# Bridging the floods

## The role of social learning for resilience building in urban water services

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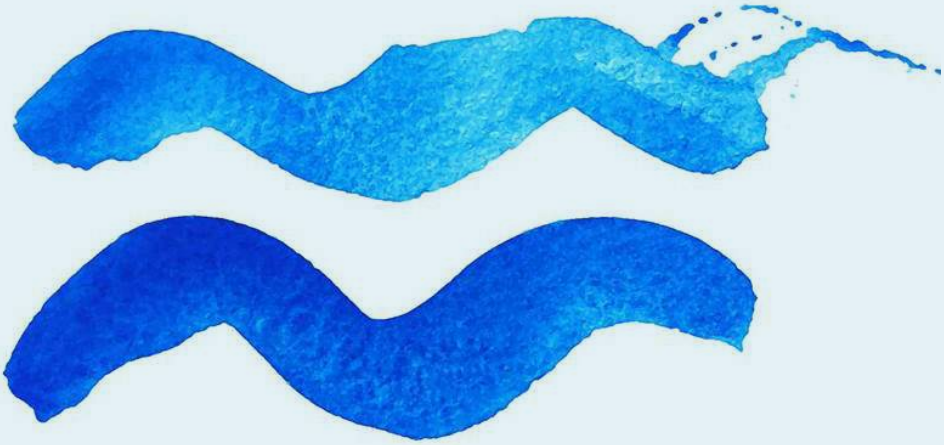

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DOCTORAL DISSERTATION

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Abstract

The development of cities is increasingly threatened by a worldwide water crisis. Urban water services (including drinking water, sanitation and drainage) are facing complex and multiple pressures, which are becoming increasingly frequent and severe. These pressures include floods, and the depletion, pollution and degradation of water resources and their associated ecosystems. These diverse pressures fall mainly within the domains of flood risk and water resources management: two working fields that are divided by different institutional structures, approaches and practices. Social learning is becoming increasingly popular as an approach that has the potential to "bridge" these silos, and ultimately, contribute to building resilience in urban water services. However, empirical analyses on this issue are rare and fragmented. Against this background, this thesis investigates the role of social learning for resilience building in urban water services. It is based on single and multiple case studies from the urban areas of Cali (Colombia), Cebu (The Philippines), Durban (South Africa), Gorakhpur (India) and Kristianstad (Sweden). The results identify challenges to the integration of the identified silos, what resilience means for urban water services, and the key elements of social learning that can support or inhibit urban water resilience. The results provide important input for new theory, policy and practice related to the United Nations' Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction and national policies on sustainable water management, risk reduction and climate change adaptation.

Key words: flood risk management; water resources management; disaster risk reduction; resilience; climate change; resilient cities; urban water services; transition; urban transformation; adaptation; climate change

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*To Stef, Sophie and Kajsa*

*"Enter into the world. Observe and wonder. Experience and reflect. To understand a world you must become part of that world while at the same time remaining separate, a part of and apart from"*
*– Halcolm's Methodological Chronicle, in Patton, 2015: 327*

# Summary

The development of cities is increasingly threatened by a worldwide water crisis, linked to the intensification of land use, which emerged at the end of the 18th century, and accelerated at the end of the 20th century. This provides several underlying risks to urban water services (including drinking water, sanitation and drainage). These include floods, and the long term depletion, pollution and degradation of water resources and their associated ecosystems. At the same time, impacts are exacerbated by current and future climate change. This situation, combined with anticipated, ongoing growth in urban areas has made the water crisis a priority area for many decision-makers and leaders worldwide.

Despite a shared understanding of the importance of addressing the water crisis, there is still no comprehensive approach that links the working fields of flood risk and water resource management, which remain separated by institutional structures, and different approaches and practices. Social learning may help to overcome this problem. Embedded in social relationships, it is seen as central to achieving the collective understanding, commitment and capacity that is needed to tackle increasingly complex problems with innovative and creative solutions. Thus, social learning is increasingly said to be a potential key for addressing the urban water crisis. However, despite wide support, related studies are often based on vague, general assumptions with little practical application, and empirical analyses are lacking.

Against this background, the overall aim of this thesis is to investigate the role of social learning for resilient urban water services. First, it investigates the challenges for integration of flood risk and water resources management. Second, the meaning of resilience in this context is unclear; therefore the concept of resilience is systematically "translated" into urban water services. Third, this thesis also identifies the key elements of social learning that can support or inhibit more resilient urban water services. The research is based on single and multiple case studies, mainly from the urban areas of Cali (Colombia), Cebu (The Philippines), Durban (South Africa), Gorakhpur (India) and Kristianstad (Sweden).

The case studies confirm low levels of integration between flood risk and water resources management. A key challenge is found to be governance arrangements,

notably in relation to river basin management. This was found to confine flood risk management to local and structural approaches, which in the long run may paradoxically lead to an increase in floods. Practitioners were found to apply an interpretation of the resilience concept at the level of the larger social-ecological system. However, practitioners were also found to refer to two other levels, identified as socio-economic and hazard resilience, but without making a distinction between any of them. This finding therefore suggests that the resilience concept could introduce confusion and imbalances if all three levels are not considered. Considerations to all three resilience levels can contribute to sustainable change while building resilience in urban water services. This thesis identifies several factors and strategies that can support such change, linked to social learning.

Applying the resilience concept to urban water services offers a novel perspective on transitions in urban water services, which highlights the role of actors and non-linear change. This is in contrast to a dominant focus on technologies in existing linear transition models. Instead, "key competencies" are proposed, which identifies, for example strategic agency as a fundamental element, which can take the form of visionary individuals who are effective communicators and build trust. Non-linearity is linked to thresholds where two types are identified: risk awareness/ perception and individual and collective action capacity (i.e. a capacity to act on a perceived risk). Action capacity was found to be difficult to achieve, especially in relation to slow disturbances, which relates to the problem of moving from knowledge to action. Although this may reflect implementation difficulties and time lags, it was also found to be influenced by working cultures and power structures, potentially creating barriers to learning and action. Various measures are recommended, for example to integrate specialist expertise from different silos, and implementing accountability measures to balance power.

The results advance theory, policy and practice related to the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction and national policies regarding sustainable water management, risk reduction and climate change adaptation.

# Sammanfattning (Summary in Swedish)

Den hållbara utvecklingen av världens städer är hotad av den ökande globala vattenkrisen, som har orsakats av människans intensiva markanvändning. Den började på allvar i mitten av 1800-talet och accelererade mot slutet av 1900-talet, och har resulterat i flera underliggande riskfaktorer på urbana vattentjänster (dricksvatten, sanitet och dränage/dagvatten), som till exempel föroreningar, vattenbrist, översvämmningar och miljöförstöring. Klimatförändringarna, både nuvarande och framtida, förstärker problemen. Den här situationen, i kombination med snabbt växande städer, har gjort vattenkrisen till ett prioriterat ämne för beslutsfattare och ledare över hela världen.

Trots att olika aktörer har förstått vikten av att ta itu med vattenkrisen, så finns inget övergripande angreppssätt mellan två relevanta arbetsområden i fokus i den här avhandlingen: översvämmningsrisk- och vattenresurshantering. Dessa områden är skilda åt av institutionella strukturer, samt olika sätt att tänka och arbeta. För att överbrygga sådana hinder och för att kunna lösa mer komplexa problem med ofta innovativa och kreativa lösningar har forskare och praktiker sett potentialen i "social lärande". Det innebär att människor utbyter kunskap, samarbetar och i processen lär sig av varandra, och utvecklar en annan, ny förståelse. Men fastän socialt lärande har brett stöd, är studier ofta för allmänna för att vara praktiskt användbara, och det saknas empiriska analyser.

Den här avhandlingen syftar därför till att undersöka rollen av social lärande för resilienta urbana vattentjänster. Först undersöks utmaningarna för närmare integration mellan övervämmnings- och vattenresurshantering. Sedan undersöks vad som menas med resiliens i urbana vattentjänster, eftersom förståelsen av resilienskonceptet är ofullständigt. Sedan undersöks frågan vilka som är de viktigaste faktorerna för social lärande som kan stödja eller hindra mer resilienta vattentjänster. Den här avhandlingen är baserad på literaturgenomgång och ca 100 djupintervjuer i fem urbana områden: främst i Kristianstad (Sverige), men också i Cali (Colombia), Cebu (Filippinerna), Durban (Sydafrika) och Gorakhpur (Indien).

Resultaten bekräftar en låg nivå av integration mellan översvämmnings- och vattenresurshantering. En viktig utmaning är styrmedel i relation till vattenhantering på avrinningsnivå. Bristen på sådana begränsar till exempel

översvämmningshantering till lokala lösningar och teknisk infrastruktur, vilket i längden, paradoxalt nog, kan leda till mer översvämmningar. Utövare tolkade resiliens delvis som en egenskap hos ett större ekosystem. De hänvisade emellertid också till resiliens som en egenskap hos två andra system, eller nivåer (här identifierade som socioekonomisk och fara-relaterad resiliens), men utan att göra någon skillnad mellan dem. Detta resultat innebär att resilienskonceptet kan medföra otydlighet och obalans i hanteringen om inte alla tre nivåer medvetet beaktas. Överväganden av alla tre resiliensnivåer kan bidra till en hållbar utveckling samtidigt som det ökar resiliensen i urbana vattentjänster. Denna avhandling identifierar flera faktorer och strategier som stödjer en sådan utveckling, kopplat till socialt lärande.

Fokus på resiliens och lärande ger nya perspektiv på övergångsprocesser som aktörs-drivna och icke-linjära. Detta står i kontrast till ett dominant fokus på teknologier i redan existerande linjära modeller. Istället föreslås ”nyckelkompetenser” där till exempel strategiska aktörer ingår, som här representerades av visionära individer som är bra på att kommunicera och bygga tillit. Icke-linjära övergångsprocesser länkas till två olika identifierade ”trösklar”: 1) risk medvetenhet/ perception och 2) individuell och kollektiv handlingsförmåga, d.v.s. en speciell förmåga eller kapacitet som behövs för att kunna hantera en risk. Den senare tröskeln är svårast att uppnå när det gäller långsamma störningar som vattenbrist, jämfört med katastrofrisker, vilket relaterar till det redan kända problemet att gå från kunskap till handling. Detta kan vara ett resultat av svårigheter och fördröjningar i praktiskt genomförande, men även rollen av maktstrukturer och arbetskulturer identifieras här som barriärer för lärande och handling. Olika åtgärder rekommenderas, till exempel att integrera specialistkunskap från olika sektorer, och sätta in redovisningsåtgärder för att balansera maktstrukturer.

Resultaten är relevanta för teoriutveckling, policy och praktisk förståelse för de Globala målen för hållbar utveckling, Sendairamverket för katastrofriskreducering och nationella styrmedel som handlar om hållbar vattenhantering, riskhantering och klimatanpassning.

# Preface and acknowledgements

This thesis has been a long time in the making, and I am grateful to many people who have been part of its process. Here I will name many of them, but not all, and their contribution.

It all started when I studied ecology, which opened my eyes to water and natural resource management. As part of my Master's thesis at Stockholm University (SU), I had the opportunity to spend four months in the field (1996–99), assisting Sari Roponen, who was studying the biodiversity of cloud forests in Ecuador. I became fascinated by the ecosystem services of cloud forests, which reduced floods in the wet season, and increased net water flows in the dry season. Back home, I took a university course in natural resources management (Department of Systems Ecology at SU), and there I became fascinated by the issues surrounding water after attending one of Professor Malin Falkenmark's lectures.

This was followed by several valuable years working with water and beginning work on my PhD thesis. Line Gordon (at SU) arranged an internship for me at SIWI (the Stockholm International Water Institute) where I later started working under the experienced supervision of Gunnel Sundbom and Sven Erik Skogsfors, and with colleagues such as Malin Falkenmark, Dave Trouba, Susanna Todorovic, Pernilla Kontio, Kerstin Harnesk, Katarina Andrejewska and Stephanie Blenkner. Meanwhile, Carl Folke found an opportunity for me to join the SU PhD programme. At the time, the Department studied – among other things – the Biosphere reserve in Kristianstad Water Kingdom. There, I started investigating flood aspects with Lisen Schultz and I had good discussions about my initial studies with Professor Klas Åmark, at the Department of History, SU. However, for private reasons, I had to take a break in my PhD studies when I moved to the United Kingdom (UK).

The following ten years were spent working in the UK, Botswana and the Netherlands. In the UK, I worked at Defra, (Department of Environment, Food and Rural Affairs) in their water policy section and I enjoyed the great teamwork with mentors such as Lee Hossain, Phil Terry, Nieves Bottomley and Pamela Premavrithan. I also joined a water consultancy company (WRc) for a short, but very interesting and productive time, where I worked with Yvonne Rees, Mike

Gardner and David Hunt. There, I contributed to the synthesis of case studies on social learning concerning the EU Water Framework Directive (HarmoniCOP) working under Claudia Pahl-Wostl and Paula Orr.

An opportunity came up at IUCN, the World Conservation Union, to work with the regional water programme in Southern Africa and, in particular, the Okavango Delta in Botswana. There, I worked on integrated water resources planning and stakeholder participation. I am deeply grateful to Portia Segomelo, Steve Monna, Sekgowa Motsumi and Mokgadi Monamati, who were a great support to me in the local government office in Maun. Sue and Andrew Walker, Kerstin and Mike Main became my family abroad. I also interacted with the IUCN offices in Geneva, Pretoria and Harare, including exchanges with Ger Bergkamp, Katharine Cross, Claire Warmenbol, Tiego Mpho, Masego Madzwamuse, Brigitte Schuster and Frank Barsch to mention just a few. Two years later, I began working for the International Water Association (IWA) in the Netherlands, where I became involved in the first high-level discussions and knowledge brokering in climate change in the water sector, thanks to Darren Saywell, and had the great pleasure to work with Henk van Schaik, Marloes Bakker and Michael van der Valk. During the development of the disaster risk programme, I worked with many great people: Ilan Juran, Andy Bastable, Daudi Bikaba, Gert de Bruijne, Arno Panesar, Elisabeth von Münch, Julien Eyrard, Niels Lenderink, Elisabeth Kvarnström, Patricilio Mucavele, Louis Lousada, Moises Mabote, Alcina Manica; Jonathan Parkinson, Louiza Campos and Phillippa Ross, Frances Lucraft, Adrian Puigarnau, Michaela Lauren, Skye Rytenskild and Carol Howe among others.

When I began working for Stockholm Environment Institute (SEI), I had the opportunity to finalize my PhD research. I had renewed contact with Thomas Hahn, who became my acting informal supervisor at the Stockholm Resilience Centre. I shall never forget that it was very much thanks to his coaching and kind perseverance that brought me deeper into the different aspects of the PhD at a critical time, through a series of discussions. Thank you, Thomas, for believing in me! I am very grateful to Arno Rosemarin at SEI, who agreed to lead an MSB project, which enabled my work. SEI provided an inspiring research environment thanks to: Johan Kuylenstierna, Lisa Segnestam, Åsa Gerger Swartling, Kim Andersson, Maria Osbeck, Karlee Johnson, Oskar Wallgren, Thor Axel Stenström, Albert Salamanca, Sarah Dickin, Rasmus Klocker Larsen, Marcus Carson, Frank Thomalla, Linn Persson and Jacob Granit, among others. I also warmly remember the support from Simon Persson, Birgitta Ahlshammar, Agneta Åkesson, and Zeynep Baser. Many thanks to Neil Powell, who commissioned paper I as part of the Baltic COMPASS work. Thanks also to external colleagues and advisors who contributed to project proposals, content discussions and papers: Dan Lewis, Prakash Kumar, Erik Rottier, Johan Köhler, Leif Jönsson, Katarina Runeberg,

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At SEI I met Christine Wamsler and Per Becker who offered me the opportunity to continue pursuing my PhD at Lund University. At the Division of Risk Management and Societal Safety I was supported by Marcus Abrahamson and Johanna Kruse. I was supervised by Per Becker and Christine Wamsler who both continuously mentored, encouraged and provided me with the flexibility that I needed. I wish all PhD students the kind of guidance I have had from them. It has been invaluable for me and enabled me to make step changes in my understanding, improving my academic writing immensely. I also want to thank Mo Hamza, Henrik Tehler, and Misse Wester who were members of a test panel, which improved my work. Thanks also to Rolf Larsson who was an inspirational final seminar opponent.

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Until now I have mainly mentioned colleagues, but I also want to thank those who have been key to the success of my efforts, which includes all the many water and sanitation professionals who generously volunteered their time and knowledge to support this work. I want to especially mention the people from Kristianstad for being so very friendly and helpful; Monica Axelsson, Anders Pålsson and Sven-Erik Magnusson. Other supporters of this work are the anonymous and non-anonymous reviewers of my thesis papers. They have many times provided critical feedback, which improved the papers substantially.

I am grateful to my mother for taking me out into nature, my father for his passion for knowledge and studies, and for the warm friendships of my beloved sister and brothers and their families. I feel deep gratitude towards my mother- and father in-law for their constant love, attention and encouragement. Lastly mentioned, but first in my appreciation is the love and overall support from my husband Stef Smits. His critical eyes have reviewed most of the papers in their final draft. Having met at a meeting for climate change adaptation between IRC and IWA, our two daughters Sophie and Kajsa, are the best impact of climate change there ever will be.

*Den Haag, July 2017*

*Åse Johannessen*

# List of papers

This thesis is based on the following papers, referred to by their upper case Roman numerals.

I. Johannessen, Å., J. and J. Granit. 2015. Integrating flood risk, river basin management and adaptive management – gaps, barriers and opportunities illustrated with a case study from Kristianstad, Sweden. *International Journal of Water Governance-Special Issue-3*: 5–24. DOI: 10.7564/13-IJWG30.

II. Johannessen, Å. and C. Wamsler. 2017. What does resilience mean for urban water services? *Ecology and Society 22* (1): 1. DOI: 10.5751/ES-08870-220101.

III. Johannessen, Å. and T. Hahn. 2013. Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden. *Global Environmental Change 23* (1): 372–381. DOI: 10.1016/j.gloenvcha.2012.07.009.

IV. Johannessen, Å., Å. Gerger Swartling, C. Wamsler, K. Andersson, J.T. Arran and T-A. Stenström. Learning and resilience building in urban water services: lessons from five flood-prone urban regions. Submitted.

V. Johannessen, Å., A. Rosemarin, Å. Gerger Swartling, G. Han, T-A. Stenström and G. Vulturius. 2014. Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: The role of public private partnerships. *International Journal of Disaster Risk Reduction 10*: 102–115. DOI: 10.1016/j.ijdrr.2014.07.002.

Authors' contributions:

- In paper I Åse is the primary author, Jacob Granit contributed to writing of the text, mainly the discussion section.

- In paper II Åse is the primary author, Christine Wamsler contributed to structuring and writing of the text and critically revising the data analysis.

- In paper III Åse is the primary author, Thomas Hahn acted as supervisor and contributed with structuring and writing of the text.

- In paper IV Åse is the primary author, Åsa Gerger Swartling contributed to the overall research approach, the methodology and the writing of the text. Christine Wamsler contributed to structuring and writing of the text and critically revising the data analysis. The other co-authors contributed to writing the text related to their respective case studies.

- In paper V Åse is the primary author, Arno Rosemarin wrote the initial abstract and contributed to the first drafts, Frank Thomalla, especially, and other co-authors contributed comments on the text.

# List of related papers

This thesis is also related to a number of other papers by the author:

- Plummer, R., J. Baird, R. Bullock, A. S. Dzyundzyak, D. Dupont, Å. Gerger Swartling, Å. Johannessen, D. Huitema, A. Lyth, MdL. Melo, S. Munaretto, T. Smith and D. Thomsen. 2017. Stakeholder Insights into Flood Governance: An International Multiple Case Study of Flood Prone Areas. Submitted to Environmental Policy and Governance.

- Thomalla, F., K. Johnson, S. Bharwani, Å. Johannessen and R. Butterfield. 2015. Transforming disaster risk reduction for more inclusive, equitable and sustainable development. Stockholm Environment Institute. Brief for Global Sustainable Development Report 2015.

- Segnestam, L. and Å. Johannessen. 2015. Potential prevention, mitigation and preparedness measures for each case study site. Deliverable No: D.4.1. RISC KIT Project Report.

- Arran, J.T., T-A. Stenström and Å. Johannessen. 2015. Stakeholder Perceptions of Disaster Risk Reduction Strategies Related to Water Sanitation and Hygiene: Case Study eThekwini. Conference paper presented at the 16th WaterNet/WRFSA/GWPSA Symposium 28–30 October 2015. Republic of Mauritius.

- Johannessen, Å., C. Wamsler, P. Becker, J. Fredby, O. Castell, E. Rottier, Å. Sivertun, G. Björklund and R. Roffey. 2014. Water and Risk: Developing Sustainable and Resilient Communities. Swedish Water House Policy Report/SIWI.

- Carson, M., Å. Johannessen, A. Beyene, E. Remling, C. Ruben and S. Peter. 2014. Institutionalising Gender Equality: DRR challenges and the impact on women and men, and girls and boys in the context of a changing climate. Report prepared for MSB. Stockholm Environment Institute. Final Report. 110 Pp. ISBN: 978-91-7383-399-8.

- Johannessen, Å., J. Patinet, W. Carter and J. Lamb. 2012. Sustainable sanitation for emergencies and reconstruction situations. Fact sheet. Working group 8. Sustainable Sanitation Alliance. 8p. URL: http://www.susana.org/en/resources/library/details/797.

- Johannessen, Å. 2011. Identifying gaps in emergency sanitation - Design of new kits to increase effectiveness in emergencies. Workshop report, Organized by WASTE, Oxfam in Stoutenburg, The Netherlands, 22–23 February 2011.

- Zwolsman, G., D. Vanham, P. Fleming, C. Davies, A. Lovell, D. Nolasco, O. Thorne, R. de Sutter, B. Fülöp, P. Satuffer and Å. Johannessen. 2010. Climate change and the water industry – practical responses and actions. Perspectives paper on water climate adaptation. Amsterdam, NL; World Water Council, Cooperative Programme on Water and Climate, IUCN and International Water Association.

# Content

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# 1 Introduction

## 1.1 Context and problem definition

The sustainable development[1] of the world's rapidly-growing urban areas is threatened by a looming water crisis, which has reached the top of the international agenda. For instance, the 2015 Global Risk Report named the water crisis the main risk humanity is facing today[2] (World Economic Forum 2015). Although access to drinking water and sanitation has taken great strides forward in the recent decades[3] (WHO and UNICEF 2015) other, more underlying, water-related risks are emerging. Flooding is a threat to urban water services (drinking water, sanitation and drainage) through damage to infrastructure and contamination (Klein and Zellmer 2007; Howard and Bartram 2010). This is especially relevant as rapid, often unplanned urban sprawl into flood plains and coastal strips has made flooding and its consequences increasingly frequent (CRED and UNISDR 2015; Jha et al. 2012). In addition, flood controls have often moved the problem downstream and encouraged building in perceived "safe" areas, which increases vulnerability (IPCC 2012a). Increased paving is another problem, as water cannot be retained or infiltrate, which also affects the water recharge (Wamsler 2014). Lack of water recharge leads to water stress, which is found in one in four cities (McDonald et al. 2014). In turn, water stress is exacerbated by pollution, notably due to a lack of adequate urban sanitation, wastewater and industrial waste management (IPCC 2012a; Wamsler 2014; Howard and Bartram 2010).

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[1] *Sustainable development* is defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987:16).

[2] This annual survey asks nearly 900 leaders in politics, business, and civic life about the world's most critical issues. The report measured 28 risks on two dimensions: the likelihood of occurring within 10 years and impact, a measure of devastation (World Economic Forum 2015).

[3] Access to drinking water is reported as 96%, and access to sanitation is reported as 82% in urban areas. However, these numbers are unrepresentative of informal (peri-urban) areas (WHO and UNICEF 2015).

This situation has serious implications for urban areas, especially in lower-middle income countries where the urbanization pace is fastest (UN 2014). About 2.5 billion people are projected to be added to the world's urban population by 2050, with nearly 90 per cent of the increase concentrated in Asia and Africa (ibid). In addition, water issues are interconnected with various other risks, such as interstate conflict, large-scale involuntary migration and climate change, forming a complex cocktail of risk multipliers (World Economic Forum 2017; IPCC 2012a). This gloomy outlook has led many scholars, government agencies and practitioners to highlight the need to secure so-called "resilient" urban water services (Howard and Bartram 2010; Ofwat 2009; Jha et al. 2011) as the key to – arguably more sustainable – development. "Resilience" is generally understood as "continuity through change" (Birkmann et al. 2012:1) through an increased capacity to cope and adapt to a changing climate and environment (Pelling et al. 2015).

As a result, various international policy agendas have been developed that address the risks faced by urban water services, and the need to build related resilience. The UN Strategy for Disaster Reduction (UNISDR) has, for instance, initiated policy agendas for Disaster Risk Reduction (DRR), such as the Hyogo Framework for Action (2005–2015) (UNISDR 2007), and its successor the Sendai Framework (2015–2025) (UN General Assembly 2015a). In this context, the term "resilience" is traditionally used in relation to reducing the exposure to pressures related to hazardous extreme events (Eriksen et al. 2015). However, more nuanced perspectives are emerging, which associates resilience also with climate variability and addressing the root causes of risk (Eriksen et al. 2014; Wamsler 2014). For example, international policies have led to initiatives such as the "Building Resilient Cities Campaign", where urban water services are identified and addressed as some of the most serious urban challenges (UNISDR 2012). In the development context, and more specifically in water resources and ecosystem management, the term resilience is also used, but mainly in relation to socio-economic issues (World Commission on Environment and Development 1987) or a broader range of disturbances in a social-ecological system (Folke et al. 2010). Here, initiatives such as the Millennium Development Goals (MDGs) have focused on targets linked to drinking water and sanitation in the context of poverty reduction (United Nations 2015). With the new sustainable development goals (SDGs), this focus has been supplemented by targets associated with water quality, water scarcity and water-related ecosystems, by adopting, for example, Integrated Water Resources Management (IWRM) (UN General Assembly 2015b). Adopting such targets, recognizes mismanagement and lack of good water governance as causes of the water crises (Hill 2013).

Despite this shared understanding regarding the importance of addressing the water crisis, in practice there is no comprehensive approach. Different working

fields are separated by institutional structures and apply different working principles and measures (OECD 2011). For example, in water resources management (linked to urban development planning) an important principle is the dependence on dynamic movements of water (or small floods) as the water ecosystem is in a constant process of adapting to changing conditions (Milly et al. 2008; Hegger et al. 2014). In contrast, flood risk management has traditionally adopted the "stationarity principle" – the idea that natural systems fluctuate within a fixed range (cf. Milly et al. 2008). This approach predominantly accommodates structural measures[4], for example embankments or drainage pipes that are designed to function as a buffer or protection from more extreme floods (Nyberg 2008; Sayers et al. 2015; Goytia et al. 2016; Gersonius et al. 2016; Vanneuville et al. 2016).

The integration of flood risk and water resources management is increasingly claimed by scholars and practitioners to create synergies, that are promoted by new, more comprehensive approaches, for example, strategic (Sayers et al. 2015) or integrated flood management (WMO 2009; section 2.1). Such approaches are increasingly acknowledged in policy and practice agendas of, for example, the European Union (EU 2012), the World Meteorological Organisation (WMO 2009); and the European Environmental Agency (Vanneuville et al. 2016), although implementation is limited (e.g. Ehrnstén et al. 2014; Svenskt Vatten 2011; Wihlborg et al. 2017).

"Social learning" is increasingly identified as a key element in change and transition processes (Berkes et al. 2003; Holling 1978; Walters 1986; Lee 1993), and in the context of resilience building in urban water services (Pahl-Wostl et al. 2007). It has also been shown to play an important role in improving understanding regarding water management policies and practices (Reed et al. 2010; Pahl-Wostl et al. 2007; Raadgever et al. 2008; Mostert et al. 2008). Other scholars have found it to be a critical component of resilience and adaptive management (Pahl-Wostl et al. 2007; Raadgever et al. 2008) and it has been claimed to have the potential to "bridge" existing water management silos and evolving water management regimes over decades (Pahl-Wostl et al. 2007). Although social learning has wide support, it appears to be limited to vague, general assumptions, while empirical evidence and guidance regarding how to achieve it in practice are lacking (Medema et al. 2014; Armitage et al. 2008; Reed et al. 2010). In particular, there is a lack of studies that are both theoretically and

[4] *Structural measures* can range from hard, engineered structures such as flood defenses and drainage channels, to more natural, sustainable, complementary or alternative measures such as wetlands and natural buffers (Jha et al. 2011). Here, they refer to hard structures such as embankments.

operationally relevant, for example studies of "non-facilitated"[5] (or spontaneous) and "stable" social learning, claimed to enable long-term capacity building, action and institutional change (Gerger Swartling et al. 2011; Pinkerton 1989). Social learning is also increasingly popular in disciplines such as ecology, which requires the process of establishing consensus and evaluating appropriate alternatives with the affected stakeholders[6]. However, this process tends to be neglected in risk management, where the debate is dominated by risk assessments based on scientific models and investigations, and prescribed solutions (Daniels and Walker 2001). Finally, social learning in the context of flood risk management is a new field of enquiry (Pfister 2015), which provides an opportunity for novel investigations.

Social learning not only implies changes in knowledge and understanding, but also refers to improved collective understanding and management through the transfer of individual learning to a larger social unit (Reed et al. 2010; Pelling et al. 2015; Medema et al. 2014; Pahl-Wostl 2002). Thus, social learning could potentially contribute to integration by bridging the different perceptions, institutions and disciplines (Feurt 2008) found in the risk and development community, in a transition process.

## 1.2 Research purpose

The overall purpose of this thesis is, therefore, to increase knowledge on the potential role of social learning for resilience building in urban water services. It is seen as central to the potential integration – or "bridging" – of the working fields of flood risk and water resources management, for the benefit of resilient urban water services. The results aim to identify missing elements that can link social learning theory and practice across the relevant working fields.

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[5] *Facilitated learning* refers to efforts that actively bring together diverse actors, who normally would not meet in their daily operations. This sometimes requires additional institutional structures.

[6] *Stakeholder* refers to anyone with a stake in an issue. It is often used in the context of consultation processes, for example, stakeholder participation (Holling 1978). However, a stakeholder is not necessarily an actor. Whenever possible, the term actor is used to refer to someone who has agency, who is knowledgeable, and has the capability to act in their society (Giddens 1982). Because transitions imply agency, the term 'actor' is often preferred to 'stakeholder' (e.g. Turnheim et al. 2015).

## 1.3 Research aim and questions

The overall aim of this thesis is: *to investigate the role of social learning for resilience building in urban water services.* To achieve this aim, it addresses three research questions (Qs):

*Q1: What are the current challenges regarding integrating flood risk and water resources management to benefit resilient urban water services?*

The problem definition given in section 1.1 identifies the different approaches taken by researchers in the working fields of flood risk and water resources management. Understanding the challenges to integration is crucial, as it helps to understand the actions that are needed to build resilient urban water services. Although the concept of resilience is both well-known and increasingly popular[7], it comes with several questions and assumptions (Olsson et al. 2015; Béné 2013). This leads to the second question:

*(Q2) What does resilience mean for urban water services?*

With few exceptions, e.g. Howard and Bartram (2010) focusing on technical solutions, there has been no systematic effort to "translate" (i.e. operationalize) resilience theory into reality and practice in the field of urban water services. The association of resilience with the behavior of social-ecological systems as complex adaptive systems (CAS) (Holland 1995; Levin et al. 2013) has the potential to frame the more dynamic aspects of how to solve the water crisis. The assumption is that this understanding could help open up new pathways and approaches.

Once we know the challenges to integration, and have an understanding of the goal (i.e. resilient urban water services), the next step is to establish the related pathways. This is expressed in the third research question:

*(Q3): What are the key elements of social learning that can support or inhibit more resilient urban water services?*

The third question therefore investigates social learning mechanisms as a potential entry point in supporting the transition from the current situation to a resilient state (figure 1).

[7] The Sendai Framework defines resilience as a priority (UN General Assembly 2015a).

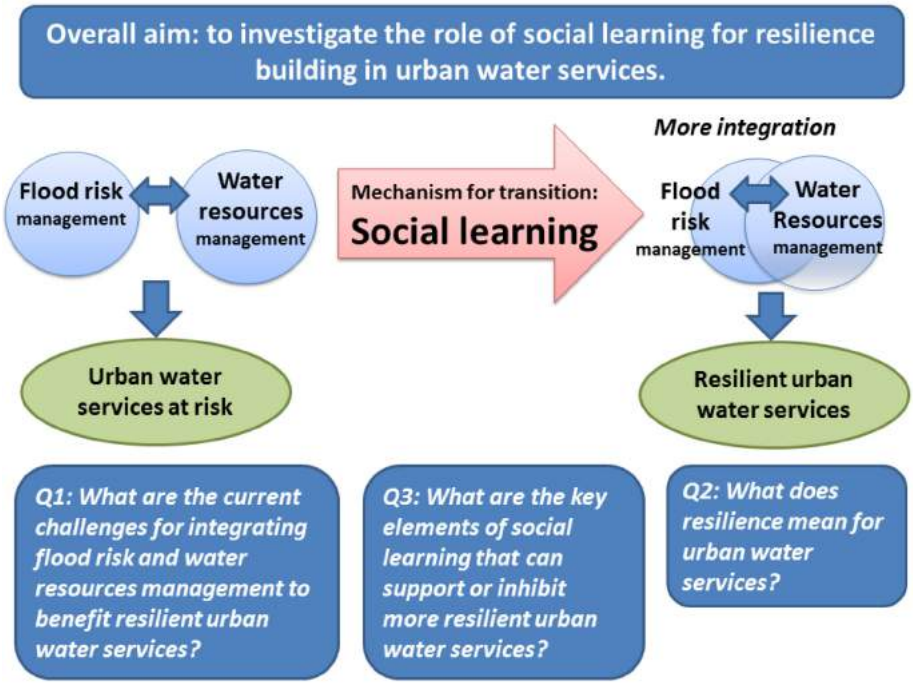


**Figure 1: Overview of the aim and the three research questions.**

## 1.4 Geographical focus

The Swedish municipality of Kristianstad (figure 2) is the subject of the investigation presented in papers I and III, and one of the multiple case studies presented in papers II, IV and V. Kristianstad is relevant for various reasons. Firstly, Sweden expects substantial climate change impacts (Westlin et al. 2012). Secondly, it is a high-income European country and one of the world's most progressive countries in terms of ecological governance (Lundqvist 2013). Thus, any findings on failures are most likely to be valid for all, or a large range of cases, making it a critical case (Flyvbjerg 2006, section 3.3.2). Thirdly, Kristianstad has the highest number of people at risk in all the 18 areas that have been identified as the most flood-exposed in the country (MSB 2011). In Sweden, municipalities are responsible for flood risk management. Kristianstad is relatively small, with 30,000 inhabitants in the inner urban area and 80,000 in the municipality as a whole. It is situated in the lower part of the Helge river basin with a catchment of 4725 $km^2$ (Helgesson et al. 1994). This landscape is part of the "Kristianstad Water Kingdom", which is listed under the Ramsar Convention, Natura 2000, and

as a UNESCO Man and Biosphere reserve (Olsson et al. 2004b). It is one of Sweden's largest (about 1600 ha) "wet grassland used for haymaking and grazing" areas (Naturvårdsverket 2009), and many farmers receive financial support from the European Union (EU) to maintain its biodiversity.

The other case studies are Cali (Colombia), Cebu (The Philippines), Durban (South Africa) and Gorakhpur (India) (figure 2). They were selected because they represent the range of urban water challenges typical of the "water crisis" (described for each urban area in paper IV). Challenges include exposure to flood hazards originating in the river basin and urban areas. Other issues affecting urban areas include a lack of drinking water, and inadequate sanitation with untreated wastewater discharging into nearby water bodies. These issues are exacerbated by, for example, poverty in peri-urban areas. They also represent lower-middle to upper-middle-income countries, in different continents. Section 3.3.2 provides more detail regarding the selection of these areas.

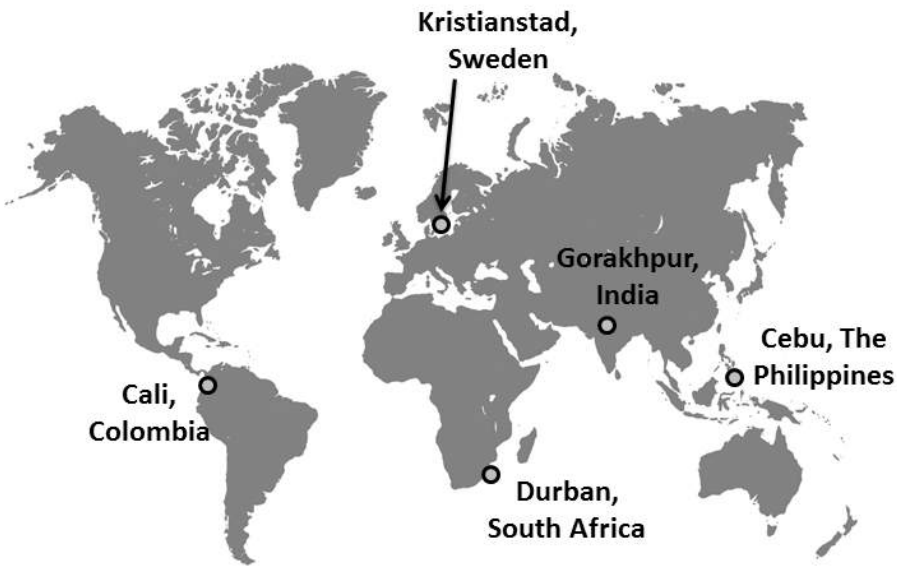


**Figure 2: A world map showing the location of the case studies. The background map was created by Layerace, available at Freepik.com.**

## 1.5 Content and outline of the thesis

This thesis is composed of six chapters and five appended scientific journal papers, which present the research outcomes in detail.

Chapter 1: Presents the problem definition, research purpose and aim, and geographical focus area.

Chapter 2: Describes the theoretical and conceptual background for the research.

Chapter 3: Describes the philosophical positioning, research design, and the methods used and applied in data collection and analysis.

Chapter 4: Describes the combined results of the appended papers.

Chapter 5: Provides a discussion of the results and presents ideas for future research.

Chapter 6: Summarizes the conclusions.

# 2 Conceptual framework

This chapter describes the theoretical and conceptual background for the research.

## 2.1 Flood risk management

Flood risk management is a process of holistic and continuous societal analysis, evaluation and reduction of flood risk (Schanze 2006). Until the end of the 20th century, society had mainly relied on structural measures, supplemented by early warning systems to mitigate floods (Nyberg 2008; Sayers et al. 2013). Since then, efforts to improve the effectiveness of flood risk management have triggered the adoption of the risk-based flood management paradigm (Nyberg 2008; Schanze 2006). This means that management is informed by assessing the characteristics of the hazard[8,9], exposure[10] to the hazard, vulnerability[11] of that which is exposed, and the consequences[12] should the hazard reach the exposed, and vulnerable elements of the potentially flooded area (Sayers et al. 2013). Part of this assessment relies on probability, for example, the probability of the hazard occurring (ibid). An example of increased probability is that climate change adds to flood risk, by an expected increase in the frequency, intensity and severity of extreme weather events (UN-Water 2013).

8 The definitions used here derive from multiple, internationally-accepted definitions (e.g. by UNISDR), but which were adapted to flood risk management in the context of the FLOODsite project (e.g. Samuels and Gouldby 2009).

9 *Hazard* refers to a physical event, phenomenon or human activity with the potential to result in harm. A hazard does not necessarily lead to harm (Samuels and Gouldby 2009).

10 *Exposure* is the number of receptors (e.g. people, property, habitats) potentially affected by a flood (Samuels and Gouldby 2009).

11 *Vulnerability* is a characteristic of a system that describes its potential to be harmed (Samuels and Gouldby 2009).

12 *Consequences* are impacts such as economic, social or environmental damage, or improvements that may result from a flood (Samuels and Gouldby 2009).

Increasing losses from floods has triggered the introduction of new approaches, which put greater emphasis on environmental approaches (Verkerk and Buuren 2013) and resilience, rather than resistance (Warner et al. 2013). This means a focus on "softer" measures such as integrated basin or coastal planning, adaptive management (see section 2.5) and safeguarding and promoting ecosystem services (Dawson et al. 2011; Sayers et al. 2015; WMO 2009). Examples of such approaches are Strategic Flood Management (Sayers et al. 2015), Integrated Flood Risk Management (Samuels et al. 2010) and Integrated Flood Management (WMO 2009).

Integrating more ecosystem-based measures[13] into flood risk management is argued to create sustainability co-benefits, especially in terms of water resources and linked ecosystems (Gersonius et al. 2016; Vanneuville et al. 2016; Kundzewicz 2002; Vis et al. 2003; Adger et al. 2005; Samuels et al. 2006; Aerts et al. 2008; Wilby and Keenan 2008; Goytia et al. 2016). Introducing natural elements increases, for instance, infiltration capacity and therefore not only mitigates floods and erosion, but also fosters groundwater recharge, which is the basic principle in Sustainable Urban Drainage Systems (SUDS) (Voskamp and Van de Ven 2015; Stahre 2008). This also counteracts the urban trend of removing important ecosystems and water bodies, and encroaching on unoccupied land (UN Habitat 2016; Wamsler 2014).

Moving to more adaptive, ecosystem-based (non-structural) measures, which co-exist with natural fluctuations, shifts the approach from resistance (or control) to resilience, providing a "safe-fail" design[14] (Kundzewicz 2002; Warner et al. 2013). This contrasts with structural solutions that are often oriented towards unrealistic "fail-safe" (no failure expected) designs (Kundzewicz and Takeuchi 1999; Sayers et al. 2015). The latter also creates incentives for further development in high-risk areas (Lebel et al. 2005). In this case, when the flood protection systems eventually fail, damage can be extensive (Kundzewicz 2002). Furthermore, controlling river flood in one area has been shown to transfer and increase flood risk to another area downstream, in which case, even a relatively modest river can result in damaging floods (Lebel et al. 2005).

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13 *Ecosystem-based measures* are measures that work with natural processes, which are often conceptualized as 'ecosystem services' and defined as the "conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997:3). When these are part of an overall adaptation strategy to help people to adapt, they are referred to as *ecosystem-based adaptation* (Wamsler 2015).

14 *Safe-fail* design guarantees absolute safety through, for instance, embankments and dikes. However absolute safety is never possible (Kundzewicz and Takeuchi 1999). A more realistic paradigm is 'fail-safe' design where measures such as zoning, building codes, flood proofing, riparian forests, reservoirs or insurance are applied (ibid).

## 2.2 Water resources management

Over time, a critical segment of the Earth's water resources[15] have been mismanaged, resulting in scarcity due to overconsumption, pollution, drought and flooding (Hill 2013), among other issues. Water moves in time and space in a hydrological cycle that is closely linked to land use (Falkenmark 1997). Human land use – and thus water use – began to intensify at the end of the 18th century, while many new activities began to emerge around 1950, and sharply accelerated towards the end of the 19th century (Steffen et al. 2015). This development was initially (and still is, by some) seen as progress. Reclaiming marshes and fens, draining moors, straightening rivers and building dams was part of the conquest of nature, in which humans transformed their landscapes to protect them from flooding and provide land for agriculture, translating into much-needed socio-economic development (Blackbourn 2006). However, these activities modified the hydrological cycle to such a degree that it has profoundly affected the flow of water across the Earth's land surface (Vörösmarty et al. 1997). Today, the international community realizes that the water resources needed for human use are in crisis, due to mismanagement, a lack of good governance (Hill 2013), resulting in "open access" (Baland and Platteau 1996), i.e. where everyone can use the available resources (Ostrom 1990).

This situation triggered the development of the Dublin Principles for water management (UN 1992), which, in turn, led to the introduction of the so-called Integrated Water Resources Management (IWRM) in 1990. IWRM has become the global norm for the sustainable development of water resources (Benson and Lorenzoni 2016; Durham et al. 2002; Schulze 2007). The concept promotes the coordinated, sustainable and equitable development and management of land and water in the river basin (WMO 2009; GWP 2000; White and Howe 2003). The river basin is seen as the natural unit of analysis for the hydrological cycle; and if the governance unit mirrors this area it is in line with the idea of spatial "fit" (Moss 2012). However, this idea has been criticized, in particular, for depoliticizing water management (Jager et al. 2016). Approaches that acknowledge IWRM focus on the water–land nexus include the development of practices such as ecosystem management, farming and forestry, and spatial planning. Associated measures have the potential to both capture nutrients and other pollutants from the water, and reduce flows, through "ecosystem-based

15 In terms of consumptive human use,(water for irrigation and drinking water etc.) water resources are relatively limited. While around 96.5 % of the Earth's water resources are salt water, fresh water constitutes only 2.5% of the total volume of water on Earth, and two-thirds of this fresh water is locked in glaciers and ice caps. Only 0.77% of all water (10,665,000 $km^3$) is held in aquifers, soil pores, lakes, swamps, rivers, plant life, and the atmosphere (Shiklomanov 1993).

measures" or "Natural Water Retention Measures". They have been applied in many places, including the Danube River Basin and are designed to contribute to sustainable development (Ebert et al. 2009; Vanneuville et al. 2016; Follner et al. 2010; EU 2012).

Implementing IWRM in practice has, however, encountered many challenges, mainly due to its theoretical origins, which has entered many planning frameworks at national level (Shah 2016). This has resulted in a "one-size fits all" approach to local water economies (Molle 2005) that, in turn, has had detrimental effects, especially in low- and middle-income countries (Shah 2016). Other challenges include linking IWRM to managing risks, while at the same time responding to, and mitigating, disasters (Medema et al. 2008). A key goal of IWRM is water security in all its dimensions, which encompasses managing risk. However, the principle seems difficult to translate into practice. For example, there is often a lack of coherence between flood risk management and land-use planning policy and practice (e.g. Roy et al. 2011; Benson and Lorenzoni 2016; Vanneuville et al. 2016), while the latter is a key component of IWRM (GWP 2000).

## 2.3 Urban water services

Urban water services are here defined as urban water supply, sanitation and drainage services (Butterworth et al. 2011a; Howe et al. 2011). From the above sections, it can be derived that both flood risk and water resources management contribute to clean water, reduced pollution and depletion, improved drainage, and thus reduced flooding. They underlie the proper functioning of urban water services, and contribute to their basic sustainability and resilience. For example, flood risk management can, if it includes ecosystem-based solutions, contribute to better water quality and environmental sustainability (EU 2012). In turn, water resources management can mitigate floods and ensure "safe-fail" solutions, avoiding catastrophic surprises (Sayers et al. 2015). For these synergies to be realized, the two areas are said to require increased integration (Vanneuville et al. 2016). One potential mechanism to achieve this is social learning, and the findings of this thesis aim to contribute to "bridge" the gap (figure 3 and sections 2.1 and 2.2). Such approaches are already known in the water sector, where "broadening" (similar to bridging) of sectoral approaches through a so- called "+plus approach" have developed into fairly robust, scalable models (Butterworth et al. 2011b; van Koppen et al. 2014). In this way, the mandate can be widened, and other actors included, in a step-like process (Butterworth et al. 2011b).

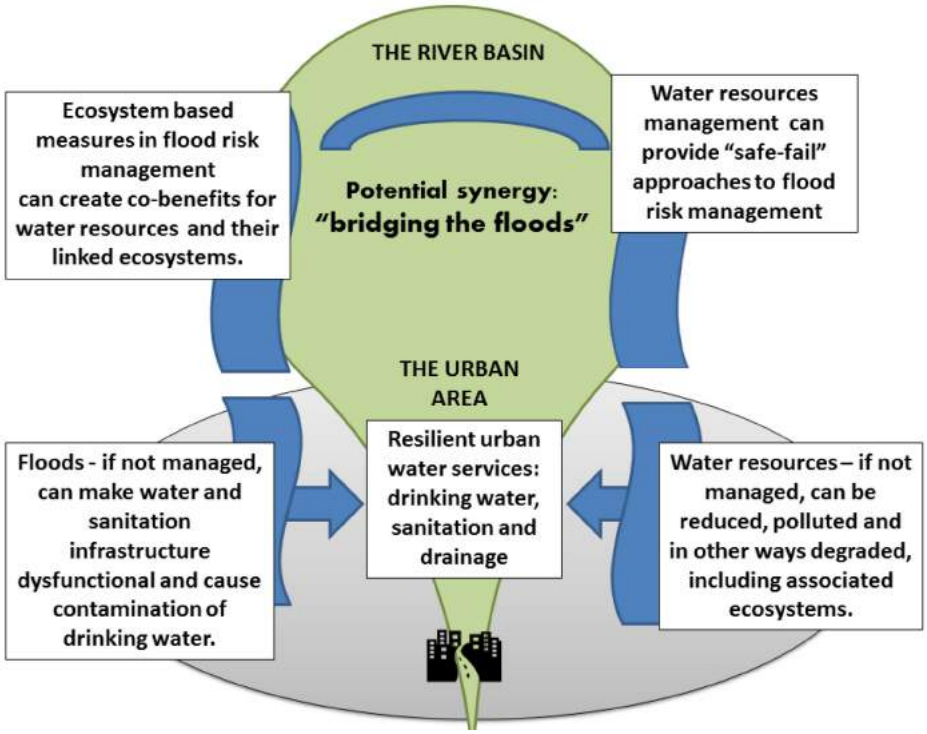


**Figure 3: The "bridging of the floods". The figure illustrates the potential synergies between water resources and flood risk management, areas which if not managed and arguably integrated, present risks for urban water services.**

To understand, and study this combined system, three other concepts are central, and will be described in the next sections: resilience, adaptive management and social learning.

## 2.4 Resilience

There are many different perspectives on resilience, but some shared understandings have been emerging. Many scholars agree on the general definition of resilience as a key concept in understanding "continuity through change" (Birkmann et al. 2012:1). Some of the most prominent actors in the field describe resilience as the ability of a social and/ or ecological system to absorb disturbances[16], (Walker et al. 2004) hazards (UNISDR 2009) or hazardous events

16 *Disturbances* encompasses both slow (such as ecosystem degradation) and rapid onset pressures (such as an annual flood or extreme events, often referred to as hazards) (OECD 2014). It also

(IPCC 2012b), while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (IPCC 2012b; UNISDR 2009; Walker et al. 2004).

In the ecosystem management literature, resilience is understood as an emergent property in the behavior of social-ecological systems as Complex Adaptive System (CAS)[17] (Holland 1995; Levin et al. 2013). This emergent property is made up of, and supported mainly through: *transitions, influencing factors* and *thresholds*. This specific understanding is relevant if the intention is to adopt ecosystem-based measures.

*Transitions:* The notion of transitions, often referred to as transformations in the social-ecological literature, (e.g. Folke et al. 2010) is interesting in that it holds a promise for learning, reorganization and improvement (Adger et al. 2005). Instead of resilience meaning bouncing back to the same (sometimes poor) state as before, resilience dynamics can thus imply an ability to transition from the current situation. Social learning (section 2.6) is a central mechanism in this, and can contribute to accelerating and guiding social innovation processes (Loorbach and Rotmans 2010). In disaster risk reduction, the triggers for transitions are often said to be sudden crises or disturbances, such as floods (Folke et al. 2010). On the other hand, in ecosystem management, such external crises are also important for transitions, but far more emphasis is placed on internal adaptive dynamics, including slower processes and disturbances, such as ecosystem degradation (Walker and Salt 2012).

*Influencing factors:* Transitions are supported (or inhibited) by context-dependent feedback processes that evolve (or self-organize) the system identity over time (Walker and Salt 2012). As such, the transition process is not determined and linear, but rather an evolving pathway with emergent properties (Turnheim et al. 2015).

*Thresholds:* When critical feedback processes change, (through, for example, crises or other disturbances) and the system can no longer self-organize to recover or keep the system in the same "domain" anymore, the system is said to reach a

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includes non-computable, unknown events (Carpenter et al 2012). Here, it also refers to social, political and financial pressures / stressors or perturbations affecting the system in question. This broad meaning is often applied in some literature emphasizing social systems' resilience (Walker et al. 2004; Folke et al. 2005).

[17] *Complex Adaptive Systems (CAS)* are characterized by self-organization where the behavior depends on local feedbacks. Thus, multiple outcomes are possible, depending on accidents of history. To a variety of degrees, corporations, whole economies, ecosystems and the biosphere represent examples of complex adaptive systems (Holland 1995; Levin et al. 2013)

threshold (Walker and Salt 2012). Thresholds are of many different types, where the system can be subject to small changes (no threshold), step changes, or an irreversible or reversible "collapse" or reorganization (ibid).

## 2.5 Adaptive management

Adaptive management has been proposed as a way to manage natural resources in the face of uncertainty, while adaptive capacity is sometimes used as a synonym for resilience (Holling 1978; Tompkins and Adger 2004). Developed by Holling (1978) and Walters (1986), and initially called Adaptive Environmental Assessment and Management, this approach emphasizes the identification of critical uncertainties regarding natural resource dynamics, and the design of management experiments to reduce these uncertainties (Walters 2007). Holling and Walters also emphasize participation from external stakeholders as central to the success of the process, as it helps to manage conflict and increase the range of potential solutions (Holling 1978; Walters 1986). The underlying rationale is that interactions between people and ecosystems are inherently unpredictable, and thus management needs to be adaptable to new information and changing circumstances (Raadgever et al. 2008). In the context of change, societal learning and adaptation is essentially based on self-organization (e.g. Trosper 2002; Berkes et al. 2003). Adaptive management seeks long-term action (Segnestam 2014) and should not be confused with coping. The latter often takes the form of emergency responses (Berkes and Jolly 2001) that offer short- and long-term gains (Wamsler and Brink 2014), but can contribute to a long-term downward spiral in adaptive capacity (Segnestam 2014).

Adaptive management is, however, not without its challenges, which could also be attributed to general problems encountered in implementation (Rist et al. 2013). For example, the focus on stakeholder engagement is often time consuming, costly and can delay decision-making. Despite these drawbacks, both adaptive management and its associated participatory approaches are increasingly found in international and regional policy, such as EU water policies (Carr et al. 2012).

## 2.6 Social learning

Social learning refers to changes in knowledge that translate into improved collective understanding and management (Medema et al. 2014; Reed et al. 2010; Pelling et al. 2015). It is related to socialization, the lifelong process through

which individuals internalize and disseminate societal norms, beliefs, and knowledge in the interaction within and between social groups (Abeling 2015). However, not all social interactions are examples of social learning. According to Reed et al. (2010) social learning requires three elements: 1) a demonstrated change in understanding; 2) a change that goes beyond the individual to become situated in wider societal groups or communities of practice; and 3) a change that results from social interactions between actors in social networks. This means that, for example, participation without a change in understanding is not social learning (Reed et al. 2010).

Social learning can contribute to tackling both straightforward but also more complex problems (Illeris 2009) that involve different learning efforts or "loops" (Hargrove 2002). The "change in understanding", noted above, refers to a change in mental models or frames where accepted truths, assumptions, and generalizations are reframed[18] or unlearnt (Schein 1999; Senge 1990). Because established mental models make sense to the individual, it is often difficult to change them (Kim 2004). The learning which requires least effort or reframing is termed "single loop learning" (Hargrove 2002) and is found when established actions are pursued. An example is strengthening an embankment, but doing it a little bit better (paper III). "Double loop learning" occurs when frames of reference or guiding assumptions change (ibid). An example is when flood risk managers in Kristianstad changed their perspective regarding flood risk, and realized there were multiple weak points, requiring the strengthening/ building 10 km of embankments rather than one (paper III). "Triple loop learning" occurs when governance changes along with underlying values and norms (ibid). An example is the Dutch paradigm shift from the "fight against water" towards "living with water/ room for rivers" (Huntjens et al. 2012). As a result, land use is adapted to allow for critical water fluctuations (or floods) as water is recognized as a natural, structural element (Pahl-Wostl et al. 2011).

Social learning is thus a well-known mechanism to achieving practical action involving multiple actors[19]. It is central in collaborative policy making, decision-making and practice (e.g. van Bueren and ten Heuvelhof, 2005; Pelling and High 2005; Pelling et al. 2008; Pahl-Wostl 2009; paper III). Outcomes include a collective commitment and capacity to tackle increasingly complex problems and find innovative and creative solutions (Plummer et al. 2013; Armitage et al. 2012; Huitema et al. 2009; Medema et al. 2014; Pelling et al. 2015). An example is experience-based improvements in organizational performance (Senge 1990).

18 *Framing* is a process by which issues, decisions or events acquire different meanings from different perspectives (Dewulf 2013).

19 *Multi-actors* refers to government, non-state, private, community and corporate actors.

Therefore, social learning is also increasingly argued to be a critical component of resilience and adaptive management, and a key element in the development of more sustainable practices in general (Pahl-Wostl 2002). As such, adaptations, transitions and other change processes in governance, management, worldviews etc. can be the outcomes of social learning processes.

Research indicates that social learning is most likely to happen at the interface between groups of people who have not already communicated with each other (Leeuwis and Pyburn 2002), for example when bringing different organizational levels or sectors together (Lee 1993). This knowledge has been applied in initiatives that aim to trigger social learning in facilitated processes, such as "learning alliances" (Iyer 2002; Khanna et al. 1998), approaches that are part of local (land and water) management planning (Janssen 2002), or "multi-stakeholder platforms" in larger river basins (Tippett et al. 2005; Steyaert and Jiggins 2007). Such models have also been applied to the integration of water resources and flood risk management, to some extent, (e.g. Butterworth et al. 2011a; Howe et al. 2011). Organizational theory emphasizes that increasing understanding of interdependent risks provides new grounds for collaboration[20] (Gray 1989). Therefore, social learning can be used to bridge the gap between people with different domains of expertise and knowledge from different sectors and disciplines, thus creating a "Collaborative Learning Bridge" (Feurt 2008: 4).

While most of the examples given above are taken from water resources management, social learning in flood risk management is a new field of enquiry. There are only a few empirical and theoretical case studies (Mauch and Pfister 2009; Pfister 2015; paper III). One example is found in England and Wales, where Regional Flood and Coastal Committees have been set up to promote more local-level participation through social learning (Lorenzoni et al. 2016).

It is easy to give social learning credit for successful outcomes, however this limits its conceptual clarity. Pahl-Wostl et al. (2008) refer to social learning as "sustainability learning". However, the outcome may not necessarily be optimal (Reed et al. 2010; paper III), or effective in the long term (Janis 1989; Berkes et al. 2003). It may even be inferior to individual learning. The term "groupthink" suggests that decision-making in groups is strongly biased towards preferable alternatives. As a consequence, relevant individual contributions can be suppressed or ignored by the group, resulting in suboptimal decision-making (Janis 1989). Furthermore, learning can be steered by whoever is able to set the

20 *Collaboration* is understood as "a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible" (Gray 1989: 5).

terms of the debate, indicating that power and interests of the actors involved plays an important role (Dewulf 2013). Also, social learning requires that what has been learnt is maintained in a social memory, which can require strong institutions or socio-cultural practices (Berkes et al. 2003). Its role in a successful intervention can lead to the effects of other mechanisms being overlooked (Reed et al. 2010). This lack of conceptual clarity has limited the ability to understand the actual function and mechanism of social learning and also to provide evidence of its occurrence and, if evidence is found, establish what kind of learning has taken place (ibid).

# 3 Research theory and methodology

This chapter is divided into five sections. First, the philosophical positioning is described (section 3.1). This shapes both the formulation of the problem and the research questions, and guides the search for information to answer the questions. Section 3.2 describes the research process. In section 3.3 the overall design of the research is presented, which refers to the overall strategy chosen to address the research problem. In section 3.4, data sampling, collection and analysis methods are described. Finally, section 3.5 discusses some key aspects related to validity, reliability and ethics.

## 3.1 Philosophical positioning

### 3.1.1 Ontological and epistemological assumptions

The work and knowledge development associated with conducting this research draws upon two philosophical domains: ontology and epistemology. Ontology is the study of being; it refers to the understanding of *what is* the nature of reality. Epistemology is concerned with how we know what we know, or *what it means to know*—what kinds of knowledge are possible and how we can ensure these are adequate and legitimate (Creswell 2013; Crotty 2015; Maynard 1994).

The approach and methodologies adopted here are based on an underlying philosophical positioning of post-positivist critical realism (Bhaskar 2013). This position integrates a *realist* ontology (there is a real world that exists independently of our perceptions, theories, and constructions) with a *constructivist* epistemology (our understanding of this world is inevitably constructed from our own perspective, and it is impossible to adopt a point of view that is independent). Thus, while critical realism rejects the idea of reality as being socially constructed, it is compatible with the idea that there are different valid perspectives on reality (Maxwell 2012; Powell et al. 2014). Critical realism is part of the post-positivist paradigm, which means that our understanding of these perspectives can be more

or less correct, and are shaped by the theoretical constructs that we bring to the observation (Maxwell and Mittapalli 2010; Yanow 2000).

### 3.1.2 Axiological assumptions

Researchers also bring their own values to a study, which forms part of the axiological assumptions, which deal with the nature of value (Creswell 2013). This can lead to the "is–ought problem" where descriptive statements (*how it is*) must not be confused with prescriptive statements (*how it should be*) (Hume 1896), without taking proper care. In this thesis, social learning is a central mechanism, and it can be tempting to associate it with predominantly positive attributes. To avoid such assumptions, models from social learning theory (e.g. Hargrove 2002; Schusler et al. 2003) have been used to cross-compare the findings. In addition, paper V expressly views social learning as an "ought" mechanism; in this case proper care was taken to ensure that the values underlying prescriptive judgments were made explicit, transparent and open to scrutiny.

## 3.2 The research process

The research questions described in section 1.3 were developed during a process that lasted 15 years. This included intensive periods of research in the beginning (three years) and the end (four years) with a long period of project and programmatic work in between. The final years were split between research and project work, which complemented each other.

These phases and the accompanying papers were linked to broader research projects run by the Stockholm Environment Institute (SEI). The research presented in paper I was part of the project Baltic COMPASS (2009–2012)[21]; papers II–V relate to the project WASH & RESCUE (2012–2015)[22]. The link to these two projects fostered critical considerations and facilitated a very high degree of

21 The Baltic COMPASS project aimed to find ways for the agricultural sector in the Baltic Sea Region to produce the daily food required by the region's 90 million inhabitants and, at the same time, preserve the Sea itself. www.balticcompass.org/

22 WASH & RESCUE is the acronym for WAter, Sanitation and Hygiene in RESilient Cities and Urban areas adapting to Extreme waters. The aim of the project was to develop a risk assessment based on a more holistic approach, taking into account broader social and environmental factors. Another aim was o to investigate effective social learning mechanisms between actors to accelerate learning about accepted adaptations. https://www.sei-international.org/

stakeholder involvement. Both projects shared similar research aims, which created links between the published papers (figure 4).

The research process consisted of two phases. The first two papers to be produced (I and III) focused on the linked system of flood risk and water resources management. The following papers (II, IV, and V) were focused on urban water services, with implicit links to flood risk and water resources management. The overall process is presented in figure 4[23].

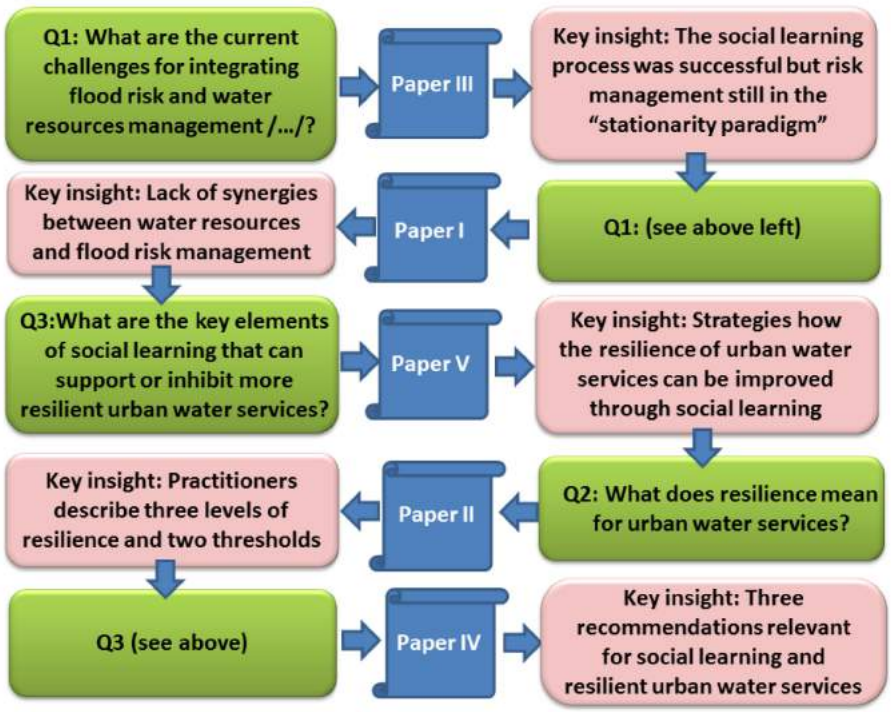


**Figure 4: The research process, the questions and insights from all the papers**

[23] The numbering of the papers is not based on order of production, but based on the logic of the research questions, see section 1.3 and table 1.

**Table 1: Summary of the research questions, purpose and aim for all papers.**

| RESEARCH QUESTION | PAPER TITLE | PURPOSE AND AIM |
|---|---|---|
| Q1: What are the current challenges for integrating flood risk and water resources management to benefit resilient urban water services? | Paper I: Integrating flood risk, river basin management and adaptive management – gaps, barriers and opportunities illustrated with a case study from Kristianstad, Sweden | Purpose: To get a critical insight into the gaps, barriers and opportunities in the implementation of flood risk management within an adaptive river basin management.<br><br>Aim: Identifying stakeholders' perceptions of wetlands as ecosystem-based measures and their perceived value and use to various stakeholders for flood and nutrient management. |
| (Q2) What does resilience mean for urban water services? | Paper II: What does resilience mean for urban water services? | Purpose: To investigate how the resilience concept can be systematized, operationalized and applied to better guide transitions to more sustainable urban water management in urban areas.<br><br>Aim: To develop an analytical framework for urban water resilience (based on a literature review, the analysis of practitioners' interpretation of resilience, and the identification of key principles or attributes of urban water resilience and related transition processes). |
| (Q1) see above and (Q3) (see below) | Paper III: Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden | Purpose: To shed light on social learning related to flood mitigation by building resilience and adaptive capacity.<br><br>Aim: To identify evidence of social learning: how social learning develops, what process attributes foster learning, and the outcomes (e.g., in terms of adaptive capacity). |
| (Q3): What are the key elements of social learning that can support or inhibit more resilient urban water services? | Paper IV: Social learning for resilient urban water services: the case of floods | Purpose: To analyse different collaborative arrangements of social learning and how they contribute to resilience building.<br><br>Aim: To examine social learning processes, and their supporting and inhibiting factors, for increasing adaptive capacity for resilience building in urban water services. |
| (Q3): See above | Paper V: Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: The role of public private partnerships | Purpose: To enhance understanding of how the resilience of drinking water, sanitation and hygiene (WASH) systems to hazards can be improved through social learning. In turn, this aimed to inform different strategies for public and private partnerships (PPPs).<br><br>Aim: To explore the potential of PPPs in enhancing the resilience of urban water services through social learning, taking the entire (social, economic and environmental) system in which the WASH system is situated into account. |

*Phase 1: flood risk and water resources management as linked systems*

Paper I investigated the level of integration in the management framework applied in Kristianstad (question 1). This framework shaped the social learning process in flood risk management investigated in paper III. Paper III mainly analyzed the key elements of social learning in this context (question 3).

Paper III also discussed the social learning process in the light of principles that were present in the integrated management framework in paper I, but more implicitly (question 1). See table 1 for a summary of the research questions, purpose and aim for all papers.

*Phase 2: Focus on urban water services*

Phase 2 extended the scope to urban water services. Kristianstad was a case study in both phases 1 and 2. Paper II was developed in phase 2; it investigated the nature of the concept of resilience, and how it could be systematically applied to urban water services (question 2). Paper IV examined the supporting and inhibiting factors for social learning in the five case studies, by applying the findings related to the two types of thresholds identified in paper II (question 3). Paper V enhanced understanding of the strategies supported by social learning, which could be used to strengthen resilient urban water services (question 3).[24] In this context a special focus was Public Private Partnerships (PPP) (section 4.3.5).

## 3.3 Overall research design

In line with the philosophical position presented in section 3.1, this thesis takes a qualitative case study approach (Denzin and Lincoln 2011). This means that the research is interpretive, which acknowledges that a researcher's perspective plays a role in data collection, analysis and outcomes through experience and judgment (Guba and Lincoln 1981). This perspective is also in line with the axiological assumptions described in section 3.1.2.

Becker (1968) states that the aim of a case study is to arrive at a holistic understanding, and be able to develop generic, theoretical hypothesis about the regularities in a social structure and process. Case studies are often described as particular, descriptive, heuristic and inductive (Merriam 1994; Flyvbjerg 2001). *Particular*, because they explore a particular situation, event, occurrence or person in depth (the case for all of the papers presented in this thesis). This makes the approach well-suited to addressing real-life practical issues, in line with realism, rather than searching for universal truths (Maxwell 2004). A case study is

24 Initially the concept of "Water, Sanitation and Hygiene" (WASH) systems was used, but this was replaced by "urban water services". This change was made following feedback from interviewees. The term "services" was seen as less open to interpretation, and a better representation of what end-users received in terms of quality, reliability and frequency. A physical system (infrastructure) will eventually have to be replaced, but a service can maintain itself or even improve. "Services" is the term typically used by practitioners.

*descriptive* in that it provides a "thick" understanding (Merriam 1994: 42), which can include values, norms, rules and the deeply-embedded attitudes and understandings of different individuals and groups (Guba and Lincoln 1981). They therefore benefit from being carried out during a longer time, which was the case in paper III and the overall research/ PhD process (Merriam 2009). The *heuristic* aspect means that they can improve readers' understanding of the object, or confirm existing assumptions. The focus on a concrete example of a complex issue has the potential to uncover a particularly rich problematique (Flyvbjerg 2001). This was applied, for example, in paper II, which increased understanding of the practical application of the concept of resilience. The case studies presented here rest on a combination of *inductive* and *deductive* reasoning. First, initial theoretical frameworks, hypothesis and questions guided the investigation (i.e. deductive reasoning), but were allowed to evolve as new information and understandings emerged (i.e. inductive reasoning) (Merriam 2009).

Case study challenges includes the risk of oversimplification, extensive fieldwork and the researcher's tolerance for an unstructured process (Merriam 2009). A case study can exaggerate or *oversimplify* certain factors, leading to incorrect conclusions (Guba and Lincoln 1981). *Extensive fieldwork* is often needed. The search for usefulness in practice requires a pragmatic approach (Merriam 2009). In this thesis, both the author and the co-authors of the various papers carried out on-the-ground investigations in Cali (Colombia), Cebu (The Philippines), Durban (South Africa), Gorakhpur (India) and Kristianstad (Sweden). The approach also required a *tolerance for unstructured process* on the part of researchers, as the next step in the investigation is unclear at the beginning (Merriam 2009). An example is the WASH & RESCUE project. This was very much designed as an exploratory project, as there were few earlier and similar studies.

### 3.3.1 Unit of analysis

The unit of analysis is the "case". Here, the case refers to social learning processes within a linked system of flood risk and water resources management. All of the papers presented here adopted this unit of analysis, and, social learning were ongoing between both individuals and groups, forming larger social contexts. The unit of analysis was studied in terms of its temporal dimension (paper III), level of integration and adaptation (paper I), and role in building resilience (papers II, IV and V).

Yin (2009) distinguishes between holistic and embedded case study designs. The cases in papers I, II, IV and V are "embedded", in the sense that there are several units of analysis that can be found within the case itself. For example, several

different social learning processes addressed different aspects of flood risk and water resources management. The case in paper III is holistic as it analyses only one social learning process over an extended period.

### 3.3.2 Selection of cases

The selection of cases was guided by three rationales: the research question (Patton 2015), replication logic (Yin 2009), and access to information. The selection was made purposely with the assumption that cases would provide valuable insights relevant to the research questions (Patton 2015). Thus, they were not selected for their statistical representativeness. This is consistent with Flyvbjerg (2005), who emphasized the need to gain concrete and context-dependent knowledge that opens up an opportunity for theory development. Case studies also enable falsification, which is one of the most rigorous tests in science, where only one observation can invalidate a proposition that consequently needs to be either revised or rejected (ibid).

First, the single case of Kristianstad was selected as it provided a specific example of social learning in flood risk management, a phenomenon which, at the time, had not been studied. Also, it can be considered as a critical case, because Sweden is one of the world's most progressive countries in terms of ecological governance (Lundqvist 2013). Any findings on failures in this regard are most likely to be valid for all, or a large range of cases (Flyvbjerg 2006). Second, cases were selected based on a replication logic, in which additional cases confirm or falsify the findings of previous cases (Yin 2009) (figure 5). Third, the selection of the case studies was guided by access to information, specifically, the presence of key informants. This was facilitated by the fact that three of the case study researchers (involved in papers II and IV) were native speakers and resident in their respective countries (Cali, Durban, Kristianstad). In three cases, the ongoing work of the SEI and associated partners provided researchers with access to local, key informants (Durban, Gorakhpur, Kristianstad).

### 3.3.3 Single and multiple case studies

The research presented here uses both single and multiple case study designs, which offers benefits, but creates certain challenges. The case study design is often criticized as an inadequate basis for broader generalizations (Flyvbjerg 2005). Although statistical generalization is often assumed, this thesis applies analytic

generalization[25] (Yin 2009). Many insights were gained from the single case of Kristianstad, which supports arguments that context-dependent knowledge is useful to generalizing from, building theory and testing hypotheses (Flyvbjerg 2001; 2006). Specifically, the knowledge gained from the long-term Kristianstad study was relevant to the other contexts studied (Stake 1978). This could be said to be a form of generalization through the "force of example" and "transferability" (Flyvbjerg 2005: 305).

Such knowledge is acquired through *naturalistic generalization*, which develop within a person as a product of experience by recognizing similarities between objects and issues, in and out of context, and detecting correlations between events (Stake 1978). "They derive from the tacit knowledge of how things are, why they are, how people feel about them, and how these things are likely to be later or in other places with which this person is familiar" (Stake 1978: 6). Some authors emphasize that generalization is only possible if different contexts are sufficiently similar (Lincoln and Guba 1985). The insights from the single case study of Kristianstad were applied to the multiple case studies in papers II, IV, and V. The multiple case study design is said to provide more robust conclusions (Yin 2009). Thus, the combination of single and multiple case studies in this thesis is considered to provide a good basis for conclusions and generalizations. A key challenge was, however, to apply a replication logic in the multiple case studies. This mainly related to identifying similar categories of interviewees across cases (Yin 2009), especially because the governance system was unique in each case.

### 3.3.4 A systems approach

Systems theory was helpful in defining boundaries of the study in this thesis. The roots of systems theory can be found in Taoism (Capra and Luigi Luisi 2014). A more recent contribution is made by Massachusetts Institute of Technology professor Jay Forrester who, in 1956, recognized the need for people to understand whole systems rather than individual parts, and to recognize interrelationships and interdependencies (Senge 1990; Sternman 2000). Systems theory focuses on the investigation of the patterns of organization and hierarchy that are common to different phenomena, rather than their shared material components (von Bertallanfy 1968). A systems perspective addresses interconnections, interrelationships and interactions in the studied system (Patton 2015). The level of understanding and analysis is social-ecological, temporal, and multi-level (Berkes and Folke 2002). The approach can capture upstream/ downstream

25 *Analytic generalization* refers to the goal of expanding and generalizing theory, rather than enumerating frequencies (statistical generalization) (Yin 2009).

freshwater processes and can account for system complexities and uncertainties (Pahl-Wostl et al. 2007). It also ensures that interdependencies and feedbacks are included in the analysis, and unwanted externalities/ surprises are excluded (Parkes et al. 2009). However, challenges include the overwhelming amount of data that is potentially relevant. I learnt over time to manage this issue by constructing suitable analytical frameworks that adequately captured the unit and level of analysis (section 3.4.3.1).

### 3.3.5 Knowledge co-creation

Knowledge co-creation is an important approach, as is said to complement traditional research that addresses complex, global environmental change and sustainability challenges (Moser 2016). "Co-creation", in this context, refers to interactions between science and practice (Regeer and Bunders 2009) that aim to create knowledge through discussion and associated learning. It is related to what Gibbons et al. (1994) refer to as Mode 2 knowledge production, also linked to transdisciplinary knowledge development (Regeer and Bunders 2009). Mode 2 is carried out in an applied context, in contrast to Mode 1, where problems are set and solved in a context that is governed by the largely academic interests of a specific community. Mode 2 is more socially accountable and reflexive; it includes practitioners, whose experiential knowledge is considered relevant (Steyaert and Jiggins 2007; Regeer and Bunders 2009).

## 3.4 Research methods

This thesis adopted various methods for data sampling, collection and analysis. The insights presented here are derived from multiple sources of information and qualitative methods (Yin 2009). Data sampling and collection methods included: purposeful and snowball sampling, semi-structured interviews, document reviews (included in document analysis), focus group discussions, and observations. Data analysis methods included: systems analysis and document analysis (see table 2 for a detailed summary).

**Table 2: Research methods and empirical data**

| PAPER | RESEARCH METHODS | EMPIRICAL DATA | GEOGRAPHY |
|---|---|---|---|
| **Paper I**<br><br>single case<br><br>Part of the multiple case project Baltic COMPASS | Purposeful and snowball sampling<br><br>Semi-structured interviews, mainly by telephone (Appendix 1)<br><br>Focus group discussions<br><br>Observations<br><br>Document analysis (all document analyses for all papers are inclusive of review) | 15 respondents (six farmers, six municipal officers, one regional water planner, two regional administrators)<br><br>Municipal group discussion: 5 participants<br><br>National workshop: More than 60 participants, yielding insights from preparations of workshop and presentations.<br><br>Regional workshop (Baltic area): More than 50 participants, including 12 informants (two scientists, two municipal officers, one hydrological modeller, one advisor, three regional administrators including one water planner, three national level planners on risk, housing and environment respectively). | Kristianstad (Sweden)<br><br>Municipal level (outlook on river basin and national level – also gained some insight into the regional Baltic level) |
| **Paper II**<br><br>multiple cases | Purposeful and snowball sampling<br><br>Semi-structured interviews face to face and by telephone (Appendix 2)<br><br>Semi-structured interviews (Appendix 4)<br><br>Focus group discussions<br><br>Observations<br><br>Document analysis | 10 interviews (two development water and sanitation experts, three humanitarian water and sanitation experts, two utility experts; three international and regional programme managers).<br><br>The case studies included a total of 50 interviews. In each case, interviewees included politicians, technical staff (e.g., city council members, urban water specialists, urban and environmental planners), private sector (e.g. water and wastewater operators) and civil society representatives, chosen for their potentially different perspectives.<br><br>Internal workshop: 11 people, several meetings (over 20) mostly of four people, but occasionally 10 (including reviewers). | Cebu (The Philippines)<br><br>Durban (South Africa)<br><br>Gorakhpur (India)<br><br>Kristianstad |
| **Paper III**<br><br>single case | Purposeful and snowball sampling<br><br>Semi-structured interviews face to face (Appendix 3)<br><br>Observations<br><br>Document analysis | 23 respondents (ten municipal officers, including one from an upstream municipality), two farmers, three regional administrators, two academic experts, five hydrological experts and one risk manager at national level.<br><br>Extensive fieldwork, involving many visits, meetings, formal and internal discussions and workshops, e.g. the Resilience Alliance workshop in 2003. | Kristianstad<br><br>Municipal level (outlook on river basin and national level) |
| **Paper IV**<br><br>multiple cases | Purposeful and snowball sampling<br><br>Semi-structured interviews face to face (Appendix 4)<br><br>Focus group discussions<br><br>Observations<br><br>Document analysis | The case studies included a total of 50 interviews. For interviewees included see paper II, this column.<br><br>Internal workshop: 11 people. Several meetings (over 20) mostly of four people, but occasionally 10 (including reviewers). | Cali<br><br>Cebu<br><br>Durban<br><br>Gorakhpur<br><br>Kristianstad |
| **Paper V**<br><br>multiple cases | Purposeful sampling<br><br>Semi-structured interviews face to face (Appendix 5)<br><br>Document analysis | Four respondents (two private philanthropy professionals, one humanitarian, and one development water and sanitation professional). | International |

### 3.4.1 Data sampling methods

In all papers (except paper V), informants were selected using a combination of snowball and purposive sampling. In snowball sampling, key informants are identified; these people are asked to identify other potential interviewees or informants[26] (Bernard 2002). Snowball sampling proved to be very useful in the urban water sector because it is often small enough for people to know each other, even if they work in different departments or areas. At the same time, care was taken to ensure that the sample reflected key competences and knowledge. Thus, the method was supplemented by purposive sampling if there was a need to find (additional) interviewees in a certain category (Bernard 2002). The categories of interviewees presented in papers I–IV included, for example, politicians, representatives and technical staff from the respective municipalities (e.g. city council members, urban planners, environmental planners, and water and sanitation specialists), private sector organizations (e.g. water and wastewater operators, environmental inspectors) and civil society representatives.

Interviewee categories were not set in stone, but aimed to provide a flexible and pragmatic starting point, which evolved as new information emerged, until a saturation point was reached (Guetterman 2015). Saturation was reached when no additional insights emerged (ibid). Snowball sampling helped to identify a sufficient number of interviewees, as the same names kept turning up. In other cases, it helped to establish whether there was a need to interview more representatives from a particular category. Prior to saturation, the process provoked new questions, which needed to be answered by new (categories of) informants.

### 3.4.2 Data collection methods

#### *3.4.2.1 Semi-structured interviews*

Semi-structured interviews have both benefits and challenges (Bernard 2002). The method is commonly used when the aim is to gain information in relation to the perspectives, understandings and meanings that people construct regarding their events and experiences (Smith et al. 2001). Although they take a long time to conduct and analyze, (ibid), they have the benefit of uncovering new issues or concerns that have not been anticipated by the researcher (Pope et al. 2002). Analytical frameworks, together with the relevant theory, helped in understanding what type of data needed to be collected, and informed the formulation of

26 *Interviewees* refers to persons who were interviewed. *Informant* refers to people who also facilitated the research process by finding new interviewees, identifying documentation etc.

interview questions. Interviews were guided by a written list of questions and topics, which could be covered in a particular order (Bernard 2002), or which could be adapted to follow the natural flow of respondent's answers (Brinkmann and Kvale 2015, see appendices 1-5). This flexible format made it possible to explore people's views and descriptions, and produced richer data (ibid). The challenge for the researcher is to avoid probing interviewees into providing the "right" response. To avoid that I learnt over time to use increasingly neutral probes, such as asking for more detailed descriptions, or echoing what the interviewee had just said (Bernard 2002). I also learnt not to become too "cosy" in an interview situation as it was important to remain an objective observer (Brinkmann and Kvale 2015).

Interviews had three aims: 1) to take stock of current ideas among practitioners, 2) to respond to the research questions, and 3) to confirm initial findings. To take stock of current ideas, paper V was informed by four key informants (two private philanthropy professionals, and two water and sanitation professionals in the humanitarian and development sectors respectively). To respond to the research questions, the interviews were designed to describe and understand the case and its context (Creswell 2013). All interviews were digitally recorded and transcribed.

#### *3.4.2.2 Observation*

To understand fully the complexities of a situation, direct participation in, and observation of the phenomenon is a fruitful method (Patton 2015). The ideal observation captures the unfolding of events, critical interactions, and their context, and includes interacting with the actors involved (ibid). Observations mainly took place during workshops, meetings and involved communications between practitioners, researchers, policy-makers, and other actors. Topics included disaster risk, climate change adaptation and mitigation in the context of the water and sanitation sector[27]. Supporting data included photos of discussion outcomes, emails, workshop notes, internal reports, publications and webpages.

#### *3.4.2.3 Focus group discussions*

A focus group usually consists of six to ten subjects led by a moderator (Chrzanowska 2002). It is characterized by a nondirective style of interviewing, where the main aim is to elicit a variety of viewpoints on a set topic. Unlike interviews, participants can hear each other's responses and make additional comments (Patton 2015). They are suitable for exploratory studies in a new domain (Brinkmann and Kvale 2015). Here, they were intended to contribute to knowledge co-creation (section 3.3.5).

27 These workshops were part of the disaster risk and climate change programme administered by the International Water Association (IWA).

Focus group discussions contributed to five aims in this thesis: 1) develop the research questions, 2) collect relevant data (including co-created knowledge), 3) adapt the research questions, 4) test preliminary research outcomes against reality, and 5) triangulation.

Some discussions aimed to cross-fertilize ways of knowing and working in different geographical areas to find innovative solutions[28] (e.g. Zwolsman et al. 2009[29]; Johannessen 2011; Johannessen et al. 2012). These groups contributed to the development of the research questions and data collection. In some cases, geography was the common denominator. In other cases, data was collected from very different geographical areas, which were classified as having the same water-related issues, or "typologies"[30]. These discussions were used for example in the iterative formulation of new activities (e.g. different projects[31]).

In terms of testing research outcomes against reality, one focus group discussion (paper I) consisted of five policy- and decision-makers from different administrations within the Kristianstad municipality, who had different views on flood risk management and who had not met as a group previously. It aimed to explore the progress and feasibility of a more integrated approach to flood risk and water resources management.

Other group discussions took place in the context of various workshops. For example, to confirm initial findings, two workshops with a wide range of actors (about 50–60 people in each) gave feedback on the initial findings of paper I.[32] Current practical experience of governance and the management system were discussed. Internal project workshops also served as an opportunity to triangulate

28 For example, two workshops were held (in 2009 and 2011) in Stoutenburg, The Netherlands, which brought together humanitarian and development professionals. This was linked to the Sustainable Sanitation Alliance (SuSanA), working group number 8 of experts with experience in emergency and reconstruction situations.

29 These discussions resulted in a series of "Perspectives" papers that were published in cooperation with The World Conservation Union (IUCN), the Co-operative Programme on Water and Climate (CPWC) and International Water Association (IWA), in the context of workshops and preparations for the World Water Forum in Istanbul, Turkey, in March 2009.

30 The main three typologies were: low-lying countries and river deltas; mountainous regions (retreating snowpack); and arid and semi-arid areas (Zwolsman et al. 2009).

31 This project was part of the EU's Water Initiative Research Area Network (SPLASH). Work was carried out with the group CLASS-A (Confederação de Legitimação e Assessoria ao Saneamento Sustentável e Água) in Mozambique, and the International Association of Water & Wastewater Utilities for Sustainable Water Security (W-SMART).

32 Part of the Baltic COMPASS project, see section 3.2.

data with fellow project reviewers/ practitioners and investigators (papers II and IV).

### 3.4.3 Data analysis methods

*3.4.3.1 Systems analysis*

As the underlying research design (e.g. case studies) is based on a systems approach, systems theory and thinking is critical to data analysis. A useful definition of systems thinking is the "analysis, synthesis and understanding of interconnections, interactions, and interdependencies that are technical, social, temporal and multi-level" (Davidz 2006). Therefore, interactions, interconnections and interdependencies, in the form of social learning processes, were studied in terms of their social-ecological and temporal dimensions, at multiple levels.

The main tool applied for systems analysis were analytical frameworks that included interactions and feedback. These frameworks helped to link the theoretical question to the empirical data by explaining what is theoretically known about the phenomena under study (Miles et al. 2014). In terms of data analysis, they provided an explanatory frame of reference, made up of categories or themes. Constructing a framework was especially useful when there was no existing theory to explain a phenomenon. The frameworks used here were developed with the help of literature reviews and document analysis[33], and led to novel insights. This was often achieved by combining knowledge from disparate fields (Adams 2005), for example conceptual models from resilience theory, water resource and flood risk management in paper I.

The following paragraphs present the analytical frameworks in relation to the research questions (Q1–3):

Q1: In paper I, an analytical framework was constructed from three schools of thought: adaptive management/ resilience theory (Pahl-Wostl et al. 2007), water resources management (Medema et al. 2008), and flood risk management (de Bruijn 2005). The case study was analyzed in terms of how it reflected this framework, which led to the identification of challenges and opportunities.

Q2: In paper II, the analytical framework proposed by Walker and Salt (2012) was used to translate the concept of resilience to urban water services. Ten water professionals from the development and humanitarian sectors were asked to

33 The term *document* includes interview transcripts.

exemplify the categories presented in the analytical framework, based on their knowledge and experience (appendix 2).

Q3: To assess the evidence for and elements of social learning, analytical frameworks were used in two ways: 1) an existing analytical framework based on social learning (Schusler et al. 2003) was applied to a ten-year implementation process (paper III); and 2) social learning attributes drawn from the literature were used to identify potential social learning processes in the case studies. This was then assessed using the conditions for social learning given by Reed et al. (2010; paper IV).

The constructing of these analytical frameworks involved sketching and grouping, by hand and using computerized tools. Sketching makes it possible to group information in an easily accessible and retrievable format, unlike sequential textual descriptions (Larkin and Simon 1987).

*3.4.3.2 Document analysis*

Document analysis is a systematic procedure for reviewing or evaluating documents. It entails finding, selecting, appraising (making sense of), and synthesizing data, in such a way that empirical knowledge is produced and understanding is developed (Bowen 2009). Documents of all types can help the researcher uncover meaning, develop understanding, and discover insights relevant to the research problem (Merriam 1994). In the process of analyzing these documents, the researcher should strive for objectivity and sensitivity, and maintain a balance between them (Bowen 2009). Document analysis was applied at all stages of this thesis. It involved being aware of the *context* of documents (e.g. when were they prepared? where? why? by whom? how? and for what audience?) (Merriam 1994; Bowen 2009). Various *dimensions* were also considered, such as whether the documents were published and peer reviewed or not; authentic and unbiased or not; representative of all relevant facts or not (Merriam 1994). Also, *the absence* of information was noted (Bowen 2009). An example was the lack of participatory documentation in local flood risk management that were dominated by modelling studies (paper III). This evaluation and review helped to assess the credibility of documents, which increased trustworthiness and thus validation (see section 3.5.1). In turn, the process served to triangulate findings from other methods such as interviewing (section 3.5.1).

The document analysis yielded data such as quotations, and insights that were coded using grounded theory (Glaser and Strauss 1967). This analysis was part of "a quality data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (Patton 2015:541). It should be noted that this did not concern *underlying*

meanings, where a second opinion is recommended in the interpretation (Hayes 1997). Qualitative data mainly concerned interview transcripts and other documents, which the document analysis aimed to make sense of. Both inductive and deductive analyses were used, and the process was divided into four stages:

1) *Defining the unit of analysis* (section 3.3.1) was done in line with the purpose and aim of individual papers, see table 1.

2) *Preparing the data* included preparing verbatim interview transcripts, which facilitated re-reading and re-interpretation and improved insights and understanding. These interpretations depended on the available knowledge and insight into the subject matter, which increased as the research progressed (Brinkmann and Kvale 2015).

*3) Defining the initial themes and categories* was done with the help of conceptual and analytical frameworks and the relevant theory (i.e. deductive analysis) (Urquhart 2013; section 3.4.3.1). Some of these were taken from previous findings (e.g. paper IV constructs an analytical framework with the help of paper II). Then, to complement this categorization, themes or categories were allowed to emerge from the data, through a process of study and comparison with existing categories (i.e. inductive analysis) (ibid). This was done with the help of "open coding"[34], which is the first of three types of coding[35] (Glaser 1978).

*4) Sorting the data, finding patterns and interpreting the findings* often lead to extending the applied analytical framework or developing new conceptual models. This was supported by a process that is similar to "selective[36]" and "theoretical coding[37]". These processes also involved reading the related literature, and comparing it to the findings that emerged from the data. This included alternative

34 *Open coding* is an analytic process of going through the data, often line-by-line or paragraph-by-paragraph, and allocating the ideas that are found to data chunks (Urquhart 2013). The aim is to identify concepts, and their properties and dimensions (Strauss and Corbin 1998). Open coding implies an openness to emerging data, while sorting it into an initial set of categories (Urquhart 2013).

35 *Coding* is "the act of attaching concepts (or codes) to data" (Urquhart 2013:191). Glaser (1978) recommends three stages of coding (open, selective and theoretical coding).

36 *Selective coding* is when open codes are grouped into higher-level categories (Urquhart 2013), for example organized around a central explanatory concept, and using several techniques, for example writing the storyline (paper III), or diagrams (papers II and IV) (Strauss and Corbin 1998).

37 *Theoretical coding* is the process of relating the codes to each other and looking at the relationships between them. This is what builds the theory (Urquhart 2013).

explanatory or interpretive frameworks, or providing different theoretical perspectives that challenged the findings. The inductive phase was important as it provided an initial confirmation of the applied framework (or "grounded" the proposed categories with the emerging data) and linked emerging findings to form (new) theories or explanations (Urquhart 2013).

In paper V, this analysis process was mainly inductive. Although various frameworks and perspectives were applied to help select the literature (i.e. deductive analysis), the main patterns emerged out of the collected data (i.e. inductive analysis).

The qualitative research presented in this thesis is characterized by iterative processes, loop-like patterns of multiple rounds of revisiting the data as additional questions and reflections emerge and more insights develop (Berkowitz 1997). These loops involved different actors and stakeholders, as preliminary findings were discussed and then adjusted based on new comments and additional inputs (see also section 3.4.2.3).

## 3.5 Validity, reliability and research ethics

The principles of validity, reliability and ethics are fundamental cornerstones of the scientific method, in terms of "getting it right" (Creswell 2013) in an ethical way (Merriam 1994). Reliability and validity are conceptualized as trustworthiness, rigor and quality in the qualitative paradigm (Golafshani 2003; Lincoln and Guba 1985) and there are many types and terms to choose from (Creswell 2013). Here I describe the approach taken in this thesis.

### 3.5.1 Validity

Validity is the attempt to assess the accuracy of findings (Creswell 2013). Here, it was ensured through triangulation, prolonged engagement, peer review and generalizability (Merriam 1994; Creswell 2013; Patton 2015).

*Triangulation* in qualitative research involves gathering and analyzing multiple perspectives, using diverse sources of data, theories, investigators, methods and different frameworks to provide corroborating evidence (Patton 2015; Merriam 1994; Creswell 2013). The aim is to test for consistencies or inconsistencies using different perspectives, which can offer deeper insights (Patton 2015). Inconsistent results are not necessarily a weakness, but illustrate the effect of different types of

inquiry on the phenomenon under study (ibid). In terms of *investigator triangulation*, the multiple case studies in papers II, IV and V involved five other investigators[38] who also revised and provided critical feedback on all of the papers. Other precautions included discussions with colleagues from different backgrounds during the research process, notably peer review. In terms of *data triangulation*, the analyses focused on different, but comparable data, for example transcripts from different interviewees or different literature. *Methodological triangulation* was applied to cross-check information gathered using different data collection methods, such as interviews, and observations, or different data analysis methods, e.g. using different analytical frameworks. *Theoretical triangulation* was applied through review, publication and exchange with peers in the search for relevant theory. For example, in several internal SEI workshops over a period of six months, the theoretical framework of paper II was discussed with team members from the Arctic Resilience Report project[39] as well as the principal four project researchers. This was important, given the influence of theory on results implied by the post-positivist paradigm (Maxwell and Mittapalli 2010; section 3.1.1). Here, the choice of Walker and Salt's (2012) work as the framework for the analysis significantly influenced the results.

In terms of *prolonged engagement* (Creswell 2013), the author has been studying Kristianstad, Sweden (papers I and III) on-and-off since 2003, i.e. nearly 15 years. This created an abundance of data, which was needed for single case studies and helped to overcome beginner mistakes, especially in interviewing. Urban water services (papers II, IV and V) is a topic that the author has studied professionally since 2007, i.e. for ten years. This has provided an understanding of the complexity of the area, which is improved by taking a step back to avoid bias. In terms of *peer review*, all papers were peer reviewed prior to publication. *Generalizability*, which is related to validity, is described in section 3.3.3.

Validity was reinforced by the fact that this research contributed to larger research projects, which provided several checkpoints for reflection, discussion, and the validation of findings. Opportunities included internal workshops, working meetings, meetings with internal review groups, and the presentation of the findings at several conferences. This diverse interaction and dialogue with peers and practitioners ensured that personal interpretations were avoided, improvements were made to the theory, and biased was limited.

38 The case study investigators involved in this thesis were: Dayana I. Hernández Vivas (Cali), Sophie Peter (Cebu), Julian T. Arran, Thor Axel Stenström (Durban), and Kim Andersson (Gorakhpur).

39 For the Arctic Resilience Report project, see www.sei-international.org.

Validity could be questioned on the grounds of a normative approach, the lack of quantifiable data (Creswell 2013), representativeness, and the breadth and depth of the case studies. These are addressed in turn.

*Normative approach* – although the analysis in paper V saw social learning as desirable, the analysis departed from a demonstration of "workability", i.e. that things work in reality, which is a central validity test in action research (Greenwood and Levin 2007). *Lack of quantifiable data* – although the thesis uses exclusively qualitative methods, this is deemed sufficient, given the nature of the investigation, which requires the description of meaning based on actors' and stakeholders' interpretation and an understanding of how individual components of a phenomenon come together as a system (Merriam 1994). *The representativeness, breadth and depth of case studies* – Kristianstad is a very small municipality compared to many of the world's larger urban areas. However, its study was justified given its extreme flood risk compared to other Swedish urban areas (MSB 2011). Therefore, the findings can be considered critical as they revealed challenges in a relatively well-governed context (section 3.3.2; Flyvbjerg 2006). Furthermore, the in-depth nature of the study yielded high-quality data over a prolonged timeframe, which provided many profound insights that were transferable to other contexts (section 3.3.3). As for the multiple case studies in papers IV and V, they could have been made more robust through a more in-depth study. However, limited resources in terms of time and money meant that improvements could not be made.

### 3.5.2 Reliability

In quantitative research, reliability refers to the stability of repeated collections of data (Merriam 1994), which in the case of qualitative research is argued to be irrelevant (Golafshani 2003) or even misleading (Stenbacka 2001). This is because a qualitative study aims to create an understanding of a phenomenon, rather than explain it (Stenbacka, 2001). Instead, it can be assessed in terms of its "dependability", which emphasizes the need for the researcher to account for the context for the research, and how any changes in this regard affected the study (Lincoln and Guba 1985). In this thesis, dependability, and thus reliability, was ensured though taking great care to conceptualize the study, collect the data, interpret the findings and report results consistently. Furthermore, the method was clearly presented in each paper, supported by an "audit trail" or "inquiry audit" in the form of field notes, digital archives, and internal reports, documenting the research process (Lincoln and Guba 1985). The extensive collaboration with other researchers was another reason to retain thorough documentation in order to be able to coordinate and manage the research process.

### 3.5.3 Research ethics

Many considerations to research ethics have been done in this thesis, and most obvious in relation to the interviews. Here, standards improved as the research progressed. Initially, the main ethical considerations consisted of explaining the purpose of the interview and the potential benefits for the interviewee (Patton 2015). While many interviewees were relaxed about the information they shared, it was nevertheless important to obtain informed consent, ensure confidentiality and consider possible consequences for interviewees (Brinkmann and Kvale 2015). Most interviewees were asked if there was anything that should not be disclosed. Confidentiality was also ensured by keeping the interview documentation safe. In some cases, when statements were sensitive or unclear, interviewees were asked to verify their responses and if they consented to their publication (Patton 2015; Brinkmann and Kvale 2015). However, it must be said that this process also involved challenges. I have sometimes avoided a discussion over wording, as the ultimate interpretation lies in the hands of the researcher. Lastly, with respect to the publication of information, attempts were made to balance the reproducibility of the data and confidentiality concerns. This was partly influenced by feedback from the reviewers and editors of the journals where the findings were published.

# 4 Results

This chapter highlights the main findings in relation to the overall research aim, namely to investigate the role of social learning for resilient urban water services. More specifically, the findings presented in papers I–V are analyzed in relation to the three research questions. First, section 4.1 presents the findings relating to the current challenges for integrating flood risk and water resources management to benefit resilient urban water services (Q1). Then, section 4.2 presents the findings related to the question of what resilience means for urban water services. These are synthesized in a conceptual model. Section 4.3 presents the findings with respect to the key elements of social learning that can support or inhibit more resilient urban water services (Q3). See table 3 for a summary of the key outcomes related to all questions.

## 4.1 Current challenges for integrating flood risk and water resources management to benefit resilient urban water services

Three main challenges for integration are identified, and can be categorized as: governance arrangements; working cultures; and knowledge, capacity and resources.

The first challenge relates mainly to "vertical integration", where governance arrangements confined flood risk planning to a local area and challenged upscaling of local efforts. For example, in Kristianstad, the governance system in place for flood risk management lacked coordination at the level of the river basin. This resulted in the fact that flood risk was only a local matter and that river basin measures were excluded. Coordination at river basin level was, however, implemented for water resources, under the EU Water Framework Directive (European Union 2000) (as described in detail in paper I). Similarly, in Gorakhpur, an integration initiative at local level could not be upscaled. This was due to incompatibilities at national level, which made a corresponding integration (paper IV). In many cases, even if there was some governance arrangements or activities

at river basin level, there was often a lack of capacity for adequate implementation, contributing to the deterioration of water resources (papers I–IV). For example, in Cebu, although a local research institute had monitored the degrading water quality since 1975, no solutions were in place to tap into new sources, or control and enforce groundwater usage (paper II). In other places, for example in Durban, implementation was difficult because of lack of enforcement due to corruption/ financial gain (paper IV).

The second and third challenge relates mainly to "horizontal" or "sectoral" integration, that are separating the two working fields through different *working cultures* and their associated *knowledge, capacity and resources*.

The second challenge; *working cultures* – can be understood as "the set of shared attitudes, values, goals, and practices that characterizes an institution or organization" (Merriam Webster 2017) . This challenge was mainly seen in terms of the lack of participatory approaches and types of applied knowledge. For example, in Kristianstad's flood risk management, technical expert opinion (results of geotechnical investigations, hydrological modelling etc.) steered decisions. It was only in Kristianstad's coastal risk management that a dialogue was initiated with stakeholders, because embankments were not an option (Segnestam and Johannessen 2015). Participatory practices (papers I–IV) were many times excluded in the case studies, or referred to as challenging (papers II and V). This contrasts with water resources/ ecosystem management, which often relied on stakeholder dialogue for decision-taking (papers I and III). Different working cultures between flood risk and water resources management communities also meant that there were differences in the application of ecosystem-based measures (all papers). For example, in Kristianstad, the technical and rescue service department were not applying ecosystem services in their official river flooding strategies[40]. Instead, embankments were the preferred measure[41] because they provided the level of security required for extreme floods[42] (papers I, III and IV). In Kristianstad, the challenge of different working cultures at local level was reinforced by national level, as the two management areas were coordinated by two different Ministries (paper I).

40 Ecosystem services are, however, indirectly referred to in relation to alluvial flooding (from rainfall in the urban area) in Kristianstad's stormwater policy (paper I).

41 This mainly resulted in mainly structural investments (the costliest measures in Sweden's modern history). Projected costs totaled more than 500 million SEK, to be finalized in 2025 (Kristianstad webpage 2017). Maintenance costs add about another 3 million SEK per year (Svensson 2017).

42 This security has been challenged by cracks and instability identified in one of the embankments (Andersson 2015).

The third challenge related to different working cultures are the *knowledge, capacity and resources* available for integration and collaboration. For example, in Durban, there was an observed resistance to collaboration, as integration was perceived to divert *resources and capacity* – human and financial – from sectoral activities, which were given greater priority. Similarly, in Gorakhpur, funding was not perceived to be a major issue, but it was seen as difficult to establish priorities due to lack of human resources (paper IV). In Cebu, capacity and knowledge on Sustainable Urban Drainage Systems (SUDS) was lacking (paper IV). Here, the drainage department instead aimed to increase the drainage pipe diameter, channeling rainwater out of town as fast as possible, while drinkable groundwater resources were critically scarce. In the other case studies, a similar dominance of technological fixes was found (papers II, IV and V).

## 4.2 The meaning of resilience for urban water services

Findings related to the meaning of resilience for urban water services include insights into several phenomena. The main four are presented below and can be summarized as: 1) there are three levels of resilience; with 2) supporting and inhibiting factors at each level; 3) there are two thresholds; and 4) associated reorganization/ non-linearity. These findings are presented in form of an analytical framework in figure 5, which shows the identified key principles or attributes of urban water resilience.

### 4.2.1 Three levels of resilience

The analysis of the interviews indicates the importance of differentiating between three different levels of resilience, which can and should be seen in relation to three types of disturbances (paper II):

i. Socio-economic resilience: this is related to disturbances that are not associated with hazards, but are located within the urban water service infrastructure and the entities that manage and govern it. Most examples are socio-economic in nature and include corruption, power dynamics, capacity gaps, etc.
ii. Hazard resilience: disturbances that relate to so-called natural hazards, disasters and crises that are external to the urban water service infrastructure, and the entities that manage and govern it[43].

43 Water and sanitation systems, and their related management systems can also be more or less susceptible to hazards. Consequently, they can cause secondary health hazards, resulting from water contamination (paper V). These aspects are also included in hazard resilience.

iii. Social-ecological resilience: this relates to long-term (slow) disturbances of the broader social-ecological system that impact urban water services, such as unsustainable resource extraction.

These three types of resilience levels (box 1 in figure 5) were not explicitly referred to in the interviews, which implies the interviewees applied the resilience concept to many types of disturbances and systems without differentiating them (paper II). This has implications, because building resilience or adaptive capacity at one level (linked to one type of disturbance) does not necessarily mean building it at another (linked to another type of disturbance) (Carpenter et al. 2001). For example, embankments may signify increased resilience to hazards (i.e. floods), however, they do not provide social-ecological resilience when floodplains are reduced. It is easy to assume that the resilience of the whole system is increasing, when in fact, only a part of it is – or even another part is reducing its resilience (paper II). This phenomenon is similar to the concept of "tradeoffs across scales" (Chelleri et al. 2015).

### 4.2.2 Supporting and inhibiting factors of resilience levels

Several factors are identified that could support or inhibit the sustainable development of the three levels of resilience (box 2 in figure 5). As described in section 2.4, these factors consist of context-dependent feedback processes, which evolve the system identity over time, and drive transitions in different directions (Walker and Salt 2012). They are important for social learning in that they equip agents with knowledge and tools that influence or determine the direction, depth and outcome of learning (paper II):

i. *Socio-economic resilience* is supported or inhibited by two main factors. The first is actors' capacity to drive developments in more (or less) sustainable directions. Here, improved knowledge and science–policy integration were seen as crucial. The second is the level of inclusive governance practiced by the many actors involved in urban water services and who sometimes disrupt it. For example, the micro- governance models found in Gorakhpur, India and Purok in Cebu, the Philippines ensured inclusive participation, especially of women, and increased knowledge and acceptance of urban water interventions. Such interventions were often related to both disaster reduction, and water and sanitation. However, politicians were said to be disruptive actors who made election promises that they could not deliver on (Cebu, Durban); similar claims were made about the public who were said to exert influence by their (not always sustainable) preferences (e.g. in Cebu, Durban and Gorakhpur).

ii. *Hazard resilience* is supported by actors' awareness of climate change and disaster risks, and perceived win-wins between socio-economic resilience and risk reduction. For example, the latter included decentralization processes that enhance modularity. An inhibiting factor is the lack of human and financial resources to handle uncertainty and anticipate "black swan events"[44] (Taleb 2010), which influence the type of action taken, especially in preparation for climate risks. For example, faced with uncertainty, there was a preference for investing in tangible measures that tackled predictable problems, such as providing access to drinking water (paper II). Another inhibiting factor is the high value placed on cost effectiveness in urban water delivery (by e.g. utility boards or steering committees), which conflicts with the redundancy (e.g. back-up systems) required to increase resilience.

iii. *Social-ecological resilience* is supported by three main factors. The first is enhanced inter-institutional coordination across scales, although it was said to be very challenging to achieve. A related inhibiting factor is the lack of knowledge of ecosystem-based planning and risk reduction across scales. The second is the importance of regulatory frameworks and policies across scales and with longer time horizons (e.g., water safety plans), which can improve management of water catchment areas (e.g., Kristianstad; Wamsler et al. 2014). Third, integrated formal and informal urban planning frameworks are identified as crucial in ensuring that resilience is considered in on-the-ground developments, such as mitigating downstream flooding in local drainage initiatives. This approach could counteract the strong drivers of rapid urbanization and short-term economic growth (paper II; Wamsler 2015).

From the above factors, it is indicated that increasing the resilience level (i-iii), also increases the implementation difficulty of the factors supporting the learning. For example, supporting social-ecological resilience requires cross-scale and cross-sectoral activities over a long period of time, addressing slow stressors such as pollution. This can be compared to relatively quicker achievements in socio-economic resilience, e.g. from introducing micro-governance. It indicates that achieving social-ecological resilience may be the most difficult of the three resilience levels.

44 *A black swan event* has three characteristics: 1) it lies outside the realm of normal expectations; 2) its impact is extreme; and 3) humans construct after-the-fact explanations for its occurrence, which make it more understandable (Taleb 2010).

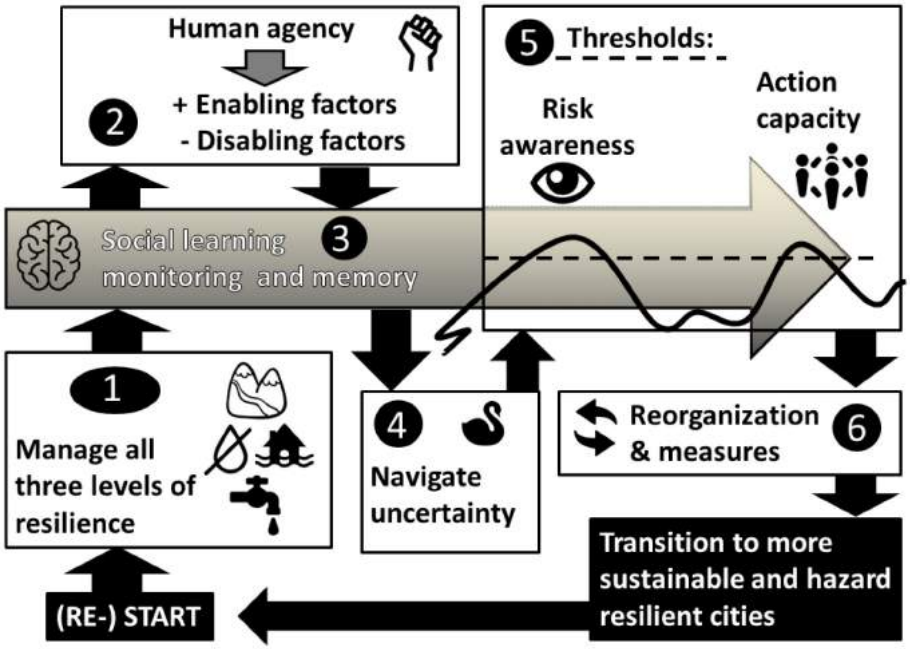


**Figure 5: Resilience as a transition process in urban water services. Boxes represent various considerations that are described more in detail in the text.**

### 4.2.3 Two thresholds

The social learning process (box 3 in figure 5; section 4.3.2) was identified to be linked to two types of thresholds (box 5 in figure 5). Reaching these thresholds depends on social learning and other factors, for example, financial resources and the capacity of actors to navigate uncertainty (box 4 in figure 5; section 4.3.4). Thresholds indicate that a critical mass has been reached to open up to change and transition (described in detail in paper II).

*i) The first threshold: Risk awareness/ perception*
The first threshold is related to the level of perceived risk; i.e. the perception that a certain disturbance (e.g. water scarcity, drought, flood) will have a certain impact (or consequence) on a given system (paper II). One example, found in several papers is the extent and pattern of (perceived) climate change-related floods, and the perceived future impact on society. In paper III, this risk awareness/ perception acquired by individual risk professionals was key to initiating a social learning process that were subsequently integrated into the organization. Here, the

threshold represents the level of risk that is accepted by individuals and/ or society; some risks are perceived as unacceptable and demand action. Similarly, in the organizational literature, the term "risk threshold" refers to a level that separates acceptable risk from intolerable risk (Project Management Institute 2013). However, to be able to act on this awareness is a different matter, where the next threshold of action capacity needs to be passed, which will be described below.

*ii) The second threshold: Action capacity*
The second threshold relates to capacities (e.g. financial, political, technical) that enable action regarding the perceived risk. An example is the financial capacity for investments in disaster-resilient urban water services (see paper II for more examples). A lack of action capacity was found in several of the case studies (Cebu, Durban and Gorakhpur). Here, less action was taken in response to slow stressors such as salinization and pollution than more shocking events such as extreme floods (paper IV). When action resulted from crossing an action capacity threshold, the direction was not necessarily sustainable. Kristianstad provides an interesting example. It can be argued that although action capacity was demonstrated through, for example, building embankments and increased integration, the related action did not really improve sustainability (papers III and IV). However, other precautions relevant to the environment and recreation were taken, for example by placing the embankments a short distance inland, thus preserving much of the natural shoreline of the wetland (Magnusson 2003).

Paper IV investigated the supporting and inhibiting factors of these two thresholds, and the outcomes are described in section 4.3.

### 4.2.4 Resistance and reorganization

The findings indicate that resistance and reorganization (box 6 in figure 5) are intrinsic properties of change and transition (paper II). Resistance to change preceded abandoning accepted truths and accepting new information (paper II). In Kristianstad, flood risk managers within the municipality first had to challenge the position of a local administrator of the viewpoint that there was no flood risk, before they could begin their activities (paper III). Later, they also had to challenge their own assumptions, which led to extending their view of what needed to be managed in terms of time and spatial scales. Challenging one's own assumptions is known to create room for new perspectives and actions (Argyris and Schön 1996; Kim 2004). Sometimes change required a collapse of old structures, for example a corrupt utility, before new structures could be built. Such change was facilitated by mechanisms such as the establishment of better

accountability mechanisms (paper II). Collapses were also associated with disasters and epidemics such as cholera, which, for example, sparked policy change and investment at national level in Durban (paper II).

## 4.3 Key elements of social learning that can support or inhibit more resilient urban water services

This section presents the key elements of social learning that can support or inhibit resilient urban water services. The description follows the conceptual model for resilience building presented in figure 5.

### 4.3.1 Social learning at the three levels of resilience

The case studies show that the different uses or understanding of resilience (described in section 4.2.1) can lead to "imbalanced" learning, where one resilience level was seen to have progressed more than others (box 1 in figure 5) (paper II). For example, in Kristianstad, local planners quickly discarded alternative, ecosystem-based measures – although in their defense, they lacked support from governance arrangements, policies and funding for such activities (paper I). In Cebu, social learning at local level promoted access to drinking water for urban neighborhoods, with successful outcomes. However, at the higher (social-ecological) level there was a lack of governance and management capacity, resulting in lack of enforcement. This imbalanced learning resulted in open access, where everybody can use all resources (Ostrom 1990), leading to over-extraction (paper II). All of the case studies reflect this imbalance; progress at local level is not reflected at the broader social-ecological level, which is eroded. The literature identifies these inherent tensions in IWRM, specifically between bottom-up and top-down approaches to management (Öjendal et al. 2011). In general, the IWRM literature argues for a better balance of top-down and bottom-up governance feedback mechanisms (GWP 2000). However, the lack of attention to such cross-scale and cross-jurisdictional dynamics in practice is evident both in the research presented here and in the ecological literature (Lee 1993). All of the papers presented here identified the need to use social learning to balance top-down and bottom-up coordination. For example, social learning platforms, where stakeholders identify and prioritize issues in a dialogue, could be better employed to inform the spatial planning process at river basin level (paper I).

### 4.3.2 Social learning, monitoring and memory

The findings illustrate that although social learning is evident, it is generally unable to overcome the prevailing 'stationarity' principle (Milly et al. 2008) (box 3 in figure 5) (paper III). The Kristianstad case study describes such a process in depth. It highlights both single and double loop learning (section 2.6), over a period of ten years. This bottom-up process was driven and owned by a small group of local risk professionals who perceived that the local embankment was an increasing risk factor. In the first phase, they overcame resistance to change, characteristic of learning processes (Argyris and Schön 1996), and systematically started to build technical knowledge about the flood risk in collaboration with other local and external experts, such as the MSB. In this process, they improved their knowledge along the lines of their own expertise, which is characteristic of single loop learning (Hargrove 2002). Double loop learning followed later, when the MSB recommended (but did not insist) that they consider a longer timeframe (paper III). This meant that their assumptions had to be re-evaluated, which is characteristic of double loop learning (Hargrove 2002). In this case, there was a clear incentive, as the MSB was a trusted partner that also provided funding. However, despite the learning process, the focus remained on structural solutions (i.e. embankments) symptomatic of the 'stationarity' principle (Milly et al. 2008). Hence, social learning did not, in this case, achieve any substantially integrated or adaptive solutions (figure 5; paper III).

Instead, changes in governance structures and legislation are identified as the key supports for social learning for integrating flood risk and water resources management (papers I, III and IV; figure 6). This finding also relates to the supporting factors for social-ecological resilience described in section 4.2.2. Changing such structures could enable a change in the underlying principles – for example, from "stationarity" to "living with water" – which in other cases has involved so-called triple loop learning (Huntjens et al. 2012). There are only a few examples of such learning in modern society, notably Dutch water governance (ibid).

There are several aspects to the social learning process, which are described below: it can be supported or inhibited by certain factors; it builds up to certain thresholds that enable change; and learning loops involve resistance to change and reorganization.

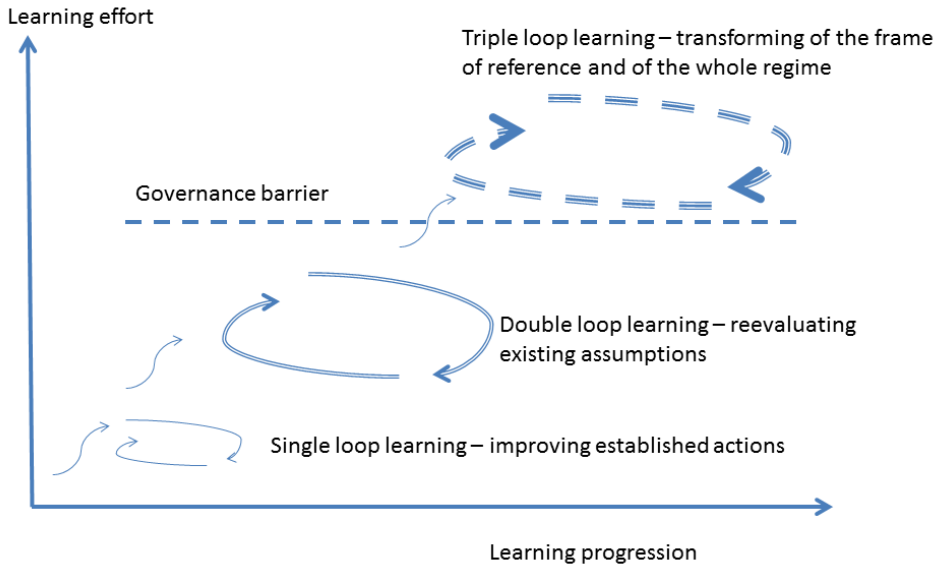


**Figure 6: An illustration of social learning theory applied to loops and the results presented in paper III. The governance barrier was identified in this paper, which is needed for triple loop learning.**

### 4.3.3 Supporting and inhibiting factors on thresholds

Supporting and inhibiting factors are identified that influence the social learning process in reaching thresholds related to "risk awareness/ perception"[45] and "action capacity" (box 5 in figure 5; section 4.2.3; paper IV). Risk awareness/ perception is influenced by actual pressures/ disturbances on the system. Action capacity[46] includes management actions and actions to mainstream and integrate management approaches (figure 7). These thresholds are referred to as "key social learning areas" and can be illustrated in a conceptual model (figure 8; paper IV).

45 *The risk awareness/perception threshold* is related to a certain level of perceived risk; i.e. the perception that a certain disturbance (e.g. water scarcity, drought, flood) will have a certain impact (or consequence) on a given system (paper II, see section 4.2.3).

46 *The action capacity threshold* is related to a certain level of capacity (e.g. financial, political, technical), which supports action on the perceived risk, for example financial capacity for investments in disaster-resilient urban water services (see section 4.2.3, see paper II for more examples).

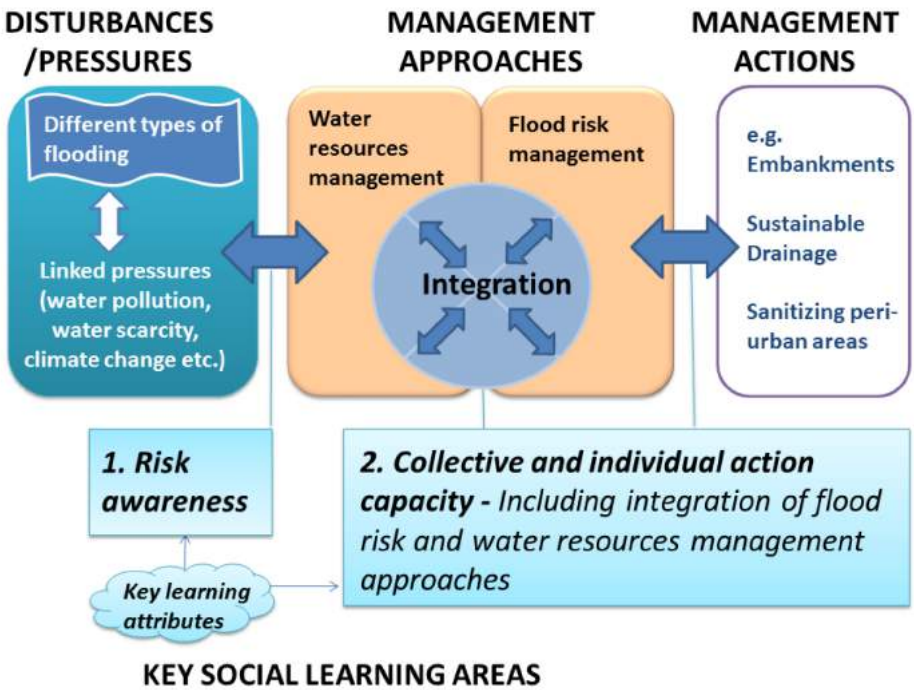


**Figure 7: Framework for the relationship between learning areas, disturbances, management approaches and actions. The two learning areas are characterized by key attributes.**

The following factors were found to influence (support or inhibit) the two key social learning areas of risk awareness/ perception and action capacity.

***Risk awareness/ perception***

*Risk awareness* is both a supporting and inhibiting factor for the learning area of risk awareness/ perception. For example, municipal risk professionals initiated the process of social learning in Kristianstad (paper III). On the other hand, a lack of risk awareness was observed in Gorakhpur, which manifested in a lack of understanding of the importance of water and sanitation (figure 8; paper IV).

***Action capacity – Supporting factor***

*Knowledge building from different sectors and actors* is found a supporting factor for adaptive capacity. This is due to the negative evidence found in the case

studies of integrating e.g. ecosystem-based measures, but also from the role of different actors coming together to exchange knowledge and learn (figure 8; papers I, III and IV).

***Action capacity – Inhibiting factors***

*Economic power dominating development priorities* is identified as an inhibiting factor for action capacity in three case studies. For example, in Durban, many decision-makers were aware of the unsanitary conditions and the toxic environment in informal areas. However, there was little change because polluting industries were seen as important to the economy (figure 8; paper IV).

*Governance challenges and lack of resources* are found to inhibit action capacity. In Durban, challenges included a resistance to collaboration between different sectors and thus learning, exacerbated by a lack of both financial and human resources within departments (figure 8; paper IV).

*Focus on conventional solutions/ lack of innovation* is another inhibiting factor. It often manifested as a focus on technological fixes, rather than, for example, water retention to increase infiltration (Cebu and Gorakhpur) (figure 8; paper IV).

***Generic supporting factors***

*(Risk of) extreme events* is a supporting factor for both risk awareness/ perception and action capacity (paper IV). Here, the findings point to the importance of existing knowledge (e.g. embankment instability) as a trigger for action (e.g. strengthening embankments) in response to extreme events (paper III). In risk management, the importance of crises in driving innovation has been established. For example, the extreme 1953 flood in the Netherlands helped trigger a different flood risk paradigm (figure 8; Huntjens et al. 2012).

*Effective communication and trust* is found to support risk awareness/ perception and action capacity. When formal avenues were (too) corrupt, informal spaces became important avenues for effective communication and trust. For example, in Cali, the best communication was found in informal networks, characterized by trust and reciprocity, which were perceived to speed up exchanges and provide more substantial information (paper IV). Trust is also found to be key to social learning processes (paper IV). For example, in Kristianstad, it was driven by a small group of risk professionals, and good inter-personal communication was seen as essential for progress. A key aspect, stressed by interviewees (in paper I), was to have an open mind to learning, for example playing their own devil's

advocate, and allowing a diversity of viewpoints in their discussions (figure 8; paper III).

*Individual leaders/ champions or other catalytic actors* (organizations) are found to support risk awareness/ perception and action capacity (all cases). These independent actors were often catalysts in learning processes. Some held formal roles, while others worked more informally (figure 8; papers II, III and IV).

### *Generic inhibiting factors*

*Corruption, (political) misuse of power and prestige* are found to inhibit both risk awareness/ perception and action capacity. In Cali, corruption and "political maneuvering" had, for instance, created considerable distrust in interactions with formal governmental institutions (figure 8; paper IV).

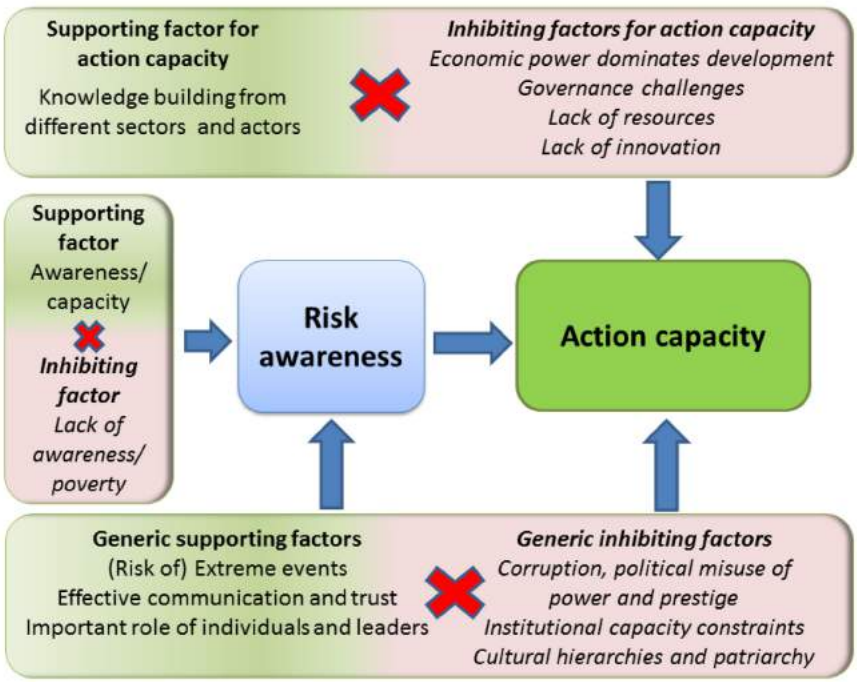


**Figure 8: Supporting and inhibiting factors of risk awareness/ perception and action capacity.**

*Capacity constraints* (institutional capacity) are found to inhibit both risk awareness/ perception and action capacity. For example, in Gorakhpur there was a lack of accountability, inefficiency and poor visionary thinking of the local administration. A stated reason was the frequent transfer of government officials (figure 8).

*Cultural hierarchies and patriarchy* are inhibiting factors for both risk awareness/ perception and action capacity. For example, in the Durban case study, cultural (and tribal) hierarchies and patriarchy, limited individual initiatives and action (paper IV). Here, the hierarchy represented differences in privilege, influence and control of power (Pratto et al. 2013). Similarly, patriarchy is a socio-cultural phenomenon where women are seen as inferior to men in both the public and private spheres of life (National Gender Policy Framework 2003). As such, it particularly limits women's action capacity through restrictions on their human rights, equality, economic empowerment, decision-making, etc. (ibid; figure 8).

### 4.3.4 Managing uncertainty

Managing uncertainty is found to be an integral part of the social learning process, and the crossing of thresholds (box 4 in figure 5). For example, reducing uncertainty is found to support action capacity and lead to crossing of this threshold. It included win-wins that increased the effectiveness of daily operations and, at the same time, ensured that key functions could be replaced during hazard events (paper II). It was often the case that there were few human and financial resources available to manage circumstances beyond 'normal' hazard uncertainty, seen in the inability to grasp all possible risk scenarios, including "black swan events" (paper II; Taleb 2010).

### 4.3.5 Reorganization and measures

The final element in the transition to more resilient urban water services is identified as reorganization and needed measures (box 6 in figure 5). Transition through reorganization often met initial resistance, consistent with single and double learning loops (described in section 4.3.2). For example, professionals were skeptical about the need to include environmental considerations (paper II). In practice, reorganization took the form of renewal of peer-to-peer collaboration, operational changes to corrupt entities that consequently collapsed, and policy and practice changes following disasters and epidemics. Associated measures were important in guiding the reorganization in a sustainable direction. For example,

accountability mechanisms opened up routes for social learning to be able to achieve transparency and combat corruption (paper II).

Paper V focuses on Public Private Partnerships (PPP), as it is argued that this form of collaboration has several benefits for urban water services. First, it enables the private sector to invest in public urban infrastructure projects that lack funding (Koppenjan and Enserink 2009). Second, it is argued that the private sector can provide a certain "strategic innovative capacity" because of its direct relationship with consumers that supports a deep understanding of their needs and priorities (Markides 1997; UNISDR 2015). In business theory, strategic solutions (put in place by strategic innovators) refers to doing something genuinely different that customers like and reward, and where accepted industry assumptions about how to compete are challenged and overturned (Styles and Goddard 2004). Thus, collaborative arrangements such as PPPs, which arguably stimulate strategic innovative capacity, are highly relevant. Several beneficial tools were identified in this context: cost-benefit analyses and Strategic Environmental Assessments (SEAs); re-evaluating the underlying development paradigm if there is a dominance of structural or "safe-fail" approaches (also called "robust" design); and organizational and corporate accountability. (These are described more detail in paper V.)

**Table 3: Key outcomes of the papers.**

| PAPER TITLE | KEY OUTCOMES |
|---|---|
| **Paper I:**<br>Integrating flood risk, river basin management and adaptive management – gaps, barriers and opportunities illustrated with a case study from Kristianstad, Sweden | Gaps and barriers:<br>• Lack of integration between local flood risk management and other relevant areas, a separation which is also reflected at national level.<br>• The municipal flood strategy did not include ecosystem-based measures<br>• The planning for flood risk is done in the municipality, while planning for water resources is done at the river basin level.<br>• Flood risk is informed mainly by technical exertise and lacks guidance regarding alternative options and an incusive appraoch to stakeholder engagement.<br>Opportunities for adaptive governance:<br>Through synergies between the Flood Directive (2007) and Water Framework Directive promoting river basin planning, and enabling actions by national agencies such as MSB and SwAM. |
| **Paper II:**<br>What does resilience mean for urban water services? | The paper identified:<br>• Three levels of resilience.<br>• The role of human agency as a driver of transition processes.<br>• Two thresholds: risk awareness/ perception and capacity for action to implement measures and reorganize in response to risks.<br>• Social learning at social-ecological resilience level was lacking. |
| **Paper III:**<br>Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden | • Evidence of a learning process was found, but did not manage to change the prevailing paradigm, due to the focus on structural measures and the stationarity principle.<br>• Role of individuals as triggers and drivers of a bottom-up social learning process.<br>• Lack of adequate governance arrangements and how they can influence social learning outcomes |
| **Paper IV:**<br>Social learning for resilient urban water services: the case of floods | • Action capacity was triggered by extreme events and less by environmental risks.<br>• Horizontal and vertical integration in governance (and knowledge building) was lacking with implications for adaptive actions.<br>• Need for an increased focus on “softer” capacities was identified, as it supported or inhibited social learning (e.g. trust/distrust). |
| **Paper V:**<br>Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: The role of public private partnerships | Three key strategies were identified:<br>• Cost-benefit analysis and strategic environmental assessments (SEAs) to inform investments.<br>• Reevaluate the underlying paradigm for development – steering directions and investments.<br>• Organizational and corporate accountability as rights-based approaches. |

# 5 Discussion

This chapter discusses the main contributions of this thesis and its implications in light of other literature. Section 5.1 highlights the role of social learning in raising awareness of the different applied paradigms and influencing the overall governance approach and thus the social learning outcomes. Section 5.1 is thus most relevant to policymakers at national and regional level, who can influence and create such governance. Section 5.2 highlights the approaches, strategies and mechanisms that influence the sustainability of social learning outcomes (Pahl-Wostl et al. 2008). Some relate to bottom-up social learning processes, and are therefore mainly relevant to urban water practitioners (section 5.2). Section 5.3 discusses insights related to the transition process in urban water services, and some novel aspects: non-linearity (thresholds), resistance to change, and strategic agency (Brown et al. 2009). These insights are not only relevant to transition and social learning theory development, but could also guide implementation by policy-makers and practitioners. Section 5.4 discusses the barriers to action and transition, related to social learning, which might help practitioners to overcome them (Kolmuss and Agyeman 2002). Concerns have been raised about the usefulness of resilience theory in the context of climate and social science (e.g., Klein et al. 2003; Olsson et al. 2015), and sections 5.1-5.4 illustrate how its application to urban water services can be useful (or not). Section 5.5 identifies areas for future research.

## 5.1 Two development trajectories – the influence of paradigms and higher-level governance

One conclusion that emerges from this thesis is that there are two main development trajectories that are shaped by different paradigms and higher-level governance structures. One is 'business as usual', where the focus remains on structural solutions to flood risk management; the other is integration with water resources management and the application of some of its approaches. While the first may lead to the "control paradox" (Remmelzwaal and Vroon 2000), the second needs to overcome "organized irresponsibility" (Matten 2004), two concepts that are described below. The ambiguity of the resilience concept

supports either trajectory, depending on whether it is associated with (only) rapid onset, or (a broader set of) slow-to-rapid onset disturbances. Social learning plays a role in: 1) becoming aware of these two trajectories and their different scenarios (i.e. risk awareness); and 2) influencing the overall trajectory through shaping governance frameworks (i.e. action capacity). These issues are described in sections 5.1.1–5.1.3.

### 5.1.1 Avoiding the control paradox – if, how and when?

The case studies confirm a low level of integration between flood risk and water resources management, although examples do exist where such integration is being promoted. Even in Sweden, with its (arguably) advanced level of progress in ecological governance (Lundqvist 2013), the current flood risk management trajectory is oriented towards more control. This is similar to the situation in the Netherlands, before they experienced the *"control paradox",* where more control, in the form of flood protection systems, paradoxically led to more flooding (Remmelzwaal and Vroon 2000). The control paradox illustrates a breaking point, where control is no longer an option, and more buffer capacity needs to be created. The Netherlands adopted a "living with water" approach, with *"fail-safe" (failing is safe)* systems that favors flood preparedness, non-structural mitigation and urban design, rather than focusing simply on flood protection (Huntjens et al. 2012; paper V; Milly et al. 2008). For example, ecosystem-based measures might not provide 100% flood protection, on the other hand, this might not be entirely essential if there is sufficient preparedness. Such design is found to some extent in, in for example the United Kingdom (Alexander et al. 2016) and Germany (Nickel et al. 2014), and are promoted for example by the European Union (EU 2012), the European Environment Agency (Vanneuville et al. 2016) and the World Bank (World Bank 2014).

By treating water as a structural element (Pahl-Wostl et al. 2011) the strategy of "living with water" inherently adopts nature's strategies, and can be compared to biomimicry (or a modified version of "hydro-mimicry"), a domain that offers many interesting ideas relevant to future flood risk management (Biomimicry Institute 2017). In Kristianstad, the only example is a newly-built wetland visitor centre "Naturrum"[47]: the centre stands on stilts in the Helge river and is designed to raise awareness of wetland issues (paper I)[48]. It has already made a significant

47 Although there is one area of Kristianstad (Österäng) that is provided with sustainable stormwater drainage, it is located in an old lake, and not designed to "live with flooding" should the embankment break.

48 It can be imagined that, instead of building embankments, Kristianstad could have allowed floodwater to enter the town. New canals, housing and other constructions could have been

contribution to the local economy: in 2016 an estimated 31 million SEK[49] were generated from tourists who came to Kristianstad with the main aim to visit the centre (Rokotova 2016). However, this demonstrates current thinking in the local water resource and ecosystem management community, which does not necessarily reflect current urban risk paradigms.

An interesting observation, in this context, is that since its inception in 1996 (continuing up to 2010), Sweden has been one of the three largest donors to the Global Water Partnership (GWP) (IEG 2010). The GWP supports the concept of Integrated Water Resources Management (IWRM), including flood risk management. However, the Swedish case study revealed that the stationarity principle continues to dominate (Milly et al. 2008), which is inconsistent with IWRM principles (papers I and III). The insights from this thesis are therefore also highly relevant to Swedish policy, legislation and initiatives at national level.

The question is if, how and when countries should adopt such flood risk management approaches and avoid the control paradox? A high level of investment in urban infrastructure is anticipated, especially in lower-middle-income countries and fast-growing urban economies such as China, India and Nigeria (UN 2014). Changing economic and demographic trends will create a great need for new infrastructure (ibid) and therefore these questions are very relevant both for national policy, and others such as investors, developers and regional development banks. What lessons can be learned from countries like the Netherlands, which have experienced the control paradox? Do countries need to experience this situation first hand, to be able to rethink and then retrofit, or can lessons already be drawn to inform more proactive approaches? A major issue is, of course, whether there is sufficient specialized capacity and knowledge of policy, planning and design; in this thesis concluded as one of the key competencies for transition in urban water services (section 5.3.1).

### 5.1.2 Top-down strategies for a more integrated paradigm

The evidence from this thesis suggests that higher-level frameworks, central guidance and coordination have an important role to play in developing an integrated paradigm. Horizontal integration between sectors and associated disciplines was found overall to be inhibited by the lack of a higher-level

designed to withstand occasional high water, with the added value that that novelty could attract tourists. However, this would have required a different kind of thinking and a shift in the development paradigm – in other words, a very concerted social learning effort.

49 31 million SEK – (Swedish Krona) was in 2016 on average 3.1 million EUR (Euro)

governance framework. For example, in Kristianstad, the municipality had the initiative for flood risk planning and implementation, which contributed to the focus on local and structural solutions (papers I and III). The lack of river basin planning was not only confined to flood risk management, but also water resources management, with implications for sustainability. For example, in Cebu, inadequate governance capacity at regional level led to an inability to control and enforce local groundwater usage (paper II). This need for vertical coordination is confirmed by a study in Uganda, which showed that water supply governance systems were unable to reach sustainable levels without a higher-level governance framework (Knipschild 2016).

Plummer et al. (2017) found that stakeholders perceive that there are many ways to govern flood risk management and decision-making. However, a river basin unit with cross-scale coordination, is argued by many experts to ensure attention to social-ecological resilience and ecological governance, even though it is very large (e.g., Lebel et al. 2005; Lundqvist 2013; Nickel et al. 2014). At regional level, governance reform is instead being promoted, for example in Europe, with the EU Flood Directive (European Union 2007), and its links to the Water Framework Directive (European Union 2000). This requires river basin management of flood risk, and thus, eventually, a change in water policy and practice in Sweden and other European countries. The question remains, however what active initiative the relevant national agencies will take in creating incentives for integration? This thesis provides some examples: adapting the governance system to reflect river basins, encouraging new development paradigms, revising governance (e.g. legal provisions, institutional arrangements and planning frameworks), and providing systematic advice on the broad variety of options available.

Looking at the Swedish progress in this regard, the results of this thesis show no signs of a major, national initiative to reform governance, despite official recommendations and initiatives[50]. One reason may be the importance of decentralization (papers I and III), which places responsibility for flood risk planning at local level (Levin 2009). The consequent lack of central coordination and guidance implies that initiating integration is going to be challenging, and is evidence of what Ulrich Beck calls “organized irresponsibility”, where risks and responsibilities are delegated to fairly open political processes in society (Matten 2004). In the longer term, current thinking about decentralization might have to be

50 For example, more-integrated flood risk approaches were promoted in a 2014 Swedish Government Investigation into sustainable use of land and water (SOU: 2014:50). Consultations on climate adaptation were carried out with municipalities in Scania, which highlighted the need to improve coordination in river basins (Ehrnstén et al. 2014). At the same time, at NGO and county administration level, tools and approaches are emerging that promote an integrated agenda (e.g. Svenskt Vatten 2011; Wihlborg et al. 2017).

adapted to include more central guidance and coordination regarding common adaptation issues (papers I, III and IV).

### 5.1.3 The resilience concept – supporting both development trajectories

The results of this thesis imply that the concept of resilience can be applied in the context of both a paradigm of increased control, and increased integration. The traditional interpretation of resilience in the context of flood risk management associates it with rapid-onset disturbances, such as an extreme flood (UNISDR 2007; Samuels and Gouldby 2009). As mentioned above, this implies the implementation of the stationarity principle, notably structural flood defenses (Nyberg 2008; Sayers et al. 2015). However, the evidence presented here also associates resilience with a wider range of disturbances, including socio-economic, rapid-onset climate hazards to slow disturbances in the social-ecological system (e.g. degrading water resources). This is in line with a growing understanding of disaster risk reduction that seeks to address multiple hazards and underlying risks (Eriksen et al. 2014; Wamsler 2014; UN General Assembly 2015a; OECD 2014). It is also consistent with the debate on the water crisis, which includes, for example, both rapid-onset disturbances (such as flooding) and slower disturbances (such as water scarcity and pollution) (World Economic Forum 2015, 2017). Such interpretations promote the application of the resilience concept in ways that address concerns about larger social-ecological systems (Folke et al. 2010). This is in line with the "living with floods" approach providing an alternative to flood control (Vanneuville et al. 2016; World Bank 2014).

However, this implicit ambiguity in the resilience concept contributes to confusion (Olsson et al. 2015). In this thesis, interviewees applied the concept to many types of disturbances and systems without differentiating them. This lack of distinction could also contribute to resilience trade-offs and maintaining imbalances, if one level of resilience is promoted at the expense of another, without it being made explicit (paper II). Thus, consideration needs to be given to all levels of resilience, which requires social learning. Arguably, the resulting (risk) awareness is critical to understanding the imperative to implement adequate governance frameworks (section 5.1.2).

These three levels of resilience, and the need to balance them, are related to the ongoing debate on multi-level adaptive governance (e.g. Chaffin et al. 2014). This approach to governance has been argued to address uncertainty in complex social-ecological systems. Furthermore, it is known to support "balanced" learning across multiple levels (Chaffin et al. 2014; Folke et al. 2005; Medema et al. 2014), offering many insights that are relevant for both the Sustainable Development

Goals and the Sendai Framework for Disaster Risk Reduction. However, relying on such capacities is easier said than done, especially as active institutions are often confined to four-year election cycles and 2–5 year planning horizons (Pahl et al. 2014), which in terms of social-ecological systems may be far too little (Lee 1993).

## 5.2 Building resilience in sustainable directions – multi-level adaptive approaches

This section highlights the multi-level and adaptive approaches, strategies and mechanisms that can influence the building of resilience in sustainable directions. It relates to the ongoing debate about the role of social learning as sustainability learning (Pahl-Wostl et al. 2008). Section 5.1 identified that profound changes in higher-level governance arrangements are required to change the development trajectory. Here, the discussion is broadened to include social learning processes and actions that influence the development trajectory from the bottom-up, issues that are relevant for both urban risk and development practitioners.

Sustainable learning implies that social learning has sustainable outcomes (Pahl-Wostl et al. 2008). However, the evidence from this thesis illustrates that without certain supporting factors, social learning processes designed to build resilience may not turn out to be sustainable. This result is supported by other scholars (Chelleri et al. 2015). However, in general, the social learning process has been found to increase integration and overall levels of knowledge, which in itself is beneficial for sustainable development (and supports Pahl-Wostl et al. 2008).

### 5.2.1 Factors underlying sustainable change

If the goal is to build resilience, this thesis suggests that more attention needs to be paid to the factors underlying sustainable change (papers II and IV). These factors were identified for the three levels of resilience (discussed in section 5.1.3).

In the case of *socio-economic resilience*, enabling factors are essentially interventions that improve capacities, such as knowledge and science–policy integration, and are linked to people's investment logic and motivations through inclusive micro-governance structures (papers II and IV). This is in line with the identified challenges for integration related to available knowledge, capacity and resources. Sustainability research has identified that understanding these factors is crucial for change (Partzsch 2015). Other scholars argue that knowledge and

capacity development requires an appropriate environment and the proper mix of opportunities and incentives to apply the acquired knowledge (Alaerts and Kaspersma 2009). The findings of this thesis thus indicate the need to articulate the role of agency-related factors in transitions, and their supporting environment (see the discussion on strategic agency in section 5.3.2 below).

For *hazard resilience,* sustainable development is influenced by the human (lack of) capacity to navigate uncertainty. In general, solutions that involved little uncertainty were preferred, rather than seeking the most sustainable alternative. For example, win-wins with socio-economic gains were favored (paper II). Human decision-making under uncertainty has been shown to be anything but rational. For example, one study has shown how risk aversion in humans is related to the stochastic nature of reproductive risk[51], which suggests that it is a primitive feature belonging to all organisms (Zhang et al. 2014). Even from the perspective of cognitive psychology, there is a significant risk of severe error in predictions and judgments made under uncertainty, because of the need to rely on a limited number of "heuristics"[52] (e.g. Tversky and Kahneman 1974). Thus, the findings indicate that reducing (perceived) uncertainty could encourage sustainable choices.

*Social-ecological resilience* is seen supported by social learning across scales and sectors (especially involving the environmental sector) and over the long term. This was difficult to achieve as there were few such supporting factors in the case studies (all papers). This confirms the many accounts of a lack of action in climate change adaptation and ecosystem management overall, and especially in low- and middle-income countries (IPCC 2012a; Lee 1993). Furthermore, it indicates an area where social learning efforts are especially needed. As discussed in section 5.1.3, one way to support efforts to navigate uncertainty in large-scale Complex Adaptive Systems (CAS) is to build adaptive governance capacity (e.g. Carpenter et al. 2012; Ostrom 1990).

### 5.2.2 Three strategies for social-ecological resilience

Three strategies are identified to improve social-ecological resilience with implications for sustainability (paper V). The first has already been mentioned above (re-evaluate the development paradigm, e.g. stationarity principle or "living

[51] *Reproductive risk* refers to risks to the reproductive systems of adult men and women, and the outcome of pregnancies (Connor et al. 2014).

52 A *heuristic* is any guiding principle that reduces information about probabilities and values to simpler models, and thus speeds up the process of, for example, problem solving, learning, or forming a judgment (Tversky and Kahneman 1974).

with floods"). The others include cost-benefit analyses and Strategic Environmental Assessments (SEAs) that provide tools to potentially change the way society looks at investments (paper V). For example, not investing in the environment can create risks, which need to be taken into account (Wegner and Pascual 2011). SEAs are a key instrument in informing the Flood Risk Management Strategies required by the EU Flood Directive (SEPA 2015). In Kristianstad, the choice of embankments as a flood risk strategy could have benefited from a more thorough assessment of ecosystem-based alternatives (paper I). Other strategies include organizational and corporate accountability (paper V), making up a rights-based approach to flood management that considers how well (or inadequately) at-risk populations are served by current laws, policies and institutions (Newborne 2008). In many cases where social-ecological resilience is being eroded, it is often the poor and vulnerable that are most at risk (Wamsler 2014; IPCC 2007; 2012a).

## 5.3 Transitions in urban water services

This section discusses the contribution of novel concepts to transitions in urban water services (Brown et al 2009): non-linearity (thresholds), resistance to change and strategic agency. These insights could help policy-makers and practitioners to action their chosen development trajectory. Insights into social learning have a role to play in facilitating the transition to whichever development trajectory is desired.

### 5.3.1 A social learning perspective on an urban transition model

Existing models of the evolution of urban water systems (arguably towards increased integration, sustainability and resilience) often imply a linear technological transition (Brown et al. 2009). In this thesis, associated concepts, such as thresholds and collapse/ reorganization take the focus off linear transitions (paper II). The notion of transitions as *non-linear* is not new, and is described by other scholars as involving context-dependent evolutionary processes with emergent properties (Geels and Schot 2007; Turnheim et al. 2015). However, the resilience perspective introduces *resistance to change* as a natural part of a social learning process. A conclusion is that actively facilitating reorganization processes around thresholds could help trigger and overcome such resistance (papers I–IV). For example, in Kristianstad, questioning an established position (there is no flood risk) met with initial resistance, but this was eventually overcome when this was sufficiently challenged (paper III). Flvbjerg (2012: 100) describes a similar

concept, termed “fault lines” that addresses “tension points”, which Foucault (1998) argues opens up opportunities for transformation. These fault lines could facilitate social learning and reorganization around thresholds when: “even a small change, may tip the scales and trigger change” (Flyvbjerg 2012: 100). This implies a greater role for strategic thinking in order to find such mechanisms, which trigger change and transition, sometimes in step changes.

This thesis suggests that mechanisms, which trigger change processes are found, for example, in micro-governance structures (paper IV) related to water, sanitation and hygiene that often empower women (paper IV; section 5.3 below). Such insights are also relevant for climate change adaptation and risk management strategies (Carson et al. 2013) where women are, in many cases, more vulnerable than men, and have less access to economic resources (Enarson 2000). Such insights on strategic approaches are highly relevant for both the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction (UN 2015ab).

Applying a “resilience perspective” to transitions identified four *key competencies* needed to build resilient water services (paper IV) these are: 1) adaptive multi-level governance (discussed in section 5.2); 2) strategic agency (discussed below); 3) specialized capacity and knowledge (section 5.1.1); and 4) the power balance (section 5.4). If developed further, this could provide an alternative way of conceptualizing transitions towards water-sensitive, resilient urban areas (Brown et al. 2009).

### 5.3.2 Strategic agency

Non-linear transitions may be related to the role of *strategic agency* found in this thesis as a basic requirement for social learning, change and transition (papers III and IV). This included here individuals who have the vision and ability to influence a process through building trust, and supporting collaboration and integration. These individuals were found key to initiate and push a social learning process, initially focusing on improving established actions (single loop learning), and in the process experiencing unexpected outcomes outside the original frame of reference (double loop learning) (paper III). They are effective interpersonal communicators who can build trust by understanding other people’s perspectives, their openness, playing devil’s advocate, and allowing a diversity of viewpoints in their discussions. Trust is particularly important in the cases, often part of informal contexts (paper IV). Trust is a form of social capital and is often mentioned as a key factor in successful collaboration (Gray 1989; Ansell and Gash 2008; Leach and Sabatier 2005), social learning (Medema et al. 2014; Pahl-Wostl et al. 2007;

Olsson et al. 2006), and specifically in relation to leadership (Childs 2013; Olsson et al. 2004a). People tend to avoid free-riding when they trust that others will meet their obligations to the group (Scholz and Lubell 1998). Therefore, it has been identified as a condition that can enhance general resilience[53] (Carpenter et al. 2012).

In this thesis, strategic agency was supported when decision-makers embraced bottom-up initiatives (paper III). This, combined with strategic agency, appears to be critical in the light of the water crisis. Supporting and enabling strategic agency is in line with the call for increased collaboration based on new, multi-actor alliances and coalitions (World Economic Forum 2017).

## 5.4 Collective non-action from social learning (lack of transition)

An inherent assumption in social learning theory is that social learning and associated action will occur if the right elements are in place (Reed et al. 2010). However, as this section discusses, there are several identified challenges that relate, in particular, to the problem of moving from knowledge to action (Kolmuss and Agyeman 2002) or inertia in transitions (Turnheim et al. 2015). Why is social learning not more effective in triggering action? This question is discussed in the context of the different identified working cultures that apply different frames of thinking (Janis 1989; Dewulf 2013) and different powerful interests that block change (Foucault 1984). These insights increase our understanding of the barriers to action.

### 5.4.1 Social factors: enabling action and non-action

The findings show that thresholds for risk awareness/ perception and action capacity are socially constructed and depend on human perceptions and the social context. Socially-constructed thresholds are nothing new. Collective action theory sees the concept of thresholds as useful in, for example, understanding the diffusion of innovation, which is confirmed here (papers II and IV). Critical mass theory also discusses thresholds (Granovetter 1978; Oliver et al. 1985) in relation to the difficulty of mobilizing collective action in pursuit of collective goods (Olson 1965), greatly influenced by group psychology (Granovetter 1978).

53 *General resilience* is resilience to all kinds of shocks and disturbances (Carpenter et al. 2012).

Although not breaking any new ground, the findings may give some added insights on some of the reasons for observed "collective non-action" in many of the case studies (paper IV). For example, the findings related to slow stressors and their lack of action illustrates the difficulty of moving from knowledge to action when the risk is known (Kolmuss and Agyeman 2002). But why does social learning not lead to more widespread action? One explanation given by Shove (2010) is that the implementation of social change is challenging. This is supported by Barrett (2004) who emphasizes that implementation processes can have outcomes that are very different to those intended. It could also reflect societal time lags between the emergence of scientific evidence and regulatory responses (the "wait and see strategy" outlined by Sterman and Booth Sweeney, 2007). This thesis provides two additional explanations related to working cultures and power structures which will be discussed below.

### 5.4.2 Different working cultures – overcoming the barrier to action

But why is social change so challenging? The results presented here indicate that collective non-action is also due to the different working cultures and associated institutional structures and mechanisms between the flood risk and water resources communities (papers I, III and IV). The frames, or ways of thinking, found in different working cultures have previously been identified as powerful barriers to learning and action (Dewulf 2013; Gersonius et al. 2016) and resemble "groupthink" (Janis 1989). One explanation in line with the findings of this thesis, may be perceived "competitiveness" of different working cultures i.e. to delivering comparable, sector-level results, such as effective protection and ease of implementation (Vanneuville et al. 2016). For example, ecosystem-based measures were not seen by practitioners in Kristianstad as competing with embankments. However, this finding needs to be put in perspective. Different working cultures, part of sectors or silos, are a fundamental prerequisite for functional specialization and technical capacity (World Bank 2011). At the same time, they are a known reform challenge to coordination and integration in the development and private sectors (World Bank 2011; AME 1988). Thus, the question is how to integrate specialist expertise from different silos, without losing the benefits of specialization and technical expertise? The "+plus approach" (Butterworth et al. 2011b; section 2.3) may be one way to integrate ecosystem-based knowledge through regulations, policies, tools and experiences available at national and international levels. Examples of such tools and experiences etc. can be found in Kling (2010), the Economics of Ecosystems and Biodiversity (TEEB

2010), the research parts of Horizon 2020[54] that include Nature Based Solutions (EC 2017), and the European Natural Retention Measures platform (NWRM)[55].

My results indicate that different working cultures is a challenge to knowledge integration, and that social learning has an important role to play to create shared understanding and action to widen mandates. Two challenges are conceived where actors from different working cultures can either be unaware they are framing issues in a particular way, or, they can also contest other's frames, without entering into dialogue (Dewulf 2013). In this thesis, actors seem to be unaware of their position in relation to other frames. This is seen, for example, in unclear references to the three levels of resilience, and blindness to the incompatibilities between water resources and flood management. Social learning, together with insights from strategic agency also have an important role to play in widening mandates (discussed above). However, integration through collaboration also requires similar priorities between different issues (Vanneuville et al. 2016). A challenge is that flood risk or water resources management can be seen as less important than (other) socio-economic issues such as agriculture, housing or infrastructure (ibid), a phenomenon that was observed in several of the case studies (papers I, II and IV).

### 5.4.3 Powerful interests as barriers to action

The socialized nature of the thresholds identified in this thesis also means that the social learning process can be influenced by parties with particular interests (paper IV). For example, in this thesis, learning in hierarchical, corrupt and patriarchal environments was found to be challenging (paper IV). Here, outdated world views (e.g. the stationarity principle, Milly et al. 2008) can be kept alive if the alternatives are inconvenient for powerful interests (Foucault 1984). Because thresholds involve the manipulation of perceptions, powerful actors can block or disrupt change (paper IV; ibid). This may be linked to the erosion of social memory, weakening institutions, or socio-cultural practices (Berkes et al. 2003) and may lead to inertia, which in turn, hinders improved governance, to the detriment of marginalized and vulnerable groups. In this thesis, accountability and transparency mechanisms were identified as important ways to boost relevant action capacity in order to combat corruption, and mitigate powerful economic interests.

54 The Horizon 2020 EU Framework Programme for Research and Innovation identifies NBS as a priority area for investment.

55 More information about the European Natural Retention Measures platform can be found at: http://nwrm.eu/

## 5.5 Future research

This thesis investigated the role of social learning for resilience building in urban water services, and the different results are relevant for researchers, policy-makers and practitioners. Here, disaster events, or the risk of such events, was found to be an important trigger for action, similar to other studies (Huntjens et al. 2012). At the same time, there was a lack of action in terms of integration, and addressing of slow stressors to the water resources – even when these were substantial. Is it possible that we can take a proactive approach to the management of our natural resources (such as water) rather than waiting until we have degraded social-ecological resilience or arrived at a "control paradox"? This is, unfortunately, part of common questions in social-ecological systems and ecosystem management research (e.g. Lee 1993; MEA 2005; Ostrom 1990). The importance of taking a proactive approach to reduce risks is increasingly present also in the risk management community at the policy level (e.g. the Sendai Framework). The question is if, how and when should countries adopt more integrated flood risk management approaches and avoid the buildup of disaster prone societies? This question is highly relevant for urban planning and investments, concerned with risk and sustainability issues, to secure these investments.

Ecosystem-based measures, also part of a global development trajectory of the Sustainable Development Goals (United Nations 2015b), were found to be a missing link for more integrated management. It would therefore be interesting to investigate the following questions: How can ecosystem-based approaches be brought to the attention of policymakers and managers? What other ideas and inspiration could be discovered by applying ecosystem-based design or "hydro-mimicry"? How can we encourage flood risk management to be based on the resilience principles discussed in this thesis? What are the workable means to encourage social learning in risk management?

The findings related to the application of the concept of resilience, and the role of social learning could be explored further. For example, the existence of thresholds and related factors, which can influence collective action (or non-action), could be examined to identify more robust evidence, and support the development of associated theory. For example, an important threshold for collective action was found to be the capacity to take a political decision. Perhaps, this needs to be further looked into with regards to associated phenomena such as corruption, hierarchies, patriarchy and other power structures.

# 6 Conclusions

The overall aim of this thesis was to investigate the role of social learning for resilient urban water services (including drinking water, sanitation and drainage) in the light of the global water crisis. It provides several insights based on a number of case studies around the world.

- The case studies confirmed low levels of integration between flood risk and water resources management. There seems to be a long way to go before water agendas become integrated and we can avoid the *control paradox*. Social learning can help in raising awareness of the development trajectories and the paradigms that shape the development of urban water services.

- Lack of governance at river basin level (i.e. a lack of vertical integration), also challenge horizontal integration. This means that a lot of the need for integrative action sits with the regional and national level, to ensure better coordination across scales to balance the local planning focus. In terms of regional capacity, this need has already been partially addressed by, for example, the EU's Water Framework Directive (European Union 2000) and the Flood Directive (European Union 2007). Managing the synergies and integration between these two Directives might be the next important step in their actual implementation. At the same time, they cannot replace national initiatives – or capacities – designed to ensure the implementation of regional policies. Here, social learning has a role in shaping the governance frameworks.

- Resilience was identified as having three levels (including socio-economic, hazard and social-ecological). This relates the resilience concept to a broader range of disturbances, ranging from hazards such as flood risk, to slow stressors. As such, it can foster an understanding of a system design which can absorb a multitude of disturbances, and encourages a "living with floods" approach as an alternative to flood control. However, practitioners are referring to these resilience levels without being explicit or even conscious they are doing so. This lack of distinction can lead to confusion, conflict and trade-offs between the resilience levels. Social learning has a role to play in making the distinction between these levels explicit.

- If the goal is to build resilience, this thesis suggests that more attention must be paid to factors that support underlying sustainable change. *Social-ecological resilience* was identified as in need of most support, in the form of social learning across scales and sectors (especially involving the environmental sector) and over the long term. Relevant tools that support social learning strategies are: cost-benefit analyses and Strategic Environmental Assessments; re-evaluating the underlying development paradigm ("living with water"), and organizational and corporate accountability.

- The resilience concept provides a different perspective on transitions in urban water services, as agency focused and non-linear, unlike current, technology-based, linear models. Non-linearity is conceptualized as "thresholds" involving elements of resistance and reorganization. This implies that a backlash or failure should be seen as part of the social learning process, and appropriate tools and support could be made available to navigate them. Two types of thresholds (key social learning areas) were identified: risk awareness/ perception, and individual and collective action capacity, i.e. a certain level of capacity to act on the perceived risk. This thesis suggests that to actively facilitate change, thresholds should be identified that tip the occurrence of events, and several examples are identified.

- Rather than addressing the transition of urban water services in terms of a linear and techno- centric model, this thesis suggests that key competencies for transition could be used. These include: 1) adaptive multi-level governance; 2) strategic agency; 3) specialized capacity and knowledge; and 4) the balance of power.

- Strategic agency was identified as a fundamental element of social learning. It is represented by visionary individuals or champions who are effective communicators that build trust, and who support inter-personal/ institutional (formal) collaboration and integration. They are, in turn, enabled by leaders who embrace bottom-up initiatives. This calls for more attention to be given to such capacities and feedbacks.

- Collective non-action, which relates to the problem of moving from knowledge to action is particularly apparent in relation to slow stressors. This may reflect implementation difficulties and time lags, but it also appears to be influenced by different *working cultures* and *power structures*, which are identified in this thesis as barriers to learning and action for integration.

- The presence of different *working cultures* appears to be a challenge for integration and collective non-action through incompatibilities of current flood risk and water resources management. For example, flood risk management was found to base its decisions on technical expert opinion, focusing on local structural measures, rather than considering ecosystem based measures and applying participatory methods, as seen in water resources management. Here, social learning has an important role to play in widening mandates, combining the expertise of actors from different areas, and facilitating a dialogue designed to reframe collective understanding and support action.

- The learning process is sensitive to group behavior and social dynamics involving *power*, such as corruption, cultural and tribal hierarchies, and patriarchy. This may be detrimental to society in general, and marginalized and vulnerable groups in particular. Thus, social learning needs to be further looked into regarding its role in counteracting and balancing such interests by, for example, promoting empowerment and accountability mechanisms.

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# Appendices 1–5

## Appendix 1: Interview guideline for paper I

1) In your view, what is the role of the wetland in terms of flood buffer?

2) In your view, what is the role of the wetland in terms of nutrient retention services?

3) In your view, what is the most important strategic and long-term intervention to address these issues?

4) Do you know whether these interventions are being implemented? If not, why not? What are possible catalysts and barriers?

5) Who is responsible for these interventions?

# Appendix 2: Interview guideline for paper II

These questions were put to ten water professionals to help "translate" the concepts of resilience into a more practical understanding. Each interview question was introduced by referring to Walker & Salt (2012).

**1. How would you translate "self-organization" to WASH[56] systems?**
If a part of a system is changed most of the time the system can handle it by "self-organizing" i.e. absorbing the disturbance, reorganize, and perform in the way it did—retaining its identity. But sometimes the system can't cope with the change and begins behaving in some other (often undesirable) way.

**2. In this discussion, can you identify any "thresholds" and their interactions?**
Thresholds are the limits to how much a self-organizing system can be changed and still recover. Beyond those limits it functions differently because a critical feedback process has changed—it has a different identity.

**3. How could "adaptive cycles (across scales)" be translated to WASH (Water, Sanitation and Hygiene) systems?**
The behavior of self-organizing systems changes over time due to internal processes. Systems undergo a period of rapid growth as they exploit new opportunities and resources. However, over time, the availability of resources decreases, while connections are increasing. The system enters a phase of "conservation", which comes to an end in a collapse. Resources are lost, but it also opens the way for renewal and a new order rises, and enters back in a phase of rapid growth.

**4. How do you translate "scales are linked" to WASH systems?**
What happens at one scale can have a profound influence on what's happening at scales above it and the embedded scales below.

**5. Are there any "trade-offs" between the two complementary aspects of resilience: specified resilience and general resilience?**
Specified resilience is the resilience of a specified part of the system to a specific shock. General resilience is the capacity of a system that allows it to absorb disturbances of all kinds, including novel and unforeseen ones. Channeling all your efforts into one kind of resilience will reduce resilience in other ways.

56 Later the term "urban water services" was used, see section 3.2.

**6. How do you see "transformation" in WASH? How do you see the difference between "adapting and transformation"?**

Adaptability is the capacity of a social-ecological system to manage resilience—to avoid crossing thresholds, or to engineer a crossing to return to a desired regime, or to move thresholds to create a larger safe operating space. Transformability is the capacity of a system to become a different system.

**7. How do you see the "trade-offs between building resilience and not doing it?"**

Building resilience isn't free; it comes with both the direct costs of the actions you take and the indirect costs of opportunities lost. Enhancing the resilience of a system usually involves reducing efficiency, staying away from maximum yield states, maintaining reserves, and so forth.

# Appendix 3: Interview guideline for paper III

The questions were adapted to the role of the interviewee – some questions were tailored to find specific facts. This is an example of the interview with Anders Pålsson, from Kristianstad rescue service.
Follow-up questions were also specific to each interviewee and appear in *italics*.
Generic questions put to all interviewees appear in **boldface**.

**Background facts about the interviewee**

- How old are you?
- What is you educational /professional background?
- How did you choose this profession?
- What is your professional role?
- Who do you work with?

**History of Kristianstad**

- When the city bought the land that was formerly Nosaby Lake (Hammarsjögården), what were they thinking? Were they aware of the flood risk?
- When did they start construction in the old lake? I know they started building in 1921 in Vilan, so it must have been before that.
- *Have there been different views on the use of the embankment, as it was constructed initially for agriculture? But it was not possible to cultivate anything? Do you remember where you read about it?*

**Actors**

- Who were the actors when the rescue service took over [the mandate of risk from the county administration] in 1980? What was the process?
- What responsibility did the County Administration have? What about the municipality?
- *Then you started working more actively on the flood risk at the technical office and rescue service? Who was responsible for the security of the embankment? And this was 2002?*
- How did your [embankment] group start in the 90s?
- *And the risk group looked at the floods only? Who was involved in that?*
- *What made you gather and form this risk group?*
- *You said earlier that the floods were the most important triggering factor in the risk assessment; why did you carry out the assessment? How was it initiated? How did this insight grow? Through the floods?*
- Who did the exercises?
- How do you think the historical perspective plays a role?

- Who were the actors in the flood in 2002? What departments? *External actors? Were SMHI and DHI also involved?*
- Who is involved in the flood management today?
- What different perspectives do these people have?
- Do people come from different sectors, and are there any conflicts?
- Do you use the same language, do you understand each other when you discuss?
- How will this be managed in the future?
- The embankments are supposed to hold for 500 years, and if you look 500 years back in time…are there lessons learnt from that time (17th century) still in Kristianstad? Is 2000-year floods the worst scenario? *Including the sea level rise?*
- Why did you start using computer models as flood protection?
- Which other strategies have been discussed? Did you discuss upstream measures? What alternatives did you think of?
- Some people have suggested dredging, but this has not been an option, why?
- How did you get the assignment to strengthen the embankment? What advice do you give?
- And if it would have been effective to dredge you would have done that?

**Cooperation, social learning**

- What forms of cooperation have there been? Do you work as one group together or several groups.. or? *So, one can claim there are several small groups and different levels that cooperate?*
- Have the actors had any negative consequences from the process?
- But you deal mainly with the city, you don't meddle with the flood risk to farmers?
- Has everyone's interests been considered? Has this been a democratic process? Have there been several perspectives that have been considered?
- If we zoom in on the process, have you learnt anything? What?
- What has made the cooperation easier? *Have there been disturbances in this process? So, there were no big conflicts but a slow lobby? How were those conflicts solved? What were the critical elements? Where and when was this [risk assessment] presented? How far back in time did the assessment go? When they reacted to this, did the process then turn in your favor? They listened to you, but was there nobody who positioned themselves against?*
- What role has the Biosphere office played? Indirectly or directly? If there have been lessons learned, what were they? Has the value of the wetland increased in the eyes of rescue service?
- When was it decided that the wetland should not be touched? Who is responsible (for the embankments)?

- How did you get this ecosystem awareness? Through the newspapers? Did you have meetings with the Biosphere office? Who initiated these meetings? What did you talk about? When did the dialogue start? Have you had contact since then?
- Are there other views than the ones from the Biopshere office which have influenced your thinking?
- Who else do you have dialogue with?
- What role do *trust and confidence* in each other play? Are these meetings structured? Unstructured? So it is good to be a small group?
- If there is an atmosphere which enables that people share their views, what elements could this consist of?
- What is your *dialogue* with the public characterized by? Also a lack of prestige? Is this something typically Scanian?
- What institutions have been critical for this embankment project? Was it your conviction that something needed to be improved?
- Who were the others?
- Then you built on this cooperation and during the process made it more inclusive, using your platform at the rescue service, what happened next?
- Is there anyone else you have managed to turn from negative to positive?
- What is the role of enthusiasm and knowledge for learning? What knowledge did you use? Scientific, experience? Empathy?
- In the future, how will you manage this uncertainty now in Kristianstad? Will the rescue service deal with the surprises?

**Ecosystem-based measures**

- Will you discuss upstream measures or other measures with the Biosphere office?
- Have you for example been considering increasing the number of wetlands or increasing meandering of water flows upstream?
- Has the role of the Biosphere office been slowing down the process, or is it because of Sven Erik Magnusson [the former Director of the Biopshere office] that you cooperate so well? His way of talking, his way of reaching consensus?
- For me as an ecologist it is a good example, because you consider the wetland at the same time as you build embankments; can one take that as an example?
- Can one claim that you who work in the municipality have a strong view that the wetland is something useful and good? How has the wetland become a priority?
- Was there something written about the urban development process in the 60s and 70s? It would be interesting to understand how they were thinking.

# Appendix 4: Interview guideline for papers II and IV (case studies)

The interview questions below were used by several case study investigators

**Purpose 1: To describe the interviewee**

- Which organization do you work for?
- What is your role within the organization?
- How long have you been in this role?
- What are your responsibilities with regards to the WASH system?
- What is your professional training (e.g., engineering, ecology, health, etc.)

**Purpose 2: To determine the vulnerability…….**

**2a: … of the WASH system**

- What are the causes of vulnerability in the WASH system that might lead to failure (e.g. in providing access to safe drinking water)?
- Which components of the WASH system are particularly vulnerable and why?
- How do you ensure the quality of the WASH system (e.g., through maintenance, repair, financing)?
- What are the solutions to address these factors?
- What are the barriers and opportunities to reduce vulnerability and build resilience?

**2b: … linked to hazards**

- How do hazards (floods and droughts) affect the vulnerability of the WASH system?
- Is the WASH system infrastructure placed in such a way to be able to cope with extreme (high and low) flows?
- Is the WASH system able to cope with other extreme conditions associated with floods and droughts?
- What are the solutions to address these factors?
- What are the barriers and opportunities to reduce vulnerability and build resilience?

**2c: … linked to urban planning and land use**

- How does urban planning and land use affect the vulnerability of the WASH system?
- What is the boundary of the WASH system for interventions to reduce vulnerability (e.g., administrative boundary)?
- What are the solutions to address these factors?

- What are the barriers and opportunities to reduce vulnerability and build resilience?
- What processes in the river basin/catchment/watershed (and perhaps even beyond that) affect the vulnerability of the WASH system?
- How do they affect the WASH systems downstream?
- How would you define the boundaries of the WASH system? (Coincide with the boundaries of the municipality? The river basin? Etc.)

**2d: … of the WASH system**

- Are there any other factors that influence the vulnerability of the WASH system we have not yet discussed?
- If yes, what are they?
- What are the solutions to address these factors?
- What are the barriers and opportunities to reduce vulnerability and build resilience?
- What is the significance of different types of hazard events?
- How do slow onset hazards influence the WASH system (and its vulnerability and resilience)?
- How do rapid-onset hazards influence the WASH system (and its vulnerability and resilience)?
- Do they interact? If so, how?

**Purpose 3: To identify how the vulnerability of the WASH system can lead to social vulnerability**

- Which social groups are most vulnerable to failures of the WASH system (e.g., the elderly, the poor, women, children, etc.)?
- Why are these social groups particularly vulnerable?
- Which vulnerable social groups does your organization target?
- Why does your organization focus on reducing the vulnerability of these particular social groups?
- How can the vulnerability of these social groups be reduced?

**Purpose 4: To identify and assess the methodology in use for assessing risks and vulnerabilities**

- How is risk to the WASH system assessed?
- Who carries out the risk assessment? How does this influence the nature and outcome of the risk assessment?
- In your view, what are the gaps in current risk assessments?
- Any conflicts in terms of administrative and environmental boundaries relating to the nature of water flows? For example, are there any administrative or temporal boundaries which you think are too narrow and needs expanding to fit the nature of water flows?

- How does governance (institutions involved, worldviews, frameworks, policies, administrative boundaries, etc.) affect the ability to conduct an integrated risk assessment, (i.e. which covers all the relevant risks)?
- How could it be improved? To provide a more comprehensive risk assessment?
- Has your organization changed the way in which it assesses risk and/or responds to those risks?

**Purpose 5: To determine the resilience of the WASH system**

- How do you define a resilient WASH system? (ability to anticipate, withstand shocks, recover and learn)
- Has your organization responded to/coped with hazard events in the past?
- If so, what were the key lessons learnt (for building resilience)?
- Can you describe how your organization improves resilience of the WASH system (considering both disaster preparedness and post-disaster relief and recovery? Microfinance /contingency fund?) See below.
- Would you say that current efforts focus more on disaster preparedness or response?
- Is there enough investment in preventive actions? Has this changed over time?
- How do you expect the system to change in the future under different scenarios?

**Purpose 6: To investigate collaboration and how the WASH system is managed/ governed (as part of resilience: learning, adaptation and self-organizing)**

- How do actors collaborate and coordinate their activities?
- What are the mechanisms for collaboration?
- How well does this collaboration work?
- What are the challenges (e.g., power relations, bottom-up vs top-down, participation, decentralized roles and responsibilities)?
- Should other actors be included? Which ones and why (see below)?
- Should other actors be included? Which ones and why (see below)?
- Does the current management/governance system sufficiently integrate the different sectors (e.g., ecosystem management, urban planning, disaster risk reduction, climate change adaptation?)

**Purpose 7: To identify capacity of actors for social learning and evidence of such**

- How would you describe the capacity of your organization to reduce risks and vulnerabilities and to build resilience?
- What factors influence this capacity and how?

- Have you observed any changes in thinking/approaches/methods to reduce risk and build resilience in your organization? Can you give some examples?
- What social learning mechanisms between WASH actors enhance learning on appropriate adaptation options?
- What has led to the changes (in thinking/ approaches/ methods / capacity) you have described?
- What made the change you have described possible (see below)?
- How were the lessons for reducing risk and building resilience learnt (see below)?
- How were the lessons for reducing risk and building resilience learnt?

# Appendix 5: Interview guideline for paper V

These questions were put to three risk and water and sanitation professionals to help formulate the research strategy for paper V.

**Good urban planning for resilient urban areas**

- What characterizes good urban planning designed to minimize health risks using holistic, innovative, environmental and cost-effective approaches
- How can you manage the balance between emergency response and urban preparedness?

**Technology systems for resilient WASH services**

- What factors are important for these technologies' sustainability and resilience to extremes, and how are these factors interacting?
- How can you make emergency solutions beneficial for long term development?

**The link with ecosystem management in the river basin:**

- How can eco-management be beneficial to urban planning and WASH services?
- What type of governance is required for capitalizing on the ecosystem services?
- What mechanisms encourage stable social learning processes to adapt to extremes?

# Paper I

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# Integrating Flood Risk, River Basin Management and Adaptive Management: Gaps, Barriers and Opportunities, Illustrated by a Case Study from Kristianstad, Sweden

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The increasing risk of floods in Europe calls for a revision of current governance and management practices. Sweden has not yet experienced flood events of the magnitude seen in central Europe over the past few years; hence flood-risk management is low on its political agenda. This paper investigates the gaps, barriers and opportunities in implementation of flood risk reduction, which to be effective needs to be part of an adaptive river basin management framework. It analyses progress on the ground illustrated by a case study from Kristianstad, the most flood-exposed municipality in Sweden. We conducted a literature review, interviews, a regional workshop and a focus group discussion. The results show that structural flood-control measures dominate in the municipality, mainly due to the prevalence of sectoral approaches, which are reinforced at the national level. There is no integrated and holistic spatial planning model for flood risk management that takes water resources management and green infrastructure into account at the river basin scale. The local planning level therefore needs guidance on a broader set of measures to manage flood risk across sectors. Also, reliance on expert opinion needs to be complemented by strengthened stakeholder participation in the spatial planning process. Future opportunities include synergies between the EU Water Framework Directive and Flood Directive guided by national priorities.

**Keywords:** flood risk management, Sweden, nutrients, wetlands, spatial planning, adaptive river basin management

## 1. Introduction

Recent European floods illustrate the need to improve current approaches to water and land development and address the risks created by these approaches. Floods are not only caused by climate events; instead they are most often the result of long term and slow changes in land use, river modification, population increase, economic shifts and human activities in hazard–prone areas (Follner, Ehlert, & Neukirchen, 2010). For example, the floodplain of the Upper Rhine, has been reduced by 60 per cent, or 130 km$^2$ (BMU/UBA, 2010), removing ecosystems which provide important services and goods such as flood

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buffer capacities, clean drinking water, biodiversity, habitats and bathing water (European Union [EU], 2012). A recent estimate predicts that extreme floods are expected to increase in frequency in Europe. The average annual economic losses due to flooding are expected to be around €23.5 billion by 2050; over five times the annual amount for the period 2000 to 2012 (€4.2 billion). Around two thirds of these increases are attributed to socio-economic growth, with the remaining third due to climate change (Jongman et al., 2014).

Sweden is yet to experience dramatic flood events of the magnitude seen in central Europe, hence flood risk has so far been low on the political agenda, with the emphasis placed instead on efficient emergency and rescue procedures. This is in contrast to other European countries such as Austria, Belgium, England, France, Germany, Hungary, Italy and Poland that have experienced recent flood events and have placed this issue high on the political agenda, in particular spatial measures to mitigate floods (Fiselier & Oosterberg, 2004). However, in recent years, economic damage from flood events has significantly increased in Sweden (Svensk Försäkring, 2014), even causing costly flood damage in cities such as Malmö, which has not even been identified as one of the 18 most flood-exposed areas of Sweden (MSB, 2011). This situation has led insurance companies to put increasing pressure on politicians to act, and insurance companies consider Sweden to be lagging behind on tackling flood rise, and being less prepared for extreme weather than the other Nordic countries, such as Denmark (Dagens Nyheter [DN], 2014). There is no lack of information about the general threat. For example, Swedish governmental agencies involved with climate adaptation jointly point to the increasing flood risks posed by climate change (Klimatanpassningsportalen, 2013). Therefore one would expect measures to avoid flood disasters (or at least to mitigate the socio-economic damage associated with severe floods) to be a higher political priority in Sweden, and for decisions to be taken and choices made about appropriate management approaches.

Integrated and adaptive river basin management approaches have been put forward as a solution for handling complex water management issues. Such approaches have been developed from the realisation that water managers have to handle uncertainty, variation and change, and involve many different stakeholders in learning processes (Raadgever, Mostert, Kranz, Interwies, & Timmerman, 2008). At the level of European policy, integrated and adaptive approaches that address challenges of flood risk and water and environmental quality are provided by the European Water Framework Directive of 2000 (WFD), and the European Flood Directive of 2007 (FD), stressing among other things the important role of ‘green infrastructure’.

Via a case study of Kristianstad municipality, this study offers a critical insight into the gaps, barriers and opportunities in implementation of flood risk management within an adaptive river basin management framework. We investigated the use of wetlands as green infrastructure, and their perceived value and use to various stakeholders for flood and nutrient management. In Sweden, municipalities are responsible for flood-risk management. We therefore investigated progress on the ground from the perspective of Kristianstad municipality and its linked Helge river basin. Kristianstad is one of the 18 areas

that have been identified as the most flood-exposed in Sweden, and has the highest number of people at risk of all the areas (MSB, 2011). Because of the area's high exposure and risk, we assumed that flood-risk management approaches there would be among the most advanced in Sweden.

Below we describe the analytical framework, the local setting, and present the findings. In the discussion we put these findings into a Swedish context with reference to flood management approaches in Germany, the Netherlands, and the UK. We then highlight the gaps in governance in adaptive river basin management in Kristianstad, and the barriers and opportunities to achieving it. We also point to implications that this case study may have for Sweden as a whole.

## 2. The analytical framework

### *2.1. Flood-risk management*

Current literature suggests a risk-based approach to flood management aimed at reducing the overall flood risk to human life and assets (van Alphen & van Beek, 2006). In general, flood risk management focuses on three things: 1) flood control, aimed at preventing flooding with structural measures, e.g., embankments or detention areas; and 2) flood alleviation, aimed at reducing flood impacts by non-structural measures such as hazard zoning and flood-adapted spatial planning, flood-proofed buildings, development or upgrading of early warning systems, insurance, awareness campaigns in order to improve the preparedness of people at risk, training and putting rescue units on stand-by; and 3) flood abatement, aimed at preventing peak flows, e.g., by the improvement of the water retention capacities of the catchment (de Bruijn, 2005).

### *2.2. River basin management (and integrative elements)*

For flood-risk management to be effective, river basin management (RBM) has to be considered. RBM follows the water's natural flow by focusing on the river basin as a management unit. Within this geographical area, all water, via lakes and rivers, flows out to the sea. This understanding implies adjustments in planning, land use and behavioural change on the part of a range of actors who share the water resource. In addition to the water sector, diverse changes in forestry, urban planning, architecture, agriculture, infrastructure and landscape management are required (White & Howe, 2003). A central goal of integrated management of water resources (IWRM) at the river basin level is to achieve water security for all purposes, as well as manage risks while responding to, and mitigating, disasters (Medema, McIntosh, & Jeffrey, 2008). IWRM hence recognizes the intersection with water security issues. In turn this requires that people recognize their interdependence and engage in both collective action and the resolution of conflicts (Tippett, Searle, Pahl-Wostl, & Rees, 2005).

### *2.3. Adaptive management*

Adaptive management can more generally be defined as a systematic process for improving management policies and practices by learning from the outcomes of management strategies that have already been implemented (Pahl-Wostl et al., 2007). Adaptive management stems from the recognition that interactions between people and ecosystems are inherently unpredictable, that current knowledge will never be sufficient for future management and thus management needs to be adaptable to new information and changing circumstances (Raadgever et al., 2008).

In a river basin there may be a multitude of co-existing legitimate views and interests. Shifts in acceptance of what constitutes a legitimate practice, or policy, may be triggered by different events and shifting trends, such as new world views, new socio-economic realities and information, which open up learning for certain groups of stakeholders (Larsen, 2011). The kind of knowledge that is sought is therefore no longer focused on the need to simply have experts who 'know more' but rather multiple types of knowledge which enable robust decision making (Pahl-Wostl, Mostert, & Tabara, 2008). The learning is highly dependent on (participatory) processes that allow for a constant exchange of information and knowledge, and co-operation between sectors and levels (Huitema et al., 2009).

To enable adaptive management, the governance framework needs to allow for flexibility, thus meeting uncertainty and facilitating public participation and financial management (Raadgever et al., 2008). However, there appear to be a number of largely institutional reasons why the adaptive management framework has not been universally and successfully translated into practice (Medema et al., 2008). Current institutional settings are often too constrained to allow continuous improvement (Folke, Hahn, Olsson, & Norberg, 2005). There is also disagreement about what adaptive management can do, for example, whether it can support policy decisions even where there is a lack of sound scientific knowledge (Medema et al., 2008).

### *2.4. Adaptive river basin management*

In summary, we argue that to manage floods effectively several elements needs to be considered; the three aspects of flood risk management, the river-basin level and its integrative elements, and adaptive management, in all comprising adaptive river basin management (see Figure 1).

## 3. The setting

### *3.1. European context*

European policies in flood risk management are governed by the EU Flood Directive (FD) (EU, 2007) which stipulates that Member States should introduce a "*framework for the assessment and management of flood risks, aimed at the reduction of the adverse*

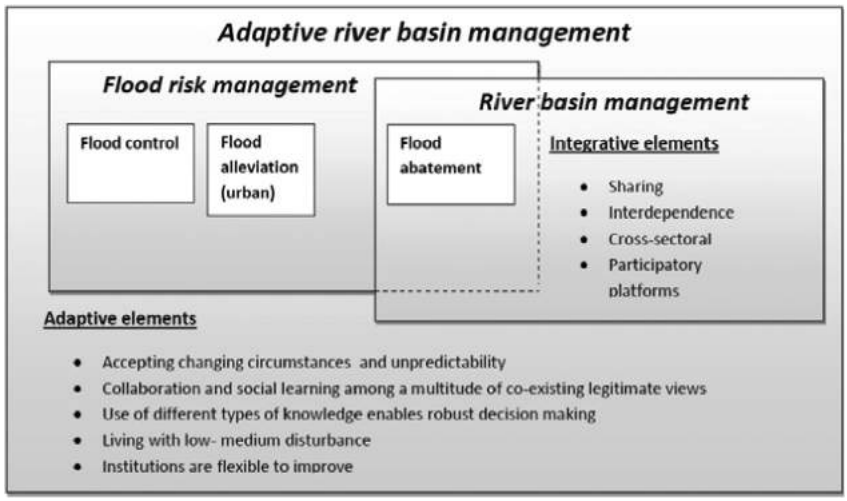


Figure 1. The analytical framework for this study: To be effective, flood risk reduction needs to be integrated with river basin management and have integrative and adaptive qualities.

*consequences for human health, the environment, cultural heritage an economic activity*" (EU, 2012). The EU Water Framework Directive (WFD) (EU, 2000), designed to act on the river basin scale, has several overlaps with the implementation of the FD and with Nature 2000 legislation. The WFD is the most important policy for sustainability in European water ecosystems, including their integration with land management and energy management. The WFD focuses mainly on water quality, but also addresses water quantity to the extent it affects quality (EU, 2012). The FD and WFD include provisions for adaptive management by encouraging learning and re-evaluating the strategy for future measures. It encourages the participation of all stakeholders at local and regional level (ibid). By December 2015 the FD requires that the Member States will produce catchment-based flood-risk management plans focusing on prevention, protection and preparedness, and which set out a prioritized set of measures. The plans should also be harmonized with the WFD river-basin management plans (ibid).

### *3.2. Swedish context*

Sweden is a highly decentralized country in which municipalities are solely responsible for protecting its citizens against flooding through planning the use of land and water within a legal framework. Every five years, comprehensive plans are developed for Swedish municipalities for current and long-term aims. These plans are not binding, but contain guidelines for the future development, approved in a participatory process. The more detailed physical development plans cover parts of Swedish municipalities and is binding (Nordregio, 2004).

The Swedish Civil Contingencies Agency (MSB) is responsible for coordinating the ongoing implementation of the FD in close cooperation with county administrations. The implementation will take place in three steps during the period 2009-2015. In the year 2000, the WFD was enacted at EU level and transposed to Swedish legislation, which was a large change in the Swedish water management system (Gooch & Baggett, 2013). The Swedish Agency for Marine and Water Management (SwAM) (under the Ministry of Environment) has the mandate to coordinate the implementation of the WFD. At the regional level, 21 County Administrative Boards are responsible for carrying out part of the work to implement both directives. Five of these County Administrative Boards are at the same time Water Authorities, which coordinate the work with implementing the WFD. Water management is carried out in a six-year cycle. Water Councils provide platforms for participation by stakeholders in river basins. Sweden has also created web-based tools for public participation: the Water Map and the Water information system Sweden data base (Weichelt, 2009).

### *3.3. Kristianstad case study*

Kristianstad has about 30,000 inhabitants in the inner city and 80,000 in the municipality as a whole. It is situated in the lower part of the Helge river basin with a catchment of 4725 km$^2$ (Kristianstad, n.d.) (Figure 2) and is part of the Southern Baltic Sea River

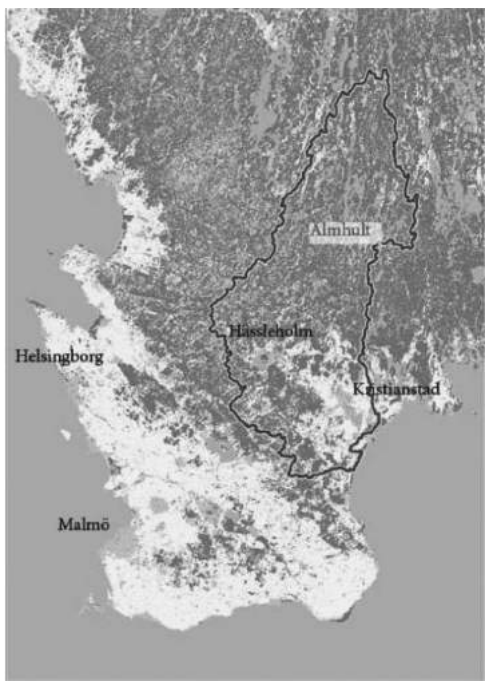


Figure 2. Map of Southern Sweden with the Helge river basin marked. The Municipality of Kristianstad is located at the lower end of the river basin. ©Lantmäteriet.

Basin District. The Helge river basin has forest in its upper reaches and mainly agriculture in the lower before it empties in the Baltic Sea. As a result of considerable physical land use changes there are issues of water quality where the majority of rivers and lakes are not expected to reach good ecological status in 2015 (Blekingekustens vattenvårdsförbund [BKVF], 2010). The Hammarlund embankment that protects parts of Kristianstad was built in 1868 (Friström, 2000) and has been challenged by floods on several occasions. The flooding is at the same time necessary for ecosystem dynamics, because it supports one of Sweden's largest areas (about 1600 ha) of 'wet grassland used for haymaking and grazing' (Naturvårdsverket, 2009), where many farmers have support from the EU Rural support programme to maintain the biodiversity. This landscape is part of the Kristianstad "Vattenrike" (Water Kingdom) which is listed by the Ramsar Convention, a UNESCO Man and Biosphere reserve and Natura 2000 (Olsson Folke, & Hahn, 2004).

## 4. Methodology

We carried out a literature review to complement the framing of the problem, and constructed an analytical framework. With the help of key informants and the analytical framework, a snowball sample (Bernard, 2002) was made of relevant stakeholders. We held semi-structured interviews between November 2011 and November 2013 with the aim of identifying stakeholders' perceptions on wetlands as green infrastructure. Complementary interviews with a few key expert people were carried out. We also refer to other interview material from research carried out in 2003. Interviews were held mostly over the phone, recorded and transcribed. Questions concerned perceptions of: 1) The role of the wetland as a flood buffer, 2) nutrient retention services, 3) the most important strategic and long-term intervention to address issues, 4) whether the former is being implemented? If not, why not? What are possible catalysts and barriers? and 5) who is responsible for such an intervention? A focus group discussion with five local policy and decision-makers reviewed the options for integrated and adaptive river management in local level planning. A workshop from 25–26th of September 2012 with a wide range of regional stakeholders (about 50 people) gave input into the findings. The information was then analyzed using the framework categorizing gaps and barriers, which were considered to be internal factors over which there is some measure of control, and opportunities, which were considered to be external factors over which there is essentially no control. The results were put in a Swedish context with reference to measures taken in Germany, The Netherlands and the UK.

## 5. Results

### *5.1. Flood control is the dominant approach to flood risk management*

Around 1995, Kristianstad started its own initiative to mitigate flood risk, successively building knowledge with the help of MSB and others. The focus in measures thus shifted from: 1) one embankment of 1 km to several embankments where flood risk was

identified from other directions and 2) a time perspective of 100-500 years to a longer time perspective of 10.000 years. The present construction of 10 km of embankments, pumping stations and stormwater drains are Sweden's most costly measures to meet the flood challenge in modern history (Johannessen & Hahn, 2012), with a projected cost of 500 million SEK in total, to be finalised in 2021 (Kristianstad, n.d.). Increasingly the focus is also on the coastal risks, with an ongoing and future coastal planning process (Kristianstads kommun, 2013).

### *5.2. Urban flood alleviation well developed for internal floods but not for external floods*

Two of the respondents from the city planning office consider stormwater management as a key solution to flood risk in the city. The local stormwater policy stresses the importance of infiltration and retention zones for rainwater, and such measures are showcased in some suburbs and a central park (C4 Teknik, 2010). While the policy is especially relevant for new developments it is perceived by local planners as difficult to retrofit stormwater solutions (Personal communication, city planning, March 2, 2012; and April 4, 2012).

However, there is scarce effort to reduce the impacts of an eventual flood from upstream areas. Instead, urban planners in Kristianstad trust the embankment security and are developing the central areas behind them. An early warning system exists, which was critical especially in 2002 (Johannessen & Hahn, 2012). But there have also been suggestions for developments in the flood risk areas by the urban planners. Risk experts both at national and local level have on such occasions engaged in dialogue with the urban planners to better include risk considerations, leading to learning by the planners in Kristianstad (personal communication MSB, Aug 2012 and Rescue service, May 25, 2012).

Prioritising development over risk has a long tradition, but risk considerations are slowly entering comprehensive planning. In the 1970s, 1300 apartments were built behind the embankment (Friström, 2000). The city planners knew about the flood risk but there was a dire need for land in the expanding city, and an extreme flood was considered "*improbable, perhaps once in 300 years*" (Personal communication, former city architect, Nov 13, 2003). Now, for example, it is mentioned in the current plan that new housing needs to be located in a non-risk zone, or adapted to cope with the flood risk, and revision of the risk levels needs to be done continuously (Kristianstads kommun, 2013). However, the only housing in Kristianstad which is built to be flood-proof (it is built on stilts) is the Naturrum museum, accessible by a footbridge. This was set up by the Biosphere office to create awareness of wetland issues (Personal communication, Biosphere office, Aug 23, 2012).

Over time, the risk issues have been better integrated with the other departments of the municipality (Johannessen & Hahn, 2012). However, our focus group discussion was the first time in this municipality that people from environmental, technical, strategic and spatial planning, and the rescue service all sat together to discuss flooding.

### 5.3. *Flood abatement in the river basin is not part of the flood risk management measures*

Some interviewees mentioned the importance of increasing retention times in the watershed to mitigate floods where wetlands, wet forests and bogs upstream were thought to be able to capture flood waters. However, these solutions were perceived as complex owing to issues of available land, financing mechanisms, legislation and political action (Personal communication, District Water Authority, April 2, 2012). A farmer mentioned the role of forest wetlands and drainage in relation to nutrient retention, and that although he thought farmers could do more, he also considered that the forestry sector had largely been exempted from implementing any measures (Personal communication farmer, April 2, 2012). The nutrient contribution from farming is still significantly higher (about 60% of N) than from forestry (about 12% total N) (Vattenmyndigheten, 2009). However, existing forest ditches constitute a significant source of 'dewatering' (Hånell, 1990), but one planner perceived that it is difficult to hold anyone accountable (Personal communication, District Water Authority, April 2, 2012).

In spite of views expressed in the interviews of the benefits of upstream flood abatement efforts, there is an absence of such measures. When the local rescue service and technical department at the Kristianstad municipality looked at alternatives to embankments, they made a basic assessment that upstream measures would not be sufficient (Johannessen & Hahn, 2012). They deliberated on upstream solutions, knowing that one of the main problems is the slow drainage of water to the Baltic Sea. They also concluded that 'the worst-case scenario' would (normally) occur in the early spring, and would entail frozen ground, with rapid snow melt, which means that large retention areas would be needed upstream. As there are no major dams regulating the flow of Helge river, measures upstream would either be inadequate or controversial (building a large dam in another municipality). They therefore concluded this was not a priority action. The rescue service in the municipality of Kristianstad said in interviews that they would be willing to take the initiative to coordinate with other municipalities but they don't have the mandate or funding to work at a river basin scale. Therefore, such activities were perceived by the rescue service as better postponed until the implementation of the WFD (personal communication Rescue service, Nov 12, 2003). Consequently, no other measures have been taken in the river basin to mitigate floods (Personal communication Rescue service May 25, 2012). However, no hydrological modelling upstream was ever done to calculate the principle effect on the flow regime from more ecosystem related measures (Personal communication flood modeller Sep 24, 2012). At the same time upstream river dredging has been carried out (e.g. in Finja Lake), without any coordination or knowledge on how this affected the flows to Kristianstad.

In terms of flood risk, only the extreme flow data seems to be interesting to risk managers. For example, mapping land vulnerable to less extreme floods in the river basin was not seen as a relevant resource by MSB for their implementation of the FD. On the other hand, the River Basin Authority has shown interest in this data (Personal

communication, District Water Authority, Sep 26, 2012). Although not life threatening, these less extreme floods were still considered by a national planner to have socio-economic impacts (Personal communication, WFD advisor, Aug 23, 2013) making them relevant for the FD.

### *5.4. Slow integration between flood risk reduction and river basin management*

The WFD implementation brings with it opportunities for measures in the river basin, but it is perceived by some of the interviewees to be taking a long time. In the meantime, other initiatives start up, such as the "model forest" pilot in the lower part of the Helge river, where planners would like to see these initiatives expand upstream in the river basin (Personal communication, Biosphere Office Aug 23, 2012).

The water authority recognizes the potentially large role of flows in their water quality strategies for the Helge river basin. They suggest that: "*to achieve the desired nutrient reduction, physical changes in the river system are needed, such as recreating meandering and wetlands, and breaking up existing culverts. These changes would also impact the flow of water and possibly extreme water levels*" (Vattenmyndigheten, 2010). According to a district planner, the implementation of the FD has also triggered the interest within the District Authority to work in a more integrated way in the river basin, which could involve activities relevant for floods in the next administrative cycle. But how this will be done is not perceived by one of the planners as evident (Personal communication, District Water Authority, April 2, 2012). A suggestion by one of the planners is to introduce basin wide comprehensive planning (Personal communication advisor WFD, Aug 23, 2013).

Interviewees tended to view the main value of wetlands to be their capacity for nutrient retention and to maintain biodiversity, but with less focus on the dynamic flood regime. In one of the interviews it appeared that the person administering an EU support to biodiversity maintenance had not thought of the flood buffering function of these lands at all (Personal communication Scania County Administrator, March 21, 2012). In the municipal comprehensive planning document, wetlands recreation and restoration are only mentioned in terms of nutrient retaining capacity (Kristianstads kommun, 2013). Also, the EU biodiversity support lacks provisions for flooding which is affecting the farmers managing the wet grasslands. One farmer mentioned that fixed dates for required cutting of grass are a problem, because it is sometimes too wet for heavy machines to operate (Personal communication farmer, Feb 12, 2012). The flood regime is also causing uncertainty in financial support affecting all landowners adjacent to Helge river in Kristianstad, as reported by another Scania County administrator handling these claims: "*conditions do not allow for a few years of flooding during the five year period.*" The farmers are also negatively affected by seasonal shifts in flooding as summer approaches, because these shifts can destroy the grass for grazing, such as in 2007. This affects farmers' willingness and ability to manage the meadows for biodiversity, as it reduces the benefits of grazing as well as profits (Kristianstads kommun, 2007).

### 5.5. Expert opinion rather than stakeholder dialogue for floods

Although farming is not always compatible with wetland management, many farmers who have been living in the area for a long time are engaged in customary practices to maintain wet grasslands for haymaking and grazing on the fields closest to the wetland. Co-management of these seasonally flooded areas is ongoing mainly for biodiversity and nutrient management purposes (Olsson et al., 2004). The municipality's Biosphere Office has worked extensively with farmers to safeguard the most valuable wetland areas under Natura 2000, with EU support. However, one "newcomer" farmer, who depends on utilizing all the land for intensive agriculture, mentioned in the interview that he sees these protected areas as obstructing farming (Personal communication farmer, May 25, 2012).

Three planners reported they would like to see less intensive farming in the wetland, especially where some fields (in total about 1200 ha) are protected from fluctuating waters by agricultural embankments. Such practices cause nutrient leakage, and when embankments occasionally break, even more nutrients are released. Instead, the three planners suggest re-creating the wet grasslands, although there is no legislation to support this (Personal communication Scania County Administrator, April 2, 2012; Biosphere Office, Aug 23, 2012; and strategic planner, March 12, 2012). Future sea-level rise and higher water levels due to climate change will increasingly challenge existing agricultural embankments (Kristianstads kommun, 2013), and there may be a time when farmers consider investments to avoid breaching to be not cost effective (Berglund, 2008).

To change existing legislation to support more optimal land use planning for nutrient retention and flood risk reduction in a river basin is a challenge and a balancing act between two different types of interests. On the one hand, landowners are known to argue that such change imposes decisions on those who have made investments (Personal communication, interest group for farmers, Nov. 13, 2013) while on the other hand an advisor to the WFD argues that there should be more consideration of the common good: "*In Sweden, the paradigm behind dredged forests, lowered water tables, lakes, agricultural embankments and digging of ditches, where the focus is on livelihood security through forestry and agriculture to feed a growing population, needs to be replaced by a new paradigm acknowledging the role of wetlands for biodiversity, recreation, nutrient and flood [risk] management*" (Personal communication, advisor WFD, Aug 23, 2013).

Stakeholder participation, often aimed at facilitating dialogue between parties to balance such considerations, is an active component in the co-management of the Biosphere reserve in the municipality (Olsson et al., 2004) as well as provided by a Water Council formed in 2012 under the WFD (Helge river water council, 2014). However, a farmers' representative perceived the set-up under the WFD to be ineffective, and instead suggested professional facilitators for smaller dialogues involving relevant people (Personal communication, interest group for farmers, Nov 13, 2013).

One city planner mentioned that maintaining good relations with the farmers is also as a key strategy for maintaining the wetland buffer capacity (Personal communication, city planning, March 2, 2012). Many farmers in this study expressed that the wetland

would need to be dredged to "clean the drain" to allow for more rapid flood reduction. The municipality met these arguments with a commissioned study by an expert consultancy to look at the effects of dredging, but which showed it to have very little effect, and to have a high cost (DHI, 2009). This dissuaded the farmers from taking action, but they are still convinced this needs to be done (Personal communication farmer, April 2, 2012).

## 6. Discussion

Traditionally, flood protection and control strategies have been dominant in Europe, while many European countries have increasingly recognized the need to adopt a broader set of risk management approaches e.g. Germany (Deutsches Komitee für Katastrophenvorsorge e.V. [DKKV], 2004), the Netherlands (Vis, Klijn, De Bruijn, & van Buuren, 2003), the UK (Tunstall, Johnson, & Penning Rowsell, 2004). Why is Sweden not following this trend? Here we discuss our key findings, summarised in the table below.

Table 1
Summarises gaps, barriers and opportunities for adaptive river basin management in Kristianstad.

| Gaps | Barriers | Opportunities |
|---|---|---|
| Flood control is the dominant approach to flood risk management with little alternative measures | 1. *Flood risk is not managed cross-sectoral*<br>2. *The coordination of FD and WFD is located at different national agencies*<br>3. *Ecosystem services not in official risk strategy*<br>4. *Planning of flood risk is done at local level* | Implementation of the WFD and FD<br><br>Emerging international experiences to be picked up by Swedish policy and practice |
| Urban flood alleviation well developed for "internal" floods but not for "external" floods (coming from the river basin) | 1. *Houses already built in flood risk areas*<br>2. *Prioritisation of development over risk has a historic tradition*<br>3. *Urban planners in Kristianstad trust the embankment security* | |
| Flood abatement in the river basin is not an active measure | 1. *Requiring political action, available land and financing model*<br>2. *The forest sector is exempted from measures*<br>3. *Only extreme water levels inform flood risk measures*<br>4. *Flood risk planning is not at river basin scale* | |
| Slow integration between flood risk reduction and river basin management | 1. *Biodiversity and water quality are the perceived main benefits from wetlands*<br>2. *Lack of provisions for flooding in the EU biodiversity support* | Implementation of the WFD and FD<br><br>Future adaptations in the Common Agricultural Policy (CAP) reform |
| Expert opinion rather than stakeholder dialogue to reduce flood risk | 1. *Different interests and paradigms competing*<br>2. *Customary ways vs unclear regulations*<br>3. *Design of participatory platform* | Future sea level rise<br>Shifting paradigms |

### 6.1. Flood control is the dominant approach

Achieving flood control has the character of an adaptive management process. However, it is open to discussion how adaptive Kristianstad's flood control measures are in the end (Johannessen & Hahn, 2012). Embankments may initially seem like an effective measure, but they influence the flow regime and create increased flooding in other parts of the water course (Tobin, 1995). In so doing, they may in the long run increase rather than reduce flood risk. Kristianstad is sometimes referred to as "little Holland". However, countries like the Netherlands are relying on both 'resistance' (defence) and 'resilience' (giving in to stress but recovering immediately) strategies, where a combination of these two very different responses of a system to external stress is considered the best option (Deltares, 2010). Kristianstad has chosen to 'resist' and be "fail-safe" (there will be no failure). This is also the case for the Dutch approach to the dikes near the ocean, although for rivers they have adopted a more resilient or "safe-fail" approach, termed 'living with floods'. This means that they use productive land as buffer zones (i.e. green infrastructure), creating synergies with nature and landscape development, cultural heritage and scenery (Vis et al., 2003). In a review of adaptation measures in Swedish municipalities, Wamsler and Brink (2014) identify that physically oriented measures are dominant in Sweden, which account for around 60 per cent of the measures identified. Environmental measures are the second most frequently mentioned measures, and hardly any social and economic measures were found (ibid). It seems therefore that there is a need to complement structural flood risk management measures in Kristianstad and for Sweden in general.

Issues of flood risk are traditionally considered an engineering problem (Halbe et al., 2013). In Sweden, at municipal level the rescue service and technical departments are often responsible for risk issues, as Kristianstad illustrates. In Europe, it is often the same department that coordinates response and recovery that also coordinates risk reduction (European Commission [EC], 2014). It has been observed that due to a lack of mainstreaming, flood adaptation in Sweden is typically managed in separate sectors with competing interests and without inter-sectoral learning and communication (Wamsler & Brink, 2014).

### 6.2. Urban flood alleviation well developed for internal floods but not for external floods

Experience shows that reliance on absolute safety through engineered solutions may in the long run create other vulnerabilities due to the inherent risk in technical deficiencies, in design construction, and the need for adequate maintenance (Tobin, 1995). The city planners' complete reliance on embankments in Kristianstad allows them to continue development as business as usual, and so increase the amount of people and property at risk. In the spatial planning culture in Sweden, land and water are not functional spaces, but valuable in terms of contributing to "attractiveness, character and beauty" (Uggla, 2010). Thus, although regulations stipulate otherwise, in practice Swedish municipalities have a long standing tradition of offering attractive near-shore areas for development to stimulate an influx of people (and taxpayers), and as such increasing exposure to floods (Statens Offentliga Utredningar [SOU], 2007, p. 60).

### *6.3. Flood abatement in the river basin is not an active measure*

Kristianstad municipality does not have the wetland flood buffering capacity as part of the official flood risk strategy; however climate change may increasingly require such capacity. The reason for this seems to be that only extreme floods are considered a risk to the city, and green infrastructure has been regarded as insufficient to protect the city against these. It is surprising that there are no mechanisms in Kristianstad, Sweden, or even Europe, to compensate farmers for providing and maintaining a flood buffering ecosystem service (Dworak, Berglund, Grandmougin, Mattheiss, & Holen, 2009). It is only in a few countries like Australia, with its massive problems of drought that have implemented paying for ecosystem services in practice (Ling Tan et al., 2008). However, with projected sea level rise, farmland bordering the Helge river will increasingly lie under water, and in places where there are agricultural embankments there will be increasing risk for breaching, and some will either need to be strengthened or removed.

Planning at a larger scale would open up the opportunity to identify strategic places for potential changes in land use where the abatement of floods in the landscape could be most effective. The suggestion made in the interviews that there should be a river-basin-level comprehensive plan is in line with future implementation of the FD (EU, 2012). Such planning would need to address the extension of the mandate for the municipalities at a river basin scale, and/or delegate this to the River Basin Authorities, which do not currently address flood risks. Chosen measures would have to build on dialogue with a diversity of landowners and several municipalities. Cooperation with neighbouring municipalities for the management of shared rivers is already ongoing in Sweden (Wamsler & Brink, 2014). Such dialogue would need to navigate a thin line between top down decisions to benefit the common good with maintaining landowners' rights and investments – a concern expressed in the interviews.

### *6.4. Slow integration between flood risk reduction and river basin management*

The FD stipulates that the delivered plans have to contain "appropriate objectives" for the management of flood risks (Mostert & Junier, 2009). Because these plans do not seem to be binding and the FD does not set any priorities (ibid) this puts emphasis on an informed Swedish strategy with active priorities. Sweden is one of the few countries in Europe where the coordination of the FD and WFD is located at different agencies (EU, 2012) which has implications for integration of these issues. Key to finding solutions and synergies will be cooperation between MSB and SwAM, where the District Water Authorities (under SwAM) are already looking at such synergies. The discussion on synergies will be partly facilitated at European level (EU, 2012). Given the upcoming schedule it is surprising that not more dialogue between the national agencies MSB and SwAM and other stakeholders is ongoing to arrive to mutual insights, a process which is seen in other European countries (Environment Agency, 2013). The dialogue between the flood risk agendas on the one hand and the environment agenda on the other seems divided as seen since the end of the Cold War (Groven, Aall, van den Berg, Carlsson-Kanyama, & Coenen, 2012). In Sweden,

an illustration of this is that only the more extreme and more infrequent flows are interesting for MSB, and the smaller and more frequent flows important for ecosystems only interest SwAM. This disregards the fact that these flows are part of the same continuum acting over a river basin scale. On the other hand in Kristianstad, there exists cooperation between the local rescue service and the Biosphere office on flood risk issues (Johannessen & Hahn, 2012), but not extending to a cross-sectoral issue in the comprehensive planning. In Sweden, it is up to the municipalities to decide what type of risk reduction measure they want to apply. At the same time there is little national guidance on a systematic and broad set of adaptation measures (Wamsler & Brink, 2014) with MSB mainly providing maps of flood risk to municipalities. This indicates a gap where a national dialogue on strategy and clear priorities have a role to play in triggering and guiding local departments in working better together and having a broader set of measures to choose from.

### *6.5. Expert opinion rather than stakeholder dialogue*

An observation in this study is that the municipality of Kristianstad relies strongly on expert information to inform decisions concerning flood risk, in absence of a more inclusive dialogue with local stakeholders. This may have limited the options for flood risk reduction measures. However, dialogues may not come without issues. For example farmers if asked how to reduce flooding would have advocated in favour of dredging. On the other hand, they may also have advocated for payments for flood buffering ecosystem services or measures in forestry. In Sweden, there are hardly any tools and structures for adaptation planning that actively involve citizens in Swedish municipalities (Wamsler & Brink, 2014). In Europe, the WFD has in general been criticised as relying heavily on expert assessment and not on stakeholder participation (Steyaert & Ollivier, 2007). In terms of stakeholder participation, there may be a role to play for the Swedish Water Councils, but currently it was not seen to provide an adequate platform or channel for influence, also observed in the Lule river basin in Sweden (Lundmark & Jonsson, 2014). More applied research to further improve local stakeholder participation seems appropriate.

## 7. Conclusions

This paper has investigated gaps in adaptive river basin management in Kristianstad, and the barriers and opportunities to achieving it. It also points to implications that this case study may have for Sweden as a whole. This study indicates that Kristianstad takes a traditional approach to flood risk management. Local flood control measures dominate over more resilient measures of flood alleviation and flood abatement in the river basin.

There may be several barriers to why the Kristianstad municipality has not adopted a broader set of risk measures:

- Flood risk is not seen as a cross-sectoral issue. National level coordination of FD and WFD implementation by different agencies reinforces this approach.

- The flood buffering capacity of the wetland (green infrastructure) is not part of the official flood risk strategy.
- Unclear mandates in flood risk governance, where on the one hand the local level has a strong planning mandate for flood risk, while on the other only water quality is governed under the WFD at the river basin scale. MSB is mandated to provide information about flood risk to municipalities but is not responsible for guidance on measures for implementation.
- Flood risk management is informed primarily by technical expertise and lacks an inclusive approach to stakeholder engagement.

We conclude that the spatial planning approach at the local level concerned with flood risks needs to extend to include the river basin scale. For this, the local planning level needs guidance on a broader set of measures to manage flood risk across sectors, including more integrated and adaptive approaches. To access a cross-sectoral set of measures, there is also a need for a strengthened platform for dialogue with stakeholders at the river basin scale to identify and prioritise issues, and for this to be included in the spatial planning process. Applied research could further improve the concrete models for such engagement.

Many opportunities exist to enable adequate provisions for adaptive river management in the Swedish governance framework through implementation of the WFD and FD, guided by national priorities to be developed by relevant agencies such as MSB and SwAM.

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# Paper II

Johannessen, Å., and C. Wamsler. 2017. What does resilience mean for urban water services?. *Ecology and Society* 22(1):1. https://doi.org/10.5751/ES-08870-220101

*Research*

# What does resilience mean for urban water services?

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ABSTRACT. Disasters and climate change impacts, as well as increased water demand, pose serious risks to the provision of sustainable urban water services, e.g., drinking water, sanitation, and safe drainage, especially in cities. These challenges call for a transition toward improved water management, including considerations of "resilience." However, because the resilience concept has multidisciplinary origins it is open to multiple interpretations, which poses a challenge to understanding and operationalizing the concept. We explore how resilience thinking can be translated into urban water practice to develop the conceptual understanding of transitions toward sustainability. The study is based on a literature review, interviews with water experts, as well as four case studies in South Africa, India, Sweden, and the Philippines. We identify seven key principles or attributes of urban water resilience and the related transition process. We find that resilience building needs to discern between and manage three levels (i.e., socioeconomic, external hazard considerations, and larger social-ecological systems) to be sustainable. In addition, we find that human agency is a strong driver of transition processes, with a certain level of risk awareness and risk perception providing one threshold and a certain capacity for action to implement measures and reorganize in response to risks being another. The difficulty of achieving "knowledge to action" derives from the multiple challenges of crossing these two types of identified thresholds. To address long-term trends or stressors, we find an important role for social learning to ensure that the carrying capacity of urban water services is not exceeded or unwanted consequences are created (e.g., long-term trends like salinization and water depletion). We conclude that the resilience term and related concepts add value to understanding and addressing the dynamic dimension of urban water transitions if the key principles identified in this study are considered.

Key Words: *climate change adaptation; disaster risk reduction; resilience; sustainable cities; urban transition; urban water; water and sanitation*

## INTRODUCTION

Disasters, climate change, and rapid urbanization pose a serious risk to the provision of urban water services including safe drinking water, sanitation, and safe drainage, especially in cities (Howard and Bartram 2010, IPCC 2014). Urban growth increases the risk for disasters because it often limits drainage capacity, while at the same time it increases pressure on urban water systems, especially affecting the poor (UN DESA 2014, Wamsler 2014). Thus, humanity is faced with serious challenges to achieve sustainable urban water management in light of growing risks.

In recent years "urban resilience" has become a popular concept to address increasing risks. It has been applied in various fields linked to sustainable development, climate change adaptation, disaster risk management, and reduction and environmental science (Béné 2013, Wamsler 2014, Olsson et al. 2015). However, the concept has multidisciplinary origins, and has been increasingly criticized for its ambiguity (e.g., Olsson et al. 2015) and challenges to operationalize it (Brand and Jax 2007). So what does the resilience concept comprise, and how could it be applied to urban water services?

Although there are many studies that address urban water services in operational guidelines that have the declared aim of improving disaster risk reduction and resilience (e.g., Twigg 2009, UNISDR 2012, Jha et al. 2013, Turnbull et al. 2013) the resilience concept is generally not operationalized, except for one study focusing on water and sanitation (Howard and Bartram 2010). In this paper we investigate how the resilience concept can be systematized, operationalized, and applied to better guide transitions to more sustainable urban water management in cities.

## CONCEPTUAL FRAMEWORK

### Resilience of urban water services: definitions and challenges

In the context of disaster risk reduction and management the term resilience is defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the efforts of a hazard in a timely and efficient manner" (UNISDR 2009). In contrast, in the community of research and practice around sustainability and social-ecology, resilience is framed in a more general sense, and "reflects the degree to which a complex adaptive system is capable of self-organization," that is, "the capacity of linked social-ecological systems to absorb recurrent disturbances ... so as to retain essential structures, processes and feedbacks ... and the degree to which the system can build capacity for learning and adaptation" (Adger et al. 2005:1036). A significant difference between the two definitions is that the former implies a positive value for society while many theorists of the latter definition would argue that resilience is value-free (Redman 2014). The latter also refers more explicitly to a multiscalar system with potential for learning and adaptation/transformation when ecological, political, social, or economic conditions make the existing system in question untenable (Walker et al. 2004, Adger et al. 2005, Folke 2006). Related key concepts used in the analysis of this paper are transitions and transformation, enabling and disabling factors, and thresholds:

*Transitions*

In sustainability and social-ecological resilience theory, the notion of transition (in that context often referred to as transformation) is interesting to urban water services in that it holds a promise for learning, reorganization, and improvement (Adger et al. 2005).

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Instead of resilience meaning bouncing back to the same (sometimes poor) state as before, resilience dynamics can thus imply an ability to transition from the current situation where many of the world's urban poor suffer from dysfunctional urban water services, to an achievement of, e.g., increased and more equitable access to water, better treatment of wastewater, and better quality water. In transition theory, social learning is central because it contributes to a robust strategy for accelerating and guiding social innovation processes (Loorbach and Rotmans 2010). Improvements through learning can require more or less mental energy, and the outcomes can be more or less "deep": e.g., learning can take place either through already established actions (single-loop learning) or changes in initial frames of reference (or worldviews) such as system boundaries (double-loop learning), or changes in underlying norms and governance structures (triple-loop learning; Huntjens et al. 2012). In disaster risk reduction the emphasis is often on disaster resilience, and hence, related transitions, in the context of sudden crises such as floods (Folke et al. 2010). Although sustainability and social-ecological resilience theory also recognize that transitions can be triggered by external crises, it much more emphasizes the internal adaptive dynamics, including slower processes (Walker and Salt 2012).

*Enabling and disabling factors*

Transitions are enabled (or disabled) by context-dependent feedback processes that evolve (or self-organize) the system identity over time (Walker and Salt 2012). As such, the transition process is not determined and linear, but rather an evolving pathway with emergent properties (Turnheim et al. 2015).

*Thresholds*

When critical feedback processes change, through, e.g., crises or other disturbances, and the so-called self-organizing capacity cannot recover the system anymore, the system has reached a limit called a threshold (Walker and Salt 2012). Thresholds are of a different nature, where the system can be subject to small changes (no threshold), step changes, or an irreversible or reversible "collapse" or reorganization (Walker and Salt 2012).

**Defining the goals of urban water transitions**

In terms of good water governance, integrated water resources management (IWRM) promotes principles for coordinated, sustainable, and equitable development and management of water, land, and related resources (GWP 2000), and is adopted by the majority of the global water community (e.g., UNWATER and GWP 2007). The approach has been further refined, e.g., integrated urban water management (IUWM), "partial IWRM" (Butterworth et al. 2011) and "water sensitive cities" (Brown et al. 2009). The Intergovernmental Panel on Climate Change (IPCC) and others have highlighted the importance of integrating adaptation to climate change in water management (e.g., Zwolsman et al. 2010, IPCC 2014). However, IWRM as a blueprint is not always fit for purpose (Shah 2016); for example, local water managers find it difficult to implement the "extensive and daunting" long list of to do's in IWRM (Butterworth et al. 2011). In addition, some authors argue that sustainable water management inclusive of IWRM cannot be realized without current water management regimes undergoing a transition toward adaptive water management. This means implementing a systematic approach to learning to account for the uncertainties in the system in question (Pahl-Wostl et al. 2007). Given the above background, an improved understanding of resilience in urban water management can contribute to the further development of IWRM / IWRM lite and adaptive water management through the related concepts of transitions, thresholds, and an understanding of what enables or disables transitions toward sustainability.

**Exploring resilience transitions in urban water services**

To assess the resilience of urban water services there is a need to define its system boundaries and the disturbances this system is being exposed to (Walker and Salt 2012). This is challenging because the urban water system involves multiple scales depending on users (e.g., households and communities), institutions (e.g., service providers and regulators), technologies, and ecosystems (Howe et al. 2011). The urban water system can also be described in terms of multiple water networks, or sectors, i.e., natural systems (including groundwater and receiving waters), water supply, storm water and sewer system (combined with storm water or separate from it; Butterworth et al. 2011) that includes surface flood pathways created during extreme events (Ellis and Viavattene 2014). The natural systems often link up to water resources and ecosystems at a river basin level where water flows are affected by land use, building distribution, and infrastructure (Ellis and Viavattene 2014). Each of the different systems in the urban water cycle is often considered without cross-reference to the other systems (Butler and Davies 2000). However, in many cases, for example in urban flooding, the complexity of the urban water system requires that it is approached in an integrated way (Ellis and Viavattene 2014). Although the term "system" may be confusing because it can be subject to much interpretation, the term "service" (used in this study) instead focuses the attention to what matters to the user. For example, a physical system will come to an end, but if replaced in due time, the service is maintained (Moriarty et al. 2013). Thus the term "service" is more widely used by the urban water community of practice (cf. Butterworth et al. 2011, Howe et al. 2011).

## METHODOLOGY

The study followed four methodological steps. First, after a literature review we conceptualized how we would apply the term resilience to urban water services, identifying basic elements for building an urban water resilience framework, which guided our empirical work. Second, we carried out interviews with 10 key informants (see Appendix 1 for affiliations) by first introducing the type of disturbances relating to flood and drought and discussing the boundaries of the system/service (see Appendix 2).

The key informants were representing both the WASH (Water, Sanitation and Hygiene) humanitarian and development community, where some had more utility focus and some more on site focus, e.g., hand pumps or latrines. The choice of including the two communities aimed to capture a broad scope of interpretations of the term resilience both from disaster and development settings.

The interview responses (see Appendix 3 for interview questions) were analyzed using the different types of identified (socioeconomic, external hazard, and social-ecological) resilience levels. The responses were then explored in relation to the key elements of transitions, which meant a "zooming in" from the interview questions to the three key concepts:

**Table 1**. A summary of the enabling and disabling factors that influence the different resilience levels identified from the empirical data.

| | Enabling factors | Disabling factors |
|---|---|---|
| Socioeconomic resilience | Technical capacity and knowhow<br>Policy-science integration<br>Microgovernance arrangements<br>Inclusive participation<br>Accountability<br>True costs accounting | Lack of practical technical capacity<br>Education distant to real issues<br>Power games and political self interest<br>Unsustainable public preferences<br>Focus on physical structures rather than capacity related |
| External hazard resilience | Awareness of climate and disaster risk<br>Win-wins between effectiveness of daily operations and hazard preparedness, vulnerability and hazard reduction | Lack of financial and other resources to handle beyond normal<br>Lack of knowledge of what increases hazard resilience<br>High value of cost effectiveness |
| Social-ecological resilience | Across scales: Interinstitutional coordination; long-term regulation and policy<br>Integrated formal and informal urban planning frameworks (e.g., linking upstream downstream areas) | Local increases of resilience reduce resilience at regional level<br>Lack of knowledge on ecosystem-based measures favoring local structural solutions<br>Lock-ins, favoring rapid urbanization and economic growth |

1. enabling and disabling factors for resilience;
2. related thresholds;
3. the identification of possible transitions through step change or collapse.

The intention was to further develop the framework and get a sense of the types of interventions that correspond to the different key elements, rather than to arrive at an exhaustive list of examples, measures, or solutions for resilient urban water services.

In the third methodological step, we conducted a comparative case study including Durban (South Africa), Gorakhpur (India), Kristianstad (Sweden), and Cebu (the Philippines). Three criteria were used to select the locations: a high level of water-related risks in terms of flood or drought, or both; a river basin context; and the potential to access relevant data. The case studies included a total of 50 interviews. A common interview protocol was used and interviews were analyzed to assess the identified key elements for urban water resilience and related transitions. In each case, the interviewees included politicians, technical staff (e.g., city council members, urban water specialists, city and environmental planners), private sector (e.g., water and wastewater operators), and civil society representatives, chosen for their potentially different perspectives. Finally, the fourth methodological step included triangulation of the different data through a one-day workshop with the project team, consisting of 11 people. We discussed the findings from the case studies and how they could exemplify the resilience framework.

## RESULTS: UNDERSTANDING URBAN WATER RESILIENCE IN PRACTICE

### Disturbances: three levels of urban water resilience

The responses from the 10 key interviews clearly indicated that the resilience concept can and should be seen in relation to three different types of disturbances (here referred to as resilience levels).

1. Socioeconomic disturbance, i.e., disturbances not associated with external hazards but within the urban water service infrastructure and the entities that manage and govern them. Such disturbances are linked to socioeconomic, political, or institutional and governance structures. Examples of such disturbance include corruption; power dynamics; capacity gaps; increases in bad debt; production, operation, and maintenance costs. Most responses (62%) discussed resilience solely in terms of this category.
2. Hazard disturbance, i.e., external hazard-, disaster-, and crises-related disturbances that come from outside the urban water service infrastructure and the entities that manage and govern them. Almost one-quarter of respondents (23%) linked resilience to this type of disturbance.
3. Long-term disturbances such as unsustainable resource extraction by the urban water services on the broader social-ecological system and vice versa. Fewer responses (15%) took this perspective.

### Enabling and disabling factors

From the key informants' responses and the case studies, we identified various forms of enabling and disabling factors in relation to the three levels of resilience (see Table 1 for a summary).

*Socioeconomic resilience*

Resilience in urban water services in relation to socioeconomic disturbances was said to be enabled (or disabled) by two key factors. The first is stakeholders' capacity to drive developments in a more (or less) sustainable direction. In this context, in terms of capacity development, improved technical knowledge and science-policy integration were seen as crucial. In three case studies, i.e., Durban, Gorakhpur, and Cebu, the lack of practical technical capacity in local government was seen as a key barrier, with university education often seen as distant to the real issues.

The second identified enabling or disabling factor is the level of good governance of the many stakeholders who drive the direction of urban water services self-organization and which sometimes disrupt it. In this context, three types of actors were especially mentioned as being potentially disruptive to transitions: informal urban water service providers, politicians,

and public users. For example, politicians were said to often hijack urban water activities for their own interests, promising the public what they want in times of elections and then do not deliver (Cebu, Durban). The public exert influence by their preferences, which includes, for example, type of solutions and deprioritizing sanitation, e.g., in Gorakhpur, Cebu, and Durban. Four types of measures emerged that could help counteract the negative influences of the three groups of actors: (i) improving governance arrangements using models for inclusive participation, (ii) improving accountability in urban water services, (iii) establishing regulatory accounting (in Table 1 referred to as "true cost accounting"), and (iv) building stakeholder capacity. For example, interviewees reported that governance arrangements for inclusive participation and involvement of multiple stakeholders has increased knowledge and acceptance of urban water interventions. Such local governance arrangements identified by respondents included microresilience planning (see Gorakhpur, Box 1) and the similar model of *Purok* to assure participation. Purok, a form of traditional community organization, are normally found in rural settings. In Cebu it is being piloted in four peri-urban areas to bring about ownership and change in, e.g., health, waste collection, disaster risk reduction, and microfinance. However, in terms of a community organizing itself to deal with shocks there is a limit to how much it can do, and it generally needs support from higher level authorities and other external agents to keep the services going. "Accountability triangles" between users, service providers, and service authorities were reported to improve accountability. For example, increased awareness about their water entitlements can enable poor communities to discipline providers and influence policy makers to increase public services. At the same time the policy makers can make providers to serve poor people better (World Bank 2003). Finally, the application of regulatory accounting for urban water infrastructure helps reflect its true costs over the life span of the service, with implications for decision making.

**Box 1: Microresilience planning in Gorakhpur, India.**

Gorakhpur has approximately 1 million inhabitants. Gorakhpur Environmental Action Group (GEAC) has piloted microresilience planning in the one of its communities. With the participation of the inhabitants, six thematic committees were formed in key themes including water and sanitation and risk-resilient construction. Practical measures were implemented such as improving the wells and the drainage, and establishing a solid waste management service. These efforts have led to changes in the population's hygiene behaviors along with a decrease in water-related diseases, decreased water-logging, better health care, and improved dialogue with the municipality. However, upscaling of this model from the ward to the entire city seems difficult because of the governance arrangements at higher scales, which do not sufficiently support cross-sectoral collaboration.

*Hazard resilience of urban water*

Two enabling factors for hazard resilience were mentioned by the interviewees. The first is stakeholders' increased awareness of the risks of climate change and disasters. Several respondents saw improving hazard resilience as fundamental to ensure the functionality and performance of urban water services. Interviewees agreed that the cost of hazard impacts has been increasing because urban water services cannot adequately cope, leading to secondary hazards, such as landslides and disease outbreaks, and far-reaching impacts on communities. This was especially highlighted in the Asian context: people living in the Asia Pacific region are four times more likely to be affected by hazards than people living in Africa, and 25 times more likely than those in Europe or North America (cf., UNESCAP and UNISDR 2010).

The second enabling factor is the existence of win-wins that increase the effectiveness of daily operations, and at the same time ensure that key functions can be replaced during potential hazard events. These win-wins included decentralization processes of urban water services enabling modularity, e.g., if one unit has closed down the other units can still provide the service.

The two most commonly mentioned disabling factors for hazard resilience were, first, the lack of human and financial resources to handle circumstances beyond the "normal" hazard uncertainty and second, the high value placed on cost effectiveness in urban water delivery. The former includes the lack of knowledge on what types of measures, organizations, and governance structures are needed to increase hazard resilience. As an example of the difficulties of grasping risks in planning, an interviewee mentioned participating in a scenario exercise that described traditional hazard scenarios on the first day but then switched on day two (which happened to coincide with the 9/11 events in 2001) to include a wider spectrum of risks. Regarding the latter, the high value placed on cost effectiveness in urban water delivery especially conflicts with increased redundancy, e.g., through back-up systems, and robustness, e.g., of materials used, required to increase resilience.

*Social-ecological resilience of urban water services*

Several interviewees highlighted that local measures aimed at increasing socioeconomic or hazard resilience can reduce resilience at regional and/or national levels, if the wider social-ecological system is not adequately considered. Local improvements in urban water service delivery might, for instance, lead to the pollution and salinization of water resources, e.g., because of open access and resultant excessive water use in Cebu (see Box 2); increase demands for water supply in water-scarce areas; or move water-related risks downstream, e.g., when water supply is augmented but the corresponding water treatment and sanitation services are not put in place.

The three most commonly mentioned enabling factors for improving social-ecological resilience of urban water services are listed below. Also, in the literature all three aspects have been identified to be crucial for climate policy integration and mainstreaming (Wamsler 2015, Wamsler and Pauleit 2016).

**Box 2: Slow-onset disaster through excessive water use in Cebu City, The Philippines.**

In Cebu City, with around 900,000 inhabitants, excessive groundwater pumping rates are resulting in drastic lowering of the groundwater levels and seawater intrusion. Leaking

**Table 2**. A summary of the two types of thresholds for the different levels of resilience identified from the empirical data: (1) the threshold for risk and perception of risk and (2) the threshold for action capacity that enables implementing measures and reorganization.

| Type of resilience | Threshold for risk and perception of risk | Threshold for action capacity |
|---|---|---|
| Socioeconomic resilience | A certain level of sufficient water supply that satisfies human needs. Certain norms influencing perception of "sufficient." | No identified threshold |
| | A certain level of perceived (dys)functionality of the system. In case of an epidemic, this is certain. | Responses to fight an epidemic. Triggering measures to address underlying vulnerabilities in the urban water system. |
| | A certain level of management of the water system. | Action to reach a certain standard of quality, quantity of water, etc. fit for human use, as defined by established indicators. |
| | A variety of different thresholds that are able to be hijacked for political purposes. | Action on relevant urban water issues (e.g., tenure, access, flood risk management) in relation to election cycles and disruptive to ongoing capacity building. |
| External hazard resilience | The extent and patterns of (perceived) climate change-related floods and its perceived future impact on society. | A level of financial capital for investments available for disaster-resilient urban water services. |
| Social-ecological resilience | The extent of drought and its perceived future impact on society in certain societies. | Political decision-making capacity in relation to building desalination plants, which is disruptive to ongoing change in terms of integrated demand and supply management. |
| | The extent of water scarcity and pollution and its (perceived) impact on society. | No threshold identified as no actions have significantly addressed the problems. |

household septic tanks and open defecation is also causing severe pollution of the groundwater. Although the Water Resources Center (WRC) has been monitoring water quality in 180 wells in the city nearly every year since 1975, no solutions are in place yet to tap into new sources, or control and enforce groundwater usage. The lack of policy prioritization, inadequate governance arrangements, and financial and human resource constraints add to the problem. At the same time a growing urban population needs access to clean water. WRC is supporting long term capacity building efforts with local water associations to provide water access. However, such access contributes to the unsustainable water outtake at the urban level without proper management of the resource. One member of the water association stated in 2015: "We have still our application (to extract water) pending since 2009 although since the beginning we have been extracting water."

First, enhanced interinstitutional coordination across scales was mentioned as an enabling factor but as very challenging to achieve. Coordination could, for example, be improved by local water and sanitation providers engaging more actively with the environmental and water service authorities. A related disabling factor includes lack of knowledge on ecosystem-based planning and risk reduction (Sudmeier-Rieux 2013), especially important in the context of Kristianstad (see Box 3) where local structural measures dominate in flood risk management.

Second, the importance of regulatory frameworks and policies across scales and with longer time horizons was frequently mentioned, e.g., water safety plans, because they can allow, for instance, better management of water catchment areas (e.g., Kristianstad, Box 3, Wamsler et al. 2014).

Third, integrated formal and informal urban planning frameworks were identified to be crucial to address "lock-ins" mentioned above and ensure that resilience is considered in on-the-ground developments such as mitigating downstream flooding in local drainage initiatives. Despite knowledge of the negative consequences of urban development, strong drivers such as rapid urbanization and short term economic growth override such resilience planning (Wamsler 2015).

**Box 3: Kristianstad: Success at local level but lack of integrated frameworks for the river basin.**

Kristianstad in Southern Sweden has approximately 81,000 inhabitants in the wider municipality. In Sweden, Kristianstad represents a successful example in flood risk management. However, on closer scrutiny the flood risk approach is largely dominated by local structural solutions, while solutions linked to environmental management at regional and national levels are scarce. This is mainly due to governance arrangements that place decision making about flood risks with municipalities, and does not sufficiently encourage integration between water quality/environmental management and flood risk management at higher levels.

**Thresholds**

Among the many thresholds we found, we identified two common issues where the first is associated with risk and perception of risk, and the second is associated with action capacity, which sometimes involved implementation of a measure or a reorganization (see Table 2 for a summary).

*Thresholds for socioeconomic resilience*

From the key informants' responses and the case studies we identified three possible thresholds for socioeconomic resilience of urban water services. The first includes measures such as technical standards (as an enabling capacity for services' functionality where a critical number of buildings, spare parts, etc. need to comply with the standards) and norms influencing user preferences (e.g., some nomadic population groups demand less water volume). These provide thresholds because they can

dramatically change services' characteristics, structure, and functions. The second threshold is health-related crises (such as epidemics), where nonfunctional urban water services have reached a "threshold of dysfunctionality" where it can transmit contaminants into the system, which can trigger epidemics. However, they also provide an opportunity to address the underlying vulnerabilities in urban water services (e.g., Durban, see section 4.4. transitions through step change). The third threshold is political interventions, mainly related to election cycles, where radical actions are announced just before elections, such as legalization of slum areas, fair water pricing, or the improvement of water access, and already established capacity dissipates when one administration replaces another.

*Thresholds for hazard resilience*
Interviewees identified two possible thresholds for hazard resilience of urban water that are supported by the literature. The first is the extent and patterns of (perceived) climate change-related floods, representing a certain (threshold of) disturbance to the service (cf. IPCC 2014). The second is the financial capital needed for investments (cf. Smits et al. 2011*a*). This threshold is associated with the actual shift to more disaster-resilient urban water services where the existence (or lack) of targeted budgets can affect the design and extension of the services.

*Thresholds for social-ecological resilience*
Two types of thresholds for social-ecological resilience of urban water were identified by the interviewees and are supported by the literature. The first comprises situations where disturbances are anticipated or announced, and reacted to in a maladaptive fashion. For example, the political decision to build desalination plants in response to the so-called Millennium Drought in Australia (1997-2009; cf. Giurco et al. 2014) led in some places to the dismissal of ongoing social change in terms of integrated resource planning, demand management, and planned water restrictions (Giurco et al. 2014). The perceived severity of the (future) disturbance and its impact on society reached a threshold. The second threshold is linked to cases where specific disturbances were not (or could not be) addressed. One of the interviewees gave an example from Lebanon, where, even before the current crisis in Syria began, water resources in Lebanon were overextracted and salinized. The war itself and an additional 1.2 million refugees then eroded and contaminated water resources in various ways, meaning that building back to normality in terms of serving the population that was there before appears hardly possible (cf. Noolkar and Erande 2014). This type of threshold is arguably also passed in some of the case studies in this paper: in Cebu, water resources are overextracted and salinized, and in Durban, Gorakhpur, and Cebu, drinking water is contaminated by wastewater, environmental degradation, water logging, and flooding.

**Transitions through step change or collapse**
The analysis of the 10 key interviews and case studies revealed various forms of transitions in relation to the three levels of resilience.

*Socioeconomic resilience*
Interviewees mentioned three potential types of transition in relation to socioeconomic resilience of urban water: continuous upgrade of urban water services, improved cross-sector coordination, and the reorganization or collapse of dysfunctional water and sanitation utilities. Several interviewees also identified existing barriers to potential transitions:

- Resistance to change among urban water professionals because of "traditional" career paths in which environmental concerns are not included, and adversity to changing what seemingly works;
- Lack of human resources, lack of coordination within the sector, e.g., between rainwater collection systems, grey water, wetland treatment, and infiltration technologies; and
- Lack of cross-sectoral coordination, especially between the water and sanitation sector and the drainage, waste management, urban planning, disaster risk reduction, housing, and transport sectors (see Box 4).

**Box 4: Durban /eThekwini, South Africa: Internationally renowned, but lacking cross-sectoral integration.**

The eThekwini Municipal Area (EMA) has about 3.4 million people, which includes some of the smaller towns around the city center. A substantial proportion of the population lives in low-income townships, including informal settlements. The eThekwini Water and Sanitation Services (EWS), renowned for providing sufficient water to the population, has been replicated across the country and has been awarded internationally for its technical capacity and inventive approach. In spite of this, there is a substantial sectoral approach between water, sanitation, disaster risk reduction (DRR), health, solid waste, catchment management, and vector control. For example, the disaster risk reduction leadership considers "potable water to be [only] an issue for the urban water sector" (Head of cluster for DRR).

*Hazard resilience*
The interviewees mentioned two processes in this context that are relevant for hazard resilience of urban water services. First, recurring floods were said to have increased local acceptance of alternative solutions and more sustainable practices, e.g., raised latrines as the pit latrines got flooded. However, interviewees also stated that disasters often do not lead to transitions to better services, but only to minimal recovery of lifesaving functions, especially in low-income contexts. Second, the collapse of an interinstitutional cooperation on climate change adaptation was mentioned as a way to understand how to better set it up; not as an academic-practitioner relationship, but rather as a peer to peer network that enables symmetric relationships and learning. This enabled knowledge building on possible effects of climate change on water services.

*Social-ecological resilience of urban water*
Two types of transitions that can lead to social-ecological resilience in urban water services were identified by the interviewees and are supported by the literature. The first type is a shift into a new regime, which presents worsened environmental conditions. For instance, in Lebanon, because of the situation described above, new treatment plants or other solutions to deal

with new contaminants in the water are needed (cf. UNHCR 2014). Mexico provides another example of such a transition. A salinity crisis between 1961 and 1973 was triggered by overextraction from the Colorado River in the U.S. As a result, Mexico now receives compensation from the U.S., and the areas affected by the increasing salinity were protected (cf. Gottlieb 2012). The second type of transition into a new regime means improvements in urban water services. For example, the implementation of water recycling in Singapore, which was assisted by people's increasing acceptance of using recycled water for drinking (cf. World Bank 2006). Another example is the response to the Millennium Drought in Australia where it can be questioned whether or not the sudden shift to desalination represents a sustainable pathway (cf. Giurco et al. 2014).

## DISCUSSION

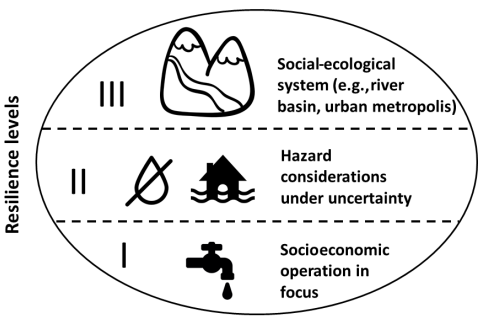
We present and discuss seven key principles or attributes of urban water resilience and related transitions that have derived from the results. They provide much needed insights for further conceptualization and clarity in applying the resilience concept to urban water services.

### The urban water service: three levels of resilience

*Principle 1*

Our results show the importance of explicitly discerning between three levels of resilience in urban water services (socioeconomic, hazard, social-ecological) through the use of more specific terminology (Fig. 1). We base this on the following two observations:

**Fig. 1**. Three levels of perceived resilience in the urban water system identified from the empirical data: (1) Socioeconomic operation in focus. (2) External hazard considerations are taken. (3) A larger social-ecological system, e.g., river basin or urban metropolis area. (Icons made by Freepik and Darius Dan from http://www.flaticon.com/.)




- Most respondents referred implicitly to resilience as relating to disturbances of a socioeconomic nature (the first resilience level), in which the urban water sector invests most (Smits et al. 2011*b*). This is in contrast to the climate change adaptation and disaster risk-reduction field that focuses on external hazard disturbances (the second resilience level) and has often neglected to consider other types of disturbances, such as social-political processes (Weichselgartner and Kelman 2015). On the other hand the ecosystem-oriented community mainly refers to resilience of the social-ecological system, which is the third resilience level, comprising a larger scale than the other two (Walker and Salt 2012).
- b. Most respondents referred to all three different levels of resilience, but without being explicit (or conscious) that they were doing so. This shows how different practitioners assume different meanings when using the resilience concept in relation to urban water. This phenomena is contributing to the existing confusion around the resilience terminology (Olsson et al. 2015). Instead, more specific terms and descriptions, such as "resilience to disaster risk" referring to the second resilience level, might be more helpful in contexts where improved urban water services are concerned.

*Principle 2*

The existence of three levels of resilience implies that if a truly sustainable water service is to be achieved, all three levels need to be addressed. This means that actors who influence the flow and quality of water have to explicitly consider cross-scale dynamics (cf. Holling and Gunderson 2002). If not, resilience and sustainability can be at odds with each other. This is because resilience is defined and addressed differently, often by different communities of practice, and between the three levels (as described above in Principle 1). For example, in Cebu, a successful example of providing water supply access by an association at the neighborhood level (resilience at level I), is one of many examples of open water access, contributing to overextraction and salinization of groundwater at a larger urban catchment scale (lack of sustainability at level III; see Box 2). Another example is the general consensus that we need a transition toward more sustainable and hazard-resilient cities (UNISDR 2012, Wamsler 2014, ICLEI 2015). However, many urban water services that could be described as resilient (i.e., at level II), such as conventional risk-reduction measures used to flood-proof a society, may involve large structural solutions, which are often unsustainable from an environmental, economic, and/or social point of view (lack of sustainability at level I and/or III; Johannessen and Hahn 2013, Wamsler 2015). On the other hand, developing green infrastructure options such as green roofs or wetlands might provide many ecological and recreational benefits where resilience and sustainability are aligned (e.g., Eastern Research Group, Inc. 2014).

### Human agency driving or obstructing the transition process

*Principle 3*

Although urban water is often viewed as a technical issue requiring infrastructure solutions, this study indicates that a key feature of transitions to more sustainable services is an advanced understanding of human and organizational perception and behavior, including individual and institutional needs, desires, wants (motivations), and power issues (cf. Giddens 1982, Partzsch 2015). This means that if such agency-related factors are matched by adequate feedbacks, e.g., adequate policies mirror people's investment logic, it supports human behavior and organization

in sustainable directions. In this context, our analysis identified feedback mechanisms that need special scrutiny: governance structures and participation, accountability, regulatory accounting, capacity development, and science-policy integration. For example, to strengthen the agency of urban water stakeholders, interviewees stated that it would be important to understand how to better enable community organization, why research institutions engage too little in local change, and why urban water professionals tend to resist change. Better understanding of the underlying human motivations and power struggles of such questions is crucial to support transition, which is also supported by recent sustainability research (Partzsch 2015).

Urban water service performance mainly depends on such agency-related factors that provide the direction of transition processes; that is to say that different agents or stakeholders can either enable or disrupt the pathway toward desired developments. Hence, concepts that aim to operationalize urban water resilience, such as the water sensitive city (Brown et al. 2009), require that transition processes are considered and described in terms of agency, instead of focusing on technologies. The previous attempts to apply the resilience concept to urban water reflect this one-sided focus (Howard and Bartram 2010). The focus on tangible measures and technologies downplays the role of agency in driving transitions, which is also illustrated by the bulk of aid money that flows to projects delivering new taps and toilets rather than (institutional) capacity building (European Court of Auditors 2012, Moriarty 2015).

*Principle 4*

Our results show that social learning is a clear driver in transition processes. For example, governance arrangements built on social learning such as the Purok in the Cebu case study, or the micro resilience planning in Gorakhpur, enable different stakeholders and different kinds of knowledge to interact, which alters understanding over time (cf. Feurt 2008). Our results indicate the importance of social learning also when comparing the levels of resilience, considering socioeconomic disturbances, hazards, and social-ecological dynamics across scales. The need for capacity development was highlighted within each level. However, in the context of socioeconomic disturbances, relevant responses focused on improving already established actions (single-loop learning). In the context of external hazard resilience, interviewees highlighted the need to (further) advance initial frames of reference and guiding assumptions, for instance in risk assessment (double-loop learning). The need for such advancement suggests that a lack of capacity in holistic and integrated risk assessments is a barrier for transition to a disaster-resilient city (cf. Rivera et al. 2015). In the context of social-ecological resilience, there were substantially more responses on the need for a social learning effort to develop capacity to influence governance structures at different levels as well as underlying norms (triple-loop learning). A reason for this could be the lack of governance structures or responsible agencies that could drive change and potentially address slow disasters such as salinization and overextraction as found in, for example, Cebu and Gorakhpur. Huntjens et al. (2012) support this finding, stating that complexity and uncertainty on a large scale require institutions to facilitate systemic learning processes to ensure triple-loop learning for more fundamental change. Although some interviewees argued that fundamental change is already happening in the water sector, in terms of a "new order" or paradigm shifts (e.g., upgrading toward more sustainable urban drainage systems, decentralization processes, use of modularity design, and information technology), others regarded these as only incremental adjustments. A trends and scenario analysis at sector level by Smits et al. (2011*b*) confirms this latter perspective and depicts the urban water sector as being highly conservative, which is perhaps a consequence of the long lifetime of water-related infrastructure. Also, even though modularity is proposed as an important characteristic of water technology in the 21st century, it is a rather old engineering solution, and there is no clear indication that it supports fundamental change (Spiller et al. 2015).

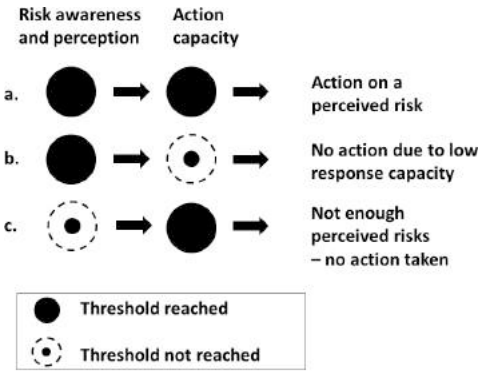
*Principle 5*

Successful urban water transitions involve navigating uncertainty, i.e., finding an appropriate balance between meeting specific or multiple hazards (prioritization) and preparing for eventualities (diversification). Human choices are also, in low-income contexts, very much influenced by ensuring day-to-day livelihoods (Wamsler et al. 2012, World Bank 2013). Especially regarding external hazard disturbances, our results illustrate how recent experience and what we expect to happen in the future makes us downplay very rare or so called "black swan events" (Taleb 2010) illustrated earlier by the scenario development before and after 9/11. In accordance with our findings, some scholars argue that it should never be assumed that risks have been eliminated, which can lead to complacency (e.g., Hollnagel and Fujita 2012). Nevertheless, our findings illustrate that although faced with uncertainty, there is a preference for investing in more tangible measures that tackle more predictable and urgent problems, such as recurring small-scale floods, or providing access. Doing anything differently is challenging given the perceived lack of human and financial resources to handle circumstances beyond the normal hazard uncertainty, and the high value placed on cost effectiveness in urban water service delivery.

*Principle 6*

Our study highlights two key thresholds for transition in urban water services (Fig. 2). The first threshold is related to a certain level of perceived risk, i.e., the perception that a certain disturbance will have a certain impact (or consequence) on a given system (see a. in Figure 2). The required levels and process to reach them is context dependent and involves many different actors; individual professionals may be the first ones to identify the risk, but various processes of social learning are needed to build this awareness with decision makers and the public (Johannessen and Hahn 2013). The level of risk awareness is influenced by socio-cultural standards, e.g., preferences and norms, in contrast to physical standards. For example, water use and demand is different between, e.g., rural nomads and urbanites who will perceive risks at different water volumes. In the case of Australia's Millennium Drought, a perceived threshold of future climate risk was identified that in the end never materialized in physical reality. Awareness of a risk can be slow to develop, especially of slowly developing stressors, as shown by, e.g., acid rain, biodiversity loss, climate change, droughts, deforestation, desertification, and famines (Mosley 2015). Monitoring such changes requires reliable monitoring systems and knowledge building over time which is also stored in social memory (Folke 2006).

**Fig. 2**. Two types of thresholds were identified from the empirical data relevant for the transition process in urban water services: (1) risk awareness and perception and (2) action capacity.




The second type of identified key threshold is related to a certain level of action capacity to act on the perceived risk, e.g., financial capital and capacity to take a political decision. For example, during Australia's Millennium Drought a shift to desalination provided a solution to growing demands in a water-depleted environment (Turner et al. 2010). This represents an action capacity in terms of decision making, although there is disagreement whether this led to sustainable management (see a. in Fig. 2). In cases where the situation might be even more pressing, and the risk awareness is available, such as in Cebu, Gorakhpur, and Durban, there seems to be a lack of action capacity to generate political decisions and implement action (see b. in Fig. 2). This gap between knowledge of a risk and acting on it has also been identified in the literature (Kolmuss and Agyeman 2002, Shove 2010). Earlier studies have likened such thresholds to a context specific "critical mass" to push a process that makes a social movement or political decision inevitable (Werners et al. 2013).This may be a question of translating science to policy, and the need for certainty in investments, illustrated by the social inertia to act on climate change (Bradshaw and Borchers 2000). The important role of (risk) perception for the crossing of thresholds may be key to understanding why societies endure certain risks. It is known that shared (and outdated) worldviews that do not match reality can be subject to manipulation and control by powerful interests (cf. Foucault 1984). As such they can resist building risk awareness or capacity for action if it does not benefit their interests.

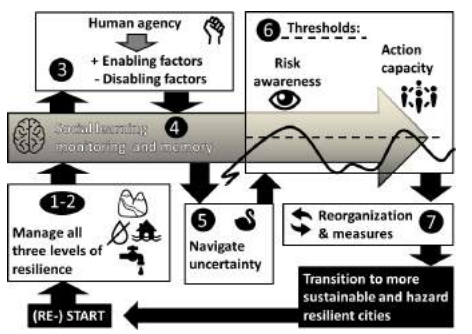
*Principle 7*

Although transition through collapse was not well received by our interviewees, because it is generally not seen as very compatible with a conservative risk-averse water industry, our findings suggest an important role for the related concept of reorganization. Transition through reorganization was often associated with some initial resistance to accepting new information and abandoning accepted truths for change to happen, which is associated with deeper learning (Schein 1999). Such change was linked to the breakdown of (corrupt) entities, which become disabled through the establishment of better accountability mechanisms, open routes for improvement and presumably more transparency. One estimate is that 20 to 70% of resources could be saved if transparency would be optimized and corruption eliminated (Transparency International 2008). Transition through collapse was more easily associated with the outbreak of disasters and epidemics such as cholera outbreaks, which was able to spark policy change and investments at the national level in Durban (Gounden et al. 2006) and in terms of acceptability of different sanitation options.

It is important to highlight here that the transition toward improved economic status may not always lead to higher disaster resilience. For example, as countries and cities get richer and more interconnected, and as economic activity becomes more urbanized with sensitive infrastructure, disasters can cause much greater economic damage than previously, which impacts urban water services (Wamsler and Brink 2016). In this context, urban water resilience better describes the dynamic functioning of a system rather than a desired outcome in the progression toward improved water management.

The different principles and their interlinkages are illustrated in Figures 1–3. Figure 3 provides the conceptual model for the transition process into a more sustainable and hazard resilient state of urban water.

**Fig. 3**. A conceptual model for the process of transition into a more sustainable and hazard-resilient state of urban water. Here, all three levels of resilience need to be taken into account (socioeconomic, external hazards, and social-ecological scale) so that focus on resilience at one level does not compromise the sustainability of another (1-2), where enabling and disabling factors for human agency (3) influence the process of social learning, monitoring, and memory (4). Actors need to navigate uncertainty through prioritization and diversification (5). When thresholds of risk awareness and action capacity are reached (6), measures are put in place, and/or a reorganization occurs (7) and the system makes a transition. (Icons made by Freepik from http://www.flaticon.com/.)



## CONCLUSIONS

Through literature review, interviews, and four case studies we explore how resilience thinking can be translated into urban water practice. We further develop the conceptual understanding of transitions toward improved management and sustainability in urban water services (illustrated in Fig. 3).

We conclude that resilience-related concepts can add much value to understanding and addressing the dynamic dimension of urban water transitions if the seven key principles identified in this study are considered. This does not necessarily support the use of the term resilience per se, but of its principal components, which can be linked to other conceptual models and frameworks. Although we have tried to capture a broad scope of interpretations of the term resilience both from disaster and development settings, the results do not provide an exhaustive list of interventions, but only illustrating the key principles adding to existing theory linked to IWRM.

Based on our assessment, the seven key principles or attributes are as follows:

Principle 1: Three levels of resilience: Resilience in urban water services needs to discern between socioeconomic disturbances, hazard considerations, and social-ecological dynamics across scales. Explicit reference to the identified three levels of resilience would enable a less conflictive and more operational use of related concepts. The understanding that resilience not only concerns external disturbances is in line with how the term is applied to analyses of ecosystems, also considering (internal) social-ecological dynamics of slow-onset disasters and crises across scales. However, it is not in line with current discourse in risk reduction and climate change adaptation, where resilience is still too often used only in relation to external hazards (Eriksen et al. 2015, Weichselgartner and Kelman 2015). Nevertheless, debates on transformational adaptation and differential vulnerability are increasingly providing more nuanced perspectives to address the roots of climate and disaster risk through action that changes the fundamental attributes of a system (Agard et al. 2014, Wamsler 2014, Eriksen et al. 2015).

Principle 2: Integrated resilience-sustainability planning: If a sustainable water service is to be achieved, all three levels of resilience need to be addressed. Cross-scale dynamics in urban water mean that resilience and sustainability can be at odds with each other. Efforts to enhance resilience to socioeconomic and external hazard disturbances, e.g., improve local access to water for citizens, in fact may erode more large-scale social-ecological resilience, e.g., create regional water scarcity. Thus, consideration must be given to sustainability of the whole system.

Principle 3: Human agency focus: Our results show a strong role for a range of diverse urban water actors to drive transitions, and there is a need to better understand, e.g., through more research, how their perception, behavior, and related power struggles can better align with desired transitions. In contrast, uncertainty in climate and disaster projections is a barrier to action, which leads to a preference for investing in more tangible measures such as infrastructure. The focus on infrastructure is reflected in previous attempts in applying the resilience concept to urban water (Brown et al. 2009, Howard and Bartram 2010).

Principle 4: Social learning: Social learning is a key driver of transitions by supporting capacity building to reach thresholds (see below) and reorganization to a new development pathway. The direction of such a pathway in terms of sustainability is in turn enabled and disabled by certain factors. Especially in the context of social-ecological resilience (resilience level III) deep social learning, achieved through, e.g., cross-scale governance arrangements, has an important role to play to support fundamental change to potentially address slow disasters such as salinization and water overextraction, which can influence the other levels of resilience.

Principle 5: Navigating uncertainty (prioritize and diversify): Resilience transitions in urban water require an appropriate balance between meeting specific hazards (prioritization) and other pressing needs, e.g., day-to-day livelihood, while dealing with high levels of hazard uncertainties (diversification).

Principle 6: Risk perception and action capacity as thresholds: A critical mass or threshold for urban water is needed, both in terms of risk awareness and perception, and also in terms of action capacity to push a process that makes a social movement or political decision inevitable. In this context, the results indicate that although it is important to have in place mechanisms to build risk awareness (monitoring systems, knowledge building arrangements, and institutional memory) to reach a certain threshold, it is crucial to also build action capacity in terms of collaboration and learning at multiple levels to reach the second threshold.

The difficulty of achieving "knowledge to action" derives from the multiple challenges of crossing the identified thresholds associated with these capacities, including changing shared worldviews and perception, qualities that are easily manipulated by powerful interests. However, although these thresholds can be crossed, the achieved action is not necessarily sustainable. In this context, we argue for enabling capacity building focusing on these two thresholds, especially concerning slowly developing stressors where sustainability is most at risk and also most challenging to address.

Principle 7: Supporting reorganization: The resilience concept implies that the reorganizing of failing structures (such as organizations) is necessary for a transition into something better. Facilitating change processes aimed at supporting reorganization of (dysfunctional) urban water systems might be important ways to push transitions forward, and should be further explored in research and practice. Arguably, the more fundamental change is required, the more resistance against new ways of thinking needs to be overcome.

*Responses to this article can be read online at:*
http://www.ecologyandsociety.org/issues/responses.php/8870

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**Appendix 1:**

Affiliations of the ten key informants:

1. Senior Programme Officer, IRC, The Netherlands (Development WASH);
2. Consultant, ResilientWASH, Sweden (Humanitarian WASH);
3. Senior Advisor for resilience and sanitation in Emergencies (SanE), Swedish Red Cross (Humanitarian WASH);
4. Senior WASH Adviser, Norwegian Refugee Council (Humanitarian WASH);
5. Director, ForEvaSolutions, USA (Utility operations);
6. Climate Resiliency Group, Seattle Public Utilities, USA (Utility operations);
7. Asia Urban Programme Manager, Oxfam GB Regional Centre, Bangkok, Thailand (Development WASH);
8. WASH Specialist, UNICEF;
9. Programme Coordinator, International Water Association (IWA), Geneva;
10. Advisor, Cities Development Initiative for Asia (CDIA).

**Appendix 2:**

Introduction given to the interviewees - System boundaries and disturbances

We first presented to the interviewees how we defined the scope for the interview questions on resilience. For the system being affected by a disturbance we first assumed urban water "system", allowing an open ended discussion about what this consisted of. However after some discussions with one of the interviewees we assumed urban water "services". Different disturbances were throughout the interviews presented as a range using the definition by OECD (2014):

1. Covariate shocks - infrequent events with an impact on almost everyone in the target group, such as violent conflict, extreme flood or currency devaluations.
2. Idiosyncratic shocks - significant events that specifically affect individuals and families, such as the death of the main breadwinner or the loss of income-generating activity
3. Frequent small impact events - seasonal shocks, such as annual flooding linked to the rainy season, food market price changes, or recurring shocks such as frequent displacement or endemic cholera in particular communities
4. Long term stresses - long term trends, weakening the potential of a system and deepening the vulnerability of its actors, like increased pollution, deforestation, exchange rate fluctuations and electoral cycles.

**Appendix 3:**

Interview questions

Each interview question was introduced by referring to Walker & Salt (2012).

**1. How would you translate "Self organization" to WASH systems?**
If a part of a system is changed most of the time the system can handle it by "self-organizing" i.e. absorbing the disturbance, reorganize, and perform in the way it did—retaining its identity. But sometimes the system can't cope with the change and begins behaving in some other (often undesirable) way.

**2. In this discussion, can you identify any "Thresholds" and their interactions?**
Thresholds are the limits to how much a self-organizing system can be changed and still recover. Beyond those limits it functions differently because some critical feedback process has changed—it has a different identity.

**3. What could be the corresponding way to translate "Adaptive cycles (across scales)" to WASH systems?**
The behavior of self-organizing systems changes over time due to internal processes. Systems undergo a period of rapid growth as they exploit new opportunities and resources. However, over time availability of resources is decreasing; connections are increasing. The system enters a phase of "conservation", which comes to an end in a collapse. Resources are lost, but it also opens the way for renewal and a new order rises up, and enters back in a phase of rapid growth.

**4. How do you translate "Scales are linked" to WASH systems?**
What happens at one scale can have a profound influence on what's happening at scales above it and on the embedded scales below.

**5. Are there any "Tradeoffs between the two complementary aspects of resilience: specified resilience and general resilience?**
Specified resilience is the resilience of a specified part of the system to a specific shock. General resilience is the capacity of a system that allows it to absorb disturbances of all kinds, including novel, unforeseen ones. Channeling all your efforts into one kind of resilience will reduce resilience in other ways.

**6. How do you see Transformation in WASH ? How do you look at the Difference between "adapting and transformation"?**
Adaptability is the capacity of a social-ecological system to manage resilience—to avoid crossing thresholds, or to engineer a crossing to get back into a desired regime,

or to move thresholds to create a larger safe operating space. Transformability is the capacity of a system to become a different system.

**7. How do you see the "Tradeoffs between building resilience and not doing it?"**
Building resilience isn't free; it comes with both the direct costs of the actions you take and the indirect costs of opportunities lost. Enhancing the resilience of a system usually involves reducing efficiency, staying away from maximum yield states, maintaining reserves, and so forth.

# Paper III

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# Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden

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ABSTRACT

Social learning is often treated as an intervention, a designed process facilitated or even initiated by a third party. We investigated how a social learning process emerged spontaneously from inside Kristianstad, one of the most flood-prone municipalities in Sweden. Twenty key persons were interviewed over 8 years, many of them several times, to assess the process. A small action oriented group of technical professionals perceived the flood risk and were key drivers providing strategic innovative capacity. We identified the process attributes that fostered the learning, the knowledge generated and other learning outcomes adapting a model by Schusler et al. (2003). Despite some elements of double loop learning, this process was not able to change the prevailing stationary principle/paradigm, feeling safe behind the embankments and continuing building on low lying land. We argue that building resilience and adaptive capacity would require a mind shift to a paradigm of flood proofing/living with floods and preparing for the unexpected, acknowledging that water cannot be controlled at a certain level. We conclude that knowledge development is inhibited by the Swedish decentralisation approach and we call for a multilevel learning strategy including learning from international experience and emphasising more active coordination at the national level.



## 1. Introduction

Human settlements are often located in low-lying and flood prone environments, as closeness to water associates with livelihood, trade and navigational routes. Society has learnt how to capitalise on, adapt to and buffer against natural hydrological variability with different means e.g. dams, canals and dredging (L'vovich and White, 1990). However, this development has altered the hydrological flows and linked ecosystem dynamics (Lammersen et al., 2002; Brandt et al., 1988) sometimes resulting in removing natural buffers and increasing the likelihood for more extreme flood events (Lane et al., 2003). In Europe, flooding is becoming the most common natural disaster, including more frequent floods with more impact (IPCC, 2007; Barredo, 2007). This has many causes, such as population growth, urbanisation and other land-use change in exposed areas, higher exposed values, increased vulnerability of buildings, goods and infrastructure, failure of flood protection systems and changes in environmental conditions (Munich Re, 1999; Kundzewicz et al., 2005). In addition to natural variability, predictions of increased frequency and magnitude of extreme events due to climate change have triggered renewed considerations of risk in local planning. This includes increasing rainfall and frequencies of severe floods (White et al., 2001; Cubasch, 2001; Milly et al., 2002; IPCC, 2008). The city of Kristianstad has the greatest flood risk in Sweden, in terms of the most number of persons within the area of a worst case scenario (MSB, 2011). Due to a locally driven initiative to mitigate the flooding, Kristianstad has become a role model to other municipalities in Sweden. The present construction of 10 km embankments is the nation's most costly measures to meet the flood challenge in modern history. Its pioneering position underscores the importance of a critical assessment, as many other cities will be learning from the Kristianstad approach.

There are different approaches to flood mitigation. A combination of coping and adaptation is generally applied as a response to climate impacts (Kabat et al., 2002), in which coping mechanisms are the bundle of short-term responses to situations that threaten livelihood systems, and often taking the form of emergency responses in abnormal seasons or years (Berkes and Jolly, 2001:2). In the context of floods, coping includes for example closing the traffic on exposed roads and putting up temporary embankments, using resources which can be mobilised at short notice. Adaptive strategies, on the other hand, are the ways in which individuals, households and communities change their productive activities and modify local institutions to secure

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**Table 1**
A selection of different social learning approaches advocated in different contexts and their focus and aim. These approaches can be planned or self-organised.

| Learning approach | Focus and aim | Example/reference |
|---|---|---|
| Deliberation in *comanagement*; a partnership between government agencies and local communities (planned and/or self-organised) | *Ecosystem focus*: fisheries, parks, protected areas, forests, wildlife, rangelands and water resources | Schusler et al. (2003) and Pinkerton (1989) |
| *Participation* by river basin stakeholders guided by river basin authority in public meetings, with media, authorities, NGOs etc. (planned and facilitated) | *River basin focus*: Collaboration and public participation under EU Water Framework Directive (WFD) for allocation and conflict management | HarmoniCOP, SLIM projects (Tippett et al., 2005; Mostert et al., 2007, Blackmore et al., 2007) |
| *Learning alliance*; a group formation with different stakeholders from authorities to communities etc. (planned and facilitated) | *Urban/rural focus*: Aimed at upscaling of different aspects of IWRM (focused on drinking water, sanitation and hygiene) | SWITCH (Butterworth & Morris, 2007); MUS (Van Koppen et al., 2009); Empowers (Moriarty et al., 2007) |
| *Ecosystem approach* including institutional design, e.g. committees, task groups etc.; (planned, coordinated) | *Ecosystem focus*: aimed at achieving integrated planning and/or management of multiple sectors in an ecosystem | Okavango Delta Management Plan, Botswana (Janssen, 2002; Pirot et al., 2000) |

livelihoods for the long-term (Berkes and Jolly, 2001:2). This can build resilience, which entails: (a) buffer capacity or robustness and (b) the capacity for learning, self-organisation and adaptation (Folke, 2006:259). For flood prone urban areas this translates for example into (a) building permanent embankments or adapting land use (b) social learning, collaboration in social networks and adapting strategies including city planning.

The predominant and traditional approach to meet flood risks is based in the 'foundational' water management paradigm which bases its assumptions on the 'stationary principle' i.e. that natural systems fluctuate within a fixed range of variability (Milly et al., 2008). Water managers who follow this paradigm work according to design rules and management criteria, based on monitoring and analysis of hydrological data (Veraart and Bakker, 2009) favouring structural adaptation measures such as embankments to be able to cope with a certain water level. A rediscovered approach of 'climate proofing' uses a combination of infrastructural and institutional measures in order to adapt (Veraart and Bakker, 2009). This includes new planning paradigms such as 'living with floods' ('flood proofing') and robust solutions acknowledging that physical structures like embankments etc. cannot give total protection and that people and their homes may get exposed to the full forces of floods from time to time (Hendriks and Buntsma, 2009; Defra, 2006). It also acknowledges the need to reduce risk of exposure e.g. adapting land use and provide for buffer zones. Strategies part of the adaptive paradigm allow for smaller disturbances, rather than shutting them out, where the system instead learns how to absorb them and build resilience (Walker et al., 2004).

To apply these strategies, adaptive capacity is required, which is the ability to adjust to climate variability and extremes, e.g. to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). *Social learning* is recommended as a way to boost adaptive capacity in a deliberate and systemic fashion (Kolb, 1984; Kim, 2004; Groot et al., 2002; Walker et al., 2004). Such social learning achieves "a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks" (Reed et al., 2010). Kristianstad's initiative, which displays a capacity for action and implementation, and ability of actively meeting challenges of flood risk in times of climate change, is therefore highly interesting in this context, and the questions arise: are there evidence of social learning and if so, how this was achieved? Did it improve the adaptability? In other places, this has been achieved by variables such as facilitation, institutional frameworks and policies, stakeholders and stake-holding processes, and ecological constraints (Steyaert and Jiggins, 2007). Social learning is key to adaptive management (Röling and Wagemakers, 1998) through developing institutions and capacities for sustainability (Pahl-Wostl et al., 2008). However, the outcome from social learning does not always have to be sustainable, or sustainability can be achieved without social learning (Reed et al., 2010). To distinguish between different outcomes, or rather, levels of intensity of learning, the concept of single, double and triple loop learning is often used. Single loop learning is the improvement of already established actions; double loop learning means a change in the frame of initial reference and guiding assumptions (such as system boundaries); and triple loop learning means a transformation of the frame of reference and of the whole regime (Hargrove, 2002).

There are no blueprints for a social learning process but lessons learnt are being promoted and documented through various approaches; see Table 1 for a selection. We are interested in a type of social learning which is 'stable', enabling long-term build up of capacities, action and behavioural change; a rather unexplored area of research (Gerger Swartling et al., 2011). We are also interested in such social learning which is ongoing in the professional day-to-day deliberations "on the job" arguably in stable contexts. This is in contrast to social learning efforts which only last for the time during active facilitation or participation (Bull et al., 2008) and sometimes requires additional institutional structures. The Kristianstad case is part of such self-organised and spontaneous processes that take place in the absence of any planned participatory process (Pinkerton, 1989), organized within conventional structures and networks.

If stable long term social learning is aimed for, we need to know what environments trigger and enable such processes. Enabling environments for learning are often characterised by trust, collective meaning and sense making and 'ownership' with respect to both the learning process as well as the solutions/outcomes (Wals et al., 2009). But that information is not sufficient to recreate a process. One critique to the social learning concept in natural resource management has been the general approach, concealing a great diversity, without distinguishing the specific mechanisms at work, and lack of empirical evidence which makes it difficult to recreate such processes in practice (Reed et al., 2010; Schusler et al., 2003). To reduce ambiguity and develop the concept of social learning for natural resources management Muro and Jeffrey (2008) suggest more empirical research. This study aims to contribute to that effort.

### 1.1. Purpose

The purpose of this empirical case study is to shed light on social learning related to flood mitigation that is useful for action to build resilience and adaptive capacity. We investigate the following questions:

**Table 2**
A summary of the basic assumptions of Schusler et al. (2003) for social learning and the corresponding findings in this case study.

| # | The basic assumptions in Schusler et al. (2003) | Modifications/comments from this case study |
|---|---|---|
| 4.1 | *Requisites for management* (capacity, knowledge, supportive policy, appropriate processes and structures, collaborative relationships, common purpose) | A policy change made the municipality responsible to deal with flood risk enabling action, but was not a trigger in itself |
| 4.2 | *Deliberation* among stakeholders enables social learning in a 2-day conference | Deliberation is facilitated on the job by a core group, driving the process and facilitating inputs from others over a long time (>10 years) |
| 4.3 | *Process attributes* that fosters learning are: democratic structure, open communication, diverse participation, multiple sources of knowledge, extended engagement, unrestrained thinking, and constructive conflict facilitation | All of these attributes were identified. The group identified (flood) risk and challenged commonly held assumptions of safety. The homogenous core group (4 persons) mentions good interpersonal communication with dialogue and lack of domination as key to their success. Other process attributes were political buy-in, a timely extreme flood and funding which motivated learning |
| 4.4 | *Knowledge generation* from the social learning process (facts, values, problems opportunities etc.) | Apart from expected knowledge on hydrology etc. and some alternative actions, the social learning generated unexpected operative knowledge which was incorporated in the municipality activities, e.g. new knowledge about larger system boundaries (10,000 year floods). An appreciation of the collective knowledge in the municipality to meet the risk also emerged from the process as well as the benefits of political and public awareness |
| | *Collaborative relationships*: The social learning contributes to collaborative relationships | The social learning contributed to an increasing openness towards the general public, better informed politicians and an increased integration of municipal administrations |
| 4.5 | *Common purpose*: The social learning contributes to common purpose | The flood risk management strategy shifted with time from a focus on an embankment of 1.5 km to a larger area and the need for flood mitigation from 10 km embankments |

- Is there evidence of social learning and if so, how did the social learning develop, and which were the process attributes that fostered learning?
- What outcomes of the social learning can be identified?
- Has adaptive capacity been enhanced?

## 2. Materials and methods

This multi- and transdisciplinary study integrates topics of ecology, city/physical planning, climate adaptation, and sociology to adequately capture the complexity of social learning related to flood risk management. It is an empirical case study (Yin, 2003) which aims to contribute to the social learning concept.

### 2.1. Sources and interview methods

In 2003, a year after an extreme flood in Kristianstad, a study was made with key informants guided by Schusler et al. (2003). When looking for evidence of social learning, this was collected using the interviewees own interpretation of different process attributes. This was followed by a literature review, including both published and grey literature, where access to such documentation was facilitated by the informants. During a period of 2 years, 20 semi-structured and open ended interviews (Bernard, 2002) were carried out, tape recorded and transcribed including nine key informants employed by the municipality of Kristianstad. Interviewees were selected using snowball sampling (Bernard, 2002) and included the relevant persons involved in the learning process. Seven years later in 2010–2011, when another flood had occurred in 2007, and the building of embankments had progressed further, a follow up with five of the interviewees was made as well as two new ones to assess the stability of the process. In total the study relies on 20 interviewees, some of them interviewed several times. Four of the respondents were employed at the County Administration level, nine persons were employed by the municipality, two were farmers in the municipality, and five were employed at national level (university, research institute and an agency).

### 2.2. Analysis

There is little consensus of what evidence is required to establish a social learning process. The analytical framework, collection and analysis of data were initially guided by the model by Schusler et al. (2003). See Table 2. We applied the model to the Kristianstad social learning process and tried to identify the equivalents of its components: process attributes, knowledge generated and the collaborative relationships it contributed to (see Fig. 8). We also adjusted the model and added other relevant attributes that emerged from the study. To assess the adaptability of the outcome of the process, we constructed an 'adaptation staircase' (see Fig. 9) from the case study material and reviewed the literature to compare with other countries, mainly The Netherlands where a flood proofing paradigm exists (Huntjens et al., 2011).

## 3. Case study description

Kristianstad is a city in southern Sweden in the province of Scania with 35,582 inhabitants in the inner city and 79,543 in the whole municipality, with large areas of natural wetlands (Kristianstads kommun, 2011). The municipality is located in the lower third of the Helgeå river basin with a catchment of 4725 km$^2$ (Helgesson et al., 1994) (Fig. 1). The natural wetland area has an annual average water fluctuation of 1.4 m (Figs. 2–4). As much as 1600 ha of flooded meadows are used for pastures and hay harvesting which is unique for Sweden (Hahn et al., 2006). Kristianstads Vattenrike (Swedish for "the Rich Wetlands/Water Kingdom") is an internationally renowned biodiversity area, listed by the Ramsar Convention in 1974. In 2005 the Kristianstads Vattenrike Biosphere Reserve (KVBR) was formed as the first UNESCO Man and Biosphere reserve in Sweden fulfilling the 1995 criteria (Olsson et al., 2004; Hahn et al., 2006).

Kristianstad city is very vulnerable to flooding, because low lying land for agriculture and housing was acquired through building of embankments and lowering of lakes in the 19th century (Kristianstads kommun, 2000). One of the largest embankments is Hammarslund, which since 1868 is keeping the waters out from the former Nosaby lake with Sweden's lowest point (−2.41 m under sea level) aided by six large pump stations installed at various places. The new embankments are designed to cope with a 'worst case scenario' flood between +3.3 m and +4.01 above sea level depending on where in the city they are situated, and with sea water levels 2.0 m higher than today's average (Kristianstads kommun, 2009). The estimated year of completion

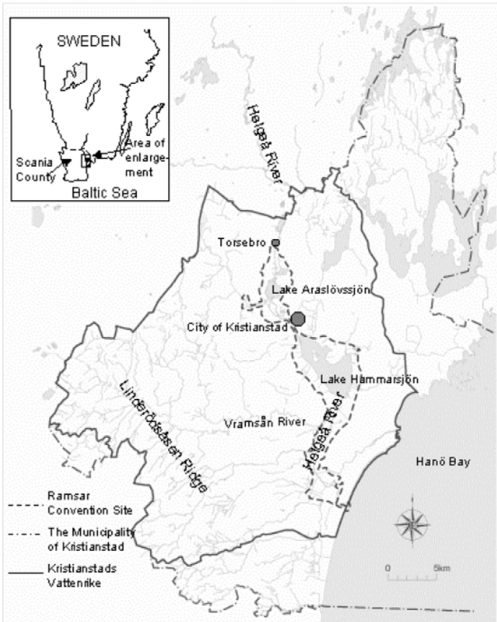


**Fig. 1.** Map of the lower Helgeå river basin, showing the Ramsar Convention Site, Kristianstads Vattenrike, and the municipality of Kristianstad (from Olsson et al., 2004).

is 2015. In total the project will cost 300 million SEK (Kristianstad website).

As Fig. 2 shows, Kristianstad has regularly experienced extreme floods (>1.90 m above sea level) in 1980 (2.04 m), 1995 (1.90 m), 2002 (2.15 m) and 2007 (1.96 m). The highest recorded level was +2.23 m in 1905. The future scenario indicates increasing precipitation in the river basin, but due to warmer winters (without snow and spring flows), the average water flows and peak flows will be reduced, which reduces the risk for the city (Andréasson et al., 2006). On the other hand, the city will be more vulnerable to sea level rise, with difficulties to drain water from the area (Dahlman, 2007).

## 4. Results and analysis

When we applied the social learning model by Schusler et al. (2003) from a 2 day conference, this agreed well with the ten year flood risk management process in Kristianstad, with some modifications (Table 2).

### 4.1. Requisite for the outcome

A policy change (PBL, 1996) occurred in Sweden in 1996, where responsibilities for risk, preparedness and safety were transferred from the national government level to the municipal level (through one of 23 County Administrative Boards – CAB in Scania). Perceptions about the flood risk differed at that time between the two levels, where the municipality felt safe behind the Hammarslund embankment, while the CAB of Scania questioned this (SOU, 1987:64). A national evaluation of the 1996 policy change concluded that it had not triggered a major change in municipal flood planning in Sweden in general (Boverket, 2001). However, in Kristianstad it had mandated the municipal level to take an active initiative and was thus a requisite for the social learning process.

### 4.2. Deliberation in Kristianstad: during day-to-day implementation and in an extreme flood situation

The deliberation that occurred was facilitated by a small homogenous action oriented group of technical people hereafter referred to as the embankment group. This group was formed in 1996 as a working group under a larger 'risk group' initiated by the municipality executive board. The risk group had been formed as a response to the policy change and after an initiative from a local

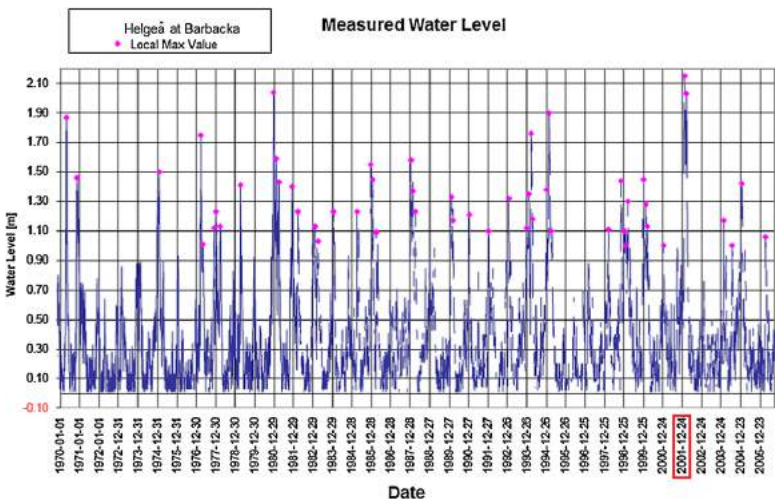


**Fig. 2.** Water levels in Kristianstad (city centre at Barbacka) 1970–2006 (Kristianstads kommun, 2007).

**Fig. 3.** Areas of upstream of Kristianstad at Isternäset during normal low water levels (summer).
Photo: Patrik Olofsson.

insurance broker. The embankment group consisted of three, and later four, persons: two from the municipal rescue service; and two from the municipal technical department. One of the rescue service members had recently worked at the Scania CAB which had a higher awareness of flood risk than the municipality. The group was convinced there was a flood risk to the city, especially from an eventual break in the Hammarslund embankment. One of them said: "*I never dropped the issue, and I had a colleague as well that did not forget about it either, and he did not leave the others alone*" (Zerpe, personal comment). Their convictions were reinforced when they discovered that geotechnical investigations had declared the embankment stability *unknown* in an expert judgement from the 1970s (Kristianstads kommun, 1979), which had never reached the decision makers.

### 4.3. Process attributes that foster social learning

#### 4.3.1. Challenging existing assumptions

The embankment group started the process by challenging the municipal assumptions of security, creating room for new perspectives and actions, which is illustrative of a social learning process (Argyris, 1990). Throughout the process the embankment group acted as a persistent driving force facilitating and coordinating the building of knowledge, infrastructure and various inputs from other actors. Although they were not external facilitators, their work descriptions and methods gave them a facilitating role. Mostert et al. (2007) conclude that such individuals with high technical competence acting as facilitators of a process, is one of the most important mechanisms to foster social learning. But it was not an easy task and the group experienced the greatest resistance in the process when people questioned why there suddenly was a problem. Changing prevailing assumptions and worldviews are often difficult because old systems make sense and people must unlearn old habits (Schein, 1999). A risk analysis presented to the politicians made them willing to change their past strategies and adapt to the changing conditions. With such active engagement of the top management, an organisation can achieve learning (DiBella and Nevis, 1998).

**Fig. 4.** Areas upstream of Kristianstad city at Isternäset during normal high water levels (winter).
Photo: Patrik Olofsson.

#### 4.3.2. Good inter-personal communication

The embankment group describes its good interpersonal communication style as central to its success, characterised by a dialogue without prestige, positioning or domination. They focused on the common problem, cooperated through open communication, unrestrained thinking, and constructive conflict resolution (Schusler et al., 2003). "*Very much depends on the people, the engagement, the chemistry and the understanding. Work in this group is amazingly quick and everybody in the group has an inner devil's advocate. No matter how we discuss, questions always arise and we discuss everything openly*" (Zerpe, personal comment). When one person in the group retired and one changed jobs and was replaced, this seemed to change the dynamic of the group and slow down the work.

#### 4.3.3. Knowledge building from multiple sources

Another very important factor mentioned by the embankment group for their own learning was media reports on extreme flood events in Europe which reinforced the group's perception of increasing flood risk, with extreme floods becoming more frequent. "*The rains that were expected to come once in 100 years now came 3 times in 100 years*" (Zerpe, personal comment). To convince the local decision makers of the risks, the embankment group started gathering evidence. In 1999 they presented a risk and vulnerability analysis (summarized in Fig. 5) to two politicians in the municipal executive board. They acknowledged that the level of preparation for extreme floods was insufficient, and the group was encouraged to continue their work. The embankment group then commissioned an increasing activity to build knowledge in the municipality about embankment stability, topography and hydrology and installed a flood warning system. Important partners for technical expertise were the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Civil Contingency Agency (MSB), the Swedish Geotechnical Institute (SGI), the Danish Hydraulic Institute (DHI) and other consultants, all of which

**The consequences of a break in the Hammarslund embankment**

- A great surge of water and a quick (5 hours) filling of the Nosaby Lake
- 700 hectares of the city will be flooded
- The cleaning of sewage for Kristianstad and 18 other cities would stop to function
- The central hospital is flooded and has to be cleared
- Great areas with housing, day care centers, school and health care have to be evacuated
- 12 000 people are affected in the worst-case scenario
- The supply of electricity, heating and water is affected
- The municipal rescue service station is flooded
- Important routes of communications are blocked
- The city is abandoned and the restoration time is estimated to 6 months

**Fig. 5.** The consequences of a break in the Hammarslund embankment. From the risk analysis by Anders Pålsson, Kristianstad's rescue service.

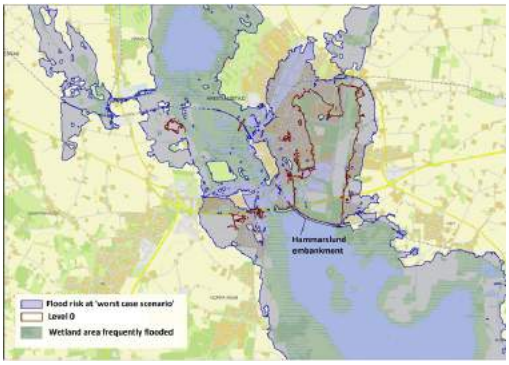


**Fig. 6.** Flood risk without new embankments apart from the existing Hammarslund embankment at 'worst case scenario'. "Level 0" marks the area, mainly behind the embankment, which would be under water if the embankment breaks at normal high water levels (e.g. 2.5 m). With a worst case scenario (3.3–4.0 m) the water could enter from behind the embankment also.

Kristianstad has a long standing dialogue with regards to flood risk (Johansson, 1984).

*4.3.4. External funding*

The investigations had prompted the decision to apply for national funds for the rebuilding of the Hammarslund embankment to withstand a 500 year flow. In 2000, the first application to the Swedish Civil Contingencies Agency (MSB) was submitted (Tyréns infrakonsult, 2000). MSB responded in January 2001 recommending that the 'worst-case scenario' should instead be a 10,000 year flow, which meant a doubling of their initial calculations and the building of 10 km embankments instead of 1.5 km. See Figs. 6 and 7. MSB made only a recommendation, but the group felt that if they did not follow it, they would not receive any funding.

*4.3.5. Political buy in*

When the group presented the complete risk scenario to the municipality executive board in 2001, the building of embankments became a political issue and city planning was stopped in the flood risk areas until the new embankments would be finalised. The support from the municipality executive board was perhaps the most crucial enabling factor to move the social learning process forward. "*All departments had known there was a threat but no one had done anything about it; that is my opinion. It was a problem the municipal rescue service should deal with*" (Wettermark, personal comment).


**Fig. 7.** Flood risk with new embankments and 'worst case scenario'. The wetland areas with different degree of wetness including flooded meadows are continuing to function as buffer zones.

*4.3.6. Extreme events (with knowledge backup)*

Only shortly after the politicians had been informed of the new scenario a timely extreme flood event occurred in February 2002 at a level of +2.15 m. Critical levels were forecasted by the early warning system, and geotechnicians advised that the embankments had to be acutely strengthened over the next 4–5 days, which also was communicated during a dramatic phone call late at night. The building up of knowledge certainly contributed to convincing decision makers at a critical moment. "*We had backup from MSB, SGI, SMHI and everybody knew about the flood issue in Europe and climate change, so we had an enormous weight behind our words. There is no politician who could have had another opinion other than that this had to be dealt with*" (Zerpe, personal comment). During the floods in 1980 and 1995, the responses had been modest compared to 2002, without such efforts and also the train on the Hammarslund embankment was stopped only during the flood in 2002. Earlier, in 2000 Anders Pålsson, an embankment group member, had requested an expert statement that the railway traffic on the main embankment should be stopped at a certain water level and therefore this could be done without further debate or delay.

*4.4. Three areas of social learning outcomes*

Our findings suggest that the social learning in Kristianstad consisted of a series of learning steps, mainly facilitated by the embankment group who acquired the knowledge and transferred it into their organisation that made operational use of it; a process defined as organisational learning (Huber, 1991). Although the definition of social learning is rather fuzzy, the process in Kristianstad also fulfills the criteria given by Schusler et al. (2003), Reed et al. (2010) and Pinkerton (1989). The long term nature shows that it was a stable process, where knowledge and collaborative relationships were allowed to build up over time. In this, three outcomes emerged which went beyond both the embankment group and the municipality's guiding assumptions and resulted in for them unexpected insights (i.e. double loop learning):

*4.4.1. New system boundaries for flood risk management*

Initially, the embankment group took the learning initiative, by challenging the assumptions of safety, but with new information from MSB which meant preparedness for a 10,000-year flood, the initiative came from MSB. "*They (MSB) said: it is good that you want to do something, but its too little. Now we had to change our original focus on a 1.5 km long embankment to look at 10 km stretch due to the low lying situation of Kristianstad. The water could enter from behind as well, and we had to redirect our efforts completely in the whole project*" (Zerpe, personal comment). The problem had unexpectedly increased its boundaries with implications for a larger geographical area. This resulted from communication across organisational levels (local and national), which is said to stimulate learning (Lee, 1993). However, the underlying paradigm continued to be the same; that embankments were the foundation of the municipality's strategy to reduce flood risk. "*The only difference is that we build an embankment that is going to last longer and perhaps building it a little more scientifically*" (Wettermark, personal comment).

*4.4.2. Institutional integration and awareness of the collective strength in the municipality*

The 2002 flood created a window of opportunity (Kingdon, 1995) enabling political prioritisation of the flood issue which resulted in institutional integration and collaboration within the municipality. "*At the same time as we pushed for this issue with the politicians, and they were deliberating about the consequences of a flood, the flood in 2002 arrived*" (Zerpe, personal comment). An extreme event thus contributes to motivate learning as actors got the feeling that there is an urgent need to solve an important problem (Leeuwis, 2002). After the flood in 2002, the rescue service experienced that it virtually moved closer to the other departments, through increased cooperation, and integration of the flood issue in the whole municipality, which also inspired and empowered individuals. "*We have learnt what effective cooperation can lead to/. . ./We have understood that there is an incredible competence and internal strength in the municipality. We have been able to work as both planners and operative in the field, and we experience the enormous knowledge that is in the municipality when it is gathered in the right forum*" (Zerpe, personal comment).

*4.4.3. Public information policy*

The flood in 2002 raised awareness of flood risks for many actors in Kristianstad. The politicians were informed daily about the situation and participated in daily press conferences, publically declaring the flood risk (Kristianstads kommun, 2002). "*The embankment project got a boost and openness, which is one of the great differences. After 2002 it is a totally open dialogue towards the public and within the municipality compared to before*" (Wettermark, personal comment). Before 2001 only a few civil servants in the municipality knew about the risk, and only two politicians. The municipality's policy was also to keep the risk unannounced to the public. In 2002 a much more open approach was adopted towards decision makers as well as towards the public when the whole municipality executive board (about 12 politicians from the largest five political parties) was informed for the first time. With the public, this did not seem to cause any panic, but was more an opportunity to raise own concerns and suggestions for solutions. A conscious strategy formed of an open dialogue with the public as one of the ways to create willingness for taxpayers to support the project.

*4.5. The common purpose – has adaptive capacity been enhanced?*

The common purpose in this social learning process has been to safeguard the city from the flood risk. To help us analyse the adaptive capacity resulting from this, we constructed a 'staircase of adaptation' (Fig. 9) which illustrates the main strategies taken or not taken to reduce the flood risk to Kristianstad. Step 1 represents the existing buffer capacity of the wetland and the flooded meadows, a traditional feature of the cultural landscape illustrated by Figs. 3 and 4. The buffering function is acknowledged by the embankment group. However, it is not an active strategy they have taken, but already provided by the wetland without costs for them. The cooperation with the Biosphere Office since 1989 has contributed to an improved appreciation of the wetland values: "*I have got a completely different understanding now, which I did not have from the start, when the wetland was just something to dredge and fill up, I can admit that*" (Simonsson, personal comment). In step 2 embankments and pumps are protecting Kristianstad city, especially at extreme water levels. As mentioned, this is the core strategy to reduce the flood risk. Although current city planning assumes safety, the embankment group recognises the futility in total flood control over the long term, because the embankments may fail 1 day. Attempts to control floods have indeed resulted in more vulnerable systems e.g. in India, China, Vietnam, and the Netherlands (Immink, 2007; Dircke and Immink, 2007). Particularly in developed landscapes with insufficient buffer capacity, there is a limit to how much water can be controlled (Remmelzwaal and Vroon, 2000). As illustrated by Kristianstad, embankments are also costly, often making total flood control an unfeasible solution (Cuny, 1991).

Urban planning (step 3) in Kristianstad is somewhat adaptive (e.g. escape routes, flood proofing cellars, retention areas, adapting storm water systems and urban drainage), but does not at all reflect 'flood proofing', 'Aquatecture' or other water based urban planning frameworks or concepts used in other countries since some time assuming water will enter (Wylson, 1986; Roggema et al., 2012) e.g. stationary elevated houses, floating and/or mobile housing for fluctuating water levels (Flesche and Burchard, 2005), relocation of sensitive activities from the flood risk area (Andjelkovic, 2001). The rationale for exploring innovation by flood proofing seems absent in Kristianstad most likely because the embankments and pumps are expected to protect the city. MSB and the embankment group have expressed concerns about recent building activity in low lying areas, which indicates that city planners do not always prioritise according to flood risk.

In 1996 when the embankment group discussed different measures to mitigate the flooding they also looked at what could be done upstream (step 4). An early warning system was developed. But as there are no major dams regulating the flow of Helgeå, they concluded that measures would either be inadequate or controversial (e.g. building a large dam in another municipality). To reduce the flood risk the main problem in Kristianstad is very much the slow rate with which the water is drained from the city to the sea. At high sea level the lower-part of the river may even change direction and flow upstream. The embankment group does however acknowledge that there could be better river basin coordination. There are some existing mechanisms for coordination in Sweden already, but neither of them have yet been regarded as relevant for flood risk reduction in Helgeå. These are Water councils ('Vattenråd') under the EU Water Framework Directive focusing mostly on water quality, and River groups ('Älvgrupper') coordinating large dam discharge.

Despite attempts by the embankment group to explore alternative strategies for flood risk management, the municipality would need to change worldview to a flood proofing paradigm in order to increase adaptive capacity. It would also require a shift in discourse for river basin measures. Both of these are beyond the embankment group's or even the municipality's mandate and capacity, instead requiring political initiative at the national level.

## 5. Discussion

The social learning process present in Kristianstad shows many interesting features: Its effectiveness in identifying risk and challenging commonly held assumptions; responding with concrete actions; with the main driver being a small and homogenous group of professionals guided by their own observations on the job. As the drive and initiative came from inside the organisation at the operational level it represents an important 'strategic innovation capacity' (Berghman, 2006) which was harnessed and given the opportunity by the decision makers. This is an important function in times of environmental change. Spontaneous learning at all levels of an organisation occurs naturally, but it is up to the organisation to facilitate communication of such learning and make use of it (Westley, 1995). Many models have been presented for learning in the water-environment sector (see Table 1) and we believe that the Kristianstad case study presents ideas for an additional model of spontaneous learning triggered by expertise at the operational level (by an 'action group'). Supporting such spontaneous learning from inside an organisation may perhaps be

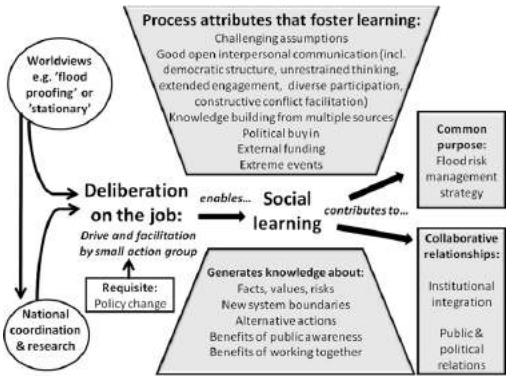


**Fig. 8.** The social learning process and its elements. Adapted after Schusler et al. (2003). The circled text represents areas of recommended improvements.

a more effective strategy compared to the externally facilitated approach.

This case study has shed some light of the specific mechanisms at work, which may also assist in recreate such processes in practice (Reed et al., 2010). The outcomes appear to be very much determined by the worldviews being put into the process and therefore we emphasise worldviews in our model (Fig. 8).

This case study partly supports the argument made by Pahl-Wostl et al. (2008) as the social learning improved capacities for sustainable resources management, and opened up opportunities for future learning. The new embankments and the two intangible social learning outcomes i.e. institutional integration and information policy in Kristianstad do constitute improved adaptive capacity, but these outcomes may deteriorate. After a certain period of time, society tends to forget about risks associated with infrequent events and as a result awareness may decline (Arthurton, 1998). The embankment group is already sensing this trend, with the delays and low priority of the project in the latest budgets (Pålsson, personal comment). The current projected delay is now 3 years and with an increase of 100 million SEK since its inception (C4 Teknik, 2000).

This case study also supports the argument made by Reed et al. (2010) that social learning is not sufficient for sustainable development and adaptive approaches. There is no doubt that embankments are necessary for the security of Kristianstad. But we believe that over the long term, assuming safety behind embankments may in this way enhance vulnerability as the city continues to develop behind them, not taking enough attention to other measures such as flood proofing of housing on low lying grounds which have been part of adaptation in other countries (Kundzewicz, 2002). This increases the size of the catastrophic consequences in case of a break in the embankments, although this probability may be very small.

The interviews with key actors at the local and national levels reveal what Ulrich Beck calls 'organised irresponsibility' where risks and responsibilities are delegated to fairly open political processes in society (Matten, 2004). Triple-loop learning – changing the mental model towards an adaptive paradigm of flood proofing ('living with floods') – would require that the learning process in Kristianstad is nested within a learning framework at higher levels. This puts the spotlight on the importance of the balance between top-down and bottom-up processes in water management, also pointed out by Huntjens et al. (2011). In this case, we argue that the balance needs to be shifted towards increased centralised coordination. Sweden has traditionally a decentralised approach, where municipalities are given a lot of independence or 'delegated responsibility' for local strategic decisions, exemplified by recent climate change adaptation strategies (SOU, 2007:60; Prop 2008/09:162). To overcome the 'organised irresponsibility' a new multilevel learning and governance approach could still allow local adaptations to emerge, but provide much more national coordination of learning and resources (Fig. 8). Three observations can be made.

First, stronger policy directives on integrated planning from the national level are needed. For example, the 2008 Swedish Planning and Building Act (PBL), monitored by the Swedish National Board of Housing, Building and Planning (Boverket), prescribe the consideration to natural hazards in construction permits and zoning. This law has already had an impact on physical planning in Swedish municipalities (SKL, 2009) and it was further sharpened in May 2011. Still, the learning process in Kristianstad, although successful in its own right, has had a difficulty addressing a shift in thinking towards more adaptive physical planning. This lack of adaptability at the municipal level may reflect a lack of capacity at the national level, providing a barrier for more profound change, or triple loop learning (Hargrove, 2002). To address this, we think a national integrated flood risk strategy needs to be developed, which among other things, considers all steps in the adaptation staircase (Fig. 9). A national strategy would consequently encourage a more multi-sectoral collaboration of various professionals at a local level (from ecologists, physical planners and regional administrators), combining different knowledge systems, worldviews and paradigms, and integrating measures. The implementation of the EU Floods Directive (EG 2007) has triggered interest to work more integrated in the river basin on floods and nutrient management through water retention. But how this should be done or financed, is a difficult question (Dobak, personal comment).

Second, the national financial and expert support to water adaptation is insufficient. Some of the most flood prone municipalities like Kristianstad and Arvika agree that there are unrealistic demands on the individual municipalities who are often left on their own to make important decisions and experiment with adaptive measures, exposing them afterwards to criticism. The embankment group has expressed frustration over the lack of

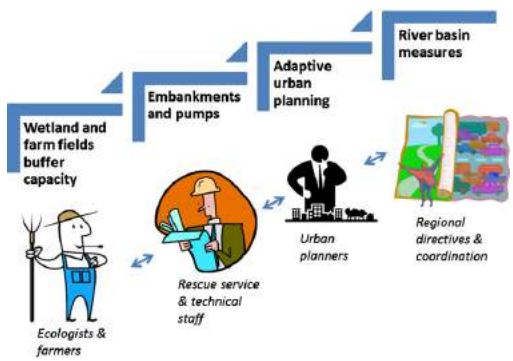


**Fig. 9.** The 'adaptation staircase' shows the different flood management strategies which Kristianstad applies: (1) Existing buffer and storage capacity in surrounding wetland and farm fields. (2) Embankments and pumps, first focusing on a 1.5 km long embankment, later on a 10 km stretch adjusting for the 10,000 year perspective. (3) Urban planning adaptations. (4) Upstream measures. Each step has its own professional actor group and collaboration and dialogue are mechanisms for integration of the strategies.

support instruments from national level relevant for them. Such support is instead available through collaborative EU projects such as Living With Flood Risk in a Changing Climate (FLOWS) and Climate Proof Areas (CPA) (SKL, 2009).

Third, our findings boil down to a need for capacity-building in research and expertise. In comparison to England, The Netherlands and Germany, funding to flood research in Sweden is almost negligible (CRUE ERA-NET, 2007). This reflects how densely populated countries with a high level of 'control' by canals, dredging, embankments on water flows have had to learn how to reverse some of these measures and explore more adaptive and innovative paradigms by necessity (Kundzewicz, 2002). This may explain why Sweden is lagging behind but it also means there is a great potential for Sweden to benefit from these countries' research efforts and learning from their experiences. Instead, when Kristianstad is regarded as a role model and acting as a climate coach to other Swedish municipalities, this only strengthens the 'stationary principle' paradigm. The existing platforms for sharing and exchange can be helpful here, such as the Swedish Association of Local Authorities and Regions (SALAR) and the Swedish National Platform for Disaster Risk Reduction, as well as the international 'Resilient cities' campaign (UNISDR website) which Kristianstad signed up to in 2011.

## 6. Conclusions

We have identified the importance of a non-facilitated learning process harnessing local strategic innovative capacity in flood risk management. We conclude that the social learning process in Kristianstad was successful within the given local institutional framework and resulted in three major outcomes: embankments with new system boundaries for flood risk management, institutional integration and a new information policy. However, this process was not able to change the prevailing 'stationary' principle, or paradigm, of 'feeling safe' behind the embankments. The shortcomings can in part be attributed to the lack of knowledge and initiatives at the national level resulting in lack of integrated flood risk frameworks balancing infrastructural 'stationary' measures with more adaptive solutions. Our findings suggest that Sweden has much to gain by learning from other countries with relevant experience. The transition from the 'stationary' to a flood proof paradigm for Swedish municipalities will require experimentation where national agencies need to take a much more active role. One important challenge is to develop adequate support to key persons driving such local social learning processes as we have studied here.

## Acknowledgements

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# Paper IV

*Manuscript submitted to an international scientific journal*

# Social learning for resilient urban water services: the case of floods

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*Keywords: social learning, resilience, urban water services, water resources management, flood risk management, adaptive governance, climate change*

# Abstract

Basic, equitable access to safe drinking water and sanitation in urban areas is increasingly challenged by stressors such as floods, scarcity, salinization, and pollution. These pressures are often managed by separate sectors and communities of practice. In recent years, social learning has become increasingly popular as a potential way to bridge such silos to, ultimately, support adaptive management and resilience. However, empirical studies are few and fragmented. Against this background, the purpose of this paper is to increase the understanding of the role of social learning in building resilient urban water services. We adopt a multiple case study approach conducted in urban, flood-prone areas of Cali (Colombia), Gorakhpur (India), Durban (South Africa), Kristianstad (Sweden) and Cebu (The Philippines). We identify two key areas of social learning (risk awareness and action capacity), and examine their supporting and inhibiting factors in detail. The results show that social learning is mainly successful in risk awareness, and that greater attention needs to be given to action capacity. This could take the form of: 1) addressing underlying risks in relation to extreme events; 2) effective communication and trust between key stakeholders, 3) individuals who act as champions; and 4) the integration of ecosystem-based approaches into existing knowledge, bringing together different expertise; and 5) providing multilevel coordination and guidance. We conclude by presenting a model to foster social learning and resilience in urban water services, which is unlike the traditional, engineering perspective. Finally, we offer some recommendations for policymaking, and identify future research areas. Our results are relevant for urban water practitioners, as well as national and international policymakers.

# 1 Introduction

There is an increasing need for integration, collaboration and learning between sectors and actors in order to address the complex issue of natural resources management (Pelling and High 2005; Pelling et al. 2008; Johannessen and Hahn 2013; Folke et al. 2005; Pahl-Wostl 2009). The latter includes ensuring the sustainability and resilience of urban water services (e.g., Rockström et al. 2014; IPCC 2012; UNISDR 2012). Action is needed in a context of rapid urbanization (United Nations 2014), climate change, and stressors such as floods, scarcity and contamination, which threaten basic, equitable access to safe water and sanitation (IPCC 2012; Parkinson 2003). This is especially relevant since urban sprawl continues into low lying flood prone areas, which has made flooding an increasing occurrence (CRED and UNISDR 2015). Social learning is understood as a mechanism that can 'bridge' water management silos, and influence the resilience and effectiveness of urban water services (Feurt 2008; Pahl-Wostl et al. 2007). It occurs when stakeholders or actors in social networks, with different perspectives and information deliberate, reflect and take action together (Keen et al. 2005; Koontz 2014; Reed et al. 2010). In doing so, their understanding changes, and extends beyond the individual to the collective. Social learning can, for example, support decision-making processes (e.g. Thorne 2014; Pearson et al. 2010), upscale innovations (Sutherland et al. 2012) and enable transition management (Bos et al. 2015; Loorbach and Rotmans 2010).

However, there are two major challenges to the application of the social learning concept in research, policy and practice. The first concerns identifying empirical evidence based on a workable definition (Reed et al. 2010), and then evaluating it (Benson et al. 2014). The other is the inconsistent use that is made of social learning in different disciplines. For example, natural resources management often requires a focus on the process of establishing a consensus, and evaluating appropriate alternatives with stakeholders (Daniels and Walker 2001). With some exceptions (e.g.

Lorenzoni et al. 2016), this approach is rarely adopted in risk management, where the debate has been dominated by risk assessments based on models and investigations, together with prescribed solutions (Daniels and Walker 2001; Johannessen and Hahn 2013; Johannessen and Granit 2015).

Against this background, the aim of this study is to examine a sample of social learning processes in order to assess their role in increasing the resilience of urban water services. *Resilience*, in this context, refers to aspects of dynamic transition (transformation) processes that are driven by social learning. This paper focuses on two aspects, taken from the social-ecological literature: 1) an adaptive capacity for the system to *self–organize* (or evolve) over time, triggered by changes in the environment or its internal capacities (Walker and Salt 2012). If the system is unable to self-organize and cannot recover, for example due to unmanageable crises or other disturbances, the process involves: 2) the passing of *thresholds* (Walker and Salt 2012). Thresholds are relevant to social processes in that they specify a critical mass that is needed to push a process or system into another state resulting in, for example, social movements or political decisions (Werners et al. 2013).

This study focuses on five flood-prone areas in four continents: Cali (Colombia), Gorakhpur (India), Durban (South Africa), Kristianstad (Sweden), and Cebu City (The Philippines). In the following sections, we present the analytical framework, the methodology, and the results, before we conclude with some policy recommendations and ideas for future research.

# 2 Analytical framework

This section presents the analytical framework. It describes how resilient urban water services are related to: i) external pressures or disturbances, such as floods; ii) different water management approaches and their actions (i.e. both integration and on-the-ground actions/ measures); and iii) learning areas or thresholds, described below (Figure 1).

External pressures or disturbances refer to natural hazards. These include all types of floods found in urban areas (e.g. pluvial, flash, coastal and river flooding), and other water stressors, such as scarcity, pollution and contamination. Handling these pressures is usually the job of flood risk (de Bruijn 2005) and water resource (GWP 2000) managers. Historically, actors in water resources management have been ready to adopt new approaches to building resilience, in order to learn and adapt in a context of change and uncertainty (Berkes et al. 2003). This ability relies on stakeholder participation in order to support, for example, adaptive management (Pahl-Wostl et al. 2007; Raadgever et al. 2008) or adaptive co-management (Olsson et al 2004; van Herk et al. 2015). The principle rationale for their adoption is to systematically improve management policies and practices by learning from experience, and be able to adapt to new information or changing circumstances (Pahl-Wostl et al. 2007; Raadgever et al. 2008). This flexibility fosters a bottom-up approach that can increase buy in, especially when stakeholders feel they have an influence in the process outcome (Benson et al. 2014).

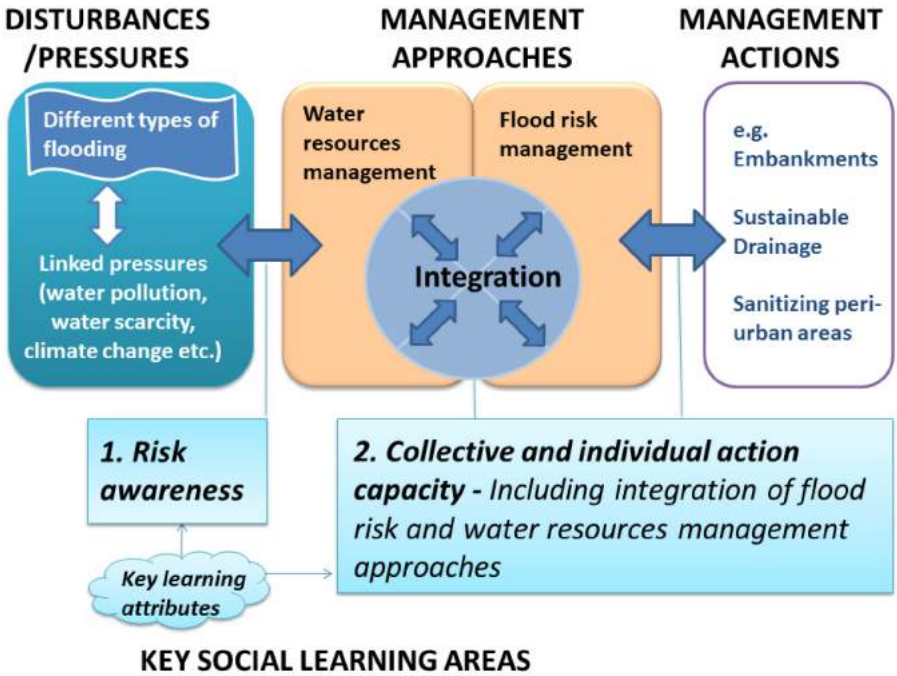


**Figure 1: The conceptual framework describes resilient urban water services as a process of social learning with two main learning areas:** 1) awareness of risk associated with pressures or disturbances; and 2) collective and individual action capacity, including management integration. The two learning areas are characterized by key attributes.

It has been argued that social learning is a key element in increasing resilience and adaptive management (Pelling et al. 2015; Medema et al. 2014). According to Reed et al. (2010) social learning requires three elements: 1) A demonstrated change in understanding; 2) a change which goes beyond the individual to become situated within wider social groups within society, or communities of practice; and 3) a change which occurs through social interactions between actors within social networks.

Two, interlinked, learning areas, related to the concept of thresholds in resilience theory, are said to be crucial to support resilient urban water services. These are: 1) risk awareness; and 2) individual and collective action capacity (Johannessen and Wamsler 2017). Risk awareness refers to an enhanced risk perception that prompts a particular water management approach (e.g. flood protection). Action capacity refers to the adoption of

new management approaches and actions that constitute a response to the pressures on the services being managed (Johannessen and Wamsler 2017). These actions can take the form of coping with new pressures, altering the pressure, or even altering the underlying driver to remain within acceptable limits. This is similar to the Driving forces, Pressure, State, Impact, Response (DPSIR) framework, which is often used to describe relationships between the origins and consequences of environmental problems (Smeets and Weterings 1999). It also includes learning-related aspects that foster inter-sectoral or multi-level integration/ mainstreaming (Wamsler 2014). Within each of these two learning areas, a range of key attributes can support social learning, as suggested by Sharpe et al. (forthcoming), Johannessen and Hahn (2013), Schusler et al. (2003), and Tippett et al. (2005). These key attributes are summarized in Figure 2.

| **CONTRAST/SIMILARITIES** | **EXTERNAL INFLUENCE** | **STRUCTURE** |
|---|---|---|
| Different ways of thinking<br>Negotiation<br>Opposition<br>*(Lack of) diverse participation*<br>Diversity<br>Shared belief systems | External funding<br>*(Risk of) extreme events*<br>Context<br>Natural environment<br>*Political buy in/will* | Facilitation<br>*(Fragmented) governance structure*<br>*Informal relational spaces*<br>*Cultural space*<br>*Formal relational spaces*<br>*Democratic structure* |
| **SOCIAL QUALITIES** | **RELATIONAL QUALITIES** | **DRIVERS** |
| Social involvement<br>Network of communications<br>Partnering<br>Engagement<br>Participation<br>*Knowledge building from different sectors*<br>*Networks*<br>Relational practices<br>*Reciprocity/Feedback*<br>Deliberation | Openness<br>Unrestrained thinking<br>Reflectivity<br>Flexibility<br>Challenging assumptions<br>Trust<br>Effective interpersonal communication | Opinion leaders<br>Technical qualities<br>Leadership<br>Content management<br>Extended engagement |

**Figure 2: Key attributes of social learning processes.** Italics refers to attributes that are analyzed in this paper.

# 3 Methodology

We adopt a multiple case study design (Yin 2009). Case studies were selected based on two criteria: i) geographical spread; and ii) the potential to collect empirical data at individual, urban and river basin level. Purposeful sampling was applied to select interviewees, and ensure that stakeholders represented the full range of perspectives, key competences and knowledge (Powell and Larsen 2012). The final sample included politicians and municipal staff (e.g. city council members, city planners, environmental planners, and water and sanitation specialists), private sector organizations (e.g. water and wastewater operators, environmental inspectors), and civil society representatives.

Empirical qualitative data were collected from November 2013 to November 2015 using semi-structured interviews (Kvale and Birkmann 2009). All interviews were recorded and transcribed. The number of interviews ranged between 7 and 17 in each case study. Questions addressed perceptions of: 1) general vulnerabilities in the water services system, and associated management practices; 2) the relationship between system vulnerability and social factors; 3) risk assessment mechanisms; 4) system resilience, notably organizational ability to reduce risk, respond to pressures, and build adaptive capacity; 5) existing water management collaborations; and 6) existing learning processes, for example, changes in understanding and their causes.
A project workshop was held that brought together all case study researchers. The analysis process began with the identification of the key attributes of social learning (Section 2, Figure 1, Figure 2). Only those attributes that were consistent with the outcome of the case studies were selected for further analysis (shown in italics in Figure 2). Next, an in-depth analysis of the data identified evidence of social learning (as defined by Reed et al. 2010). This was facilitated by the fact that some case studies had already identified such evidence, e.g. Gorakhpur (Wajih et al. 2010), Kristianstad (Johannessen and Hahn 2013), and Cali (Hernández Vivas 2014). Finally, the third analysis explored the presence of factors that supported or inhibited either risk awareness or action capacity, or both (Section 2, Figure 1).

# 4 Results

The results describe factors that support or inhibit either risk awareness or action capacity, or both. Table 1 presents the local contexts for the comparison of the five case studies. Figure 3 summarizes the findings identified in the analysis.

## 4.1 Supporting factors

This section describes factors that supported risk awareness or action capacity, or both. One risk awareness supporting factor was identified: the increased (risk of) extreme events and water-environmental degradation. Building knowledge from different sectors (integrating ecological knowledge) and actors, supported action capacity. Three supporting factors were found to influence both areas: 1) the (risk of) extreme events; 2) effective communication and trust; and 3) the important role of individuals with visionary leadership. These are described in more detail in the following sections.

### *4.1.1 Risk awareness: Identification of the increased (risk of) environmental pollution*

Identification of the increasing (risk of) environmental pollution was shown to be an important supporting factor. Three case studies (Cebu, Durban, and Gorakhpur) found the biggest risk factor to be the living conditions in informal peri-urban areas, which were affected by a variety of diseases, epidemics and anti-social activities. The same areas reported issues of over-extraction, salinization and pollution. In Durban and Cebu, officials were aware of the inadequate state of water resources, and its effects on the living conditions of poor urban communities through monitoring and local reports. Nevertheless, insufficient measures had been implemented to change the situation. In Gorakhpur, this awareness was reported to be even lower.

**Table 1: Overview of the local context in the case study areas.**

| CASE STUDY | PRESSURES / DISTURBANCES / (HAZARDS) | PRESSURES / DISTURBANCES / (WATER RESOURCES ISSUES) | URBAN WATER SERVICES |
|---|---|---|---|
| **Cali, Colombia** (about 2, 300, 000 inhabitants)<br><br>Hernández Vivas (2014) | Floods exacerbated by La Niña. Intense rainy season affects the urban area due to flat topography, low capacity of the surface to absorb large volumes of water and increasing volume of river water. | Pollution of Cauca River. Informal settlements on the Aguablanca dike, which are being relocated; insufficient water and sanitation services. | Water sources are Cauca, Cali, Meléndez and Pance rivers. |
| **Gorakhpur, India** (700, 000–1, 000, 000 inhabitants)<br><br>Andersson (2015) | Frequent flooding, waterlogging, drought and other water-related problems caused by extreme precipitation. | High levels of arsenic and fluoride in groundwater. Lack of drinking water, open defecation, inadequate sanitation. Untreated wastewater in drains discharges into nearby water bodies. Situation especially grave in the 100 slums: 33% of the inhabitants. Waterlogging issues due to building in wetlands and flood-prone areas, and poor solid waste management. | Groundwater is the main source of drinking water. Only 22% of the urban area is connected to sewage facilities. There are two sewage treatment plants. |
| **Durban/ eThekwini, South Africa** (about 595,000 people in the inner city and 3.4 million people in the eThekwini Municipal Area (EMA).<br><br>Arran et al. (2015) | Flash floods, with informal settlements being the most severely affected. Coastal erosion and associated property damage due to tidal surges and storm. Frequent droughts. | Unsanitary conditions, especially in peri–urban areas (backyard shacks: 34%; and rural households: 12%). Significant lack of basic infrastructure, worsened by high population density, lack of space and land, and poor environmental conditions. Rivers are heavily polluted. | The Umgeni river mainly supplies Durban's piped water. 63.4% of the population has access to a flushing toilet connected to the sewer system, which is very susceptible to stormwater inflows. Sewage is treated by 13 wastewater treatment plants and discharged into rivers. |
| **Kristianstad, Sweden** (30, 000 inner city, and 80,000 municipality residents)<br><br>Johannessen (2015) | River flooding and difficulties in draining into the sea. Several embankments raised to protect against river floods. Intensive rainfall leads to urban flooding (urban area is low-lying and embanked). | Issues include eutrophication and brownification of river water, increasing pressure on groundwater resources, pollutants in groundwater. | All drinking water is sourced from groundwater.<br><br>There is 100 % access to clean water and sanitation sewage connections. |
| **Cebu, The Philippines** (870, 000 people in Cebu city and 1.4 million in Metro Cebu)<br><br>Johannessen and Peter (2015) | Typhoons, storms, floods, earthquakes. | Groundwater is subject to seawater intrusion, (salinization) overextraction, and contamination from human waste. Rivers are heavily polluted. The drainage system is mainly based on pipes that are blocked by siltation and garbage. | Groundwater is the main water source. Most households are not connected to sewage systems. One waste treatment plant was opened in 2014. |

### *4.1.2 Action capacity: Building knowledge from different sectors and actors*

Building knowledge from different sectors, notably integrating ecological knowledge, but also from different actors, was identified as an supporting factor. For example, in Cali, it was initially perceived to be difficult to engage actors from 'formal spaces' (e.g. environmental management, water management, land-use planning and disasters prevention) in flooding issues. However, a planning initiative for the Cauca river basin triggered cross-sectoral dialogue and learning. An actor from the regional environmental authority stated: "[…] *At the (initiative) forum, engineers were able to listen to biologists [...] that generates knowledge [...] it makes up the process of collective construction*". In Kristianstad, planners noted that involving the right people from relevant sectors from the beginning avoided delays and conflict later in the process. Furthermore, effective communication and increased trust (see below) with the environmental department had led some risk managers to completely change their attitude to wetlands, which in turn influenced their actions to some extent (Johannessen and Hahn 2013).

### *4.1.3 Supporting both learning areas: (Risk of) extreme events*

The assessment highlighted that the risk of extreme events was a generic supporting factor. In Cali and Kristianstad, learning processes, leading to widescale action, were reported in relation to river floods. In both areas, the process was triggered by concern for the safety of embankments and their infrastructure (Johannessen and Hahn 2013; Hernández Vivas 2014). In Kristianstad, planners also learnt from 'monster' rain in the urban areas of Copenhagen (Denmark) and Malmö (Sweden), which led to a new focus on urban flood management and modelling of extreme rainfall, as the areas are part of the same meteorological region. In Cali, abnormally high rainfall in 2010–2011 had highlighted the severe socio-economic consequences of the overflow of the Cauca River, followed by a broken dike. Here, potential damage related mainly to water supply and waste treatment infrastructure, while in Kristianstad it related to waste water treatment. Several stakeholders described the risk of the extreme event combined with political will as a learning opportunity. In both cases, the outcome was better risk awareness, a change in perceptions, and the reinforcement of embankments (Johannessen and Hahn 2013; Hernández Vivas 2014). In Cali, it also led to the creation of institutional disaster risk management mechanisms, notably the National Adaptation Fund. This was designed to foster cooperation between local, regional and national actors with a stake in flooding, and fund the

reinforcement of the Aguablanca dike. In Kristianstad, it also led to the integration of institutions into municipal planning.

In Cebu, disaster events, such as the typhoon Yolanda in November 2013, were perceived to have helped to move risk issues (in terms of climate adaptation in urban planning) up the policy agenda (i.e. policy integration), when earlier efforts had been unsuccessful.

In other cases, crises triggered measures to address environmental problems (Section 4.1.1), which had not been actioned previously. For example, in Durban, a cholera outbreak in 2000–2001 highlighted the considerable gap between the promise of basic municipal service delivery and reality, and sparked an intense debate on sanitizing rural peri-urban settings. This learning triggered action, for example in the form of the Disaster Management Act, which provided management structures to deal with the crisis (Hemson and Dube 2004).

#### *4.1.4 Supporting both learning areas: Effective communication and trust*

Effective communication and trust supported both learning areas, especially in Kristianstad, Cali, and Cebu. For example, in Kristianstad, dialogue between municipal departments fostered learning about problems and solutions, while effective communication between municipal planners and policymakers was supported by trust. In Cali, the Adaptation Fund provided a platform for dialogue between actors. It facilitated sharing of knowledge, learning and cross-scale coordination. From this, spaces emerged, such as a technical network, that encouraged informal communication, which was regarded as effective. The Fund's work was characterized by trust and reciprocity, which was perceived to accelerate discussion and provide better information. In Cebu, effective communication proved to be an supporting factor that motivated communities to participate in learning processes. This was based on building trust, a sense of ownership and respecting their views.

#### *4.1.5 Supporting both learning areas: The role of individuals and visionary leadership*

Individuals and visionary leadership played an important role in both learning areas. For example, in Cebu and Durban, individual champions facilitated micro-resilience planning initiatives, triggering learning within communities. In Durban, local leaders were hailed as heroes due to their ability to encourage resourcefulness, support learning and creativity, and encourage

engagement. A community member involved others in a river stewardship initiative where they learnt about undesirable activities and pollution, Similarly, efforts to raise the profile of climate adaptation were driven by individuals who influenced others, in order to slowly change institutional attitudes. In Gorakhpur, an organization acted as a catalyst for learning (Wajih et al. 2010). In Kristianstad, initiatives taken by a few leading individuals were reported to be supported by a cohort of competent, younger people, together with opportunities for training, discussion and openness to new ideas.

## 4.2 Inhibiting factors

This section presents factors that appear to inhibit risk awareness and action capacity. Unsurprisingly, lack of awareness inhibited the learning area of risk awareness. Three factors appeared to inhibit action capacity: 1) economic power; 2) fragmented governance; and 3) conventional solutions/ lack of innovation. Factors inhibiting both learning areas were identified as: 1) distrust due to corruption, misuse of power and prestige; 2) capacity constraints; and 3) cultural hierarchies and patriarchy.

### *4.2.1 Risk awareness: Lack of awareness*

A lack of risk awareness was found to be a inhibiting factor. For example, in Gorakhpur, there was a perception of a lack of awareness of the importance of water and sanitation infrastructure, its maintenance, and the health risks of open defecation (Wajih et al. 2010). This was, in turn, associated with a lack of community resources (poverty) and property rights, and thus the inability to invest in toilets. Creating awareness among decision makers was seen as crucial, as political will is a critical factor in improving systems. At the same time, awareness was thought to have improved somewhat over the past 20 years.

### *4.2.2 Action capacity: Economic power*

In this context, a inhibiting factor was the overriding role of economic power in development. In Durban, many decision makers were aware of the unsanitary conditions and toxic environment in informal areas. One ward councilor said: "*Most of the [risk] factors are health risk factors. For instance, the municipality has built the transit camps on toxic soil [in close*

*proximity to industry and flood prone water bodies] ... which is dangerous especially for young children and in that transit camp over 100 children have died because of that hazard and the municipality is well aware of that*". However, there has been little change because polluting industries (predominantly petrochemical) are powerful actors in the economy, (and the affected populations not) and therefore are not pressurized into providing cleaner technologies. In Cebu, interviewees expressed a sense of hopelessness, as they did not think it was realistic to demand powerful urban developers to take action. Similarly, in Kristianstad, socio-economic priorities dominated; here, interviewees mentioned that flood risk was often low down on the political agenda.

### *4.2.3 Action capacity: Governance challenges and lack of resources*

Governance challenges were found to inhibit action capacity. In Kristianstad, despite an ongoing flood risk management learning process, the approach remained predominantly focused on local, structural solutions (Johannessen and Hahn 2013). With respect to the river basin, a inhibiting factor was the decentralization of risk governance to the municipality, which represents only one, downstream part of the system (ibid). This was in exacerbated by a lack of integration, and hence support for more adaptive solutions at national level (Johannessen and Granit 2015). Governance challenges were also reported in Gorakhpur when trying to upscale local efforts to build micro-resilience. A major cause was a lack of integration at higher levels. Therefore, the need to link and coordinate different sectors and levels (ward – urban area – state – national) was identified as a crucial issue in building urban resilience by the local NGO Gorakhpur Environmental Action Group (GEAG), who led a pilot micro-resilience planning project. In Durban, challenges included a resistance to collaboration between different sectors and thus learning, exacerbated by a lack of both financial and human resources within departments.

### *4.2.4 Action capacity: Conventional solutions/ lack of innovation*

Lack of innovation was found to be due to a lack of input from other sectors. In Gorakhpur, the overall flood risk management approach is structural. Embankments provide protection from river floods (TERI 2012), and planned measures include, for example, installing drainage culverts. Conventional solutions dominate, due to a narrow definition of development that is limited to infrastructure, for example, the construction of bridges, roads or hospitals. More innovative measures, such as water retention, are not included in the official paradigm.

Similarly, conventional approaches dominate in Cebu, despite a good level of awareness of the flood and water resources issues. Interviewees reported the growing amplitude of urban floods due to an increase in paving and reduction in groundwater infiltration. Nevertheless, the official focus remains on storm pipes draining into the rivers and the relocation of vulnerable communities. Neither of these measures address the problem of over-extracted and degraded groundwater resources. Efforts had been made by a local institute to advocate a Sustainable Urban Drainage Systems (SUDS) that aimed to improve groundwater recharge, but one interviewee stated that they had "hit a wall" trying to promote it. At the same time, interviewees from the drainage department said they were unaware of the this approach to drainage. Instead, they had understood from Cebu's role model city in this matter, Yokohama, Japan, that they needed to construct even bigger big storm pipe solutions, (Pantaleon and Bongcac 2013).

#### *4.2.5 Inhibiting both learning areas: Corruption, (political) misuse of power, and prestige*

Corruption, and political misuse of power were generic inhibiting factors. In Cali, corruption and political maneuvering had, for instance, created considerable distrust in formal governmental institutions. The Adaptation Fund was seen as a welcome initiative that offered transparency and supportd learning. In Durban, although governance was found to be adequate, enforcement was difficult due to corruption and financial gain. For example, authorities had given consent to build on areas designated as illegal, where there are informal settlements. In Kristianstad, dialogue with stakeholders was criticized as one-way, and illustrative of a power asymmetry. Interviewees highlighted that personality had played an important role in preventing action. This was attributed to personal prestige and territory, which were seen as barriers to working together.

#### *4.2.6 Inhibiting both learning areas: Institutional capacity*

The lack of long-term capacity building was found to be linked to issues of discontinued institutional capacity. For instance, in Gorakhpur the local administration's inefficiency, and a lack of vision and accountability were identified as challenges. One reason for this appears to be the frequent transfer of government officials; one director stated: "*It needs to be recognized that building capacity in the governance system is a long-term process*". Similarly, funding was perceived to be a inhibiting issue, not in

absolute terms, but in relation to prioritization and allocation, linked to the issue of capacity. In Durban, the expansion of the municipality was followed by a significant reorganization, which lead to siloed organizational structures that severely impacted service delivery.

*4.2.7 Inhibiting both learning areas: Cultural hierarchies and patriarchy*

Cultural hierarchies and patriarchy were found to be generic inhibiting factors. For example, in Durban, the legacy of apartheid and ongoing affirmative action policies were influencing resilience building at regional scales. Challenges appears to originate in a brittle social fabric that has been made vulnerable by urban immigration, poverty, unemployment and crime. Cultural hierarchies, patriarchy and tribal affiliations remain both prevalent and influential, particularly in informal settlements.

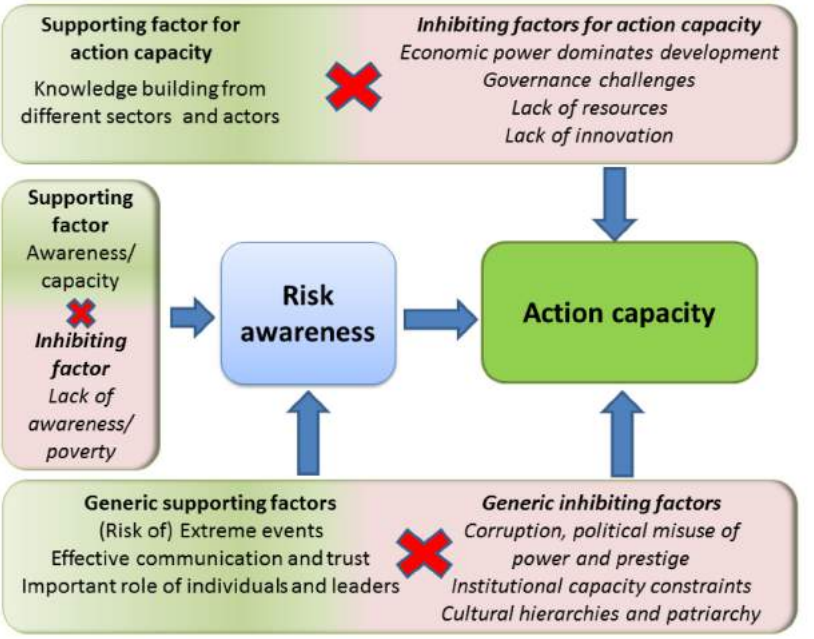


**Figure 3: Framework illustrating the factors that support or inhibit risk awareness and action capacity.**

# 5 Discussion

This study examined two social learning processes (risk awareness and action capacity), and assessed their role in building resilience in urban water services. The selected case studies illustrate several factors that support or inhibit these processes. The resultant framework (Figure 3) raises two key questions that are discussed in the following sub-sections: i) Why does social learning in the area of risk awareness not necessarily lead to action capacity?; and ii) When and why does it result in action capacity?

## 5.1 Why does social learning in the area of risk awareness not necessarily lead to action capacity?

Risk awareness is arguably the basic requirement for social learning. However, the findings presented here illustrate that it does not necessarily lead to action capacity. This is seen when powerful economic actors play a dominant role in development priorities. For example, in Durban, polluting industries were seen as necessary for society, despite increasing the exposure of communities to health risks. Psychometric research into risk perception has shown that people tolerate bigger risks if there are perceived benefits (Slovic et al. 1982). Especially in Durban, Cebu and Gorakhpur this tolerance appears to be driven by the unequal distribution of power; those who benefit are more likely to have power and influence, and those who pay are more likely to be vulnerable communities with very little influence. The role of power structures in preserving certain interests has been extensively explored (e.g. Foucault 1984). In relation to water issues, it is articulated in the Santa Cruz Declaration on the Global Water Crisis (2014). For example, a lack of action in providing access to water is linked to multidimensional causes that include injustice and inequality, historical decisions about infrastructure, and the use of water to accumulate wealth and power (ibid). If transformed,

"equitable access could bolster people's capacities, liberate their creative energies, enhance social status and validate citizenship" (ibid:247).

## 5.2 When and why does social learning in the area of risk awareness lead to action capacity?

Risk awareness and action capacity were identified as being supportd by five factors: 1) extreme events; 2) effective communication and trust; 3) the role of individual champions and leaders; and 4) knowledge building from different sectors and actors (Section 4.1). The latter is in turn depending on 5) multilevel coordination and guidance, which is added as a fifth factor. In this section, we discuss how these factors are related to social learning processes.

### *5.2.1 (Risk of) Extreme events*

Consistent with earlier research (Birkland 2006; Birkmann et al. 2008; Voss and Wagner 2010; Sabatier and Jenkins-Smith 1999; Pahl-Wostl et al. 2013), our case studies illustrate how increased awareness of (the risk of) extreme events can result in action. In Cali and Kristianstad extreme events triggered action, while slow processes such as environmental degradation made little difference (e.g. in Cebu). Although in many cases actors were aware of, and even monitored environmental degradation, this did not result in an increase in action capacity. Extreme events act here as "focusing events" and as such draw attention on a problem and have the power to set the political agenda (Kingdon 2003; Pahl-Wostl et al. 2013). Slovic (1987) argues that part of the power of an extreme event is that it triggers deep emotional reactions. Such events are known to be able to prompt transformative learning processes (so-called 'triple loop' learning). For example, in The Netherlands, the 1953 North Sea flood disaster helped trigger social learning, resulting in a new flood risk paradigm (Huntjens et al. 2012). This suggests that learning from extreme events can also lead to underlying risks, such as land use approaches, being addressed. This was found in the Durban case study, and led to action to improve sanitary conditions in peri-urban areas. A conclusion is thus that a window of opportunity to support action to address underlying risks could be found in relation to extreme events.

### *5.2.2 Effective communication and trust*

Effective communication and trust were found important in both formal and informal spaces. For example, work related to the Adaptation Fund in Cali led to the emergence of informal spaces characterized by trust and reciprocity. The Fund provided a transparent, cross-scale mechanism that counteracted more inflexible (and corrupt) formal arrangements. It is already known that stakeholders engage reluctantly with governmental agencies that are perceived as corrupt, as corruption undermines public services and trust (Pelling and High 2005; Rouse 2013). However, informal spaces may be overlooked in formal modes of engagement, and it is important to clarify what is meant by participation. This line of thinking echoes the feminist literature on the importance of "informal" or "alternative" spheres of engagement (McEwan 2000; Staeheli et al. 2004). In Kristianstad, effective communication and trust seemed to be linked to certain individuals and personalities who preferred to work together. This could be considered as an informal space within the formal space. Trust is known to support inter-personal/ institutional (formal) collaboration and integration (e.g. Leach and Sabatier 2005), and is important for social learning as it helps to maintain social contracts. The latter represent an (often implicit) informal agreement, where people do their part when they trust that others will do theirs (Scholz and Lubell 1998).

### *5.2.3 Individual champions and other catalytic actors*

Individual champions were found to support social learning. In Kristianstad, Durban, and Cebu these people were seen as "project champions" (Taylor 2012), who were able to navigate change processes within institutions, by applying their influence and personal attributes. The case studies highlight the important role of specialist (or technical) knowledge in promoting social learning, combined with an empathic understanding of what motivates people. For example, champions supported communities in micro-resilience planning by increasing resourcefulness, and providing a link with other actors. For example, in Cebu they supported a public–private partnership. In Durban, they fostered active and engaged citizenship by instilling ownership (e.g. individual ward councilors). In Kristianstad and Durban they provided a bridge between technical specialists and policymakers. Both individuals and organizations, and mechanisms were found to be catalysts. Examples include (leadership) organizations (GEAG in Gorakhpur, a Trust in Durban) that initiated a process, and international and national actors (the Adaptation Fund in Cali) who introduced a policy. The role of such leaders has been identified

by earlier research (e.g. Mostert et al. 2007; Rees et al. 2005). At the same time, other types of champions were identified as sorely needed. For example, in Gorakhpur and Cebu, we consider that "innovation champions" (Duncan and Ford 2005) are needed to provide alternatives to the orthodox, short-term vision. In Sweden, we consider that "policy entrepreneurs" (Brouwer 2015) are needed to change policy and create more holistic planning frameworks.

### *5.2.4 Integrated knowledge building*

The case studies identified a recurrent lack of knowledge building involving different sectors and actors. Examples include water resources and flood risk, and their integration with land use (Roy et al. 2011), which inhibits more adaptive actions (Pahl-Wostl et al. 2013). In Gorakhpur and Cebu, the lack of knowledge of SUDS resulted in a focus on technological fixes. This is perhaps part of the general trend in low- and middle-income countries to look to technology to build resilience (Dayal and Brown 2014), although experience has shown that it is infeasible (Grover and Krantzberg 2013). It is already known that a lack of specialized capacity and knowledge in local government inhibits social learning (OECD 2006). In Gorakhpur, one reason for this deficit was identified as the transfer of government officials, which disrupted capacity building. Furthermore, siloed organizational structures discouraged cross-sectoral knowledge building (seen in Durban). In the water, sanitation and hygiene (WASH) and irrigation (sub)sectors, a so-called *+approach* have been explored and proven to be fairly robust and scalable (Butterworth et al. 2011). The aim here is to broaden silos by accommodating other stakeholders and measures, (ibid).

### *5.2.5 Providing multilevel coordination and guidance.*

Scholars have identified that integrated knowledge building needs to be supported at multiple levels (Pahl-Wostl 2009, 2013; Wamsler 2014). However, the case studies here illustrate vertical fragmentation in this regard. Fragmentation rewards those who are able to concentrate upon, and defend their own areas of interest (Varis et al. 2014). For example, social learning regarding the provision of urban water services at neighborhood level in Cebu benefited local communities. However, the absence of social learning at higher levels regarding the enforcement and control of water outtakes in the catchment has eroded the water supply to the entire area. Similarly, many of the social learning efforts found in the case studies are partial. It has been

argued that the lack of such “balanced learning” with respect to the whole system can lead to surprises (Walker and Salt 2012).

Current knowledge/ frameworks for mainstreaming with respect to all cross-cutting topics, highlight the issue of social learning (i.e. the establishment of learning mechanisms and structures) at all levels (Wamsler 2015; Wamsler and Pauleit 2016). However, the Kristianstad, Gorakhpur and Cali case studies illustrate the known problem of coordinating different levels and scales (Chaffin et al. 2014), often due to inadequate and inflexible governance. For example, in Kristianstad, the governance setup resulted in incomplete flood risk planning that only focused on the lower river basin – despite European Union policy that clearly provides for river basin management of floods, and integration with water quality management (EEA 2015). The long Swedish tradition of decentralization (Levin 2009) might have to be adapted through social learning to include more central guidance and coordination of common adaptation issues (Johannessen and Hahn 2013). These findings relate to the ongoing debate on multilevel adaptive governance (e.g. Chaffin et al. 2014), which will be discussed more below.

In sum, this paper has illustrated the importance of several elements of social learning. In the next section, we propose a model for transition in urban water services based on these elements or key competencies. Our findings suggest that four elements are especially important in sustainable progression: strategic agency; specialized capacity and knowledge; adaptive multilevel governance; and finally, the balance of power (Figure 4). These elements are described in greater detail in the conclusions.

# 6 Conclusions

The purpose of this study was to identify the challenges associated with, and increase understanding of, the potential role of social learning in building resilience in urban water services. The results show how social learning can be supported (or inhibited) by different factors, and could provide important support for international and national agendas that aim to increase transformation and adaptation capacity. The approach applies concepts with predominantly ecological origins, such as adaptive management and resilience (Holling 1978). It may therefore offer new insight for urban water professionals, who tend to apply risk management principles to water systems, and adopt engineering-based concepts when asked about resilience and transformation (Smith et al. 2013; Brown et al. 2009).

Four important key competencies emerge, which could potentially guide building resilience in urban water services and be an alternative to existing technology focused models (Brown et al. 2009): 1) adaptive multilevel governance; 2) strategic agency; 3) specialized capacity and knowledge; and 4) the balance of power. Each is presented below, with two (possibly parallel) steps and key recommendations for policy and future research.

*1) Adaptive multilevel governance*

We argue that there should be a greater focus on capacity building in adaptive multilevel governance that balance the focus on technologies and infrastructure seen in our case studies. Innovation and the integration of ecological knowledge, together with strategic agency (i.e. other key competencies), was here found to be closely linked to governance – i.e. the system of institutions, including rules, laws, regulations, policies, social norms and organizations (Chaffin et al. 2014; Folke et al. 2005). In this context, adaptive governance has been argued to address uncertainty and different actors' contribution to the management of complex social-ecological systems (Chaffin et al. 2014; Folke et al. 2005) – providing a first step. In addition, multilevel governance structures are known to support and support 'balanced' learning across multiple levels – providing a second step

(Chaffin et al. 2014; Folke et al. 2005; Medema et al. 2014), with many insights relevant for both SDGs and the Sendai Framework. Here, trust supports inter-personal/ institutional (e.g. formal) collaboration and integration (e.g. Leach and Sabatier 2005). An interesting research area is the role of alternative avenues in informal spaces, which has so far received little attention.

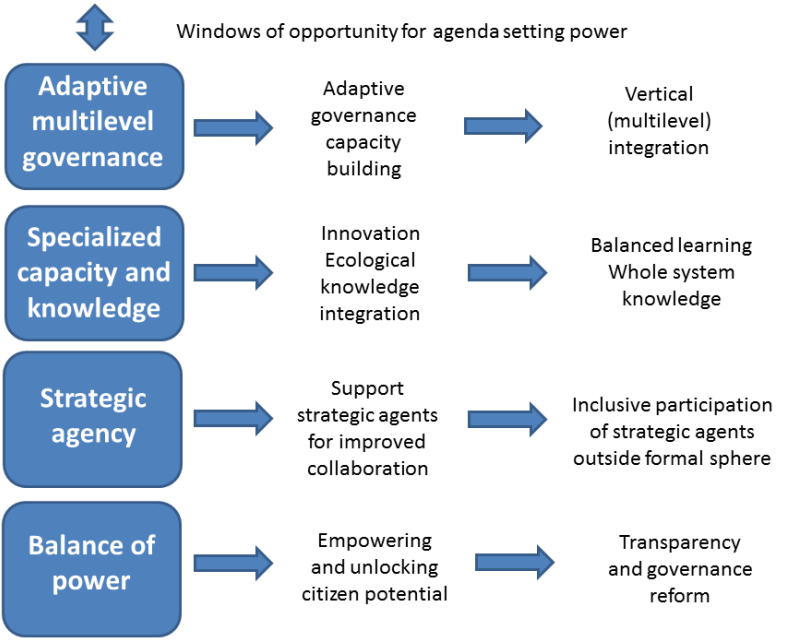


**Figure 4. Progression of four key social learning competencies to support building resilience in urban water services.**

*2) Specialized capacity and knowledge*

We argue that it is important to capitalize on the agenda-setting power of extreme events. Increased knowledge of broader disturbances should be used to highlight slow degradation processes that exacerbate disasters. This could promote social learning of the underlying risks, which is relevant in the context of the Sendai Framework (UN 2015a). Knowledge building could be extended in two ways: A first step would be to support innovation and go

beyond conventional technological fixes by integrating knowledge and experience about environmental measures in risk management. A second step would be to gain an understanding of the linkages in the overall system (e.g. upstream and downstream). This could provide arguments that could be used to reform the governance system, and address slow system changes.

*3) Strategic agency*

We argue that there should be a greater focus on strategic agency and supporting related capacities, in both policy and practice. This is highly relevant for both Sustainability Development Goals (SDGs) and the Sendai Framework (UN 2015ab). Strategic agency works to understand people's needs and priorities (Markides 1997). This can help to navigate and trigger change processes, by challenging and overturning accepted assumptions (Styles and Goddard 2004). In our findings, it took the form of visionary individuals or champions who achieved effective communication and trust, and supported inter-personal/ institutional (formal) collaboration and integration. Such competencies can initially support adaptive governance through inter-organizational collaboration (Leach and Sabatier 2005). Next, it may transform into more inclusive participation and the involvement of a broader set of actors and stakeholders, aiming for a +approach and multilevel adaptive governance. This progression and the +approach would need to be explored by further research.

*4) Balance of power*

We argue that there should be strong measures to counteract corruption, cultural and tribal hierarchies, and patriarchy. This is relevant for both SDGs and the Sendai Framework. These powerful, informal mechanisms are designed to preserve vested interests and the status quo, blocking social learning. Empowerment, especially of women, could unlock the capacity of citizens to improve the resilience of urban water services. A second (or parallel) step addresses the need for governance reform. Accountability and transparency mechanisms should be established to combat corruption and the influence of powerful economic interests. Although there are many tools that can, for example, increase transparency in the water sector (de Asís et al. 2009) more research is needed regarding the role of patriarchy in social learning.

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# Paper V

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# Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: The role of public private partnerships

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ABSTRACT

The aim of this paper is to enhance understanding of how the resilience of water, sanitation and hygiene (WASH) systems to hazards can be improved. In turn, this aims to inform different strategies for public and private partnerships (PPPs). In a new approach, to acknowledge the multi levelled nature of resilience; risk at the relevant levels are taken into account, (regional/river basin, urban area, and individual). For these levels, we first describe the different components of risk, vulnerability and resilience of the WASH system that influence people's exposure to hazards. We illustrate these components using examples from case studies in the literature. Using a social learning lens - a crucial ingredient of resilience - we examine opportunities for reducing risks through improving public–private engagement. These are presented as strategies which could guide investment decisions: As pressures from climate change and development add up, businesses must become aware of the risks involved in operating and investing without considering ecosystem health, both in terms of the services they provide for mitigating floods and droughts, as well as in terms of the development approaches that define how ecosystems are managed (e.g. "making space" for, rather than controlling water). There is a need to develop an institutional culture that strives towards greener and more resilient urban environments with the help of various quality assurance methods. Partnerships must reach the poorer customer base, encourage informal small entrepreneurs, and boost financial mechanisms (e.g. micro-insurance, micro-finance) to support the most vulnerable in society.


## 1. Introduction

One of the largest risks to people living in urban areas in the developing world is a lack of improved water, sanitation and hygiene (WASH) provision [117]. Access to water and sanitation is an important factor in determining social vulnerability to natural hazards, not only for meeting immediate needs, but also for the wider application of relevant disaster prevention [115]. Especially, the state of sanitation is a global crisis, and addressing the Millenium Development Goal (MDG) for sanitation is lagging significantly behind the other goals [33]. According to

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GLAAS [33], 83% of countries have fallen significantly behind the national targets they have set for sanitation. Many cities and their peri-urban areas, particularly those in low-income countries experiencing rapid urbanization, are struggling to address basic WASH needs to keep up with service provision due to deficits in financing, capacity and governance. This in turn leads to serious economic, social, and health implications [53]. In other words, even without considering "external" hazards such as floods or droughts, cities can become unsustainable from "internal" health hazards because WASH systems are not properly designed, implemented and maintained.

Despite the apparent urgency of current and future challenges from climate change and development, few studies have explored how the resilience of WASH systems to hazards can be enhanced. Oates et al. [75] provide a recent review of progress and challenges in WASH service provision and explore the potential impacts of climate change on WASH risk assessment and planning. They argue that near-term changes, impacts and the practical needs of decision makers remain poorly understood, while studies have mostly focused on modeling long-term changes. In the context of climate change, recent work on the resilience of water supply and sanitation was conducted by Howard & Bartram, [40]; Howard et al., [41]; Calow et al. [24] and Batchelor et al. [13].

This paper aims to identify strategies for investments by public and private partnerships (PPPs) based on an enhanced understanding of how the resilience of WASH systems to water-related hazards (e.g. floods and water scarcity) can be improved. We argue here that the scope for PPPs has not been explored to its full potential limited by a lack of systems analysis, taking the entire social, economic and environment system in which the WASH system is located into account. We argue that investments must not only focus on access and provision of WASH services through infrastructure development, but should be much more strongly coordinated with the activities of stakeholders across the entire integrated urban and river basin system, even with regional and global influences, with which the WASH system is linked through ecosystem services, such as hydrological flows, purification and waste treatment, flood and drought control, etc. [49]. This includes a stronger emphasis on the non-structural solutions requiring social learning between the involved stakeholders.

The provision of safe and resilient WASH services is intrinsically linked to processes of water management, land use planning, and DRR across the entire river basin and even beyond, as well as to the urban area in which they are located. Many hard won investments in WASH systems can be undone by not taking the entire system processes into account set by boundaries of the river basin and even beyond. Within urban areas, a lack of planning can lead to inappropriate development that in turn can increase people's exposure to flash floods, which heighten risks from inappropriate sanitation options that can result in the contamination of potable water sources [80]. Despite the need to take DRR into consideration in upstream areas connected to the WASH system, such links and feedbacks are seldom considered in investment decisions relating to WASH systems. Similarly, health-related costs are often given little weight in decisions about specific interventions to protect against hazards such as floods. Ahern et al. [3] conclude that one reason for this might be a poor understanding of the downstream health impacts caused by floods. They therefore highlight the need to quantify the degree to which climate change and land use change contribute to flood risk and the resulting health impacts in different settings.

Public Private Partnerships (PPP) are increasingly seen as a way to motivate private sector investment in urban WASH infrastructure projects that lack public funding [53]. PPPs have the potential to expand the range of service providers beyond traditional public sector monopolies and inject a measure of efficiency, dynamism, innovation, increase of access, improvement in quality, cost-recovery and consumer responsiveness [1,61]. Currently, the proportion of private investment in the water and sanitation sectors in developing countries is low, representing only 35% of the market compared to 80% in the developed world [114]. Some authors (e.g. [61]) therefore suggest that private sector participation should be encouraged to increase service efficiency, quality and accountability. However, privatization cannot be seen as a panacea. The wave of privatization of water utilities in the 1990s, for example, has been viewed as a failure by some observers [7]. Privatization has shown to actually reduce competition in the operation and management of water and sewerage services. On the other hand, public–private cooperation can work to everyone's benefit. The key criterion is that public services should remain under public control [44].

PPPs have also recently emerged as important and necessary mechanisms to strengthen DRR efforts in general. This has been motivated by an improved understanding of the vulnerabilities of supply chains and infrastructure assets to hazards. The enormous potential for private sector engagement in building resilience through corporate social responsibility (CSR) and philanthropy has recently been demonstrated by the United Nations Office for Disaster Risk Reduction's Private Sector Partnerships in DRR [119]. However, the areas in which private sector engagement would provide the most appropriate and effective contributions have not yet been well defined, and this study aims to provide some direction.

Resilience is the ability of a system to absorb shocks and to maintain its functionality, structure, identity and feedbacks, while coping and adapting to change, variability and extreme events [122,116,94]. We use the concept of social learning in our analysis, which is an important element of resilience in addressing environmental change [32,113,35]. Social learning is widely argued to have the potential to share knowledge and lessons, both formally and informally, between many levels and across different sectors. As such, insights and knowledge can transfer beyond the individual to organizations or communities of practice [113,89]. Social learning has a great potential in underpinning the strategic innovation needed to radically improve the modus operandi of private sector involvement for more resilient WASH systems. In the context of WASH, social learning has so far only been explored in relation to the governance of WASH systems

[22,121,70,95,83,77,110,71,17]. However, it has not been explored in detail in relation to DRR and WASH system resilience at the river basin level [78].

## 2. Framing the construction of risk and vulnerability to hazards in WASH systems

### 2.1. Data collection and analysis

The evidence presented in this paper is based on a review and analysis of the academic and non-academic literature. We conducted a comprehensive search of relevant literature using the electronic databases Science Direct, Google Scholar, and an internet search using Google applying the keywords 'WASH, sanitation, hygiene, disaster risk reduction, resilience, PPPs'. The search identified about 55 documents relevant for the analysis presented in the paper. Selected case studies were analyzed to identify key challenges, gaps and opportunities in building more resilient WASH systems involving social learning relating to the three levels - regional/river basin, urban area, and individual. The study is also based on conversations with private actors (two private philanthropy professionals), and three interviews with representatives of the humanitarian and development sectors (one humanitarian WASH professional, one development WASH professional, and one former Mayor).

We first describe the different components of risk, vulnerability and resilience of the WASH system that influence people's exposure to hazards at different levels. We distinguish between regional/river basin, urban and individual levels to account for different dynamics and processes. Using empirical examples from published case studies we then illustrate these components and examine the resulting increased vulnerabilities and health impacts in communities at risk. Finally, using a social learning lens we examine opportunities for improving public–private engagement and as such resilience at the different levels. These opportunities are presented as strategies which could guide investment decisions through new and innovative approaches and mechanisms that involve social learning and collaborative partnerships between private and public actors, and potentially also urban communities.

### 2.2. Disaster risk in WASH systems

Disasters are often described as a result of exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences [116]. A disaster can be defined as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources." [116]. A hazard, such as a flood or drought, can lead to a range of secondary hazards. For example, a health hazard might arise through the exposure of people to contaminated water in the WASH system. In the framework presented here, we consider the "disaster of disease" [116] as a consequence of a dysfunctional WASH system. For example, enteric (intestinal) pathogens from infected humans, including symptomless carriers, represent a hazard under the UNISDR definition.

The impact is not exclusively on human health, but will also affect and impact on downstream ecosystems and communities and activities in a river basin context including fisheries and tourism in addition to destruction of water resources heavily polluted by nutrients and organic compounds [30]. As water is very much a driver of economic development, the degradation of this resource will trigger indirect and direct financial impacts on businesses and the public sector with negative implications on long-term economic growth rate, sustainable development and resilience [92,91].

### 2.3. Vulnerabilities of WASH systems to water-related hazards at different levels

Vulnerability is defined as the capacity of a receptor to experience harm from a specific hazard or a range of hazards [52,19,111,2]. Disasters occurring in WASH systems tend to result from vulnerabilities to a range of hazards impacting upon the system at different geographical levels.

In order to identify all vulnerabilities in the different WASH system components, to understand interdependencies and feedbacks, and to exclude unwanted externalities/surprises [81] it is crucial to consider the entire river basin as the natural boundary of the linked water and WASH system. By selecting this boundary, upstream/downstream processes of the WASH system can be captured and system complexities and uncertainties can be accounted for [79]. We use the term regional to complement the river basin level and relevant influences beyond this, such as migrants and refugees, politics, economic trade systems, pathogens and the hydrological cycle, originating even at global levels. We also distinguish between the urban system and the individual in order to capture the dynamics at these different levels.

### 2.4. WASH system vulnerabilities at the regional / river basin level

Land use in the river basin, without investment in DRR, can affect the functionality of downstream WASH systems. For example, in 2005 Hurricane Katrina illustrated this very well with about 50% of existing treatment plants and 20% of sewage collection systems needing rehabilitation in the Greater New Orleans area after the storm [25]. Waterborne infectious diseases were of major concern, both due to the physical destruction of the water and sanitation system infrastructure, as well as the impact of the enourmous amounts of floodwater in the city due to the failure of the levees [98].

In terms of linkages to the regional level and river basin it was concluded that important existing buffers to natural hazards were less functional than anticipated. It is not possible to assess if the breaching of the levees would not have occurred, but the increased exposure of New Orleans to Hurricane Katrina was an important factor. For example, a levee manager in Louisiana said in relation to Hurricane Katrina: "There is no doubt about it that…[the] biggest factor in hurricane risk is land loss. The Gulf of Mexico is,

in effect, probably 29 miles [or 32 km] closer to us than it was in 1965 when Hurricane Betsy hit". Some of these land losses were ironically due to the levees and the dam barriers which were built to protect the city from previous hurricanes [51]. Such influence from structural measures on natural processes, e.g. sedimentation in deltas, which maintain shorelines, is even considered more important than sea-level rise associated with global warming and the global ocean volume increase [107]. New Orleans exemplifies a situation, where the embankments and levees in fact made the populations behind them even more vulnerable to the consequences of a breach by providing a false sense of security. This reliance on infrastructure measures was catastrophic as consequences of failure were not anticipated or planned for.

Not only coastal protection, but also protection from river flooding has a tradition for centuries, especially in high income countries, that the river should be controlled by building dikes to reduce the risk of flooding [45]. But controlling floods has also here showed to have unforeseen consequences, due to the dynamic nature of water systems. Trying to control floods has resulted in the "control paradox", where applying controlling measures creates the need for more control as floods consequently increase [90]. Alternative or complementary measures of non-structural mitigation requires knowledge of such approaches [99], but the choice of hard infrastructure is also more susceptible to corruption [108]. Transparency International's 2005 report highlights 13 different features of infrastructure projects that make them particularly prone to corruption [101]. For example, large complex projects such as hydroelectric dams create ample opportunity for corruption in addition to lack of oversight or insufficient controls [43]. Corruption can also discourage the selection of softer management options. For example, Burra et al. [21] showed how politicians in India were opposed to community-led processes because they did not like working with groups they found difficult to approach for bribes.

Land use such as deforestation at river basin level can also contribute to flooding of downstream WASH systems. For example, in Bangladesh, the 1988 deforestation contributed to flooding resulting in the disruption of the Greater Dhaka's drinking water, sewage and drainage systems and seriously affected the 11 million inhabitants. As a result, diseases such as diarrhea and hepatitis, caused by the polluted water and contaminated food, rapidly spread within poor areas of the capital [73].

### 2.5. WASH system vulnerabilities at the urban level

A number of processes influence vulnerability of WASH systems at the urban level. The lack of adequate urban WASH facilities and rapid urban development in developing countries combine to increase health risks. Risk-related human exposure grows mainly because of unplanned environments with increasing crowding, inadequate operation and maintenance, dysfunctional facilities and consequently open defecation [34]. In many countries, for example India, large cities do not even have the capacity to treat sewage in an appropriate manner [72].

At the same time the removal of flood mitigating (green) buffers in a city is a slow but steady process. Increasing the impermeable surfaces and encroachment of urban waterways such as rivers and creeks, canals, floodplains, mangrove forests, urban green zones and public parks, that function as a network for stormwater runoff, limit the ground's infiltration capacity and exacerbate urban flash flooding and erosion, and increases the clogging of drainage canals [10,63]. In many cities, structural measures such as flood protection walls, embankments, drainage channels and other efforts to control floodwaters have proliferated. This has created incentives for further development in high risk floodplains, and it has also transferred flood risk downstream. In Bangkok this has had the effect that even a relatively modest river flow can result in damaging floods [55]. In the cities of Bangladesh, diminished water bodies and interrupted river flows are important factors in increasing flood risk [88]. For example, many canals in Dhaka have been filled in to construct settlements and small businesses [87].

Exposure to hazards varies between urban sites and are dependent on the hydrological and morphological characteristics within the river basin. Low-lying floodplains are naturally more exposed and likely to be affected by floods causing inappropriate sanitation systems to leak and contaminate potable water sources [79]. The impact is also dependent on geo-hydrological conditions for groundwater. Both are the case in many cities, and especially low income areas which are often located in flood-prone areas [16]. In spite of this, human settlements continue to develop in risk prone areas [36] through population expansion (e.g. rural-urban migration and city expansion via informal settlements on peri-urban boundaries).

Scarcity of water represents an environmental limit which should rule out options which rely on relatively large amounts of water to function. However, there are examples from Cambodia where school latrines were designed with flush toilets where no water source was available [123]. Alternative options such as simplified or condominial sewerage are, for example, promising low-cost options which have shown to be cost efficient, and can also be retrofitted in unplanned areas [104]. This sanitation option is especially suitable for low-income coastal areas subject to regular annual flooding. The city of Salvador, capital of the Brazilian state of Bahia, has one of the largest simplified sewerage systems in the country [69]. There, an epidemiological investigation revealed that after the system had been introduced, the prevalence in children under five of two types of roundworm and *Giardia* reduced significantly [12].

### 2.6. WASH system vulnerabilities at the level of the individual

Ironically, efforts to increase access to improved WASH system services at the household level often do not adequately consider risk reduction to protect public health in the community. Even if household options are implemented, untreated wastewater is frequently discharged into ditches or open storm-water drains (if they exist), which defies the purpose of the household efforts. Children

playing in the streets become exposed when partially treated and pathogen-laden overflow from septic tanks or other sanitary installations are drained to curb-side open channels, or households directly flush their toilet waste into street drains. Such drains are often clogged from silting or the dumping of garbage, thus causing overflows. They are further impacted during heavy rainfall causing further spread of contamination [104]. The drains are often directly accessed for drinking and washing water thus further increasing exposure. Conventional sewerage is not possible when the capital costs and water requirements are too high for the area in question. Other factors hindering such infrastructure investments are the additional costs for operation and maintenance, lack of financial and technical strength within the local administration, and too narrow streets in unplanned settlements. When conventional sewerage is ruled out for poor urban areas, pour flush or pit latrines along with septic tanks seem to be the only remaining option [104]. However these options are not appropriate in flood prone settings because they cause contamination and leakage, especially in areas with high water tables [37,38]. Unfortunately, alternative approaches are not provided. Instead a single technology, often dysfunctional, is often promoted with subsidies attached to it [85].

Access to hand-washing facilities, improved sanitation and safe water, can be an effective barrier against health hazards, as can hygienic behavior [60]. However, if service is only provided for a few hours every day the systems are vulnerable to contaminants that can enter through leaks when pipes are empty or pressure is low. Even where access was once provided, the reported rates of non-functionality of (mainly rural) hand pumps across the sector in 20 of Sub-Saharan countries is as high as 30–40% [58], and provide a strong signal that existing mechanisms for financing capital maintenance are inadequate. Existing systems are failing or have become dysfunctional due to lack of investments in operation and maintenance or upgrading of aging systems, resulting in system failures and wasted donor and government investment, for example in Asia Pacific [123]. Lack of access can also be caused by the inability of service providers' to respond to community motivations, needs and preferences, or to be sensitive to gender issues, disability and the needs of children. Furthermore, in cities in the global south, dysfunctional systems have economic implications, especially for the poor, who often have to rely on less safe water sources or on private water vendors who deliver water from unspecified sources (e.g. small pipe systems, jerry cans or tankers) usually also at a unit cost several times higher that delivered via public water supply systems to the middle and upper classes [11].

## 3. Strategies for linking investment in PPPs with DRR and building resilience in WASH systems

Any business interested in ensuring the safety of long-term investments will have to start thinking of the adequate strategies for managing disaster risk. While businesses are accustomed to managing business risks, in terms of disaster risk they often focus in on the response and reconstruction phase, and are yet to integrate the long-term risks of development or climate change into their strategies. They are also not preparing to grasp the competitive advantages that will accrue to those taking early action [54]. Consequently, relatively little attention has been given to the extensive partnership possibilities and innovations possible of PPPs for boosting resilient WASH systems beyond traditional ways. Questioning the business as usual approach could improve access to safe WASH services, alongside economic opportunities and security in vulnerable urban communities, which would have positive feedbacks on societies and economies in turn, offering more routes out of poverty [27]. In terms of resilience, this process can be described as transformation, which alters the fundamental attributes, such as paradigms, power systems, goals [47] value systems, regulatory, legislative or bureaucratic regimes, financial institutions, and technological or biological systems [46] which underlies the way decisions and actions are made which shape risk reduction and future risk generation.

In Sections 3.1 to 3.7 we provide insights into some important strategies for investments which also include measures at the urban and river basin/regional levels, as well as involving social learning. These are illustrated in Fig. 1, and could guide investment decisions through PPP initiatives and that could at the same time reduce vulnerability and build resilience of the WASH system at different levels. (Table 1).

### 3.1. Environmental limits: profitability reexamined

Profitability is one of the main conditions for a business enterprise. However, cost-benefit analyses may now change the way we look at investments if we take into account risks caused by a lack of focus on, or investment in, environmental buffers for floods. Comparisons of losses with investment in ecosystem services are becoming increasingly convincing arguments for private companies to become active in Corporate Social Responsibility (CSR) potentially as part of PPPs. For example, in 2011 Bangkok experienced a serious flood affecting approximately 13.6 million people and costing 1425 billion baht (US$ 45.7 billion) in economic damages and losses as of 1 December, 2011 [124,125]. Most of these were linked to manufacturing industry. This made it the world's fourth costliest disaster as of 2011 – only less than the 2011 earthquake and tsunami in Japan, the 1995 Kobe earthquake, and Hurricane Katrina in 2005. These events may trigger awareness of the need for business to be aware of the risks of a lack of investment in environmental services. It is perhaps too early to say whether the Bangkok floods have triggered such investment. However, this was the case in, for example, coastal mangrove restoration in the Indian Ocean after the tsunami in 2004, where PPPs have been successfully launched in Gujarat [100]. However, the linkages between investments in ecosystem services and actual value of risk mitigation downstream may not be obvious. One method of assessing appropriate measures based on ecosystem services is to do strategic environmental assessments (SEAs). These provide tools for social learning among various partners in the public and private domain around collaborative decision making over investments.

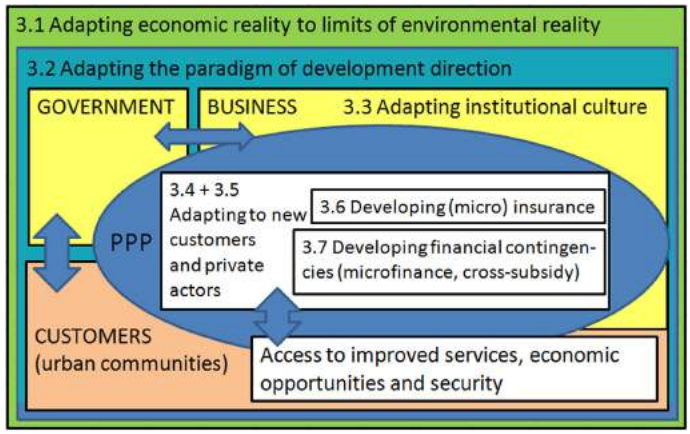


**Fig. 1.** The relationships and organization of the different strategies for linking investment in PPPs with DRR and building resilience in WASH systems. Note: The government and business form the basic units for the PPP, sometimes also involving the urban communities, and ultimately benefiting customers and the public. Communities can benefit from PPPs in terms of improved access to WASH services, economic opportunities and security, which in turn can have positive feedbacks on society and economy.

**Table 1**
A list of strategies matched to different levels for which they are most relevant.

| Strategy | Level |
|---|---|
| • 3.1 Adapting economic reality to limits of environmental reality<br>• 3.2 Adapting the paradigm of development direction | River basin level/ regional |
| • 3.3 Adapting institutional culture<br>• 3.4 + 3.5 Adapting to new customers and private actors<br>• 3.6 Developing microinsurance<br>• 3.7 Developing financial contingencies (microfinance, cross-subsidy) | Urban level |
| • Access to improved services, economic opportunities and security | Individual level |

These can compare ecosystem investment with alternative investments, so by promoting these tools investment decisions may look very different, particularly because they take into account potential maladaptation and are inclusive of ecosystem services. For example, in the outskirts of Kampala, Uganda, the Nakivubo Swamps provide the important ecosystem service of treating and filtering the biological waste water from much of the city. Ideas to drain the wetland in order to gain agricultural land were dropped when an assessment of this service showed that running a sewage treatment facility with the same capacity as the swamp would cost the city around 2 million US$ annually (TEEB case by [5]). In Belgium, a strategic assessment favored the restoration of approximately 5500 ha of the Scheldt Estuary, alongside dike reinforcement and dredging, instead of a storm surge barrier to meet flood risk. This solution was chosen because it had an estimated payback period of 14 years, compared with the 41-year payback period for the storm surge barrier [26,68,18].

### 3.2. The paradigm underlying development

Resilience building is ultimately about transformation towards approaches that work over the short term (meeting economic viability objectives), long term (ensuring sustainability) and which can manage change and uncertainty. To ensure that the working strategy of a business can enable progress on these horizons, it is essential to look at the overarching paradigm, worldview and basic principles that underlie its assumptions about socio-economic development. One area where business can add value is in terms of innovation and forward thinking for solutions. In terms of resilient WASH systems, opportunities are offered by adopting the innovative paradigm of 'living with water' as opposed to seeing water as something to shut out, dredge and remove from human economic development activities. This entails more integrated social and technical programmes that incorporate flood preparedness and non-structural mitigation, taking down or relocating dikes, lowering flood plains, creating water storage or removing obstacles [99]. This multifunctional land use approach includes a great effort in design and development, [74] where PPPs has a potential to play a role. Other changes follow from adopting this new paradigm, such as new management measures, new physical interventions in the river basin, uncertainties being addressed, changes in the regulatory framework and the introduction of new norms and values [42]. One result of such a paradigm shift is the Netherlands 'Room for the River' programme, (www.ruimtevoorderivier.nl). A collective learning of the critical and real hazard of flooding

from the sea led to a transformation of the existing approach. This programme now represents the state of the art in flood risk management, governing all other approaches and interventions in the Netherlands.

### 3.3. Changing business institutional cultures, competitive branding and 'license to operate'

Urban companies are increasingly developing and engaging in branding, programmes and campaigns that include the approach of "resilient" and "green cities", which takes in water risk management [117]. There are a range of different quality assurance approaches and methodologies which can contribute to a company's 'social license to operate', for example corporate citizenship, corporate social responsibility (CSR), good business values and brand reputation. This can be done through a business' own initiative, global standards, for example the Global Reporting Initiative (GRI), the UN Global Compact, ISO-standards, and liaising with programmes such as UNISDR's new programme on risk sensitive business investment [118]. In the same vein, many businesses factor in continuity and long-term reliability and resilience of urban energy, water, and transportation infrastructure into their investment decisions [76]. The city of Miami has used the CITYgreen Tool, a Geographic Information System (GIS) for systematically including green infrastructure, such as parks, urban forests and wetlands, into urban planning. This is done mainly for storm water protection, enhancement of air- and water quality and climate regulation. Using this, a riverine area was rehabilitated that subsequently generated a range of positive side effects (e.g. recreational and property values) [109]. In Sweden, a process of sustainability certification for urban areas is underway. Such tools could be used to mobilize private sector codes of conduct, in integrating DRR with sustainability criteria, such as aspects of drainage and run-off, flood risk, heat absorption, cooling, and ensuring weather-resilient development [50]. The "narrow view" of CSR justifies initiatives when they produce direct and clear links to firm financial performance (e.g. immediate cost savings. The more businesses take a "broad view" of the business case for CSR and similar efforts, the more they can enhance their competitive advantage and create win–win relationships with stakeholders. Support from stakeholders is necessary to create a market for virtue and a business case for CSR in the space where a firm's economic objectives and the social objectives of society converge [23].

### 3.4. Identifying a new segment of customers

Studies show that there is untapped potential to introduce PPPs in informal areas. In business theory, strategic innovators do something genuinely different that customers like and reward, based on a deep understanding of customers' needs and priorities [62] often overturning and challenging accepted assumptions [102]. To do that, it is for example critical to understand and work with community user preferences. Urban slums are often inhabited by migrants seeking employment [93]. Such people are often temporary tenants and tend to lack incentives to act within the community to reduce the WASH systems hazard. It is important to assess these people's world view, motivations and economic opportunities, because, if the needs, preferences, and buying patterns of these customers at the "bottom of the pyramid" were properly understood, new market opportunities would open up [84].

But there are many challenges to overcome in introducing PPPs for WASH service provision in informal areas. Limited awareness and information contribute to mistrust and a lack of mutual solutions between service providers and their poor constituents (USAID 2006). On the one hand, the urban poor often lack the social, organizational or political skills needed to approach providers or government officials to negotiate access to the services that are so vital to their social and economic well-being [9]. On the other hand, the private sector is risk-averse usually focusing on investment opportunities with wealthy communities, and while avoiding poor urban community service provision since this means operating on narrow margins with poor clients. Businesses are also often ill-prepared to service the low-income market, and their lack of experience with poor clients makes them even more wary of exploring profit-making opportunities in the slums [9]. This lack of experience furthermore creates misconceptions which do not encourage business to engage. For example, the main challenge facing the 'Sanitation as a Business Program' in Uganda (which is based on a pro-poor business model and employs a market-based approach) is dealing with delays in getting bank loans for entrepreneurs. Sanitation entrepreneurs cannot begin operating their businesses until they receive funding through bank loans. It has been observed that banks have limited information on the viability of small businesses in the sanitation sector [120]. This risk aversion is partly based on the lack of awareness that the urban poor are both able and willing to pay for water services, and banks generally do not recognize the potential economic and political benefits of serving the urban poor. For example, poor people living in slums often pay 5 to 10 times more per liter of water than wealthy people living in the same city [121]. But regulation may not provide an enabling environment. For example, there may be challenges in the way publicly or privately operated utilities serve the majority of low-income households [20].

When WASH system innovations become successful, such as low cost options stormwater drainage tailored to the needs of crowded urban environments, these need to be scaled up [82]. To help trigger and scale up innovations, so called 'learning alliances' are networks which are set up to trigger cross-learning to make use of existing knowledge across different levels and segments of society, where the community level also can play a role and provide insights of needs, preferences and pro-poor business models. Some cities have piloted city-wide 'learning alliances' [105] or 'learning and 'action alliances' [8].

### 3.5. Adapting to new private actors: informal services also count

Experience shows that the lowest-income groups, with the least access to water and sanitation services, receive

the fewest benefits from private provision [61]. Here, PPPs require strategic decisions on financing in order to optimize the public and private capacities to generate funds but also to maintain them. This sort of "reality check" is what has made PPPs a difficult solution for the most needy segments of society in developing countries, including slum communities in peri-urban areas.

However, it is important to acknowledge that the informal sector already delivers WASH services in slum areas. Small-scale independent providers (SSIPs) or non-state provision (NSP) have for a long time provided water supply; not of great quality, and at a high price, but nevertheless providing access and a service appreciated by community members [14]. Small (illegal) operators have been legalized and formalized, for example in Phnom Penh, Cambodia, and in Mozambique. This ensures they provide an adequate service at a regulated price, in return for being able to run a legal business [59] and also enables risk reducing measures by making the business subject to quality control and tasking them with improving the quality of water sources [14].

There are a lot of challenges to empowering and legalizing these informal players and service providers. For example, they lack the benefits of economies of scale, investment capital, long term corporate accountability, and integration of the slums into the larger city – things that are normally pursued by private sector partnerships [9]. In terms of support from the government there are also challenges. While policy now generally supports non-state provision (NSP), it is often repressive and effectively designed to protect established interests [14], and practice is more often unsupportive and relationships are surrounded by mistrust. Government approaches have unfortunately often been trying to replace those informal players rather than assist them [66]. In addition, for larger private companies operating in other areas of a city they represent competitors, even though they are operating in areas where the larger companies have not yet developed coverage [96].

Increasingly, however, formalizing service provision by small-scale independent providers (SSIPs) is practiced in partnership with formal utilities as an alternative model, but little is known about how these partnerships actually function or about their potential to serve as an alternative model for service provision in peri-urban areas. Not only is legalization necessary, but also sustained and non-politicized dialog. The main providers of non-state services—local entrepreneurs, individual practitioners, community organizations and small non-governmental organizations (NGOs)—are largely absent from any dialog with government or city authorities [59]. At the same time, government led processes are also perceived as being very politicized, because persons are replaced after a mandated period, which leads to reduced motivation from other actors, for example NGOs, to cooperate (29). Local government can also be reluctant to get involved [21]. Hesitancy can also be found in communities, possibly due to a mistrust of the efforts of government, politicians and NGOs as a result of past disappointments [112].

Local governments sometimes face the challenge of designing and implementing PPP contracts with private sector partners who may have much greater technical expertise and knowledge of the project requirements. In the case of formalising services provided by the informal sector, community-based organizations (CBOs) and NGOs, power asymmetry play a role. In the Organisation for Economic Co-operation and Development (OECD) there is a suggestion of how to minimize this asymmetry, through technical assistance to cities by national governments. This could take the form of what has been called "dedicated PPP units", specialized public bodies with PPP experts, which already operate at the national level in several OECD countries to increase the capacity of the public sector in engaging in PPPs [76]. Efforts to redesign this support for developing countries would need to include capacity building for pro poor business models, and PPPs tailor-made for collaboration with community groups and local small-scale service providers.

### 3.6. Develop insurance mechanisms for the most vulnerable people

Commercial insurance companies rank among the most resourceful actors in the private sector for sharing and redistributing financial risks from extreme events. Insurers make disasters insurable by pooling risks across time, space and large numbers of policyholders who differ in their exposure to risks [64]. Private life, health and property insurance is an important complement to welfare state risk-sharing mechanisms in developed countries. In many high-income countries, private insurers cover a large proportion of the financial burden from natural disasters. In developing countries, on the other hand, market penetration of private insurance is usually low, and governments often rely on humanitarian assistance and financial aid to respond to disasters. Furthermore, limited availability of non-life insurance in these countries means that private insurers shoulder little to none of the losses [124,125]. A healthy domestic insurance market can be a conduit into the international reinsurance market, allowing countries to tap into a pool of over US$400 billion of capital to aid recovery in the aftermath of a disaster. One explanation why Chile proved to be resilient in face of the February 2010 earthquake was that domestic carriers passed on 95 percent of the insured losses to the international reinsurance market. Worldwide, the fraction of insured losses coming from the reinsurance market over the last ten years is around 35 percent [124,125]. Aside from conventional insurance, catastrophe bonds and contingent credit contracts are two potential alternative instruments that can help developing countries to finance disaster risk management [103]. United Kingdom water utilities sign mutual help agreements to prepare for disaster events. This allows water service providers to request assistance from other water companies in case of a low key event, a major event or an emergency. The assistance ranges from the provision of bottled water supplies, tankers, equipment or specialist staff. Such sectoral self-insurance has further scope for replication and adaptation in developing countries [127].

### 3.7. Microinsurance

Microinsurance schemes are mechanisms that can help vulnerable populations in developing countries to deal with the financial risks from disasters. They are increasingly seen as a way forward in spreading and transferring risk. Microinsurance could help many of the poorest people—2.4 billion people live on less than US$2 per day in 2010 [126]—to escape poverty and fill gaps in risk management. There is a large scope for improvements. In an assessment of 121 local governments progress in DRR this area scores almost lowest of all areas in the 'Making Cities Resilient' campaign (run by the United Nations Office for Disaster Risk Reduction), [48].

Microinsurance schemes normally involve a number of partners from the private sector, governments, NGOs and other actors. These schemes are particularly important in places where people are not bankable. In many developing countries, less than half the population has access to formal financial services, and in most of Africa less than one in five households has access [15]. Microinsurance for health, in some African cases [65], seems to have a much greater chance of becoming a growing market than insurance for WASH systems per se. However, indirectly, microinsurance can play a key role for WASH systems. Risk of eviction is one of the biggest barriers for infrastructure development in slums, and microinsurance in housing could help to manage this risk better. For example, in slum areas of Dhaka, Bangladesh, people managing 'water houses' that provide WASH services would see insurance as an incentive to improve the facilities, which often are of poorest quality and very unhygienic [127].

For insurance to target poor people it is important to, for example, conduct demand studies, in order to understand the customer base and what type of insurance low-income people want to buy. Health insurance is the top priority for low-income households, as one big risk is hospitalization, which often happens suddenly and in most cases requires cash for service. A challenge is that very few companies reach out to develop the kind of relationship of trust and direct contact (both physical and psychological) with potential clients that is necessary for entering the low-income market directly. A challenge in terms of health insurance is that the poor are very much aware of the burden of diseases which mean small costs but which occur often, but these are difficult for a health insurer to cover. The claim process is high cost because it is difficult and expensive to obtain the information needed to verify claims. For a viable health insurance scheme, it is therefore recommended that policyholders and the community be involved in the business process, thus mobilizing their social capital: The greater the degree of convergence of the interests of insured and insurer, the more viable the arrangement will be [86].

### 3.8. Build (micro) financial contingencies

In high-income countries, governments are typically equipped with financial reserves and quick budget reallocations to cover their legal and social post-disaster responsibilities. There are also directly supporting instruments, for example social funds and livelihoods programmes, which can enable communities to make investments that are vital for building resilience and to transition to new livelihoods, often in new sectors and in urban areas where they may need temporary support. The financial implications of impacts from disasters on WASH are shared to varying extent in existing social welfare state arrangements [97]. The European Union Solidarity Fund, launched in 2002 may become a benchmark example of how risks from disasters can be pooled on a regional level across different sovereign countries.

In developing countries, supporting instruments such as social funds and livelihood programmes can enable communities to make investments that are vital for building the resilience needed to make transitions to new livelihoods. This can be combined with safety nets in the form of cash transfers (both conditional and unconditional), workforce programs and in-kind transfers. In the context of social protection instruments, several countries, including Malawi, have explored productivity-enhancing safety nets, direct welfare transfers and appropriate market interventions [28]. But experience in these has not migrated into the WASH sector as much as it has in food, health, shelter, or transportation. However, cross-subsidies exist in some cases, usually where utilities working across richer and poorer urban neighborhoods agree to government conditions for PPP service contracts that combine profitable projects with unprofitable ones to benefit poorer communities [53]. Creative solutions such as cross subsidies, social funds and livelihood programmes are necessary in order to generate interest from both public and private investors. There is, however, a large gap between the more typical PPPs involving utilities, when a private company is partnering with a public authority to provide a service, and the social protection or social safety activities that are needed to build resilience in poor communities [28]. A recent model which promises to fill this gap is the Asian Development Bank's introduction of a technical and financial toolkit and framework to support urban septage and sewerage management, which involves a range of actors from the sector [6]. Such constructs could lead to more private sector engagement.

Investments at the 'bottom of the pyramid' might seem like an obvious route forward because of the size of the potential market and the enormous need among such customers for facilities and services. However, several important hurdles will need to be overcome for such investments to increase because of the nature of informal settlements that require broad-based upgrades in infrastructure, housing and services, among other things [106]. Finding incentives for businesses to invest in this segment of society is part of the challenge of making river basins and urban areas and hence local WASH systems resilient to hazards. For business to do so, some sort of return on investments is necessary within a reasonable turn-around time, but without appropriate governance structures the investments are not forthcoming. If 'bottom of the pyramid' investments are to succeed, a positive investment climate and the governance capacity to build and maintain both simple and complex infrastructure systems is required.

There are many moral hazards involved. Where subsidies are too great it can create the perception that WASH

services are a free commodity. There can also be disincentives to maintenance, for example communities often do not find it worthwhile to invest in operations and maintenance for DRR if they know that when there is a breakdown, governments or NGOs will come to the rescue [31]. Donor support in times of emergencies can also risk crowding out existing private actors [57], and after a humanitarian intervention residents suddenly need to start paying for services that were free and of much better quality (29).

Also, when social security nets are being introduced it is important that already informal systems are not destroyed—a lesson learned from European social history [56]. Developing countries have a long history of informal systems, for example reliance on neighbors and families during disasters, which are important for strengthening resilience to water-related disasters. In Bangladesh, for example, people who have lost their homes due to flooding are in some cases allowed to rebuild on other people's land, under the assumption that the favor will one day be returned [39].

### 3.9. Microfinance

A review of microfinance programs for water and sanitation suggests that there is a large potential demand. However, while there are many pilot projects, very few have achieved scale. Microfinance institutes still show a low interest in the water and sanitation sector, especially urban sanitation, for it continues to be relatively unknown and is perceived as high risk [67]. In the Philippines, community-level microfinancing exists for both DRR and WASH [117]. Members of a so called Purok system, a micro-governance system at community level, voluntarily contribute to a bank used by those in need of emergency funds after a disaster. Private sector actors also have a role to play in supporting such community microfinance. In the Philippines, a real estate company in the city of Cebu has taken the initiative to transfer the Purok system to a peri urban area. This is motivated by legislation, which prescribes a certain percentage for CSR, as well as by a wish to leave a legacy. Financial capital is built up in a system of co-finance, where the community delivers its part, such as setting up an organization and activities, and then receives incentives accordingly (4).

## 4. Conclusions

We have described in this paper the different ways in which risk, vulnerability, and resilience to water-related hazards is constructed in WASH systems, how dysfunctional systems result in health impacts for communities at risk, and why these problems should be of grave concern to the global community.

Investments in WASH systems are often narrowly framed. They tend to focus on the provision of access to safe water and sanitation facilities and services at the level of the city at the most or at the community or individual level. Because of a lack of integrated WASH investments, the cost-effectiveness of existing investment decisions can be questioned. We argue in this paper that building the resilience of WASH systems to water-related hazards and resulting health risks requires a broader set of investments across the entire socio-economic system to which the WASH system is linked. This system includes the river basin (and sometimes beyond it) and the wider urban area in which the WASH system is located, right down to the point of access for the individual user. Building resilience to hazards consequently requires better coordination and collaboration between stakeholders engaged in a broad range of different sectors who influence the way in which land and water resources are used at different areas, such as agriculture, energy provision, natural resource extraction, conservation, housing and infrastructure development, industrial development, and disaster risk management. Profound changes or transformations in the way we manage natural resources will ultimately be needed as urbanization and development in river basins increasingly constrain systems.

Central to our examination of resilient WASH systems is the role of Public Private Partnerships (PPPs) and social learning, and the opportunities that exist for strengthening investments that are based on a more integrated view of the different elements of the WASH system and how they interact.

### Business strategies

We identified a number of business strategies that could help to reduce the vulnerability of people and businesses to water-related hazards in urban areas, and that have direct and indirect positive impacts on enhancing the resilience of urban WASH systems, emphasizing the important role of social learning. These strategies are summarized below.

1. Reexamine the profitability of existing WASH investments in light of expected losses and damages caused by water-related hazards. Cost-benefit analysis and strategic environmental assessment tools can help raise awareness of the benefits of investing in ecosystems.
2. Replicate and upscale approaches that acknowledge that water needs to have adequate space. This entails more integrated social and technical programmes that incorporate flood preparedness and non-structural mitigation, and a multifunctional land use approach.
3. Create an institutional culture for private sector investment based on accountability, facilitated by quality assurance approaches and methods. Strive towards a more green and resilient city environment, and promote concerns about the continuity and long-term reliability of investments.
4. Develop a better understanding of the customer base, including worldviews, needs and preferences, motivations, and purchasing power. Find out how the 'Bottom of the pyramid' investments can become profitable through strategic innovation, especially in poor urban communities.
5. Support a new segment of private entrepreneurs through legislation, as well as empowerment of and

dialog with (informal) small private actors. Create an enabling policy, and a supportine practice in building trust, capacity and dialog.

6. Develop micro-insurance mechanisms in dialog with vulnerable communities to help them cope with financial risks. The most needed insurance is likely to be for health risks.
7. Build (micro) financial opportunities which can enable vulnerable people to make a transition into new livelihoods and reduce poverty. Consider how to reduce moral hazards when a service is provided for free or at a subsidized price.

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Sustainable urban development depends on urban "resilience" to cope with, and adapt to an increasing global water crisis created by multiple pressures that include flooding, scarcity and pollution. However, these pressures are managed by different working areas divided by institutional structures and applying different approaches and practices. This thesis investigates the role of social learning in improving urban resilience, and understanding what this means in the context of urban water services (drinking water, sanitation and drainage).

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