the links between the impact of a dimension (or variable) and the characteristics of a network (or organisation).

3.3 Theoretical framework

3.3.1 Formulation of theoretical framework based on works of Nahapiet and Ghoshal (1998) and Nan Lin (1999, 2017)

The last section provided an overview to the formulation of the concept of social capital, and presented the analyses of social capital at a different level and scope, using different measurements, and indicators. While Bourdieu, Coleman, and Putnam each contributed to the formulation of social capital concept in relation to network and bonding, this research needs to draw on conceptualisation and establish models of social capital in relation to knowledge transfer and learning.

Social capital theory has been adopted in the analysis of knowledge sharing among actors involved in a network (Masiello et al., 2015). Nahapiet and Ghoshal (1998) offered this explanation in their work to connect social capital dimensions to the mechanisms and processes of knowledge creation and transfer.

> **Given the social embeddedness of intellectual capital, we suggest that such a theory is likely to be one that is primarily concerned with social relationships. Accordingly, we believe that social capital theory offers a potentially valuable perspective for understanding and explaining the creation of intellectual capital** (Nahapiet and Ghoshal, 1998: 250)**.**

Nahapiet and Ghoshal (1998) described social capital in terms of three clusters or dimensions and explored their effects on combination and exchange actions that would eventually lead of creation of new knowledge and knowing capabilities, or intellectual capital. They constructed the concept of social capital using three dimensions: structural, cognitive, and relational. As Figure 3-3 in the previous section explains, the structural dimension has direct impacts on the conditions of accessibility, the cognitive dimension influences both accessibility, anticipation of values, and combination capability, and relational dimension has influence over accessibility, anticipation of value, as well as the motivation to engage (Nahapiet and Ghoshal, 1998).

The present study adopts the dimensional interpretation of social capital, for it provides structure to the analysis of different facets to the concept. However, the model built by Nahapiet and Ghoshal (1998) needs to be modified in order to reveal how knowledge is transferred in Sponge City. They defined social capital as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit, [it] comprises both the network and the assets that may be mobilised through that network (Nahapiet and Ghoshal, 1998: 243)". In their definition, social capital comprises both the **network** and the **assets** that may be **mobilised** through that network. One can see that the two key components of social capital are the network, whose properties can include its structure in terms of size and range, and configuration in terms of density and openness; as well as the assets that can be mobilised through the network. Therefore, one can argue that the key elements of social capital are the resources available through and derived from the network, in other words, the ability to access the resources; as well as the ability to mobilise such resources. In comparison to the original model (Figure 3-3) that charted the role of social capital in the combination and exchange of intellectual capital which eventually led to the creation of new knowledge, their interpretation could be better represented using the model of social capital theory devised by Lin (2017)[6]. In Lin's model (Figure 3-2), the leftmost block represents the collective factors and individuals' position in the social structure that serve as preconditions for social capital. A second block represents the access and the use of social capital, linked by the process of mobilisation. And a third block represents the possible returns for investing in social capital. As

[6] Lin (2017): "social capital can be defined as resources embedded in a social structure which are accessed and/or mobilized in purposive actions."

one looks back on Nahapiet and Ghoshal (1998)'s model, one can observe that what they have identified as social capital facets are rather factors that influence the use of the network and the resources made available through the network.

Before formulating the theoretical framework for the present research, the following definition of social capital is adopted. It is **the resources embedded within a network of relationships possessed by an individual or social unit, which can be accessed and/or mobilised through that network** (Lin, 2017; Nahapiet and Ghoshal, 1998). With this definition, the researcher reorganised Nahapiet and Ghoshal's framework using Lin's model, as seen in Figure 3-4. The commonality is found in their emphases on the access and the mobilisation of social resources as critical components of social capital. Though in Nahapiet and Ghoshal's conceptualisation, the structural, cognitive, and relational factors of social structure are being recognised as the facets of social capital, and this is reflected in the reorganised framework (figure 3-4). They attributed each facet to a number of conditions or processes for resources exchange in a network. The structural dimension (A) primarily impacts the accessibility of social resources (B), and the cognitive and relational dimensions (A) primarily impact conditions including anticipation of value, motivation, and capability for combination, which are factors that influence the quality of the use of resources (B), which in this case, to combine and exchange knowledge to create new knowledge (intellectual capital) (C).

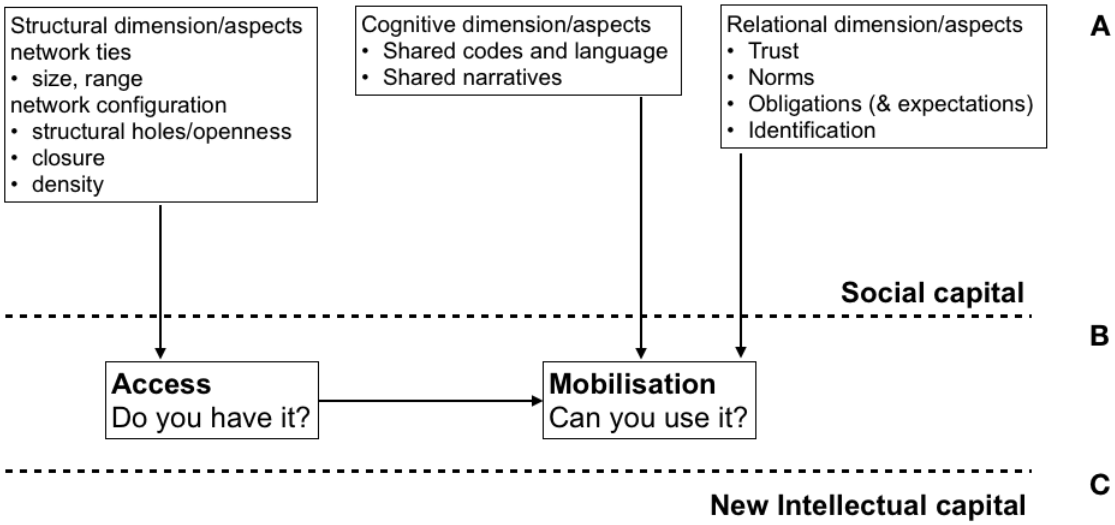

Figure 3-4 Theoretical framework modified from the framework of Nahapiet & Ghoshal

One can see in the previous section that "appropriable organisation" is also one of the facets clustered under the structural dimension, but it was not included in Figure 3-4. What Nahapiet and Ghoshal intended to convey using this term was that the context or the social setting can influence the use of social capital, and multiplex relationships can facilitate the use of the same contacts for accessing different types of resources. The researcher believes that this term describes the quality of the resources that can be obtained *through* the ties, not directly of the network ties. Therefore, instead of including it in the structural dimension in Figure 3-4, the modified framework (Figure 3-5) incorporated the influence of historical, cultural background, on the mobilisation of social resources. Lin (1999)'s subconcept of *collective assets* could be used to convey this idea. Lin argued that "social

capital, as a relational asset, must be distinguished from collective assets and goods such as culture, norms, trust, etc. (Lin, 1999: 33)". The researcher believes that to analyse the role of social capital in knowledge learning and transfer between individual Sponge City actors, factors such as trust, respect, and norms (subject to individual interpretation) are better clustered with relational dimension of preconditions, because they relate more to personal relationships rather than collective assets.

If social capital is being characterised by the accessibility and the mobilisation of resources through a network of relations, social capital (B) in figure 3-4 is thus relabelled as preconditions/precursors for social capital in Figure 3-5. Also, new intellectual capital (C) is replaced with outcomes that include both intellectual capital (knowledge, knowing capability), which may impact the factors in cognitive dimension, and other returns including power, reputation, which may impact the factors in relational dimension.

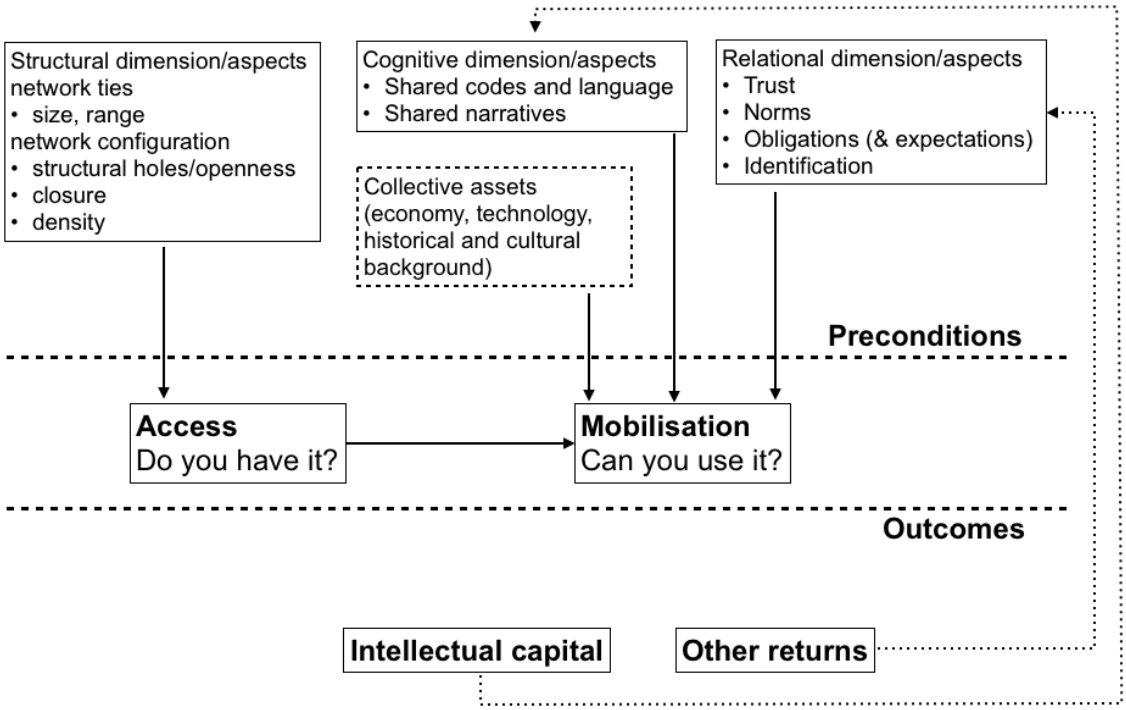

Figure 3-5 Finalised theoretical framework of social capital access and mobilisation

3.3.2 Application of the theoretical framework to the tacit knowledge

The theoretical framework displayed in Figure 3-5 describes the conditions that influence the access of social network, which is where social capital is embedded, and the utilisation of these resources. Knowledge is form of social capital, especially when working among and with actors from such a variety of professional and disciplinary backgrounds, where one must learn and share knowledge with another in order to achieve any positive result.

As explored in 3.1.1, the communication of tacit knowledge can be challenging due to various reasons, thus making it not readily expressible, understandable, or digest able. However, it is established earlier that tacit knowledge can be expressed if given adequate means and appropriate

pathways (Collins, 2013; Polanyi, 1966). The following outlines the reasons why tacit knowledge access and mobilisation can be difficult.

Access of tacit knowledge could be difficult if

- It is kept hidden from some actors, for example, it is only shared with a private group of actors (relational)
- It is determined to be less efficient to clarify (relational)
- There is mismatched salience between actors - one is not sure of how much another person knows (relational)
- An actor does not recognise that they possess a particular knowledge that others need (relational)
- The knowledge can be better explained by pointing/showing than describing, but the medium may not be available (relational)
- An actor has trouble describing how knowledge is being applied (somatic)
- It is not being shared due to reasons such as mistrust, prejudice, etc. (collective)

Mobilisation of tacit knowledge could be difficult if

- The knowledge can be better explained by pointing/showing than describing, but the medium may not be perceived well (relational)
- An acctor has trouble applying the knowledge being described (somatic)
- It is not taken well by the receiving actor due to reasons such as mistrust, prejudice, etc. (collective)

Since knowledge is a form of resources embedded in and can be accessed through a network, it is, therefore, appropriate to use the theoretical framework based on social capital to analyse the preconditions that influence the access and mobilisation of tacit knowledge.

3.4 Summary

Tacit knowledge is a buzzword in the field of knowledge transfer, especially when it is in the context of management of complex systems. It is important because of much of what actors in urban water systems do rely on communication of knowledge and effective collaboration for success. It is also exceptionally challenging since learning and communication are being prevented by a combination of social and cognitive barriers. This chapter has presented the theoretical positions behind some of the most prominent characterisations of tacit knowledge, identified the links between the role of socialisation in transferring tacit knowledge and the concept of social capital. Finally, after reviewing

the conceptualisations of social capital theory, a theoretical framework is established for this research, which is endeavouring to examine the tacit component of sustainable urban water knowledge, identify factors that influence positively the transfer of such knowledge as well as the role of various professionals especially in urban planning in this process.

4 Analysis context: China's Sponge City and the role of planning

In a study of social capital and its role in the dynamics of organisational and personal connections, one must consider the social and cultural characteristics in order to accurately reflect the values and resources embedded within and generated through a network of relationships. "Collective assets" such as the economy, technology, historical and cultural background have an impact on the mobilisation of social capital which influences the outcomes of knowledge transfer and other returns. This chapter will provide a context to the social, cultural, and political backgrounds that have an impact on the access and use of social capital.

4.1 Environmental governance in China

In the past 60 years, China has trekked very far on the path of economic growth, while jeopardising environmental protection that has resulted in severe air and water pollutions (He et al., 2012). The economic reform and increasing international pressure have paved the way for a shift in environmental management, and a transition from monolithic economic growth to a balance between social, environmental, and economic development (Ibid). Meanwhile, the planning sector underwent a significant shift from state-oriented industrial style planning to more localised and commoditised planning, coinciding with the de-centralisation of economic decision making (F Wu, 2015).

Since the establishment of People's Republic of China in 1949 to the end of the Cultural Revolution, there are no major signs of progress in environmental legislation during this period while the nation was still battling various political and economic challenges (Qin and Zhang, 2018). In 1972, the United Nations Conference on the Human Environment (UNCHE) pushed the Chinese government to elevate awareness of environmental issues and the impacts and consequences of the interactions between human activities and the ecosystem (Ibid).

The increasing population and consumption since the modernisation in the 1970s are putting a strain on the environment, as a result, "environmental protection" was introduced and became a duty of the state since 1978 (Qin and Zhang, 2018). The economic reform in the late 1970s led to decentralisation of environmental policies, which allowed for greater flexibility to adapt to local socio-economic situations, and yet resulted also in a rise in conflict between local economic growth and development of environmental policies and enforcement of regulations and standards (Mol and Carter, 2007). During this period, planning also adapted itself to better suit the market environment to become an instrument of the local government for urban growth and expansion, and planning institutes were slowly getting decoupled from the government (F Wu, 2015).

Later, the separation between the state-owned enterprises (SOE) and local level governments further transferred the decision making on production from political to economic domains (Mol and Carter, 2007). In 1989, the Environmental Protection Law marked the beginning of modern environmental legislation in China, and shortly after the United Nations Conference on Environment and Development (UNCED) in 1992, Chinese government decided to incorporate sustainable development as the guideline and fundamental principle for all environmental legislation in China (Qin and Zhang, 2018).

More recently, the increasingly severe environmental problems and further global integration economically and politically became the socio-political driver for the transition towards better integration of environmental and economic goals. The more heightened environmental awareness is manifested in the incorporation of energy and environmental targets in the 12th Five Year Plan (FYP), the increasing status of environmental agencies, the use of more market based instruments such as the pollution permits, environmental fees, tax reductions, as well as the increasing presence of civil society

such as non-governmental organisations (NGOs) and the media (He et al., 2012; Lewis, 2011; Li, 2013; Mol and Carter, 2007).

The evolution of environmental management since 1972 is well summarised in Table 4-1. During the 1970s and 1980s, the command and control environmental management strategies reflected the centrally planned economies at the time, while planning was primarily a government activity to better serve the industrialisation of cities (He et al., 2012; F Wu, 2015).

In the past decades, efforts and priorities in environmental management have been slowing catching up to those in economic development, but many challenges still exist where some are more specific to China's cultural and political environment. The significant success in China's economic growth has led to some critical problems in environmental governance, the increasing pollution intensity, and the dominance of economic policy institutions over environmental policy institutions (He et al., 2012). Additional causes to environmental policy implementation include the national-local gap on sustainability and environmental programs due to the aforementioned autonomy of the local government works (Ibid). The increasing challenges prompted new changes to environmental legislation, and in 2014, the Environmental Protection Law was amended to enforce stricter penalties and take stronger measures against environmental violations (Qin and Zhang, 2018).

From 2015, more stringent regulations and policies on water environment protection are issued and updated every year (Xu, 2018). For example, the State Council and the Communist Party of China (CPC) Central Committee demanded the full establishment of the river chief mechanism by 2018, which will assign river chiefs at four different levels to take responsibility for the rivers and lakes under their jurisdiction, as well as to coordinate and resolve trans-jurisdictional conflicts between different regions and departments (Ibid). The environmental protection tax law was published in 2016 and enforced in 2018, which aimed to strengthen the social control of environmental regulation (Khan and Chang, 2018). Moreover, since 2016, institutional reforms were implemented to integrate the government departments and agencies, align goals, and eliminate administrative redundancy (Cell Press, 2019).

Table 4-1 Evolution of environmental management in China (He et al., 2012); last row (Cell Press, 2019; Sha, 2018)

Period	Stage classification	Style of management	Focus of management
1972-1991	Shaping the environmental arena: improving environmental conditions for human health	Top-down strategy; command and control; environmental standards; no stakeholder involvement	Controlling air, water, and solid waste pollution from major industries
1992-2001	Encouraging pollution prevention: protecting environmental conditions for humans and ecosystems	Internal integration: from reactive to proactive policies, integrated management at pollution source	Strengthening industrial pollution control, and rural, key cities, regional pollution control and conserving biodiversity
2002-2012	Sustainable development: opportunities for multi-sectoral benefits	Promoting the integration of environmental, economic and social interests	Energy-saving and emission reduction, ecological conservation, integrated ecosystem management
2012-present	Ecological civilisation: committed to tackling the climate crisis	Streamlining agencies' responsibilities and reducing functional overlaps. Chinese environmental NGOs are becoming active post-2015.	Reducing aluminium smelting volume and dismantling coal-fired power plants. Focusing on air and water pollution. Encouraging tech companies to be green innovators

Table 4-2 A timeline of environmental legislation in China (Qin and Zhang, 2018); last row (Khan and Chang, 2018; Sha, 2018)

Period	Milestone
1949-1978 (the early stage)	1972 United Nations Conference on the Human Environment
1978-1989 (the emerging stage)	1979 Environmental Protection Law (for trial) 1978 and 1982 Constitution
1989-2015 (the maturity stage)	1989 Environmental Protection Law 1992 United Nations Conference on Environment and Development 2014 Environmental Protection Law
2015 – present	2015 Environmental Protection Law 2017 Environmental Protection Tax Law Formation of Ministry of Ecology and Environment

In the SWITCH project discussed in chapter 2, as well as recent sustainable urbanisation projects in China, such as the eco-cities, there are several noticeable characteristics of policy implementation and environmental governance. Firstly, environmental governance in China seems to be top-down, command and control, or authoritarian, where national regulation dominates and policy process tends to be non-participatory (de Jong et al., 2015; Lo, 2015). A closer look at the national and local government relations can reveal that policy implementation in China can be more complicated than previously anticipated by both researchers and the national government to some extent.

In a study on the policy implementation of China's eco-cities at a systematic level by de Jong et al. (2015), the authors identified three Chinese national programs for eco-cities initiated by three different central ministries. For all the programs, the policy implementation is assumed to be unidirectional between the national and the local government. The national government believes the local governments are cooperative executioners of national policies, while the goals of the local governments, as well as the significance of other policy actors such as the developers, consultants, and the residents, are largely neglected (de Jong et al., 2015). An implementation gap, therefore, exists due to the misalignment of the anticipated project outcomes and the practical reality of eco-city development at the local level, as a result of the aforementioned false assumptions. It was observed that although the national ministries are assuming steering positions at the centre of these programs, in reality, they very much need to rely on the cooperation of the intricate network of policy actors, as well as close alignment of their motivation (de Jong et al., 2015; Wu, 2012). Another study on the low-carbon governance in China by Lo (2015) also revealed a similarly complex relationship between the central and local governments and its impact on policy implementation. The seemingly authoritarian environmental governance becomes de facto neoliberal environmentalism in some places due to the conflicts in central-local relations and the lack of control from the top despite regulations made by the central government (Lo, 2015).

Secondly, the Learning Alliance in Beijing in the SWITCH project was not able to form a multi-stakeholder platform. In the SWITCH project, the universities and researchers served as the "honest brokers" between stakeholders since trust cannot be readily established in a multi-stakeholder environment. As seen in the two studies above as well, the competition between government agencies at both local and central levels allow rooms for lax monitoring and evaluation, which prevent effective policy implementation and any potential collaboration. It is thus exciting to wonder as China experiences progress in environmental management and governance, what milestones can Sponge City achieve.

4.2 Planning and environment

To examine the relationship between planning and the environment in China, one should understand the backstory of the relationship between human and nature as viewed from a Chinese perspective. What is nature to the humankind is an intricate and complex subject in Chinese culture; is it a relation of harmony, or one between the exploiter and the exploited, or both? Hou (1997) argued that by tradition, Chinese people are close to nature in every aspect of their lives, from agriculture to medicine, to literature, and governance. From her perspective, the traditional Chinese view of nature is harmonious and is drastically different from the view taken at this industrialising stage. At the time of the article (1997), the nation was growing at the cost of environmental degradation. She argued that the balance between nature and human could be restored once China enters the post-industrial stage, and the eminence of traditional views are re-established. Other scholars may offer different opinions.

Nature represents power and peace, it is to be respected and appreciated, but it is also to be tamed and conquered (Ball, 2016).

Just as 'nature' may change its meaning as perceived by people from different periods, the role of urban planning in Chinese society has not been constant throughout history. Urban planning has changed its functionality and motivation since the planning of the first cities 3000 years ago. It began as rules for site selection and social differentiation, to the legitimisation of power in the early Republic of China, to development control during the planned economy, and to an instrument for growth promotion (Abramson, 2006; F Wu, 2015). Table 4-3 summarised the milestones of planning development in China since the establishment of the People's Republic of China in 1949. The planning system has gone through a socialist period where the focus was on industrialisation and production, a stagnant period during the Cultural Revolution, an economic reform period that targeted economic development and growth. Since the enactment of the 1989 City Planning Act, a comprehensive urban planning system started to form and evolve, and a system of hierarchical plans was set up. The shift in planning and environmental governance goes hand in hand. Planning was a tool to transform nature into lands that provide economic benefits, and it gradually became an instrument for growth and political advancement (F Wu, 2015; Xu, 2015).

Table 4-3 Condensed timeline of planning development in China since 1949, adapted from F Chen (2016)

Socialist planning - 1949-1960 Two-tier planning system: master plans and detailed layout plans. Following the Soviet model, industrial development is prioritised to turn consumption centres into production centres. Planning focused on the selection of appropriate sites for key industrial projects.
Cultural revolution - 1966-1976 Planning was abandoned
Economic reform - 1978 - 1980's Urban planning regulations announced to meet the needs of economic development
Comprehensive urban planning system - 1989 1989 City Planning Act: city system plans, master plans, district plans (for big cities only, detailed plans (detailed development control plans, or DDCPs), and detailed construction plans (DCPs).
Coordinating urban and rural development, facilitating sustainability - 2008 2008 City and Rural Planning Act: strategic development plans or outline strategies to bridge the gap between system plans, specific master plans, and topic-related plans.

As global and domestic pressures for environmental protection built up, the state-level interest in environmental governance reached a new height, environmental awareness is also being pushed forward on the agenda of the local governments, and environmental concerns are being incorporated into planning practice (Xu and Chung, 2014). As environmental awareness was gaining spotlight among the public, top-down environmental regulation and the visions of urban planners were not able to align with and had to give in to the local governments' interests in economic expansions and growth (Xu, 2015). Urban planning is a crucial instrument to strike a balance between economic growth and environmental protection. Essentially, urban planning as a profession is a very useful political and

institutional tool that is attached both to the national goal of market-oriented economic development, and the local governments' visions of priorities and values (Abramson, 2006; Xu, 2015). One should note that not all planners work for the government, planning is facing commodification, and many plans are done through consultant services (F Wu, 2015).

Planning is used to strengthen the power of the state and at the same time, to promote economic growth locally. At the local level, planning has become a top priority of the leadership (F Wu, 2015). It occupies a strategic position between central and local government, as a conduit of policy transfer and mobility, and maintains a balance between the wishes of private developers as well as local government clients and the policymaking institutions (Zhao, 2015). However, it is not within the scope of this study to conduct a thorough review of the history of planning since the establishment of the People's Republic of China or to scrutinise the impact of urban planning on the long-term environmental agenda and the environment.

4.3 Urban water management in China – Pre-Sponge City

Water is a multi-dimensional subject, any attempt to understand the mechanisms and dynamics of urban water management in China should not neglect the cultural (and historical) and socio-political contexts that may influence the behaviour of individuals and organisations. This section delves into the salience and awareness of the concept and importance of management of urban water as well as the role of sustainability.

Ancient civilisations in China have always been living closely with water, balancing both the economic prosperity it brings and the life-threatening disasters it causes. In ancient China, the urban water networks were regarded as the bloodline of the cities; the supply and distribution, drainage, and flood control and prevention were crucial parts of city planning, design, and development (Du and Wei, 2011). Cities employed canal transportation and secured multiple water sources to safeguard supply, developed connected urban water networks, constructed facilities for regulating and managing the water system, and established legislation and regulation for the water resources to protect their quantity and quality (Ibid).

Integrated urban water management may have a different definition and interpretation in China compared to its conventional meaning. For example, while it is usually understood as holistic management of urban water cycle in coordination of hydrological cycle with inter-disciplinary and inter-sectoral efforts, it may have been interpreted more as the unification of all water-related administrative units under a single ministry. Whether this interpretation should be corrected by providing more learning and capacity building opportunities, is yet to be determined given the unique culture and administrative structure in China.

In the modern days, China's water resources management adopts policies and laws that are centrally set and locally administered, where multi-level jurisdictional framework (national, provincial,

prefecture and county levels of administration) is combined with a catchment-based approach to river basin management (Cosier and Shen, 2009). This is a very complicated situation for water management. While all agencies at a central level have corresponding line agencies at the provincial, prefecture and county levels, and they look to the national agencies for technical guidance and implementation of laws, these agencies report administratively to the local governments (Shen and Liu, 2008). During an informal interview with a senior planner in CAUPD conducted in 2016, the researcher was informed that the Chinese administrative structure can be characterised by "a line (tiao)" and "a block (kuai)". The "line" refers to hierarchical relations from the CPC committee down to the provincial government, while the "block" refers to the government network at the provincial and city level. The "block" exists because the local governments have considerable autonomy over their own policies. Therefore, it is not guaranteed that the intent of the central government can be met with a similar level of implementation support from the local government. It creates another layer of problem to integrated management because each party involved may have different or even conflicting priorities and objectives. Figure 4-1shows the urban water management framework that is composed of different policy components relating to water issues. It is worth highlighting here the important role planning and plan-making in the management of (urban) water resources in China.

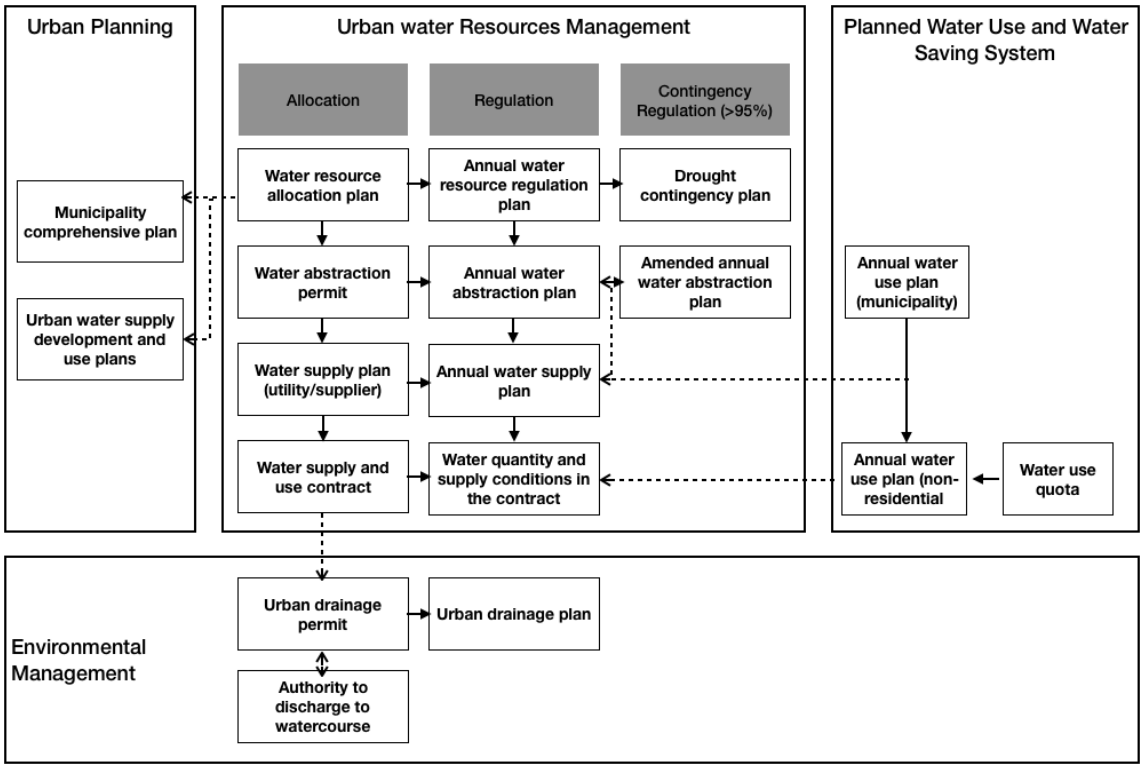

Figure 4-1 China's urban water supply and management framework *(Cosier and Shen, 2009)*

There are extreme regional variations in China in terms of climate and rainfall, and both the regional differences and the historical practices are influencing the urban water management in Chinese cities today (Cosier and Shen, 2009; Lashford et al., 2019; Tang et al., 2018). Compared to the south of Yangtze, where water resources are more abundant and stable, the north area experiences a high

seasonal variation of precipitation and much lower per capita water availability (Shen and Liu, 2008). Cosier and Shen (2009) found through comparing the water supply and management practices of Beijing and Shanghai, that the environmental and economic contexts account for the differences in their approaches towards the implementation of national policies and regulations. Specifically, northern cities such as Beijing tend to have a better implementation of planned water use and water-saving system, while southern cities that are more abundant in water availability tend to be better at adopting water supply and use contracts because they have fewer incentives to restrict water consumption levels.

Cities in China have inherited their own water culture and remnants of physical structures of historical waterworks, and they influence their modern-day practices to different extents. As a city chosen for the Sponge City pilot program, Ningbo has a long history with what can be described as "blue-green" water management. Early in the city's history, water control works were constructed using natural materials such as stone, mud, and soil, where plants used for reinforcement were able to stabilise the soil and provide food for the silkworm (Tang et al., 2018). At the time, the system of small waterways and waterbodies supported biodiversity while meeting the society's needs for irrigation, freshwater and drainage, but urbanisation and industrial development caused a shift from "natural" to grey infrastructure, and the surface water network functions primarily as urban drainage and flood control as agricultural lands are converted to impervious surfaces (Ibid). What happened in Ningbo was experienced in most of the urban centres as they develop and modernise, but Ningbo has a rich history of sustainable water management which bequeathed the city engineering and cultural assets that may still be useful today.

This case study by Tang et al. (2018) comparing the modern-day urban water management in Ningbo to its historical water management was from a recently published research. A search in the database Web of Science using the keywords "China" and "urban water management" reveals that there are only 12 out of 44 eligible studies are published before 2014 (as of May 2019), which is the year that Sponge City initiative was officially launched. Prior to 2014, the 12 research articles found related to urban water management in China are in the following categories (Web of Science categories):

- Environment sciences
- Water resources
- Environmental engineering
- Civil engineering
- Chemical engineering
- Urban studies

Research papers published since 2014 are covering a broader range of categories. In addition to engineering-focused research, many are now also articles published in the areas of multidisciplinary sciences, management, and sustainable science and technology:

- Environmental studies
- Multidisciplinary geosciences

- Green sustainable science technology
- Multidisciplinary engineering
- Management
- Multidisciplinary materials science

As Sponge City initiative launched in 2014, there is also an increase in the quantity of papers published and the times cited (Figure 4-2 and Figure 4-3). 10 out of 32 journal/conference articles published including the term "urban water management" in the title or abstract are concerning Sponge City. Figure 4-4 and Figure 4-5 illustrate the number of articles published and cited that are associated with Sponge City, which is increasing every year since 2016, attesting to the rise in the level of research interest and government funding in this area.

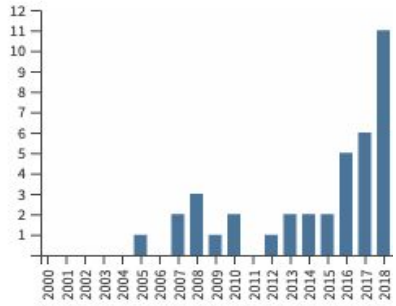

Figure 4-2 Total publication by year (Web of Science) - Urban water management

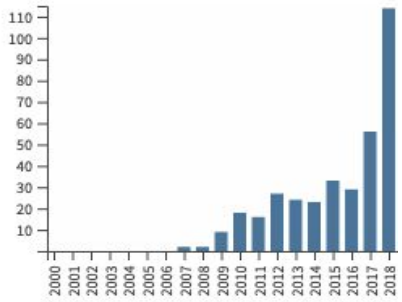

Figure 4-3 Sum of times cited by year (Web of Science) - Urban water management

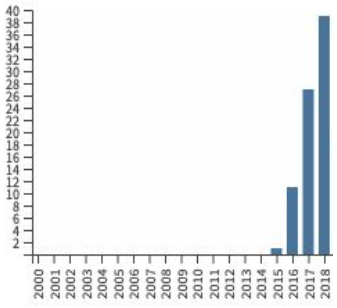

Figure 4-4 Total publication by year (Web of Science) - Sponge City

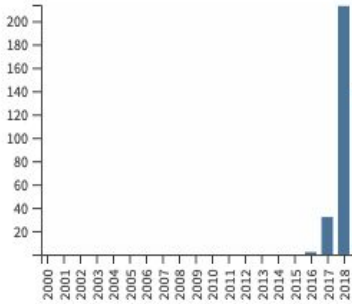

Figure 4-5 Sum of times cited by year (Web of Science) - Sponge City

4.4 Sponge City and the role of urban planning

The Sponge City initiative is a national program that aims to promote sustainable urban development, but with a set of more focused objectives targeting water management in urban areas. The word "sponge" was initially used by researchers to refer metaphorically to the flood management abilities

of the natural environment (Yu et al., 2015). As extreme flooding events and other water-related problems became more frequent and severe, the "sponge city" concept was adopted by the State as a means to fulfil the goals in built-infrastructure network construction and maintenance as outlined in the 13th Five Year Plan (2016-2020) (Austrade, 2016).

Several characteristics differentiate this initiative from past sustainable projects. Firstly, the interests of the national and local government are more aligned on the subject of water management. Secondly, the national government recognises the existence of other policy actors and encourage their participation (Office of State Council of People's Republic of China, 2015). Thirdly, the urban planning sector is intimately involved at each stage of the project cycle and has a potential to bridge the "missing link" between actors and governments at different levels (MOHURD, 2014). And lastly, although Public-Private Partnership (PPP) is actively promoted as a funding mechanism for each project, which is different from eco-cities and low-carbon cities that utilised joint ventures between Chinese investment corporations and foreign development corporations (Wu, 2012).

A sponge is a material known for its capabilities in absorption and adaption in shape and volume. When the words "sponge" and "city" are combined, it is to describe a city that has high resilience, adaptability, and sustainability (Yu et al., 2015). In the case of the Sponge City Initiative in China, a city is being described as a "sponge" for its abilities to soak up and release water when necessary, which means it is equipped with healthy water system network that co-exists and co-evolves with the urban residents and other urban infrastructures. The Sponge City principles aim to find the balances in urban water quantity and quality, centralised and decentralised infrastructure, landscape and water function, water ecology and water safety, as well as green and grey infrastructure (Zhang, 2016).

The sponge city initiative is supported by policy, and the projects are led by the government since it is the primary funding body. The pilot cities are chosen as the experiment points receiving a various amount of funding depending on its administrative level from the central government. The experimentation scheme was first proposed in 1993 by the CCP Central Committee, with the intention of using *bold experiments* to try out the government plans first in selected localities or areas and then extended after the experience has been gained (Heilmann and Melton, 2013). The "model" or "pilot" city projects are welcomed by both the central government in Beijing and the local governments as they can both benefit from the experimentation scheme.

In 2015, the Office of State Council issued advisory guidance on the implementation of Sponge City (Office of State Council of People's Republic of China, 2015), which officiated the concept of Sponge City and the piloting program. Sixteen pilot cities selected by a multi-ministry panel (Ministry of Finance, MOHURD, and Ministry of Water Resources) based on the scores of the proposals submitted. In 2016, another fourteen cities were selected through the same process, among which are Beijing and Tianjin. While the responsible parties and technical guidelines are slightly different in each pilot city, they all derive from the same guideline and standards distributed from the national ministries.

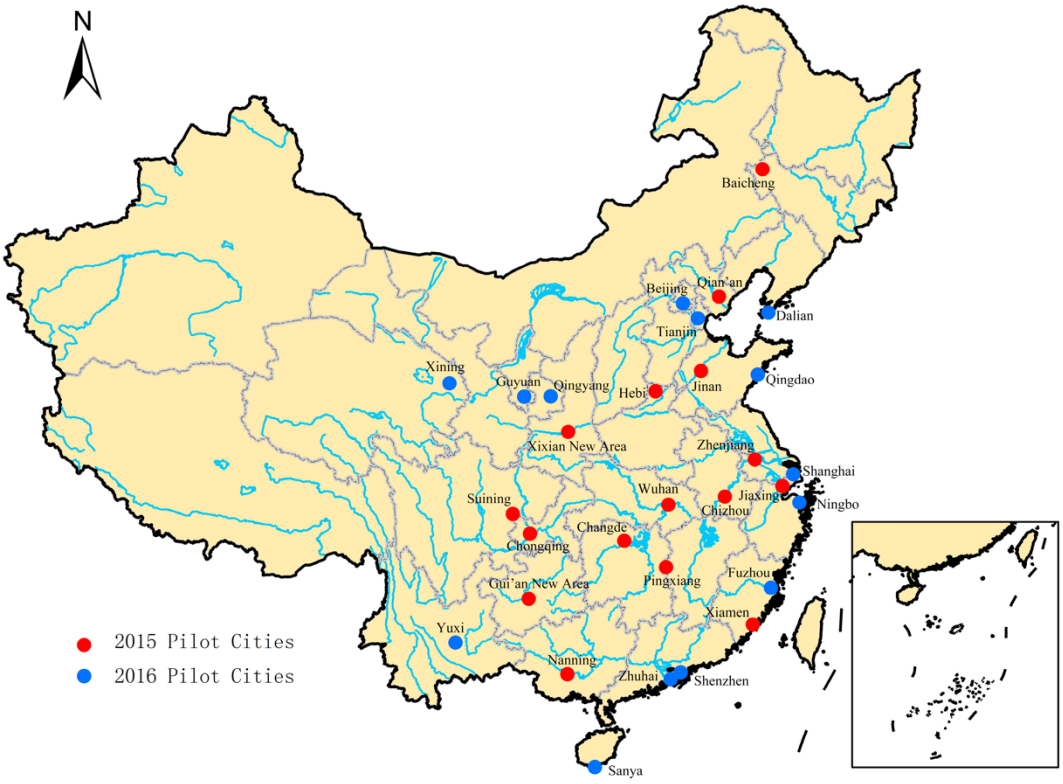

Figure 4-6 Location of 2015, 2016 Sponge City pilot cities in China. Source: Li et al. (2017).

As emphasised in the guideline, planning plays a leading role and should be the first and key step going into Sponge City. Consequently, the guideline provided very detailed instructions on the making of plans at various levels for different purposes. The importance of planning and what should be achieved at this stage are clearly outlined in the guideline. It stated that planning has a significant role in the design, implementation, construction, as well as monitoring and evaluation of all the Sponge City projects. The projects have three major stages (MOHURD, 2014), following the first stage where responsibilities have been distributed from the municipal government to the various government agencies, the project proceeds to the "planning" stage where policies regarding technical guidance, implementation, and evaluation (reward) are developed. The final stage is where the design, construction, and operation & maintenance of each specific project take place. The planning of the project should be "problem-oriented", where local problems should be identified and considered at the system level. Meanwhile, planning also aids the interpretation of the Sponge City concepts, priorities, and approaches.

To fulfil the leading role, urban planning as a profession has been undergoing changes and reforms. Traditionally, urban planning aims to streamline development policies and strategies, regulate the construction and promote economic development, as well as improve the socio-cultural environment of the cities (Ren, 2015). To meet the demands of Sponge City projects, urban planners need to pay additional attention to the integration with other disciplines and departments, and the integration of social, cultural, and technical factors (Ibid). As illustrated in figure 4-7, planners study and interpret

policies in the context of local social, economic, and cultural backgrounds, conduct literature review and data collection on the local water system, climate characteristics, identify problems that meet the scope of Sponge City, and then set general and specific targets and indices which should be integrated into the city's existing plans at various levels (Ibid).

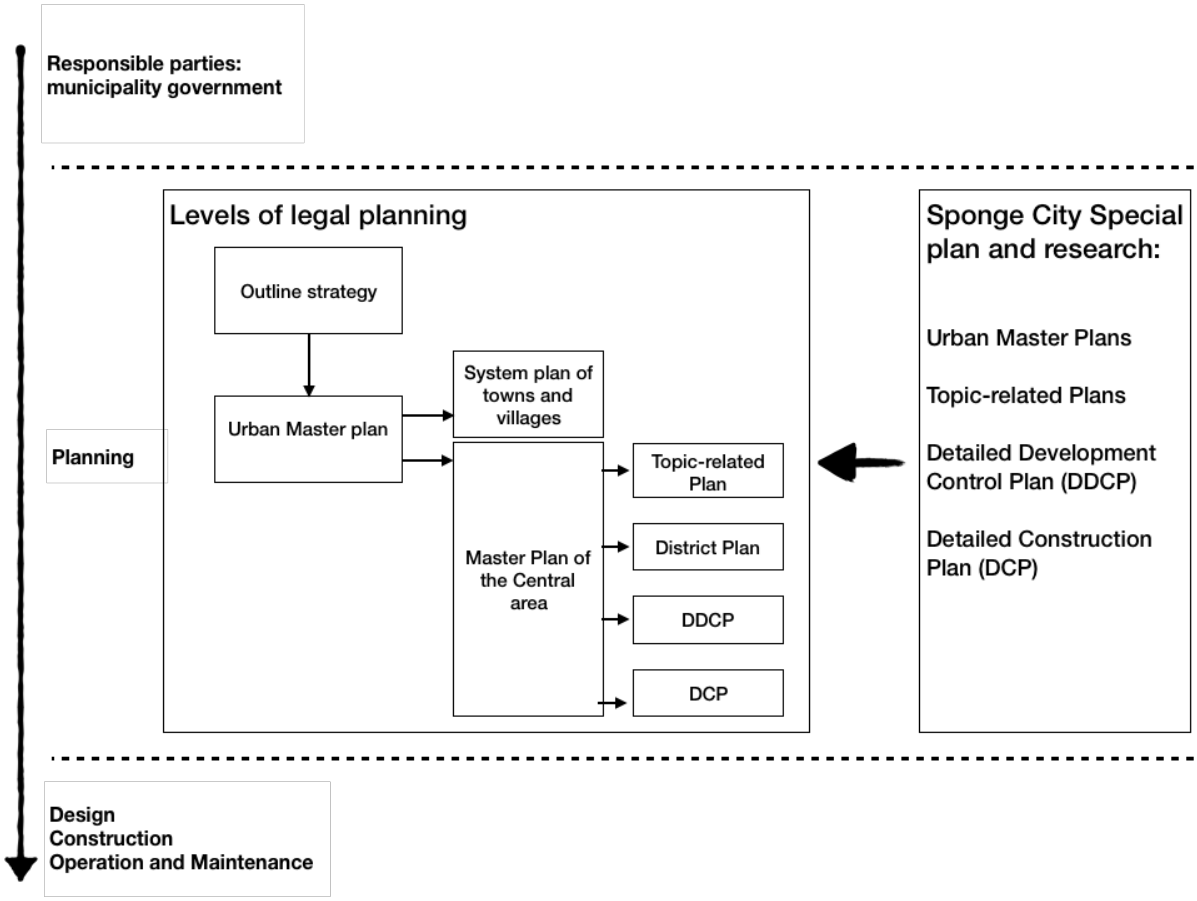

Figure 4-7 Sponge City Special Plans and researchers are embedded in the legal plans of a city, adapted from Chen (2016) and Ren (2015).

4.5 Reflections – early Sponge City

Given the history of environmental governance in China, it is reasonable to doubt the success of the Sponge City initiative. In the past, government-funded projects on public infrastructure tended to lack transparency and efficiency as a result of poor central-local communication and sometimes even conflicting interests, and the financial funding sometimes would not be used to meet environmental targets (Xinhua City, 2016). Scott (2008) defined three mutually reinforcing "pillars" that are essential to successful institutional changes – cognitive, normative, and regulative. Within the context of sustainable urban water management, past institutional reforms were rarely a success because interventions were usually focused on one or two of the pillars (Wong and Brown, 2008). The past failure in environmental governance of China could be attributed to the lack of balance of changes

within each pillar. As described by Lo (2015) in his study of the low-carbon governance of China, regulations imposed by the central government often fail on the ground because the local government and enterprises' values are misaligned with those of the national government. Because of the absence of knowledge support as well as the necessary shift in the values towards energy conservation at the local level, the central government was having a difficult time gaining control of the progress and impose reward or punishment effectively. The Sponge City programme faces similar challenges but also has advantages over past efforts. In contrast to the low-carbon governance, where energy conservation could conflict with the local interest in economic growth, the implementation of sustainable urban water management in line with the local government's target in reducing risks associated with floods and droughts. In recent years, the local authorities have been trying to reform urban development, but there is lack of necessary skills and support, so the Sponge City initiative is readily taken up by the local government since it is seen as a solution to their problem (W Wu, 2015).

By pushing for the Sponge City initiative, the central government provides a space for innovative technologies and infrastructure to compete with conventional approaches, and minimise the influences of financial implications and technological and infrastructural lock-ins (Marlow et al., 2013). Incremental changes are typical to technological transitions because radical new technologies usually have a hard time to fit in the already established socio-institutional framework (Geels, 2002). In the case of urban water management in China, some of the technologies being used are not radically new, so it is not definite that the institutional context in China can better foster innovation. However, what differentiates the Sponge City initiative from others is the opportunities for closer cooperation of local government and enterprises, thus giving new technologies a better chance to compete against conventional approaches.

Sponge City is one of the initiatives implemented by the Chinese central government to promote a more sustainable and healthier environment, and its target area is urban stormwater treatment and control. It excludes elements in a water system such as the collection, treatment, and recycling of grey and black water. Although wastewater recycling is listed as mandatory for cities under a certain number of population or has very low-quality water environment (Ren, 2015), the definition of wastewater is likely to be limited to stormwater (greywater). Similarly, the emphasis on wastewater recycling in general is on the retention and reuse of rainwater. This initiative also does not expand to watershed management. Although watershed pollution problems have been recognised, the Sponge City initiative currently does not provide financial or technical support for projects at the watershed level. On the one hand, there are fewer factors to be considered when projects are local and small scale, but on the other hand, it does not contribute significantly to the management of water resources as a holistic cycle where multiple cities (sharing a watershed) will be involved.

The central government is aware of the limitations of the current programme design. Although "Sponge City" is a standalone initiative, it is on the agenda that also pushes for treatment of "black" water bodies, construction of underground pipelines, and treatment of rural environment (Xue, 2016). Furthermore, among the requirements of proposals for the 2016 pilot cities selection, the candidate

city must demonstrate that it plans to include a greater percentage of old city areas compared to last year, as a way to integrate the design with other programmes on the agenda (Yu, 2016). There are a couple of cities sharing borders among the pilot cities selected in 2016, which is an opportunity or even a necessity for decision making to be coordinated between the two cities. As more cities will be selected as pilot cities at various government levels, the need for having cross borders and cross programmes coordination, as well as the necessary requirements and guidelines will become more apparent.

In addition to the horizontal coordination, which is across different infrastructure and service types as well as geographic and political boundaries, there is also a need for vertical coordination, which is across different levels of government. In order to achieve true integration of urban water management using the Sponge City concept, there needs to be an alignment of interests, objectives and knowledge capacity at all levels. Given the unique political structure and historical background of China, it is not the lack of willingness to introduce the sponge city concepts into local government planning agenda that warrants concerns, but rather is the potential lack of knowledge and support needed by the local authorities to adhere to the water management principles as outlined in the national policy. Furthermore, the indirect control the central government has over the city-level government is also adding difficulty in monitoring and evaluation. The MOHURD recognises the importance of having the city authorities understand the intention and objectives behind the design guidelines, and it will only make a difference if there is enough expertise at the local level (W Wu, 2015).

The SWITCH program (Chapter 2) identified the Learning Alliance as a key platform for bringing cross-discipline expertise together to foster a learning environment that can benefit all stakeholders. This network needs to include a broad range of stakeholders to ensure social equity, as well as outsiders, to enforce transparency (Chlebek et al., 2011). What is more important is the level of commitment and cooperation of the stakeholders, and it sometimes is highly relied on effective facilitation and strong leadership that pulls the members with different expertise together. While some cities such as Accra (Ghana) benefited from the SWITCH approach and was able to bring together stakeholders and identify key water issues and transition strategies, it was more difficult in Beijing to establish trust between stakeholders by holding frequent multi-stakeholder meetings for ideas exchange, due to cultural reasons. Although the multi-stakeholder platform was not successful in the project in China, a similar platform is needed for the Sponge City programme to encourage information exchange across disciplines, and prevent single experts or ideas from dominating the conversation (Schot and Geels, 2007). Currently, it is a common practice in the private sector where teams from various disciplines (firms) cooperate in bidding for a project. However, it is still more difficult to realise close cooperation between ministries or disciplines because they are involved in the projects at various extents and have different levels of power.

Effective communication and coordination between different levels of government in monitoring and evaluation process are most crucial at the pilot stage, as it provides feedback for the incorporation of the initiative to formal planning and environmental regulation. According to the "Evaluation Methods"

published by the MOHURD, cities self-report their progress, and the monitoring and evaluation of city-level progress is carried out by provincial level Housing and Urban Rural Development Ministries, and MOHURD will select few cities for inspection based on the results submitted by the provinces (MOHURD, 2016a). This scheme of M&E can be efficient if there is proper supervision, but there is also risks of having incomplete or biased reporting of progress in order to obtain rewards or avoid penalisation. Other potential problems may include misrepresentation of the sponge city concept to increase public support but results in false expectation, as well as sustainable management and operation of the ever-increasing number of projects in each city (L Chen, 2016).

In 2016, the eligibility requirement for the second batch of pilot cities was including the monthly submission of progress up to the competition deadline as well as the ability to continuing the submission after being selected (Xue, 2016). It is, in fact, worth noting how the emphasis placed on the information technology can enable better information and knowledge sharing among city departments as well as across multiple city authorities. These measures include online portals for local authorities to submit data and report progress, online platforms targeted at the general public or interested persons and private sector business owners. Apart from this, social media is also playing a significant role in information and knowledge dissemination, as well as public participation. At the moment, these are separate platforms and access to some pages are restricted. As the programme matures, MOHURD should consider having all the platforms consolidated into one to provide easy access for information sharing and monitoring purposes.

IUWM is mainly decentralised and dependent on the local context, but the centralised planning system is subjecting all the cities under a universal design and technical "guideline". Consequently, many people in academia and industry alike question the likelihood of success of the Sponge City initiative based on this criterion, and some even believe that the initiative will again fall under the "tiger head snake tails" category and will not be able to achieve the goals that are set out.

In recent years, the PPP model is becoming an important source of project funding and is promoted by the central government as the go-to business model. In fact, the proportion of financial investment in PPP is one of the criteria for success in progress evaluation (MOHURD, 2016b). While the PPP model may help promote private sector's investment in public service infrastructure, and lower the burden of debt on the local government, aside from the known uncertainties and risks associated with PPP (Thieriot and Dominguez, 2015), it also creates a problem that can lead to blind uptake of new technologies without considering the needs.

A similar issue is the tendency of certain officials to use sponge city as a "one size fits all" fix of urban water problems. While the MOHURD understands the transition into "Sponge Cities" is a long term process (20-30 years), the success depends on how well the local government interprets the policy and understands the time commitment required (W Wu, 2015; Xue, 2016). If the local government is being too anxious to demonstrate success by investing in projects that are an "overkill" or even a disturbance

to the local environment, then the purpose of implementing sponge city is defeated, and funding is spent wastefully (Xinhua City, 2016).

The Sponge City initiative is bringing different disciplines together, and many disciplines other than engineering are beginning to be more present on occasions such as technical seminars and conferences. However, some disciplines, such as landscape architecture might still be marginalised. Some landscape architects expressed that they have not been involved in urban water management or drainage design projects until now, and they are still trying to catch up on the technical knowledge and engineering concepts introduced in the Sponge City projects. On the other hands, engineering disciplines felt that landscape architects are not an essential part of the team since they have not crossed paths in the past.

As elucidated in the last chapter, the access of social capital is influenced by the network ties and configuration. It is important that this research collects data on the network of the participants. It should be mentioned that guanxi (and the guanxi network) which is unique characteristics of social ties and relations between people in China, also impacts the development of trust and dynamics of the social network. Guanxi is transferable from one person to the relationship between two other people, reciprocal because not returning favour loses face/mianzi, and somewhat intangible because it is an exchange of obligations and favours that are not defined in extent or frequency (Gu et al., 2008; Park and Luo, 2001).

4.6 Shifts in discourse and progress since 2014

In 2014, the Ministry of Housing and Urban-Rural Development (MOHURD) issued a technical guideline (provisional), outlining the aims and rationale of Sponge City construction, as well as detailing the objectives and methods of urban planning, design, construction, and maintenance and management (MOHURD, 2014). Four years later just as the first batch of pilot cities are scheduled to complete, MOHURD issued an official standard (GB/T 51345-2018) with the title of "Assessment standard for Sponge City construction effect" (MOHURD, 2018). In this section, the researcher conducts a deep dive into the context and content of Sponge city by comparing the two documents. Henceforth, the Technical Guideline for Sponge City - Low Impact Development Stormwater Management System Construction – provisional is referred to as "the guideline", and the "Assessment standard for Sponge City construction effect" is referred to as "the standard".

4.6.1 The rationale behind the documents and the concept of Sponge city

Table 4-4 Rationale behind the document - a comparison between two documents – 2014 and 2018

The Technical guideline	The Assessment standard
The guideline aims to facilitate the promotion and application of **Low Impact Development (LID).** To enforce strict source control of rainwater runoff, prioritise natural drainage system, construct ecological drainage facilities, employ urban green fields, roads, water systems as part of rainwater treatment system, in order to restore to pre-development level hydrological characteristics, attenuate urban flooding, reduce urban runoff pollution, protect water resources, and improve urban ecological environment.	The standard aims to provide assessment for the improvement of urban ecological environment, strengthen urban resilience, **provide a larger selection of quality sustainable products, increase residents' satisfaction of quality of life**, standardise assessment of Sponge City construction outcomes.

Table 4-5 Meaning of Sponge City concept - a comparison between two documents - 2014 and 2018

The Technical guideline	The Assessment standard
Sponge City refers to cities that function as a piece of sponge, which can adapt to environmental changes and be resilient to natural disasters, by absorbing, storing, infiltrating, and treating rainwater during rain events and release such water when it is needed. Sponge City construction should integrate low impact development stormwater system, urban stormwater drainage system, as well as the excessive stormwater runoff discharge system. These are not three separate systems, and there are no clear boundaries between them. Instead, they complement and rely on each other, and together become the fundamental elements of Sponge City.	Sponge City is a collection of measures and methods for achieving multiple objectives, including the restoration of urban water ecology and water resources, the improvement of the urban water environment, water security, and water culture. Through urban planning, construction controlling, the application of "source reduction, process control, systematic governance", integrating technical measures, systematically coordinate and manage the following pairs of relationships: water quality and water quantity, distributed and concentrated, green and grey, landscape and function, on and off the ground surface, on and off the water surface. It should effectively control the urban stormwater runoff, and reduce to the largest extent the impact of urban development on natural hydrological characteristics and water ecology so that the cities can be like Sponges that can adapt to urban changes and be resilient towards natural disasters.

A notable difference between the two documents is the removal of the use of LID in the standard. The technical guideline was partially based on the research of low impact development by a research group. One can see that at the time when the guideline was made, Sponge City was defined as "low impact development", and the rationale behind the concept development was narrowed down to the technical solutions urban stormwater systems. Four years later, the standard removed the reference to LID in the definition of Sponge City. Furthermore, it expanded the meaning of Sponge City beyond stormwater management, by including sustainable products and people's perception of the quality of life in the urban "sponge" system. The guideline did outline the five fundamental principles of Sponge City[7], which mention the consideration of local context, but the language used was relatively prescriptive. In comparison, where the use of "concept" was mostly attached to LID in the guideline, in the standard, the Sponge City has become a concept of urban water management. Since both documents share many of their principal authors and editors, this shift in the language use signifies an increase in the familiarity and understanding of the Sponge City concept and practices among practitioners and professionals. The standard also emphasises in specific language the multiple considerations one should make for each case. Moreover, the standard uses the specific terms such as "green infrastructure", "grey infrastructure", "green-grey integration" in the description of suitable measures, and these terms were not found in the guideline.

Another notable difference is in the use of the term "system" comparing the two documents. In the guideline, the system is used predominantly as a noun, in conjunction with terms such as "rainwater", "drainage", "ecological", except for one instance where it is used in the context of the "systematic nature" of stormwater, surface and groundwater. In the standard, the word "system" is used both as an adjective, in the context of describing administration, and "systematic nature", and as a noun in conjunction with drainage, control, engineering, ecological, and global.

[7] 1.Planning (taking a leadership role): Planning at all administrative levels and across all relevant disciplines should reflect the Sponge City and LID contents in the plans, and take advantage of the abilities of planning in setting control and leading implementation
2.Ecological protection: Urban plans should define the "blue and green lines". Urban development should protect water bodies and water sensitive areas, prioritising natural drainage systems and LID measures, in order to realise stormwater storage, infiltration, treatment, and recycling, which can improve the natural recovery of ecological systems and the maintenance of urban ecological functions.
3.Safety: To ensure residents safety and economic stability, LID construction and management should use both engineering and non-engineering methods, in order to eliminate safety risks and become better equipped to combat natural disasters in the cities.
4.Local context: All cities should consider their natural geographic conditions, hydrologic characteristics, water resources conditions, rainfall patterns, water environment protection and urban flooding protection standards, in order to make the appropriate LID objectives and indices, and to select measures such as sunken gardens, raingardens, permeable pavements, vegetated swales, etc.
5.Integrated construction: Multiple cities should incorporate the Sponge City construction into the urban general plan making, and make sure the objectives and techniques of LID are specified in those plans. The Sponge City infrastructure measures construction should be concurrent with the main construction, and they should be ready for use at the same time.

4.6.2 Evaluation requirements

The Standard evaluates seven categories of effects of Sponge City implementation. While most are present in the guideline, some contents are newly added, and some terms are modified or formalised. The Table below outlines the seven categories that are evaluated in the new Assessment Standard (left column), and how it was presented in the Guideline published in 2014 (right column).

Table 4-6 Evaluation requirements on the Sponge City projects, comparing the items listed in the Standard (2018) to the content of the Guideline (2014)

	Standard (2018)	**Guideline (2014)**
1	Annual total runoff control rate	This was discussed in detail
2	Water quantity and quality source control (residential communities, roads/parking lots/squares, parks and green buffer zones)	The term for water quantity and quality source control was not yet formalised in the guideline
3	Surface ponding and waterlogging control and prevention	There was a discussion on surface ponding
4	Urban water bodies quality	The term "water system" was used instead of "water bodies"
5	Natural ecological configuration control and coastline protection	There were no requirements on natural ecology
6	Groundwater depth changes	The specification "water table" was not present in the guideline
7	Urban heat island effects attenuation	There was no discussion of heat island effects

4.7 Summary

As a developing modern country that is growing and modernising at a rapid pace, the sustainability of the urban water systems is attracting more attention and effort as environmental damages are accumulating and leading to health, economic and social problems. As reviewed in earlier chapters, the management of urban water systems demands delicate choreography among relevant stakeholders, to cooperate, communicate, and advance as a team. China's environmental governance is changing, from command and control to a style that can integrate the management of different systems as well as the stakeholders involved. The Sponge City initiative has the advantage of the central government's support and leadership, which removed some obstacles that originated from the top-down administrative structure.

Meanwhile, sustainable urban water management requires a higher level of trans-jurisdictional collaboration and coordination that is hindered by the administrative structure, as well as a higher level of inter-disciplinary and inter-sectoral communication and learning among actors that were not so attuned to the style of practice. Sponge City was adopted at a time when there is high motivation for improvement to the urban water environment as well as accumulation of research and practice expertise and experience from past endeavours. Since the start of the first batch of Sponge City pilot city projects, the definition and description of the concept are being updated as actors learn from direct and indirect experiences through various channels. The requirements and objectives, as well as their evaluation methods, are also revised, reflecting the transaction of knowledge and experience between actors.

5 Research design and methodology

Social science research typically proceeds with an identification of the philosophical position of the researcher with respect to knowledge or information (Evans et al., 2014). This chapter begins by describing the epistemological stance of the research, with a description of pragmatism and why it is adopted as the theoretical position of this research. Then, it introduces the case study-mixed methods research design. Finally, it describes the quantitative and qualitative research methods as well as methods used for data analysis.

5.1 Epistemological position and research paradigm

Realising that the challenges of urban water as a social-technical system require more than engineering and technical solutions, urban water researchers had been using social research and theories to generate the social and institutional changes needed to achieve sustainable urban water systems (Bos and Brown, 2013). As a work of social research, this chapter will address the epistemological positioning, the paradigm assumptions, preferred theories, and methodological approaches of this research (Daly, 2007).

Paradigms are the collective or shared beliefs among communities of scientists and researchers, and the perceptions of the researchers have implications on the theories used and methodological approaches of the research (Daly, 2007). Philosophical assumptions and the worldview of a researcher are crucial to the conduct of research and the understanding of the different types of scientific activity and beliefs. In many instances, such assumptions are formed and influenced by the researcher's past experiences and research environment (Creswell, 2014; Daly, 2007). Epistemological position informs how an inquirer perceives knowledge, and one's paradigm assumption can be positioned at any point on the spectrum with objectivism on one extreme and subjectivism on the other. A selection of widely discussed paradigms is presented in Table 5-1.

Table 5-1 A selection of paradigms or worldviews (Creswell, 2014; Daly, 2007)

Postpositivism	(Social) constructionism	Transformatism	Pragmatism
Positivists believe both natural and social worlds can be understood and explained	Often combined with interpretivism, reality is between a perceived external reality and a subjective meaning-making process	Transformatists believe Postpositivism and constructionism do not address enough marginalised individuals in the society	It is not committed to any system of reality. The attempt to produce knowledge occurs with a social context, through the continual interaction between beliefs and action
Postpositivists recognise that we cannot be positive about our claims of knowledge when studying the behaviour and actions of human	Social constructionists believe we construct meanings in the course of interaction	It includes groups of researchers that are critical theorists, participatory action researchers, Marxists, feminists, racial and ethnic minorities, and other minorities	Researchers focus on the research problem and use all approaches available to understand the problem
Objective, determinist, reductionistic, empirical observation and measurement, theory verification	Understanding, multiple participant meanings, social and historical construction, theory generation	Political, power and justice-oriented, collaborative, change-oriented	Consequences of actions, problem-centred, pluralistic, real-world practice-oriented
In qualitative research, researchers create distance while recognising their interpretive influence	In qualitative research, the process is usually inductive, where meaning is generated from the data collected in the field	Research contains an action agenda for reform that may change the lives of the participants, the institutions the individuals dwell in, and researchers themselves	A philosophical underpinning for mixed-method studies. Researchers use a variety of methods, techniques, and procedures of research

5.1.1 Shaping by pragmatism

Classical pragmatism originated in the United States with the works of Charles Sanders Peirce, William James, and John Dewey (Legg and Hookway, 2019). At the core of pragmatism is a shift of the meaning of truth and reality away from the polarising beliefs that truth is either existing out there to be discovered or that it takes on the form of the knower. Peirce was credited for coining the term of pragmatism as a research worldview. He believed that truth is "what works" although there is an ultimate truth out there that may be unthinkable to us at the moment. He presented an idea of an endpoint of science, which is echoed by the works of Thomas Kuhn. Peirce made the distinction between what is perceived as true and what is actually true, and whether the perceived truth is actually true can be revealed at the endpoint of science, as Kuhn put it, when the current paradigm can no longer account for the reality scientists encountered and new collective belief takes cover (Bragg et al., 2005; Daly, 2007). Pragmatism is the most promising epistemological position for the investigation of tacit knowledge and social capital in Sponge City. Denzin (2012: 81, cited in Morgan, 2014: 1046)

argued that "[classical pragmatism] rests on the argument that the meaning of an event cannot be given in advance of experience. The focus is on the consequences and meanings of an action or event in a social situation". The pragmatic philosophy spoke to people who cared about social changes (Bragg et al., 2005). This study is trying to tackle a problematic situation and investigating how knowledge as a social resource can be better used and communicated. Consequently, the inquiry into the transfer and learning of tacit knowledge and how, as a social capital it can be accessed and mobilised to facilitate better communication should, therefore, be positioned in the pragmatic paradigm.

Dewey and James do not share the distinction between perceived and actual truths mentioned above, and James supposed that what one believed was true might not be true to another person. Dewey believed that philosophy should both be a spur and informed by social change, and his approach towards epistemology is to emphasise inquiry and the practices of inquiry (Bragg et al., 2005). In his views, inquiries are collective and social, which are started by being in a problematic state that will be brought back to an unproblematic state through the gathering of evidence in the process of inquiry. If there is enough evidence to present that something is true, then it is deemed warrantedly assertible. Furthermore, competent inquiries can determine truth, and knowledge is an outcome of such competent inquiries (ibid).

Morgan (2014b) pointed out that Dewey's views led to the recognition of any process of inquiry to be social, for it is the human experiences and interpretations that determines whether there is sufficient evidence to decide if something is true. Morgan argued that the incompatibility of research paradigms due to ontological differences is far from the reality that reflects how researchers actually conduct studies (Morgan, 2007). What is true is by choice, but more importantly, it is what works or what is useful. In other words, from a pragmatic point of view, it is more important to make decisions based on how well the actions and consequences can address the problem (Morgan, 2014a). The advantage of employing pragmatic approach in the research of complex system management is that it treated the different approaches to research as differences presented in the social context (Morgan, 2014b). It enables researchers to use both quantitative and qualitative methods within the same study, thus widening the scope of the research and deepening the understanding of the subject (van Griensven et al., 2014). More specifically, it gives researchers an opportunity to combine the strengths of relevant qualitative and quantitative methods, such as case study, survey, and interviews, so that the combined methods can have the greatest potential to answer the research questions (Morgan, 2014a).

5.2 Case study-mixed methods research design

This research was a study of the influence of conditions, contexts, and actor characteristics on knowledge sharing in the management of China's urban water system. However, the results from this study were expected to have impacts that could be generalised beyond the specific case. To achieve the objectives set out for this project, seeking direct and immediate relationships between variables in

such a complex system became insufficient and somewhat impossible. Yin (2018: 15) articulated the scope and features of a case study:

- "A case study is an empirical method that investigates a contemporary phenomenon (the 'case') in-depth and within its real-world context, especially when the boundaries between phenomenon and context may not be evident."
- "A case study copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result benefits from the prior development of theoretical propositions to guide design, data collection, and analysis, and as another result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion."

Case study methods are used to investigate a contemporary social phenomenon in unique cases where the data are collected from natural and real-life contexts (Aaltio and Heilmann, 2012; Gray, 2014). They are useful to add insights to the understanding of issues where the relationship is ambiguous or uncertain, and they are often trying to explain the causal relationships in addition to describing the situation (Gray, 2014). Sponge City initiative consists of 30 national-level pilot cities and thousands of participants from a range of professions. The initiative began in 2015, with the first batch of cities completing in 2018, and the second batch in 2019. Many of the participants are simultaneously involved in multiple pilot cities, so it is appropriate to adopt the case study method to seek extensive information from a small sample that is representative of the actors involved in Sponge City pilot projects. The analysis context chapter presents a detailed description of the case.

Mixed method research designs can follow different models: convergent parallel, explanatory or exploratory sequential, transformative, embedded or multiphase mixed methods (Creswell, 2014). The case study has a nested mixed methods design. It allows the research to use both quantitative and qualitative methods to gain a complete understanding of the case (Guetterman and Fetters, 2018).

Quantitative research makes objective measurements, and findings can be generalised across groups of people from a sample to a population. Data usually are close-ended, have large sample sizes that are representative of the population, and the collection of data is conducted using structured research instrument (survey, questionnaire), and analysis can be statistical, mathematical, or numerical (University of Southern California, 2018b). A quantitative study can be either descriptive (subjects measured once) or experimental (subjects measured before and after treatment. A descriptive study establishes only associations between variables, while an experimental study establishes causality (Creswell, 2014).

In qualitative research, one does not experimentally examine or measure in terms of quantity, amount, intensity, or frequency. The researcher instead stresses the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape enquiry, which is value laden. Qualitative data tend to be open-ended, such as thick description and direct quotes captured in interviews (University of Southern California, 2018a). These methods tend to generate rich, detailed data that leave the participants' perspectives intact and provide multiple contexts for understanding the phenomenon under study (University of Southern California, 2018a).

For this research, a convergent parallel mixed-methods design was adopted. The primary purpose of using this approach was comprehensiveness. Quantitative and qualitative methods could be used to collect information that could be integrated to produce overall results (Creswell, 2014). This research design facilitates the comparison of different perspectives drawn from both types of data which can enrich research findings or insights. As mentioned earlier, mixed methods design is useful to researchers who are trying to answer questions that were multifaceted and integrated (Tashakkori et al., 2015).

Among the 210 publications on China's Sponge City from 2012 to 2019[8], there is not a single study[9] that employed qualitative methods. Furthermore, there is no existing study that investigates the acquisition and transfer of tacit knowledge in the context of Sponge City in China. In fact, a search in databases (Web of Science) showed that there is no existing qualitative study on urban water in China that is published in international journals. The lack of the use of qualitative methods reflected a knowledge gap in the area of urban water management and Sponge City in China, which hinder Chinese and international urban water professionals and researchers from gaining a clearer understanding of the collaboration and communication processes and effectiveness in the field of urban water management.

The methodological choice of this study was made to provide the means to understand how water professionals achieve knowledge communication across disciplines and professions. The present study concerned two aspects of knowledge transfer, namely the type of knowledge being used, and the other was the means of transferring or communicating such knowledge. The quantitative study is aiming to extrapolate the general patterns of usage of media and pathways for knowledge acquisition, but it does not offer insights into the knowledge transfer process between individuals. The qualitative study allows researcher to probe deeper into personal experiences and unique contexts. Therefore, to sufficiently address the research question and objectives, both quantitative and qualitative methods should be employed to it is appropriate to choose a mixed-methods design so that close-ended questions could be used to investigate the first aspect, and open-ended questions to probe the second aspect of the research questions.

For a convergent parallel design, qualitative and quantitative data were collected simultaneously, which is the structure that this study followed. A close-ended survey was conducted in the quantitative phase. The aim was to measure 'what knowledge is being shared'. It was a necessary step because the data collected were context-free and had a large sample size that allowed the researcher to make generalisations to a larger population of actors. Semi-structured interviews were conducted over three months, to measure "how knowledge is being shared". The interviews explored various levels and types of knowledge possessed and used by the actors, the mechanism, and the quality of their interactions during the projects. Both forms of data were collected and were integrated into the

[8] Data gathered from Web of Science and ProQuest Central.
[9] Published in English language

analysis that was presented in the discussion chapter. The steps of the research design are displayed in the Figure below.

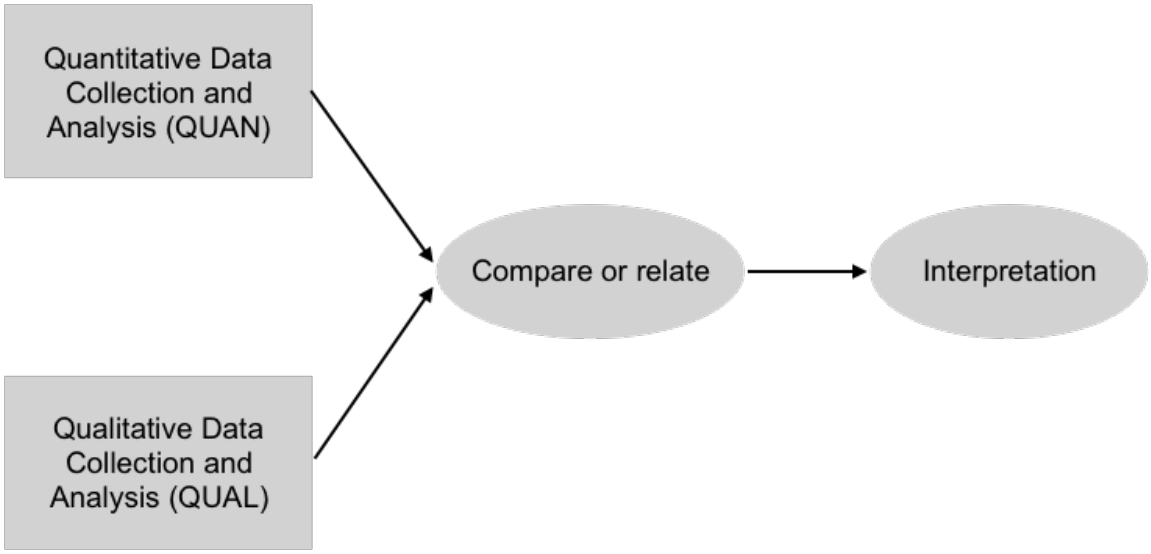

Figure 5-1 Steps of convergent parallel mixed-methods design (Creswell, 2014)

Both methods were measuring the concept of the use and transfer of tacit knowledge, but different sample sizes were used. The sample size for the qualitative data collection was smaller because the aim was to gather extensive and useful quality information, whereas sample size for the quantitative data collection must be much more significant to meet the requirement of meaningful statistical tests (Creswell, 2014). In this study, the sample size was considerably larger in quantitative data collection than in qualitative data collection, though there were overlaps between the databases.

Table 5-2 mixed methods design: quantitative and qualitative research methods (Onwuegbuzie et al., 2009)

	Paradigmatic element: Pragmatism	**Analytical technique:**
Quantitative analysis	All forms of descriptive and inferential statistics	Variable-oriented: Descriptive analyses (statistics)
Qualitative analysis	All forms of qualitative analyses	Case-oriented: Matrix analysis

Onwuegbuzie et al. (2009) outlined the appropriate research methods under various research paradigms. Since this study's epistemological position is shaped by pragmatism, all forms of descriptive and inferential statistics could be used for quantitative analysis, and all forms of qualitative analyses are deemed appropriate (Table 5-2). The analytical technique of this study was "case-oriented" for the

qualitative analysis, which means the analyses "focus primarily or exclusively on selected case(s), wherein the goal is to analyse and interpret the meanings, experiences, attitudes, opinions, or the like of one or more persons with a tendency towards particularising and analytical generalisations (Onwuegbuzie et al., 2009: 117)". For quantitative analysis, the analytical technique was variable-oriented.

5.3 Research methods

This section details the tools and techniques used to gather, create, and generate data (Daly, 2007)[10]. Quantitative data was collected using the survey method, and qualitative data collection type was semi-structured interviews and review and analysis of public documents.

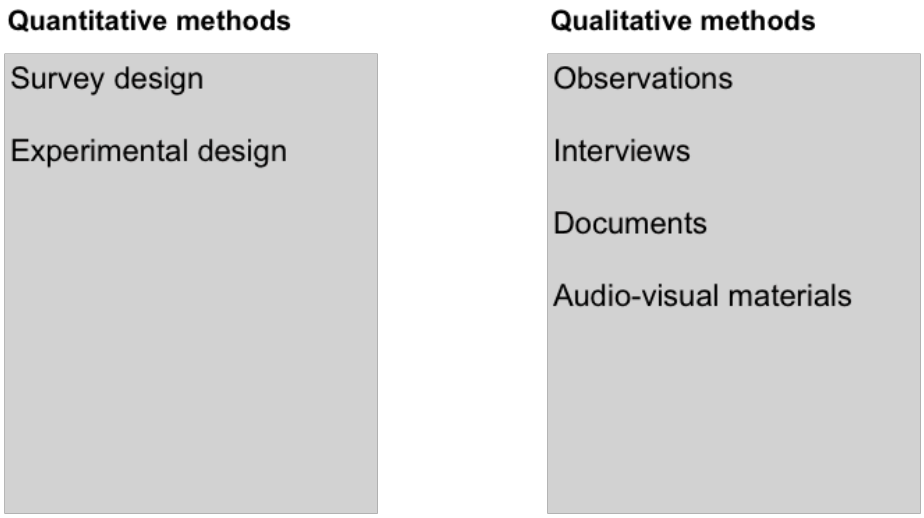

Figure 5-2 Data collection methods for both quantitative and qualitative methods (Creswell, 2014)

5.3.1 Survey design

Survey research is a type of non-experimental study. It is used to provide a quantitative or numerical description of trends, attitudes, or opinions of a population by studying a sample of that population (Creswell, 2014). As discussed in the previous chapter, there was no distinct boundary between tacit and explicit knowledge, and while the definition of what is tacit and what is explicit could differ among the specialists in this area, there was a consensus that different types of knowledge presented different ranges of "tacitness". The survey aimed to discover the use of different types of knowledge and the sources of learning in the Sponge City communities. It was designed to measure the respondents' self-evaluation of their knowledge level on various topics as well as the knowledge sources that they relied

[10] Daly (2007) spoke of the epistemological assumptions associated with the language used on the methods described. The use of "collection" and "gathering" may imply that the researcher assumes the position of the gatherer while the researched are the provider, which reinforces the emphasis on objectivity of the methods used. In this section, "gather, create, and generate" are first used to emphasise the role of the subjectivity of the researcher in the process, and "collect" or "data collection" is used for simplification.

on the most. It also measured the respondents' tendency to using knowledge in the tacit form compared to the knowledge that was made explicit. It was cross-sectional, which means that all data were collected at one point in time (within a week). The entire survey was conducted through the internet; it was anonymised and at no point of time was identifying information collected.

5.3.1.1 Administration

Although the researcher is bilingual speaker of English and Mandarin Chinese, the survey was first designed and piloted in English. This decision was made to ensure the quality of the creation and revision of the survey, due to the limit to the researcher's linguistic skills in Mandarin Chinese. it was later translated from English into Mandarin Chinese with the help of a Chinese literature expert, to ensure that the correct message is conveyed in the native language of survey respondents.

The final design was completed on a secure online platform (Wenjuan.com) and was administered via this platform because it could be shared widely using a social media app dubbed WeChat, which had more than 900 million active daily users (Iqbal, 2019b). The platform was chosen due to its ability to ensure one response per device. It was also able to ensure the anonymity of the respondents because it did not require the respondents to create a personal account of the website or log in using a social media account. The survey was also administered via emails when social media was inconvenient for some respondents. The actors identified for the semi-structured interviews were first recruited, they were then asked to disseminate the link to the survey on social media app WeChat or via other channels such as email. The researcher's personal network was also employed to disseminate the link to the survey using social media. Since participation was anonymous, the relevance of the survey participants is screened based on the time taken to complete and the quality of the answers, which will be elaborated further in section 5.4.

5.3.1.2 Items on survey

Ritter and Sue (2007b) reviewed the essential guidelines for designing online survey questions, which should be clear, short, unbiased, and relevant to the targeted audience. As the researcher expected participants to access the survey on a phone or tablet device, it was especially important to make sure that the questions' clarity and length would not compromise the response rate. There were, in total, 11 questions in the survey. Table 5-3 outlined what each item measured and how they were used in the analysis. Both English and Mandarin Chinese versions of the survey could be found in Appendix A.

The first three questions asked the respondents' geographical location, education level, and work experience. The fourth question asked the respondents to identify their profession(s)/fields they worked in; they had the choice to identify with multiple professions. In the self-evaluation questions, a five-point Likert scale was used to measure the extent to which the respondent agreed with a statement, and to rate their knowledge level. The categories of response had directionality where 1 represents the least extent or lowest score, and five represents to the greatest extent or the highest score.

Participants were allowed to choose all the professions/stages of projects that they identified with, so there would be overlaps of participants in different categories. Each profession category was composed of everyone who identified with the said profession. This survey was not designed to test for correlation between variables. In each question, the percentage of each profession was equivalent to the portion of people who identified with that profession and also identified with a statement. In terms of the identification of knowledge source, what the results showed was the likelihood of a profession to use a certain type of knowledge.

Table 5-3 Variables, survey items, and corresponding thesis sections

Thesis Section	Items on survey	Measuring	Variable
	Q1	Geographical location	Control variable
6.1.2	Q2, Q3	Education level Years of employment	Independent variables: demographics
6.1.1	Q4	What is one's disciplinary/academic background	Dependent variable: professional experience
6.3.1	Q5	To what extent are different types of knowledge utilised	Dependent variable: preferences on tacit or explicit knowledge
6.4.1 6.4.2	Q6, Q8, Q10	What is the self-evaluated knowledge level before and after the project	Dependent variable: extent of learning
	Q7, Q9, Q11	What is the largest contributing source to knowledge	Dependent variable: source of learning
6.3.2 6.3.3		Association of knowledge type used with education level, years of employment, and professional experience	Q5 and Q2-4
6.4.1		Association of knowledge level and contributing source with education level, years of employment, and professional experience	Q6-Q11 and Q2-4
6.4.3 6.4.4		Association of a source of learning with changes in self-evaluated score	Q7, 9, 11 and Q6, 8, 10

Questions five consisted of a series of statements on the acquiring and use of information during the projects and respondents were asked to what extent they would agree with each statement, with 1 being 0% and 5 being 100%. The nine sub-questions intended to measure how much each participant would use tacit or explicit knowledge. Depending on the wording of the question, a higher rating for some questions would point to more use of tacit knowledge. Hence, they were in the group of "tacit knowledge", and for others would point to explicit knowledge. Each question was targeting one aspect of the characteristics of tacit or explicit knowledge, but fundamentally they were an elaboration of the question "to what extent do you rely on tacit or explicit knowledge". This set of questions measured how much each participant used the knowledge that could be expressed and codified, such as in the form of instruction, guideline, procedure.

The remaining six questions were grouped into three pairs. Each pair corresponded to a group or type of knowledge. Questions 6 and 7 were regarding knowledge that belonged to various academic disciplines. Questions 8 and 9 are on conceptual knowledge. Questions 10 and 11 are on practical skills. Questions 6, 8, and 10 asked the respondents to rate their knowledge level on various topics **before** as well as **after** they have participated in a Sponge City project, from **1 (not familiar) to 5 (very familiar).** The knowledge categories were selected because they were essential to Sponge City projects. Knowledge group A is discipline and field-specific knowledge. This group of questions was used to evaluate participants' level of knowledge as well as the learning sources of their own and other professions. Knowledge group B is conceptual knowledge, which focused on concepts that are important to Sponge City projects. Participants from some professions may not have been familiar or have heard of them until they started working on Sponge City. Knowledge group C is technical and practical knowledge. This group of knowledge tended to be learned by practice or by training because they are skills that are needed to accomplish specific tasks.

Questions 7, 9, and 11 asked the respondents about their primary source of knowledge, from choices including written materials (guidelines, regulation/policy, textbooks, etc.), interpersonal interactions (discussion, workshop, study trip, conference, etc.), case studies and review articles, and personal investigation (other channels of choice, seeking and synthesising information from multiple sources).

Table 5-4 Categories in each knowledge group, as appeared in survey questions 6-11

Knowledge group A:	**Knowledge group B:**	**Knowledge group C:**
Discipline and field-specific knowledge.	Conceptual knowledge	Technical and practical knowledge.
Urban planning	Green infrastructure/SUDS/LID design	Hydrological modelling
Landscape Architecture	Sponge City objectives	Public engagement/resident mediation
Project management	Green infrastructure/SUDS/LID construction	Adaptation of design to local site conditions
Construction materials	Climate change	
Construction Management	Public-Private Partnership	
Water sciences, water technology	Stormwater management	
Architecture		
Municipal Engineering		
Atmospheric Sciences		
Plant arrangement		
Structural engineering		
Drainage and water supply		
Transportation		
Ecology		

5.3.2 Semi-structured interview design

During the initial field trip before the interview design, some actors approached expressed unwillingness to participate in interviews in fear of violating a company or organisation's code for practice. In this case, a structured interview with a questionnaire style format might be more appropriate, since it could capture data more quickly and better ensure the respondents' anonymity (Gray, 2014: 387). Furthermore, questions needed to be framed carefully to avoid being too offensive or intruding, which was likely to result in a lower response rate (De Lange et al., 2004).

The interview was semi-structured, which contained a set of open-ended questions. The interviewees were welcome to talk freely in addition to the pre-determined questions. There were three parts to the open-ended questions. First part regarded the interviewees' understanding of the objectives of the Sponge City initiative and their personal opinions on the role of planning in achieving the objectives. The second part asked the interviewees to talk about their experiences on Sponge City projects, including accomplishments, difficulties, thoughts on improvement. The third part asked the interviewees to explain the network of actors (at the organisational level) that they interacted and worked with throughout the Sponge City projects. The second part of the interview was more conversational and was often led by the interviewees. This allowed them to bring out the interactions that are significant to their experiences. The interview questions and the language used were developed and modified with the help of supervisors and researchers familiar with social network studies. An extended pilot study was conducted with a Sponge City actor to further solidifying the survey structure and questions.

Convenience sampling method was used to identify the initial interviewees, although a strict boundary was drawn where only people who worked on the Sponge City pilot projects (2014-now) were considered. This group of actors included the contacts established during the initial field trip as well as researchers in universities that became acquainted through personal connections. These people were all actively involved in different stages of Sponge City projects in multiple cities. The network expanded by employing a snowballing sampling approach. At the end of each interview, the interviewee made suggestions on whom to contact next. Usually, it was someone he/she had worked with on one of the projects. The anonymity of the interviewees was guaranteed by assigning each a unique code, and only this code was used to identify the interviews.

Table 5-5 Question topics and purposes

#	Topic	Sub-topic	Purpose of the topic
1	Personal experience in Sponge City	Describe your job How are you involved What is your role	Starting the conversation, building rapport, exploring the actor's involvement in Sponge City
2	Sponge City initiative	Objectives Goals	Clarifying the actor's level of understanding (depth and breadth)
3	Urban planning	Role of urban planning in Sponge City Importance of urban planning	Clarifying the actor's understanding of the role of urban planning both spelt out in the guidelines as well as according to their own opinions
4	Specific projects	Accomplishments, difficulties, thoughts on improvement (In general, as well as in the context of communicating and learning)	Exploring actor's relationships with other actors and with the project, and having actors volunteer information on what they find difficult or easy in terms of communicating and learning knowledge for Sponge City projects
5	Actor-network (organisational level)	Whom they interact with, how often, and what is the quality of the interaction	Identifying the actor's network

5.3.2.1 Target informants and sample size

There were 30 national pilot cities in the Sponge City initiative, and there were many more provincial pilot cities or cities independently pursuing Sponge City. The number of actors involved at different stages of the project, in each city, or in total, was hard to estimate. At the planning stage, actors were mostly from large scale and renowned planning institutes or organisations that provide such a service. The actors that worked on the Sponge City plan tended to provide the service to multiple pilot cities, which was also the case for the actors that provide technical/engineering consulting services. As the project proceeded onwards to design and construction phases, there were more local firms involved and the number of actors across all cities also increased.

By adopting a convenience sampling strategy, the recruitment started with the established contacts in university and planning institutes. The snowballing sampling strategy was then used to branch out from the original samples, and which naturally resulted in project clusters since the actors tended to recruit their collaborators or colleagues next. The only selection criterion was that the actor identified must be working on Sponge City projects in one of the national pilot cities. The interview aimed to include actors from all disciplines involved across all project stages. Given the time constraint for data collection (three months) and the time and resources required for the transcription and analyses of the data, the target sample size for the interviews was n=40. The actual number of valid interviews was n=38. The interview participants were grouped by their current profession (Category), the disciplines of knowledge they have studied (Disciplines), and the stages of Sponge City projects that they have been part of (Project stages).

5.3.2.2 Conducting the interview

The first contacts with the informants were made through online messaging platform or phone conversations. They were informed of the purpose of the study and how the interview was going to be conducted. All 38 interviews except for two were conducted face-to-face; two interviews had to be conducted on the phone because they were based in other cities and were not available to meet. Before the interview, the consent form and the interview pro form were presented to the informant in print. Each informant was briefed on the voluntariness of participation and the guarantee of confidentiality. Also, each was asked for permission to be recorded. Among all the informants, two declined to be recorded. The interview duration ranged from half an hour to two hours, depending on the time availability and the amount of information the informant was willing to offer.

Table 5-6 Characteristics of the actors interviewed

Actor	Category	Disciplines	Project stages
U1	University	Environmental engineering Landscape architecture	Design Planning Consulting
U2	University	Water resources engineering	Design Planning Consulting
U3	University	Landscape architecture	Design Research
U4	University	Landscape architecture	Design
U5	University	Landscape architecture	Design
U6	University	Landscape architecture Industrial design	Design
U7	University	Landscape architecture	Design
U8	University	Landscape architecture	Design Planning
U9	University	Landscape architecture	Design Planning
U10	University	Landscape architecture	Design
P1	Professional organization	Civil engineering	Planning
P2	Professional organization	Urban planning Environmental engineering	Technical support Design Planning
P3	Professional organization	Urban planning	Planning Technical support
P4	Professional organization	Civil engineering Planning	Design Planning
C1	Private sector	building/subway construction management	Construction
C2	Private sector	building/subway construction management	Construction
C3	Private sector	building/subway construction management	Construction
C4	Private sector	Construction engineer	Construction
C5	Private sector	Construction engineer	Construction
C6	Private sector	Water resources engineering	Design Planning Consulting
C7	Private sector	Water resources engineering	Planning Consulting
C8	Private sector	Construction engineer	Construction
C9	Private sector	Construction engineer	Construction
C10	Private sector	Environmental engineering	Design
C11	Private sector	Landscape architecture	Design
C12	Private sector	Landscape architecture	Design
C13	Private sector	Environmental engineering	Design Planning Construction Product development
C14	Private sector	Civil Engineering	Design
C15	Private sector	Civil Engineering	Design Planning Consulting
C16	Private sector	Landscape architecture Architecture	Design Planning
C17	Private sector	Urban planning Architecture	Design

(Continued)

Table 5-6 (continued)

Actor	Category	Disciplines	Project stages
C18	Private sector	Environmental engineering	Design
C19	Private sector	Landscape architecture	Planning
C20	Private sector	Environmental engineering	Implementation management
C21	Private sector	Project management	Implementation management
C22	Private sector	Environmental engineering	Implementation management
C23	Private sector	Landscape architecture	Implementation management
G1	Government	[not specified]	Implementation management

5.3.2.3 Other sources of data

Other sources of qualitative data include Sponge City guidelines and standards issued by the national government:

1. Technical Guideline for Sponge City - Low Impact Development Stormwater Management System Construction – provisional (2014)
2. Assessment standard for Sponge City construction effect (published in 2018, implemented in 2019)

Source 1 was used to benchmark the actors' responses to questions regarding the Sponge City objectives and the role of urban planning. The two documents were published four years apart. By comparing them, one could examine the shifts in discourse and changes in the use of terms, which would be a result of knowledge accumulation and exchange.

5.4 Data analysis

5.4.1 Quantitative data

The survey yielded a total of 536 responses as recorded by the online platform. All the data were downloaded as one file from the website upon closing of the survey. The internal validity of the research design may be threatened when the variables other than independents are causing part or all of the observed effects on the dependent variables (Moutinho, 2011). To avoid the biases, the data was cleaned based on two criteria: the response time and impossible and some improbable answers (ex. one person choosing the same score for all items), resulting in 387 responses used for analysis. Both the number of survey questions and the evidence gathered at pilot testing showed that it would be not possible to finish the survey in less than two minutes. Therefore, all entries that were finished within two minutes are nullified. Among the rest of the entries, the ones that gave the same score to all sub-questions were nullified. Values that were improbable but possible were challenging to eliminate because extreme values should receive more careful treatment, and options should be considered to afford the most accurate and ethical data reporting possible (Ritter and Sue, 2007a). Under this specific circumstance, the actors were being asked to evaluate their competency level on a

large variety of topics related to Sponge City. It was designed to include all relevant knowledge areas possible, and many of them were not interrelated at all. Therefore, it should be safe to assume that being very competent on all of the topics would be impossible and unrealistic, and therefore should be eliminated.

To collect data on the usage of different types of knowledge (Question 5), a 5-point Likert scale was used, with one being "to the least extent", and five being "to the greatest extent". Other than the two extremes, the other categories were not given a description. When designing the survey, a 3-point scale was not considered because it might not present sufficient discrimination to the survey participants. In the analysis, the 5-point scale was treated as a 3-point scale because it was assumed that people tended not to choose the extreme categories, so the lower two categories (1, 2) and the higher two categories (4, 5) were lumped together while 3 signifies the respondents' neutral opinion about the statement (Jamieson, 2013). However, given the sample size, the 3-point scale was further collapsed to a two-level scale (0, 1) to ensure no reduction in test power occurs in the analyses. It is understood that the intervals between the scale are not equal and the scale represents a directionality of the responses, and that it is problematic to apply Likert-type scales to parametric tests (Bishop and Herron, 2015; Clason and Dormody, 1994; Dawis, 1987). Therefore, the data are analysed as categorical data, where the focus is on the "frequencies of observations that fall into each of two or more categories" (Howell, 2010: 140). The Statistical Package for the Social Sciences (IBM SPSS) software was utilised to perform descriptive and chi-square statistical tests. A plan of descriptive and statistical analysis for all the variables is shown in Table 5-7.

To upkeep the reliability of the statistical tests, the assumptions of chi-square must not be violated. For the last four items shown in Table 5-7, the two variables used in each run of the test are mutually exclusive, measured at ordinal level or are categorical data, and independent (Howell, 2010; Mchugh, 2013). The assumption of independence is met by limiting each device to one entry only, and eliminate entries that didn't meet the requirements as specified above. The removal of the ineligible entries is part of the quality control process aimed at maintaining the internal validity of the test so that the participants of the survey can remain representatives of the population (Patino and Ferreira, 2018).

Table 5-7 Analysis plan for all variables

Items on survey	Measuring	Variable	Analysis plan
Q1	Geographical location	Control variable	-
Q2, Q3	Education level Years of employment	Independent variables: demographics	Descriptive statistics
Q4	What is one's disciplinary/academic background	Dependent variable: professional experience	Descriptive statistics
Q5	To what extent are different types of knowledge utilised	Dependent variable: preferences on tacit or explicit knowledge	Descriptive statistics
Q6, Q8, Q10	What is the self-evaluated knowledge level before and after the project	Dependent variable: extent of learning	Descriptive statistics
Q7, Q9, Q11	What is the largest contributing source to knowledge	Dependent variable: source of learning	Descriptive statistics, Chi-squared
	Association of knowledge type used with education level, years of employment, and professional experience	Q5 and Q2-4 (categorical)	Chi-squared
	Association of knowledge level and contributing source with education level, years of employment, and professional experience	Q6-Q11 and Q2-4 (categorical)	Chi-squared
	Association of source of learning with changes in self-evaluated score	Q7, 9, 11 and Q6, 8, 10 (categorical)	Chi-squared

5.4.2 Qualitative data

The qualitative research analysis was "seeking to provide an explicit rendering of the structure, order and patterns found among a group of participants" (Lofland, 1971, p.7, as cited in Daly, 2007). The interviews were conducted in the native language of the informants (Mandarin Chinese), and all but two informants had given consent to being recorded. The analysis of the qualitative data followed the iterative process outlined in Table 5-3. The interviews were transcribed, and the transcriptions and the notes were reviewed thoroughly before proceeding to the coding stage. The audio recordings of the interviews were transcribed directly using NVivo 11 Pro software. Coding was an analytic process that assigns symbolic meaning or attributes to descriptive or inferential information in the form of data chunks (Miles et al., 2014).

After the interviews were transcribed, a network ties diagram of actor connections was built for each participant, using Gephi, a network analysis and visualisation software. Although reciprocated ties are generally deemed as more valid because the two ends of the ties may have different perceptions of their relationships, in this study, it was not feasible to obtain reciprocated ties since certain actors were inaccessible, as well as because the actors were asked to identify groups instead of individuals. However, since network analysis tends to focus on the more stable patterns (ones that are easily identified and persistent in the network), it is sufficient to rely on the actors' views of their social networks (Prell, 2012).

After that, an initial round of coding was conducted in the original language to preserve meaning and avoid misinterpretation. This round of coding was deductive, where pre-determined codes were derived from the Sponge City guideline (MOHURD, 2014) and the interview questions. Hereafter, an inductive coding process was carried out as themes emerge from the interviews; at this stage, many codes were collapsed into more condense categories. Then, another deductive process of coding using more meaningful units of analysis derived from the social capital framework was performed. The codes generated this way were condensed into themes which are then used to facilitate data description. Data that described the quality of interaction between actors (topics #4, 5) were identified for each actor and were then clustered into matrices according to themes derived from the social capital framework (chapter 3).

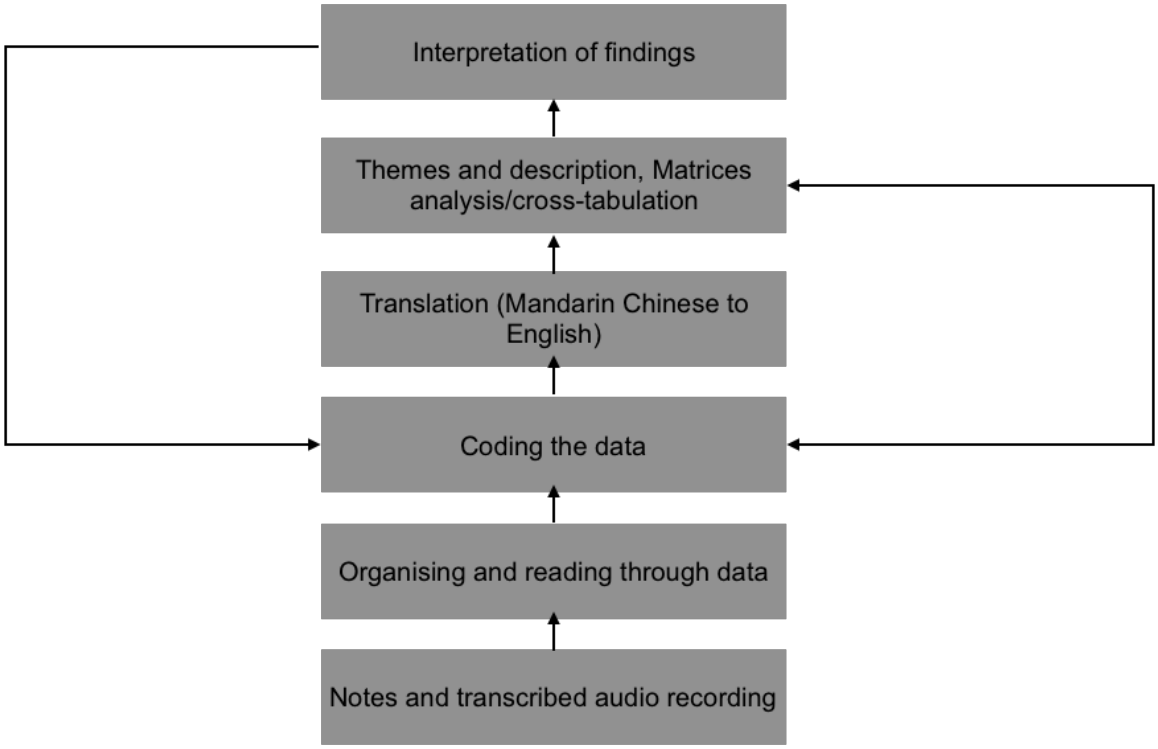

Figure 5-3 Qualitative data analysis flow, adapted from (Creswell, 2014)

Conceptually clustered matrix is a form of conceptual or thematic documentation, it allows

- The display of all relevant responses of all key participants;
- An initial comparison between responses and between participants;
- To see how the data can be analysed further (Miles et al., 2014).

After the interactions between actors were identified and coded, they were entered into a matrix. The coded materials for each actor were further broken down to "enabling" or "constraining" according to whether the interaction led to a positive or rather negative outcome. This matrix was then used to construct the conceptually clustered matrix with social capital framework elements down the columns, and participants across the rows.

5.5 Considerations and limitations

Qualitative studies, such as in this research that involved human participants, must consider ethical issues prior, during the data collection as well as when analysing, reporting, and sharing the data and results (Creswell, 2014). Before data collection, the researcher sought ethics consent from the UCL Research Ethics Committee (project ID: 9321/001). This project was also covered by the UCL Data Protection Registration (Z6364106/2017/03/110 social research). The interview participants were given an information sheet and had provided consent. The online survey was exempt from ethics approval for meeting the following requirement:

> **"Research involving the use of educational tests, survey and interview procedures on human participants in the public arena (e.g. elected or appointed public officials, candidates for public office, artists) (UCL Research Ethics Committee, 2018)"**

Anonymous online survey did not require a consent form, for "consent can be assumed through completion of an online survey/questionnaire without the need for a consent form" (Lally, 2019).

Measures had also been taken throughout the study to ensure the quality of the findings and conclusions. The interviews employed a case study method, and 39 interviews were conducted with actors from diverse roles and positions, and they were representative of actors involved in Sponge City. The researcher aimed to ensure the representativeness of the participants sampled. Given that all the actors contacted were performing tasks relevant to the Sponge City, all the actors interviewed were selected based on availability alone to avoid biases in selection. However, as expected, it was harder to contact government actors. During data collection and analysis, the researcher intended to avoid biases by avoiding asking leading questions or present personal opinion or judgement, asking a participant to provide background and historical information and checking to examine and include outliers and negative evidence (Miles et al., 2014).

To maintain the quality of interpretation, the researcher used context-rich, meaningful, and thick description to convey the findings (Geertz, 1973 as cited in Miles, Huberman and Saldana, 2014, p. 313). The data presented in the findings were well linked to the theory of social capital and the conceptualisation of tacit knowledge.

5.6 Summary

In this chapter, a description of the epistemological position and research paradigms was provided, thus giving the direction to the selection of methodology, research methods, and the data analysis methods. This study adopted a pragmatic research paradigm and used a convergent parallel mixed methods research design to investigate what type and from where the actors in Sponge City acquired relevant knowledge. This information was obtained by conducting a completely anonymised online survey. The data is analysed using IBM SPSS, and descriptive statistics and chi-square tests were performed. The qualitative segment of the study examined using semi-structured interviews and participant provided documents with the access and mobilisation of knowledge assets among the Sponge City actors. The interviews were transcribed and coded using NVivo 11Pro. The analysis followed an iterative process, where data underwent both deductive and inductive coding and cross-tabulation of the coded data for display and interpretation. Chapter 5 will present the analytical context to provide some background insights on the environmental governance and integrated urban water management in China, as well as the technical guideline and assessment standards of the Sponge City program.

6 Using and learning of tacit knowledge

"Professional knowledge is mismatched to the changing character of the situations of practice – the complexity, uncertainty, instability, uniqueness, and value conflicts which are increasingly perceived as central to the world of professional practice (Schön, 2016: 14)."

This chapter of findings addresses the research *objective a*. It determines the elements influencing the types of knowledge being learned and used for different purposes, as well as the factors affecting a participant's choice of learning methods and sources in the context of integrated urban water projects (Sponge City). The findings result from a quantitative analysis of the survey of Sponge City project participants from all relevant disciplines and professions (N_raw=536, N_valid = 387).

6.1 Demographic information

This section summarises the survey respondents' professional background, education level, as well as their years of employment. It also probes the individuals' understanding of their knowledge expertise by looking at the identification of their professional background.

6.1.1 Professions of respondents

A profession is defined as "a calling requiring specialised knowledge and often long and intensive academic preparation" (Merriam-Webster, profession entry). One objective of the survey is to have a better understanding of the influence of one's professional background, which includes the history of education and training, on respondents' learning preferences. Individuals nowadays may pursue other career paths after having an undergraduate and or even a postgraduate degree in a field of study, work as a part of highly multi-disciplinary project teams and multi-sectoral projects, or switch to another profession mid-career. Therefore, a single profession may not suffice to characterise the range of specialised knowledge and academic preparation a person has had. To accurately reflect a person's knowledge background in order to understand whether and how it influences her acquisition of knowledge, the survey asks the respondents to select all the professions that they identify within the context of Sponge City.

Table 6-1 displays the number of respondents that identified with each profession. The total number here exceeds the total number of respondents due to the selection of multiple professions.

Table 6-1 Profession of respondents (occurrences); Note some professions are grouped together to form planning, design, and construction stages for analysis purposes, the sum of each stage is smaller than the sum of all the professions within that stage

Profession (# of occurrences)			
	Count		Count
Urban planning	92	Planning Stage	104
Consulting	21		
Landscape architecture	70	Design Stage	192
Municipal engineering	58		
Environmental engineering	48		
Water resources	27		
Environmental protection	72		
Architecture	50		
Project management	48	Project management	48
Government	45	Government	45
Neighbourhood committee, property management	34	Neighbourhood committee, property management	34
Construction general contractor	34	Construction stage	67
Construction Special contractor	17		
Construction Labor contraction	15		
Site supervisor	13		
Material supplier	14		
Auditing	22	Auditing	22
University and research organizations	54	University and research organizations	54

In the survey, respondents are asked to choose all the professions that they identify with during Sponge City projects. If a respondent has chosen more than one profession, that means that he or she is taking on multiple roles under the Sponge City initiative. In Table 6-2, each row describes the percentage of the leftmost profession that also identified with each of the other professions. For example, 27 out of 92 people who identified as urban planners also chose landscape architects, so the percentage is 27/92 = 29%.

An interesting point that emerged quickly is that the chart is not symmetrical, which means that the percentage of respondents of profession A that identifies with profession B is not equivalent to the percentage of B that identifies with A. Firstly, this demonstrates how the boundary between professions is blurry and in practice there is no strict division between them. It also shows that the perception of what they know and what their expertise lies could be different, and this may have an effect on where and how they acquire knowledge. Schön (2016) remarked that modern professionals are increasingly aware of the mismatch between the niche expertise and the education that is supposed to prepare it, when they are being faced with uncertainty, complexity, instability, uniqueness, and conflicting values in practice. The unsymmetrical overlap of professions displayed in Table 6-2 demonstrates the multiplicity and diversity of expertise knowledge each profession apparently possesses.

Table 6-2 How actors identified their own professions

	Urban Planning	Landscape Architecture	Municipal Engineering	Environmental Engineering	Water Resources	Environmental Protection	Architecture	Project Management	University and Research organizations	Government	Neighbourhood Committee Property Management	Consulting	Construction General contractor	Construction Special contractor	Construction Labor contraction	Site supervisor	Material Supplier	Auditing
Urban Planning		29%	26%	28%	18%	30%	14%	20%	14%	15%	17%	10%	13%	8%	5%	8%	5%	8%
Landscape Architecture	39%		26%	26%	20%	34%	20%	20%	26%	19%	14%	9%	16%	11%	10%	10%	7%	6%
Municipal Engineering	41%	31%		40%	28%	29%	28%	28%	16%	21%	14%	12%	24%	10%	9%	9%	3%	5%
Environmental Engineering	54%	38%	48%		38%	50%	27%	27%	23%	21%	25%	13%	23%	10%	10%	8%	4%	10%
Water Resources	63%	52%	59%	67%		59%	41%	26%	26%	37%	22%	26%	37%	11%	15%	11%	7%	11%
Environmental Protection	39%	33%	24%	33%	22%		19%	18%	24%	14%	21%	10%	14%	14%	8%	11%	11%	14%
Architecture	27%	29%	33%	27%	24%	29%		24%	18%	22%	12%	12%	22%	10%	10%	12%	6%	10%
Project Management	39%	31%	35%	29%	16%	29%	24%		20%	24%	16%	18%	24%	18%	12%	12%	12%	10%
University and Research organizations	17%	30%	13%	21%	13%	26%	13%	15%		13%	6%	4%	6%	6%	4%	4%	2%	11%
Government	31%	29%	27%	22%	22%	22%	22%	18%	24%		16%	13%	16%	11%	13%	11%	4%	13%
Neighbourhood Committee Property	47%	29%	24%	35%	18%	44%	15%	21%	18%	21%		21%	12%	9%	9%	12%	9%	9%
Consulting	43%	29%	33%	29%	33%	33%	24%	38%	19%	29%	33%		19%	14%	19%	19%	10%	19%
Construction General contractor	35%	32%	41%	32%	29%	29%	29%	32%	15%	21%	12%	12%		18%	18%	21%	9%	3%
Construction Special contractor	41%	47%	35%	29%	18%	59%	24%	47%	24%	29%	18%	18%	35%		35%	29%	18%	12%
Construction Labor contraction	33%	47%	33%	33%	27%	40%	27%	33%	20%	40%	20%	27%	40%	40%		33%	7%	7%
Sitesupervisor	54%	54%	38%	31%	23%	62%	38%	38%	31%	38%	31%	31%	54%	38%	38%		23%	15%
Material Supplier	36%	36%	14%	14%	14%	57%	14%	36%	29%	14%	21%	14%	21%	21%	7%	21%		7%
Auditing	32%	18%	14%	23%	14%	45%	18%	18%	32%	27%	14%	18%	5%	9%	5%	9%	5%	

6.1.2 Education level and years of employment

Respondents reported their highest degree achieved. More than 50% reported to have a Diploma or bachelor's degree, and 11.6% has a postgraduate degree (Table 6-3).

Table 6-3 Education level of respondents

All respondents: Education level		
	Frequency	Percent
< 9th Grade	51	13.2
High School	60	15.5
Diploma	87	22.5
Bachelor	144	37.2
> Masters	45	11.6
Total	387	100.0

There could have been a misinterpretation of the names of the professions, because most professions listed with the exception of environmental protection*, and construction special and labour contractor, would require a degree of high school and above. Most of the design, engineering, consulting, and academic professions would require a professional or vocational degree (diploma) or above (ICE, 2018). Among the respondents that reported an education level of less than 9th grade, the most popular professions other than the ones that don't require higher degrees, are urban planning (18.5%), landscape architecture (14.3%), municipal engineering (15.5%), water resources (22.2%), environmental protection (23.6%), and neighbourhood committee (14.7%). Most of the professions mentioned fall under the "design stage" group, and all 51 respondents but one answered the question to reflect their backgrounds best.

Table 6-4 Years of employment of respondents

All respondents: Years of employment		
	Frequency	Percent
<1 yr	78	20.2
2-3 yrs	68	17.6
4-9 yrs	124	32.0
10-19 yrs	75	19.4
>20 yrs	42	10.9
Total	387	100.0

Among all respondents, the most frequently reported length of employment is 4-9 years. This is followed by less than one year of work experience, where 48% of university and research organisation respondents reported to have had work experience of one year or less, which could be because many of them responded to the survey were students who have not yet had any job experience. In the profession group of neighbourhood committee and property management, there is a larger portion of respondents reported to have longer than 20 years of employment history (Table 6-5).

Table 6-5 Respondents' years of employment as displayed by profession group (%)

Years of employment: by profession groups (% of profesison group)

	Planning stage	Design stage	Construction stage	University and research organisations	Government	Neighbourhood committee, property management	Auditing	Project management
<1 yr	16.3	21.4	16.4	48.1	11.1	14.7	31.8	25.0
2-3 yrs	23.1	16.1	14.9	14.8	8.9	11.8	18.2	14.6
4-9 yrs	32.7	32.3	40.3	24.1	37.8	23.5	13.6	29.2
10-19 yrs	16.3	17.7	17.9	7.4	33.3	23.5	27.3	25.0
>20 yrs	11.5	12.5	10.4	5.6	8.9	26.5	9.1	6.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

6.2 Use of tacit and explicit knowledge

The participants are asked to rate the extent to which they agree with statements regarding the use and acquirement of knowledge during Sponge City projects, with one being least and five being the most. The set of questions intends to measure how much they use the knowledge that is tacit in nature, and how much they rely on knowledge that is explicit (Table 6-6).

The overall result is there is no observable difference in the reliance on tacit versus explicit knowledge, because the average percentage of participants agreeing to each set of statements (rated 4 and 5) is similar for both types of knowledge. Participants have rated highly regarding some statements and less highly for others, and there is a more significant difference between statements than between two types of knowledge. Some statements are rated low by the majority of the profession, and some have consistently received high rating across all professions.

Table 6-6 Survey questions 5.1 - 5.9

Use of "tacit" knowledge	Use of "explicit" knowledge
Q5.1 "Did you rely on prior experience and knowledge"	Q5.2 "Could the steps for a Sponge City project be written down so that other people can be successful"
Q5.3 "Did you utilise informal channels to enhance process and result (Such as social media, blog, etc.)	Q5.5 "Did you have to invent steps or methods to solve a problem
Q5.4 "Did you utilise personal interactions to enhance process and result (Such as phone call, informal discussion, etc.)"	Q5.6 "Did you rely on written materials (such as guidelines, textbooks, etc.)"
Q5.7 "Could your experience in one project be generalised to other projects"	Q5.8 "Could you adapt the steps used in one project to another project"
Q5.9 "Did you rely on your professional common sense"	

When looking at the scores of the professions collectively, a non-parametric test on the occurrences of scores equivalent to "to a large extent" reported the unequal distribution of preference for learning methods, $c2(8, N = 9401) = 71.271, p < 0.001$. However, a closer look at the residuals in the frequencies table below, one could identify the two data points that deviate from the expected N the most, compared to others.

Table 6-5 Occurrences of scores to questions Q5.1-Q5.9

Occurrences of scores[a]

	Observed N	Expected N	Residual
Q1	1033	1044.6	-11.6
Q2	1245	1044.6	200.4
Q3	865	1044.6	-179.6
Q4	1041	1044.6	-3.6
Q5	1057	1044.6	12.4
Q6	1013	1044.6	-31.6
Q7	1045	1044.6	0.4
Q8	1069	1044.6	24.4
Q9	1033	1044.6	-11.6
Total	9401		

a. occurrences of top scores of 4 and 5, the equivalent to "to a large extent"

Table 6-7 Occurrences of scores to questions Q5.1, Q5.4-Q5.9

Occurrences of scores (excluding Q2 Q3)[a]

	Observed N	Expected N	Residual
Q1	1033	1041.6	-8.6
Q4	1041	1041.6	-0.6
Q5	1057	1041.6	15.4
Q6	1013	1041.6	-28.6
Q7	1045	1041.6	3.4
Q8	1069	1041.6	27.4
Q9	1033	1041.6	-8.6
Total	7291		

a. occurrences of top scores of 4 and 5, the equivalent to "to a large extent"

When a non-parametric test is performed with Q2 and Q3 excluded, the result becomes $c2(6, \mathrm{N} = 7291) = 1.887, p = 0.93$, where the distribution of preferences for learning methods is no longer significantly unequal. One can conclude that the respondents are equally likely to use tacit and explicit methods of learning, with the exception of two. As mentioned in the survey design, these questions have different wordings and focus on various aspects of the knowledge characteristics. Q2 asks the respondents whether their knowledge could be made explicit for others, and Q3 intends to ask how much each participant would make use of informally organised communication, which is an opportunity for exchanging tacit knowledge.

One possible explanation could be complications in the translation of the survey questions, because the wording in the Chinese version may induce misunderstanding of the statements. For question 5.3, the wording may be perceived as having a negative connotation in the context of Chinese culture. "Informal" in this statement means communication channels or opportunities that are not formally organised or provided, but when translated into Chinese, it may be perceived as "unprofessional" or "improper", which is different from the intended meaning of the word.

Non-parametric chi-square tests are also performed on each profession group. As Table 6-8 shows, none of the profession groups displayed significant differences in the use of tacit and explicit knowledge.

Table 6-8 Non-parametric chi-square tests on each profession group's use of tacit vs explicit knowledge

Profession group	Test statistics
Planning stage	$c2(8, N = 572) = 5.951, p = 0.655.$
Design stage	$c2(8, N = 1113) = 7.892, p = 0.445.$
Construction stage	$c2(8, N = 349) = 3.341, p = 0.911.$
University and research organisations	$c2(8, N = 299) = 3.057, p = 0.933.$
Project management	$c2(8, N = 287) = 2.976, p = 0.938.$
Government	$c2(8, N = 270) = .733, p = 0.999.$
Neighbourhood committee and property management	$c2(8, N = 205) = 2.702, p = 0.954.$
Auditing	$c2(8, N = 152) = 3.487, p = 0.906.$

The results have taken into account the limitation and outliers, and indicate that the participants have used somewhat equally tacit and explicit knowledge to accomplish their tasks in Sponge City projects. It shows that the assumption that participants will choose to use one form of knowledge over another is flawed. For the tacit and the explicit parts of knowledge are virtually inseparable, as Polanyi stated, "all knowledge falls into one of these classes: it is either tacit or rooted in tacit knowledge…deprived of their tacit coefficients, all spoken words, all formulae, all maps and graphs, are strictly meaningless" (Ray, 2008: 244–245). As the results have shown, participants have relied to a large extent upon explicated knowledge in the form of writing, procedures, steps to follow, but these materials or resources need to be accompanied by the prior personal experience and the exchange of such personal knowledge. Just as demonstrated in the writing of Polanyi, "in order that we may formalise the relations that constitute a comprehensive entity…this entity, must be first identified informally by tacit knowing, the meaning of a [theory] of the [entity] lies in its continued bearing on this still tacitly known [entity] (Polanyi, 1966: 20)".

Therefore, it is not the type of knowledge being communicated that studies on knowledge transfer should dwell on, instead, it is the source of learning and the channel/process being used to extract and exchange.

6.3 Source of learning

The survey questions ask the participants to identify their sources of learning for each type of knowledge. Case studies and review articles, and written materials are sources that provide knowledge that is documented, relatively measurable, and could be broken into steps. Interpersonal interaction

and personal investigation are sources of knowledge that are embedded in personal experience, a person's unconscious mind, and the context of learning.

Three types of knowledge are distinguished for this study: discipline-specific knowledge, conceptual knowledge, and practical knowledge, the topics measured in each category is shown below.

Table 6-9 Knowledge types and topics appeared in the survey

Discipline-specific knowledge	Conceptual knowledge	Practical knowledge
Urban planning	GI, LID, SUDS design	Hydrological modelling
Landscape architecture	Sponge City objectives	Public engagement
Project management	GI, LID, SUDS construction	Adaptation of design to local site conditions
Construction materials	Climate change	
Construction management	Public-private partnership (PPP)	
Water sciences/technology	Stormwater management	
Architecture/design		
Municipal engineering		
Atmospheric sciences		
Plant arrangement		
Structural engineering		
Drainage and water supply		
Transportation		
Ecology		

6.3.1 Preferences in learning sources of different types of knowledge

As can be seen in the data cross-tabulated in Table 6-10, the frequencies of sources of knowledge used are significantly different within each of the three types of knowledge.

For discipline-specific knowledge, $c2(3, \mathrm{N} = 387) = 51.605, p < 0.001$.

For conceptual knowledge, $c2(3, \mathrm{N} = 387) = 58.013, p < 0.001$.

For practical knowledge, $c2(3, \mathrm{N} = 387) = 21.010, p < 0.001$.

Table 6-10 Frequencies of knowledge sources for all knowledge types and all respondents

All respondents: Frequencies									
	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	87	96.8	-9.8	81	96.8	-15.8	100	96.8	3.3
Interpersonal interaction	137	96.8	40.3	147	96.8	50.3	115	96.8	18.3
Personal investigation	44	96.8	-52.8	46	96.8	-50.8	59	96.8	-37.8
Written materials	119	96.8	22.3	113	96.8	16.3	113	96.8	16.3
Total	387			387			387		

Overall, respondents have a strong preference for interpersonal interaction and written materials across all knowledge types. Personal investigation is the least favourite source, though for practical knowledge, the use of case studies and review articles as well as personal investigation increases slightly.

6.3.2 Association with education level and years of employment

As the test statistics show below, there is no significant relationship between education level and source of learning, or between years of employment and source of learning, for all three types of knowledge. This means that the choice of learning source and learning channel is not determined by an individual's education level or years of employment.

Education level and discipline-specific knowledge: $c2(12, N = 387) = 15.176, p = .229$

Years of employment and discipline-specific knowledge: $c2(12, N = 387) = 7.902, p = .803$

Education level and conceptual knowledge: $c2(12, N = 387) = 17.263, p = .142$

Years of employment and conceptual knowledge: $c2(12, N = 387) = 22.639, p = .032$[11]

Education level and practical knowledge: $c2(12, N = 387) = 19.553, p = .075$

Years of employment and practical knowledge: $c2(12, N = 387) = 8.789, p = .724$

As demonstrated by the results from the previous section, tacit and explicit knowledge are used equally by most survey participants. What is shown above is the difference in how they obtain knowledge and learn. The initial assumption was that different channels of learning would be preferred for each of three types of knowledge asked in the survey. The results show that there are no clear-cut preferences on the use of tacit or explicit sources to learn the different categories of knowledge.

However, when comparing the learning sources/methods against one another, one can see that the preferences on learning sources are present in one level of educational background or length of employment but not in another. For discipline-specific knowledge, individuals with the formal education of high school and below showed no significant difference in their choices of learning sources, while individuals having a diploma and above did. As the p-value of 0.8303 indicated, all respondents besides those with 10-19 years of employment showed significant to very significant differences in frequencies. For conceptual knowledge, individuals having a degree of bachelor and above showed statistically significant differences in the frequencies of learning sources selected. Individuals of all lengths of employment history showed significant differences in frequencies. For practical knowledge, frequencies of the learning sources are very significantly different for individuals with a degree of bachelor and higher. Individuals of all lengths of employment aside from 10-19 years showed no significant differences in the frequencies, meaning they did not prefer one type of learning source significantly over another.

[11] The minimum expected count is 4.99, which is less than 5. Although it is convention to require expected frequencies to be at minimum five, but the chances of having Type I error in a table of this size are low (Howell, 2010: 151)

Table 6-11 Nonparametric test on frequencies of learning sources used for discipline-specific knowledge, as organised by education level and years of employment

Discipline-specific knowledge					
	Category	**df**	**N**	**Chi-square value**	**p-value**
Education level	<9th grade	3	51	2.098	0.569
	High school	3	60	4.933	0.185
	Diploma	3	87	14.011	0.003
	Bachelor	3	144	29.833	0.000
	> Masters	3	45	11.800	0.008
Years of employment	<1 yr	3	78	14.513	0.002
	2-3 yrs	3	68	11.412	0.010
	4-9 yrs	3	124	16.323	0.001
	10-19 yrs	3	75	5.587	0.136
	>20 yrs	3	42	11.714	0.009

Table 6-12 Nonparametric test on frequencies of learning sources used for conceptual knowledge, as organised by education level and years of employment

Conceptual knowledge					
	Category	**df**	**N**	**Chi-square value**	**p-value**
Education level	<9th grade	3	51	5.392	0.151
	High school	3	60	4.933	0.185
	Diploma	3	87	7.483	0.059
	Bachelor	3	144	34.500	0.000
	> Masters	3	45	18.556	0.000
Years of employment	<1 yr	3	78	32.564	0.000
	2-3 yrs	3	68	10.000	0.019
	4-9 yrs	3	124	10.581	0.014
	10-19 yrs	3	75	16.147	0.001
	>20 yrs	3	42	8.095	0.042

Table 6-13 nonparametric test on frequencies of learning sources used for practical knowledge, as organised by education level and years of employment

Practical knowledge					
	Category	**df**	**N**	**Chi-square value**	**p-value**
Education level	<9th grade	3	51	2.569	0.492
	High school	3	60	9.600	0.022
	Diploma	3	87	1.138	0.783
	Bachelor	3	144	14.333	0.002
	> Masters	3	45	11.978	0.007
Years of employment	<1 yr	3	78	7.128	0.068
	2-3 yrs	3	68	6.706	0.085
	4-9 yrs	3	124	4.710	0.202
	10-19 yrs	3	75	8.253	0.040
	>20 yrs	3	42	2.571	0.496

As a result, although statistically there is no association between one's education level and her choice of learning source, individuals with degrees of bachelor and higher consistently differed from the rest of the respondents, where significantly few numbers of respondents chose personal investigation.

6.3.3 Association with profession groups

The reliance on different sources of knowledge for each knowledge type is further broken down by profession group. The assumption of independence is met for this test. Because although each respondent is allowed to choose multiple professions, the association tested is between each

profession (group)[12] and the choice of learning source, instead of between the professions (groups) or between knowledge types. Therefore, the observations were independent.

Among the actors that identified their professions as University (higher education) and research, significant differences in the frequencies can be seen for discipline-specific knowledge $c2(3, N = 54) = 18, p < 0.001$, and for conceptual knowledge $c2(3, N = 54) = 8.074, p < 0.05$. For practical knowledge, there is no strong preference for interpersonal interaction or written materials, $c2(3, N = 54) = 4.222, p = 0.238$.

Table 6-14 Source of learning: university and research stage

University and Research: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	14	13.5	0.5	16	13.5	2.5	15	13.5	1.5
Interpersonal interaction	24	13.5	10.5	19	13.5	5.5	19	13.5	5.5
Personal investigation	2	13.5	-11.5	5	13.5	-8.5	10	13.5	-3.5
Written materials	14	13.5	0.5	14	13.5	0.5	10	13.5	-3.5
Total	54			54			54		

Within the group of professions at the planning stage, as can be seen by the frequencies cross-tabulated, the preferences for a source of learning are not equally distributed for all types of knowledge. Discipline-specific knowledge $c2(3, N = 104) = 13.769, p < 0.005$, conceptual knowledge $c2(3, N = 104) = 32.154, p < 0.001$, and Practical knowledge $c2(3, N = 104) = 10.615, p < 0.014$. Interpersonal interaction and written materials are more strongly preferred as ways to acquire all types of knowledge.

Table 6-15 Source of learning: planning stage

Planning stage: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	21	26.0	-5.0	13	26.0	-13.0	25	26.0	-1.0
Interpersonal interaction	36	26.0	10.0	45	26.0	19.0	35	26.0	9.0
Personal investigation	13	26.0	-13.0	11	26.0	-15.0	13	26.0	-13.0
Written materials	34	26.0	8.0	35	26.0	9.0	31	26.0	5.0
Total	104			104			104		

At the design stage, actors in these professions also showed strong preferences for using interpersonal interaction and written materials for learning all three types of knowledge. Discipline-specific knowledge $c2(3, N = 192) = 28.417, p < 0.001$, conceptual knowledge $c2(3, N = 192) = 28.542, p < 0.001$, and practical knowledge $c2(3, N = 192) = 22.792, p < 0.001$.

[12] Some professions are grouped together for analysis, any multiple selections within a group counts as one occurrence.

Table 6-16 Source of learning: Design stage

Design stage: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	47	48.0	-1.0	42	48.0	-6.0	53	48.0	5.0
Interpersonal interaction	69	48.0	21.0	70	48.0	22.0	66	48.0	18.0
Personal investigation	19	48.0	-29.0	21	48.0	-27.0	21	48.0	-27.0
Written materials	57	48.0	9.0	59	48.0	11.0	52	48.0	4.0
Total	192			192			192		

Construction professions showed unequal preferences for discipline-specific and conceptual knowledge, discipline-specific knowledge $c2(3, N = 67) = 15.687, p = 0.001$, and conceptual knowledge $c2(3, N = 67) = 11.269, p = 0.01$. There is no such difference for practical knowledge $c2(3, N = 67) = .761, p = .859$.

Table 6-17 Source of learning: Construction stage

Construction stage: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	12	16.8	-4.8	11	16.8	-5.8	14	16.8	-2.8
Interpersonal interaction	26	16.8	9.3	25	16.8	8.3	19	16.8	2.3
Personal investigation	6	16.8	-10.8	9	16.8	-7.8	17	16.8	0.3
Written materials	23	16.8	6.3	22	16.8	5.3	17	16.8	0.3
Total	67			67			67		

For actors who identified as project managers, the frequencies cross-tabulated below show that the distribution is only significantly unequal when acquiring discipline-specific knowledge, $c2(3, N = 48) = 9.167, p < 0.05$. The differences in frequencies are not significant for conceptual and practical knowledge, $c2(3, N = 48) = 5.50, p = .139$, $c2(3, N = 48) = 4.667, p = .198$, respectively.

Table 6-18 Source of learning: Project management

Project Management: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	15	12.0	3.0	14	12.0	2.0	16	12.0	4.0
Interpersonal interaction	18	12.0	6.0	17	12.0	5.0	12	12.0	0.0
Personal investigation	4	12.0	-8.0	6	12.0	-6.0	6	12.0	-6.0
Written materials	11	12.0	-1.0	11	12.0	-1.0	14	12.0	2.0
Total	48			48			48		

For government actors, the unequal distribution of frequencies is not observed in any type of knowledge. Discipline-specific knowledge, $c2(3, N = 45) = 6.644, p = .084$. Conceptual knowledge, $c2(3, N = 45) = 3.089, p = .378$. Practical knowledge, $c2(3, N = 45) = 1.844, p = .605$.

Table 6-19 Source of learning: Government

Government: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	11	11.3	-0.3	10	11.3	-1.3	10	11.3	-1.3
Interpersonal interaction	18	11.3	6.8	16	11.3	4.8	11	11.3	-0.3
Personal investigation	6	11.3	-5.3	8	11.3	-3.3	9	11.3	-2.3
Written materials	10	11.3	-1.3	11	11.3	-0.3	15	11.3	3.8
Total	45			45			45		

Among the actors that identified as neighbourhood committee professionals, unequal distribution of frequencies is only observed in the learning of practical knowledge, $c2(3, N = 34) = 8.118, p < 0.05$. There are no significant differences between the knowledge sources for the other two types of knowledge. Discipline-specific knowledge, $c2(3, N = 34) = 6.941, p = .074$. And conceptual knowledge, $c2(3, N = 34) = 6.235, p = .101$.

Table 6-20 Source of learning: Neighbourhood committee

Neighbourhood Committee: Frequencies

	Discipline-specific knowledge			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	7	8.5	-1.5	8	8.5	-0.5	6	8.5	-2.5
Interpersonal interaction	13	8.5	4.5	10	8.5	1.5	13	8.5	4.5
Personal investigation	3	8.5	-5.5	3	8.5	-5.5	3	8.5	-5.5
Written materials	11	8.5	2.5	13	8.5	4.5	12	8.5	3.5
Total	34			34			34		

Auditing professionals showed a strong preference against the use of personal investigation. For the acquirement of discipline-specific knowledge, observed N = 0 for personal investigation. The frequencies of rest of the three knowledge types are not unequally distributed, $c2(2, N = 22) = .091, p = .956$. [N = 0 for personal investigation, thus skewing the chi-square value]. For conceptual knowledge, the distribution of frequencies is unequal, where the case studies and review articles, as well as interpersonal interaction, are preferred, $c2(3, N = 22) = 9.273, p < 0.05$. There are no preferences shown in the learning of practical knowledge $c2(3, N = 22) = 5.273, p = .153$.

Table 6-21 Source of learning: Auditing

Auditing: Frequencies

	Discipline-specific knowledge(a)			Conceptual knowledge			Practical knowledge		
	Observed N	Expected N	Residual	Observed N	Expected N	Residual	Observed N	Expected N	Residual
Case studies and review articles	7	7.3	-0.3	9	5.5	3.5	9	5.5	3.5
Interpersonal interaction	8	7.3	0.7	9	5.5	3.5	7	5.5	1.5
Personal investigation				1	5.5	-4.5	2	5.5	-3.5
Written materials	7	7.3	-0.3	3	5.5	-2.5	4	5.5	-1.5
Total	22			22			22		

a. Observed N is 0 for Personal Investigation

Actors of professions at the planning and design stages had strong preferences for their sources of learning of all three types of knowledge. On the contrary, government actors do not display unequal preferences in their learning sources for any type of knowledge. Project management professions reported no preferences in conceptual and practical knowledge, the neighbourhood committee actors reported no preferences for discipline-specific and conceptual knowledge, and auditing professionals had no strong preferences in practical knowledge category. Before going into a more detailed discussion of the differences, it is worth noting that the sample size for some profession groups is

very small (auditing, N=22), compared to other profession groups. However, all the expected frequencies are greater than five.

Their preferences reflect the results obtained for all respondents. For acquiring discipline-specific knowledge, all profession groups but government actors and neighbourhood committee actors reported the unequal distribution of preferences. This type of knowledges is usually learned through formal education (technical college, university, continuing education). It is knowledge specific to a discipline or profession, and one who becomes proficient in such set of knowledge may be deemed a specialist in that area (Koehler, n.d.). The results demonstrate written materials (i.e. textbooks, journal articles) and case studies and review articles, which are sources that are able to "tell" the knowledge in the form of texts and figures, are more useful for acquiring this type of knowledge. While both the other knowledge sources or acquiring methods are for more "personal" knowledge, interpersonal interaction is favoured and the actors interviewed found it to be more helpful.

For conceptual knowledge, which is understanding of concepts, principles, theories, models, classifications (Training Industry, 2019), respondents in planning, designing, and construction profession groups again displayed highly significant differences in the distribution of preferences on learning sources and methods. Similar to discipline-specific knowledge, these three profession groups preferred to use written materials and interpersonal interactions, and less of case studies and review articles and of personal investigation. The topics that were listed under this category encompass knowledge from various disciplines, and they are part of the foundation knowledge needed by actors in these professions to engage in any task. Respondents in the auditing group also showed significant preferences, for case studies and review articles and interpersonal interactions.

The topics under practical knowledge require some on-the-job training and learning. Planning and design profession groups displayed highly significant unequal distribution of preferences in terms of learning sources and methods, and personal investigation is the learning source/method that is chosen by much fewer respondents. Respondents from the neighbourhood committee group also displayed a significant difference in distribution (small sample size, personal investigation is less preferred)

6.4 The extent of learning as reported by participants (changes in knowledge level)

This section of the survey intended to measure whether the extent of learning is influenced by the type of knowledge being acquired, the source of learning used, as well as other factors including education level, years of employment, and the professional background. The respondents self-evaluated their level of knowledge regarding the topics as outlined in Table 6-9, both currently after some involvement with Sponge City projects, and retrospectively, before their any participation in any Sponge City project. In this section, the results of the analysis on the variations in the change of knowledge level and the association with various factors are presented.

6.4.1 Self-evaluated knowledge level before project

The mean score of all the respondents (n=387) across all topics is 2.94/5.00. A further breakdown of the mean score for each topic is displayed in the Table below. There is very little difference between the topics and between the knowledge types when comparing the average scores of all the respondents.

Table 6-22 Self-evaluated knowledge level before involvement in Sponge City projects

Discipline-specific knowledge	Mean	Conceptual knowledge	Mean	Practical knowledge	Mean
Urban planning	2.98	GI, LID, SUDS design	2.90	Hydrological modelling	2.80
Landscape architecture	3.04	Sponge City objectives	2.93	Public engagement	2.93
Project management	3.02	GI, LID, SUDS construction	2.87	Adaptation of design to local site conditions	2.88
Construction materials	2.99	Climate change	2.88		
Construction management	2.99	Public-private partnership (PPP)	2.84		
Water sciences/technology	2.96	Stormwater management	2.93		
Architecture/design	2.93				
Municipal engineering	2.98				
Atmospheric sciences	2.89				
Plant arrangement	2.97				
Structural engineering	2.93				
Drainage and water supply	2.97				
Transportation	2.97				
Ecology	3.06				
Column mean	**2.98**	**Column mean**	**2.89**	**Column mean**	**2.87**

When the self-evaluation scores are grouped according to the respondents' education level (self-identified), it can be observed that the self-evaluated scores for all three types of knowledge are the highest for the bottom two levels (<9th grade, and high school), and decreases as the education level rises (Figure 6-1). However, a similar trend is not observed when the resulting scores are grouped by their years of employment (self-identified), as seen in Figure 6-2.

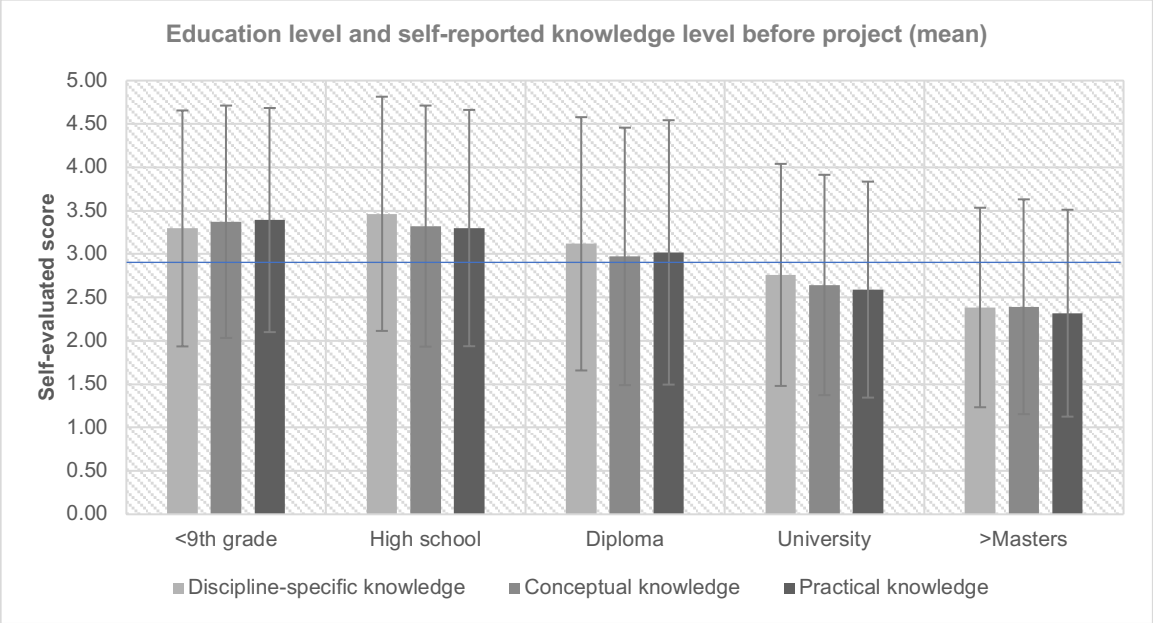

Figure 6-1 The self-evaluated knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by educational level (horizontal line represents the mean of the entire group = 2.94)

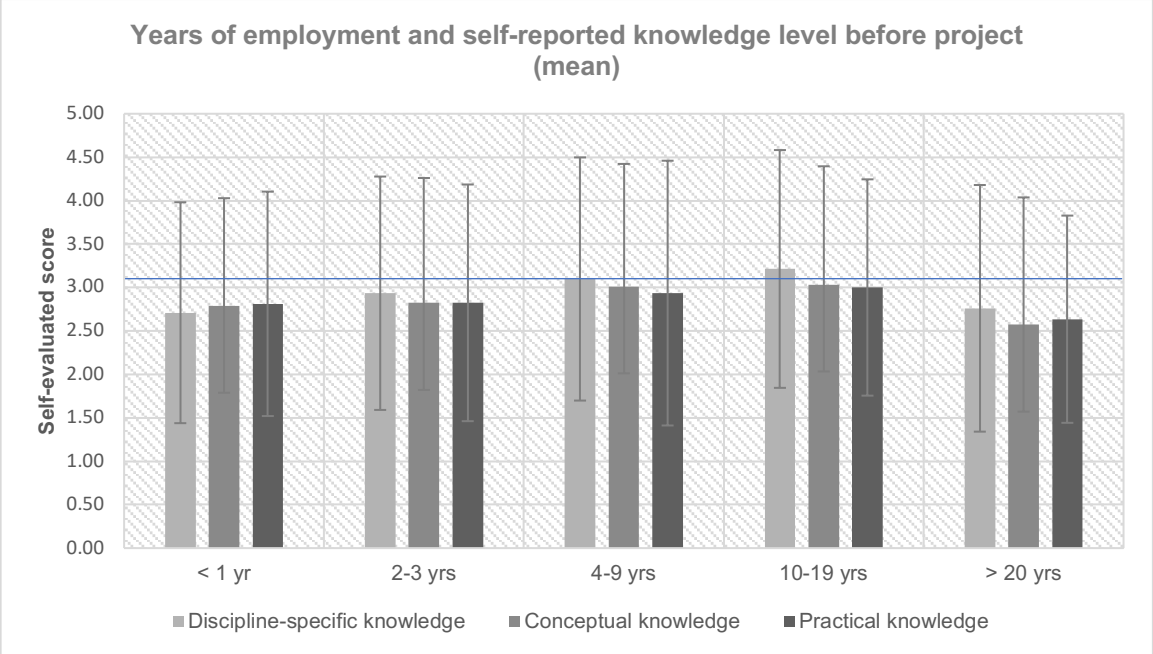

Figure 6-2 The self-evaluated knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by years of employment (horizontal line represents the mean of the entire group = 2.94)

As seen in Figure 6-3, some profession groups have more consistent scoring across different types of knowledge, and some have more variations than others. Notably, the respondents in the University and research profession group gave themselves much lower scores compared to other professions. Comparing the scores within each profession, one can see that discipline-specific knowledge usually received the highest score while the other two have similar scoring. Auditing and Neighbourhood

committee profession groups presented different patterns because their scoring for conceptual knowledge is the lowest. University and research group, on the other hand, has a mean conceptual knowledge score that is the highest amongst the three types. However, considering that the range of score displayed on the x-axis (2.40 – 3.30), the differences between the profession groups as well as between knowledge types are not substantial.

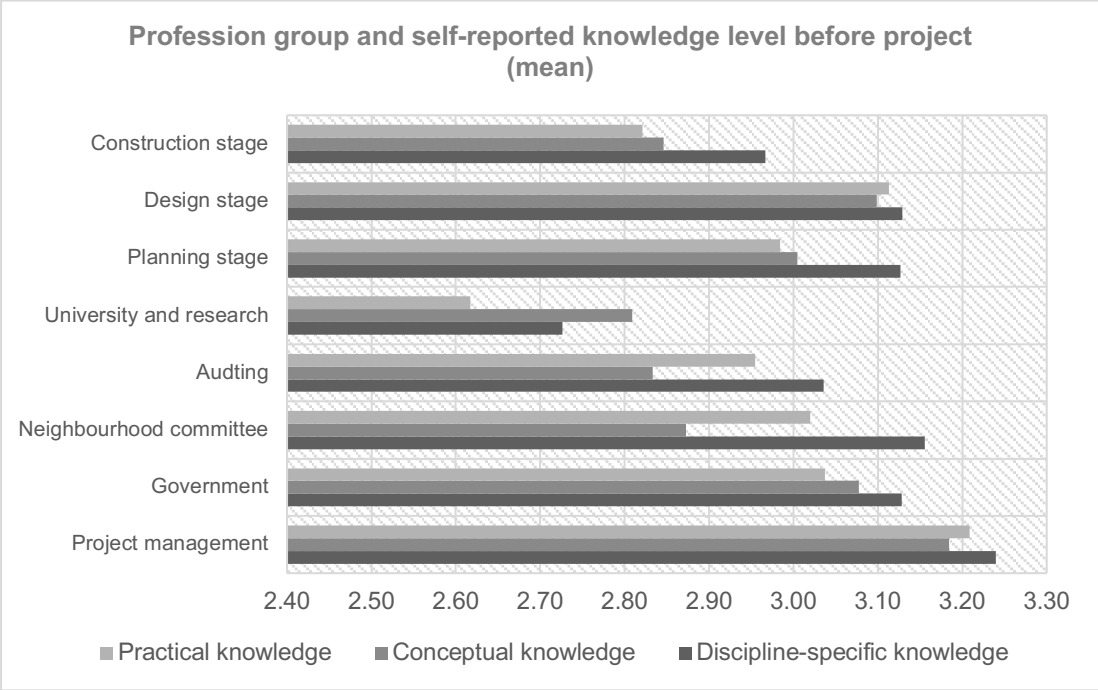

Figure 6-3 The self-evaluated knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by professions

6.4.2 Changes in self-evaluated knowledge level

The last section outlined the results of respondents' self-evaluated score on various topics of discipline-specific, conceptual, and practical knowledge. In this section, the changes that are reported by the respondents are analysed.

Table 6-23 Change to self-evaluated score after some participation in Sponge City projects

Discipline-specific knowledge	Mean	Conceptual knowledge	Mean	Practical knowledge	Mean
Urban planning	0.90	GI, LID, SUDS design	0.90	Hydrological modelling	0.84
Landscape architecture	0.81	Sponge City objectives	0.96	Public engagement	0.88
Project management	0.79	GI, LID, SUDS construction	0.98	Adaptation of design to local site conditions	0.88
Construction materials	0.80	Climate change	0.88		
Construction management	0.83	Public-private partnership (PPP)	0.91		
Water sciences/technology	0.77	Stormwater management	0.85		
Architecture/design	0.80				
Municipal engineering	0.85				
Atmospheric sciences	0.76				
Plant arrangement	0.81				
Structural engineering	0.79				
Drainage and water supply	0.86				
Transportation	0.83				
Ecology	0.84				
Column mean	**0.82**	**Column mean**	**0.91**	**Column mean**	**0.86**

The mean of the changes in score reported by all respondents is 0.85/5.00. The means of each type of knowledge, discipline-specific, conceptual, and practical, are 0.82, 0.91, and 0.86, respectively. If one looks at all the respondents in its entirety, there are no substantial differences between the topics or knowledge types

As the changes in scores are grouped by the respondents' education levels, a trend can be observed where the number of the score becomes larger as education level rises, which is the opposite of what was seen in Figure 6-1. As shown in Figure 6-4, the line represents the mean change in score of the entire group, while the group mean for all three types of knowledge of below 9th grade is well below the global mean, the group means for above Masters are well above the global mean. However, such phenomena cannot be observed when the data are grouped by years of employment, as shown in Figure 6-5.

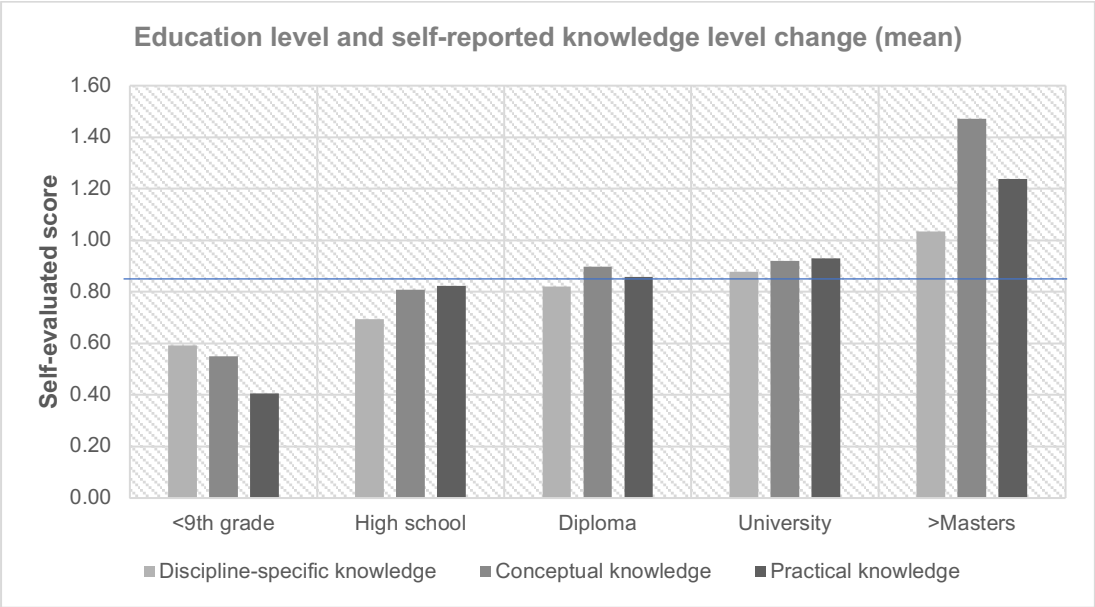

Figure 6-4 Change in self-evaluated knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by education level (horizontal line represents mean of entire group = 0.85)

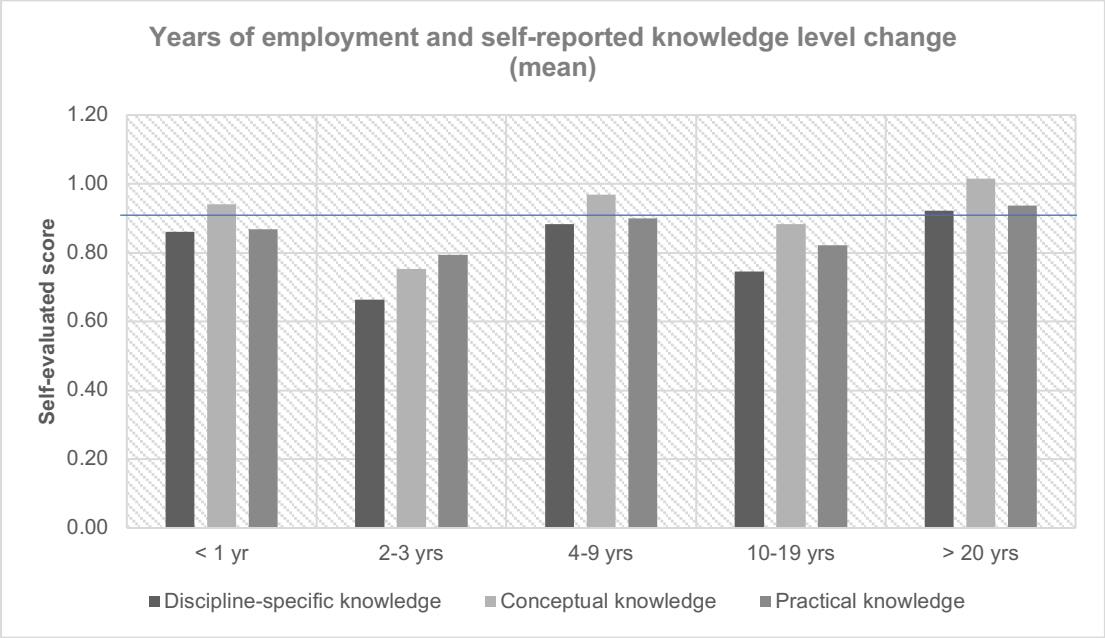

Figure 6-5 Change in self-evaluated knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by years of employment (horizontal line represents mean of entire group = 0.85)

Most profession groups, except for "university and research" as well as "government", the greatest change in score is for conceptual knowledge. For each type of knowledge, the "university and research" profession group has the greatest changes in scores.

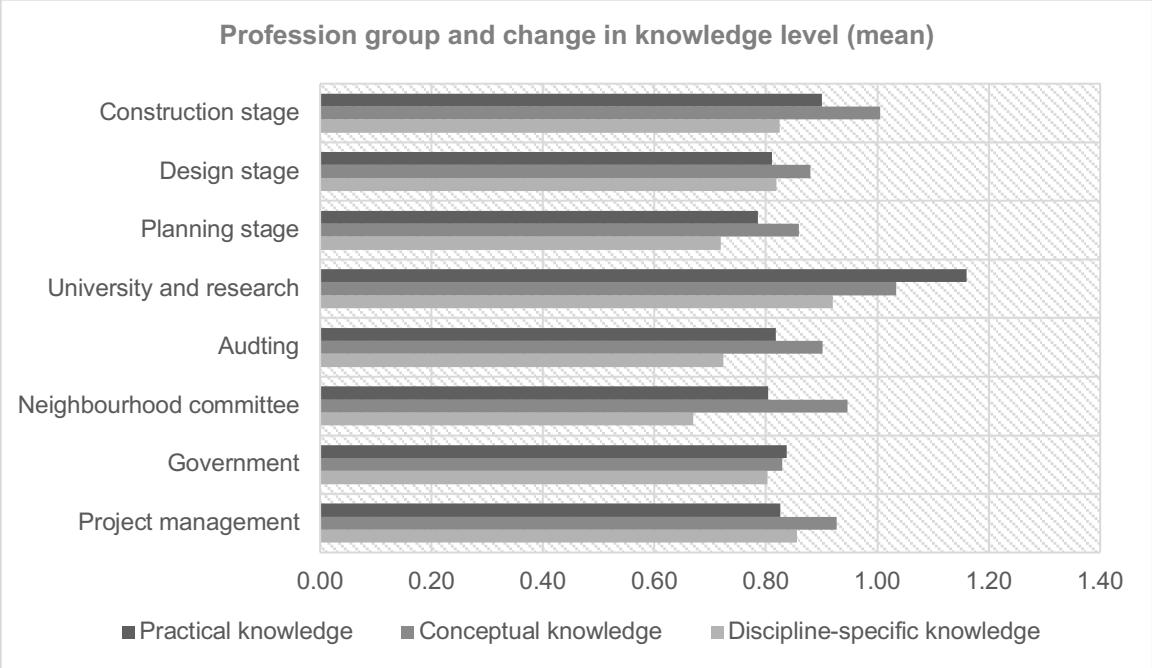

Figure 6-6 The change in knowledge level of discipline-specific, conceptual, and practical knowledge types, as grouped by professions

6.4.3 Source of learning and changes in score

The global mean of the change in score is 0.92, which suggests that the average amount of a respondent's self-evaluated score has changed post-project compared to pre-project.

Table 6-24 Change in knowledge level as grouped by learning sources and methods

Discipline-specific knowledge	Mean	Conceptual knowledge	Mean	Practical knowledge	Mean
Case studies and review articles	0.73	Case studies and review articles	1.04	Case studies and review articles	0.84
Interpersonal interaction	0.95	Interpersonal interaction	0.92	Interpersonal interaction	1.06
Personal investigation	0.59	Personal investigation	0.55	Personal investigation	0.62
Written materials	0.82	Written materials	0.96	Written materials	0.81

For discipline-specific knowledge, interpersonal interaction is a source or method that resulted in higher than the average change in score. For conceptual knowledge, higher than the average change in score is associated with case studies and review articles and written materials. As for practical knowledge, interpersonal interaction is the source that is associated with a higher than the average change in score. The results shown in Table 6-23 do not explain the causation of the variations in the change in scores, because education level, as well as the professional background to a degree, also contribute to the change in self-evaluation. However, while it is uncertain whether and to what extent the choice of learning sources has contributed to the change in self-evaluation of knowledge level, it is certain from the analysis which sources are used by those that identified more significant changes to their own knowledge level.

6.4.4 Adjusted data: change in score and its association with factors

In the survey where the respondents are asked to perform self-evaluation of knowledge level on various topics, the change in score is obtained by calculating the difference between the score after and before the involvement in the projects. On the survey (see Appendix A), the respondents are asked to rate their knowledge level pre-project first, and then post-project. This question order was adopted because when the post-project question is placed before the pre-project question in the pilot study, a number of test respondents made mistakes on the question order. Although this problem was rectified for the actual survey, there are still some respondents that provided a lower knowledge level post-project compared to pre-project, resulting in a negative change in score. There are in total of 112 cases of respondents reporting as least one negative change in score pre-post project. However, 38 cases reported only one negative change in score, out of 23 topics evaluated. As the frequencies calculated show (Table 6-24), only one person reported 22 negative change in a score out of 23 topics, and 99% of respondents reported less than ten negative change in score. It is sensible to speculate that the respondent who had 22 changes in scores that are negative made a reading error, but it is not so clear to whether the rest of the cases occurred because the respondents truly felt a relapse in their knowledge level after the project, or due to respondents' misreading of questions that contributed to measurement errors.

Table 6-25 Frequencies of occurrences of negative change in self-evaluated score pre-post projects

The occurrence of negative change in score	Frequency	Per cent
.00	275	71.1
1.00	38	9.8
2.00	14	3.6
3.00	8	2.1
4.00	11	2.8
5.00	14	3.6
6.00	7	1.8
7.00	4	1.0
8.00	4	1.0
9.00	5	1.3
10.00	4	1.0
11.00	1	.3
12.00	1	.3
22.00	1	.3
Total	387	100.0

When the mean of the score change is re-calculated using the adjusted data, the mean change in scores is 1.05 for discipline-specific knowledge, 1.18 for conceptual knowledge, and 1.15 for practical knowledge. Although conceptual and practical knowledge means increased to a slightly larger extent than that of discipline-specific knowledge, the differences between the three knowledge types remain minimal.

Using the adjusted data, the difference in change of scores due to education level becomes less prominent. In fact, respondents having university and master's degree only have greater changes in score for conceptual and practical knowledge topics. The average change in score across all topics is μ=1.09.

Table 6-26 Mean changes in the score (adjusted) as displayed by knowledge type

Discipline-specific knowledge	Mean	Mean (adjusted)	Conceptual knowledge	Mean	Mean (adjusted)	Practical knowledge	Mean	Mean (adjusted)
Urban planning	0.90	1.18	GI, LID, SUDS design	0.90	1.14	Hydrological modelling	0.84	1.08
Landscape architecture	0.81	1.07	Sponge City objectives	0.96	1.28	Public engagement	0.88	1.19
Project management	0.79	1.01	GI, LID, SUDS construction	0.98	1.24	Adaptation of design to local site conditions	0.88	1.17
Construction materials	0.80	1.03	Climate change	0.88	1.12			
Construction management	0.83	1.04	Public-private partnership (PPP)	0.91	1.15			
Water sciences/technology	0.77	1.04	Stormwater management	0.85	1.16			
Architecture/design	0.80	1.04						
Municipal engineering	0.85	1.05						
Atmospheric sciences	0.76	0.95						
Plant arrangement	0.81	1.03						
Structural engineering	0.79	0.98						
Drainage and water supply	0.86	1.07						
Transportation	0.83	1.05						
Ecology	0.84	1.13						
Column mean	**0.82**	**1.05**	**Column mean**	**0.91**	**1.18**	**Column mean**	**0.86**	**1.15**

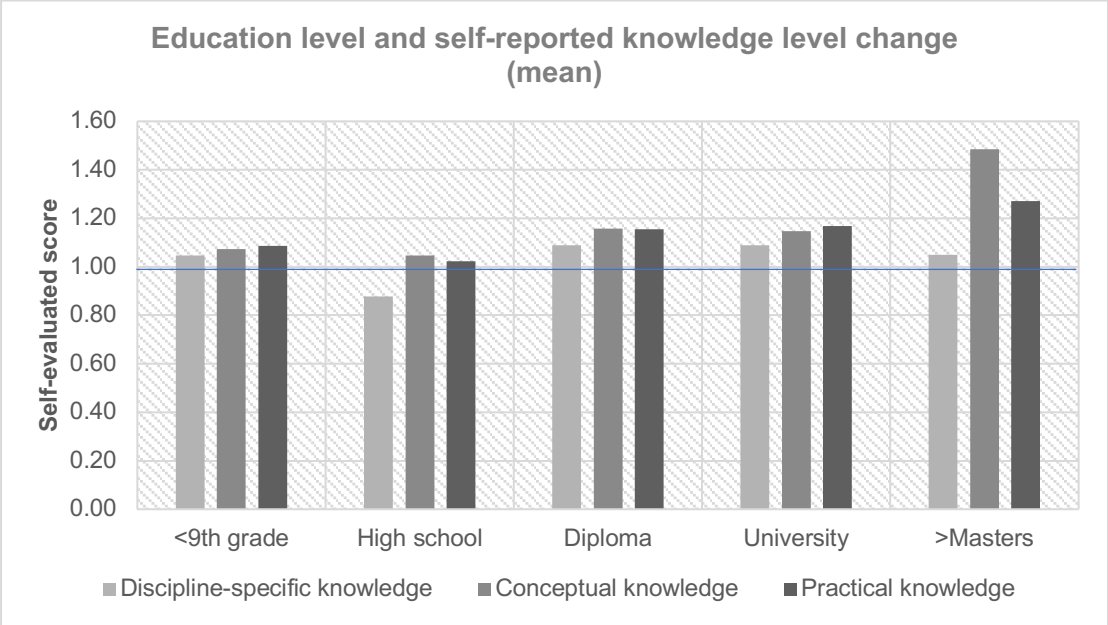

Figure 6-7 Education level and self-reported knowledge level change (mean, adjusted data)

As for years of employment, the change in scores increased for respondents of 2-3 years and 10-19 years of employment history, making the difference between the categories even smaller.

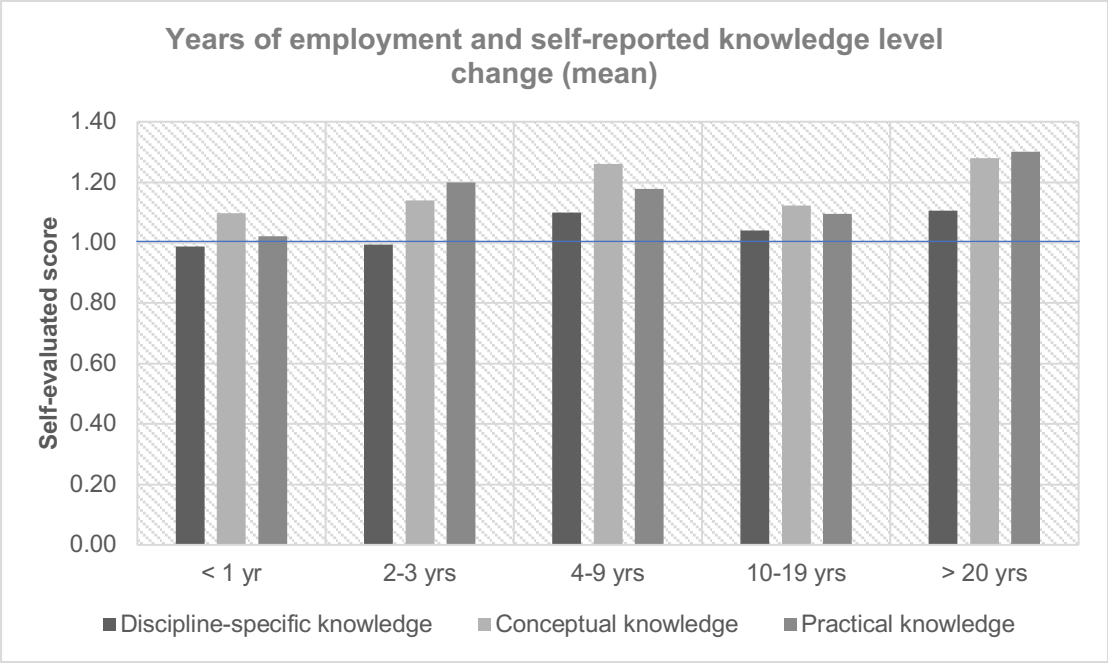

Figure 6-8 Years of employment and self-reported knowledge level change (mean, adjusted data)

The score differences between the profession groups did not change very much, though the positive change is more substantial for profession groups of neighbourhood committee and government.

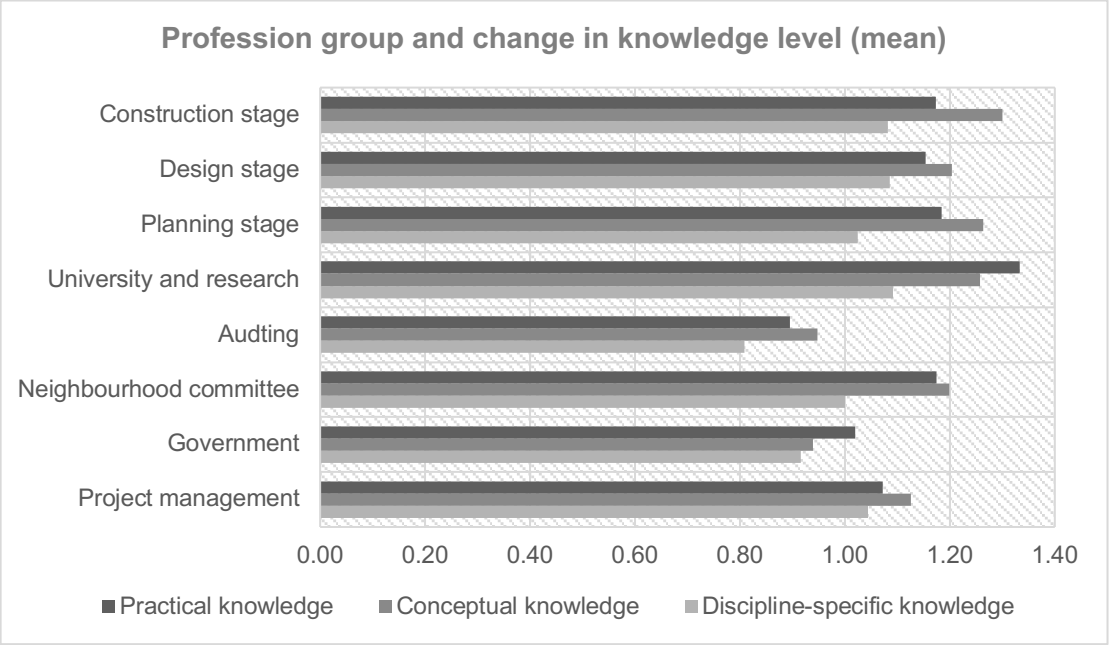

Figure 6-9 Profession group and change in knowledge level (mean, adjusted data)

Using the adjusted data to determine the contribution of different learning sources to change in knowledge level, the preferences on the learning sources for each type of knowledge have not changed noticeably. Personal investigation still contributes to the lowest change in score, while written materials are contributing to a larger change to conceptual knowledge than calculated before.

Table 6-26 Comparison between mean of change of knowledge level before and after adjustment to data

Discipline-specific knowledge	Mean	Adjusted Mean	Conceptual knowledge	Mean	Adjusted Mean	Practical knowledge	Mean	Adjusted Mean
Case studies and review articles	0.73	0.87	Case studies and review articles	1.04	1.18	Case studies and review articles	0.84	1.05
Interpersonal interaction	0.95	1.22	Interpersonal interaction	0.92	1.22	Interpersonal interaction	1.06	1.35
Personal investigation	0.59	0.68	Personal investigation	0.55	0.75	Personal investigation	0.62	0.92
Written materials	0.82	1.13	Written materials	0.96	1.31	Written materials	0.81	1.12

6.5 Limitations

As explained in 6.1.1, the survey respondents are asked to choose all the professions that accurately describe themselves, in order to better reflect the reality of respondents' professional background. However, the trade-off of using this measure of data collection created several limitations for the study.

For all the analyses performed to show the effect of the profession on the self-evaluated knowledge level, the results emerged could be less prominent due to the fact that each respondent was included in the analysis of more than one profession if more than one was chosen. If each respondent limited her choice to a single profession, then the differences in both the before project knowledge level and the change in knowledge levels would have been more substantial between the professions.

For the same reason, the significance of the differences between the profession (groups) is not possible to be tested due to violation of the assumption of independence of variable as a consequence of the survey design. Although the measure of data collection used reduced the survey's capability to draw a conclusion on the relationship between professions and learning preferences (sources and extents of learning of various types of knowledge), it is important to remember that it better captured the distribution of knowledge among all professions involved in Sponge City projects. Some modifications to the survey can be made to more accurately study the effect of professions on the use and learning of knowledge. The question could be modified from asking respondents to make multiple selections to ranking all the professions that apply, which is then followed by open-ended questions aiming to gain a deeper understanding of a person's professional background.

Another limitation is due to the accuracy of the self-reported data, which would affect the accuracy of the profession reported, as well as the score of knowledge level both before and after projects. The respondents were expected to truthfully report their professional backgrounds by selecting all the professions that applied to them. However, the choices of each respondent are dependent on her own understanding of the boundaries of each profession listed, which could be different from that of another respondent. The reporting of a respondent's knowledge level before projects could be distorted by errors in recalling, and the scores of the self-evaluation both before and after projects could be affected by the extent to which a respondent knows "how much she knows and how much she does not know" about a subject. The results of the change in knowledge level could have been distorted if respondents misread the questions or made mistakes on the question order.

In addition, there is a trade-off between recognising the multi-disciplinarity of one's knowledge base and needing to categorise a person for statistical analyses. Based on the scoping interviews conducted early in the research process, it was found that practitioners in one profession (ex. Urban planning) were from various disciplinary training backgrounds (ex. Urban planning, landscape architecture, civil engineering). In order to realistically reflect the influence of the knowledge an actor possessed on her choices of learning, instead of the influence of any arbitrarily defined discipline, the researcher believed it was more meaningful to ask respondents to report all the disciplines instead of choosing one group of knowledge that they possess. This decision, however, reduced the variability and significant differences between the disciplines, since the same person may be accounted under multiple disciplines. On the other hand, any statistically significant differences between disciplines under these circumstances mean that the differences are quite substantial. However, the study could have improved on the quality of results by asking the respondents to rank the disciplines provided. This is an oversight of the survey design and should be improved upon in future studies.

Lastly, the survey was initially constructed in English and then translated into Mandarin Chinese with the help of native speakers. However, misalignment of meanings of the terms used could still be a factor influencing the accuracy of the survey results. This limitation was accounted for and was discussed in the analysis.

6.6 Summary of findings

6.6.1 Tacit or explicit

The initial assumption of this research was that some people might rely more on the use of knowledge that draws from experience and personal, subconscious sources (tacit), and others rely more on knowledge that comes from conscious thinking and reasoning, or the type of knowledge that we can know that we know (explicit). However, the results of the survey show no evidence of respondents preferring to use a more tacit or more explicit type of knowledge. This is a confirmation of Polanyi's notion of tacit knowledge being "an indispensable part of all knowledge" (Polanyi, 1966: 20) that the respondents relied on a combination of explicated knowledge on various media, as well as prior personal experience and subconscious understanding to accomplish tasks in Sponge City.

6.6.2 Source of learning

Overall, one can conclude that there are highly significant differences in the distribution of choices of sources, but this distinction is not between text-based or person based. There is no significant relationship between education level and source of learning, or between years of employment and source of learning. Though the professions did have an influence over the respondents' choice. Most of the profession groups reported a preference for interpersonal interaction and written materials for learning the discipline-specific type of knowledge. Professions who have tangible experiences applying Sponge City concepts and principles to projects also preferred interpersonal interaction and written materials to learn conceptual knowledge and practical knowledge. Actors in government displayed no such preferences. There are significantly fewer respondents choosing personal investigation as a learning source or method. Taking into account the limitations due to the translation process, one can still perceive that respondents find it more useful to learn directly from the text or another person, and less useful (or less used) to learn indirectly from looking and searching.

6.6.3 Extent of learning

The respondents were asked to rate their knowledge level before and after their participation in Sponge City projects. It was found that an increase in the education level (highest degree achieved) is associated with a decrease in the self-evaluated level of understanding of a topic, but with an increase in the amount of change in knowledge level. However, there is no such association with the years of employment. Most profession groups thought they had a better grasp of the discipline-specific type of knowledge than conceptual knowledge, but respondents that identified with university and research organisations on average rated themselves higher on their level of conceptual knowledge. When looking at the comparison between profession groups of the average change in knowledge level,

university and research organisation respondents had the highest change in practical knowledge level while others increased the most in conceptual knowledge. Written materials and interpersonal interactions are the learning sources or learning channels that contribute the most to a larger increase in the level of all three types of knowledge.

7 Access and utilisation of knowledge and social resources in the Sponge City network

This chapter examines the access and utilisation of knowledge in the Sponge City network by the actors. The sections 7.2-7.4 of this chapter address the research objective b) to uncover the factors influencing knowledge transfer between actors from different professional backgrounds. Section 7.5 addresses research objective c), which aims to evaluate how urban planning is perceived by professions in urban water management in China and the impacts it produced on knowledge transfer. The semi-structured interviews with actors from various Sponge City professions are analysed using the theoretical framework derived from the conceptual models of social capital by Lin (2017) and Nahapiet and Ghoshal (1998). The theoretical framework of social capital considers tacit knowledge to be a type of socially embedded resource that can be accessed and mobilised when actors socialise one another. This socialisation process is sustained as long as enough knowledge is being exchanged or transferred. The process may take different shapes depending on structural, cognitive, relational preconditions, and the collective assets that influence a large percentage of the population, so the clarification of this process will be the focus of this chapter.

7.1 Background: actor description

The quality of interaction between actors can depend on many conditions, regarding the actors (giving and receiving), the knowledge being exchanged, and the dynamics of the interaction. There are several steps to explain how the differences in individuals' experiences and opinions on interdisciplinary collaboration influence the outcomes of the interactions, and whether certain enabling or hindering conditions for knowledge exchange can be universally applied or only to a specific set of individual characteristics. The first step of the analysis should be to describe the unique characteristics of each actor including their roles, attitudes and experience in interdisciplinary collaboration, as well as personal opinion on the challenges in their work with collaborators. This will be followed by the description of the actors' understanding of the objectives that Sponge City initiative is aiming to achieve, as well as what they believe the role of urban planning is playing.

The actors interviewed can be divided into five groups based on their professions, as determined by the type of organisation in which their work is based. The groups are the following: university, government, private sector, professional organisations. The distinction between companies and professional organisations is made by whether an organisation is affiliated with a government bureau or commission; if not, then it falls under the "private sector" category. Many actors work under different titles and the group that the actor belongs to derives from his or her main title.

In this section, the interview participants in each group are being described based on three sets of characteristics: academic disciplines, project stages, and personal characteristics.

7.1.1 Description of actors' background

There are ten (10) interviewees from four different universities (denoted by U1-U10). Often in the universities, the higher education model in China (production, education, research) gives the staff opportunities to work in the private sectors, especially since it is a common practice for universities to establish planning and design companies. There are four professors/associate or assistant professors, four students that discussed the projects they were involved in during undergraduate or master's studies, and one person who is a recent PhD graduate and became a staff member that works with one of the professors interviewed. The staff members have been doing research related to green infrastructure and low impact development for several years to over a decade. The students are recent graduates, and they have had the opportunities to work on Sponge City projects from the start of the initiative as part of a research project team or for one of the university's companies.

University A Actors U1 and U2 are from the same university, which will be referred to as University A, which is one of the top architecture universities in Beijing. Actor U1 describes the university in the following fashion:

> **"Although our university doesn't have a very high ranking, since we have been doing [LID] for so long, we have a good relationship with the MOHURD, and since one of our campuses is very close to the MOHURD, we maintained a good relationship with them, we often collaborate with them. (U1)"**

The staff from these universities are well known for their work in urban stormwater and environmental engineering, and their close relationship with the MOHURD allowed them to be closely involved in Sponge City initiative from a very early stage, and help to shape the scope and technical foundation of Sponge City.

University B Actors U3 – U6 work for the same university which will be referred to as university B, which is one of the top-ranking universities in China and has a high reputation and credibility among the public. All the actors interviewed know each other personally, and have worked in the same lab or for the same professor at different times. They all were involved in Sponge City projects while they were studying for Master's degree (which is a three-year program in China), and three out of four have worked on at least one of the pilot cities. All of them had the opportunities to work on these projects because their dissertation advisor and other researchers in the same university have been doing research and are recognised as experts in the field of urban design and landscape architecture, and suggested in the interviews:

> **"Our professor […] is the landscape architecture expert on the expert panel for sponge city. He is one of the only two. [The other expert] specialises in suburban areas, wetlands. Therefore, our professor […] is the one that is specialised in sponge city implementation in urban areas. (U4)"**

> **"[I was involved] mainly because my dissertation advisor accepted some works on the national pilot projects, as well as because some researchers in [my university] are doing some of their experiments on the university campus. I was a graduate student back then, and I mainly participated in the design works. (U5)"**

University C Actors U7 – U10 are from the same university referred to as university C, which is a high-ranking university, especially in the field of landscape architecture. The university has two affiliated design firms, and many staff members are juggling between academic and business responsibilities.

> **"Since the technical guideline came out in October 2014, there have been changes. Almost all the green spaces projects need to incorporate sponge city concepts and techniques. Therefore after 2014, [we] have been having a lot of projects…I feel good about how we approach sponge city from a landscape architecture perspective, and we should be one of the pioneers doing this. (U10)"**

Graduate and undergraduate students alike can choose to work on projects from the design firms of their own university or of another university (for example University B).

> **"This is the professor's project. We are responsible for many tasks under that project. I am in direct contact with [my project supervisor], who is a sponge city expert and professor in landscape architecture in [University B], as well as graduate students and research assistants. (U7)"**

There are four interviewees from four (4) different professional organisations (denoted by P1-P4). These organisations are different from private companies in several ways, even though they are legally corporations. These organisations are affiliated to and were once part of government bureaus or commissions. They maintain close relations with their affiliated bureaus or commissions, and they often assist the government on policymaking and distribution and are the forerunners on the dissemination of policies and regulations by leading the application and providing training to local government and practitioners.

Actors P1, P2, and P3 are from planning institute, and P4 is from a research institute. P1 and P4 did not agree to participate in a recorded interview, so only the responses to the standards questions and the description of the actor's immediate network are available. These two actors are the only ones that did not give their consent to being voice recorded.

P2 and P3 are working for the same organisations but in different departments/divisions. They give the following descriptions of their organisation, which highlight the active and early involvement of the organisation in the Sponge City projects.

> **"We provide a fairly complete set of service, from policymaking, to making standards, teaching how to make plans, giving training sessions across the country, doing all kinds of plans, design consulting, assessing projects across the country, etc." (P2)**

> **"Since we work in an urban planning institute, and a national one, so we started to get involved in sponge city from a very early stage. The earliest among us was involved since the application stage of the first batch of pilot cities." (P3)**

There are 23 people interviewed from nine (9) companies in the private sector (denoted by C1-C23). Each company tends to specialise in one or two stages of the project, and this will be elaborated on in later sections. Some of the companies listed here are also closely linked with the local municipal government, much like the organisations in the previous group.

Company 1 (C1-C4,) Company 9 (C20-C23) Company 1 is a large-scale construction general contractor company who has recently started to incorporate sustainability design and consulting services. It has formed an SPV (Special-Purpose Vehicle) under public-private partnership (P3) along with Company 9 - a company specialises in water resources and infrastructure.

Company 2 (C5), Company 4 (C8, C9), Company 7 (C14-C18) Companies 2 and 4 are construction contractors working with Company 7. C5 is working on a different site than C8 and C9, but all of them have a background in building construction and are new to water infrastructure construction. Company 7 specialises in engineering design of municipal infrastructure.

Company 3 (C6, C7) Company 3 is affiliated with a top university in China where the researchers are actively working on Sponge City related projects. It is a planning and design company

Company 5 (C10-C12) Company 5 is a small scale, newly formed landscape architecture design company, but the senior members are experienced and have worked on multiple Sponge City projects previously.

Company 6 (C13) Company 6 is a company that provides integrated services including design, construction, material supply, and research, so it is an integrated supply team. It is the only actor in this group that belongs completely to the private sector with no affiliation to any municipal government.

Company 8 (C19) Company 8 is a large-scale landscape architecture design company and has been a forerunner in green infrastructure design and implementation.

G1 is the only actor in the municipal government that agreed to be interviewed. The actor is employed under the Bureau of Construction in one of the pilot cities, and the department is a member of the Sponge City Bureau. The main job, as described by the actor, is the management of Sponge City projects.

7.1.2 Description of actors' fields of study and stages of involvement in the project

Actors U1-U10 are in a relatively closed group due to the sampling process used (snowballing). Therefore, it is no surprise that most of the actors have a background in landscape architecture. Despite having similar disciplinary backgrounds, the actors do not usually work closely with each other, so their work and research experiences and environments can be very different.

> **"I come from a cross-disciplinary background, I majored in landscape architecture, and I have been doing water-related work in the past few years, so my perspective is neutral. (U1)"**

Actors in the urban planning sector (or working on Sponge City related plans) are predominantly from either urban planning or engineering or both backgrounds.

Actors in this group come from a variety of disciplinary background. There is a pattern that emerges from the following table. The discipline of actors who work as construction general contractors and sub-contractors is construction management and engineering. The rest who work on design tend to be a mixture of landscape architecture, planning, and civil/environmental/water resources engineering.

All the actors in group 1 are involved in the early stages of Sponge City projects. Apart from the teaching and research works as expected of academic staff and students, all the actors interviewed

were involved in plan-making and design. U1, U2 have performed project consulting or technical support for one or more pilot cities, where they would follow the project from beginning to end.

> **"Every pilot city is a bit different. We provide technical support and guidance for the entire pilot project area (in the case of Ning Bo it's more than 40 km^2), including all the sponge city procedures-policy, laws and regulations [interpretation], design, construction, checking, monitoring and maintenance. Our team is involved in 30 cities overall, and we did project consulting for about eight cities. In other cities, we did some parts of planning, design, and monitoring, etc." (U2)**

Actors in this group tend to be engaged in the projects at relatively early stages, and they remain on the projects for multiple stages. They tend to also serve as technical support or technical consultant to the cities with which they work. In this case, they would usually follow the projects from either very beginning stage of preparation/planning or at the beginning of design, to the end of the project cycle.

In the private sector group, actors whose main stage of focus is construction and implementation/management stages usually work on one stage only, while those who work on design may also work on planning (or vice versa). Those that work on technical consulting for a city would usually also be working on either planning or both planning and design.

Table 7-1 Academic disciplinary background of actors interviewed

Actor	Disciplines	
U1	Environmental engineering	Landscape architecture
U2	Water resources engineering	
U3	Landscape architecture	
U4	Landscape architecture	
U5	Landscape architecture	
U6	Landscape architecture	Industrial design
U7	Landscape architecture	
U8	Landscape architecture	
U9	Landscape architecture	
U10	Landscape architecture	
P1	Civil engineering	
P2	Urban planning	Environmental engineering
P3	Urban planning	
P4	Civil engineering	Planning
C1	building/subway construction management	
C2	building/subway construction management	
C3	building/subway construction management	
C4	Construction engineer	
C5	Construction engineer	
C6	Water resources engineering	
C7	Water resources engineering	
C8	Construction engineer	
C9	Construction engineer	
C10	Environmental engineering	
C11	Landscape architecture	
C12	Landscape architecture	
C13	Environmental engineering	
C14	Civil Engineering	
C15	Civil Engineering	
C16	Landscape architecture	Architecture
C17	Urban planning	Architecture
C18	Environmental engineering	
C19	Landscape architecture	
C20	Environmental engineering	
C21	Project management	
C22	Environmental engineering	
C23	Landscape architecture	
G1	unclear	

Table 7-2 Stages of participation of each actor interviewed

Actor	Project stages			
U1	Design	Planning	Consulting	
U2	Design	Planning	Consulting	
U3	Design	Research		
U4	Design			
U5	Design			
U6	Design			
U7	Design			
U8	Design	Planning		
U9	Design	Planning		
U10	Design			
P1	Planning			
P2	Technical support	Design	Planning	
P3	Planning	Technical support		
P4	Design	Planning		
C1	Construction			
C2	Construction			
C3	Construction			
C4	Construction			
C5	Construction			
C6	Design	Planning	Consulting	
C7	Planning	Consulting		
C8	Construction			
C9	Construction			
C10	Design			
C11	Design			
C12	Design			
C13	Design	Planning	Construction	Product development
C14	Design			
C15	Design	Planning	Consulting	
C16	Design	Planning		
C17	Design			
C18	Design			
C19	Planning			
C20	Implementation management			
C21	Implementation management			
C22	Implementation management			
C23	Implementation management			
G1	Planning	Design	Consulting	

7.1.3 Definition and objectives of Sponge City from actors' perspectives

This section takes a look at the interviewed actors' perspectives on the definition and objectives of Sponge City, as well as to which extent they have incorporated the elements presented in the Technical Guideline for Sponge City – Low impact development Stormwater management system construction (provisional) (2014). The responses of the actors usually contained one or more of the following, from strict extraction from the Technical Guideline to actor's personal interpretation.

A. Protection, restoration, and repairing of natural water bodies and urban ecological environment, and tackle urban water problems, as well as urban development problems
B. Low impact development concepts should be followed, and its objectives and measures should be integrated into the city's overall planning and construction
C. Should consider low impact development of rainwater system, urban water drainage system, as well as excessive stormwater runoff drainage system
D. Sponge city projects should engage and mobilise various organisations, disciplines and professions
E. Actor described Sponge City as a concept or an approach towards solving problems regarding urban drainage and urban development.

As expected, most actors interviewed described the fundamental definition of Sponge City as presented in the Technical Guideline at national, provincial, and city levels. Statements B and C both relate to LID, so most actors chose either the LID concept should be followed or considered. Statements D and E are not elucidated in early government documents, so the actors who provided a definition of this type most likely sourced from their existing knowledge and experience.

Table 7-3 Actors' understanding of the definition and objectives of Sponge City from their perspectives

Actor	A	B	C	D	E
U1				✓	
U2	✓			✓	
U3	✓				✓
U4	✓				
U5	✓	✓			
U6	✓	✓			
U7	✓			✓	
U8	✓		✓		✓
U9			✓	✓	
U10	✓		✓	✓	✓

(Continued)

Table 7-3 (continued)

Actor	A	B	C	D	E
P1	✓		✓	✓	✓
P2	✓		✓		✓
P3	✓		✓		✓
P4	✓	✓			
C1			✓		
C2	✓		✓		✓
C3			✓		✓
C4					
C5			✓		✓
C6	✓		✓	✓	
C7	✓		✓		✓
C8			✓		
C9			✓		
C10		✓	✓	✓	✓
C11	✓	✓			✓
C12	✓	✓			
C13	✓				
C14					
C15	✓	✓	✓		✓
C16	✓			✓	✓
C17	✓				✓
C18	✓		✓	✓	
C19	✓			✓	
C20	✓			✓	
C21		✓		✓	✓
C22	✓		✓		
C23					✓
G1	✓	✓	✓		✓
	26	9	19	13	18

7.2 Access to social capital

The structural dimension of social capital describes a cluster of facets that concern the physical characteristics of a network. Nahapiet and Ghoshal (1998) included in this cluster the network ties, network configuration, and appropriability, where the ties provide channels for information flow, configuration describes the network structure in terms of its density, connectivity, and hierarchy, and appropriability points to the ability of a network formed under one context to function as well in another context. Inkpen and Tsang (2005) in their studies added a facet of network stability, which is defined by them as the change of membership in a network, where a network's ties weaken when members frequently come and go. The characteristics of the structural facets determine the ease and difficulty in knowledge exchange in the network. Section 7.2.1 provides a more in-depth description of different network patterns and configurations and their benefits and challenges.

In this section, the pattern of relationships at different stages of Sponge City is examined. During the interviews, the actors were asked to identify other actors with whom they interacted and exchanged information. The participants were not asked to recall the names of individual actors. Instead, they identified the organisations or groups of individuals. A Sponge City network consists of some features of intracorporate network, strategic alliance, and industrial district[13], because the same actor or groups of actors may simultaneously be operating and interacting with actors in an intracorporate network, a strategic bi/multi-lateral alliance network, and an intimate network of independent organisations in related sectors in close locations. Therefore, the network may display structural characteristics of all three types of network.

While this dimension primarily concerns the structure of the network ties, the construct of social capital considers the quality of the ties between actors as well. While the analysis of this section focuses on the structural dimension, it is important to keep in mind that the structure and the quality of the network ties are interrelated and have mutual influences.

7.2.1 Network ties

The actors are divided into groups based on the project stage for which they have described their networks. Actors recalled other main actors that they interacted with during a project stage. This had two consequences; firstly, the diagram does not provide an exhaustive list of actors that each person has come to contact with, and secondly, the ties are uni-directional. The diagrams of dyads below display the network ties at each stage, which aid the analysis of the accessibility of information.

[13] Inkpen and Tsang (2005) distinguished three network types in their studies; intracorporate network is conceptualised as an interorganisational grouping of a unified corporate identify; strategic alliance describes a group of firms that enters into "a voluntary arrangements that involve exchange, sharing, or codevelopment of products, technologies, or services"; and industrial district refers to a network of independent firms that "operate in the same or related market segment", and occupy a shared geographic locality.

All actors interviewed but one that works in a university environment identified other actors in the category of university and research organisations (Figure 7-1). While each actor is linked to different sets of other actors or groups of actors depending on the nature of the project she is involved in, what these actors had in common was their connections to actors in university and research environment. This commonality may be able to facilitate better and more comfortable interactions, and being able to reach in the proximity other actors having similar disciplinary or educational background could have an effect on relational and cognitive facets as well. The actors interviewed had or recalled no immediate/direct interaction with other actors in the national ministries, technical committees, consulting companies, auditing companies, property developers, property management/community committees, or residents. Though, they may have had indirect interaction with some of them, including the national ministries, local government bureaus and residents.

At the design stage, one can see that some actors are more well connected than others. As the diagram shows (Figure 7-2), the highly connected nodes are construction companies, city/provincial government bureaus, property management/community committees, site supervisors, and other designers or design engineers. Those interviewed did not report immediate interaction with others in the categories of technical support centre/companies, surveyors, property developers that are engaged more frequently at pre-design phase, as well as with actors in auditing companies and material and equipment providers that are usually engaged at the end or after the design phase.

All the actors at the planning stage are directly interacting with the city and provincial-level government bureaus (Figure 7-3). In fact, they must work very closely with them. Other highly connected nodes are district-level government bureaus, designers and design engineers, and residents. Sponge City bureau is engaged with by many actors, but it is possible that while all the actors are connected with them, but some categorised the bureau with the city government bureaus. In the interviews, the actors did not recall direct or immediate connections with the technical committee, technical support centre/company, surveyors, consulting companies, auditing companies, or property management/community committees.

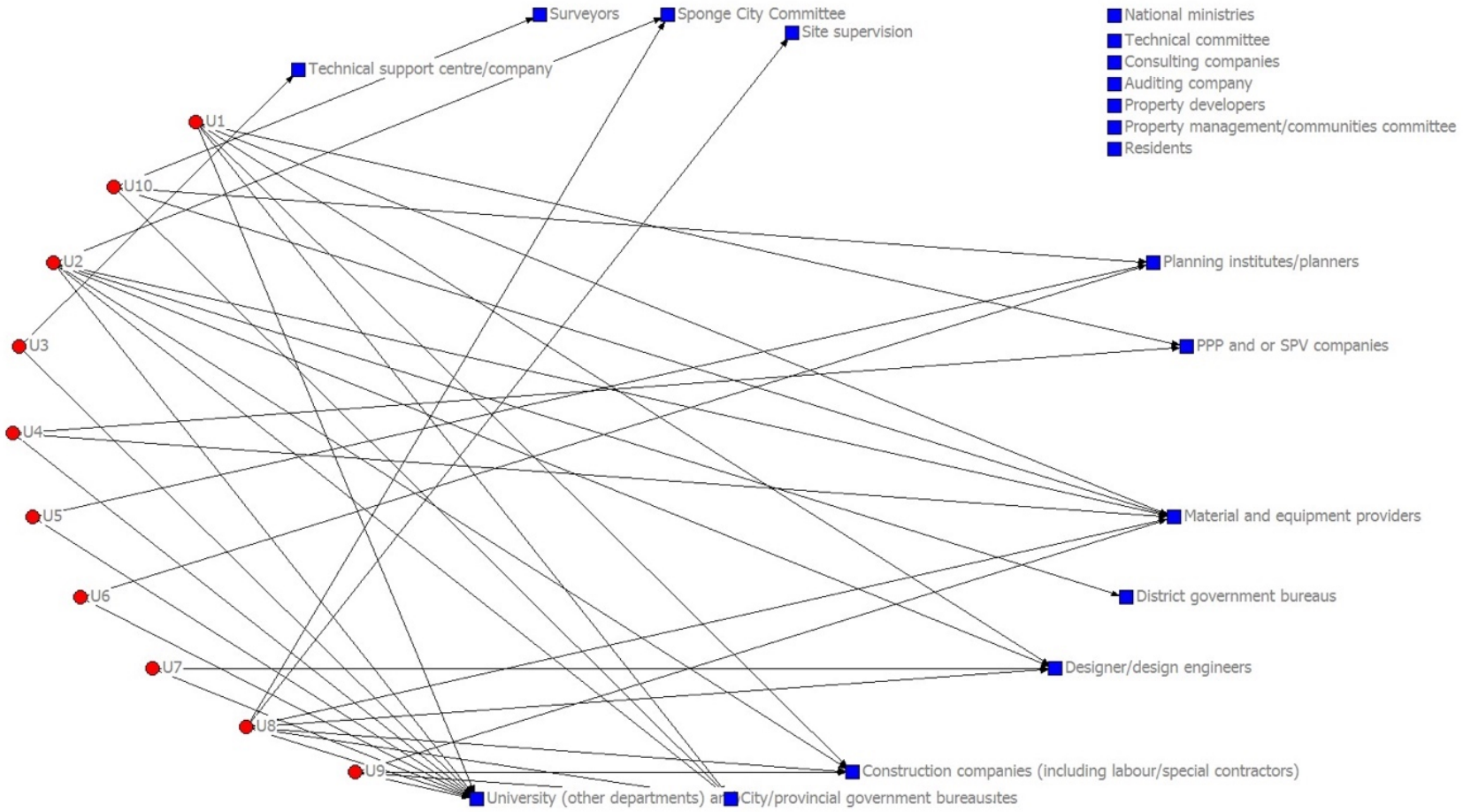

Figure 7-1 Network map: university dyads

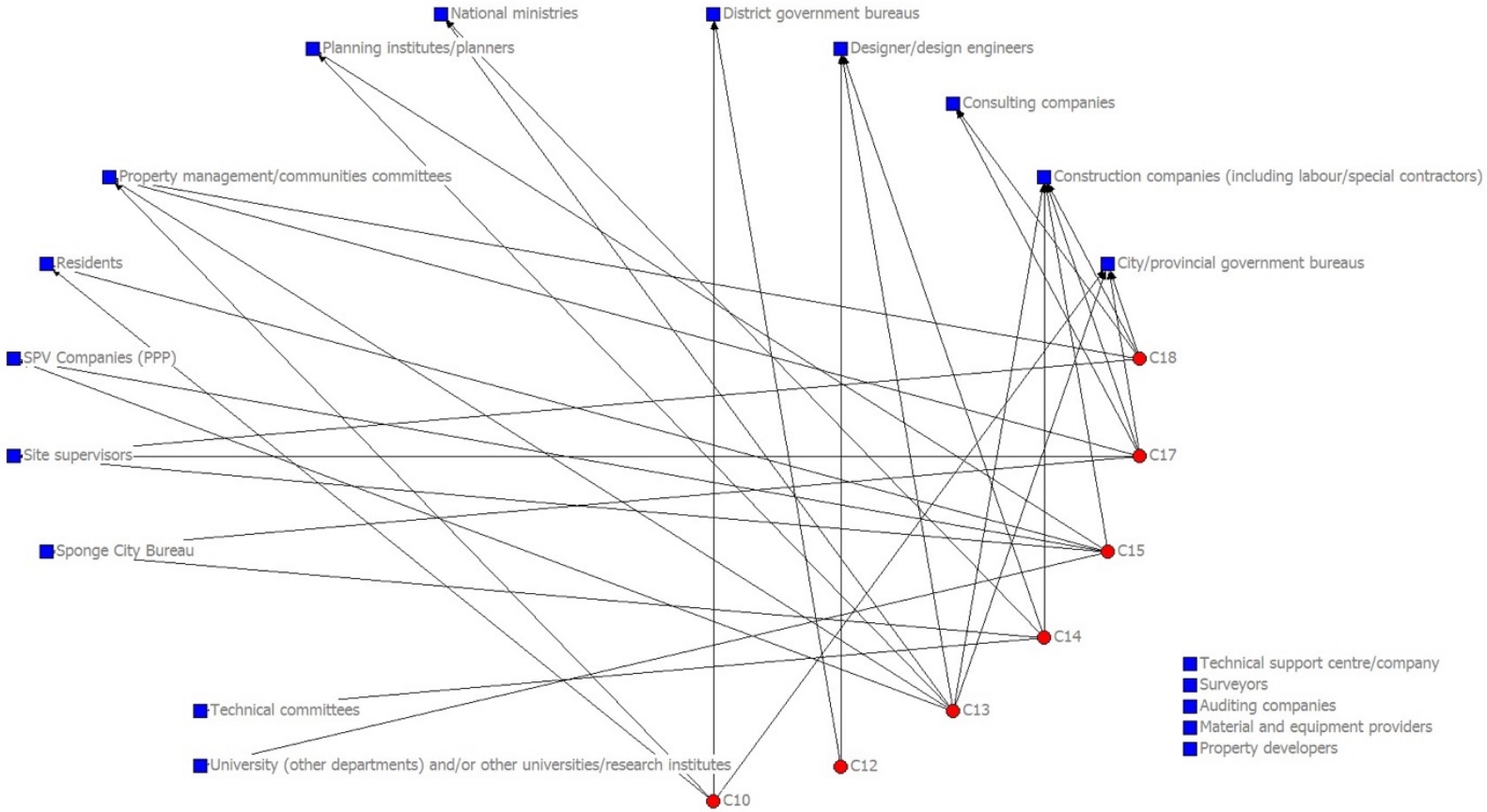

Figure 7-2 Network map: Design dyads

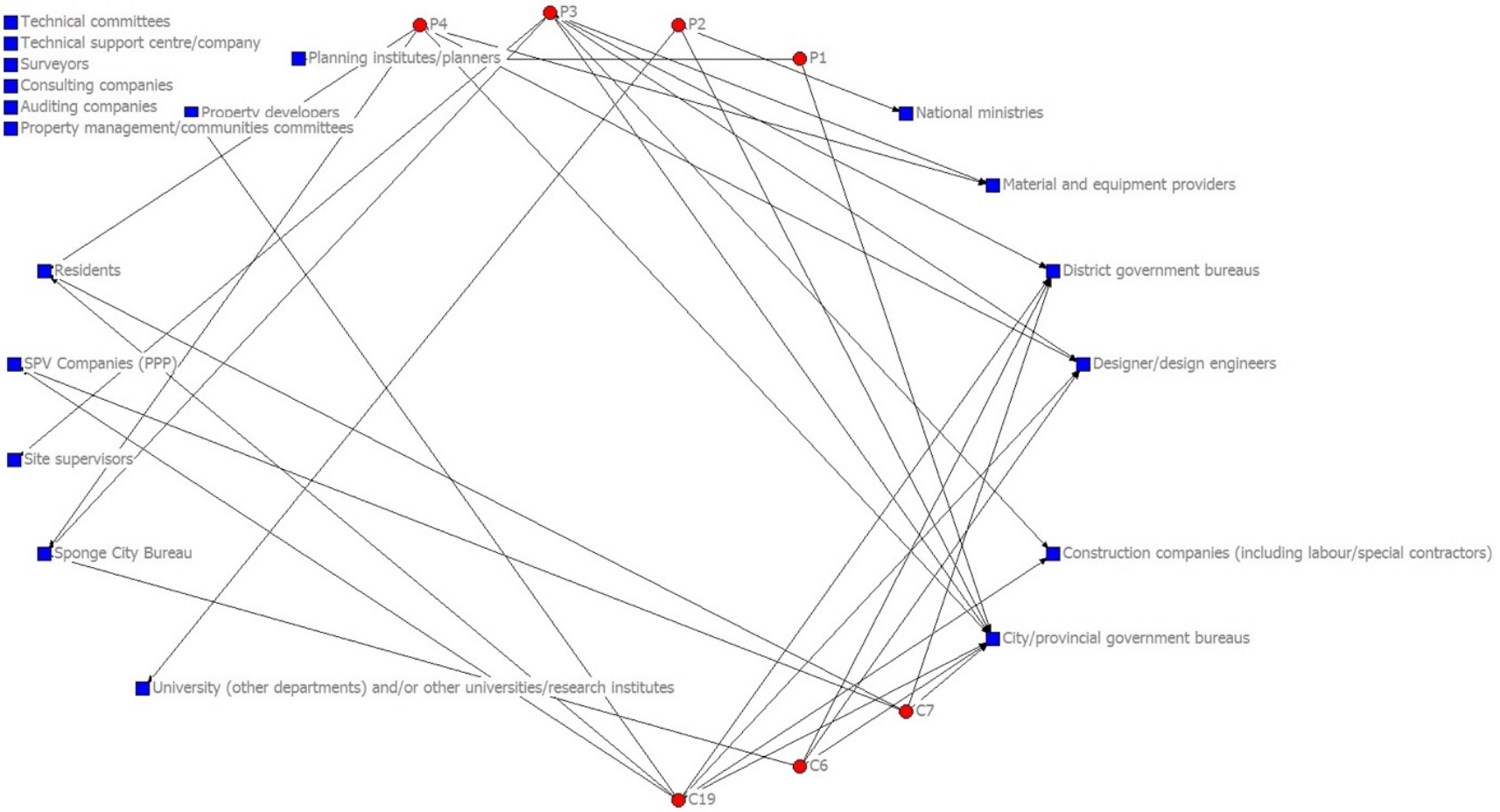

Figure 7-3 Network map: Planning dyads

Actors from PPP and SPV companies may get involved in a Sponge City project at different stages, and they may be involved in different numbers of stages (Figure 7-4). Therefore, they are analysed as a separate group. The most connected nodes, as displayed below, are designers/design engineers, Sponge City committee, and city/provincial government bureaus. Some actors also engage with construction contractors directly. Categories of actors that were not recalled in the interviews are university and research organisations, national ministries, technical committee, and property developers.

At the construction project stage, actors interviewed were from two projects located in two different cities. They are all directly engaged with designers/design engineers, property management/community committees, residents, site supervisors, as well as other construction contractors on the same project. Many revealed in the interviews that they spend more than usual time and effort on communicating with residents, their representatives, and property and community management, but many of the interactions should actually be made indirectly through Sponge City committee or district/city bureaus. Although they are in frequent contact with the Sponge City bureau, the actors did not list district or city level government bureaus as direct ties. Other categories that were not mentioned include the national ministries, technical committee, planners, property developers, and university/research organisations.

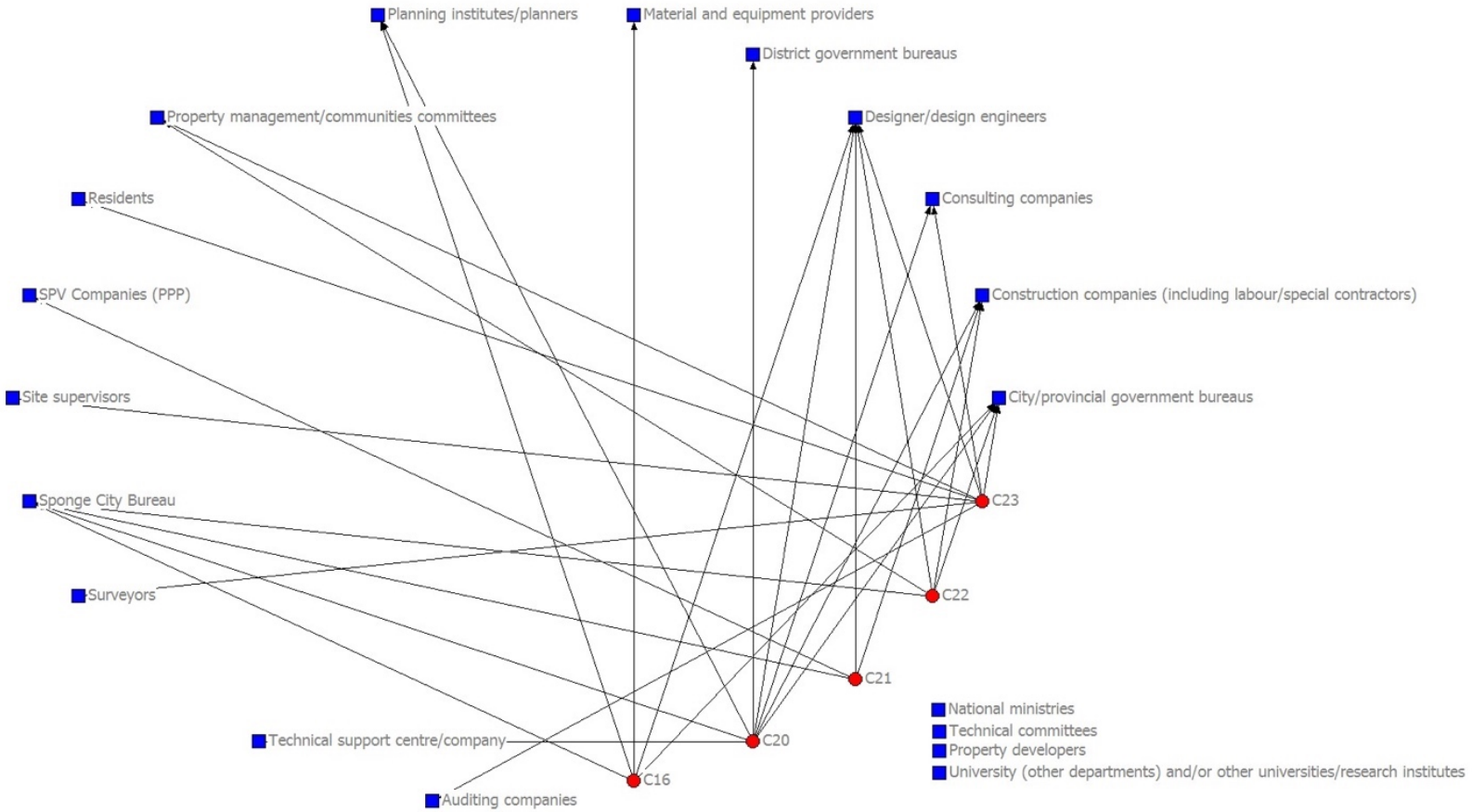

Figure 7-4 Network map: SPV companies in PPP dyads

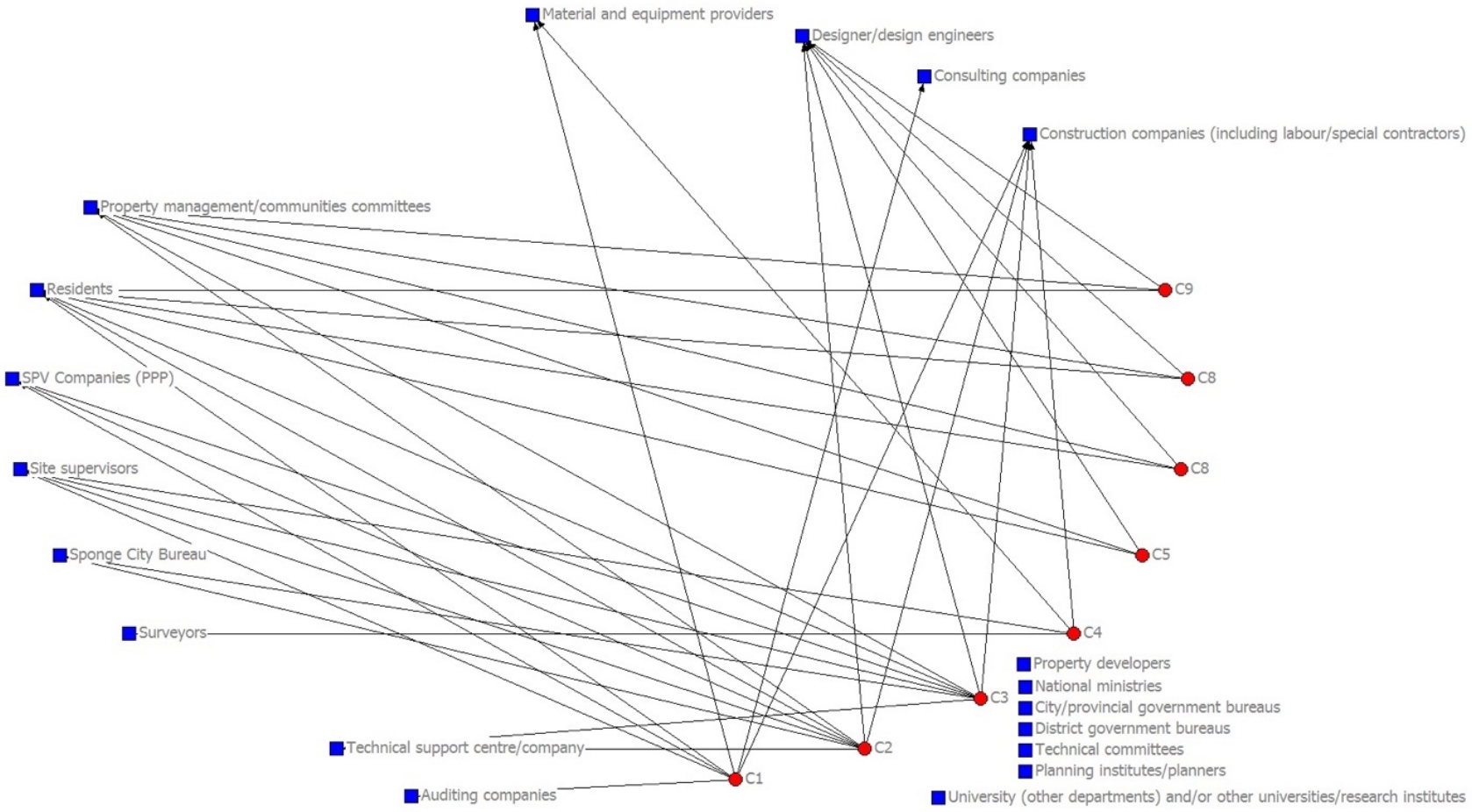

Figure 7-5 Network map: Construction dyads

7.2.2 Network configuration and the role of urban planners

Figure 7-6 displays the direct ties of all five groups of actors. The strength of each direct tie from an actor group (red triangle) to a category (blue square), is the sum of all the direct ties in that actor group (sum of all ties from red circles from figures 7-1 to 7-5). The tie strengths are displayed by the thickness of the lines and the size of the arrows. This diagram summarises the following information provided by the interview participants.

- There are two clusters of nodes that are most connected to. All the groups contain some actors that have direct ties with designers, construction companies, site supervisors, Sponge City bureau, and SPV companies (PPP).
- Actors from the groups of PPPs (SPV companies), university, design, and planning have many direct ties with government bureaus (city, province, district levels), and planners, while actors at construction stage did not identify any direct tie with any of these categories.
- Actors interviewed in the category of University have no direct ties with residents
- Actos interviewed from construction stage indicated direct ties with the university, and few ties with government bureaus, and no direct ties with planners.
- The groups of actors (red triangle) towards the centre of the diagram are directly connected to more categories of actors than the groups towards the upper and bottom sides. An actor from an SPV company corroborated the findings from the diagrams and reflected that they had minimal contact with other actors besides construction and design companies. However, another actor from a different company that is involved in PPP type of projects said that they were involved in almost all stages of Sponge City projects and were very well connected.
- Most actors in the universities and research organisations mentioned people from other departments or research groups as direct ties. Some expressed that face-to-face communication opportunities useful, such as organising or attending an academic conference or workshop.

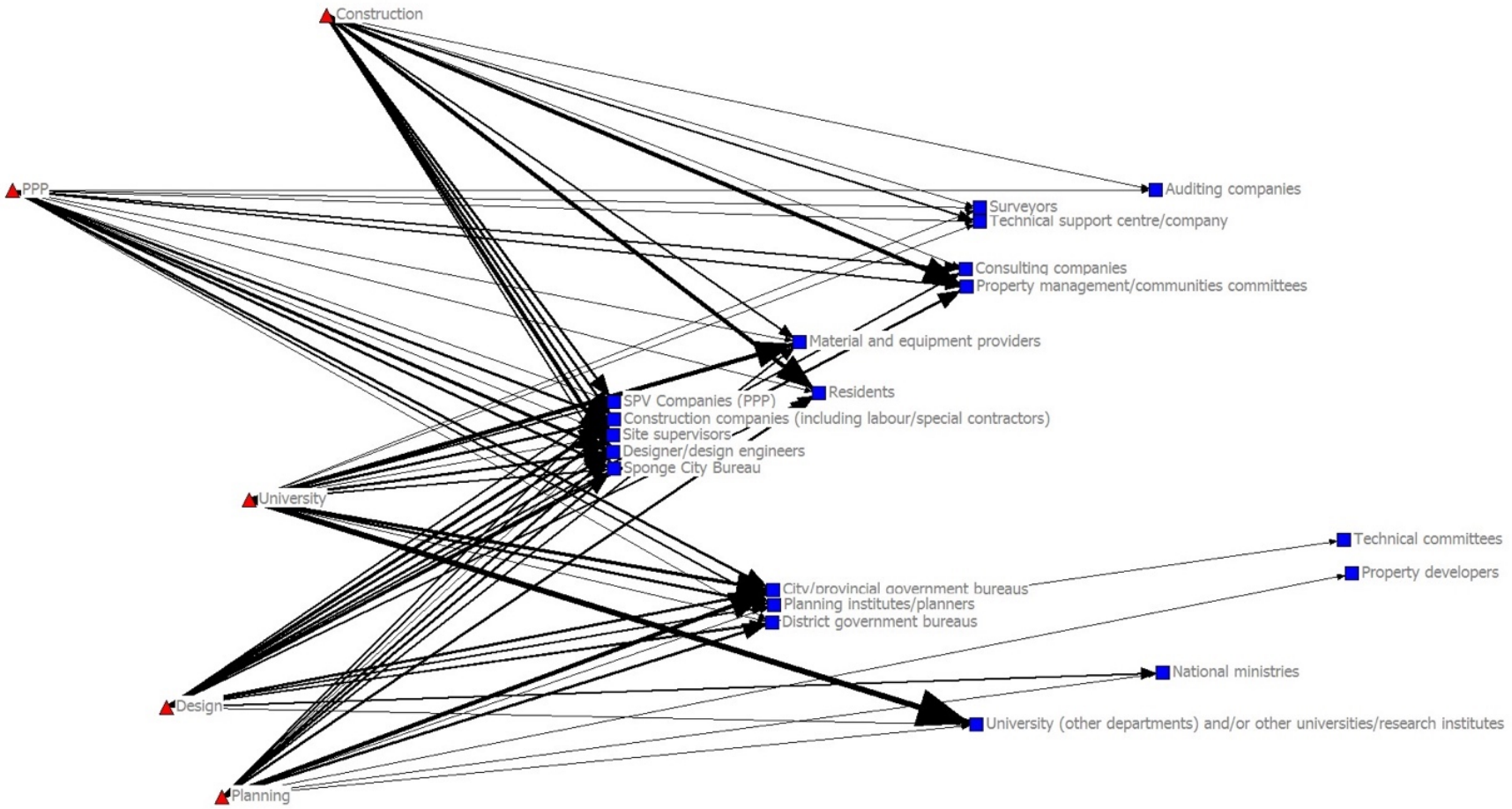

Figure 7-6 Network map: all actors (grouped by project stage)

The Sponge City plan is a specific plan that each city is required to have, though not all the cities apart from the pilot cities at various levels are translating the plan into action. It could be worked on by a local planning institute or planning bureau, or outsourced to competent consultancies from urban planning companies/institutes elsewhere, therefore the actor that assumes the role of an urban planner could be from different professional backgrounds in different settings. As a result, the experience and the relationship between actors and urban planning actors were different because they worked with different cities and teams.

The Technical guideline issued together by three Ministries in 2014 clearly stated that the first element in the fundamental principles of Sponge City is *planning leading* (MOHURD, 2014). As described in 4.4, the making of Sponge City plans is important because it is the process that translates strategies and goals into specific policies, which will then guide the design, construction, and operation and maintenance processes. There is no dispute to the importance and the position of the Sponge City plan in a project. All the actors who had experience in working on a project stated one of the following:

> **"Planning should be the first step."**
>
> **"Planning's role is leading."**
>
> **"planning is very important."**
>
> **"It is the top-level design/guidance."**

All actors agree that *planning* is the first step as dictated by the project flow, so planners (other than people who have worked on the application for pilot status) are the first point of contact, in other words, this is one of the first ties to be formed as a city seeks to pursue the Sponge City[14]. As a result, planners tend to work closely with the local government bureau that is in charge of the project, as well as the Sponge City bureaus for the Pilot cities. Actors in other stages of the project may or may not have a direct relationship with the plan makers, but they are all indirectly linked with planners via the documents they produced. However, a tie between planning and design may weaken for various reasons, and this will be discussed further in the relational dimension section.

Sequentially and temporally, planning is placed at the top of the network. Most actors stated that the plan (and related documents) is the "link between different areas of the project (C12)" and "the plan informs the network components (U8)", but the urban planning professionals may not have direct connection with those who are connected via the plan (and related documents). In addition, many actors speak of the top-down system in China, and the network hierarchy affects the role of urban planning assumes. Many actors mentioned the importance of having an appropriate plan because it can increase the connectedness of the network if it is correctly done while decreasing the stability of the network if it is not well done. The action of planning and the document that is the plan can connect

[14] Or any other urban water infrastructure project that is similar to Sponge City, since similar project or initiatives have been in action since the Sponge City started, and some of them overlap in terms of their targeting problems.

different professions and disciplines. Many actors pointed out the top-down characteristics of the network and its benefits. The description "top-down" is muttered frequently in the interviews. As shown in the previous section, many people believed in the power of authority in improving communication, and a good plan seems to be an excellent tool to establish the hierarchy. However, the network struggles to form the hierarchy or the connections when the plan is not meeting the expectation of the project, or when there are changes that need to be made to deviate from the plan due to various reasons. From the interview excerpts, it is possible to see that there is a minimum flow of information from "downstream" professions to "upstream" planners.

Box 1 Two juxtapositions regarding the role of urban planning

In 4.4, it was mentioned that in order to fulfil the leading role in Sponge City, urban planners are expected to step out of their comfort zones, and pay more attention to the integration with other disciplines and departments, the integration of social, cultural, and technical factors, and the balance the global strategies and local contexts. In the interviews, actors offered their opinions on what they believe urban planners are expected to achieve or the role that they hope they can fulfil. While all the actors have identified that planning should play a 'leading role' as explained above, some pointed out the importance for urban planners to also play an 'integrating role'.

Juxtaposition 1: Regarding the integration of multiple factors and local contexts, the actors addressed both the expectation and the problems they were facing when expectation on urban planning was not met. On the one hand, actors expressed that: "right decision needs to be made at the planning stage; it's the first stage (U6)" and "the various tasks and feasibility of options are determined at the planning stage, and are likely to change once the project starts (C3)". On the other hand, actors pointed to challenges they faced when "planning and implementation are not well linked up, and the downstream actors are not well linked up so even with a plan they don't get to communicate and collaborate (U3)", or when the plan is done but "not all planning organisations would like to engage with designers (U10)".

Juxtaposition 2: Regarding the integration of disciplines and departments, the actors recognised that "[the plan] brings together planning bureau and experts from various institutes/bureaus (C6)", and "planning is to take into account the whole situation and provide overall consideration (C18)". However, some expressed that "we need to make the rules at the planning level because the top-down approach is the most powerful (C1)", and "in China, you must force them to do it, if you don't make it mandatory nobody would want to do it. The plan should *require* the collaboration of [multiple disciplines] (C16)". From here, it is possible to see the tension between a network configuration linked by urban planners, and a hierarchical configuration with planning at the top of the ladder. Due to the combination of needing urban planners to integrate different disciplines and departments, and the extant hierarchical, or top-down relationship between the actors, the task of urban planners become more challenging, since "if the design is not well done, whatever we do at the downstream could risk being overturned (C23)", and "[when] the sponge city plan is not stable… people find it difficult to agree on things (C20)".

7.3 Mobilisation of social capital

If the structural dimension speaks of the physical characteristics of social capital, then the relational dimension concerns the quality or the role of direct ties between actors (Inkpen and Tsang, 2005). Nahapiet and Ghoshal (1998) demonstrated that the relational dimension could affect one's access, the anticipation of value, as well as one's motivation to engage in knowledge learning and exchange. While a good relationship between actors can increase the opportunities for engaging with others to access and transfer knowledge, as well as increase an actor's expectation and confidence in the value of new knowledge to be gained through the exchanges. A more considerable impact of having a good relationship between the actors is on their motivation, or willingness, to engage with others in learning

and knowledge exchange activities (ibid). The behavioural view of organisation argued that intrinsic motivation (self-applied, for her own internal satisfaction or fulfilment) is presented in the form of obligations of personal and social identities, as well as identification with a network's strategic goals, shared purposes and the fulfilment of norms for its own sake (Osterloh and Frey, 2000).

In the semi-structured interviews, the actors are asked to describe their experiences of working with other actors, evaluate and explain the outcome of such interactions. In the following sections, the interviews are analysed according to the relational facets, especially that of trust (and the sense of trustworthiness), as well as social norms, and obligations. The analysis is presented in two parts, first on the interaction between actors and authority figures, and then the interaction between the actors. As mentioned before, the dimensions of social capital are inter-related. The facets of obligation and trustworthiness that are discussed in this section are undoubtedly affected by the structural properties and can affect the cognitive facets which will be discussed in section 7.3.2.

The inclusion of a cognitive dimension of social capital was decided on the basis that knowledge and meaning are always embedded in a social context and that the exchange and combination of knowledge thus require the sharing of context to some extent (Nahapiet and Ghoshal, 1998). However, the cognitive dimension of social capital receives the least attention in research compared to the other two (Nahapiet, 2009). It is perhaps because the cognitive dimension cannot be tangibly measured, as it along with the relational dimension relate to the mental state of a person and the interpretation of a shared reality (Claridge, 2018). This study finds that the cognitive facets of social capital have layers of influence over the actors' knowledge sharing behaviour, and it provides useful information to form a more complete picture of the barriers to cross-disciplinary knowledge transfer.

In the interviews with the Sponge City actors, not all of the actors made mentions or attribution of success or obstacle to the sharing of language and codes between collaborators. Sponge City, as well as integrated urban water management and many other similar terms, describe concepts that are relatively new and in the process of building and expanding. Expectedly, the practitioners in the Sponge City network have various degrees of understanding of the different facets of the concept. As displayed in chapter 4, the actors' definition and opinion of the objectives of Sponge City initiative can be different for various degrees. When the actors made comments on the influence, need, or absence of shared language, code, and narratives, there are variations in the depth of knowledge needed by the actors to achieve excellent communication, the level of sharing that actors would like to achieve and the type of materials to be shared to achieve that level.

7.3.1 Relational aspect

Interacting with government actors

When interacting with authority figures, such as government decision-makers, trust is a critical factor in determining the success of communication and collaboration. Mishra (1996) articulated four

dimensions of the construct of "trust"; using the dimensions he defined trust as "one party's willingness to be vulnerable to another party based on the belief that the latter party is 1) competent, 2) open, 3) concerned, and 4) reliable." Mishra (1996) emphasised in "The Centrality of Trust" that the concept of trust is defined by the incorporation of the notion of vulnerability because to trust is to have belief in another actor (individual or group) even when by doing so there are chances of the potential loss exceeding the potential gain.

How trust is being used when communicating with authority figures is different from the trust found in relationships between non-governmental actors. The display of trust or lack of trust when interacting with authority figures is subject to a common condition, which precedes the consideration of competence, openness, concernedness, and reliability of an actor. The following text in Box 2 uses an example from the interviews to illustrate this condition.

Box 2 Spatial variety in the trust levels in the leading government unit of Sponge City

In chapter 4, the relationship between "line" and "block" was explained - the Chinese administrative structure can be characterised by "a line (tiao)" and "a block (kuai)". The "line" refers to hierarchical relations from the CPC committee down to the provincial government, while the "block" refers to the government network at the provincial and city level. The "block" exists because the local governments have considerable autonomy over their own policies. Each city manages this relationship differently, and the structural differences are reflected in how well government actors and non-government actors work together.

Although the members of the Sponge City bureau are more or less the same across all the pilot cities, the leading or coordinating government unit varies. Many actors pointed out that whether the collaboration between the government bureaus in a specific city's Sponge City network and the non-government actors depended on the power relation between the coordinating bureau and the others in the network. U10 mentioned that "the efficiency of collaboration depends on how much authority the coordinator has", and U2 expressed that the effort other government actors put in varies according to the (authority) level of the leading bureau. P1 went a step further and stated that the success of their work as a non-government actor depended on who was leading the Sponge City bureau.

Power and trust are firmly related, this "condition" observed can be explained by looking at how authorities' coercive and legitimate power impact cooperation and the perception of trust. When interacting with government actors, trust is defined more by whether the coordinating government bureau has legitimate power. Moreover, when power is perceived as a coercive power, trust can increase an actor's perceived competence and improve enforced compliance from other actors. Though this is also a manifestation of trust originating from the willingness to believe in collaborators' good intent, which is in this case, vouched by the legitimate power the collaborator holds.

When cooperating with government actors, the trust associated with the power of another actor is a precedent of trust associated the actors' competence and reliability in delivering quality outcomes. As revealed in the interviews, it is usually when the coordinator role is assigned to a government bureau

that can assume a superior position in the hierarchy of local government network, that this type of trust can develop between the government actors and non-governmental actors. Firstly, the willingness of the actors to be vulnerable to government actors or authority holders is based on the actors' evaluation of government actors' competence. If the government actors are judged to be competent, the trust between the actors will grow and aid future cooperation, but it could also lead to a break in trust that results in weak knowledge communication and learning if they are judged to be incompetent. In the prior case, consistently delivered work with quality from the government collaborators breeds trust that stems from reliability. This sense of trustworthiness towards the collaborators, in turn, produces smooth cooperation.

> **Cooperation with the government is the simplest compared to with other partners because you don't need to worry about money, they are cooperative, and there aren't too many factors to worry about, the process is simple (C21)**

In the latter case, actor C20 decided based on their early collaboration outcomes with the government selected technical support centre, that the skills of the centre are insufficient to support their work going forward. Hence cooperation and the subsequent learning opportunities ceased to exist.

> **Collaboration with one technical support centre was unsuccessful because we believed they didn't have the skills we needed (C20)**

Finally, besides the different layers of trust that was discussed above, there is another facet of social capital that has significant influence over the outcome of the collaboration. The willingness, or rather, the unwillingness, in this case, to develop good cooperation and learning opportunities is affected by identification, or whether "individuals see themselves as one with another person or group of people (Nahapiet and Ghoshal, 1998: 256)". As actors C17 and P1 revealed in the interviews, difficulties of identifying with another person or group of people prevented them from being more open to cooperation and learning, and from developing trust in another person or group of actors.

> **It's different than [projects in the past that] people are not sure which group to identify with, because it's not clear anymore what each discipline or profession is in charge of anymore (C17)**

> **The problem now is that people are not sure whom they are working for (P1)**

Interacting with other non-governmental actors in the network

Concerning the interactions between non-governmental actors, there are three levels of interactions described by the actors, inter-organisational, intra-organisational, and within the same unit of the same organisation. Moreover, the level of interaction affects the dynamics of the knowledge exchange between actors. Compared to the interactions with governmental actors, the power-based effect of trust is less prominent, while the perceived competency level of collaborating actors is more significant. Although the competency level is subject to one's own perception and judgement, it may be influenced by the presence or absence of the cognitive dimension of social capital. In the interactions between the actors outside of the government, the relational dimension and the cognitive dimension are more

intertwined since the determination of trust and trustworthiness is more expertise-based and less formal power-based.

First of all, the level of communication is high between actors from the same unit of the same organisation. Due to the familiarity with one another in the group, personal relationships could potentially foster a high level of trust between these actors. Moreover, they are likely to be governed by the same social norm, which also facilitates their willingness to be open to communication and cooperation.

> **We are constantly communicating and exchanging information (U8)**

The image a person forms about another actor affects her attitude and therefore, what and how she communicates. As U10 said, whether someone can learn from any source depends on the type of person that she is. The common factor the actors took into consideration when judging the trustworthiness of their collaborators is to decide whether their competency level meets the actors' expectation.

Box 3 Different relationships between researcher/designer and material supplier

Actor U8 considers the information from the material supplier to be essential and beneficial. In the interview, he described very positively about his relationship with the suppliers that he worked with, and this can be attributed to the high quality and value of the information they provided. His impression of the suppliers is reciprocated by them, therefore contributing to a smooth collaboration and mutual learning. This way, trust facilitated knowledge exchange and combination between the actors from very different professional and disciplinary backgrounds. On the contrary, U9, who was a researcher and designer from a different project, had a different approach. He believed that the material suppliers should make decisions according to the design, instead of the other way around.

While both actors expressed that it was important to have an interdisciplinary project team, they had different opinions about actors from other stages. One considered the suppliers to be collaborators and exchanged knowledge with them, while the other one was of the opinion that the suppliers didn't have anything valuable to offer him since they are experts from drastically different fields.

In the case of actor C11, the actor did not comment directly on the competency of any collaborator, but the trust in other actors is embedded in his recognition of the expertise of different disciplines and the need to work together. Similarly, actors U5 and U6 explained that a good way to collaborate is to let each group or unit carry out their own tasks and come together.

> **When you do a project, you get the project and then get in touch with them, they will provide some calculations, which we will use for design. They don't do design, only the algorithms and calculations... (U5)**

> **By working together, I mean we each carry out our own tasks separately (U6)**

In these three cases, the actors expected the collaborators to demonstrate competent skills within their own expertise, and such trust dwindles for other types of tasks. However, while this type of

relationship enables better collaboration process, this type of manifestation of trust limits knowledge exchange and combination between actors from different disciplines, for the actors did not engage in social exchange or learn beyond the already codified knowledge. The mutual trust between the actors is based on their expectations of "give and take" from the collaborators.

On the contrary, due to the lack of trust, the communication between C5 and the site supervisor proved to be less successful in terms of the cooperation outcome as well as knowledge combination. Although one could argue that he insisted on the signing off by the site supervisor is a consequence of the influence of power, it is also evidence of the actor's lack of trust in the supervisor's judgment, i.e. the competency. The lack of trust in the case of actor U9 is due to the lack of concernedness from both U9 and the collaborating planners because each of them is not convinced that the other side will not be opportunistic. Actor U9 was not impressed about the collaboration experience with the planners because they seem to be obstructing the process, or worse, sabotaging the process. Consequently, both sides are not successful in gaining new knowledge from each other, for they do not believe that the other side considers their interests or the interests of the whole.

> **[Planners] not only will refuse to collaborate with me; they will be uncollaborative (U9).**

7.3.2 Cognitive aspect

Interacting with government actors

Authority figures, in this case, are actors that hold political power and make decisions, which are usually government actors. When non-governmental actors interact with authority figures, usually from a department/bureau/ministry of the government, the success of communication largely depends on whether the actors share enough disciplinary language and code to enter discussion and exchange information. Actors that have direct interaction, which requires some forms of exchanging of information and knowledge with authority figures, come from all project stages. The data used are from interviews conducted with non-governmental actors, and the outcome of their interaction with authority figures are derived from their account of the experience.

Sharing of language and code enables discussion and exchange of information between actors. As asserted by some actors, an essential factor for successful communication with actors in the positions of authority is whether the authority figures are being or becoming familiar with the Sponge city concepts and developing a better understanding (U1, U2, C21, C7). It is also important that decision-makers can communicate with other actors on the details of their decisions and information, in order to eliminate the amount of "guesswork", as in the case of P3. Actors tend to find communication to be smoother when the governmental actors have either been introduced to the language in past projects or are becoming familiar with the use of codified information in the form of guidelines and standards, as well as by learning during their current projects. The examples in Box 4 illustrate cases of successful learning and communication by government actors.

Box 4 Success in learning and communication by government actors

All the actors that have experienced or are expecting to experience success in communication with other actors have met the following two conditions. Firstly, they all have identified the opportunities or already have had access to learning a new "language". Secondly, they anticipated the value of the interaction and exchange.

G1, a government actor, recounted that to prepare for their city's pilot city application, they approached the research team in a renowned university because they wanted to collaborate and learn from them. They have since then formed a good working relationship, and actors from both sides expressed during the interviews that they appreciated each other throughout the process. Another example of successful communication and knowledge exchange was told by U1, an actor from research and design background. During her interaction with government actors, she noticed that some of them started to pick up on the vocabulary as the project went on, and began to apply their newly acquired knowledge to ask questions and offer their opinions during project meetings.

While many actors have identified that having some exposure to Sponge City project and knowledge provides a positive impact on sharing a language and vocabulary, which allows them to communicate and exchange information and knowledge, such exchange has not been able to enable actors to form a common framework of perception and interpretation. Actors C20 and C1 attributed their challenges

in communicating with authority figures to having "different perceptions or angles of approach" towards the same issues, and actor C17 expected improvement to the quality of their exchanges could be achieved if actors could "think on the same track". Similarly, many expressed their expectation of having a shared goal or objective, but they think this is mostly dependent upon people's willingness to learn and seek opportunities for exchange. Some actors elaborated that it would be important to show a willingness to act, be it learning or working towards the same direction, for it would be a factor for increasing the motivation for learning and exchanging of knowledge. In the case where communication was challenging, the strategy used by C1 in reaction to the situation is to give the government actors the benefits of doubt. This facet is closely linked to the relational dimension, because being willing to see the diversity in perception and to embrace it takes both the anticipation of the value of other perspectives and trust in the actors that hold them.

Interacting with non-governmental actors

Actors involved in Sponge City are expected to work collaboratively with various relevant disciplines, some within the same organisation and some not. In universities, an actor could work with colleagues within the same department or research group, as well as collaborate with other researchers from different departments and groups.

Whether the actors have access to people and their information determines the outcome of their communication. At the same time, having access alone cannot promise a positive outcome if the parties involved do not have sufficient overlap in their knowledge base. The interviews revealed that having an understanding and being able to learn more of the knowledge that is specific to other disciplines and professions are important. It is because an overlap in vocabulary enables better interaction that can lead to knowledge exchange and learning. The results show that belonging to the same institution and profession do not necessarily mean more natural knowledge transfer process, as demonstrated in Box 5. On the other hand, C9 is from a construction background and has abundant experiences working with various designers. Although this was his first time working on green infrastructure construction, he is a very experienced construction team manager that has worked with designers on various types of building construction before. This experience allowed him to communicate effectively with the design engineer and "work out everything".

By not having an adequate overlap in the knowledge base, it would not be possible to build a shared mental framework given actors involved tend to have different if not conflicting trajectories for the project. This barrier is recognised by many actors, as they have expressed the need and expectation to increase the success of knowledge communication by learning about the knowledge that belongs to other disciplines and professions, in anticipation of values in those pieces of knowledge. However, being able to converse with people and recognising the benefits of having a shared vocabulary does not necessarily translate into enhanced ability to combine or acquire knowledge. Two more factors can influence how much shared-language can improve knowledge acquisition – intense exposure to prior knowledge by the learning actor, and good explanation skills by the teaching actor. Box 5 uses examples given by two actors to demonstrate the difficulties from both learner and teacher's perspectives. The absorptive capacity, or the ability for an individual to assimilate and exploit new knowledge, depends not only on exposure but also the intensity of such exposure to prior knowledge relevant to the learning of new knowledge (Cohen and Levinthal, 1990). The more novel a new knowledge domain, the more difficult it is to assimilate and exploit such knowledge. Therefore, the communication between some actors was not effective because of two reasons: there is insufficient overlapping of knowledge (a priori relevant knowledge) between them, and that the learning actor did not accumulate enough knowledge to close the gap between her current and expected knowledge level.

When asked to evaluate the success or failure during the process of working on Sponge City projects, those who related the outcome of communication to shared language and narrative also voluntarily expressed the importance and the willingness to acquire more knowledge from other disciplinary and professional backgrounds. However, many of them still found the act of learning and communicating hindering the quality of exchanges. What also made knowledge transfer and learning difficult, is the inability of actors to adequately explain a concept to another individual who has a different knowledge background. Many said that they either could not find the right way to get their messages across, or their colleagues could not perceive the need for additional explanation or understand the point of confusion.

Box 5 Two sides of the same coin: not being able to explain or to understand

C12 is an urban planner, but working on Sponge City plans required the actor to have some understanding of topics such as hydrology and urban flooding. Despite working on the same project in the same office, she was not as able to learn as much as she would like to from her colleagues who were the experts on the water topics. Previously, it is shown that time and effort are required to assimilate and exploit new knowledge, the interviews revealed that the task of explaining becomes more complicated when there is not enough overlapping of knowledge between the actors. Designer C19 had similar experiences in another company. As a landscape designer who has had experience working on water models before, she struggled to explain certain concepts and indices used in the models to other designers who did not have water modelling knowledge before.

Construction engineer C9 was able to carry out the construction based on the design since he could communicate effectively with the designer and have her help on the interpretation of the construction drawing. Knowledge was transferred between the designer and the construction engineer because the designer was familiar with the construction drawings and how to interact with construction teams. In comparison, C12 and C19 were not as successful because firstly, the overlap in disciplinary-specific knowledge between the actors is smaller while the complexity of learning is higher; secondly, both sides were not familiar with conducting such in-depth explanations of concepts to collaborators from different disciplinary backgrounds.

7.3.3 Actors in Sponge City network and Urban Planning

The actors all agreed that the purpose of a plan is to provide guidance, administratively and strategically. This guidance informs what the designers and actors in later stages should and should not do. It is supposed to be comprehensive and completed with a "higher perspective and the control of the whole situation" (C12). As a form of guidance that translates the technical requirements into actions, it helps to construct collective narratives for the initiative. As many actors explained, the plan or the plan-making process gives the initiative and its projects a structure and boundary that form the foundation for the following steps.

> **Planning only provides guidance in a broad sense, it is a top-level guiding structure (C7)**
>
> **planning is the guiding principle, like a constitution (C3)**
>
> **a good plan can positively guide the design and construction, as well as the management that follows (C18)**
>
> **Planning is to determine the direction of the tasks that follow. It should consider the large scale. It determines the direction of the project (C22)**
>
> **planning can help set regulations that are strictly enforced, because it can make rules that people must follow (C1)**
>
> **planning is key…its main task is to divide up the targets to implement (you need to provide guidance) (C16)**

With this plan, the actors could operate using common code and language. The actors doing Sponge City projects come from many different professional backgrounds, and the plan provides them with a language to use to communicate with everyone. This way, everyone could work under the same scope and towards a common goal.

> **The role of sponge city plan is to lead and make a requirement. It guides the sponge city construction, set targets on every project. Its objectives are providing technical guidance and requirements on the objectives. (C6)**
>
> **The plan must consider the city's watershed, or drainage area, and consider how the water circulates in this city, as well as the hydrology. These are all things that need to be considered in planning, and we are carrying out the project accordingly (G1)**
>
> **A detailed plan can instruct implementation, including which measures to use (U1)**

However, the excerpts above are referring to what they envision the role of planning is. In essence, a good plan was set out to have the purposes indicated above, but in reality, it has not yet able to achieve its intended goals as reflected by several actors.

> **When there is no standardised plan…sponge city bureau can hardly provide us with any guidance…there was many conflicts. you need to have a plan that guides the project (C20)**
>
> **the plan should provide guidance, so far it is not sufficient (C15)**
>
> **its message is quite unclear: it's has redundant or conflicting information (C13)**

if the plan is unstable…you can't achieve the integrated sponge city outcomes (C4)

it is useful because it can guide the development, but it is not easy to implement (the language is hard to adopt) (C21)

Special plans definitely can guide design making. but it's a bit distant from reality (C17)

7.4 Limitations

A limitation that warrants discussion concerns data collection for the semi-structured interviews. Firstly, there was very limited access to government actors for the interviews, and yet this group of actors serves an important link or bridge between other groups of actors. Requests to the government actors were made multiple times through some of the actors interviewed, but all invitations save one were rejected. However, this situation was foreseen; the study of factors affecting knowledge transfer between government actors is out of the scope of this research and can be investigated in future studies.

Regarding the accuracy of actors' nomination of network contacts, omittance and mistakes were reduced by asking the actors to identify contacts at an organisational or sub-organisational level as well as prompting them with categories of contacts that were identified by researchers in advance. Given the questions were well designed to elicit the presence instead of the quality of contact, this limitation should not reduce the validity of the respondents' nominations.

Another limitation is caused by the fact that interviews could not be conducted at various points in time with the same participants. The data collected are static, thus representing the actors' state of mind at one specific moment. Although they are asked to retrospectively reflect on progress made since the start of the projects, the study could not capture the change in the actors' attitude and behaviour as they become more involved in the projects. However, it was still able to capture what the actors have in common in terms of the effects of social capital facets on knowledge exchange and learning.

7.5 Summary of findings

7.5.1 Access of social capital: structural aspect

In the interviews, an actor involved at the design stage expressed that her place in the network was different for every project, and it was not that easy to connect with others even if she wanted to. The network is thus relatively unstable, which may contribute to the difficulties in learning from other actors as well as identifying with a group and the group's norms. Sharing of space can be enabled by belonging to the same group or unit at work, and this communal sharing, where members of a group or dyad treat each other by focusing on commonalities and disregarding distinct individual identities, creates a sense of cohesion among actors which encourages sharing of knowledge (Boer et al., 2011).

The network diagrams suggest that actors in certain professions don't have direct or meaningful interactions, because the procedure of the project, and there weren't as many time knowledge exchange opportunities such as conferences and workshops to bring together professions that are traditionally farther apart, such as planning and construction, and university (research) and construction. The differences in language, codes, narratives, or values between professions should not be determined by their structural and social distances.

7.5.2 Mobilisation of social capital: relational and cognitive aspects

Successful knowledge exchange and learning when working with government actors depend on the extent to which the leading decision-maker is being trusted and respected by other government actors and subsequently by other non-government actors. Furthermore, network culture and norm that appreciates the importance of collaboration across disciplines and professions need to be established. Also, actors need to acclimatise to their new network identities, and this may require more transparency and detailed briefing so that actors have a better understanding of the big picture.

Challenges in working with government actors can originate from two sources. One is the lack of trust and respect for the leading decision-maker from other actors, as well as the lack of authority to coordinate the collaboration between government actors. Second is whether the government actors are perceived as technically competent. The communication between government actors and other actors are more successful when the government actors either had prior knowledge and experience or managed to learn to some extent through the project. It is thus important that the government actors are willing to learn from each other and non-government actors.

The actors that had less than satisfactory communication experiences attributed some challenges to the fact that government actors have different perspectives and approaches and disagreements amongst themselves, thus sending unclear and ambiguous messages to other actors. Some suggested that improvement can be made if the government actors can streamline their perspectives, approaches, and angles of attack. Improvement can be contingent upon the extent of social capital achieved in the relational dimension, and the level of trust and norms that can be established are in turn contingent upon the network composition and the roles of the actors in the network. In addition, actors who are working with government actors need to be able to recognise and understand the diversity in their values and perspectives.

The knowledge exchange and learning between non-government actors are more successful in the sense that a collaborative task is more likely to be completed. It is successful when the actors trusted and valued the collaborators' technical expertise, which is enabled by having a common language established, or having shorter and stronger ties in the network. Sometimes, actors will find other actors trustworthy if they are vouched by government or other authoritative sources.

Working efficiently together is not equivalent to exchanging information. There is limited knowledge exchange when the actors recognise the importance of cross-disciplinary collaboration but are working

independently together because although the collaboration process is efficient, it does not warrant the same degree of knowledge exchange as working cooperatively together. Actors that had more successful experiences reported that one should deliberately learn more about other disciplines' knowledge from other actors, and one should also aim to understand and consider a problem using different perspectives. Active learning should be encouraged, and communication skills outside of the technical comfort zone should be developed and enhanced.

Challenging experiences are attributed to two main factors. The first factor concerns the inability to reconcile with the different angles of the approach used by actors with different disciplinary training backgrounds. Secondly, the knowledge exchange is hindered by the inability to establish a common language between actors of different knowledge background, range of vocabulary and jargons. Little common grounds established in both aspects is making learning between the actors difficult.

7.5.3 Actors' perspectives on Sponge City planning

Planning as an early stage of Sponge City project (and other urban infrastructure projects alike) has the potential to influence and mediate learning and transfer of knowledge between the different stages and among actors from different professions and disciplinary backgrounds. As many actors emphasised, the making of the Sponge City plan takes place first, which should be able to structurally facilitate knowledge exchange between the different stages since it can assume a position of authority. The document produced is codified knowledge that will be passed onto and consulted by professionals at design, construction, and other stages of the project, which should be able to facilitate communication by providing a common language and narrative. However, the plan makers cannot fulfil the role of knowledge mediator if the plan is not written in an accessible language, or it is not made after considering both the relevant engineering and design disciplinary knowledge as well as practical knowledge that is much valued at later stages.

8 Transferring tacit knowledge to improve integrated urban water management

The discussion chapter brings together the quantitative and qualitative findings to address the research question. It places the tacit knowledge concept back into the social capital theoretical framework and identifies the several categories of barriers to knowledge access and mobilisation. The next section contextualises the concept of tacit knowledge as defined by Polanyi and Collins in urban water management, and uses the insights drawn from the findings to clarify the factors that influence the different ways Sponge City actors *socialise* with one another to use access and utilise the *socially embedded* resources or tacit knowledge.

8.1 How do urban water professionals communicate to deliver IUWM?

By placing the tacit knowledge concept back into the social capital theoretical framework, it is possible to illustrate how the ability and the inability to access and mobilise such resources can affect the transfer and uptake of knowledge resources. There are two groups of factors that determine the accessibility of knowledge in the network, one is the time and place, and the other is the types of media. Actors in the Sponge City network can achieve knowledge transfer through either direct interaction with other actors, which means the time and place are the prerequisite conditions for interactions. Knowledge transfer can also be achieved through indirect interaction via media (including social media, books, articles), which means the type of media used is a prerequisite of success.

Box 6 How much knowledge transfer is enough?

Paulin and Suneson (2012) explained that knowledge transfer and knowledge sharing are used interchangeably in the literature, and the lack thereof is more or less equivalent to knowledge barriers. However, they added that the concept can be used at different levels of analysis (individuals or groups/organisations), or with different views of knowledge (as an object or a subjective contextual construction), thus bearing different names. The researcher thinks it helps to remind the readers that the term 'knowledge transfer' is used here to loosely represent the action of communicating knowledge between individuals and groups of individuals.

As stated in 3.1.3, Polanyi's perspective on tacit knowledge and tacit knowing forms the philosophical basis of this research, while Collins' mapping of tacit knowledge provided a structural framework that categorised the concept of tacit based on the reason behind the inability to tell what one knows, as well as the mechanism that could enable tacit knowledge to be made explicit. Collins (2014) used his personal experience of working on case studies in different scientific realms to explain the different levels of knowledge being *transferred* to him. Collins described that "developing interactional expertise is not a trivial undertaking: it is not just having a bit more than no expertise…[It] is the job of months or years of interaction (Collins, 2014:129)". He described in a later article that the process of acquiring "specialist tacit knowledge" is to be "socially embedded in the appropriate groups of experts", and the outcome is the gain of the "ability to do and understand things that one could not do and understand before" (Collins, 2016: 2).

In Box 4 and Box 5, examples were given to illustrate the successes and challenges in the acquisition of expertise that allows for cross-disciplinary communication. Actors in the examples were from different stages of project and professional backgrounds, the initial level and the gap in the topic of knowledge to be acquired were also different. However, some of them were able to "[understand] things that one could not do and understand before (Collins, 2016:2)", while others struggled. Upon reflection, the researcher realises that the success of communication between actors from different knowledge backgrounds relied not necessarily on the acquisition of interactional expertise, but rather *just enough* knowledge. Therefore, the knowledge transfer that this research was referring to, was not full-scale transfer of what Collins called contributary expertise, nor interactional expertise in the strictest sense. It was instead referring to the transfer of *just enough* knowledge to allow for effective interaction or communication and to avoid misinterpretation and confusion.

In the survey (chapter 6), respondents selected their sources of learning from case studies and review articles, interpersonal interaction, personal investigation, and written materials. This was by no means a conclusive list of means to access knowledge; it was to investigate whether specific categories of knowledge are better conveyed and easily accessed as documented and step-by-step knowledge (explicit) or knowledge that requires the person who possesses the knowledge to clarify in the context of personal experience and problem background (tacit). As survey results showed, the initial hypothesis of a clear association of type of knowledge and the tacit/explicit preferences was not valid. Going back to Collins's description of tacit knowledge, while some knowledge remains tacit because they cannot be explained, others are tacit because they are not being exposed and expressed adequately. The interview results revealed just that - some information and knowledge are not being conveyed to the extent that is easily accessible and absorbed by the actors, no matter it is transmitted on paper or through experience. The following diagram is constructed to show the potential barriers based on whether the knowledge is being accessed directly through person-to-person interaction, or through mass media.

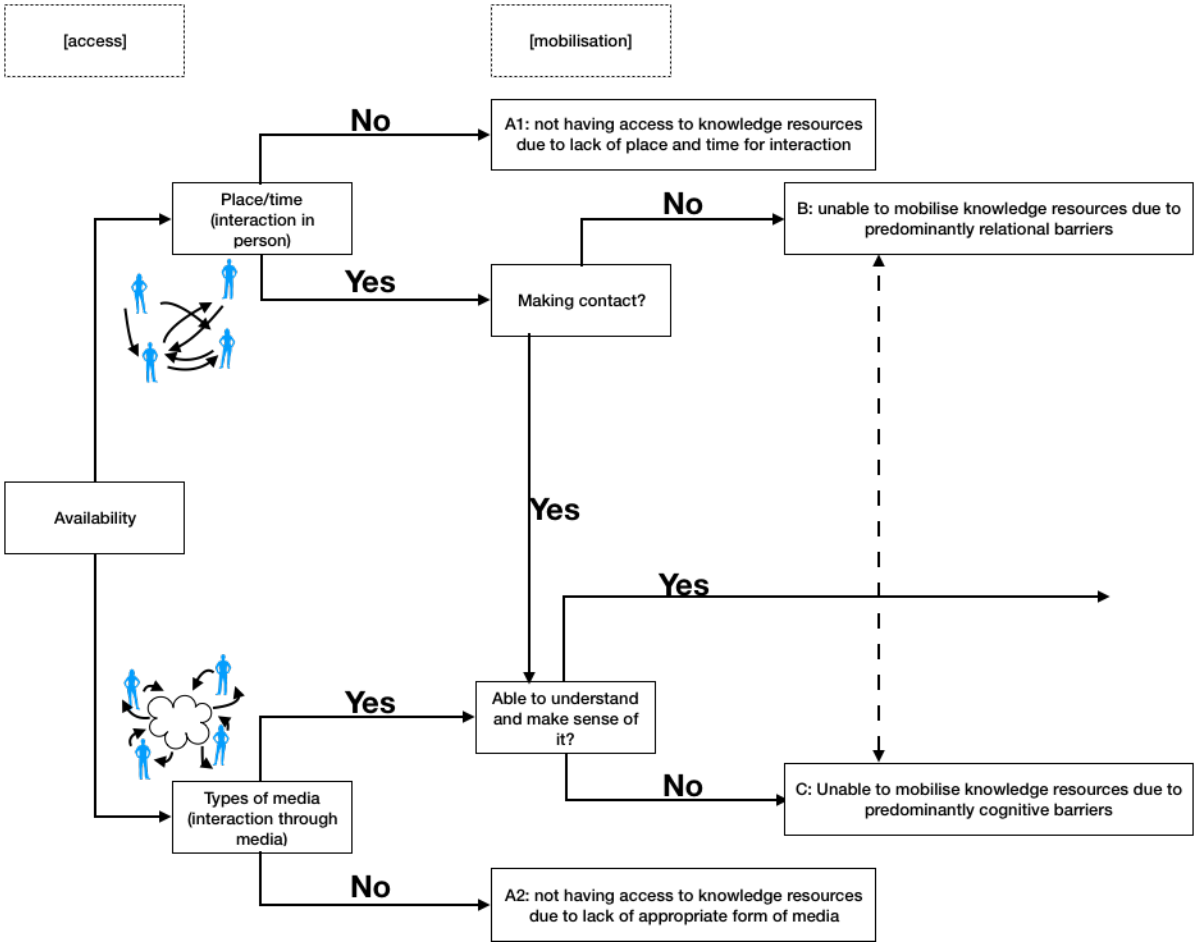

Figure 8-1 Flowchart explaining the potential barriers to accessing and mobilising knowledge

A1. Not having access to knowledge resources due to lack of place and time for interaction.

There are structural barriers that prevent the actors from being able to interact with each other face-to-face or having dialogues. Note that "structural" here refers to the factors relating to the location the actors occupy in a network – the factors in the structural dimensions (Nahapiet and Ghoshal, 1998), both in terms of the hierarchical and physical position and distance from others. The network map constructed in chapter 7 revealed that actors from certain project stages do not make contacts with one another. For example, the actors from the construction stage reported no contacts with planners, university, ministries and bureaus at various levels (they did have frequent contacts with the Sponge City Bureau which consists of members from all relevant city level bureaus).

A2. Not having access to knowledge resources due to lack of an appropriate form of media.

In addition to obtaining knowledge directly from other actors in settings such as conferences, seminars, meeting (physical and virtual), one can also access and exchange information by using mass media. The survey results (chapter 6) revealed the actors' preferred uses of different learning sources. Other than personal interaction, which could be a face-to-face meeting or online exchange, written materials are the most used across all professions, for all three knowledge types. The survey did not specify written materials as print or digital, but one could conjecture that more frequently they are accessed via mobile or computer applications, based on the fast turnover of information in such short period of project time, as well as the centrality of mobile apps to contemporary Chinese life (Iqbal, 2019a). The same barrier that prevented some professions from making in-person interactions could also deny them exchanges of knowledge through mass media.

The research did not identify specific challenges posed by the lack of accessible materials via mass media. Unlike conferences and seminars, online sources are quicker and easier to access, but one needs to make sure that they can be used by all professions to reach a broader and more diverse audience. Currently, what major online platforms and active knowledge disseminators share tend to focus more on review and interpretation of policies and regulations. Some materials are only available in print, which reduces their accessibility.

These two barriers are structural challenges that prevent access of knowledge due to the lack of appropriate time and space or appropriate transmitting media. This type of barrier causes knowledge to remain tacit because the knowledge is being concealed, and this is characterised by Collins as relational or a "weak" tacit knowledge. To amend this situation, one should organise more meeting opportunities, such as (tele)conferences, seminars, so that actors that usually do not have a chance to connect or are not aware of conference or seminar opportunities outside of their own selected fields, could have more opportunities to do so. Knowledge resources, whether in person or through media, should be made more accessible across different fields and professions and increase the diversity of participants and readership. Lastly, it is beneficial to recognise the potential of the planning profession and planners, as well as the potential of other professions in knowledge dissemination.

B. Unable to mobilise knowledge resources due to predominantly relational barriers

When the knowledge resources are directly obtained from the interaction with other individuals, even if the time and location are well-coordinated, and the actors are able to have physical or virtual exchanges with one another, such resource will not necessarily be mobilised due to various barriers. Collective assets are preconditions that can influence the mobilisation of social resources, these factors include the historical and cultural background of the society, and the economic and technological characteristics emerged with this historical and cultural backdrop. As one of the preconditions, collective assets were not treated as a dimension in the analysis, because instead of directly affecting whether and how social capital is mobilised, they affect the behaviour of individuals and collectives which influences the features of the cognitive and relational, to some extent, structural dimensions of the social capital preconditions. The position it occupied in the theoretical framework was determined upon review of literature on past integrated urban water management projects and the socio-political backgrounds of China. The collective assets were set aside because studies often indicated that the differences culture and governance approach contributed to the unanticipated and often unsuccessful outcomes (4.1).

While somethings can be changed, for example, the provision of knowledge resources that actors are more likely to find useful and easily accessible. However, the relational barriers require changes in attitude and behaviour, which are influenced by the social, political, and cultural factors that are shifting and mutually shaping. The social, cultural, and political roots in society far exceed the length of their experience with the concept of integrated urban water management. However, just as the following remark on the influence of culture on development expressed, that cultural conditions and other socio-political factors are instrumental in the shaping of people's attitude and behaviour, but their influence on the outcome of development (in this case the development of integrated urban water management) is not deterministic.

> **As means, culture influences economic behaviour by shaping attitudes to work, aspirations, entrepreneurialism and risk taking, and culture can generate economic growth through the production and marketing of arts, crafts and cultural tourism, for example. Cultural conditions can also shape how people participate in political processes. By influencing value formation, culture functions as a lens through which development interventions are perceived, received and enacted. The enjoyment of literature, art, music and other expressions of culture is an important part of human well-being, and therefore culture is also a constitutive part, or end, of development. A sense of belonging, community and social solidarity are important to well-being and often culturally based, though [Amartya] Sen points out that culture can also be an instrument of exclusion and discrimination. Culture matters along with many other social factors, like class, race and gender as well as political factors and institutions, and it is shaped by these factors. Hence culture is constantly changing and not internally homogeneous, and thus cannot be fixed, preserved or used as causal factors in development** (Schech, 2018: 293).

In the spirit of a true pragmatist, the researcher reflects again upon the relational barriers that were attributed to the governance characteristics, the cultural influences, among others. They are not a source of the problem, but rather should be considered as part of the system when designing for a solution. The relational aspects of knowledge transfer barriers consist of a lack of trust, and its level is influenced by the power structure and governance characteristic. In addition, another factor is the lack of awareness of the values of what others have to share, and this is tied up with the cognitive aspect of knowledge transfer barriers, which is the topic of discussion in the next section.

Trust was identified as a vital overarching element of a successful knowledge exchange experience. At the same time, one's actions can be determined by the urge to conform to a norm, fulfil an obligation, or contribute to a group that she identifies with (3.2). Regarding the impact of identification, chapter 2 mentioned that strategic planning is a long-term process which allows for the building of trust among the stakeholders, but this process may be disrupted because of the instability in the structure and composition of Learning Alliances. In comparison, the Sponge City programme is facing similar difficulties. Many actors reported the challenges posed by the frequent changes to the composition of the project groups as well as to their roles. The lack of trust which then led to unsuccessful exchanges of knowledge is linked to the disruption caused by the frequent change of network and project group compositions, as well as to the confusion caused by the changes to the role an actor used to assume. These challenges can be overcome as actors accumulate experience, and the actors become more comfortable and familiar with the networks and their members.

Meanwhile, it is necessary to expand on the discussion on the tendency to gauge the level of trust using the level of legitimate power, for it is a phenomenon that is full of Chinese features that makes a conversation different and necessary. There is no time to delve into the emergence of Sino-capitalism and its historical influences. Though, its socio-economic and environmental consequences are behind the symptoms that many actors reported in the interviews regarding the challenges in the process of knowledge exchanges. Sino-capitalism is characterised by state capitalism and "strong bottom-up dynamics of capital accumulation, based on informal institutional adaptations and the use of family and guanxi networks" (Mcnally, 2018: 276). Similar to the economic development, the Sponge City program is also being implemented by balancing the state and local administrative and hierarchical power and relations, as well as public and private capitals and interests (4.3). Therefore, it was not a surprise when the results presented relational barriers that are centred around power and trust.

In a study on the interpersonal trust among managers and their peers, McAllister (1995) distinguished two kinds of interpersonal trust – Cognition-Based Trust and Affect-Based Trust. Cognition-based trust is generated based on "good reasons" and "evidence of trustworthiness" (Lewis and Wiegert, 1985:970, as cited in McAllister 1995). Interestingly enough, the author found that the theory-based predictors were not associated with cognition-based trust, and these are a peer's reliable performance, professional credentials, and social-ethnic similarity. Whereas a peer's supervisor's assessments of performance were found to be strongly associated with a manager's cognition-base trust in this peer. Affect-based trust is based on the emotional bonds between individuals, where interpersonal

citizenship behaviour (altruistic actions to assist, support and develop colleagues), and frequent interactions are inducive to higher trustworthiness. In another study on the cultural influence on interpersonal trust in the context of e-commerce, Kim (2005) concluded that affect-based trust is contributing more to consumer trust in a collectivist culture (South Korea) than in an individualist culture (United States).

The setting in which interpersonal trust is discussed in this study is different from organisational relations or e-commerce. Nonetheless, the power-based and expertise-based types of trust can be categorised under cognition-based trust, since they are formulated with "good reasons" and "evidence of trustworthiness" despite the sources of evidence are quite different. The study was not specifically designed to measure interpersonal trust, so one cannot conclusively state that the competency level, reliability, and professional credential of the actors do in fact play a role in their trustworthiness perceived by others. However, the findings presented such evidence which provides the basis for further research on the correlation of these factors and cognition-based trust.

The study conducted by Kim (2005), despite the limitations, brought a glimpse of the effects of cultural factors on how trust is determined. However, in the case of Sponge City, the impact of culture on trust is more than collectivist vs individualist, it is formed by the unique state-local dynamics and the sociocultural characteristics of China. In a nutshell, the legitimate power, be it possessed by an actor, or vouched by an actor who has it, is a significant determinant of trustworthiness, which itself is a prerequisite of knowledge transfer between actors. This determinant is shaped by the historical roots in China's political economy and administrative structure. It is part of the contemporary culture of China, and thus instead of regarding it as an obstacle, better results of cross-disciplinary and cross-profession knowledge exchanges can be more productive by incorporating it into the solution.

At this point of the discussion, it seems paradoxical that project such as Sponge City often rely on trust between actors to pave the way for effective knowledge communication, and yet the actors often do not have the opportunities to forge personal relationships and develop trust based on shared values and experiences of cooperation. Though trust has been identified as a key factor of knowledge exchange in this research, it does not imply that effective knowledge transfer depends on a well lubricated network that has high levels of trustworthiness between the actors that were built up gradually with time and experience. As the examples in Boxes 2 and 3 showed, the factor that determined the outcome of a cooperation opportunity was whether an actor trusted other enough to allow for access to tacit knowledge.

In summary, the second barrier (B) relates to the behaviour and social rules; therefore, one could say that it is a 'relational barrier'. Some relational barriers, such as not being able to identify with a group or network, are easier to rectify. For it is also a type of concealed knowledge, and only those who belong to the social space can have access to resources that remain tacit to those who are outsiders (Collins, 2013). However, the knowledge that remains tacit due to relational barriers that are rooted in social rules and social contexts is much more difficult to be made explicit. Collins described this type

of tacit knowledge as collective, where "the right way to do things can only be captured through experience" because the knowledge does not locate in any individual but is permeating in the society (Collins, 2013: 122). Just as mentioned in the earlier section, such tacit knowledge understood without being explained explicitly by those who are part of the social group, but almost impossible for outsiders to grasp without practice. Consequently, it would be more effective and efficient to empathise with other actors first to better conduct knowledge transfer when there are such relational barriers.

C. Unable to mobilise knowledge resources due to predominantly cognitive barriers

As pointed out in chapter 2, understanding the local power relations and internal dynamics can be a quite slow process, especially when actors enter into a project without proper anticipation of such "cultural shock". In comparison, the cognitive barriers present more tangible, and more or less universal challenges that have been troubling any cross-disciplinary communication and knowledge transfer. One could argue whether it is even necessary to invest time in acquiring detailed knowledge on all relevant disciplines and fields, and in truth, it would be over-ambitious to aim for such goals. However, being able to exchange knowledge through dialogues would be able to prevent some difficulties identified by many actors presently. Just as actors expressed in the interviews (chapter 7) that plans are important for they inform the subsequent design and construction, but Sponge City plans often did not live up to their expectations. Other than the lack of channels for knowledge exchange between the implementers and plan makers (A1, A2), the inability to convey and understand presents an obstacle.

Communication difficulties can be attributed to the lack of overlap in the actors' knowledge bases and thus their worldviews and perspectives. Although many said that it was easier to have a technically oriented discussion with government actors that had prior exposure to IUWM knowledge, most of the times this kind of overlap was not enough to reconcile the differences in their approaches towards a problem. Between non-governmental actors, in addition to the different mental frameworks, there are concepts, jargon, and processes that actors from different professions do not share.

One solution that was often brought up was to have people on a project team to adopt a similar worldview in order to "think on the same track". While putting oneself in someone else's shoes is a good strategy to understand where the others are coming from, it is doubtful that having a consensus among all actors is always beneficial? After all, individuals should bring their knowledge, experience and skills so together they are working towards a common goal as a team (Nancarrow et al., 2013). Indeed, there are subjects that actors working together should agree on such as an end goal, but it would be too lofty and too counterproductive an objective to ask for homogeneity for the sake of more comfortable communication. Actually, while the focus of the discussion is on the difficulties of transmitting knowledge across the boundaries of disciplines, one shall not forget that the disciplines themselves are heterogeneous and often have not an agreed set of problems, objectives, practices, theories, and so on (Barry et al., 2008). In other words, not having sufficient knowledge overlap and

standard vocabularies is not a new or insurmountable challenge because of the arbitrary field in which each actor decides to confine herself, but it certainly adds to the difficulty level when a surface water engineer has to communicate with not only another groundwater engineer but with a landscape architect.

In summary, the third barrier concerns the cognitive aspect. When an actor fails to explain a familiar concept to someone outside of the discipline or field, the knowledge can be described as somatic tacit knowledge. A classic example of this is Polanyi's story of bicycling. The person who possesses the knowledge is able to carry out the motions and yet fails to tell how to do it. The person could even input instructions into a machine and produce results. However, it can be more difficult to explain in steps to another individual (Collins, 2013). Cognitive barriers also block the transfer of tacit knowledge due to not knowing what others already know (mismatched saliences) and not knowing what actors themselves already know (unrecognised knowledge). To transfer tacit knowledge across this type of barriers, one should possess and practice the skills of explaining to an unfamiliar individual verbally and in writing. More importantly, one should anticipate the existence of gaps in knowledge and develop the skills to gauge the level of understanding between the individuals involved in the conversation.

8.2 Can tacit knowledge in urban water management be made explicit?

If tacit is the equivalent to not being communicated in action or words, then it implies that tacit knowledge *can* be made explicit, if it *is* communicated. However, if knowledge either is tacit or rooted in tacit as Polanyi said, this question becomes invalid. Tacit, is an adjective that means understood or implied without being stated (Oxford English Dictionary 2015, tacit entry). And 'imply' means to indicate the truth or existence by suggestion rather than explicit reference (Oxford English Dictionary 2015, imply entry). Upon reflection, the researcher maintains that knowledge as a collective group of ideas, concepts, information, cannot be split into either tacit or explicit. Secondly, a knowledge that is tacit in nature can be made explicit, or in other words, "stated clearly and in detail", but it does not go through distinct stages such as socialisation and externalisation to get there.

At the beginning of chapter 2, the description of tacit knowing/knowledge of Polanyi was provided as a starting point of deciphering what tacit knowledge is and how well it can be explained between people. However, further elaboration on the mechanisms of extraction of this kind of knowledge is much needed so that it is possible to characterise different pathways and the extent to which tacit knowledge can be better learned and exchanged between actors to improve urban water management.

Polanyi emphasised the personal element of knowledge as a characteristic of being tacit. In his view, one cannot separate the personal elements of knowledge, for the tacit knowledge is a dispensable part of all knowledge. He also stated that "true knowledge lies in our ability to use it (Polanyi, 1966: 17)". Hence, we can "know more than we can tell (Polanyi, 1966: 4)". An example he gave was of someone

being able to operate a machine without knowing how exactly works while an engineer would know more about the construction and operation of the machine. Under the condition that explicit and tacit elements are both indispensable parts of knowledge, he juxtaposed the practical knowledge against theoretical knowledge, where theoretical knowledge was said to be "far more revealing (Polanyi, 1966: 20)". Thus far, he has presented several levels of 'knowing', from not being able to operate a machine, to be able to operate but unfamiliar with the intricate mechanisms, to be able to theorise how to operate, and finally to be able to theorise *and* operate.

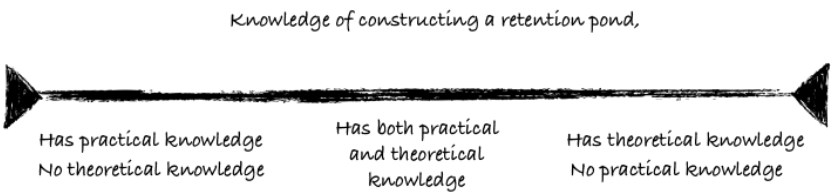

Figure 8-2 a conceptualisation of Polanyi's description of the possession of practical and theoretical knowledge, and that one cannot replace the other

Following the logic of Polanyi, Figure 8-2 illustrates that one can have either or both practical and theoretical regarding the construction of a retention pond in a neighbourhood. It is therefore important to acknowledge that 'knowing' is also a concept that falls on a spectrum, and it is not to anyone's advantage to judge hastily whether someone 'knows' nor the value of anyone's knowledge. Knowledge is a resource constituted by one's perception and understanding. It is made explicit when it is transmissible from one person to another in the sense that another person can take this resource and perform the same task as well. Urban water management is a social activity, so perhaps the knowledge of constructing a retention pond can also be conceptualised in another way according to Harry Collins's terrain of tacit knowledge. As a reminder, the three levels of tacit knowledge introduced by Collins are relational, somatic, and collective. Relational tacit knowledge is mechanically able to be explicated because it refers to knowledge that is intentionally or unintentionally unrevealed. Somatic tacit knowledge refers to knowledge that can potentially be broken down into steps to a point where a machine can replicate the performance, but one does not follow each detailed step to use of knowledge to perform a task. This is also the type of tacit knowledge that fits Polanyi's description of tacit the best. Collective tacit knowledge, on the other hand, is likely to remain tacit because it is deeply embedded in the social understanding that is collectively formed by the society. Figure 8-3 uses this map to describe how the knowledge of retention pond construction can be tacit to different extents.

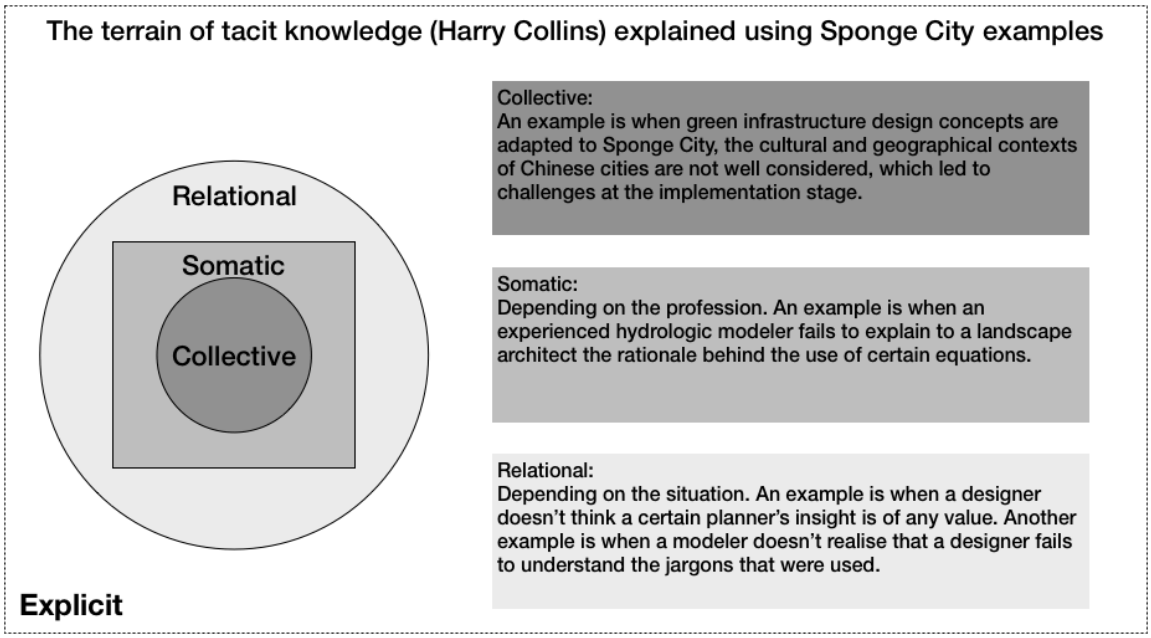

Figure 8-3 The terrain of tacit knowledge applied explained using Sponge City examples

8.3 Amendment to conceptual map of urban water management constraints and barriers and the social capital theoretical framework

Tacit knowledge became the focus of this research because sustainable urban water management demands that contributing professionals be able to work with actors and their knowledge and skills that represent a wide range of fields and disciplines. The urban water network thus contains vast amount of existing capacities and competencies to be tapped and shared (International Water Association, 2016). Previous literature on social capital theory and tacit knowledge has not looked at learning and transfer of knowledge in the context of integrated urban water management. The aim of this research was not to overshadow the importance of technological solutions and technical innovations with the extensive discussion emphasising the importance of social and cultural factors, but first and foremost, it is the human actors that wield power to enable/disable, and have the capacity to receive and experience the subsequent changes and their outcomes.

In section 2.3.3, a map of constraints and barriers in sustainable urban water management was developed from the literature review. With the new insights gained from the findings, this map should now be updated accordingly. There are additional factors to consider besides the human components of water management, the access and mobilisation of social resources by actors, and research that benefits from and contributes to the practice of management and the use of knowledge resources. As illustrated in Figure 8-4, the discussion of the social or human components of urban water management should be placed in the context of the economic, political, and cultural contexts. In

addition, the actions of non-human actors and their consequences are also some factors that add or subtract barriers to knowledge transfer.

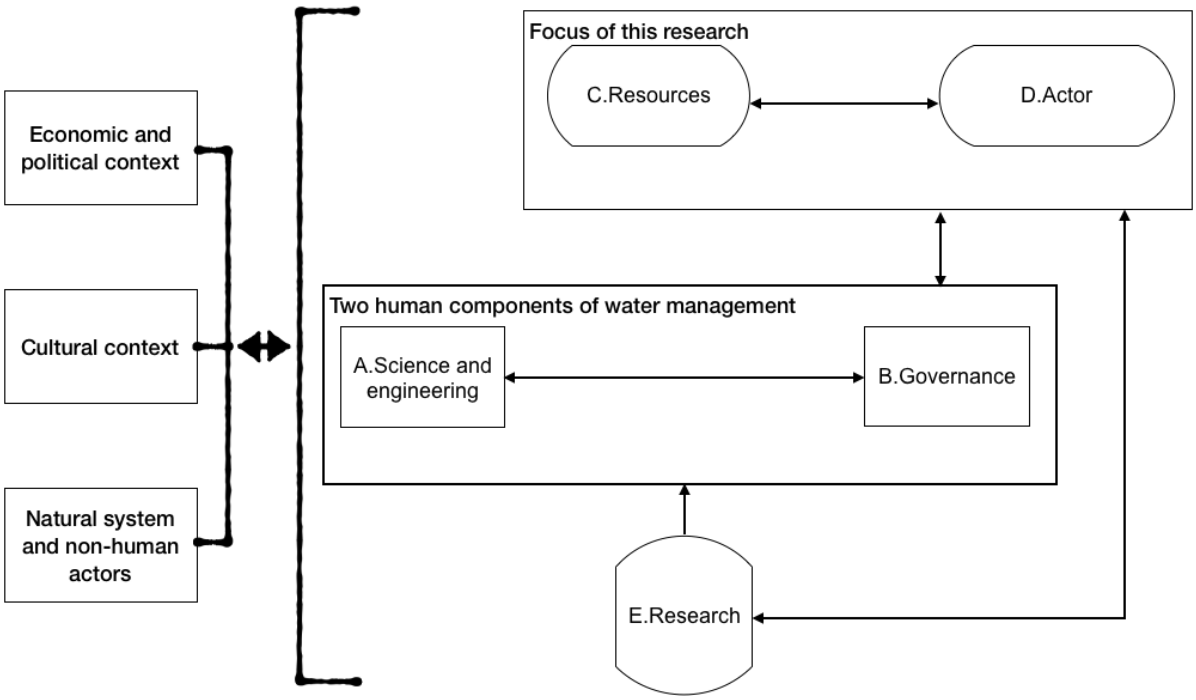

Figure 8-4 Modified map of the relationship between human components of water management, social resources, actors, and research, with consideration of economic, political, cultural contexts and the natural system that includes non-human actors

In previous sustainability projects in China, expected successes were often unmet because the technical expertise and capacities are not well aligned with planning discourses or government mission statements (Lo, 2015). The Sponge City program had the advantage of aligning the technical expertise with the government mission statements, and the planning profession has the potential to become knowledge broker between the government and non-government actors, as well as between various relevant fields and disciplines. Adopting a pragmatist perspective again here, we shall recognise the plurality of truth, and that what is true to one person may not be true to another. It is thus important to recognise and embrace the complexities in a sustainable urban water management problem, since the same problem may have different manifestations and require different solutions depending on the perspective of the actor, as shown in Box 2. Therefore, it is not worth the effort to work on finding what is the true right answer or solution; instead, what is important is how to communicate and form a collective *workable* "truth".

In Philip Ball's book 'The Water Kingdom', he drew attention to the historic anthropocentric view of the environment and nature. From the ancient Confucian's idealism to the recent history of dam building, it seems to claim that the culture itself is not inducive to environmental protection and preservation, and to this he refuted by clarifying that "none of this suggests that there is something uniquely bad for the environment about an authoritarian, socialist form of government (Ball, 2016:

296)". Cultural factors and the attitudes and behaviour that they are shaping should not be targeted as the root cause of challenges arise when trying to implement integrated urban water management in China, but it is still necessary to look into the means to guide a shift in the culture that governs the relationship between water professionals (Brown et al., 2009; Fjalar J De Haan et al., 2015; Rogers, 2003).

The urban water system is entangled with the social, economic, political, and cultural contexts which are governed by the rules of the society. Furthermore, to manage and tackle the problems in the urban water system, a large amount of knowledge from all relevant disciplines and fields needs to circulate and transfer among the professionals. To improve knowledge communication between water professionals in order to deliver better results in Sponge City and IUWM in general, it is imperative that one considers the structural, cognitive, and relational aspects of barriers. Likewise, strategies for tackling the challenges should span all the aspects as well.

Equipped with the understanding of both the meaning of tacit knowledge from the literature review and the challenges and barriers of communicating tacit knowledge in urban water management from the research findings, one can see that the position of collective assets in the framework should be changed. Therefore, the theoretical framework of social capital should be amended accordingly (Figure 8-5). The collective assets were initially described as one of the preconditions for the mobilisation of social capital. However, as demonstrated through the examples in Boxes 1 to 5 and the amendments made to the conceptual map of constraints and barriers (Figure 8.4), the *collective assets* are actually the elements that underpin the preconditions which can be categorised into structural, cognitive, and relational aspects. This echoes the terrain of tacit knowledge developed by Harry Collins because this 'collective assets' prerequisite describes the conditions that attribute to the collective tacit knowledge (the use of 'collective' in both terms is coincidental).

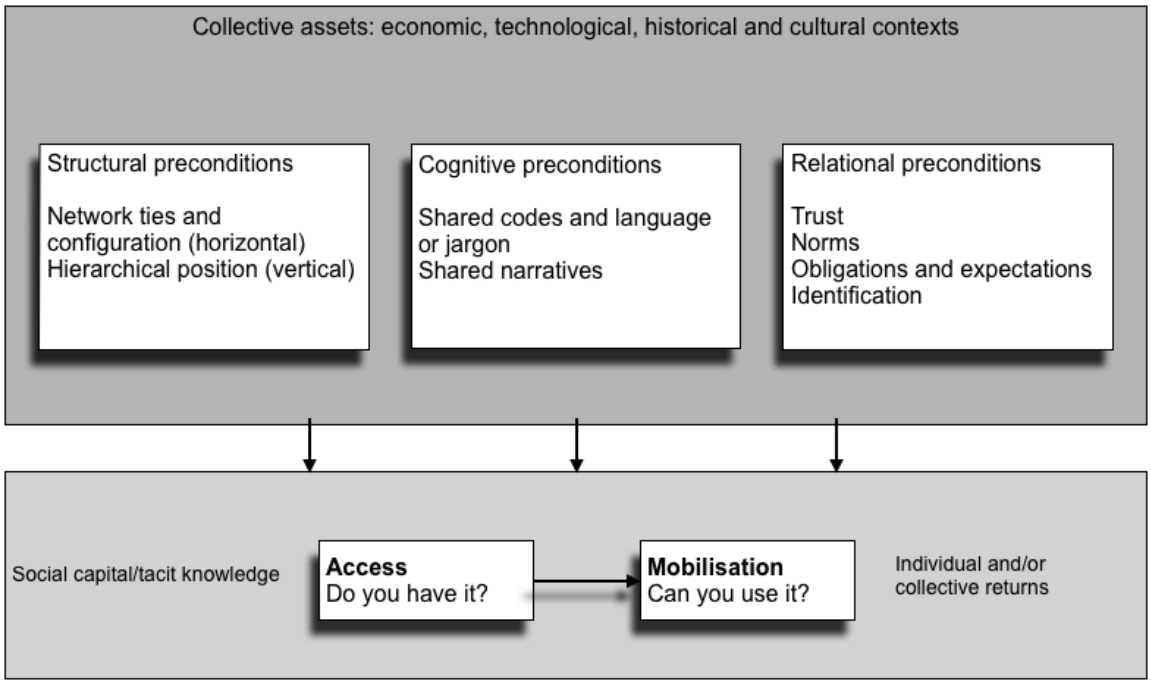

Figure 8-5 Modified theoretical framework of social capital access and mobilisation

The structural preconditions affect the access to social capital, and knowledge is kept relationally tacit when there are barriers that prevent it from being revealed, whether intentionally or unintentionally. The cognitive preconditions affect the mobilisation of social capital, and knowledge is likely to be kept somatically tacit when there are discrepancies between the steps that a task requires and the steps that an actor actually takes to accomplish it. The cognitive preconditions can also cause the knowledge to remain relationally tacit when an actor is not aware and hence does not fill in the gap of knowledge. The relational preconditions are likely to cause knowledge to remain collectively tacit. Although the direct consequence of the lack of trust, obligation, or identification with a group can be the refusal to reveal the knowledge, a more profound cause lies in the social understanding and unspoken rules. This aspect is complicated because of how much it is embedded in society. The Sponge City case study demonstrated that though sometimes it is the actors' inability to articulate or comprehend a piece of knowledge that destroys the building of a network that is inducive to knowledge transfer, the nature of the relationship can predispose the individuals to failure of knowledge communication due to vertical and horizontal structural barriers and relational barriers that keep knowledge tacit.

9 Conclusions, contribution, and future work

This study embarked on a journey to investigate the ways water professionals communicate across disciplines and fields in order to deliver integrated urban water management. To disclose the challenges in the communication of knowledge across the boundary of disciplines and fields, the study is zoomed in on tacit knowledge, or the knowledge that is not communicated with clarity, and its movement in the network of Sponge City. Using Sponge City as a case study, the study queried the actors' preferences for acquiring and using different types of knowledge and investigated structural, cognitive, and relational factors that induce and obstruct the knowledge transfer between actors from different backgrounds. This final chapter draws from the discussion of the findings and concludes this entire thesis. It outlines the contributions of this work towards advancing the understanding of the theory on tacit knowledge as social resources and improving urban water management practices. Finally, it introduces several streams of future work to further the contribution of this research in the areas of integrated urban water management within and outside of China.

9.1 Conclusions: in relation to the research objectives

9.1.1 The "tacit" in integrated urban water management

A competent water manager should possess the ability to communicate with a wide range of disciplines, professionals, stakeholders and users, and be able to understand and convey ideas and opinions (Cosgrove and Loucks, 2015). Undoubtedly, the acquisition and learning of knowledge are crucial in the context of integrated urban water management. To achieve the first research objective, "define the tacit component in integrated urban water management and how it affects knowledge transfer", quantitative data on the actors' tendency to use and the learning strategies for different types of knowledge are gathered using an online survey instrument. The answer provided by the quantitative analysis is further supplemented by the findings from the qualitative aspect of the study.

Table 3-1 described three theoretical positions of tacit knowledge. There are distinct differences between the interpretations of each theory. Where the theories agree is that knowledge can display either or both tacit and explicit qualities. This raised the question of whether certain pieces of knowledge are more deeply embedded in a person's experience and context, while others are straightforward and describable. Given such characteristics of knowledge as discovered in the literature review, the initial assumption was that the type of knowledge an actor tends to use or find useful would be different depending on that person's disciplinary background and the tasks to be accomplished.

The findings did not confirm this assumption. Instead, it demonstrated the similarities in complexity and behaviour of actors from different fields. With no differences found in the preferences over the use of tacit or explicit knowledge, it shows that actors rely on various types of knowledge to accomplish their tasks. The difference then emerged in the communicating process, and problems occur on both the giving and receiving ends. The same piece of knowledge may be configured differently when a person is accessing it, using it, and communicating it, and a person may or may not be able to achieve all three actions. What can be accessed may not be used, and what can be used to solve a problem may not be communicated with another person. Interpersonal interaction was preferred by all professions, though for a slightly different type of knowledge, as a learning method. However, in the interviews, some revealed that they had trouble explaining a concept that they knew well, thus unable to communicate and transfer the knowledge to a colleague who was seeking for clarification. The challenge displayed here is an example of the tacit component of the urban water management community.

Tacitness is also reflected in the obstruction of communication between individuals and organisations due to other social and relational reasons. The difference here is that the knowledge is not being transmitted, therefore remained unclear to others. Section 7.2.2 showed that some professions do not have connecting ties and therefore, no direct interactions. An example is a disconnect between actors at the construction stage and urban planners as well as researchers, which can leave insights and ideas concealed and unexplained between them.

The tacit component also lies with the method of knowledge acquisition, for resources of knowledge on some topics are not readily available and of good quality. When looking at the methods of acquiring knowledge, interpersonal interaction and written materials stand out as the preferred (then case studies/review articles, and after that personal investigation). In general, interpersonal interaction and written materials were used to obtain disciplinary-specific and conceptual knowledge, while case studies and personal investigation were used for practical knowledge. An exception was that case studies were used more to obtain conceptual knowledge by university/research actors, and project managers used written materials more for practical knowledge. Other than personal preferences, this is an indication of the availability or the quality of learning sources for different types of knowledge. To learn practical knowledge such as modelling skills, contextualising solutions, public engagement, the interaction with other actors and the text-based materials were usually not sufficient.

9.1.2 What influences knowledge transfer among "water professionals"?

The second research objective sought to "characterise the factors influencing knowledge transfer between actors from different professional backgrounds, as well as between these actors and communities". A theoretical framework of social capital theory derived from the works of Nahapiet and Ghoshal (1998) and Lin (1999, 2004) was used to guide the analyses of the data collected via semi-structured interviews with Sponge City actors. Knowledge is the individual and collective resources embedded in the network of actors involved in Sponge City projects. The resources are being acquired and used by actors to generate ideas and solve problems, and meanwhile, new knowledge is generated and added back to the pool of resources.

Structural barriers directly affect the access to socially available resources, making it particularly difficult to obtain knowledge in the network, including those that one might not even know existed. The availability and the immediate accessibility of information are important to the success of knowledge transfer and uptake. Sponge City projects had two characteristics that are causing structural challenges. First, the networks were unstable, and members are frequently changed. Second, the responsibilities of the actors involved were ambiguous.

Cognitive barriers relate to challenges associated with the understanding the vocabularies used, and the ability to unpack difficult concepts for an unfamiliar audience. Many actors attributed the difficulties with communication to the differences in the perspectives, and the lack of a common language. There are two variations to this challenge. First, the actors struggled to understand when they are faced with different and sometimes contradictory explanations. The second is actors having trouble clarifying what they know using vocabulary and logic that others can understand well.

Another factor is the willingness of the actors to learn and participate in the collaboration. Some actors expressed the eagerness to learn or the awareness of learning or working with other people with other

types of expertise. Whether this willingness can be translated into success in knowledge transfer of course still depends on the interaction with other factors.

Relational barriers are characterised by lack of trust in other actors, which can stem from different causes that include adverse effects of the structural and cognitive barriers, as well as some cultural characteristics. Several reasons are contributing to the lack of trust. First, when the decision-maker is not the one that holds the most authority administratively. This is strongly influenced by the cultural dynamics and governance characteristics of China, especially the overlaps and gaps in responsibilities and the conflicting priorities due to the complicated "line" and "block" administrative structure (see 4.2). The power dynamics of the administrative bodies and the existence of guanxi then determine whether an actor can be perceived as competent and trustworthy. Needless to say, trust can also emerge from experiences of interaction. In addition, whether there is trust affects an actor's willingness to anticipate and accept the values of opinions and knowledge that are "foreign".

The findings showed that the two dominating factors were the perceived creditability (or the perceived legitimacy) and the perceived trustworthiness of other actors. However, it is interesting to see that the complaints mainly revolve the knowledge import rather than knowledge export. People interviewed are generally comfortable with sharing their own opinions and insights but are more selective about accepting knowledge from others.

Studies have shown that reason-based trust [15] increases as the authorities being perceived as knowledgeable and legitimate, and authorities with a high level of legitimate power are perceived as competent (Hofmann et al., 2017). In their study, findings from one experience showed that high level of legitimate power also increases the perception of coercive power, and legitimate power wielded exclusively or in combination with coercive power, can increase reason-based trust, as well as reduce the perceived antagonistic climate (ibid).

Although not commonly found in the interviews, there were some actors that reflected on how having a trusting relationship between actors and tight personal networks can allow for easier collaboration. It is easy to notice that the actors that talk about successes in their collaboration with another individual or group/organisation, often express their trust and sometimes praise the abilities of their partners. This trust is the manifestation of the perceived credibility or legitimacy that the actor bestowed on the collaborators. On the contrary, low perceived credibility is expressed as lack of leniency in judgement, avoidance of open dialogue, and unsuccessful collaboration effort.

9.1.3 Are urban planners the "knowledge brokers" in Sponge City?

What urban planners can achieve for China's urban water management should be considered within the unique cultural and historical context of the nation. The description by Philip Ball below captures

[15] System 2 trust, trust that is taken after some consideration, in contrast to implicit trust

the significance of water management and the essence of the objective of Sponge City. Albeit promoting decentralised measures and the consideration of local contexts, the Sponge City initiative is united under one vision that is defined in the State Council issued implementation guidance and clarified in the Sponge City plans. In this sense, plan makers or actors that make plans relevant to Sponge City can play a pivotal role in the success of integrated urban water management in China.

> **It is tempting to ascribe the many shortcomings of the modern water conservancy to bad, overly centralized management, bureaucratic corruption and inefficiency, technical incompetence, hubris and negligence. One can find all these things, but there was nothing new in that – it was the same story from the Sui to the Qing. What is more revealing is how the traditional rhetoric surrounding water management was mobilized for the purposes of constructing a particular vision of modern China** (Ball, 2016: 220).

It is reflected in official documents that the role of planning should be "leading" the project and provide interpretations and clarifications to the Sponge city concepts, strategies, and requirements. The plan makers are thus placed in a unique position where they are connecting the vision and the actors working to realise it, through their interpretation and understanding captured in the planning documents. Although they occupy a potential "knowledge broker" position in Sponge city projects, the actors interviewed revealed that the plans and the planners have not been fulfilling this role well enough. Previously structural, cognitive, and relational barriers to knowledge transfer in Sponge City were identified, and urban planners have the abilities to tackle them from several approaches. It is important to note that "urban planners" actually describes a group of practitioners that are from a wide range of disciplinary training, including planning and other various engineering and design fields.

Urban planners and the plans they make can provide stability to the Sponge City network. Experienced and renowned plan makers (sometimes it is an individual, sometimes it is an institute or organisation) are often involved in the writing of plans for several projects from different cities. At the moment, the planners are indirectly connected to actors at all levels through the documents they produced, but they are not directly in contact with design, construction and other implementation stages actors. It is of course not feasible to propose that the plan makers of each Sponge City project group should converse and exchange ideas with designers and construction contractors from each of the projects in the group, it is also impractical since the plan cannot be modified at once based on each piece of feedback. However, as revealed in the interviews, planners could should be given more opportunities to exchange insights and opinions with implementation actors upon completion of all projects.

Since the pilot projects started, practitioners reflected on the progress and identified more attention paid to the implementation quality of the plans at later project stages (Tong, 2017). However, actors interviewed reported challenges associated with the implementability of the plan. Many actors expressed in the interviews unsatisfaction with the applicability of the plan, while most planners interviewed neglect such allegation because they believed that a Sponge City plan is meant to be consulted and adapted to different local contexts and is not supposed to provide specific methods and explanations. As a result, the knowledge gaps that may exist between the planners and actors performing design and construction are left unfilled. This research showed that the knowledge gap

between researchers, planners, policymakers, and the actors at design and construction stages should be bridged. Urban planners can help bridge the gaps in knowledge between the actors at different levels and backgrounds. One way to do that is to ensure that the language used in the plans have high levels of clarity, consistency, and are accessible by all disciplines that refer to the writing (7.3.1). By studying and consulting the Sponge City plans and other resources they are able to produce to circulate their experiences, the actors at different stages can develop to a certain extent "interactional expertise" among them that will enable better communication and knowledge transfer. To achieve this, the plans or other documents planners can produce should be written in a language that avoids unexplained jargons, and with consideration of local context and the knowledge backgrounds of the local actors.

9.2 Knowledge, communication, and urban water

9.2.1 Contribution to knowledge

Overcoming knowledge transfer barriers in urban water management

Many studies have identified challenges of blending two or several disciplines and fields of studies involved in urban water management, which tended to fall under the categories of policy, resources, governance, and individual and societal perceptions, attitude and behaviours (Barron et al., 2017; Bell, 2014; Brown et al., 2009; Cosgrove and Loucks, 2015; Dhakal and Chevalier, 2017; Qiao et al., 2018). This study zoomed in on a root cause of the above-mentioned challenges – the difficulties regarding the communication of knowledge between actors (Chapter Seven). Two categories of challenges to knowledge access and two categories of challenges to knowledge mobilisation were of focus in this study. Structural barriers due to lack of appropriate platform and media are identified to cause challenges to knowledge access in a network. Relational and cognitive barriers mainly prevent the mobilisation of knowledge due to difficulties with establishing and maintaining a good relationship, as well as being able to express and comprehend other actors. The study thus emphasised that any strategies to improve knowledge communication between water professionals should make the following consideration. They should consider the interconnectedness of the influence of social-political constraints on network structure and configuration, the influence of societal rules on the relationships between individuals and communities, and the influence of complexity in urban water management on knowledge transfer between actors.

Tacit knowledge discussion in sustainable urban water management

The transition of urban water management requires a distinct shift in cognitive, regulative, and normative pillars of institutional practice, and changes to waters are underpinned by political and economic changes (Ball, 2016; Brown et al., 2009). Discussions and recommendations regarding urban water management, water policy, and water governance are abundant. Unlike technological solutions, sociological, institutional, organisational solutions tend to be grand in scale, but one needs to keep in mind that changes are made through the individual and collective actions of the people involved, and

that transitioning from one paradigm or frame of mind to another is extremely difficult. Therefore, the contribution of this research is not aiming at a higher-level integration. Instead, this thesis is hoping to contribute to the smallest change that can be implemented at more minuscule levels. After all, knowledge originates from and are exchanged directly and indirectly between the individual actors, and these individuals form a temporary network that is the network of Sponge City

The discourse of tacit knowledge is infrequently found in the context of urban water management. To fill in the gap, sociological tools were used in this research to study how water professionals are able or unable to communicate effectively due to the tacitness of knowledge being transferred. There are three prominent contributions made by this study. First, the meaning of tacit is clarified and applied to sustainable water management. Second, different connotations of tacit knowledge in the context of urban water management are delineated based on the means and tools needed for its communication. Third, strategies are identified to bring clarity to the communication of knowledge that remains tacit for different reasons.

9.2.2 Contribution to methodology

Semi-structured interviews for identifying Sponge City knowledge transfer barriers

Qualitative methods are used to explore and understand the themes and patterns regarding a social problem, which are emerged from the individuals' answers to the open-ended questions. This study is one of the few pieces of research on China's Sponge City that employs qualitative methods, specifically semi-structured interview method. A majority of studies regarding Sponge City is advancing knowledge in areas such as modelling tools and systems, materials, and methods. Often, existing literature that identifies challenges and provides recommendations drew upon national and international experiences and literature review. This study captured the reflections and opinions of actors involved in Sponge City. It is to draw upon the experiences of the actors so that recommendations on improvement can be provided from bottom-up (Chapter Seven).

Using social capital theory with a mixed-methods approach

In a working paper produced by the University of Manchester Brooks World Poverty Institute, the authors concluded that the combination of qualitative and quantitative approaches to the assessment of social capital has several advantages, including generating more nuanced understanding of the local contexts, providing baseline socio-economic information, yielding better impact and evaluation data, and enabling better understanding when disseminated locally (Jones and Woolcock, 2007). A search in Web of Science showed that while there are a few studies that followed mixed-methods approach, they are in the fields of education and business economics. Studies using social capital theory and employing a combination of quantitative and qualitative methods are not found in urban water management. One relatable study is conducted by Sechi et al. (2018), which examined environmental learning and behaviour using a social capital based approach and the three-dimensional framework of Nahapiet and Ghoshal (1998). However, this study was a quantitative analysis. This research used a

case study mixed methods design, employing both quantitative surveys with 387 valid data entries, and qualitative semi-structured interviews of 38 Sponge City actors. It allowed at the same time the generalisation of patterns and habits of the utilisation of different forms of knowledge by Sponge City actors, and the in-depth analysis of the factors that impact the actors' acquisition and utilisation of the knowledge.

9.2.3 Contribution to theory

Conceptual development of social capital theory

This study created and refined a new theoretical model for researchers in the fields of organisational learning and knowledge management to examine tacit knowledge access and utilisation. It presented a conceptual framework that merged and modified the models developed by Nan Lin and Nahapiet and Ghoshal, and it allows for the examination of the access and mobilisation of tacit knowledge using a social capital-based approach. Building on the Nahapiet and Ghoshal (1998)'s argument that social capital facilitates the development of intellectual capital or knowledge, the conceptual framework in the present study adopted a three-dimensional configuration by them, however, instead of using it to describe social capital, the configuration describes the preconditions for social capital access and mobilisation. The change was inspired by Lin (2017)'s argument that the dimensional factors influence the networks and utility of embedded resources, instead of being alternative forms of social capital. This allows tacit knowledge to be analysed as a type of embedded resources in a network. Meanwhile, socialisation is treated as a less lengthy and sustained process with various mechanisms, during which the actors use social capital to exchange and extract tacit knowledge from one another.

9.2.4 Contribution to policy

Recommendations on sources and methods of knowledge acquisition

The survey findings offered insights on how actors acquire different types of knowledge, which can be used to inform policy and practice. There is a number of conferences, seminar, and workshops offered, as well as a range of materials such as articles and book(lets) on- and off-line. Nonetheless, as shown in the survey, the type of knowledge, and how it is acquired depend on the actors' disciplinary and professional backgrounds. The results recommended that different categories of knowledge (discipline-specific, conceptual, practical) should be distinguished. This way, it is possible to provide different opportunities via appropriate media and channels in order to tailor to the needs of professionals from all backgrounds (Chapter Six). Furthermore, learning methods for one group of knowledge should be made available for other groups if they are beneficial to the actors. For example, actors benefit from site visit because one could better learn from the context and receive information in both visual and auditory channels. Likewise, one should also have the opportunity to conduct "design process visit" or "construction process visit" in order to learn such knowledge directly from the context via multiple channels.

Recognising urban planners as knowledge brokers

Sustainable urban water management usually faces various challenges due to clashes in understanding, opinions and motivations that present difficulties in inter-disciplinary collaboration and communication. In the context of China, additional layers of challenges are added because of the cultural and socio-political setting (He et al., 2012; Hou, 1997; Lo, 2015; Tan and Fang, 2016). Because of the strategic position occupied by the planning profession, and the diversity in their academic and professional backgrounds, urban planners have the potential to improve knowledge communication between different stages of projects and different professions.

9.3 Future works

Causal relations between knowledge acquisition methods and social capital access and mobilisation

This research investigated through survey and interviews how actors in Sponge City acquire knowledge as well as the factors that influence their access and mobilisation of knowledge with others. However, it was beyond this research's scope to determine how and to what extent these knowledge acquisition paths and influencing factors can be reinforced and undermined. Future research opportunities should longitudinally investigate the effect of changing either the methods of obtaining knowledge or the preconditions of social capital access and mobilisation. Effort should also be made to determine the causal relations between sources and methods of learning and the access and mobilisation of social capital. An option is to use a participatory system dynamics approach, which should involve the actors in the reflection and change-making process.

Reforming the current education system and improving the pedagogical methods

In China, secondary and higher education still do not have the curriculum to develop the communication, self-investigation, and research skills mentioned in on page 183 (Henderson, 2011) . Therefore, this work should be used to contribute towards the development of an educational program, and in the case of China's STEM education, it requires an innovative shift in both secondary and higher education curriculums. Educational research should involve educators, students, and practitioners to study the approaches and methods of teaching and learning to attain desirable outcomes. In addition, further research should be carried out to use cognitive sciences and social psychology to improve cross-disciplinary learning in complex fields such as integrated urban water management.

Including government actors in future studies

A challenge that this study encountered early on was the inclusion of government actors. Although this study was funded by the China Scholarship Council, the research was conducted without formal collaboration with research groups and institutes within China. For this reason, it was difficult to invite

government actors to participate in the interviews. In this study, the dynamics of knowledge transfer between government actors and non-government actors were extracted from the interviews with non-government actors. While the data is valuable and was able to illuminate on the opinions of actors who worked with government actors, having the data obtained directly from government actors would add valued insight to the factors influencing the access and mobilisation of social capital.

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Appendix A: Survey sample

Chinese version:

海绵城市建设参与者知识结构调查-博士课题第二阶段调研

欢迎参加本次答题

1、您所在的城市是 (下拉填空题 *必答)

省份
城市
区/县

2、受教育程度 (单选题 *必答)

○ 高中及以下
○ 大专
○ 本科
○ 硕士
○ 博士及以上

3、工作年限 (单选题 *必答)

○ 1 年及以下
○ 2-3 年
○ 4-9 年
○ 10-19 年
○ 20 年及以上

4、您的参与方式,（选择所有适合的，如无最佳选项请选择其他并添加您的答案） (多选题 *必答)

☐ 城市规划
☐ 园林景观设计
☐ 市政工程
☐ 环境工程
☐ 水利
☐ 环保
☐ 建筑
☐ 项目管理
☐ 政府部门
☐ 街道办，居委会，业委会
☐ 咨询公司
☐ 施工（总包）

□ 施工（专业分包）
□ 施工（劳务分包）
□ 监理
□ 材料供应
□ 审计
□ 当地居民
□ 大学、研究机构
□ 其他 _____

分割线

5、问题一： 请根据真实情况评估您在参与海绵城市项目时，在多大程度上... (打分题 请填 1-5 数字打分 *必答)

会依靠之前的经验和知识 _____
可以将海绵城市项目的实现过程逐步写出来为别人起到指导作用 _____
利用了非正式渠道来达到或接近预期目标 _____
利用了个人交流的方式来达到或接近预期目标 _____
通过新的办法或措施来解决问题 _____
会依靠书面材料，例如导则，文件，教科书 _____
可以将其中一个项目相关经验转换利用到另一个项目中 _____
可以将其中一个项目中的经验予以改善后应用到其他项目中 _____
会依赖于您的专业常识 _____

从第 7 到第 12 题，请您对下面各类别（A-C）1. 评估您在参与海绵城市之前和之后专业水平和经验程度的变化；2. 并且选出对于提高相关认知影响最大的因素

7、类别 A：专业领域第一问：请根据以下条目来评估您在参与海绵城市之前和之后专业水平和经验程度的变化 1 星 为不熟悉，5 星 为非常熟悉 (矩阵打分题 请填 1-5 数字打分 *必答)

	参与海绵城市项目之前	现在
A. 城市规划		
A. 景观园林		
A. 项目管理		
A. 施工材料		
A. 施工管理		
A. 水科学，水工艺		
A. 建筑设计		
A. 市政工程		
A. 大气科学		
A. 植物搭配		
A. 结构工程		

A. 给水排水		
A. 交通		
A. 生态环境		

8、类别 A: 专业领域第二问：请从下列项中选出对于提高相关认知影响最大的因素 1.书面材料（导则，规范，教科书，等）2.群体性学术交流（讨论，工作坊，访学，会议，等）3.个案调查和总结报告 4.个人调查（通过其他渠道自己调查） (矩阵单选题 *必答)

	1. 书面材料	2. 群体性学术交流	3. 个案调查和总结报告	4. 个人调查
影响最大因素	○	○	○	○

9、类别 B: 概念性知识第一问：请根据以下条目来评估您在参与海绵城市之前和之后专业水平和经验程度的变化 1 星为不熟悉，5 星 为非常熟悉 (矩阵打分题 请填 1-5 数字打分 *必答)

	参与海绵城市项目之前	现在
B. 绿色基础设施，SUDS，LID 的设计		
B. 海绵城市建设目标目的		
B. 绿色基础设施，SUDS，LID 建设过程		
B. 气候变化		
B. Public-Private Partnership (PPP)		
B. 雨洪管理		

10、类别 B: 概念性知识第二问：请从下列项中选出对于提高相关认知影响最大的因素 1.书面材料（导则，规范，教科书，等）2.群体性学术交流（讨论，工作坊，访学，会议，等）3.个案调查和总结报告 4.个人调查（通过其他渠道自己调查） (矩阵单选题 *必答)

	1. 书面材料	2. 群体性学术交流	3. 个案调查和总结报告	4. 个人调查
影响最大因素	○	○	○	○

11、类别 C: 技能第一问：请根据以下条目来评估您在参与海绵城市之前和之后专业水平和经验程度的变化 1 星 为不熟悉，5 星 为非常熟悉 (矩阵打分题 请填 1-5 数字打分 *必答)

	参与海绵城市项目之前	现在
C. 水文模型		

C. 呼吁社会共识，处理当地居民与施工影响的公共关系		
C. 为适应应用地点具体情况而改善相关设计		

12、类别 C: 技能第二问：请从下列项中选出对于提高相关认知影响最大的因素 1.书面材料（导则，规范，教科书，等）2.群体性学术交流（讨论，工作坊，访学，会议，等）3.个案调查和总结报告 4.个人调查（通过其他渠道自己调查） (矩阵单选题 *必答)

	1. 书面材料	群体性学术交流	3. 个案调查和总结报告	4. 个人调查
影响最大因素	○	○	○	○

English translation (used as pilot survey, demographic questions were omitted):

For the sake of the pilot, please just use a project that you are involved in now for all the questions, and when you see "sponge city", substitute that with your own project

5、In your involvement and participation of Sponge City projects

To what extent... (Score from 1-5, 1 is the least, and 5 is most)

Did you rely on prior experience and knowledge? _____
Could the steps for a Sponge City project be written down so that other people can be successful? _____
Did you utilize informal channels to enhance process and result? (Such as social media, blog, etc.) _____
Did you utilize personal interactions to enhance process and result? (Such as phone call, informal discussion, etc.) _____
Did you have to invent steps or methods to solve a problem? _____
Did you rely on written materials (such as guidelines, textbooks, etc.)? _____
Could you experience in one project be generalized to other projects? _____
Could you adapt the steps used in one project to another project? _____
Did you rely on your professional common sense? _____

6、

Category A: Field

Part 1: Please assess your level of experience/expertise in the following, now and before the participation of Sponge City projects

	(now)	(before)
A. Urban planning		
A. Landscape Architecture		
A. Project management		
A. Construction materials		
A. Construction Management		
A. Water sciences, water technology		
A. Architecture		
A. Municipal Engineering		
A. Atmospheric Sciences		
A. Plant arrangement		
A. Structural engineering		
A. Drainage and water supply		
A. Transportation		
A. Ecology		

Category B: Conceptual knowledge

Part 1: Please assess your level of experience/expertise in the following, now and before the participation of Sponge City projects

	(now)	(before)
B. Green infrastructure/SUDS/LID design		
B. Sponge City objectives		
B. Green infrastructure/SUDS/LID construction		
B. Climate change		
B. Public-Private Partnership		
B. Stormwater management		

Part 2: Based on Part 1, pick the biggest contributor to difference in knowledge level, from **written materials (guidelines, protocols, textbooks), interpersonal interactions (discussions, workshops, study tours, observations), case studies and review articles, personal investigation:**

	Written materials	Interpersonal interactions	Case studies and review articles	Personal investigation
B. Conceptual Knowledge	○	○	○	○

Category C: Skills

Part 1: Please assess your level of experience/expertise in the following, now and before the participation of Sponge City projects

	(now)	(before)
C. Hydrological modelling		
C. Public engagement/resident mediation		
C. Adaptation of design to local site conditions		

Part 2: Based on Part 1, pick the biggest contributor to difference in knowledge level, from **written materials (guidelines, protocols, textbooks), interpersonal interactions (discussions, workshops, study tours, observations), case studies and review articles, personal investigation:**

	Written materials	Interpersonal interactions	Case studies and review articles	Personal investigation
C. Skills	○	○	○	○

Appendix B: Interview guide

Interview questions for the project: Knowledge transfer in urban water management: role of planning in China's Sponge City

Participant:

Date:

Recorded? (Y/N)

Project description, consent form, Q&A (10min)

Questions (55 – 65 min)

Part 1: Participant Information and Opinions

1. Can you describe your job to me? How are you involved in Sponge City projects, and what is your role? 描述你的工作, 海绵城市方面的参与方式与过程

    a. What is your understanding of the objectives and goals of Sponge City? 您对海绵城市的目标目的以及推行的手段是怎样理解的

    b. What is your understanding of the role of "planning"? 您认为规划起到的作用是什么？

    c. How long have you been working on…? 参与有多久了

2. How does it compare to past projects you have worked on? 和以前类似的项目相比，有什么不同，尤其是在跨领域部门合作方面？

3. So far, what is working and what is not working? 您参与项目中最满意的地方在哪，哪里您认为不是很合理或者还需要再改进？

Part 2: Sketching exercise 构成合作，共事关系网图, 并且对关系网排序

Dimensions:

政策，规章条例制定
规划
设计，工程
运行，评估，维护，监测
财政，资金运转

1. Regarding [dimension], can you walk me through how you connect and collaborate with other departments and/or organisations? 在_____方面，你的主要上下游关系，和哪些部门有接触和共事

Part 3: Network ranking 对关系网进行不同性质的排序

1. Rank the top three sources of your information:对信息/知识来源排序

第一	
第二	
第三	

2. Rank the top three sources of information that you trust or rely or go to when you have questions or concerns the most: 依可靠性对信息/知识来源排序

第一	
第二	
第三	

3. Rank the top three (individuals/organisation) that you would like to collaborate closer with: 是否有向更密切合作共事的组织机构

第一	
第二	
第三	

4. Rank the top three receivers of information from you: 对信息/知识接受方进行排序

第一	
第二	
第三	

Part 3: Comments/Suggestions

1. *Would you suggest anyone else that could be helpful to this research?*
2. Any other suggestions or comments?

Appendix C: Analysis context and description of quotes

C-1 Context and description of the quotes for the analysis of relational dimension concerning the interactions with authority figures

Actor	Actor category	Context of quote	Mutual respect, trust and trustworthiness	Context of quote	Obligations and expectations, norms, identification
U1	University (Research, teaching, project)	successful experience	The respect and trust from the authority are valued more because communication would be easier when the leader agrees with your ideas	successful experience	collaboration is easier once the norm of practice in Sponge City design is established
U2	University (Research, teaching, project)	condition for success	Working with other actors in the government is easier when the leading actor is respected and trusted	successful experience	Cross-disciplinary collaboration becomes easier when there is a growing awareness of its importance in the network culture
U4	University			challenging experience	Collaboration is difficult because there is no social norm of openness to collaboration and risk-taking that is tied to it
U10	University	successful experience	Collaboration is good here because the authority figure is trusted and respected because the efficiency of collaboration depends on how much authority the coordinator has		
C17	Design			challenging experience	Collaboration is difficult when actors are unsure of their identities and what their professional responsibilities should be

(Continued)

C-1 (continued)

Actor	Actor category	Context of quote	Mutual respect, trust and trustworthiness	Context of quote	Obligations and expectations, norms, identification
C20	PPP	challenging experience	Quality of collaboration with government is affected by the unsatisfying technical skills of the support centre		
C21	PPP	successful experience	Working with the government is the easiest since they have money and power to coordinate collaboration		
C22	PPP	challenging experience	Our success in working with other actors inside and outside of government depends on how much effort the leading government bureau puts into coordination and how much authority it has in the network		
P1	Planning	challenging experience	Whether our work with the government can succeed depends on who leads the Sponge City bureau (the more authority it holds, the better)	challenging experience	Our collaborators have a problem with identification: they are unsure whom they are working for
P3					
C7					
C1					
C2 and C3	Construction	condition for success	It depends on how competent the sponge city bureau is in terms of coordination [the level of the person/office who is in charge]		

C-2 Relational dimension: between non-governmental actors

Actor	Actor category	Collaborator category	Context of quote	Mutual respect, trust and trustworthiness	Context of quote	Obligations and expectations, norms, identification
U3	University	University				
U4	University	University				
U5	University	University	Condition for success (but collaboration does not need so much communication)	Collaborators are trusted to do tasks aligned with their expertise, and not trusted to do anything different		
U6	University	University	Conditions for success (but collaboration does not need so much communication)	Good collaboration happens when each person does his or her own tasks		
U9	University	University				
U8	University	University	Success	Internal collaborators are most trustworthy (within the same group)		
U6	University	Planning	success	Worked well with collaborators because they were trusted due to their work experience and degree.		
U9	University	Planning	Condition for success	the actor is not being trusted and respected by collaborator unless being "vouched" by the government authority		
U8	University	Material Suppliers	success	Collaboration with the material supplier was good because we find them trustworthy and we can use each other's information for future		
C10	Design	Design				
C11	Design	Design	success	Actor declares that "we must work together" because every discipline's value is different		
C12	Design	Design				
C14	Design	Design				

(Continued)

C-2 (continued)

Actor	Actor category	Collaborator category	Context of quote	Mutual respect, trust and trustworthiness	Context of quote	Obligations and expectations, norms, identification
C15	Design	Design				
C17	Design	Design				
C19	Planning	Planning				
C1	Construction	Design			success	Interaction between actors can go beyond contractual obligations because actor believes it benefits the Sponge City as a whole
C9	Construction	Design	success	A friendly and trusting relationship is observed between the actor and the design engineer, and actor said they are working well together and that the engineer is beneficial		
C1	Construction	Construction				
C5	Construction	Site supervisor	Unsuccessful	Actor is not happy with the communication outcomes with the site supervisors because he does not trust their decision, and would trust his own experience and that of the design engineer more		

C-3 Cognitive dimension: interacting with authority figures

Actor	Actor category	Context of quote	Mechanism	Elaboration on mechanism
U1	University (Research, teaching, project)	successful experience	Using Sponge City guidelines and standards	Having a shared goal or objective is very important. They must be willing to work in the same direction
U2	University (Research, teaching, project)	successful experience	Collaborators having prior experience with a similar type of projects	Quality of collaboration depends on the government's willingness to learn or do something
U4				
U10				
C17	Design	expectation for improvement	Ensuring actors are thinking on the same track	
C20	PPP	challenging experience	Various departments having different perceptions of the same issues	It is imperative to have shared visions and goals. This condition usually depends on the power balance of the collaboration dynamics
C21	PPP	successful experience	collaborators in the government develop a better understanding by getting involved in the projects	
C22				
P1				
P3	Planning	expectation for improvement	Government decision-makers sharing more of their knowledge with practitioners	
C7	Planning	successful experience	Government collaborators becoming familiar with terms and concepts by getting involved in the projects	
C1	Construction	challenging experience	Collaborators approaching a problem from different angles and backstories	Actor acknowledges the problem and where the government collaborator comes from
C2				
C3				

C-4 Cognitive dimension: between non-governmental actors

Actor	Actor category	Collaborator category	Context of quote	Mechanism	Elaboration on mechanism
U3	University	University	Challenging experience	Every discipline involved approaching the problem from a different angle	
U4	University	University	Challenging experience	Disagreeing on the value of the use of some computer tools	
U5	University	University			
U6	University	University			
U9	University	University			
U8	University	University			
U6	University	Planning			
U9	University	Planning			
U8	University	Material Suppliers			
C10	Design	Design	Expectation for improvement	Learning more about other disciplines' knowledge	And then work towards the same goals is possible
C11	Design	Design			
C12	Design	Design	Challenging experience	Not being able to understand jargons and collaborators not recognising the difficulties	difficulties in communication: an actor is trying to understand, but sometimes colleagues are aiming to just meet the requirements from the project owner
C14	Design	Design			
C15	Design	Design	Successful experience	Considering the water problem from a higher and more integrated perspective	
C17	Design	Design	Successful experience	Learning about other discipline's specific knowledge	
C19	Planning	Planning	Challenging experience	Different disciplines' training backgrounds making it difficult to understand and explain concepts and thoughts	
C1	Construction	Design			
C9	Construction	Design	Successful experience	Working closely with a designer to understand the drawings	
C1	Construction	Construction			
C5	Construction	Site supervisor			

Appendix D: Final report for UCL Research Ethics Committee

Ethics Application: 9321/001

Zeyu Yao

Final report for UCL Research Ethics Committee

The interview aims to include actors from all disciplines involved across all project stages. Given the time constraint for data collection (three months), and the time and resources required for the transcription and analyses of the data, the target sample size for the interviews is n=40. The actual number of valid interviews is n=38. The first contacts with the informants were made through online messaging platform or phone conversations. They were informed of the purpose of the study, and how the interview was going to be conducted. All the interviews except for two were conducted face-to-face; two interviews had to be conducted on the phone because they were based in other cities and were not available to meet. Prior to the interview, the consent form and the interview pro form were presented to the informant in print. Each informant is being briefed on the voluntariness of participation and the guarantee of confidentiality, and is asked for permission to be recorded. Among all the informants, two declined to be recorded. The interview duration ranged from half an hour to two hours, depending on the time availability and the amount of information the informant was willing to offer.

For the purpose of confidentiality during analysis, each participant is given a unique code, and all the files pertaining to this individual is being managed and displayed using that code. The participants are only referred and described using terms to that avoid recognition of their identities.