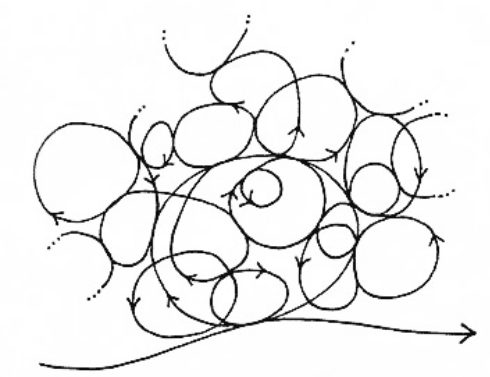
Water utility providers in urban water management transitions

Participatory governance experiments and socio-institutional change in Amsterdam urban water management regime



Andrea Fulgenzi

950315248090

June 2019

MSc Thesis Environmental Policy Group

Supervisor: Bas van Vliet

WAGENINGEN
UNIVERSITY & RESEARCH

Environmental Policy Group
WAGENINGEN UNIVERSITY

Summary

The scholarship on sustainability transition in urban utility sectors is gaining increasing attention thanks to its combination of social and technical issues related to service provision and consumption. Although the frameworks of Transition Management and Strategic Niche Management acknowledge the need for radical changes in both these social and technical aspects, several scholars have argued for a lack of insights into the institutional and political impacts of sustainability transitions in urban utility networks. Moreover, there is an increasing number of so-called 'transition experiments' that envisage an active role of end-users, with the aim of modifying the behaviour of these actors and the deeply-rooted practices that hinder the adoption of more sustainable ones. Among these, well-known examples are the co-creation project of Amsterdam Rainproof, and the two citizen-science projects of Freshness of Water and Clean Water Experiment.

This research aims at analysing the role of water utility providers in urban water management transitions, by evaluating the impact of three participatory transition experiments that directly involved the citizens of Amsterdam, The Netherlands, with functions that have usually been attributed to regime actors. The role of water utility providers is defined as the ability of reconfiguring the components of the regime (actors, processes, structures and influences). Such reconfiguration process has an impact on the relation between providers and end-users, which can in turn change the way decision-makers prioritise and allocate investments in the urban water management sector.

The research revealed that the three case studies can be considered as exemplary participatory governance experiments that have been successful in introducing systemic changes from within the urban water management regime. The cultural structures of the regime have been the most affected, as the sense of 'distance' between end-users and regime actors has been bridged thanks to intermediary organisations (Amsterdam Rainproof) and to the development of new meanings and practices related to the urban water system among citizens (Freshness of Water and Clean Water Experiment). These changes represent the first step to introduce radical and more systemic changes in the relations between providers and end-users, as well as in stakeholder perception of investment decisions.

The participation of citizens in urban water infrastructure management will eventually have to be mainstreamed and regulated, in order to be effectively used to delegate responsibilities and functions that have been traditionally attributable to water utility providers only. The future development of participatory governance experiments will be crucial for ensuring wider application of co-creation and citizens-science and to safeguard scientific validity, especially for transferring these initiatives in other urban utility sectors such as electricity provision and waste management. Future research should hence focus on investigating the perspectives of specific actors for engaging end-users with additional roles and delegating responsibilities and/or functions to them, as well as addressing issues related to political dynamics and allocation of financial resources for implementing more sustainable practices in the urban water management sector.

Acknowledgements

Having eventually arrived at the end, I realize how long this MSc thesis writing process period has been an interminable and painstaking process of iteratively conceptualizing, writing, revising, adjusting and updating that challenged my skills and knowledge both at the academic and personal level. I must acknowledge all the help that friends, family, and colleagues gave me throughout this period.

First of all, I would like to thank Bas van Vliet for all the support he gave me from the beginning until the end of this research. I am grateful for his enormous amount of patience, for his help in keeping me grounded to simplicity and realism, and for always being available to answer my questions. I am also significantly grateful for his help in finding the internship I am currently carrying out, which is so much related to this thesis that I am almost happy that the two overlapped at the beginning. I hope I managed to show him the passion that grew in me towards the topics that he himself taught me. Maybe, into the overly-abstract reasoning and conceptual discussions that we had in these months, he would recognise some of the same passion that guided him as well as a student.

Second, I would like to thank the friends who I shared this thesis-writing period with: thank you Francesca, for being our mutual peer-reviewers in the thesis rings; thank you Marzia, for reminding me that it is important to be aware of the choices we make; thank you Gianluca, for always being ready to remind me that our lives continue after the thesis project.

Thank you to Greta, Giordano, and Flavio as well: even if we live in three different countries, we share the same roots and the same commitment to make the world a better place. I hope more than ever that we will converge towards this goal.

Third, I would like to thank my family, without whom I would not have had the possibility of spending these two incredible years in The Netherlands in the first place. I hope that you are proud of what my sister and I have become. Thank you to my grandparents as well, whose memory and passion are carried on through their grandchildren.

Last but not least, thank you to Nicola, who has always been near for support and motivation. I am grateful for having shared this experience with you, for having started a new life together, and for being the person to hold on to anytime I feel overwhelmed by anxiety for the future. Now more than ever I realise how much you are part of the future I am building for myself.

Table of Contents

List of Figures

List of Tables

List of abbreviations

AGV	Amstel, Gooi, and Vecht
CE	Circular Economy
ICT	Information and Communication Technologies
IPCC	International Panel on Climate Change
KWR	KWR Watercycle Research Institute
PVPs	Photovoltaic panels
RWA	Regional Water Authority
SNM	Strategic Niche Management
STS	Science Technology and Society
TM	Transition Management

1. Introduction

The last special report from the International Panel on Climate Change (IPCC) laid strong emphasis on the urgency of implementing the "rapid, far-reaching and unprecedented changes in all aspects of society" (IPCC, 2018a, p.1). These changes include "transitions in energy, land, urban and infrastructure […] system" as a pathway to limit global warming to 1.5°C (IPCCC, 2018b, 21). New approaches are hence needed to steer the future development of these interrelated systems.

The future development of urban areas should therefore converge towards a unitary, connected system where the water, energy, and waste flows are managed in a circular and integrated way. Reducing the ecological impact of our consumption production patterns and our lifestyle is, however, a difficult challenge because these unsustainable practices are deeply rooted in our complex and adaptive societal system.

One of the reasons why such transformation has not materialised yet is that it is extremely hard to introduce such radical a change and to scale it up until the 'new' system replaces the 'old' one, because of a series of "systemic and interrelated […] barriers" (van de Meene, Brown & Farrelly, 2011, p.1118) that slow down or hinder the innovation process. This is particularly relevant for the urban water infrastructure sector, where the development of the system follows small incremental steps usually focused on efficiency improvements (Rotmans & Loorbach, 2009; van de Meene et al., 2011).

Sustainability transitions in the urban environmental infrastructure are considered as a pathway to move past the lock-in and path-dependency of current production and consumption systems (Frantzeskaki & Loorbach, 2010). The concept of *sustainability transition* specifically deals with systemic change in societal system towards more sustainable practices. The term 'transition' here refers to the "gradual, continuous process of change [that] transforms the structural character of a society" (Rotmans, Kemp & van Asselt, 2001, 16). Urban areas are in this sense considered as "critical hotspots" (Wolfram, 2016, p.125) for developing strategies and measures for implementing sustainability transitions in urban societal systems.

Such transformative change is usually introduced by "experimentation" (Bos and Brown 2012, p.1341), by in other words testing technological innovations and multi-stakeholder governance approaches in small-scale projects. Although so-called 'transition experiments' have been carried out in approximately every sector related to climate change and urban sustainability, the urban infrastructure system is the most common sector worldwide where such experiments are conducted (Bulkeley & Castán-Broto, 2013). Several authors describe the development of urban water management paradigms (Van der Brugge, Rotmans & Loorbach, 2005; van Vliet et al., 2005; Brown, Keath & Wong, 2009), each with its own predominant governance structure and mode of organising the infrastructure network.

The literature here refers to "infrasystems" (Jonsson, 2005) as a "type of societal system that includes both the physical component that is the infrastructure and the institutions regulating and managing it" (p. 1293). Transitions in infrasystems are therefore processes of "fundamental change in the institutional component and in the design of infrasystems" (Frantzeskaki & Loorbach, 2010, p.1293). These changes at

infrasystem level have substantial implications for the future design of urban environmental governance, as policymakers and practitioners need to engage in reflexive strategies to stimulate organisational and social learning, and increase institutional capacity (Voss, Smith & Grin, 2009). This process is translated in practice into experimentation with governance structures, where "governing is conducted through multiple sites and forms of intervention" (Bulkeley & Castán-Broto, 2013, 362).

The scholarship on urban water management and infrastructure development also attributes the lack of transformative capacity as a "lack of insight into [the] governance approaches required to support [more sustainable] practices" (van de Meene et al., 2011, p.1118). The reviewed literature on socio-technical transitions lacks extensive investigation on the extent to which changes in urban water governance influence the dynamics of socio-technical transitions. For example, Rotmans et al. (2001) emphasise the need of further research on the "social and institutional aspects of transitions" (p.29) and on the governance challenges associated with them.

There are examples of how infrasystems development implied changes in the role of end-users, especially in the case of urban water, energy, and waste management. Scholars focusing on the political and governance challenges related to transitions in these sectors have investigated shifts in power balances and in socio-political contexts (cf. Browne, 2015; Shove & Walker, 2007; Avelino et al., 2016). Hooghe and Marks (2003), for example, argue that "modern governance" is moving "away from central states" and that it is being "dispersed across multiple centres of authority" (p.233)

The urban water management sector is facing similar dynamics, as the modes of organisation of urban water infrastructure are shifting towards an increasingly active role of end-users (van Vliet, Chappels & Shove, 2005): citizens are not regarded anymore as "captive consumers" (p.47) but are increasingly involved in the co-creation of these systems and/or in the co-provision of related services. This provides ample opportunities for "changing users' practices and routines" (Frantzeskaki & Loorbach, 2010, p.1294) with more sustainable ones.

To introduce more sustainable modes of urban utility management, it is therefore necessary to reconfigure both the way infrastructures are managed and their associated socio-institutional structures. In other words, analysing the development of multi-level governance in urban water infrastructure can be done by analysing how its current regime is changing, and in which direction.

Three innovative projects recently implemented in Amsterdam, The Netherlands, are examples of how participatory transition experiments can effectively steer urban water management towards more participatory governance structures. These projects are *Amsterdam Rainproof*, *The Clean Water Experiment,* and *The Freshness of Water.* They have been used in this research as representative case studies of two different ways of introducing multi-level water governance arrangements, and both need to be taken into account for a complete analysis: co-creation in the first project, citizen-science in the other two.

This research is divided into the following main sections. After this introduction, the following section states the research objective, the main research question and sub-questions, together with the scope and limitation of the research. Then, chapter 2 presents the theoretical framework and the literature review that has been performed to build the conceptual framework of the research. Section 2.4 describes how key concepts selected

from the reviewed literature have been combined into the conceptual framework that guides the analysis of the role of water utility companies in sustainability transitions. Chapter 3 presents the research methods used in the research, and the rationale behind the selection of case studies. Chapter 4 gives an overview of the transition in urban water management that has been unfolding in The Netherlands. Section 4.3 presents to the reader the three case studies selected in the research. The following chapter 5 contains the results of the semi-structured interviews and questionnaire, according to the key concepts of the conceptual framework. Chapter 6 analyses these results in a more critical way, and section 6.2 discusses them in relation to the broader scholarship on sustainability transition and urban water management. Then, Chapter 7 presents the conclusions of the research and provides recommendations for future research and for Amsterdam water utility provider.

1.1. Research objective

The aim of this research is to understand how water utility providers influence urban water management transitions, by analysing the relation between infrastructural and socio-institutional change in three participatory projects in Amsterdam, The Netherlands.

The research combines studies on infrastructure development and urban water governance to analyse changes in the social and institutional components of the urban water infrasystem, as a result of ongoing sustainability transitions in urban water management. This research aims at addressing current knowledge gaps on sustainability transitions, their governance challenges, and the reconfiguration of socio-institutional structures (cf. Browne, 2015; Rotmans et al., 2001; Shove & Walker, 2007; Avelino et al., 2016).

1.2. Research questions

The main question driving the research is: *in what ways does the Amsterdam water provider Waternet influence the ongoing transition in urban water management?*

Sub-questions

The main research question has been further divided into sub-questions to increase its clarity and specificity:

1. To what extent did previous transitions in water governance reconfigure the urban water infrasystem in Amsterdam?
    1.1. How did the four regime components (actors, influences, processes, structures) of Amsterdam water governance change?
2. To what extent do ongoing experiments in urban water management drive reconfigurations in the governance of Amsterdam urban water infrasystem?
    2.1. How are the four regime components (actors, processes, structures, influences) of Amsterdam water governance changing?
3. What are the resulting changes in the rules and norms that guide Waternet management strategy?
    3.1. How are the narratives affecting the distribution and interdependency of resources changing?

1.3. Scope and limitations

The research provides an in-depth and up-to-date understanding of the ongoing transition in Amsterdam urban water governance and in the management strategy of the Amsterdam water utility provider. The analysis of the ongoing transition has been based on a preliminary evaluation of three participatory projects of co-creation and citizen-science carried out in Amsterdam, in the extent to which they potentially contribute to the reconfiguration of the urban water governance regime components towards a closer relationship between end-users and the water utility provider Waternet.

The research has been carried out combining semi-structured interviews with a Likert-type questionnaire (cf. chapter 3). Both have been administered to senior managers and project coordinators, which provided in-depth insights on the strategy of regime actors —namely, Waternet, the Regional Water Authority AGV Waterschap, and the Municipality of Amsterdam. The research has a strong qualitative nature, and the use of a quantitative method has been conceived as complementary to conduct an in-depth investigation into the strategy of institutional actors and their perspective towards issues related to investment decisions and other general environmental policy issues.

The main limitation of the research, therefore, concerns the limited sample size of the research methods. The selected sample of respondents has a representative function, as the participants cover senior managerial and decision-making positions in their respective organisation (cf. Annex I). The choice of limiting the sample to these specific individuals has been based on the fact that decision-makers at high organisational levels the most important actors for investment decisions, and they are in charge of developing the strategic vision of their organisation —often together with other relevant stakeholders. They are considered as key interviewees for providing information on the direction towards which their institution is moving.

2. Theoretical framework

The interdisciplinary and cross-cutting nature of the approach used by the scholarship on sustainability transitions requires a theoretical framework that integrates multiple sets of literature, in order to analyse urban infrastructure development. There are several existing conceptualisations of sustainability transitions, which be used to analyse the co-evolution of urban infrastructure systems and their related societal system in socio-technical transitions. Among these, the Transition Management (TM) framework describes the development of large socio-technical systems as a continuous process of "destabilisation, emergence, and institutional change" (Loorbach et al., 2017, p.605), which unfolds until the configuration of the previous system is replaced or absorbed into a new one (Rotmans & Loorbach, 2009; Rotmans, Kemp & van Asselt, 2001).

The predominant approach for managing urban environmental infrastructures, and for explaining their transition to different system configurations, has been however criticised by contemporary literature as focused on an overly technocratic-engineering approach, which leads to prioritising technical, incremental, and efficiency improvements with low-risk investments (van der Brugge, Rotmans & Loorbach, 2005; Farrelly & Brown, 2011; Marlow, Moglia, Cook & Beale, 2013). Focusing on mainly technological innovations represents a path-dependency for the development of socio-technical systems such as the urban utility network. Such technological path-dependencies affect the way utility networks are configured, how they are provided to end-users, and the approaches adopted by institutional and political structures to manage and regulate them (Van Vliet et al., 2005; Avelino et al., 2016; Shove & Walker, 2007).

Sustainability transitions therefore affect both the physical and socio-institutional structures of the urban infrasystem. It follows that the 'unfolding' of sustainability transitions in urban utility sectors should also inevitably rely on both technical and institutional innovations. However, the urban water management sector has been criticised for focusing mostly on technological and efficiency improvements while paying little attention at the more social aspects of urban water management, such as organisational learning, social innovations, and participatory approaches to utility management (Pahl-Wostl, 2007; Pahl-Wostl, Mostert & Tàbara, 2008; Agudelo-Vera et al., 2014; Browne, 2015).

The following chapter presents the theoretical framework of this research. It comprises four sections and a conclusions paragraph at the end of the chapter. First, an overview of the main body of literature of this research is provided, laying the theoretical foundation to the dynamics of sustainability transitions in urban water infrastructure systems. The second section explains the development of urban water infrastructures, outlining recent alternative approaches to traditional urban water management paradigms and identifying potential knowledge gaps in the existing scholarship. The third section introduces the discourse on urban water governance and its relevance with the development of urban infrastructure systems. The fourth sets out the operationalisation of urban infrastructure development as the result of socio-institutional restructuring, with a specific section describing the three key concepts that drive the analysis of the role of water utility companies in urban water management transitions.

2.1. The dynamics of sustainability transitions in socio-technical systems

Research on Science Technology and Society (STS) constitutes the core set of literature behind this research. The term *sustainability transitions* in STS refers to fundamental, systemic changes in joint socio-technical systems towards more sustainable configurations and practices (Markard, Raven & Truffer, 2012; Loorbach, Frantzeskaki & Avelino, 2017). In general, *transitions* have been defined as the "restructuring of a societal system" (Rotmans & Loorbach, 2009, p.185) that introduces new "structures, cultures and practices" or radically modifies the existing ones (Frantzeskaki & de Haan, 2009, p.594). This process assumes the 'sustainability' dimension when these radical and structural changes move socio-technical systems towards alternative patterns of lifestyle, production and consumption that are considered 'more sustainable' than the previous system configuration —referring to a "qualitative shift from (perceived) persistent unsustainability" (Loorbach, Frantzeskaki & Avelino, 2017, p.605).

Scholarship on sustainability transitions is highly interdisciplinary and integrates a broad range of theories and frameworks. Transition Management (TM) and Strategic Niche Management (SNM) are considered the "systemic" and "far-reaching" (Markard et al., 2012, p.956) frameworks that specifically analyse how to steer the pace and direction of societal systems towards a desired outcome or transition objective (Loorbach, Frantzeskaki & Avelino, 2017). TM deals with issues of capacity building, inclusiveness, and social learning as challenges associated with the policy-making and agenda-setting processes of sustainability transitions; SNM aims at stimulating co-evolution processes between technology and society using real-life experiments (Loorbach, Frantzeskaki & Avelino, 2017). The common aspect of both frameworks is that innovations are introduced in bottom-up processes of change, and hence they oppose to the current system configuration and have to be embedded at higher policy levels.

TM and SNM share the same heuristic analytical model to explain and analyse transitions, based on the interaction between *levels* (i.e., regime, niche, landscape) and *phases* of socio-technical system development (Geels & Schot, 2007). The *multi-level perspective* (MLP) is a core concept that relates the transformation of socio-technical system to an evolutionary process, where the current configuration of an infrasystem is affected by changes at the *micro*, *meso*, and *macro* levels (Rip & Kemp, 1998; Rotmans, Kemp & van Asselt, 2001). The meso-level corresponds to the *regime,* described as a "community" of different stakeholders that share the same "cognitive routines" and "patterned development" (Geels & Schot, 2007, p.399). Besides engineers, the literature using the MLP concept includes among the regime members also "scientists, policy-makers, users and special-interest groups" (Geels & Schot, 2007, p.400). All these actors are therefore the key agents that define the dimensions of the regime —i.e., markets and user preferences, industry, science, policy, culture, and technology.

The roles and responsibilities of actors, the practices of end-users, as well as cultural and normative structures are therefore key elements that influence the development of urban infrastructure systems — besides technological innovations which lead to path-dependencies. The stability of a regime is threatened by *niches* (micro-level), which consist of radical innovations in one or more dimensions of the regime. A niche has the potential to upscale and bring about systemic change to the whole regime, therefore contributing to the

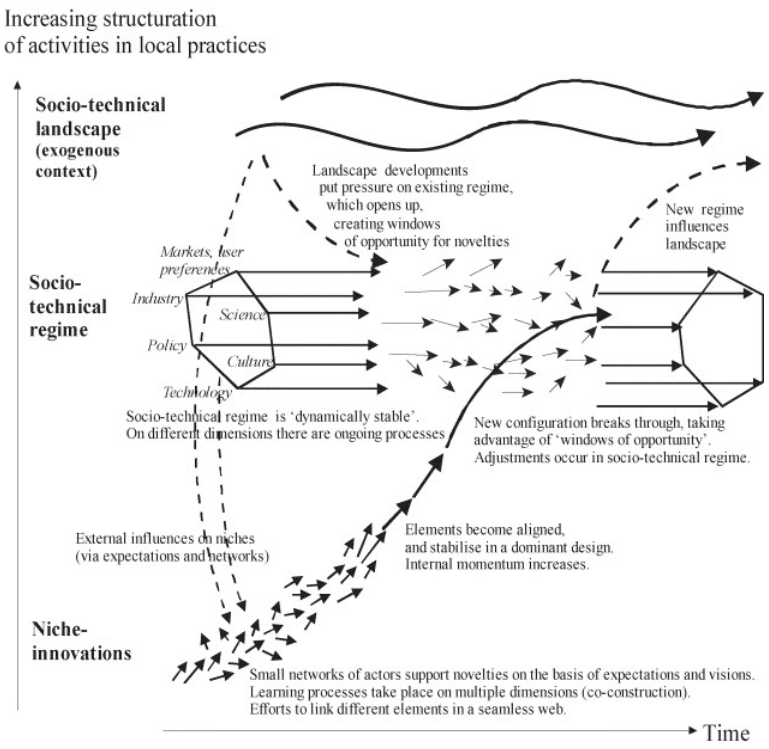


Figure 1: The Multi-Level Perspective on sustainability transitions.

Recent refinements of the model included the two downward, dashed arrows moving from the landscape and the regime to the niches, to acknowledge that the regime itself as well as the landscape have a significant role in the selection of nice-innovations. Source: Geels & Schot, 2007.

breakthrough of new regime configurations in the socio-technical system (Geels & Schot, 2007). According to SNM, niches create space for new practices and production-consumption patterns, by coupling the development of technologies with their context of end-users behaviour and expectations, legislative and regulatory frameworks, and market selection (Loorbach, Frantzeskaki & Avelino, 2017). The macro-level of the MLP is the *landscape,* which corresponds to an exogenous environment where slow-paced and far-reaching changes affect the configuration of the socio-technical regime, by dynamics that are either unforeseeable or uncontrollable by the regime.

The *multi-phase perspective* of sustainability transitions defines the stages through which transitions come about and upscale until they replace the existing regime —pre-development, take-off, breakthrough, stabilisation (Rotmans, Kemp & van Asselt, 2001). Systemic changes are introduced by "a set of connected changes [that] reinforce each other" (Rotmans, Kemp & van Asselt, 2001, p.16) through positive feedbacks among the changes in different dimensions of the regime. After the *predevelopment* and *take-off* phases, it is specifically during the *breakthrough* phase that structural changes in the regime begin to upscale and reinforce each other, thanks to the "accumulation of socio-cultural, economic, ecological and *institutional* changes" (Rotmans, Kemp & van Asselt, 2001, p.17, emphasis added).

The multi-level and multi-phase perspectives do not conceptualise niches as mere 'antagonists' to the regime: the two models have been revised to include the way "broader regime and landscape developments" influences the perception of and support to niches (Geels & Schot, 2007, p.400). Figure 1 shows a well-known

representation of the multi-level perspective for sustainability transitions, which envisages transformation in the dominant regime as a quasi-evolutionary process.

2.2. Development and management of the urban water 'infrasystem'

In the urban water management literature, increasing attention has been given to "alternative[s] to the traditional way in which urban water systems are managed" (van de Meene et al., 2011, p.1117). Such alternative approaches to natural resources management specifically refers to the adoption of adaptive management strategies to cope with climate change adaptation and the associated uncertainty, complexity, and risks (Pahl-Wostl et al., 2007). The taxonomy of these alternative approaches differs in the way they aim to fill policy-implementation gaps in specific urban water management issues. These paradigms reflect the historical evolution of urban water management paradigms as a function of socio-political drivers and service delivery (Brown et al., 2009). Figure 2 shows how the functions of urban water management actors evolved in time, relating each socio-institutional configuration with a specific development in the physical structures of the urban water system.

Similarly to the general concept of sustainability transitions, the literature considers Sustainable Urban Water Management (SUWM) as the answer to the need of a "radical co-evolutionary change" (Marlow et al., 2013, p.7155) in the socio-institutional, cultural, and infrastructural components of current urban water management regimes (Brown, Keath & Wong, 2009; Farrelly & Brown, 2011). SUWM is an umbrella term, defined as "a generalised goal to manage the urban water cycle to produce more benefits than traditional approaches have delivered" and "enhance social, ecological, and economic sustainability at various scales" (Marlow et al., 2013, p.7151-7152). This urban water management approach wants to strategically address the challenges that the sector is facing, especially for those related to climate change, population increase, and nature areas conservation and protection (van de Meene et al., 2011).

Several authors from the SUWM scholarship, however, argued that the adoption of SUWM strategies in urban water management at international level has been slow and difficult to implement, because of limitations in available budgets and limited knowledge in governance approaches to support policy implementation phases (van de Meene et al., 2011; Farrelly & Brown, 2011; Marlow et al., 2013). The literature argues that more structural approaches are needed, to upscale innovations beyond niches and pilot projects, and to support systemic changes at strategic governance levels (Farrelly & Brown, 2011; Marlow et al., 2013).

2.2.1. The nature of urban water 'infrasystems' development

Given the complexity inherent to large socio-technical systems such as the urban water infrastructure, systemic approaches should be applied in studying urban water management transitions. As one of the central tenets of STS, this kind of approaches can account for the different *levels* and *phases* that lead to the replacement of the existing urban water management paradigm with a new one (Rotmans & Loorbach, 2009; Rotmans, Kemp & van Asselt, 2001). In turn, system-thinking would require the implementation of innovative solutions in all the different phases of urban water infrastructure management, so that cutting-edge technologies are applied homogeneously throughout the various elements of the system and are oriented towards the same objective —

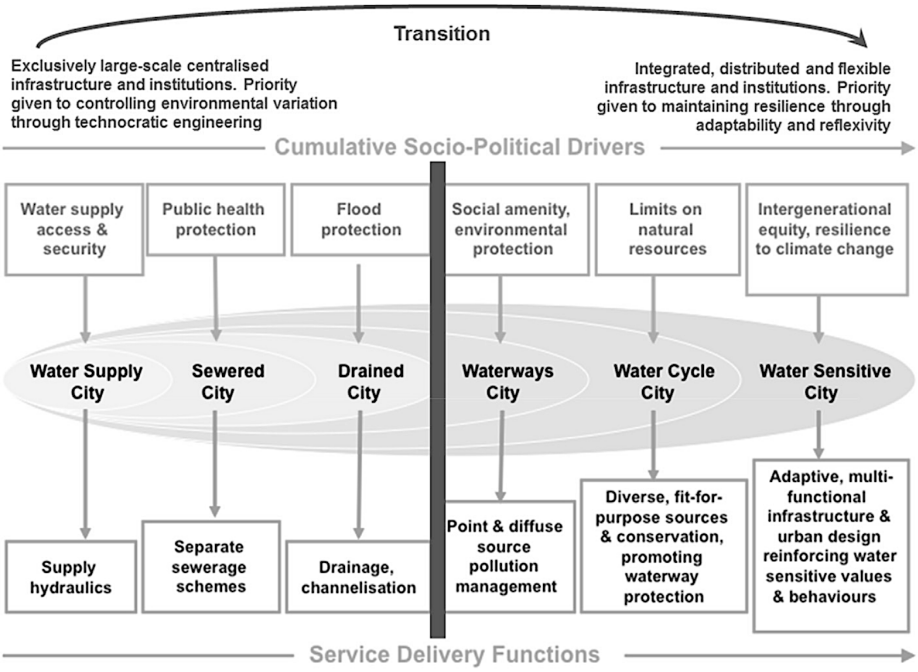


Figure 2: Urban water management transitions as interaction between socio-political drivers and service delivery functions. The vertical segment in the middle represents the division between historical and aspirational states. Source: De Haan et al., 2015.

minimising emissions of pollutants and closing as much as possible the loops of materials and nutrients. However, intervening in all the sub-elements of the infrasystem is often regarded as "too costly, undesirable or socially unacceptable" (Wolfram, 2016, p.125). Bos and Brown (2012) state that there is a "historical division between the infrastructure and management" (p.1341), which prioritises asset management issues of end-of-life infrastructure. The introduction of innovations has therefore always been dependent on the limited budget available to water utility providers, which does not leave space for testing innovations that could foster social learning in open or informal networks where multiple stakeholders collaborate and co-create knowledge.

The concept of "infrasystems" (Kaijser 1994, in Jonsson, 2005) is a more systemic perspective for analysing urban utility systems. It conceptualises urban utility infrastructures as unitary systems comprising both physical as well as socio-institutional structures. Infrasystems have been defined as "large technical systems with a public character, […] imply[ing] considerable and long-term conditions for public activities" (Jonsson, 2005, p.2). The urban water infrastructure system is also an infrasystem with a public character, in which the 'public activities' are the ensuring of water safety and flood protection for citizens. It is the interplay of "individual preferences, activity patterns, business cultures, and the role of public authorities" (Jonsson, 2005, p.3) within an infrasystem that determines the 'direction' of its future development. In other words, the transition objective of infrasystem development reflects exactly this interaction between technical and organisational elements of socio-technical systems.

Urban water infrasystems are highly complex and adaptive systems, and there are several factors contributing to the policy-implementation gap identified by the SUWM literature: their development is path-dependent to sets of practices that became established as the dominant paradigm after years of managing the

infrastructure in the same efficiency-oriented way; professionals rely their know-how on traditions and 'silo-thinking,' while sustainability transitions in urban water infrasystems require 'cross-cutting' and interdisciplinary competencies and a continuous generation of knowledge to face uncertainty and ambiguity; moreover, the complexity of the system requires high-level expertise in order to directly intervene on it, but this kind of knowledge should be reflexive and adaptive to change (Frantzeskaki & Loorbach, 2010; van Vliet et al., 2005; Voss & Kemp, 2006). Some authors in the urban water management scholarship include among these challenges a general preference for "scientific, technical, and linear solution and an emphasis on the efficiency of outputs" (Farrelly & Brown, 2011). It is therefore difficult to change urban water infrasystems by introducing radical and systemic disruptions, as the regime is highly resistant to change and prioritises efficiency improvements, low-risk investments in innovation, and incremental development steps.

2.3. Governance experimentation and stakeholders participation

Several authors stated that TM tends to "overlook the political processes" (Voss, Smith & Grin, 2009, p.277) related to the transition from one regime configuration to another. The design of new governance approaches, according to the literature, should be reflexive, based on "long-term guidance" while keeping in mind "short-term contextuality," aiming to solve the "uncertainty" (Voss, Smith & Grin, 2009, p.281) related to adaptive and reflexive measures. Research and applications of TM should account more for the institutional and political context of transitions and how institutional and political dynamics influence the design of governance approaches and the agency of stakeholders (Voss, Smith & Grin, 2009). Similarly, Markard (2012) states that sustainability transition research consists of an analysis of the "institutional, organisational, technical, social, and political aspects" (p.959) of sustainability transitions in socio-technical systems.

Most innovations introduced in the water infrastructure take the form of pilot projects in urban areas, referred to as "transition experiments" (Bos & Brown, 2012, p.1347; Wolfram, 2016). *Transition experiments* are defined as "strategically chosen projects […] that are expected to make a major contribution to a transition, from which participants can learn about a social task and the accompanying system innovations and transition processes" (Transitiepraktijk, 2009). These real-life projects are similar to living labs, and they have been used to test the social acceptance of end-users to new technologies and the penetration of these innovations into households (Agudelo-Vera et al., 2014), or to evaluate the additional roles that residents may have for implementing climate change adaptation measures (Hegger et al., 2017).

Experimentation serves also as a mean to stimulate social learning, to understand (and implement) strategies of urban water governance that differ from traditional command-and-control measures (Farrelly & Brown, 2011). In this sense, the concept of transition experiments is similar to SNM in the distinction between bottom-up innovations in niches vis-à-vis a regime that resists to such changes. In fact, transition experiments have been specifically used for introducing new configurations of actors and/or institutional arrangements within an existing regime, as well as aggregating and transferring knowledge and introducing new practices within the dominant governance paradigm (Matschoss & Heiskanen, 2017).

2.3.1. Governance experimentation and socio-institutional change

Several authors support the idea that sustainability transition research should also consider how different governance approaches and policy mixes can contribute to the upscaling and speeding up of socio-technical transitions. The concept of transition experiment has also been applied to new governance approaches for managing urban utility sectors such as water, energy, and waste management. Bos and Brown (2012), for example, define *governance experiments* as innovative governance approaches which "aim to alter the configuration of decision-making" (p.1341). They argue that governance experimentation enables social learning, which in turn systemic changes in the "norms, values, goals, operational procedures, actors that govern decision-making processes and actions implemented" (p.1341). Governance experiments are conceived as alternatives to traditional command-and-control mechanisms, used by policymakers to stimulate social and organisational learning and eventually support the embedding of innovations from niches. Other authors also support research approaches that depart from a 'traditional' technocratic focus towards a more socially encompassing perspective on sustainability transitions, to acknowledge the relevance of social actors and individuals, their expectations, consumer preferences, and use of technologies and infrastructures (Browne, 2015).

Governance experiments also raise challenges concerning the relation between state and non-state actors, the role of citizens and end-user in the development of the urban water infrastructure, and the governance approaches applied to urban water management paradigms. Bulkeley and Castàn-Broto (2013), for example, show that transition experiments most of the times take the form of public-private partnerships, and that this processes create new political spaces within the city.

2.3.2. Stakeholders participation in transition experiments

The process of redefining participation for the upscaling of governance experiments is strictly connected to the contemporary discourse on multi-level governance, which envisages different roles for central state actors —or municipal and regional state actors when considering the water infrastructure system at urban scale. This is also visible in the prevalence of public-private partnerships configurations for carrying out transition experiments and for testing new approaches of environmental resources governance. There are several existing theories that categorise, with different terminologies, the various extents of stakeholder participation (**Figure 3**).

The participation of citizens and/or end-users creates new political spaces, implementation measures, and forms of interventions lacking in traditional hierarchical approaches (Bulkeley & Càstan-Broto, 2013; Hooghe & Marks, 2003). The arguments supporting alternative governance approaches to the traditional command-and-control is based on the fact that "state actors rely upon non-state actors in the formulation and implementation of public policy" (Smith et al., 2005, p.1498).

Engaging end-users and stakeholders in adaptive governance approaches also raises questions related to the re-definition and re-evaluation of the role of residents and non-state actors in the reconfiguration process of the urban water management regime. Hegger et al. (2017), for example, state that residents have a key role for the implementation of climate change adaptation measures, which raises questions on "the effectiveness of certain forms of engagement of residents and […] whether certain roles belong with [them]"

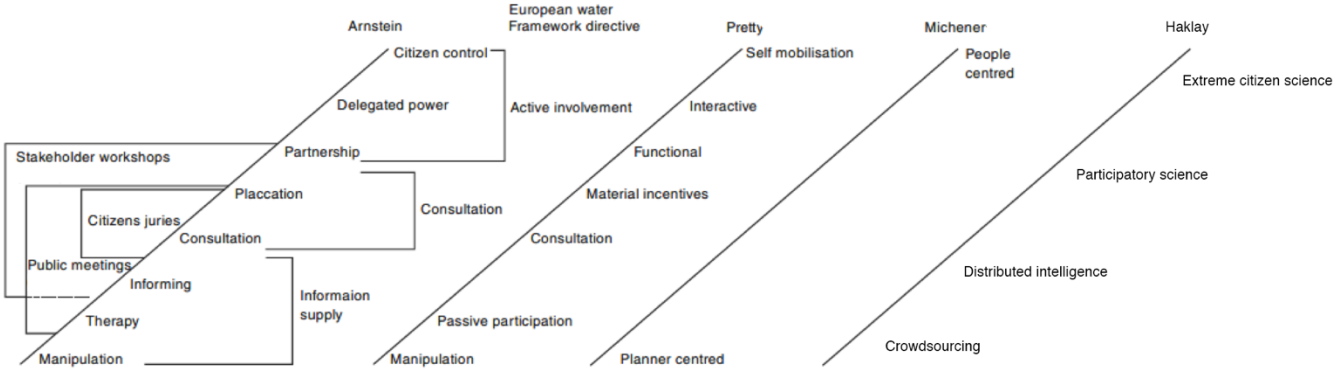


Figure 3: The existing categorisations of stakeholder participation, including Haklay's (2012) citizen-science framework. Adapted from Carr, 2015.

(p.347). The introduction of new roles of end-users, as well as unforeseen uses of the urban water infrastructure and technologies, redefines therefore the way the network of utility provision is organised (van Vliet et al., 2005). This, in turn, affects the relation between the actors responsible for the management of the urban water infrastructure and its end-users —i.e., between water utility providers and residents.

An example of reconfiguration of this relationship can be seen in innovations in the urban water infrastructure in The Netherlands, which recently took the forms of *co-creation* and *citizen-science* projects, which both envisage water utility companies as increasingly involved in setting the course for the future configuration of urban water infrasystems in close-contact with end-users and residents. Co-creation and citizen-science have been carried out for increasing the participation of non-state actors into the processes of urban infrastructure development and urban water governance. These two methods are examples of urban water management approaches based on stakeholder participation as a central design requirement to stimulate social learning. The relevance of such participatory approaches for urban water infrastructure development is that the interaction among stakeholders with contrasting framings of problems and policies, different normative values, practices and expectations increases social learning and the circulation of knowledge and resources among stakeholders.

2.4. Conceptual framework:

Participatory governance experiments in urban water infrasystem transitions

This section describes the analytical framework used to analyse sustainability transitions in urban water management from the perspective of water utility providers and their engagement with end-users. Three key concepts guide the analysis of the role of water utility providers in urban water management transitions: configuration of regime components, user-provider relations, and the so-called 'option space' of regime members, as shown in Figure 4. The interplay of these three concepts potentially determines the 'direction' of urban water management transitions. The concepts are therefore considered as key factors that drive the development of the urban water infrasystem.

The rationale behind the first key factor *(configuration of regime components)* is based on the fact that the niche is usually the unit of analysis the sustainability transition research, because it is the place where innovation is created and it must be 'protected' against the incumbent regime. In this research, the unit of analysis has shifted from bottom-up and mostly technological innovations (i.e., from niches), to top-down initiatives and institutional change (i.e., from within the regime). The refinement of the multi-level perspective (cf. Geels & Schot, 2007) does not include further explanations on the way regime members undertake processes of self-adaptation and restructuring, of so-called 'endogenous renewal.'

The second and third concepts include changes in the physical and the institutional structures of the urban water management regime. The second key factor, *user-provider relations,* refers to changes in the relations between institutional actors and end-users in the urban water infrasystem. This is indirectly related to

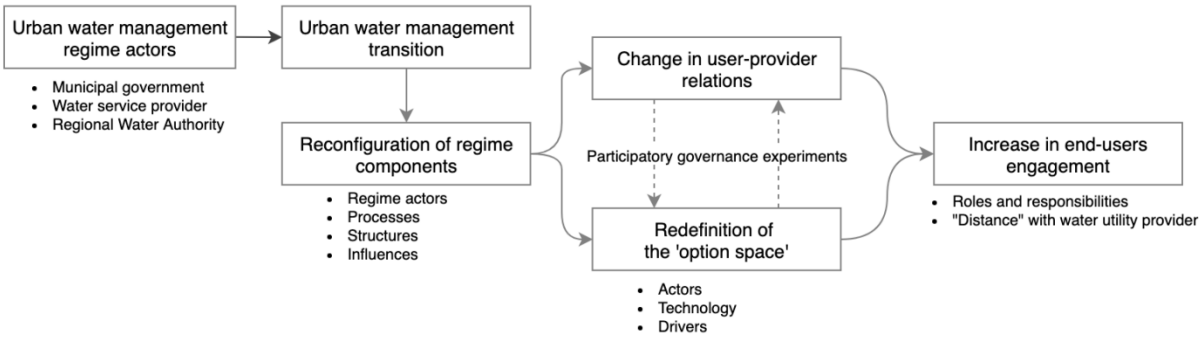


Figure 4: Urban water management transitions and the increase in end-users engagement through participatory governance experiments. The two dashed arrows mean that the implementation of participatory governance experiment can arise both from a change in user-provider relations or from a redefinition of the 'option space.'

Sustainability transitions in urban water management result in a reconfiguration of regime components (actors, processes, structures, and influences). Through the implementation of participatory governance experiments, such reconfiguration process can in turn influence user-provider relations and the definition of the 'option space' (according to the characteristics of the actors, the technology, and the drivers of innovation). The result is an increase in end-users engagement, which has an impact on the distribution of roles and responsibilities across regime actors and on the "distance" between end-users and the water utility provider.

changes in the physical urban water infrastructure, because changes in the relationships between end-users and utility providers influences the modes of water utility provision and the way the infrastructure network is organised and managed (van Vliet et al., 2005).

The third key factor, *option space*, considers the embedding of innovations in the development of the urban water infrastructure as dependant on a set of elements, shown in Figure 7. According to Marlow et al. (2013), the decisions of investment allocation for the embedding of innovations in urban water management are strongly influenced by these interrelated elements, which include the narratives of utility providers, their normative values, targets and expectations, and attitudes to risk.

2.4.1. Configuration of regime components: actors, processes, structures, influences

Sustainability transitions result in changes in four components of a regime (actors, processes, structures, and influences), and the configuration of these components determines the governance approach used to manage and regulate urban utility systems (van der Brugge, 2009). A schematisation of how these components interact with each other can be found in Figure 5 below.

Analysing the change in the configuration of regime components can therefore provide insights into the future development of the institutional structures of the urban water infrasystem. The 'governance approach' in this context is defined as the "people, organisations, […] and the corresponding policies and legislation" (van de Meene et al., 2011, p.1118). Regime actors have formal responsibilities and specific functions related to the different phases of urban water management —from drinking water provision to wastewater treatment and discharge. The expression 'urban water governance regime' adopted in this research therefore refers to the set of actors that are both involved with the practical management of the urban water infrasystem as well as those involved with the provision of resources and functions.

The literature on TM and SNM shows how niche-innovations can be developed in so-called 'transition arenas,' which are protected spaces exogenous to the regime that allow for the further upscaling and embedding of niches into the resulting new regime (Loorbach et al., 2017). Similar arguments have been raised

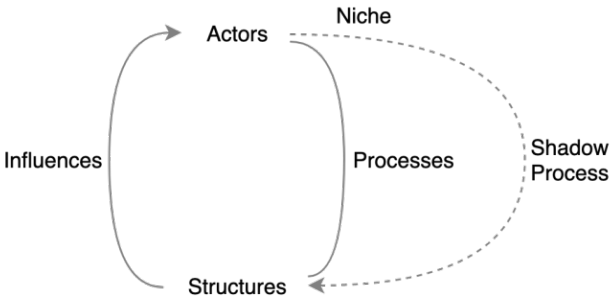


Figure 5: Schematisation of the regime components configuration. Adapted from van der Brugge, 2009.

These component refer to the dynamics and influences among actors in the current governance regime —as well as who these actors and 'relevant stakeholders' actually are— the processes that regulate these interactions, and the configuration of physical and socio-institutional structures. Niches can also initiate so-called shadow processes that change the infrastructural, institutional, and cultural structures of the regime.

in retrospective studies to analyse historical transitions in urban water management (Wolsink et al., 1998; van der Brugge et al., 2005; Agudelo-Vera et al., 2014). In these cases, the regime is considered as a "black-box" (van der Brugge, 2009, p.87). It is conceptualised, in other words, as a homogeneous set of actors that behave rationally and coherently, and without looking at internal dynamics such as conflicting interests and different framing of policy issues. Moreover, the current reconfiguration of the urban water governance regime is in line with the process of decentralisation and restructuring of the central state towards multi-level governance (cf. Hooghe & Marks, 2003; Bulkeley & Castàn-Broto, 2013). This argument is also in line with the concept of *governance by provision*, according to which "the provision of infrastructures and services […] influence[s] the practices of individuals and the trajectories of future developments" (Schroeder & Bulkeley, 2009, p. 354).

However, there have also been cases where actors already considered part of the regime prompted processes of systemic change, and several authors have investigated the role of specific actors as constraining or enabling factors in the implementation of sustainable transitions (e.g., Smith et al., 2005; Rotmans et al., 2001; Rotmans & Loorbach, 2009). An example is given by the energy transition from fossil fuels to renewable energy sources, where the central state has been a key player for the provision of incentives, subsidies, or other policy instruments for stimulating the penetration of technologies for renewable-energy provision. The same can be said for the traditional urban water management approach in The Netherlands, where governmental authorities had been the most influential actors and had the capacity to establish procedural and quality standards through a hierarchical and centralised approach (Wolsink, Herzt & Slingerland, 1998). This approach has also been regarded as highly collaborative and involving all relevant stakeholders, including residents (Wolsink et al., 1998; van der Brugge, 2009).

This type of transition dynamic stemming from within the regime has been referred to as a process of "endogenous renewal" (Avelino et al., 2016) of the urban water governance regime. This process is characterised by close interactions among regime members and other stakeholders, who engage with resource coordination and interdependency, creation of networks and partnerships, and generate knowledge.

2.4.2. User-provider relations

The relations between households and the water utility provider influences the modes of water utility provision and the way the infrastructure network is organised and managed (van Vliet et al., 2005). When end-users have the opportunity to participate in the development of the urban water infrasystem, they can become co-providers of the utility and co-generators of knowledge. The first case relates to co-creation, as in the example of households collecting rainwater that can be reused as a substitute for non-potable water; the latter can be found in citizen-science, where end-users collect data for the water service provider. In this research, the change in user-provider relations has been investigated in cases studies on co-creation and citizen-science, by looking at how these initiatives contributed to the redefinition of responsibilities and functions among members of the urban water governance regime.

Regime members are the most influential actors in the development of the urban water infrasystem. In fact, the agency of water utility providers is believed to be "more intensive" than other actors of the urban water infrasystem regime, and their exercise of agency is "neither homogeneous nor clearly bounded" (Smith et

al., 2005, p.1504-1505) for the practical functioning and evolution of the regime. However, van Vliet et al. (2005) show how agency has recently been redistributed across regime members towards roles for end-users as of co-producers of urban utilities like energy, water, and waste management.

As the responsibilities and functions related to urban water infrasystem development are not anymore concentrated into the hands of regime-members, other actors gain more relevance and power in the regime (Hegger et al., 2007). This can make it easier to align the different and potentially conflicting cultures, values, and visions of the stakeholders involved in urban water governance, which in turn supports the upscaling of urban water management transitions.

2.4.3. 'Option space' and investment for innovation

Investments decisions are a crucial issue in urban water management transitions. The flow of investment in the urban water infrasystem is especially in relevant in relation to asset management and end-of-life infrastructure. Marlow et al. (2013) conceptualise the flow of investment in the urban water sector as the interaction between two feedback loops (Figure 6). One is *metric-driven*, consisting in asset-management issues and service-delivery functions. The other is *opinion-driven,* based on stakeholder perception of the outcomes of these investments.

The concept of 'option space' influences the way decision-makers in urban water management identify solutions that can potentially be implemented (Marlow et al., 2013). There are several factors that determine the option space of a solution considered for implementation, depending on the technology to be implemented, on the drivers of innovation, and on the actors involved in implementing it. Marlow et al. (2013)

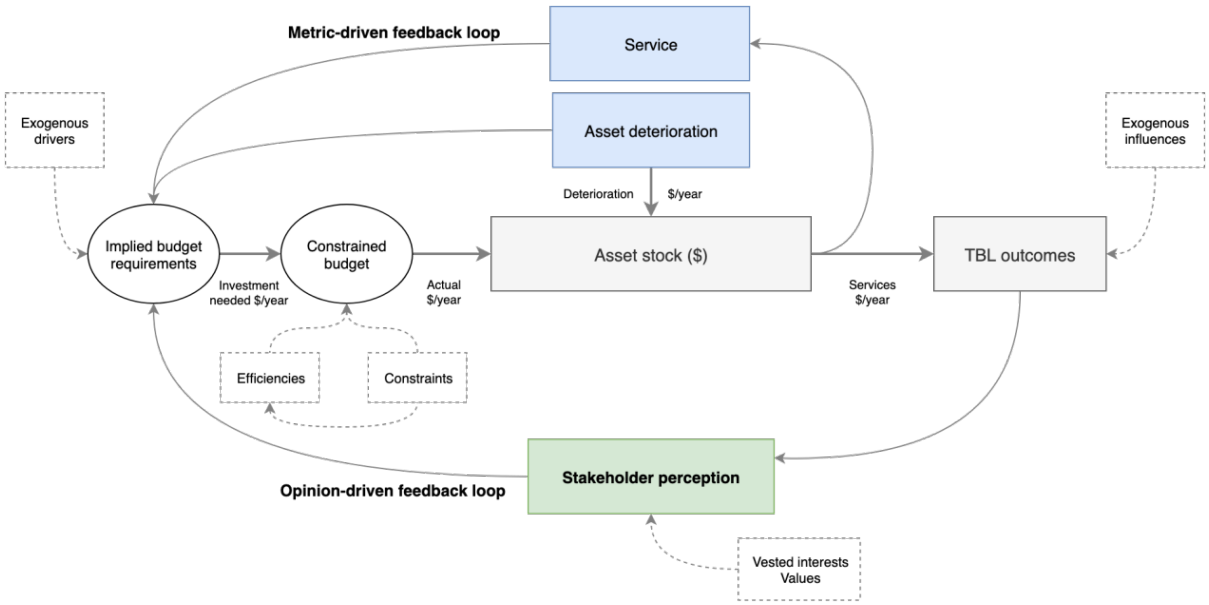


Figure 6: Schematisation of the investment flow in the urban water sector. Adapted from Marlow et al., 2013.

The accumulation over time of capital stock contributes to the delivery of utility services. The flow of investment is influenced by both a metric-driven and an opinion-driven feedback loop. The latter reflects the perception of broader triple bottom line (TBL) outcomes. Perception of stakeholders are in turn influenced by vested interests and values.

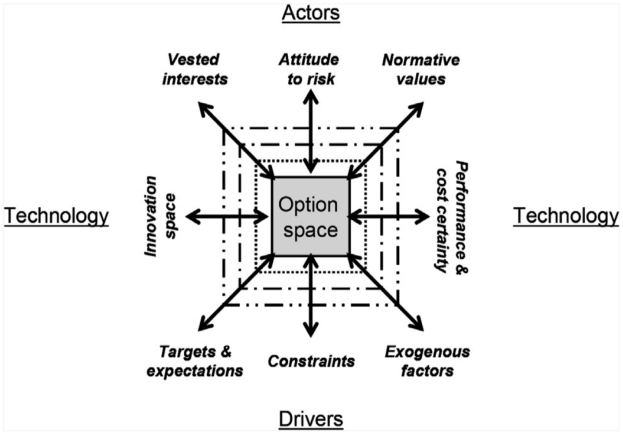


Figure 7: The set of dynamic and interrelated factors that influence the definition of the *option space*. These factors are categorised in their relation to technology, drivers, and actors. Source: Marlow et al., 2013.

provide a list of eight elements divided according to their relation with the technology considered, the drivers of innovation, and the actors involved in the implementation process (Figure 7).

Changes in stakeholder perception in turn results in "demand for change in the way investments are justified and/or the type of solutions funded" (Marlow et a., 2013, p.7156). The perception of regime actors of the outcomes delivered is therefore an important element that determines the prioritisation and allocation of investments (Pot et al., 2018). Similarly, Agudelo-Vera et al. (2014) state that decisions and strategies of water service providers have been crucial for determining the successive developments of transitions in urban water management —making reference to urban water management transitions in The Netherlands.

2.5. Theoretical framework: conclusions

The literature defines *transitions* as a process of "restructuring of a societal system" (Rotmans & Loorbach, 2009, p.185), which introduces new "structures, cultures and practices" or radically modifies the existing ones (Frantzeskaki & de Haan, 2009,p. 594). In socio-technical systems, sustainability transitions are related to changes in both the physical and the socio-institutional structures of the system.

The urban water infrastructure system is a socio-technical system with a public character, in which the 'public activities' are the ensuring of water safety and flood protection for citizens. The interplay of "individual preferences, activity patterns, business cultures, and the role of public authorities" (Jonsson, 2005, p.3) within the system determines the 'direction' of its future development. The transition objective of infrasystem development reflects exactly this interaction between technical and organisational elements of socio-technical systems.

Sustainability transitions and socio-institutional change

From the reviewed literature, it emerges that research on sustainability transitions has been criticised for overlooking the relation between the institutional and political impacts of transitions, on the one hand, and the socio-technical systems that is undergoing the transition on the other. Research and applications of the TM framework should take more into account the analysis of institutional and political context of transitions, and how this environment influences the design of governance approaches and the agency of stakeholders (Voss, Smith & Grin, 2009).

The urban utility sector requires a highly technical knowledge base to be managed and regulated, which can explain why the type of innovations introduced in these sectors are mainly focused on technological aspects through small and incremental efficiency improvements. In the specific case of urban water utility systems, increasing attention has been given by contemporary scholarship on the more 'social' aspects related to water consumption, innovation, and learning processes. The focus on so-called "practice-oriented approaches" (Browne, 2015) to urban water management is believed to increase the acceptance of (radical) innovations by end-users. Such conceptualisation can be traced back to the concept of "infrasystem" (Kaijser, 1994, in Jonsson, 2005), defined as a system that comprises both the physical structures of an urban utility system (the infrastructure itself) and the institutional structures that regulate and manage the system.

Behind the concept of institutional and organisational restructuring of urban utility infrasystems, there is also a more general enquiry about the relationship between public actors and citizens, especially regarding the participation and inclusiveness of end-users into the policymaking process of urban water management. The topic of end-users and, in general, active stakeholder participation into policymaking is related to issues of problem-framing and power, democratic legitimacy, and interactions among stakeholders. The changing relationship between different governmental levels and citizens is evident in the urban (water) governance literature, as the division between public and private authority has become 'blurred' and power is 'dispersed' from the central state to decentralised actors (Bulkeley & Castàn-Broto, 2013; Hooghe & Marks, 2003). Some authors therefore refer to "infrasystem governance" (Loorbach et al., 2010, 1200) or "transition governance"

(Turnheim et al., 2015), to specifically address the co-evolution of social-technical systems in parallel with changes in institutional, political and cultural structures of urban utility networks.

Considering urban utility networks as socio-technical systems (infrasystems) requires taking into account the institutional and political dynamics that allow or prevent the adoption of social and technical innovations by the regime. It follows that the development of urban water infrastructure should encompass both physical transformations that redefine the practical components of utility provision (e.g., modes of network organisation and provision of water, energy, and waste management services) as well as the implications on the governance of urban water infrastructure (e.g., relations among institutional and non-state actors, interdependency of resources, and roles of specific actors). The literature therefore refers to 'transition experiments,' defined as processes that not only change the physical elements of the infrastructures, but also contribute to socio-institutional change and to the creation of new political spaces within the institutional structures of the infrasystem.

Three key concepts: regime components, user-provider relations, and option space

The conceptualisation of sustainability transitions in urban water infrasystems is based on three key concepts: the reconfiguration of regime components (van der Brugge, 2009), the relationship between end-users and water service providers (van Vliet et al., 2005), and the 'option space' (Marlow et al., 2013). Such conceptualisation aims at analysing the role of water utility providers in sustainability transitions towards more participatory and "practice-oriented approaches" (Browne, 2015). Combining these three key concepts allows for a more holistic analysis of the changes in urban water infrasystems.

The first concept, developed by van der Brugge (2009), conceptualises the evolution of a socio-technical regime as a process of reconfiguration of its four main components: actors, processes, structures, and influences. Sustainability transitions change the way these components are configured and how they interact among each other. In general, regime actors use certain processes to change the structures of the socio-technical regime, which include the physical infrastructure, the institutional structures, and the cultural structures of the regime. Changes in these structures in turn bring about the development of new influences, which have an impact on the roles and functions of regime actors. In the model of van der Brugge (2009), niches are included among the actors, although on a separate level, and the processes introduced at niche-level are referred to as "shadow processes."

Second, the concept of user-provider relations has been used to analyse the changing role of end-users in urban utility systems towards more active and influential roles. The relations between households and the water utility provider influences the modes of water utility provision and the way the infrastructure network is organised and managed (van Vliet et al., 2005). Although regime members are considered to be the most influential actors in the development of the urban water infrasystem, the agency of regime actors has increasingly been redistributed towards end-users, which can become co-providers of the utility or co-generators of knowledge for the utility provider. The relation between end-users and providers implies therefore that the responsibilities and functions related to urban water management are not anymore

concentrated into the hands of regime-members. In turn, other actors gain more relevance and power, becoming in fact part of the regime urban water management regime (Hegger et al., 2007).

Third, the concept of 'option space' has been developed to explain how stakeholder perception influences the flow of investment into the urban water sector. Stakeholder perception influences the way decision-makers in the urban water management regime select solutions and innovations to be implemented (Marlow et al., 2013). Several factors influence the 'option space' and stakeholder perception of investment decisions. Marlow et al. (2013) categorise them according to their relationship with the technology to be implemented, on the drivers of innovation, and on the actors involved in implementing it. Since the decision-makers at top managerial position are considered to be the most influential actors in the development of the urban water infrasystem (Pot et al., 2018), analysing the factors that determine the 'option space' is believed to provide significant insights into the rules and norms that guide water utility providers' strategy, and into the way resources are distributed and shared among regime actors.

These three concepts (reconfiguration of regime components, user-provider relations, and 'option space') have been used to guide the analysis of the role of water utility providers in sustainability transitions. Each of these concepts relates to a specific research method, which are presented in the following chapter.

3. Research Methods

Given the complexity of the topic under research, the use of a qualitative is well suited to understand and explain how governance actors are involved in the socio-institutional restructuring of urban water infrasystems. The role of Amsterdam water utility company in urban water governance transition has been analysed in a qualitative cross-sectional research design with multiple case-studies (Kumar, 2014). This study design provides enough flexibility to combine different research methods, within a study that draws from multiple sets of literature. As mentioned earlier, there are three research methods that correspond to the three main concepts presented in the theoretical framework (reconfiguration of regime actors, user-provider relations, and 'option space'). The research methods are, respectively, a systematic literature review, semi-structured interviews, and a Likert-type questionnaire administered as complementary method to interviews.

The following chapter describes the methods used in this research, presented in chronological order. The first section presents the literature review that has been carried out at the beginning of the research and after gathering the results of semi-structured interviews. The second section provides the rationale behind the selection of the case studies. The third describes the use of semi-structured interviews, and the fourth presents the Likert-type questionnaire.

3.1. Literature review and secondary data

The first step of this research is to review relevant literature to define scope and objective of the research, and to develop the research questions and theoretical framework. Secondary sources have been reviewed through desk research, including national and municipal policy documents on urban water governance and infrastructure development, as well as European-level policies related with urban sustainability transitions and citizen participation. Reviewing these sources helped to reconstruct the historical development of the water management paradigms in The Netherlands, and how this context shapes the current water management regime.

At further stages of the research, the results obtained via semi-structured interviews have been compared with the literature previously reviewed and with additional one related to urban water governance, stakeholder participation, and long-term investment decisions in the urban water sector.

3.2. Case-studies selection

The three case studies used in the research complement each other and provide a holistic analysis that takes into account different perspectives of urban water management transitions. The case studies have been selected as representative for experimentation in urban water governance, showing how such transition in urban water management could benefit from participatory approaches with the involvement of key stakeholders. Combining these cases provides an in-depth analysis into current experimentations in the urban water governance sector.

The combination of multiple cases provides a more realistic and contextual analysis of the dynamics and reconfigurations processes of socio-technical transitions in the urban water sector, taking into account its related legislative framework and socio-cultural setting. The analysis is applied to the configuration of the governance components of the urban water management regime (Van de Meene et al., 2011). The city of Amsterdam, The Netherlands has been chosen as location of the case studies, because it had already undergone changes in the management of urban water infrastructure, in terms of reconfiguring the relations among actors, governance arrangements, and physical structures. The three case studies selected for this research are representatives examples of to analyse changes in the components of urban water governance (van de Meene et al., 2011) to define the relation between citizens and water utility providers in the development of the water infrastructure system (van Vliet et al., 2005); and, and (iii) to analyse changes in the factors influencing transitions in the urban water infrastructure system (Marlow et al., 2013).

The case studies differ from the niche innovations analysed in the traditional Transition Management literature, where these "originate accidentally and not as a result of a pre-conceived […] strategy" (van der Brugge et al., 2005, 173). In fact, the three cases of this research originate from purposeful actions of actors directly identified as the urban water governance regime —e.g., the Municipality of Amsterdam and the Amstel Gooi Vecht waterboard— or highly involved in the projects themselves —as in the case of *Amsterdam Rainproof.* The case studies hence complement each other, by tackling both changes in physical and social structures (*Amsterdam Rainproof*) as well as the relationship between the water provider and end-users (*Freshness of Water* and *Clean Water Experiment*). The selection of these three cases fell on the *Amsterdam Rainproof, Clean Water Experiment,* and *Freshness of Water* projects because they are represent at best the dynamics driving present urban water governance reconfigurations: they are relatively recent projects, with the first set in 2014, the second in 2016 and third in 2017; they are highly innovative, as they are the first examples in The Netherlands of co-creation and citizen-science at wide spatial scale; and they are all examples of interdisciplinary projects aiming, among other objectives, to foster organisational and social learning.

The division of case studies among co-creation and citizen-science is intentionally uneven, and it reflects the asymmetry in available information on the three projects. For example, one of the aims of *Amsterdam Rainproof* has specifically been to raise public awareness on climate-change impacts (Amsterdam Rainproof, n.d.), by disseminating a high volume of communication materials in different formats and in both Dutch and English. On the other hand, the *Clean Water* and *Freshness of Water* projects had a set audience of researchers and practitioners in the water sector (Brouwer et al., 2018), with few official informative materials in English. The lack of available information on the citizen-science projects has been one of the reasons to select semi-structured interviews as the main method to collect primary data. The other methods adopted to answer the research questions are literature reviews and field observations, as well as the use of a Likert scale as supportive to interviews.

3.3. Semi-structured interviews

Given the qualitative nature of the research, semi-structured interviews are the most straightforward method to gather primary data (Kumar, 2014). They have been conducted with managers and strategic-tactical level

employees of the water utility company in the Amsterdam, the municipality, and the Amstel Gooi Vecht Waterboard. This method allows access to specific information, tacit knowledge, and experience in more practical contexts, which make it possible to identify the factors that enable or inhibit innovation in urban water management paradigms (van de Meene et al., 2011). Conducting interviews with the project managers of the three case studies is also a way of gathering more detailed information on these projects, in the cases where it is not enough or missing. The most straightforward way to circumvent the language obstacle of official informative documents is to directly ask interviewees about information on the actors, processes, and results of the project.

A list of interviewees can be found in Annex 1, where interviewees are listed according to the institution or organisation they belong to and their position. Interviewees have been selected from policy documents and communication materials from the case studies, as well as snowball sampling. However, the latter method did not provide additional interviewees, because the participants referred to other high-level decision-makers that had already been included in the interview list. Moreover, the response rate to interview requests has been low, probably because of the limited time availability of the decision-makers that had been contacted.

3.4. Likert-type questionnaire

Besides semi-structured interviews, additional closed questions have been added in the form of a Likert-type questionnaire administered at the end of each interview. Likert-type questionnaire are often employed to quantitatively measure the diversity and spread of attitudes, feelings, and framings of issues (Kumar, 2014). The questionnaire has been employed to carry out a quantitative assessment of the factors constituting the 'option space,' including questions about the environmental attitudes, knowledge, and behaviour of the interviewees. Interviewees have then been mapped according to their score on the different sections of the questionnaire, to have an overview of their framing of specific topics.

The factors constituting the 'option space' *have been* selected based on their relevance with the research, leaving out the factors of *vested interests* and the factors related to *technology* (cf. Figure 7). The first has been discarded because of the difficulty of measuring vested interest, in the light of the scope and limitations of the research; the *technology* category has been left out because it encompasses two elements, 'innovation space' and 'performance and cost certainty,' which refer to specific technological artefacts, while none of the three case studies envisaged the use of just one technology. Moreover, there is limited available information on quantitative assessments of the performance and cost certainty of these technological innovations.

Interviewees have been asked to score 46 Likert-type statements related to nine categories: lifestyle, consumption patterns, risk perception, environmental attitudes and knowledge, and so-called 'pro-environmental behaviours.' These categories, as well as the questions in each one of them, have been selected from several previous studies using similar quantitative methods for measuring environmental perceptions (Dunlap, 2000; Weber et al., 2002; Williams & McCrorie, 1990; Metin, 2010; Hiramatsu et al., 2015; Milfont &

Duckitt, 2010). Responses to the questionnaire have been compared across categories and among respondents. The categories showing the highest differences among respondents have been then selected and analysed.

The use of a Likert-type questionnaire also served the purpose of ruling out as much as possible potential biases of respondents that could be overlooked by semi-structured interviews alone (Marlow, 2013). In fact, scholars and practitioners supporting circular and integrated approaches to water management could have a "bias in favour of their own technological innovation or mode of organisation" (Marlow et al., 2013, 7154), positioning them in a specific value system which in turn influences their framing of specific issues related to environmental awareness and commitment, risk perception, and transition objective.

4. Transition experiments in the Amsterdam context

The Netherlands are often regarded as the country with the best water management system in the world, it is often taken by example at the international level as a source of best practices in the sector because of its long tradition of managing water resources. Because of the morphological characteristics of the area (it is a river delta with more than 50% of land below sea-level) The Netherlands found a way to keep the water out of urban areas, to provide good quality drinking water to its citizens, and to use waterbodies for shipping, agricultural, and industrial purposes (van der Brugge, et al., 2009). The technocratic regime of water management focused on draining water and raising dikes, in order to reclaim land for agriculture, housing, and economic development, was the dominant approach for managing water resources until the beginning of the 21st century. In that moment, it became evident that Dutch water management was not effectively able to cope with the impacts of climate change on water resources, especially related to pressures on the water system because of anthropogenic activities and to pressure of water on available lands (*ibidem*). This eventually resulted in a transition that van der Brugge et al. (2005) traced back to 40 years ago and that has reconfigured the water management regime in The Netherlands. The liberalisation of utility markets, moreover, led to differentiations in the role of end-users of the infrastructures for water, because each mode of network organisation envisaged a specific interpretation of what the role of end-users/consumers was for providing urban utilities and managing demand (van Vliet et al., 2005).

The urban water management regime and its development can be explained in the light of the TM and SNM frameworks. The *niches* are the mostly technological innovations for wastewater reuse, recycling, and recovery of nutrients, e.g., rainwater harvesting and reuse, and separated wastewater collection. The *regime* constitutes the set of actors with the authority and responsibility of setting quality standards, rules and procedures, and the legal framework for managing the phases of water extraction, drinking water provision, and wastewater collection treatment and discharge. Reducing the scale of the socio-technical system at urban areas, then the regime encompasses municipal and public actors involved in the different phases of the urban water utility provision. The *landscape* is the (supra)national legislative framework and set of standards for drinking water provision and wastewater collection and discharge, which in turn affects the innovations conceived in niches and the development trajectory of the regime. The members of the urban water management regime usually operate at regional or national scales and are hence represented by national ministries or regional public authorities, such as in the case of the Dutch urban water management paradigm (van der Brugge et al., 2005).

The current regime of water management in Amsterdam is on the verge of the abovementioned transition in urban water management in The Netherlands, and the changes that are happening nowadays in this regime can be explained in the light of how it evolved from the traditional, technological-scientific approach to a more ecological and socio-cultural approach. This chapter therefore aims to understand how this ongoing transition determined the current configuration of the urban water management regime in Amsterdam,

introducing valuable information for understanding how the case studies supported the activities of Waternet to influence the ongoing transition. The first section of this chapter presents the (re)configuration of the urban water management regime in The Netherlands following the regime conceptualisation of van der Brugge (2005), and it is further divided in actors, processes, and structures. The second section describes the three projects selected as case studies for understanding the role of Waternet in the current transition in urban water management, laying the foundations for the following results chapter.

4.1. The transition of the Dutch water management sector

The ongoing transition in urban water management identified in the literature can be traced back to the first shift from *technocratic* to *integrated water management* (van der Brugge et al., 2005; Van der Brugge, 2009; Agudelo-Vera et al., 2014). The *Delta Works,* one of the major infrastructural project in the South-West province of The Netherlands, represented the tipping point of such technocratic-engineering approach. After that, a series of developments and events were triggered, mutually reinforcing each other and eventually facilitating the paradigm shift "from fighting the water to accommodating the water" (De Wit, 2000 in van der Brugge, 2009, 105). The Delta Works are representative of the *modus operandi* of the previous regime, because they were criticised for not taking into account the impact on the ecosystems in the area (van der Brugge et al., 2005). To mitigate these damages, the *Rijkswaterstaat* —the main governmental body dealing with water management in The Netherlands— enlarged its knowledge base by including biologists in one of its regional departments, which made it possible for technicians and engineers from the Rijkswaterstaat to cross-fertilise with experts from a different background.

After the Delta Works, the *Plan Ooievaar* from 1987 is considered one of the niche developments that were opposing their contemporary water management approach, by putting forward a new vision for future water management that would integrate different functions and policy domains. A series of pilot projects based on this plan was implemented, to address the concerns and expectations of the civil society at that time who was asking for more consideration of the environmental impacts of dike enhancements (van der Brugge et al., 2005). Behind the growing environmental awareness of Dutch society there are landscape dynamics such as the publication of the book 'Limits to Growth' by the Club of Rome in 1972 (van der Brugge, 2009).

The combination of niche developments and landscape influences on the regime made it possible to introduce changes in the perception of water issues by the Rijkswaterstaat, which was then followed by specific policies and official memoranda for developing a new strategy for water management departing from sectoral, purely technical-engineering solutions. In 1974, a governmental committee was established to evaluate the possibility of restructuring the institutional design of the waterboards, which suggested to merge the waterboards to increase their scale. This merger was further accomplished by the 1989 "3rd Memorandum on Water household," which was in turn based on the 1985 policy report called 'Dealing with Water.'

The 3rd Memorandum represents another tipping point, because it introduced a new policy paradigm based on integrated water management and it further stimulated changes in institutional structures of the regime. More specifically, it integrated issues of water quality with those of water quantity based on a water-cycle approach, and it promoted more ecologically-oriented solutions for nature conservation. The following

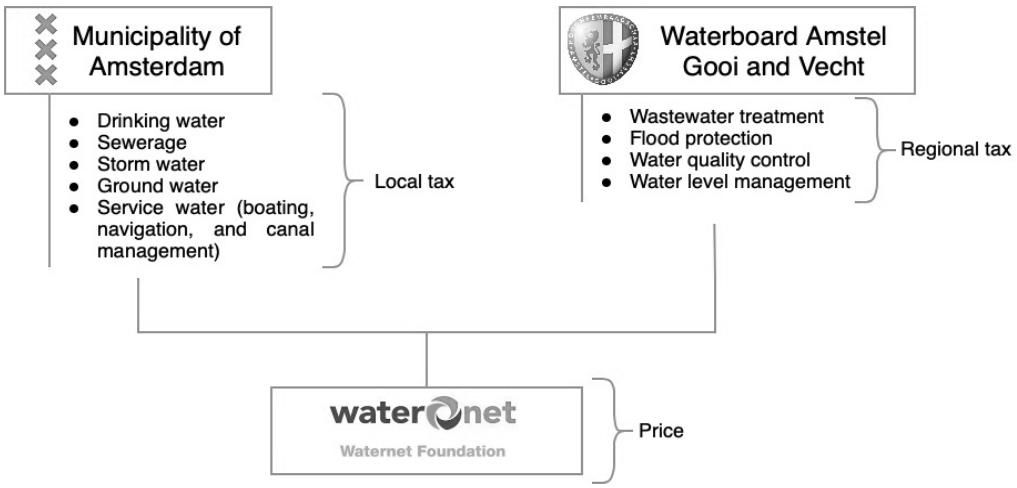


Figure 8: Institutional structures of Amsterdam water management. To the right of each actor, the mechanism applied for financing their operations is shown. Source: OECD, 2014.

major paradigm shift in water management took place with the 2000 policy "Dealing differently with water," usually referred to as "Water Policy for the 21st century," which integrated water management with spatial planning in the light of climate change adaptation and mitigation (van der Brugge, 2009).

4.2. Configuration of Amsterdam urban water management regime

Water management started to focus on urban areas towards the end of 1980s. This represents another important change in the contemporary water management regime, as it opposed the previous approach that envisaged water management as strictly interdependent from the agricultural sector (van der Brugge, 2009). Historically, the development of urban water management can be explained as the interaction between social and political drivers, which correspond to a certain socio-technical regime (Brown et al., 2009) (cf. Figure 2).

In Amsterdam, the water company Waternet and the Municipality are considered to be the main stakeholders in urban water management. The Environmental Protection Act stipulates that municipalities have the obligations to collect wastewater from households, which is then transported to the RWA to be treated (Wolsink, Hertz & Slingerland, 1998). Figure 5 provides an overview of the institutional structures regulating water management at watershed and municipal level. The current regime of water management in Amsterdam is made up of three main actors: the Municipality of Amsterdam, the AGV Waterboard, and Waternet. Waternet is represented by a foundation that is co-owned by the Municipality of Amsterdam and the AGV Waterboard (OECD, 2012). It is referred to as a 'water cycle company,' meaning that the different water management functions of the water cycle come together in the Foundation. This institution is therefore responsible for drinking water provision, wastewater collection and treatment, and monitoring and management of groundwater and surface water. This is the first case in The Netherlands of a water company that embeds responsibilities of municipal and provincial governments in respect to water. Figure 6 provides an institutional map of urban water management in Amsterdam, with a clear representation of the different responsibilities and functions of actors that are also located beyond the urban scale of Amsterdam.

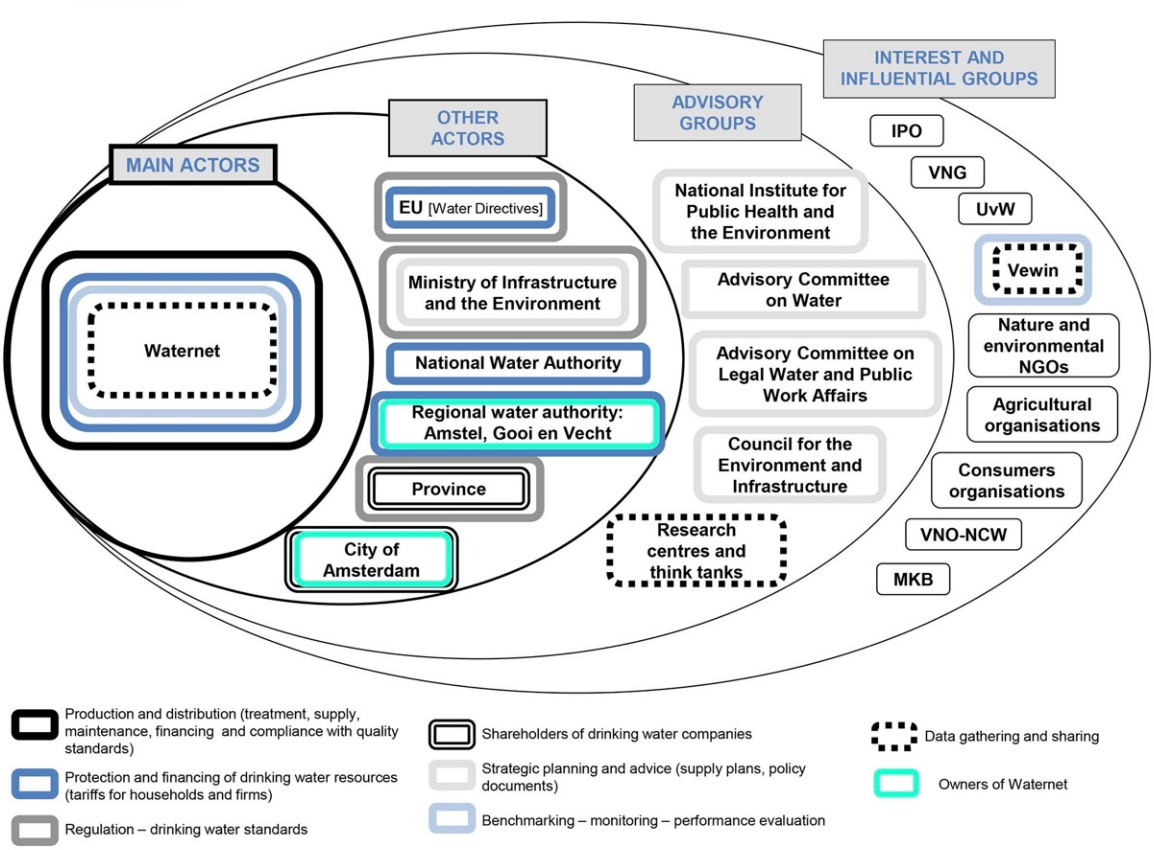


Figure 9: Institutional map of urban water management in Amsterdam. Source: OECD, 2012.

The socio-technical system under analysis is the urban water infrasystem, hence comprising the social, institutional, and physical structures that guarantee provision of safe, high quality drinking water, and the collection, treatment, and disposal of wastewater. The scale of the infrasystem is the urban area of Amsterdam, which is managed by Waternet through the whole life cycle of water. The water service provider Waternet is therefore the most important actor in the development of the urban water infrastructure, because it concentrates different urban water management functions and resources that are traditionally divided between municipalities and waterboards.

4.3. Description and aim of the case studies

The three projects selected as case studies were chosen because of the contemporaneity and innovative nature of the projects, and because they were carried out by actors that are internal to the regime: in fact, *Amsterdam Rainproof* was an initiative of Waternet —which, as mentioned above, is also owned by the Municipality of Amsterdam; while the projects *Freshness of Water* and *Clean Water Experiment* were conducted by KWR, which is a research institute whose shareholders are the Dutch water companies and the Belgian association of water companies. The following section describes the content of the case studies and provides a general overview of their main activities and aims.

4.3.1. Co-creation: Amsterdam Rainproof

The rainfall that hit Copenhagen in 2011 caused damages for the city of more than €700 million (EEA, 2013). It represented a window of opportunity to draft and adopt the Climate Change Adaptation Plan for Copenhagen, as multi-stakeholder effort (ICLEI, 2017). A similar case took place in Amsterdam in 2014, when a severe rainstorm hit the city with 90 mm of rain in few hours (Amsterdam Rainproof, n.d.). This event happened just six months after Waternet launched a new city-wide initiative called *Amsterdam Rainproof,* aiming at increasing flood resilience with the participation of citizens, businesses, and the municipality (Reimerink, 2017, Feb 9). The project aims at targeting policy issues laying outside the responsibilities and influence of the Municipality of Amsterdam and the AGV Waterboard, namely implementing climate adaptation measures for Amsterdam and its water system. These interventions are located outside formal responsibilities and roles because they target both privately owned urban spaces, which the Municipality is not able to directly intervene on, and actors that the Municipality struggles to take on board in its climate adaptation plan, such as residents. In fact, an OECD report showed that although the Dutch water management paradigm can be considered as a "global reference" (Havekes et al., 2017, 10), the Dutch RWAs still struggle to establish a relationship of active engagement, awareness, and direct connection of residents with the water domain and with the activities that these institution carry out (OECD, 2014a). The lack of awareness among end-users can be attributed by the lack of recurrent water management issues and on the trust that residents attribute to RWAs and drinking water companies, but it also implies that residents and other stakeholders are not aware of the risks and opportunities that they face due to flooding, extreme rainfall, or climate adaptation in the urban water system.

The project is therefore inherently related to engaging with new institutional roles and structures, and additional ways to involve residents in climate adaptation and water governance. The main (English) publication of *Amsterdam Rainproof* states that the water service provider, Waternet, had the purposeful intention of "chang[ing] its traditional role," exploring alternative approaches to deal with urban water management and climate change adaptation (p.37). To do so, the project has the explicit goal of adopting a "network-based approach" (p.9) to establish a broad coalition of actors. This approach characterises the project as a multi-stakeholder and interdisciplinary collaboration for the development of the urban water infrasystem as a whole — targeting, in other words, all three institutional, physical, and cultural structures of the infrasystem.

The *Amsterdam Rainproof* project has been chosen as case study in this research because, first of all, it is a project carried out by actors corresponding to the current urban water governance regime in Amsterdam —

namely, the Municipality, the Regional Water Authority (RWA), and the water utility provider. The project established itself as well-known example of participatory approaches that attribute to residents and other non-state actors a direct, active role in developing the urban water infrastructure, together with actors covering formal responsibilities in the water utility sector. It is therefore in line with the objective of this research to focus on processes that, by assigning and reproducing new roles to non-state actors, reconfigure the urban water infrasystem and the distribution and interdependencies of resources.

4.3.2. Citizen-science: Freshness of Water and Clean Water Experiment

Two years after the launch of the *Amsterdam Rainproof* project,, the *Freshness of Water* project took place, which aimed at analysing the "potential of citizen-science in the drinking water sector, and to evaluate the experiences and meanings of involving citizens in this domain" (Brouwer, van der Wielen, Schriks, Claassen & Frijns, 2018, 3). This project was the first citizen science project conducted in The Netherlands in the drinking water sector. The project set the scene for the larger *Clean Water Experiment,* the first large-scale citizen science project in this field in The Netherlands, which brought together public utility companies, academic institutions, public administrators, and private actors (KWR, 2017). The common goal in these two projects was to promote an innovative role of citizens in 'making' the city, by increasing their direct involvement in water governance innovations.

This type of citizen-science projects has a significant implications for the relationship between citizens (i.e., end-users) and their water utility provider, as they influence the trust in both the activities of the water provider and in the quality of the drinking water itself (Brouwer et al., 2018). In fact, the projects were carried out two years after an OECD report evaluating the current urban water governance paradigm in The Netherlands. This report emphasised that, although the Dutch *polder* model can be considered as a global reference by other policy- and decision-makers in the water sector, there is a significant distance between institutional actors and end-users (OECD, 2014). The first correspond to the members of the current urban water governance regime, while the latter are private residents.

The contribution of citizen-science to the development of the urban water infrasystem, and to the upscaling of sustainability transitions in urban water governance, is specifically related to the relationship between end-user and providers. By involving citizens in different phases of the project life-cycle, water utility providers have the opportunity to engage with additional processes of generating knowledge and gaining access to data. Moreover, attributing these type of new responsibilities and functions to end-users also serves as a mean for bridging the knowledge gap between engineers and average residents.

Citizen-science has therefore gained increasing prominence in the scholarship on water resources management, especially among authors dealing with processes of knowledge management and stakeholder engagement (e.g., Paul, Buytaert et al., 2018). However, citizen-science can also end up being counterproductive when end-users are involved with simple data-gathering functions, hence used as passive (or even unaware) citizens-sensors. Moreover, the knowledge produced in citizen-science projects could also turn out to have negative impacts on the relationship between end-users and providers, being in other words detrimental to the trust-relationship between these two actors (Lemos et al., 2018). For example, making end-

users aware of the quantity of bacteria present in the drinking water provided to them is by no doubts against the communication strategy of the drinking water provider, who wants to tell its customers that their drinking water is clean and safe (Brouwer et al., 2018).

The two projects *Freshness of Water* and *Clean Water Experiment* have been chosen as case studies in this research because their analysis provide interesting insights into current approaches for increasing the engagement of water utility providers with end-users. Moreover, both projects were carried out with the support and cooperation of actors belonging to the current urban water governance regime in Amsterdam. It is therefore in line with the research objective to investigate how these two projects could influence future developments in the relationship between end-users and the water utility provider in Amsterdam.

5. Results: transition experiments in urban water governance

Changes in the institutional, cultural and physical structures of the regime affect transitions in urban water governance and water infrastructure development in two ways. First, shifts in the cultural and political landscape of the regime have an impact on the relationship between providers and end-users, where to the latter is attributed a more autonomous and conspicuous consumption of urban utility services (van Vliet et al., 2005). Second, utility providers and stakeholder groups change their perception towards the way investments contribute to the achievement of triple bottom line outcomes (Marlow et al., 2013).

The contribution of co-creation and citizen-science for urban water governance is an increase in participation of citizens concerning the governance and development of the urban water infrasystem. The *Amsterdam Rainproof* project increased the number of actors that are involved in urban water governance, empowering citizens, businesses, and other stakeholders that could act as 'intermediaries' between institutions and private citizens. The inclusion of different stakeholders followed a so-called 'network approach' that is similar to the concept of network governance, and it made it possible to implement climate adaptation measures in both public and private spaces based on reciprocity, consensus, overlapping themes, and shared interests. Processes for urban water governance based on public participation have been further developed in the case of co-creation, while the projects *Freshness of Water* and *Clean Water Experiment* introduced for the first time citizen-science in the Dutch drinking water sector.

A direct participation into urban water governance contributes to making citizens feel closer to the institutional structures of the water infrasystem, and it brings benefits to both the water utility provider and to end-users. As for the benefits for the water utility provider, participatory initiatives can first of all support policies and deliver better policy outcomes, by tailoring them to specific needs and concerns of citizens. Second, the involvement of citizens in the data-gathering process makes it possible to access data related to water quality that otherwise would not have been measurable. Third, the policies and solutions implemented are more likely to be accepted by citizens when the latter are involved in the processes that deliver these policies. As for the benefits for citizens, their participation makes it possible to include social and environmental-protection objectives next to public health and service provision; moreover, citizen participation increases the legitimacy of water-provider's policies, as end-users perceive them to be more connected to and interested in their needs and expectations.

The following chapter is divided into three sections. The first presents the reconfiguration of the Amsterdam water governance regime, divided according to actors, processes, structures, and influences. The second section analyses the changes in the user-provider relationship, analysing in particular whether Waternet is dealing with a new type of citizen-customer with specific needs and expectations. The third section investigates the changes in norms and values that guide the vision and strategy of Waternet, and how this influences the way investments are allocated for implementing solutions.

5.1. Reconfiguration of the Amsterdam infrastructure governance regime

The regime reconfiguration has been analysed following the *multi-pattern analysis* of van der Brugge (2009). This heuristic tool is particularly useful for this research: it allows to identify the most important elements of the regime that are subject to change, by linking the activities carried out in the case studies to broader, regime-level changes that are implemented top-down; and it gives insights into the way the regime is organised and into its internal dynamics, which eventually add up and lead to transformative change. A schematic overview of the multi-pattern analysis of the reconfiguration of regime components can be found in Figure 10, while Table 1 provides a summary of the results.

This section is divided into four parts: the first presents the changes in the actors of the regime, with specific emphasis on the new actors that became involved in Amsterdam water infrastructure governance; the second describes the processes that these actors implemented to modify structures of regime; the third investigates the extent to which these processes reorganised the institutional and physical structures of Amsterdam water infrasystem; and the fourth describes how the case studies contributed to developing new ways to influence the activities of regime-actors.

5.1.1. Actors: multi-stakeholders processes for urban water governance

The fact that end-users are more actively involved in the governance of Amsterdam water infrastructure is the most important contribution of all three case studies to the transition towards SUWM. The Amsterdam water governance regime is moving towards a configuration that is similar to network governance: there are new responsibilities and functions of regime actors, which are increasingly including social objectives in their mandate and increasing the participation of citizens in the development of the urban water infrasystem.

	Change in Regime Component			
Case study	Actors	Processes	Structures	Influences
Amsterdam Rainproof	Inclusion of private citizens, businesses, and *intermediaries*.	*Network approach:* bridge between citizens and water utility provider; Co-creation in initial phases of project life-cycle (*consultation*).	Horizontal policy integration between Waternet and Municipality of Amsterdam.	Private adaptation measures integrated with intervention in public spaces; Development of new legislative framework (*Omgevingswet*).
Freshness of Water	Citizens gathering 'inaccessible' data.	Citizen-science: first time in drinking water sector.	Change in Waternet communication strategy with its customers.	Waternet delegating responsibilities and functions to end-users.
Clean Water Experiment	Whole city of Amsterdam for data-gathering.	Citizen-science: first large-scale application in drinking water sector.	Waternet seeking active involvement of and closer relationship with end-users and citizens.	ICT and technological developments increase opportunities for engaging end-users with more active roles.

Table 1: Overview of the results from the analysis of the reconfiguration of regime components: contribution of the three case studies for the reconfiguration of water infrastructure governance regime in Amsterdam.

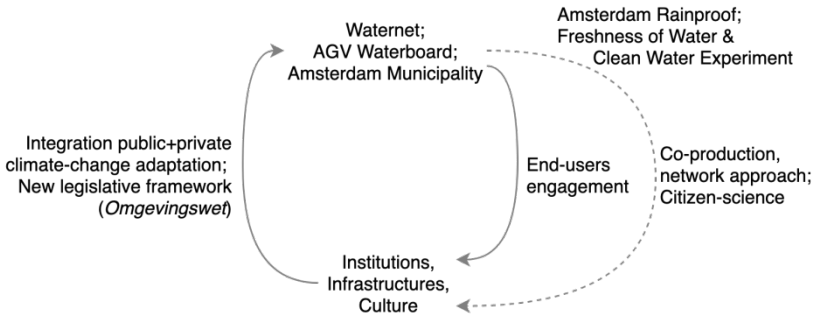


Figure 10: Schematic representation of the reconfiguration of regime components (cf. Figure 5).

This process is related to an ongoing transition in the governance of water resources, where citizens are not anymore considered as *captive-consumers* but have their own needs, preferences, and opportunities of differentiation within the utility market (van Vliet et al., 2005). Increasing the level of public participation has been possible thanks to co-creation and citizen-science projects, which have been adopted by the Municipality of Amsterdam and Waternet.

Towards network governance

The ability to reach for residents, businesses, and small and medium enterprises is what made the *Amsterdam Rainproof* project famous. Its proponents refer to this mechanism with the expression "network approach," which corresponds to the concept of network governance where policy development is inherently participatory and based on reciprocity and consensus (van de Meene et al., 2011). In the context of *Amsterdam Rainproof*, it specifically refers to the process of creating communities with a broad range of relevant stakeholders having "overlapping themes and shared interests" (Amsterdam Rainproof, n.d., 17). The establishment of such networks is considered central to exploit synergies between residents and businesses, as well as between residents and the urban water governance institutions for implementing climate adaptation measures.

Waternet and the Municipality of Amsterdam, thanks to the network approach of the *Amsterdam Rainproof* project, managed to engage with a large number of stakeholders involved in different parts of the urban water cycle, which acted as intermediaries between the *Amsterdam Rainproof* and the residents. One interviewee mentioned the example of garden centres, which have been involved because they are "the place where people go to when they want to remake their garden" (Interview 3, 28/01/19), and could hence offer customers the opportunity to implement climate adaptation measures in their garden.

Awareness, participation and behavioural change

All interviewees acknowledged the importance of raising residents' awareness towards climate adaptation issues, especially concerning the impacts of climate change to the urban water system —although the communication materials from *Amsterdam Rainproof* purposefully avoided using the term 'climate change' (Amsterdam Rainproof, n.d.). All three case studies implicitly linked awareness to behavioural change, considering it to be the trigger to social learning processes that generate useful knowledge for policymakers and can stimulate the adoption of more environmental-friendly behaviours among citizens.

Waternet and the Municipality of Amsterdam are engaging in a process of increasing awareness of end-users and reconnecting them to the urban water infrasystem and the water theme. Most of the interviewees, in this respect, have explicitly stated that making people aware of issues related to climate change and infrastructure management is "the first step towards changing behaviour of citizens" (Interview 1, 28/01/19) to introduce more sustainable practices. In the context of *Amsterdam Rainproof*, these include rainwater storage, greening of paved private areas, and the adoption of private flood-defence mechanisms (Amsterdam Rainproof, n.d.). The same argument can be applied for the citizen-science projects: in the projects *Freshness of Water* and *Clean Water Experiment*, Waternet has been specifically interested in trying to establish a closer interaction with citizens, and the initiator of the project wanted to evaluate the expectations, motivations, and meanings of citizens for participating in drinking-water research. As an outcome of becoming themselves researchers and increasing their knowledge on drinking water, participants' increased awareness led them to modify their water consumption behaviour, similarly to how residents introduced new rainwater storage practices after they got acquainted with the benefits these may have on their house and on the environment.

Making residents aware of what could happen to their city in the future is a way to circumvent the issue of low public participation when it comes to climate adaptation issues, such as the fact that often "only those directly affected are the ones that actively participate" (Interview 1, 28/01/19). Flood-defence technologies are an example of this issue, because interventions of this type are only carried out by the households living at the ground floor of residential buildings —the people whose home could actually be flooded. In turn, only directly-affected residents will be willing to and interested in implementing climate adaptation measures in private spaces.

Stimulating awareness and learning in residents through public participation has been also at the centre of the projects *Freshness of Water* and *Clean Water Experiment*. By exploring the potential of citizen-science in the drinking water sector, these two projects demonstrated that residents can and, most importantly, are willing to have a direct role in the urban water infrasystem. These new roles are not limited to *crowdsourcing*, and could in fact move towards higher levels of Haklay's (2012) citizen-science framework to effectively engage in the knowledge co-creation process between water scientists and residents.

Experimenting with new roles for residents, such as co-ownership or co-management, is therefore a necessary step to increase the level of public participation in urban water governance. Given the fact citizen-science has quite recently established itself as a research method, it still remains to be seen whether in the next decade it will represent even more a pathway for increasing citizens' participation, making them engage with new functions, and eventually accept new roles and responsibilities that had traditionally been attributed to regime actors.

5.1.2. New processes of developing Amsterdam water infrastructure

The dominant approach behind the three case studies is to bring together different stakeholders into the development of the urban water infrasystem, with the help of intermediaries connecting private citizens with organisations such as Waternet and the AGV Waterboard. These processes, in the form of co-creation and

citizen-science, aimed at increasing the awareness and engagement of end-users in the issues related to urban water governance —as well as learning about the practical potential of these new methods.

In turn, these processes created connections among stakeholders in the water governance regime, which decreased the 'distance' between Waternet and its customers: end-users have been brought closer to the "water theme," and Waternet has been able to "reach out" to them (Interview 6, 18/02/19). The topic of low citizens participation in urban water governance is related to the fact that The Netherlands are considered the best example of water management and water governance at international level, which makes it so that end-users in urban areas often take for granted topics such as water quality and water security. Residents consider it "as a given" (Interview 6, 18/02/19) because it is an asset that they had for their whole life. Moreover, the livelihood of urban residents is not directly affected by the water cycle, as it is for end-users in rural areas, and this creates a significant difference in the extent to which residents participate to urban water governance. For example, several interviewees mentioned the fact that the general elections for the executive boards of the Waterboards usually have a very low turnout in cities, while it is drastically higher in rural areas (Interviewee 1, 28/01/19; Interviewee 6, 18/02/19; Interview 4, 30/01/19).

Citizen participation for co-creation is strictly related to the generation of knowledge through second-order learning processes, which has been initiated by all three case studies thanks to the establishment of the above-mentioned networks of stakeholders. Specifically to the *Amsterdam Rainproof* programme, these networks offered opportunities to share resources and conceive solutions exploiting synergies among stakeholders at small geographical scales, such as neighbourhood- and street-level. The *Freshness of Water* and *Clean Water Experiment* projects, on the other hand, laid the emphasis on the way knowledge is generated through multi-stakeholder interactions and public participation. All three cases also linked citizen participation to opportunities for changing water consumption practices, although the project did not specifically address issues of consumer behaviour.

Throughout the Transition Management literature, there is the belief that key actors can act as leadership figures for increasing the number of stakeholders involved and for providing vision and guidance. The same can be applied to the *Amsterdam Rainproof* case study, where important public figures had been involved in the programme, such as the Special Envoy for International Water Affairs (Amsterdam Rainproof, n.d.). The presence of strong leadership figures, and the reputation of the project itself, made it possible to generate trust among stakeholders and to facilitate the construction of a shared identity and sense of belonging.

Co-creation and citizen-science in water infrastructure management

The case studies introduced deep participatory processes that include multi-stakeholder participation from the initial stages of projects, especially because this allowed for the combination of expert knowledge from different, interrelated policy domains. Initiatives of co-creation in the Amsterdam water infrasystem have therefore limited applications for supporting a transition toward SUWM, mainly due to a significant difference the knowledge base between experts and citizens. This factor aligned the application of and citizen-science with the already existing ones for end-users participation used by Waternet to tailor its services to the preferences of their customers.

The interviews highlighted that the approach adopted by Waternet for end-users engagement did not assume a direct participation of citizens into water infrastructure development processes. Currently, the formal mechanisms for citizen participation into policymaking process of urban water governance are limited to the urban (re)development sector and mostly in the final stages of the project life-cycle, such as for consultations on designs of public spaces, and/or for validating context-specific problem formulations by Waternet and the AGV Waterboard.

In the case of *Amsterdam Rainproof*, climate adaptation has been considered as a policy issue that goes beyond administrative boundaries and requires policymakers to redefine what the optimal scale should be for implementing solutions: one interviewee stated that considering "climate adaptation as a broad concept" requires the integration of different perspectives, "not only from the aspect of what the government can do and not only from a technical standpoint: [it] is about climate adaption as integrated in policies, through multi-stakeholder participation" (Interview 3, 30/01/19). The interventions within the *Amsterdam Rainproof* programme have hence been created by designers, engineers, civil servants from the Municipality of Amsterdam, and experts from Waternet (Amsterdam Rainproof, n.d.). In the case of the citizen-science projects, there experiments had an implicit aim of highlighting the relevance of social learning processes for generating scientific knowledge. Such a way of co-creating knowledge has been critical for effectively managing urban water infrastructures, as additional context-specific knowledge will be needed to deal with the uncertainty and complexity related to climate adaptation.

These processes are valuable for Waternet because they allowed it to align different interests, strategies, and resources to be shared among the members of the network. This contributed to the generation of useful knowledge for more effective policies that have specifically been tailored to a specific problem framing and socio-economic context. This argument has been mentioned by one of the interviewees by stating that, in their opinion, Waternet has been "too autonomous" (Interview 4, 30/01/19) in the activities it carried out in the past and in the resources employed, especially in respect to knowledge.

5.1.3. Structural reconfigurations: institutions, infrastructure, culture

The co-creation and citizen-science projects contributed to the reconfiguration of the physical, institutional, and cultural structures of the water governance regime in Amsterdam, although these three elements have not been addressed at the same level. This reconfiguration process has been endogenous to the regime, as the project had been initiated by actors belonging to the current water governance regime, and can be interpreted as a continuation of the current transition in urban water management in The Netherlands (van der Brugge et al., 2005). Although the extent to which these structures changed is limited by contemporaneity of the projects, the analysis of the structural reconfigurations revealed that there is an alignment between the current urban water governance regime and the multi-level governance arrangements described in the reviewed literature (cf. Hooghe & Marks, 2001).

First of all, changes in the physical infrastructures have been implemented only in the case of co-creation, with the redevelopment of several areas within the city ranging from street- to neighbourhood-level (Amsterdam Rainproof, n.d.). In this case, entire neighbourhoods or streets have been redesigned with the

introduction of climate adaptation measures, with both high-tech infrastructures as well as solutions requiring cheaper investments (Interview 1, 28/01/19). Participation of end-users has been limited by the highly-technical level of the topics that have been addressed, making it difficult to citizens without a scientific-engineering background to be actively engaged during the whole project-life cycle. One interviewee, in this respect, stated that the opportunities for co-creation decrease as the level of expertise of the issues increases, limiting the role of end-users to consultation in design issues:

> "When it really becomes technical, it's less co-creation. The real technical issues about urban water management […] are really done by Waternet. Unless it really and directly influences the citizens." (Interview 4, 30/01/19)

The same applies to the citizen-science projects, where the role of end-users has been limited to data-gathering functions (Interview 2, 28/01/19).

Second, the institutional structures of urban water governance in Amsterdam are increasingly assuming the characteristics of multi-level governance arrangements, with ad-hoc institutions or organisation operating beyond administrative boundaries. This can be seen from the overlapping of functions among regime actors, as in the case of the *Amsterdam Rainproof* project that has been explicitly based on a 'network approach.' The actual platform carrying out the project is a "semi-autonomous organisation" (interview 3, 30/01/19) that is owned by Waternet and the Municipality of Amsterdam but has its own (separated) offices, logo, and employees, as well as its specific language and organisational culture. In practical terms, the programme is more or less autonomous in creating its own vision and in carrying out activities, but it is not independent in terms of financial and human resources — at least in the initial stages, the *Amsterdam Rainproof* team was made up of employees of both Waternet and the Municipality (Interview 3, 30/01/19).

It is important to note that the *Amsterdam Rainproof* platform is an organisation located outside the formal institutions of Waternet and the Municipality, and therefore its development did not represent an internal restructuring of the institutions managing the urban water infrastructure. The connection is more indirect, as the programme made use of social media for communicative purposes and for citizens engagement, and it has been successful in increasing the accessibility to information from Waternet and to get in touch with the people behind the organisation: one of the interviewees stated that "people can now bypass the organisational structure by simply shooting messages at us […] on Twitter or on digital media, […] and we will see those messages" (Interview 6, 18/02/19). The increasing use of ICT technologies will introduce further changes in the organisational structure of Waternet, as specific and dedicated human resources have to be employed for community management, monitoring social media, and for keeping a close-knit communication with consumers (Interview 5, 18/02/19).

Waternet is also an example of cross-boundary, ad-hoc institutions. It is a 'water cycle company' that is responsible for managing the whole water system in Amsterdam, and this characteristic is unique for The Netherlands: usually, there are companies responsible for drinking water provision while municipalities and Waterboards are in charge with collection and treatment of wastewater. Having a single institution responsible for the whole water cycle has been a step forward in the integration of interest and activities across governance

actors. In this way it has also been easier to coordinate shared resources and engage in co-generation of knowledge, as well as to create visions guiding the water infrastructure sector as a whole.

The interviews showed that the most significant change can be seen in the regime culture, which consists in the paradigm, discourse, values, and knowledge base of the regime (van der Brugge, 2009), and determines the implementation of changes in the infrasystem (Jonsson, 2005). Waternet and the AGV Waterboards are past the "dynamic conservatism" phase mentioned by Jonsson (2005), where existing technical and institutional solutions are improved but without the introduction of new technologies or organisational forms: there is increasing reliance on big-data and ICT to learn more about the needs and expectations of citizens, as well as how end-users use the water infrastructure (Interview 5, 30/01/19).

5.1.4. Development of new influences: changes in the political and legislative landscape

The initiatives of Waternet, the Municipality of Amsterdam, and the AGV Waterboard represent an overall realignment of visions throughout the water governance regime. The regime actors for urban water governance in Amsterdam are undergoing a process of reconfiguration that is going to be completed only in the long-term, and this time scale is extended beyond the mandate of the executive boards of these institutions. A key driver of the future strategy of Waternet will be dynamics at the higher-level regime of national Dutch environmental policy. In the incoming decade, it is expected that there will be additional changes in the functions of regime actors, as their strategies and visions will co-evolve with the extent to which participatory processes for urban infrastructure development such as co-creation and citizen-science are applied in the field. The interviews showed that the urban water governance regime in Amsterdam will face two main obstacles, one related to political dynamics and the other to financial resources.

First, there is an inherent political dimension related to the allocation of investments and in the creation and reproduction of "political lines" (Interview 6, 18/02/19). Changes in the political landscape are likely to affect the institutionalisation process of participatory measures for urban water governance, especially thanks to a recent legislation called Environment and Planning Act (*Omgevingswet),* adopted by the Dutch Parliament in 2016 and coming into force in 2019. This legislation will provide a general framework to provide harmonisation, simplification, and integration of the current regulations and procedures related to environmental issues, including urban development, water management, and infrastructure development (Ministerie van Infrastructuur en Milieu, 2017). The interviewees believed that this framework will be particularly helpful in further upscaling participatory methods for co-creation with private citizens and increase the level of autonomy of municipalities: for example, one interviewee stated that the *Omgevingswet* will be helpful in creating "visions on the scale of the city [and] neighbourhood" and that "there is going to be more influence for citizens to participate in legislation and in policy" (Interview 3, 30/01/19); another stated that it will be useful to have a common, nation-wide vision for urban infrastructure that integrates "different challenges in the same area" (Interview 4, 30/01/19), and this vision is "made together with the different stakeholders" (Interview 6, 18/02/19). The new Environment and Planning Act is therefore believed to reinforce contemporary transition dynamics and it is likely to accelerate the transition towards multi-level, participatory urban water governance. A key aspects of this legislation is that it provides integrated visions which will make it

easier for different local governments to collaborate and coordinate their activities within a common legislative framework, as a way to "get all these cities in the right direction" (Interview 6, 18/02/19) and to set clear rules for municipalities and regional authorities on what best practices are and what should be avoided. One interviewee specifically addressed the issue of capacity building for smaller municipalities and their ability of integrating urban water management with other policy domains:

> "In the municipalities and the provinces […] there is very little capacity about what water needs and what the requirements are from the construction sector or other domains […] to deal with the water dimension" (Interview 6, 18/02/19).

Another important aspect of the new Environment and Planning Act is that it has been created in a multi-stakeholder process and it is believed to establish similar inter-governmental collaborations, as well as to support the initiatives of private citizens and other stakeholders. This has been a recurring topic in the interviews, as several participants believe that in the next ten years there is going to be more collaboration among municipalities, drinking water companies and waterboards in The Netherlands, to "think more about social benefits instead of […] own benefits and losses" (Interview 2, 28/01/19). According to another interviewee, public actors with the formal responsibility of developing urban water governance strategies, and waterboards in particular, should "reach out and really become a more proactive actor" (Interview 6, 18/02/19) and be the initiators of a collaborative dialogue across policy domains based on multi-stakeholder participation by design.

Second, limited financial resources are often considered a major obstacle to the implementation of all the measures that regime actors would like to implement:

> "the biggest constraint is, and always will be, money. […] It is not as bad as not allowing us to do anything, but we are not able to do everything we want, we still have to choose what spot to priorities [for climate adaptation]." (Interview 1, 28/01/19)

The lack of financial resources is also related to the financial capacity of end-users: private citizens often rely on subsidies or incentives for adopting private climate adaptation solutions, but whether or not measures such as greening one's own garden or creating green roofs will be subsidised is something that "will be discussed also at the political level" (Interview 3, 30/01/19). Another interview mentioned the fact that the AGV Waterboard has a democratic mandate arising from the collection of public taxes, and hence it is difficult to determine what are the actions that the Waterboard is allowed to carry out using these money. According to them, waterboards should define and formalise their relations with municipalities and determine the official boundaries of responsibilities between one entity and the other: "[the Waterboard is] putting time into municipal management while actually it does not get paid to do this" (Interview 6, 18/02/19).

5.2. Change in user-provider relations: co-evolving roles of end-users and the water utility provider

The case studies brought citizens closer to the water theme and to the institutional structures of the urban water infrasystem. This contributed to the redefinition of consumer roles towards one that is a hybrid between *citizen-consumers* and *co-providers*. It could be argued that with the upscaling of citizens participation in urban water governance there will be a predominance of the *citizen-consumer* configuration. One reason behind this is that nowadays it is easier for Waternet to learn about the needs, concerns, and expectations of citizens, because the latter are becoming more active in the formulation or (re)framing of policy issues. In this way, "the needs and preferences [of their customers] matter to providers" (van Vliet et al., 2005, 48), because it is easier for Waternet and the AGV Waterboard to cater to their needs and wishes by using ICT and big-data. It is indeed expected that further technological developments will make it possible for Waternet to access massive quantities of information thanks to ICT, although "it remains a level of aggregating data from million[s of] people that live in the [Amsterdam] area" (Interview 6, 18/02/19). The citizen-science projects had positive effects on the relation between end-users and the water utility provider, by increasing the trust towards water quality and Waternet itself, and it is therefore a promising method for strengthening the relations between Waternet and its end-users. Similarly, co-creation has been helpful for aligning social-environmental objectives next to the asset management and technical ones.

The interviews showed that urban water governance is increasingly moving towards co-creation, and the role of citizens and end-users in this scenario may take the form of *co-providers*. In the case-studies, Waternet has been employing co-production dynamics but not in the water infrastructure management domain, because this is still a predominantly-technical domain that is managed in a sectoral way and characterised by tensions between different governmental bodies: the conflicts are between "above- and below-ground perspectives" and responsibilities, "public vs. private spaces" (Interview 1, 28/01/19), and in the "[balancing of] public and private interests" (Interview 5, 18/02/19). Co-production, in this case, is therefore more related to the co-generation of knowledge and the establishment of social learning processes: for example, in *Amsterdam Rainproof* there have been employees in charge of managing the social organisations created in the form of communities, and participants to the projects have been exchanging information on best practices, on how to deal similar issues, and to organise collective activities; likewise, the two citizen-science projects also aimed at understanding the motivation of citizens to participate in the experiments, which gave valuable insights into how citizen-science can effectively contribute to scientific research.

The co-creation of the physical infrastructure was, once again, mainly related to urban (re)development projects that involved consultation usually at neighbourhood- or street-level, where citizens are usually consulted for the design of public spaces, for identifying the priority issues that policies should address, and for validating the problem framing. It is important to notice that the *Amsterdam Rainproof* project specifically assigned citizens a co-provider role by introducing rainwater collection mechanisms in private households (Amsterdam Rainproof, n.d.). As of today, however, potential new roles for citizens are still limited to low levels of the citizen-science and participation frameworks present in the literature (cf. Haklay, 2012; Arnstein, 1969), because in the case studies citizens have mainly been used in *crowdsourcing* and *consultation*.

Beyond crowdsourcing and consultation?

The new roles and functions assigned to end-users in citizen-science have been limited to crowdsourcing, because there is still today some reluctance from professionals and scientists in letting citizens intervene directly into all the phases of the project life-cycle. This is especially true for the design phase of projects related to water infrastructure development, due to the high-level of technical knowledge required to deal with the topic. Practitioners tend therefore to avoid the direct participation of citizens in this sector, and prefer to rely on the democratic systems that ensure citizens representation through the civil servant they have the opportunity to elect. One interviewee added that, however, there have been educative methods that could have been applied to address this knowledge gap and enable a more direct participation of citizens: "of course they are still including the wishes and needs of the people, but [now] it is still indirectly" (Interview 2, 28/01/19). Similarly, the level of participation is still limited to consultation, because the involvement of citizens for co-production has been often present only in urban development projects, especially in the design of the public space.

It still remains to be seen how citizens would fit in the current configuration of institutional structures, especially because of the knowledge gap between them and the experts/scientists employed in Waternet and the Municipality of Amsterdam. Several interviewees pointed out that this is an issue of matching different scales, because higher participatory processes are mostly applied to small scale —i.e., neighbourhood and street-level. As citizen participation in urban water governance will upscale to the regional or national level, the institutions involved in the policymaking process will have to allocate significant amount of resources in managing the participatory process itself, therefore also taking into account the educational activities to address the knowledge gap. An example of the scale mismatch can be found in the difference between rural and urban areas, in the extent to which end-users participate to the policymaking process: citizens in rural areas usually participate more into the policymaking process, because they are more directly connected to the water sector as their livelihoods depend on water management and on the spatial configuration of the water system:

> "The average [Amsterdam resident] will keep on being worried about their daily life and other things that are not strictly related with water management or climate adaptation if they are not confronted with these issues directly. […] If you go outside the city though, you have a lot of farmers whose livelihood depends on water management and the interest of the average citizen is suddenly a lot higher, just because it is something that is in their livelihoods. As climate change will become more and more noticeable, the interest of people and the attention of the average citizen will also increase." (Interview 1, 28/01/19)

There is also the question of how more or less direct participatory processes would effectively be a valuable input for decision-makers, while still safeguarding the democracy of these institutions: one of the interviewees pointed out that, in their opinion, the willingness of citizens to actively participate in the policymaking process is something that "we romanticise about" and that "is sometimes overestimated" (Interview 6, 18/02/19), because higher levels of participations require citizens to give away a considerable amount of their free time. Hence, only the people who can afford to allocate that time to urban water

governance will see their input on the table, and this inevitably decreases the level of democratic representations of citizens in urban water governance policies.

The case of co-production follows a similar argument, where the level of citizen participation has been mainly limited to consultation. Their role is not entirely as co-providers, because the technologies that could enable higher co-provision did not penetrate into households. The application of these technologies is large, but in practice there are not a lot of end-users that decide to choose co-production in the water infrastructure management domain. In this sector, participatory processes are more an issue of co-ownership and co-management than policymaking. Within citizen-science, the potential for upscaling co-creation is more promising than for co-creation: in these projects, technologies mediated the participation process, and have been 'accepted' by participants even if sometimes they were not at all acquainted with the methods — sometimes also making mistakes— or with the instruments used for the measures (van der Meulen et al., 2018). In the *Clean Water Experiment*, these technologies have been made accessible for participants in the form of a 'waterbox,' which became representative for the project itself. In the incoming decade, the development of monitoring technologies and big-data would probably facilitate the use of citizens for data-gathering purposes and make it easier for citizens to use these technologies in the most reliable way, contributing to the validity of the data. As this is one of the criticisms raised to citizen-science, the development of data-gathering technologies would contribute to the application of this method for generating knowledge and conducting scientific research (cf. Brouwer et al., 2018)

5.3. Changing narratives and 'option space'

The reconfiguration of cultural structures, including the creation of new strategic visions and increasing the establishment of multi-stakeholder partnerships, had an impact on the way long-term investment decisions are taken, specifically in respect to the *opinion-driven* feedback loop that influences investment allocation (Marlow et al., 2013). The option space and norms and rules that guide the vision and strategy of Waternet today have been affected by a reconfiguration of the structural components of the water infrasystem. This is especially relevant in relation to the cultural structures, which redefine the relationship between Amsterdam residents and Waternet. The priorities of Waternet significantly changed in the last two decades, increasingly including socio-environmental objectives next to the asset management ones. For example, issues of design of public spaces are now included in infrastructure development projects.

Waternet also acknowledged the fact that climate adaptation requires the introduction of adaptive governance mechanisms into its activities. One interviewee, for example, stated that Waternet is moving towards "another way of working […] in a more agile and flexible way, not making plans for five years but more by keeping in mind the vision and then look[ing] every three months at how things are moving and if there is the need to change a little" (Interview 5, 18/02/19). The current Amsterdam water governance regime is therefore exploring future opportunities for increasing the reuse, recycling, and recovery of materials and nutrients in the Circular Economy (CE) context. These perspectives offer a lot of potential for citizen participation in different phase of the project life-cycle, thanks to the development of ICT and new technologies for data-gathering.

As mentioned earlier, the boundaries of different regime actors' responsibilities are not clearly defined, which makes it problematic for water infrastructure managers to engage in municipality-management activities without having the necessary resources to carry out this task, both in terms of financial and human resources. Furthermore, budget constraints have always been a major obstacle to the implementation of climate adaptation measures as well as of infrastructure modernisation projects. This financial issue has been addressed in the case studies with the establishment of informal social networks, as in the case of the communities of intermediaries in the *Amsterdam Rainproof* project, which have been proven useful for mobilising resources that can be then shared with utility providers to create new forms of social organisations that can co-generate useful knowledge for the institutions regulating and/or managing the urban infrastructure — in other words, without the need to tap on their resources. The interviews showed that the major challenges related to end-of-life water infrastructure are related to the availability of financial resources and to the way investment allocations are prioritised. There is a set of elements that play a role in this discourse, namely problem framing, the type of knowledge required for implementing solutions, the political line behind investments allocation, and the perception of solutions as feasible to be implemented.

Problem framing

First, the continuous framing and reframing of policy issues related to water safety and hydrological risk reduction has been an increasingly multi-stakeholder process, even if still characterised by conflicts between public and private interests, responsibilities, and roles. In the case studies, for example, the *Amsterdam Rainproof* project promoted the application of its approach and organisational culture in other municipalities as a potentially new paradigm for urban water governance and infrastructural development, incorporating from the beginning climate adaptation measures into the design of solutions instead of just calculating additional costs for project developers. This is something that one interviewee laid particular emphasis upon, by stressing the fact that

> "project managers have to take into account rainproof in all of the public space projects. […] This is already a concept that people see as 'the way they want to work,' the message was not that it is going to cost X million euros to make Amsterdam a rainproof city in, say, 50 years, but that rainproof has to be integrated in all of their projects, and it is going to cost a little more. This sounds better, people said they were ok with that." (Interview 3, 30/01/19)

Level of expert knowledge required

Second, the reframing of policy issues has been related to the degree of expert/technical knowledge required to carrying out these measures, monitoring, and evaluating them. The interviews showed that the urban water infrastructure management sector is still dominated by technical expertise and the use of each institution's own resources, while all the interviewees stated that in the future there will be higher cooperation between governmental agencies at different levels — or, at least, it is something that they expect and hope for in the next ten years. The case studies stressed the value of delegating responsibilities to citizens, so that they could carry out tasks that have been traditionally assigned to Waternet or the Waterboard. This is especially true for

the citizen-science projects, whose proponents stress the fact that citizens and volunteers could be used as cheap labour force even just for data-gathering purposes (Brouwer et al., 2018; Buytaert et al., 2016).

This idea is however against the recent tendency of involving end-users in all the phases of the project life-cycle instead of just for crowdsourcing, and technological development will enable increasingly cost-effective applications of citizen-science beyond *crowdsourcing*. Another way of decreasing the costs associated with the implementation of participatory mechanisms is to establish *boundary organisations* that can manage the whole knowledge co-production process and act as intermediaries between institutions and end-users (Lemos et al., 2018). The *Amsterdam Rainproof* project offers an example of such boundary organisation, as it has been specifically created to mediate between Amsterdam residents and Waternet becoming semi-independent from Waternet and the Municipality of Amsterdam.

Political lines

The third aspect is the political landscape behind the urban water governance institutions. All of the interviewees mentioned that the dynamics at political level will greatly influence the financial resources allocated for climate adaptation, water infrastructure development, as well as determining the extent to which participatory measures are implemented by the actors within the urban water governance regime. Moreover, the activities carried out by Waternet are financed by public taxes, and this raises issues related to accountability and transparency within the organisation as well as related to the accessibility of this information by end-users. Specifically, one of the interviewees mentioned that there is a "political line" behind the AGV Waterboard that "is maintained intact" between the current board and the Municipality of Amsterdam (Interview 6, 18/02/19). Another interviewee brought the attention to the fact that the current board is much more focused on co-creation in respect to the previous one, where the emphasis is no more "on autonomy and solving the problems in our own organisation" but in "aligning to other governments" (Interview 4, 30/01/19).

Stakeholders perceptions and investment decisions

The fourth element defines whether a solution is considered feasible for implementation, referred to as *option space* in the literature (Marlow et al., 2013). Among the factors that determine the option space, the normative values and attitude to risk of actors, the innovation space, performance and cost certainty of the potential technologies have been investigated with a questionnaire presented during the interviews.

The redefinition of the relationship between Amsterdam residents and Waternet and reconfigurations in the structural components of the water infrasystem (esp. culture) had an impact on the option space and in the norms and rules that guide the vision and strategy of Waternet today. Regime actors aim at avoiding political and economic risks by engaging in multi-stakeholder processes for creating visions and scenarios to address uncertainty and complexity arising from climate adaptation. These actors rely on creating partnerships and building consensus among all stakeholders involved, which is referred to in the literature as the Dutch *polder* model (Wolsink et al., 1998).

The questionnaire showed that there is not a significant difference in the perception of interviewees in relation to their environmental awareness, knowledge, and attitudes, and in their normative considerations on

environmental protection. The factors showing biggest differences among interviewees have been economic concern, support for intervention policies, confidence in science and technology, and risk perception (cf. Annex 3). The results show that the representative of the Municipality of Amsterdam scored highest in risk acceptance and in support for intervention policies. The respondent from Waternet scored surprisingly lowest in the confidence in science and technology, while the representative of the AGV Waterboard scored highest in economic concern. Although the small sample size does not allow for a generalisation of results and they do not have statistical significance, it can still be noted that Waternet and the AGV Waterboard, with more responsibilities connected with important issues like public health and water safety are predominantly risk-avoiding. On the other hand, the Municipality of Amsterdam is the actor with highest confidence in the role of science and technological development for addressing climate adaptation and safeguarding environmental protection. The differences in the extent to which regime actors support a more central role of the state for issuing standards and stringent measures against pollution can be ascribed to the mandate of regime actors. This is to say that, unsurprisingly, the Municipality is in favour of increasing the measures that local governments can take to manage and protect their environmental resources.

It is interesting to notice that Waternet and the AGV Waterboard have a lower level of confidence in science and technological development in respect to the Municipality of Amsterdam. This could be explained in the light of the changes in their institutional culture, which is currently moving towards greater consideration of social innovations and stakeholder engagement instead of prioritising experimentation with new technologies, which is in line with the analysis of the impact of the case studies.

5.4. Results: conclusions

The three participatory projects of co-creation and citizen-science can be considered as successful transition experiments for raising the awareness of a wide range of stakeholders towards water-related issues of climate adaptation and urban infrastructure management, and they offer interesting opportunities for increasing the engagement of end-users in urban water governance and infrastructure management in Amsterdam. The three case studies analysed in this research are governance experiments that have introduced reframing dynamics proper of second-order learning loops. Second-order learning processes play a key role in shaping strategic visions, because they allow for the reframing of policy issues and reflexivity in the activities and projects carried out by institutions (Pahl-Wostl, 2009).

The type of systemic changes needed to support the urban water governance transition towards SUWM have been mainly observed in the cultural structures of the urban water governance regime. The transition towards multi-level governance arrangements for implementing SUWM practices in Amsterdam is therefore supported by increasing the cooperation among regime and non-regime actors, and by integrating water infrastructure management with other policy domains —namely, climate adaptation and urban (re)development. The design and overall architecture of the institutions belonging to the urban water management regime in Amsterdam are not affected by these changes: no one among the interviewees supported the idea of restructuring the organisational design of Waternet or the AGV Waterboard in the next decade, focusing instead on horizontal integration across policy domains.

Although these projects have been carried out by actors corresponding to the institutional structures of Amsterdam water infrasystem, deep participatory initiatives like citizen-science and co-creation are still at the beginning of their process of institutionalisation. The upscaling of transition experiments largely depends on the development of governance arrangements that facilitate the mainstreaming of pilot projects into new regime configurations. Such embedding, or mainstreaming, of governance experiments into water-related policies is considered to be necessary for upscaling niches and implement systemic changes in the urban water governance regime (de Graaf & van der Brugge, 2010; van de Meene et al., 2011).

The interviewees recognised that increasing the awareness on water resources management is the first step towards changing practices related to utility consumption. However, the case studies did not have a follow-up for specifically addressing changes in end-users behaviour. Waternet and the AGV Waterboard do believe that public awareness towards issues of climate adaptation and water infrastructure development is the first step for increasing the participation of citizens into urban water governance, and that these two processes have a positive feedback on each other, but the interviews showed that these institutions are reluctant to engage citizens with more direct and active roles for co-developing the urban water infrastructure

So far, the opportunities for co-producing the urban water infrasystem between Waternet and citizens are limited to consultations on the designing of public spaces, and to end-of-life infrastructure management. The lack of formal participatory mechanisms in water infrastructure management could be explained by looking at the water sector itself, which is characterised by a significantly different knowledge base among stakeholders. The interviewees from Waternet and the AGV Waterboard emphasised the fact that these two institutions have

no formal requirement to engage in deep participatory processes with end-users. In fact, the only formal initiatives of this kind are the elections of representatives in the boards of the RWAs. This is another indicator that the institutionalisation process of co-creation and citizen-science is still at early stages (cf. Havekes et al., 2017).

6. Analysis and discussion of the results

The urban water governance regime in Amsterdam is undergoing *endogenous* change, as the three case studies have been initiated and carried out by actors that correspond to this regime.[1] The transition towards multi-level governance arrangements for implementing SUWM practices in Amsterdam is therefore supported by increasing the cooperation among regime and non-regime actors, and by integrating water infrastructure management with other policy domains —namely, climate adaptation and urban (re)development. The impact of the overall process of increasing end-users engagement takes more time to materialise for the *institutional* and *physical* infrastructure than for the *cultural* ones. Nonetheless, some changes are already taking place in the city, as Waternet and the Municipality of Amsterdam have been implementing climate adaptation measures and SUWM practices when addressing end-of-life infrastructure issues.

The following chapter provides an analysis of the results presented in the previous chapter and a discussion of the results in respect to the wider literature. The first section provides a critical summary of the results, analysing the ways and extent to which the case studies contributed to structural changes in the urban water management regime. The second section presents the discussion of the results in the light of the broader literature in urban water management and sustainability transitions, with specific reference to the possibility of upscaling participatory governance experiments in other urban utility sectors.

6.1. Governance experiments and structural changes from culture to institutions

The *institutional structures* are slowly starting to be affected by changes in the *cultural structures*: one of the case studies, for example, required Waternet to adopt a drastically different communication approach with its customers, by engaging in a more transparent and two-ways communication strategy and increasing the accessibility of information to the public (Interview 3, 30/01/19). This in turn brought to the creation of a dedicated team within Waternet with the task of monitoring and using social media (Interview 5, 18/02/19). However, the design and overall architecture of the institutions belonging to the urban water management regime in Amsterdam are not affected by these changes: no one among the interviewees supported the idea of restructuring the organisational design of Waternet or the AGV Waterboard in the next decade, focusing instead on horizontal integration across policy domains.

The interviewees from Waternet and the AGV Waterboard emphasised the fact that these two institutions have no formal requirement to engage in deep participatory processes with end-users. So far, only

[1] Although the projects *Freshness of Water* and *Clean Water Experiment* have been set up and carried out by the research institute KWR, there are two reasons why these projects can still be considered as initiated by regime actors. First of all, the projects have been created in consultation with Waternet, which had to formally accept the initiation of these citizen-science projects. Second, KWR is a 'water cycle research institute' whose major shareholders are the drinking water companies in The Netherlands and the Belgian *Watergroep* (KWH, n.d.).

formal initiatives of this kind are the elections of representatives in the boards of the RWAs. This is another indicator that the institutionalisation process of co-creation and citizen-science is still at early stages (cf. Havekes et al., 2017). In fact, Waternet do acknowledges the difference between its formal responsibilities and functions, such as public health and flood-defence, and its more 'social' functions that have usually been attributed to other governmental bodies, like RWAs. One of this 'social responsibilities' is to work in close contact with municipalities and to engage with citizens and other stakeholders for developing the urban water infrasystem.

The responsibilities and functions of the urban water governance regime are hence fragmented, divided in an incohesive and uncoordinated manned among the regime actors, and this is one of the challenges for upscaling of urban water governance transitions in Amsterdam. This can be seen, for example, from the fact that there is a limitation to the scope of governance experiment in the urban water sector, arising from a clear and long-standing division of responsibilities and function between the "above-ground" and "below-ground" issues related to urban water governance (Interview 1, 28/01/19).

6.1.1. Institutionalisation of governance experiments: deep participatory initiatives and behavioural change?

A further development of this institutionalisation process is necessary to address the obstacle of low end-users engagement for experimenting with co-management strategies between citizens and Waternet or the Municipality of Amsterdam. Formalising deep participatory initiatives like citizen-science could also contribute to making sure that policy actors accept these initiatives as the new paradigm for climate adaptation and urban water governance. One of the main challenges that emerged from the interviews is that citizens' active participation cannot be taken for granted, either because the average citizen "does not care about" (Interview 1, 28/01/19) or is "'distant' from the water theme" (Interview 6, 18/02/19), or because they do not have the resources to participate in the policymaking process. However, the two citizen-science projects demonstrated that in fact citizens accepted and fulfilled the responsibility of performing the periodic measurements for data-collection, and in the case of co-production the creation of communities established new informal structures among residents implementing climate adaptation measures at neighbourhood level.

Therefore, experimenting with co-management strategies could be a way to move beyond low-levels of participation and citizen-science and in turn increase the interest of end-users towards the 'water theme.' They may also develop new meanings attached to green-blue public spaces, and modify their behaviour around water consumption. The whole social practice around water would be affected: the *meaning* behind the practice becomes closer to socio-ecological discourses on the relationship between man and the surrounding environmental resources; new technologies and artefacts are introduced among the *materials*, which allow easier and wider applications of citizen-science for monitoring the overall quality of water resources; the *competencies* of citizens develop together with the use of new and/or more specific technologies, which in turn increases the potential and validity of the data generated via citizen-science.

The level of participation between rural and urban areas would nonetheless remain unequal, because urban citizens consider water resources as a "given," something that is taken for granted because, according to

the interviewees, there have never been major issues regarding water quality as it happens in Southern-European countries (Interview 4, 30/01/19; Interview 5, 18/02/19).

The connection between raising awareness and behavioural change is also related to changing the meaning behind water consumption practices: it is specifically by reframing water-related issues and perceptions of end-users towards their water utility provider that citizens participating to the case studies felt more involved with and interested in the implementation of private adaptation mechanisms, and in engaging with new roles and responsibilities. Bringing residents closer with the institutions of the urban water infrasystem, and building upon practices shared among members of stakeholders networks, contributed to the creation of a sense of shared ownership of the urban water infrastructure. For example, introducing rainwater harvesting mechanisms in your garden is a demonstration of "being Rainproof" and it is something that individuals can show to others, by using banners or stickers stating that "my garden is Rainproof" (Amsterdam Rainproof, n.d., 20).

Waternet and the AGV Waterboard do believe that public awareness towards issues of climate adaptation and water infrastructure development is the first step for increasing the participation of citizens into urban water governance, and that these two processes have a positive feedback on each other, but the interviews showed that these institutions are reluctant to engage citizens with more direct and active roles for co-developing the urban water infrastructure. There is therefore a limitation in the extent to which future initiatives envisaging co-management or co-ownership strategies could be applied to formalise and institutionalise the new functions that end-users and citizens could cover in a future urban water management paradigm. Such strategies would represent a significant empowerment of end-users, but they also depend on the extent to which citizens are actually interested in and able to accept new responsibilities that the water utility provider could share with them.

The institutions of Amsterdam water infrasystem, moreover, have different interpretations of the idea of changing end-users' behaviour related to water consumption. The interviewees recognised that increasing the awareness on water resources management is the first step towards changing practices related to utility consumption. However, the case studies did not have a follow-up for specifically addressing changes in end-users behaviour. Waternet and the Waterboard do not aim at modifying their customers' practices, nor at changing the way citizens use the existing infrastructure. One of the interviewees stated that the behavioural-change topic "sounds like a political agenda that [the AGV Waterboard] do[es] not have" (Interview 6, 18/02/19). There is some disagreement even on the topic of whether end-users should be asked to modify their use of drinking and surface water. On the one hand, in the case studies the concept of *using* the water infrastructure, besides social practices around water consumption, is also related to the relationship between citizens and the blue-green spaces in the city, how they use these areas and the meaning citizens attach to them. For the water utility provider, on the other hand, this topic does not fit into their mandate. This discrepancy can probably be attributed to the fact that The Netherlands have a low level of water stress and because water scarcity has never been an urgent issue for the country besides during periods of drought in summer (FAO, 2016). Nonetheless, there are some future challenges, in relation to so-called 'new substances,' such as micro-pollutants, medicines, and micro-plastics, which affect both water quality (chemically and

ecologically) and the treatment of wastewater (*ibidem*). These threats to the functions of water governance institutions can specifically be addressed by changing end-users' behaviour and practices.

6.1.2. The role of end-users in upscaling co-creation and citizen-science for knowledge management and value creation

The analysis of the case studies shows that there are limits to current applications of co-creation and citizen-science in the urban water sector. So far, the opportunities for co-producing the urban water infrasystem with citizens and end-users are limited to consultations on design of public spaces and to end-of-life infrastructure management. The lack of formal participatory mechanisms in water infrastructure management can be explained by looking at the water sector itself, which is characterised by a significantly different knowledge base among stakeholders. It is clear that the average resident in Amsterdam does not have the same in-depth, scientific knowledge of engineers in Waternet regarding the way the water infrastructure network works and where to prioritise investments.

It is then not surprising that Waternet considers it to be ineffective, or even "worrisome" (Interview 6, 18/02/19) to engage citizens with more active roles in urban water infrastructure management. Neither Waternet nor the AGV Waterboard have enough resources to engage in individual consultation with every stakeholder affected by their activities —the costs behind these processes cannot be covered by means of public taxes alone (Interview 6, 18/02/19). It still remains to be seen whether the future development of data-gathering technologies would increase the potential of citizen-science by, *inter alia*, reducing the costs behind these projects: on the one hand, developments in ICT could increase the reliability of data and hence the application of the citizen-science method; on the other, over-relying on these technologies may oversimply data-gathering processes, and in turn reduce the role of end-users to passive crowdsourcing mediums.

The interesting aspect in the conceptualisation of the option-space is the acknowledgement that changes in stakeholders' perception have an impact on decisions of investments allocation. This process goes beyond traditional asset-management perspectives and focuses specifically on the agency of water utility providers. A similar argumentation has been raised earlier, when characterising the agency of water utility providers as 'more intensive' than the one of other members of the urban water governance regime. Water utility providers have the role of embedding technological innovations into the current regime of urban water infrastructure management, but behind this process there are considerations of whether an investment provides enough returns to be seriously taken into account and implemented. In this respect, there is a need for future research that will specifically analyse the diversity and alignment of the perceptions of regime actors and other stakeholders.

6.2. Discussion: the potential of upscaling co-creation and citizen-science experiments in other urban utility networks

The frameworks of TM and SNM focus on how technological innovations from niches become embedded within a particular societal and institutional regime. Applying these frameworks to the case studies showed that the upscaling of transition experiments largely depends on the development of governance arrangements that facilitate the mainstreaming of pilot projects into new regime configurations. Considering urban utility networks as infrasystems emphasises the necessity of understanding how dynamics of endogenous institutional renewal work, and the extent to which strategic changes introduced in the regime are a response to changes in the socio-economic context and in the environment.

The three participatory projects of co-creation and citizen-science can be considered as successful transition experiments for raising the awareness of a wide range of stakeholders towards water-related issues of climate adaptation and urban infrastructure management, and they offer interesting opportunities for increasing the engagement of end-users in urban water governance and infrastructure management in Amsterdam. Although these projects have been carried out by actors corresponding to the institutional structures of Amsterdam water infrasystem, deep participatory initiatives[2] like citizen-science and co-creation are still at the beginning of their process of institutionalisation. Such embedding, or *mainstreaming*, of governance experiments into water-related policies is considered to be necessary for upscaling niches and implement systemic changes in the urban water governance regime (de Graaf & van der Brugge, 2010; van de Meene et al., 2011).

The case studies represent the first steps towards a potential re-evaluation of the current urban water management paradigm as a whole. Second-order learning processes play a key role in shaping strategic visions, because they allow for the reframing of policy issues and reflexivity in the activities and projects carried out by institutions (Pahl-Wostl, 2009). Experimentation is not limited to changes in policy instruments such as the public tax on drinking water provision and wastewater collection and treatment, but it introduces reframing dynamics proper of second-order learning loops. By fostering organisational and policy learning, Waternet would have ample opportunities for implementing systemic changes in the current paradigm of water infrastructure management, and for (re)defining what their transition objective is.

The type of systemic changes needed to support the urban water governance transition towards SUWM have been observed mainly in the *cultural structures* of the urban water governance regime, such as the redefinition of the vision and strategy of regime actors as well as their perspective towards end-users engagement and citizen participation for infrastructure development. The limitation of the impact of the case studies on infrasystem structures can be attributed, on the one hand, to the contemporaneity of these projects.

[2] Deep participation has been defined as a "level of participation that generally correspond to the highest levels of Arnstein's (1969) ladder" (Potvin & McQueen, 2009, p.150). Roark (2015) adds that deep participation is a "basic mechanism underlying social transformation," whose overall objective is a "change-in-type social change characterised by greater inclusiveness and social integration" (p.162).

This consideration suggests that systemic changes and governance experiments in so-called "monolithic regimes" (van Welie et a., 2018, p. 263), such as the water management sector in The Netherlands, could be implemented and upscaled by regime actors only after a reconfiguration of their cultural structures. On the other hand, the significant difference in knowledge base between engineers and citizens is a limiting factor to a more active involvement of the latter in the urban water management sector. This also means that the application of co-creation and citizen-science experiments in this sector is limited.

Despite this knowledge gap, however, the citizen-science projects demonstrated that even end-users without a specific background in water governance or infrastructure management could actively participate in the sector, specifically by providing data that the water utility provider would not be able to gather otherwise. Moreover, both projects contributed to increasing citizens' trust towards Waternet, especially because they have been now able to understand what water safety entails and the meaning behind purely technological and scientific data, such as the microbial composition of tap water (Brouwer et al., 2018).

The future development of the legislative framework will need to provide new norms and regulations for further integrating different policy domains related to urban water governance, including climate adaptation and water safety. Also here, the development and maintaining of political lines within governmental institutions will influence the integration process: the *Omgevingswet* is believed to give more autonomy to municipalities by introducing deregulations and normative simplification, as emphasised in the interviews, but moving towards deregulation could in fact be detrimental to lower-level governments that lack the necessary capacity and resources to impose urban (re)development standards that include climate adaptation or sustainable urban water management *a priori*.

Co-provision of energy and waste management services

One way to demonstrate the value of co-creation and citizen-science would be the application of these methods in other urban utility sectors, namely energy and waste management. Similarly to the water sector, future researches could investigate the extent to which urban utility providers in these sectors benefit from end-users participation for supporting sustainability transitions. Energy and waste management are also two utility sectors that have a significant social component. Their consumption has often been explained through the lenses of Social Practice Theory, to investigate changes in the meanings attributed to energy consumption and waste production.

In both sectors, co-creation and citizen-science could be applied to reconfigure user-provider relationships and to experiment with delegation of responsibilities and/or functions from utility providers to end-users. In this respect, in the energy sector, co-creation has already taken the form of co-provision of energy when, for example, households putt back in the grid the excess energy produced by their PVPs. The same can be said in the urban water management sector, where citizens implement rainwater harvesting measures and re-use the water they collected. Therefore, citizens have already begun to cover roles of *co-providers,* with significant impacts on the dynamics between them and utility providers (cf. van Vliet et al., 2005).

In the case of waste management, the role of end-users is similar to the one they have in the water sector: there is a 'distance' between them and the service provider, which can be regarded as a 'flush and

forget' mentality that makes them consider waste management as 'a given' that is not entirely dependent on their behaviour. This condition would imply, on the one hand, that there is enormous potential for increasing the collaboration between end-users and waste management providers, as deep participatory initiatives are mainly applied to account for state-failures —that is, lack of service provision for waste management. On the other hand, it could be argued that there are significant challenges to delegate waste management functions to citizens since waste production is strictly dependent on social dimensions that vary from person to person, such as individual consumption patterns, lifestyle, disposable income, and environmental awareness.

Applying co-creation and citizen-science experiments to the waste management sector could also be an opportunity to address co-management and co-ownership issues that inevitably arise when applying the circular economy framework with increased end-users participation: in the case of co-management, for example, waste management companies would rely more on upstream waste separation (i.e., before collection), and end-users will have a key role in separating waste and in doing it according to the waste treatment process applied in their municipality; in the case of co-ownership, the co-provision of waste management services would also entail that citizens will be paid for the materials and nutrients that can be recovered or recycled from their waste.

6.3. Reflections on scope and future research

This research aimed at investigating how Amsterdam water utility provider can influence sustainability transitions in urban water management, towards a more active and direct engagement of end-users and other relevant stakeholders. Given the complexity of the topic at hand, it has been necessary to integrate multiple sets of literature, research methods, and case studies that could effectively integrate different perspectives around the same issue of urban water governance and infrastructure management. The construction and application of such complex conceptual framework has been indeed at odd with the time limitations of the research, This choice nonetheless allowed for a more holistic analysis that included both technical and socio-institutional aspects, which is proper of the current scholarship on socio-technical transitions and urban water governance.

Carrying out this research method has proved to be a difficult task from the beginning, due to the limited response rate from potential interviewees invited to participate to the research. The major limitation of this research is the lack of statistical significance of the research methods carried out to answer the research questions. The size of the sample (n=6) in fact does not allow for the generalisation of results to the whole water utility sector, and the interviewees may not reflect the position of their institution or organisation as a whole. Although snowball sampling techniques have been applied in every interview, they proved to be ineffective to increase the sample size, as the interviewees referred to each other as additional experts to be interviewed.

The same considerations apply to the questionnaire administered as complimentary method to semi-structured interviews. Again, statistically significant results cannot be inferred from the small sample size (n=5) and not all interviewees (n=6) succeeded in filing and sending back the questionnaire. This complimentary method had a qualitative nature, to gain further insight into the perceptions and perspectives of institutional actors towards specific environmental policy issues, such as risk-perception, investments allocation, environmental awareness and cognitive-affective dimensions.

Therefore, the limitation of having a small sample size does not significantly hamper the validity and relevance of the research, as the representative nature of the interviews provides an in-depth analysis of the narratives and strategies of decision-makers in the Amsterdam water governance regime.

7. Conclusions

This research has been carried out to investigate the role of water utility providers in urban water management transitions, by adopting a qualitative, multiple case-study approach. Specifically, it aimed at evaluating the extent to which three projects of co-creation and citizen-science contributed to the reconfiguration of Amsterdam water governance regime, to the redefinition of the relationship between end-users and regime actors, and to changes in the definition of feasible solutions for investment in the urban water sector.

The interviews carried out with top executives from the institutions responsible for water infrastructure management in Amsterdam brought the following findings: the projects (i) increased the number of actors involved in urban water infrastructure management; they (ii) further developed existing co-creation processes for urban water governance and introduced citizen-science as a new participatory process in the Dutch drinking water sector; the case studies (iii) fit into the contemporary discourse on public participation for integrated water management, which emphasises multi-level and participatory governance; and (iv) this new paradigm of active stakeholders engagement in turn affects the culture, norms, and narratives of the water infrastructure governance regime in Amsterdam. These findings reinforce the argument that urban water management in Amsterdam is undergoing a transition, which can be referred to the general transition in water resource management in The Netherlands. The case studies are therefore representative of the *momentum* in the current urban water management transition: they are the example of how the current water management regime in The Netherlands is being destabilised by the adoption of participatory and multi-stakeholder processes in policymaking.

The research aimed at answering the question of how Amsterdam water utility provider influences the ongoing transition in urban water governance. The case studies have engaged end-users and citizens with a more direct and active role in the development of Amsterdam urban water infrastructure, and this has contributed to the reconfiguration of the cultural structures of the regime and to the redefinition of user-provider relationship. In turn, these changes have an impact on investment decisions of regime actors, by influencing changes in the norms and narratives that guide the strategies of regime actors.

Reconfiguration of regime components, user-provider relationships, and option space

Starting point of this study has been the acknowledgement that traditional frameworks for analysing changes in water management approaches lack analyses on the specific impact of transitions on more socio-institutional restructuring. At the heart of this research therefore lies a conceptualisation of the urban water infrastructure as an *infrasystem,* defined as a system comprising both the physical structure (i.e., the infrastructure network) as well as the institutional structures that regulate and manage the infrastructure system. It has been possible to identify and evaluate the changes in technical and socio-institutional components of the infrasystem, through the application of a conceptual framework combining three key concepts selected from the reviewed literature.

The first is the configuration of regime components (actors, processes, structures and influences), which conceptualises the development of socio-technical systems like the urban water infrasystem as changes

in the way these components interact among and influence each other. The three case studies had an impact on all regime components: new actors are gaining more and more relevance within the existing urban water governance regime, thanks to new participatory processes that envisage a more active role and direct involvement of end-users and citizens. The cultural structures of the regime have been the ones that changed the most, showing an alignment of discourses, values, and knowledge base between regime actors and other stakeholders that facilitated the acknowledgement of the added value of participatory processes for urban water governance. Changes in the physical structure of the infrasystem have mainly been related to end-of-life infrastructure issues, and the role of citizens and end-users has mostly been a *consultation* and *crowdsourcing* one. The institutional structures of the regime have been affected in a very limited way, and there is a significant degree of scepticism towards a potential restructuring of the organisational design of urban water governance regime actors. A recent new legislative framework introduced new ways to influence the role and functions of regime actors, and its future development will in turn affect the relationship among regime actors at different governmental levels.

Second, the concept of user-provider relationships has been used to analyse the impact of participatory governance experiments on the way the infrastructure network is organised and managed. The main impact of the case studies has been to bring citizens and other relevant stakeholders closer to the 'water theme,' which includes both climate adaptation and infrastructure development issues.. The three case studies engaged citizens and end-users with processes of co-creation and citizen-science, which had not been extensively applied in the urban water management sector —or never applied at all in the case of citizen-science. Amsterdam water utility provider and the Regional Water Authority have been striving for bridging the 'distance' between them and the average citizen, and the case studies of co-creation and citizen-science managed to bring citizens closer to the activities of urban water governance regime actors and to increase the trust among them. Experimentation with new end-user roles, beyond *consultation* and *crowdsourcing*, is however still limited because of the knowledge gap between engineers and citizen. Future developments of ICT and data-gathering technologies could promote a more active role of end-users in this context, but they may also reduce citizens to passive sensors.

Third, the concept of option space analyses changes in the factors that make a certain innovation feasible for implementation, which include characteristics of the technologies, innovation drivers, and of the actors involved in the process. Changes in stakeholder perception of investment decisions has an impact on the investment flow in the urban water sector, by redefining normative values and attitudes to risk of policy- and decision-makers. The factors showing biggest differences among interviewees have been economic concern, support for intervention policies, confidence in science and technology, and risk perception. The case studies introduced changes in some of the factors influencing the option space, especially in relation to problem framing and to decision-makers' perception of stakeholder participation in urban infrastructure management.

Co-creation and citizen-science as participatory governance experiments

Changes in the physical, institutional, and cultural structures of the Amsterdam water infrasystem have been introduced to different extents by the case studies, and their use of participatory processes is also case-specific.

Co-creation and citizen-science can be considered as successful transition experiment in respect to how they influenced the reconfiguration of Amsterdam water governance regime, especially in relation to the cultural structures of regime actors. Although co-creation has also been the only process that introduced changes in the physical infrastructure of the urban water infrasystem, the level of citizen participation in this process is however still limited, because the knowledge gap between end-users and practitioners prevented a higher involvement of lay citizens in project life-cycle. Citizen-science offered promising opportunities for engaging end-users with a more active role, by allowing Waternet to delegate to citizens functions of data-gathering (and, partially, problem validation) that it would not have been able to fulfil otherwise.

The contribution of co-creation and citizen-science for urban water governance is an increase in participation of citizens concerning the governance and development of the urban water infrasystem. This brings benefits for both the water service provider, Waternet, and for Amsterdam citizens, because through the use of participatory initiatives such as co-creation and citizen-science, Waternet has been able to reduce the distance between the water theme and the average Amsterdam citizen. Initiatives of end-users engagement can support policies and deliver better policy outcomes, provide access to data that would not have been measurable without the involvement of citizens, and increase end-users' acceptance of policies and solutions implemented by regime actors. High levels of participation of residents makes regime actors include social and environmental-protection objectives next to public health and service provision, and end-users perceive the water utility provider as more connected to their needs and expectations.

The institutional structures of the regime are currently moving towards new governance arrangements with similar characteristics of so-called 'multi-level governance.' The establishment of *Amsterdam Rainproof* played a key role for supporting this transition, as it represents an *ad-hoc*, intermediary organisation that deals with policy issues across administrative boundaries and policy sectors. It is interesting to notice that Amsterdam water utility provider Waternet shares similar characteristics, because it is configured as a so-called 'water-cycle company:' a single institution responsible for managing the whole water cycle in the Amsterdam area, incorporating responsibilities that are usually fragmented between municipalities and Regional Water Authorities. This type of intermediary organisations make it easier to coordinate shared resources and to create shared visions for the whole urban water governance sector.

The fact that the three case studies have been carried out by the regime itself demonstrates that Amsterdam water governance regime is redefining its institutional culture, norms, and narratives towards a new paradigm of urban water infrastructure management that is more integrated across policy domains and is more supportive of (and supported by) social innovations. Changes in organisational culture brought to the establishment of a new paradigm for urban water governance, which is slowly but steadily being accepted by policy- and decision-makers as 'the new normal' for climate adaptation and citizen participation. Future developments at the political and legislative landscape will be crucial for establishing collaborations across government levels, and for supporting social innovation initiatives for moving towards SUWM. In this respect, the Environment and Planning Act (*Omgevingswet*) is believed to support the ongoing transition towards multi-level and participatory urban water governance, by providing a general framework to harmonise and integrate regulations and procedures for urban development, water management, and infrastructure development.

Upscaling participatory governance experiments: new roles and meanings

The new roles for end-users that have been introduced in the case studies are still limited to *consultation* and *crowdsourcing.* Higher levels of participation, similar to what is currently being done in the urban planning sector for the design of public spaces, are difficult to implement in the water infrastructure sector because of several reasons: a general reluctance for including the average citizen in policies that influence important issues like public health and infrastructure development; there is a significant knowledge-gap between engineers and end-users in the urban water governance sector; and the penetration of technologies that allow citizens to really become co-provider of water utilities, such as separated wastewater collection or rainwater harvesting and reuse, are still limited to few examples that are shared as exemplary cases and best practices. There is a different argument in the case of co-creating knowledge through citizen-science, where technologies have been made accessible and easy to use for citizens and hence played a key role as mediators between lay people and scientists. Moreover, regime actors rely on the fact that citizen participation is already safeguarded through public elections for electing the board members of the regional water authorities in The Netherlands. Nonetheless, some interviewees criticised the fact that the active participation and interest of citizens in the water governance sector seems to depend on the extent to which they are directly affected by water-related policies. This argument can be seen by the fact that the elections for the RWAs have a very low turnout among urban residents in respect to rural ones.[3]

The future prospects for upscaling co-creation and citizen-science, depend on whether these methods will be accepted by regime actors as the new standard of participatory mechanisms for knowledge co-generation and value creation. In fact, the current urban water governance approach is fragmented and regime actors have different interpretations of the extent to which end-users could and should participate in the water sector. The major issues, in this respect, is a significant difference in knowledge base between engineers from Waternet and citizens in Amsterdam. Moreover, regime actors also have different interpretations of issues related to end-users' behaviour: the Municipality of Amsterdam, Waternet, and the AGV Waterboard agree on the fact that raising awareness among residents is the first step towards changing their behaviour related to water consumption, but they do not consider behavioural aspects as part of their agenda.

Although water consumption has been considered inconspicuous (i.e., not carrying a specific meaning or expressing a certain status or lifestyle), the three case studies also had an influence on the meaning that end-users attribute to urban water resources. The participants to the co-creation and citizen-science projects selected as case studies had, in fact, the opportunity to show-off their front-yard garden as adaptive to cloudbursts, or to put on a white coat for conducting measurements in the canal in front of their house. Although beyond the scope of this research, it would be interesting to investigate whether Waternet is

[3] On March 20th, 2019, The Netherlands had general elections for the regional water authorities. The turnout at these elections has been reported to be the highest since the 2015 elections (43.5% in 2015 and 50.5% in 2019) (UvW, 2019, March 21). Amsterdam, nonetheless, has been the city with the lowest turnout (44.4%) (AGV Waterschap, n.d.).

purposefully redefining the meaning that people attach to water resources, with the aim of making their daily activities more connected to urban water governance and climate adaptation.

7.2. Recommendations for policy and research

The results showed that future research should specifically focus on governance experiments in urban water infrasystems, through the use of mixed methods and multiple case studies. These experiments should not focus predominantly on technological innovations, but should take into account the much broader complexity of the socio-institutional system in which these technologies are embedded.

That is to say, research should be carried out to analyse social issues of urban water infrastructure development, including how water utility providers can benefit from co-creation and citizen-science initiatives and from the delegation of responsibilities and functions to end-users. This would provide insights into practical issues related to experimentation with co-management of urban water resources, such as knowledge gaps or the lack of interest among residents in engaging with monitoring and evaluation of water bodies.

Future research should also attempt in applying more objective and systematic methods for analysing stakeholder perception of investment decision and, in general, changes in the norms and rules guiding the management strategy of urban water utility providers. A good alternative to Likert-type questionnaires can be found in Q methodology, which has been used for quantitatively assessing the diversity and variance in specific stakeholders' perspective around a certain issue (cf. Brown, 1980; Raadgever et al., 2008). Moreover, the fact that Q methodology has already been applied to the water resources management sector makes it particularly relevant for analysing the extent to which the narratives and policy frames of specific stakeholders at niche-level are reproduced or modified by actors at regime-level, or vice versa. It could also be used to identify the expectations, needs, and strategies of different actors throughout the urban water governance regime, and to evaluate the perception of regime-actors towards specific components of the option-space.

There are three main policy recommendations that Waternet, as well as other regime actors such as the Municipality of Amsterdam and the AGV Waterboard, could introduce to foster citizen engagement and implement Sustainable Urban Water Management practices. The establishment of participatory methods such as co-creation and citizen-science requires human capital, time, specific knowledge on how to make these mechanisms valuable for policymakers, and financial resources. One of the ways to circumvent constraints arising from limited budgets is to focus redefining organisational culture and the rules, strategies, and norms of the institution, instead of attempting to introduce institutional change in the water infrasystem structures.

The role of intermediary organisation for bridging the socio-cultural gap between urban water utility providers and citizens

The first policy recommendation is related to the relationship between Waternet and social innovations introduced by so-called "intermediary organisations" (Matschoss & Heiskanen, 2017). Multi-stakeholder participation and social learning are crucial for Amsterdam water governance transition, because they serve the purpose of validating new problem identification and framing with the use of specific facilitating methods and tools. Moreover, the diffusion of new technologies for closing the loop of nutrients in the water cycle or for

ecological sanitation significantly depends on whether, how, and with what effects these technologies penetrate in society. The participation issue also raises further questions related to inclusion and representation of relevant stakeholders and power balances, which are not the object of this research and should be addressed by further research in specific socio-institutional and economic contexts.

The establishment of a closer relationship between Waternet and Amsterdam residents could be a way to address the issue of co-management or co-ownership, because it will serve the twofold benefit of fostering social innovation and increasing the active participation of citizens. These could be done by the establishment of communities such as the ones created in the *Amsterdam Rainproof* project, to engage in practices around infrastructure management and urban water governance and develop new meanings related to the water theme.

Carrying out governance experiments that specifically address knowledge management issues could in other words provide Waternet with valuable returns in building trust among stakeholders and bringing them closer to the functions carried out by regime actors in Amsterdam water infrasystem. Allocating human and financial resources for engaging with initiatives of knowledge co-production with end-users can also bridge the gap in knowledge base between laymen and engineers. In turn, educational activities for end-users could take the form of citizen-science initiatives, which are expected to become even cheaper solutions for delegating tasks from the water utility provider to citizens —even if the latter are considered as cheap labour force.

Alignment of stakeholder perception for a common 'SUWM vision'

The second policy recommendation is to further align the different perceptions of water governance actors in Amsterdam towards a common understanding of what SUWM practically entails, and how each actor can contribute to implementing SUWM solutions. During previous transitions in urban water governance in The Netherlands, the decisions taken by regime actors have been crucial in determining the future development of socio-technical infrastructure systems, especially related to the use of policy instruments and to the allocations of investments for technological innovations (Agudelo-Vera et al., 2014).

Although it could be argued that there is not necessarily a causal relationship from changes in regime actors' perceptions to changes in their behaviour, the strategic vision of the water utility provider can still serve as a general framework guiding everyday activities of the organisation towards a specific transition objective shared among all stakeholders. When this vision is constructed through participatory methods, it is more probable to be translated into concrete policy measures and to affect the decisions guiding investments allocation.

Citizen participation and higher-order learning

Third, the institutions in Amsterdam water governance regime should keep in mind that the establishment of participatory initiatives, such as co-creation and citizen-science, is "not an outcome *per se"* (Lemos et al., 2018, 723) . Citizen participation should be sought after for exploiting the benefits it conveys, and for exploring possibilities of delegating responsibilities and functions, but institutions in urban water infrastructure management should not lose sight of the overall sustainability transition objective that they want to achieve.

Participatory mechanisms such as co-creation and citizen-science are part of an overall process of institutional change for fostering sustainability transitions in urban water governance and infrastructure management, but they should be considered as tools or methods rather than goals in achieving climate adaptation and multi-level governance.

It is of paramount importance that co-creation and citizen-science experiments are implemented for the achievement of objectives with different temporal scales and for "second-" and "third-order learning" (Pahl-Wostl, 2009). On the one hand, there are short-term goals such as water provision, flood-risk management and wastewater treatment. On the other, more long-term objectives include policy learning, building trust among stakeholders and end-users, and improving the overall quality of the water system and water bodies. Third-order learning entails changes in the dominant assumptions and values that guide the activities of institutions, organisations, and individuals alike (Hargrove, 2002, in Pahl-Wostl, 2009). This type of multi-level learning process is the only one that can support the establishment of new institutional structures or the change of existing one, and that exploits learning networks through the implementation of new governance arrangements.

8. References

Agudelo-Vera, C.M., Blokker, E.J.M., Büscher, C.H., Vreeburg, J.H.G. (2014). Analysing the dynamics of transitions in residential water consumption in The Netherlands, *Water Science & Technology: Water Supply*, 14 (5), 717-727.

AGV Waterschap (n.d.). *Uitslag waterschapsverkiezingen 2019,* Waterschap Amstel Gooi en Vecht. Available at https://www.agv.nl/waterschapsverkiezingen/uitslag/. [Accessed 25 Mar 2019]

Amsterdam Rainproof (n.d.). Amsterdam Rainproof English magazine, Naafs, S. (ed.). Available at https://www.rainproof.nl/sites/default/files/downloads/rainproof. [Accessed 30 Oct 2018]

Arnstein, S.R. (1969). A Ladder of Citizen Participation, *Journal of the American Institute of Planners*, 35 (4), 216- 224.

Avelino, F., Grin, J., Pel, B., Jhagroe, S. (2016). The politics of sustainability transitions, Journal of Environmental *Policy and Planning*, 18 (5), 557-567.

Bos, J.J., Brown, R.R. (2012). Governance experimentation and factors of success in socio-technical transitions in the urban water sector, *Technological Forecasting & Social Change*, 79, 1340-1353.

Bosman, R., Loorbach, D., Frantzeskaki, N., Pistorius, T. (2014). Discursive regime dynamics in the Dutch energy transition, *Environmental Innovation and Societal Transitions*, 13, 45-59.

Brouwer, S., van der Wielen, P.W.J.J., Schriks, M., Claassen, M., Frijns, J. (2018). Public participation in science: the future and value of citizen science in the drinking water research, *Water*, 10 (3), 284.

Brown, R.R., Keath, N., and Wong, T.H.F. (2009). Urban water management in cities: historical, current and future regimes, *Water Science and Technology*, 59 (5), 847-855.

Brown, S.R. (1980). *Political subjectivity: applications of Q methodology in political science.* New Haven and London: Yale University Press.

Browne, A. (2015). Insights from the everyday: implications of reframing the governance of water supply and demand from "people" to "practice", *WIREs Water*, 2, 415-424.

Bulkeley, H., Castán-Broto, V. (2013). Government by experiment? Global cities and the governing of climate change, *Transactions of the Institute of British Geographers*, 38, 361-375.

Buytaert, W., Dewulf, A., De Bièvre, B., Clark, J., Hannah, D.M. (2016). Citizen science for water resources management: toward polycentric monitoring and governance?, editorial, *Journal of Water Resources Planning & Management*, 142 (4): 018160002.

Carr, G. (2015). Stakeholder and public participation in river basin management — an introduction, *WIREs Water,* 2, 393-405.

Converse, J.M., Presser, S. (1986). *Survey questions – handcrafting the standardized questionnaire*. Sage University Paper series on Quantitative Applications in the Social Sciences, 07-063. Beverly Hills: Sage Pubns.

de Graaf, R., van der Brugge, R. (2010). Transforming water infrastructure by linking water management and urban renewal in Rotterdam, Technological Forecasting & Social Change, 77, 1282-1291.

Dewulf, A., Buytaert, W., Hannah, D. M., De Bièvre, B., Clark, J. (2016). Citizen Science for Water Resources Management: Towards Polycentric Monitoring and Governance? Journal of Water Resources Planning and Management, 142 (4), 01816002.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, 56 (3), 425-442.

EC, 2018. 22 new circular economy, nature-based solutions, raw material and cultural heritage projects to share €218 millions of EU funding, 17 May 2018. Available at https://ec.europa.eu/easme/en/news/22-new-circular-economy-nature-based-solutions-raw-material-and-cultural-heritage-projects. [Accessed 19 Oct 2018]

EEA (European Environmental Agency) (2013). Climate change and flood risk in European cities, 01 Mar 2013. Available at https://www.eea.europa.eu/highlights/climate-change-and-flood-risk. [Accessed 30 Oct 2018]

FAO (2016). AQUASTAT data, Food and Agriculture Organization of the United Nations (FAO). Available at data.worldbank.com. [Accessed 06 Mar 2019]

Farrelly, M., Brown, R. (2011). Rethinking urban water management: experimentation as a way forward?, *Global Environmental Change,* 21, 721-732.

Ferguson, B., Brown, R., Frantzeskaki, N., de Haan, F., Deletic, A. (2013). The enabling institutional context for integrated water management: lessons from Melbourne, Water Research, 47, 7300-7314.

Frantzeskaki, N., de Haan, H. (2009). Transitions: Two steps from theory to policy, Futures, 41, 593-606.

Frantzeskaki, N., Loorbach, D. (2010). Towards governing infrasystem transitions Reinforcing lock-in or facilitating change?, Technological Forecasting & Social Change, 77, 1292-1301.

Geels, F.W. (2005). Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective, Technological Forecasting & Social Change, 72, 681-696.

Geels, F.W., Schot, J. (2007). Typology of sociotechnical transition pathways. Research Policy, 36, 399-417.

Grin, J., Rotmans, J., Schot, J., Geels, F.W., Loorbach, D. (eds.) (2010). Transitions to sustainable development: new directions in the study of long term transformative change. Routledge, New York.

Haklay, M. (2012). Citizen science and volunteered geographic information – overview and typology of participation, in Sui, D.Z., Elwood, S., Goodchild, M.F. (eds.), *Volunteered geographic information, public participation, and crowdsourced production of geographic knowledge.* Berlin, Germany: Springer; 2012.

Havekes, H., Koster, M., Dekking, W., Uijterlinde, R., Wensink, W., Walkier, R. (2017). *The Dutch water authority model,* Unie van Waterschappen (Dutch Water Authorities). Opmeer BV, Den Haag.

Hegger, D.L.T., van Vliet, J., van Vliet, B. (2007). Niche management and its contribution to regime change: the

case of innovation in sanitation, *Technology Analysis & Strategic Management*, 19 (6), 729-746.

Hey, J. (2007, Jul 24). Recording ethnographic observations: six useful frameworks. Palojono, 24 July 2017. Available at http://palojono.blogspot.com/2007/07/recording-ethnographic-observations.html [Accessed 15 Dec 2018]

Hiramatsu, A., Kurisu, K., & Hanaki, K. (2016). Environmental consciousness in daily activities measured by negative prompts. *Sustainability (Switzerland)*. https://doi.org/10.3390/su8010024

Hooghe, L., Marks, G. (2003). Unravelling the central state, but how? Types of multi-level governance, American *Political Science Review*, 97 (2), 233-243.

ICLEI (2017). *A storm is brewing and Copenhagen is ready*, City Talk, 04 May 2017. Available at http://talkofthecities.iclei.org/a-storm-is-brewing-and-copenhagen-is-ready/. [Accessed 30 Oct 2018]

IPCC (2018b). Summary for Policymakers. In: Global warming of 1.5°C. World Meteorological Organization, Geneva, Switzerland. Available at https://www.ipcc.ch/report/sr15/. [Accessed 2 Dec 2018]

IPCC (Intergovernmental Panel on Climate Change) (2018a). Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments, IPCC press release, 2018/24/PR, 8 Oct 2018. Available at http://www.ipcc.ch/pdf/session48/pr_181008_P48_spm_en.pdf. [Accessed 17 Oct. 18]

Jonsson, D.K. (2005). The nature of infrasystem services, *Journal of Infrastructure Systems*, 11 (1), 2-8.

Kumar, R. (2014). Research Methodology. London, Sage Publications.

KWH (n.d.). Shareholders and shareholding. Available at https://www.kwhwater.nl/en/over-kwh/de-aandeelhouders/. [Accessed 10 Apr 2019]

KWR (2017, June 30). Looking for citizen scientists for Amsterdam water research, 30 June 2017. Available at https://www.kwrwater.nl/en/actueel/looking-for-citizen-scientists-for-amsterdam-water-research/. [Accessed 30 Oct 2018]

KWR (n.d.). The Clean Water Experiment. Available at https://www.kwrwater.nl/en/projecten/the-clean-water-experiment/. [Accessed 30 Oct 2018]

Lemos, M.C., Arnott, J.C., Ardoin, N.M., Baja, K., Bednarek, A.T., Dewulf, A., Fieseler, C., Goodrich, K.A., Jagannathan, K., Klenk, N., Mach, K.J., Meadow, A.M., Meyer, R., Moss, R., Nichols, L., Sjostrom, K.D., Stults, M., Turnhout, E., Vaughan, C., Wong-Parodi, G., Wyborn, C. (2018). To co-produce or not to co-produce, *Nature Sustainability*, 1, 722-724.

Loorbach, D. (2007). Transition Management, New mode of governance for sustainable development. PhD dissertation, Erasmus University Rotterdam, International Books.

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-based Governance Framework, *Governance*, 23 (1), 161-183.

Loorbach, D., Frantzeskaki, N., Avelino, F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change, *Annual Review of Environment and Resources*, 42, 599-626.

Loorbach, D., Frantzeskaki, N., Thissen, W. (2010). Introduction to the special section: Infrastructures and transitions, *Technological Forecasting & Social Change*, 77, 1195-1202.

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects, *Research Policy*, 41, 955-967.

Marlow, D.R., Moglia, M., Cook, S., Beale, D J. (2013). Towards sustainable urban water management: A critical reassessment, *Water Research*, 47, 7150-7161.

Matschoss, K., Heiskanen, E. (2017). Making it experimental in several ways: the role of intermediaries in raising the ambition level of local climate initiatives, *Journal of Cleaner Production,* 169, 85-93.

Mayntz, R., Hughes, T.P. (1988). The development of large technical systems, Schriften des Max-Planck-Instituts für Gesellschaftsforschung Köln, 2. Campus Verlag, Frankfurt a. M.

Meijerink, S., Huitema, D. (2010). Policy entrepreneurs and change strategies: lessons from sixteen case studies of water transitions around the globe, *Ecology and Society*, 15 (2):21.

Metin, M. (2010). A study on developing a general attitude scale about environmental issues for students in different grade levels. *Asia-Pacific Forum on Science Learning and Teaching*, 11 ,2:3, 1-19.

Ministerie van Infrastructuur en Milieu (2017). *(Unofficial) Translation of the Environment and Planning Act,* report, 28/02/2017. Available at https://www.government.nl/binaries/government/documents/reports/2017/02/28/environment-and-planning-act/EnglishtranslationEnvironmentAct.pdf. [Accessed 31/01/19]

OECD (2012). *Water governance in cities: Amsterdam city profile.* Organisation for Economic Cooperation and Development (OECD), Water Governance Programme. Available at http://www.oecd.org/cfe/regional-policy/water-governance-in-cities-amsterdam.pdf. [Accessed 06 Mar 2019]

OECD (2014a). *Water governance in The Netherlands: fit for future? Assessment and recommendations*. Leterme, Y., Organisation for Economic Cooperation and Development (OECD). Dutch Ministry of Infrastructure and the Environment, 17 March 2014, The Hague, Netherlands.

OECD (2014b). *Water governance in The Netherlands: fir for the future?,* OECD Studies on Water, OECD publishing. doi: 10.1787/9789264102637-en.

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change, *Water Resources Management,* 21, 49-62.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes, *Global Environmental Change,* 19, 354-365.

Pahl-Wostl, C., Mostert, E., Tàbara, D. (2008). The growing importance of social learning in water resources management and sustainability science, *Ecology and Society*, 13(1), 24. [online] Available at: http://www.ecologyandsociety.org/vol13/iss1/art24/. [Accessed 2 May 2019]

Paul, J.D., Buytaert, W., Allen, S., Ballesteros-Cánovas, J.A., Bhusal, J., Cieslik, K., Clark, J., Dugar, S., Hannah, D.M., Stoffel, M., Dewulf, A., Dhital, R.M., Liu, W., Nayaval, J.L., Neupane, B., Schiller, A., Smith, P.J., Supper, R.

(2018). Citizen science for hydrological risk reduction and resilience building, *WIREs Water,* 5:e1262.

Pot, W.D., Dewulf, A., Biesbroek, G.R., van der Vlist, M.J., Termeer, C.J.A.M. (2018). What makes long-term investment decisions forward looking: a framework applied to the case of Amsterdam's new sea lock, *Technological Forecasting & Social Change,* 132, 174-190.

Potvin, L., & McQueen, D. V. (2009). *Health promotion evaluation practices in the Americas: Values and research*. *Health Promotion Evaluation Practices in the Americas: Values and Research*. https://doi.org/10.1007/978-0-387-79733-5.

Raadgever, G.T., Mostert, E., van de Giesen, N.C. (2008). Identification of stakeholder perspectives on future flood management in the Rhine basin using Q methodology, *Hydrology and Earth System Sciences,* 12, 1097-1109.

Reimerink, L. (2017, February 9). *Every Drop Counts in Making Amsterdam "Rainproof"*, Urban Land, 09 Feb 2017. Available at https://urbanland.uli.org/industry-sectors/infrastructure-transit/every-drop-counts-making-amsterdam-rainproof/. [Accessed 30 Oct 2018]

Rip, A., Kemp, R. (1998). Technological change. In Rayner, S., Malone, E.L., Human Choice and Climate Change, 2, 327-299. Batelle Press, Washington DC.

Roark P.D. (2015) Formulating a Participatory Social Theory. In: Social Justice and Deep Participation. Palgrave Macmillan, London.

Rotmans, J., Kemp, R., van Asselt, M. (2001). More evolution than revolution, *Foresight*, 3 (1), 1-17.

Rotmans, J., Loorbach, D. (2009). Complexity and Transition Management, *Journal of Industrial Ecology*, 13 (2), 184-196.

Rutherford, J., Coutard, O. (2014). Urban energy transitions: places, processes and politics of socio-technical change, *Urban Studies*, 51 (7), 1353-1377.

Schroeder, H., Bulkeley, H. (2009). Global cities and the governance of climate change: what is the role of law in cities?, *Fordham Urban Law Journal*, 36 (2), 313-359.

Shove, E., Walker, G. (2007). CAUTION! Transitions ahead: politics, practice, and sustainable transition management, *Environment and Planning A*, 39 (4), 763-770.

Transitiepraktijk (2009). *Definitions.* Transition in practice, tools and competencies. Available at https://transitiepraktijk.nl/en/experiment/definitions. [Accessed 04 Jun 2019]

Turnheim, B., Berkhout, F., Geels, F.W., Hof, A., McMeekin, A., Nykvist, B., van Vuuren, D.P. (2015). Evaluating sustainability transitions pathways: bridging analytical approaches to address governance challenges, *Global Environmental Change,* 35, 239-253.

UvW (2019, March 21). *Opkomst waterschapsverkiezingen fors omhoog,* Unie van Waterschappen, 21 March 2019. Available at https://www.uvw.nl/opkomst-waterschapsverkiezingen-fors-omhoog/. [Accessed 25 March 2019]

Van de Meene, S.J., Brown, R.R., Farrelly, M.A. (2011). Towards understanding governance for sustainable urban water management, *Global Environmental Change*, 21, 1117-1127.

Van der Brugge, R. (2009). *Transition Dynamics in Social-Ecological Systems - The Case of Dutch Water Management*, PhD dissertation, Erasmus University, Rotterdam.

Van der Brugge, R., Rotmans, J., Loorbach, D. (2005). The transition in Dutch water management, *Regional Environmental Change*, 5 (4), 164–176.

Van der Meulen, S., van der Zaan, B., van Houten, P., Mol, G., Brouwer, S., Levelt, O., Hersbach, L., Alberti, A. (2018). *Het Schone Waterexperiment; Amsterdammers onderzoeken de kwaliteit van oppervlaktewater.* Available at https://www.deltares.nl/app/uploads/2018/02/Rapport_Het_Schone_Waterexperiment1.pdf. [Accessed 11 Mar 2019]

Van Vliet, B., Chappells, H., Shove, E. (2005). Infrastructures of consumption: Environmental innovation in the utility industries. London, Earthscan.

Vitens (2013). *Hoeveel water gebruiken we per dag?*. Available at https://www.vitens.nl/service/hoeveel-water-gebruiken-we-per-dag. [Accessed 06 Mar 2019]

Voss, J.P, Kemp, R. (2006). Sustainability and reflexive governance: introduction. In: Voss, J.P, Bauknecht, D., & Kemp, R., Reflexive governance for sustainable development. Cheltenham: Edward Elgar.

Voss, J.P., Smith, A., Grin, J. (2009). Designing long-term policy: rethinking transition management, *Policy Science*, 42, 275-302.

Weber, E. U., Blais, A. R., & Betz, N. E. (2002). A Domain-specific Risk-attitude Scale: Measuring Risk Perceptions and Risk Behaviors. *Journal of Behavioural Decision Making*. https://doi.org/10.1002/bdm.414

Williams, S. M., & McCrorie, R. (1990). The analysis of ecological attitudes in town and country. *Journal of Environmental Management*. https://doi.org/10.1016/S0301-4797(05)80005-2

Wolfram, M. (2016). Conceptualizing urban transformative capacity: A framework for research and policy. *Cities*, 51, 121-130.

Wolsink, M., Hertz, B., Slingerland, S. (1998). *Utility sectors in The Netherlands,* Wageningen: DOMUS-project. EU Report.

9. Annexes

Annex 1: List of interviewees

#	Interest group	Position	Date
1	Municipality of Amsterdam	Advisor water and climate adaptation	28/01/19
2	KWR	Senior researcher	28/01/19
3	Amsterdam Rainproof	Programme manager	30/01/19
4	Waternet	Head of policy and asset management	30/01/19
5	Waternet	Managing Director	18/02/19
6	Waterboard Amstel Gooi and Vecht	Chairman of the executive board (*Dijkgraaf*)	18/02/19

Annex 2: Semi-structured interview guide

1. *Interview with Municipality of Amsterdam, 28/01/19*

1. *How would you describe the responsibilities and main tasks that you have in your organisation?*
2. *Could you tell me something about the vision of your organisation for the future developments of urban water infrastructure?*
3. *Could you tell me about the actions that your organisation takes for achieving this vision?*
4. *Could you give me an example of an important result that you achieved so far?*
5. *In your opinion, which would be important results for your organisation that you would like to achieve in the future?*
6. *In your opinion, how could Amsterdam residents contribute to achieving this vision?*
7. *In your opinion, what would be the major challenges for your organisation to achieve its vision?*
8. *In your opinion, how could Amsterdam residents contribute to overcome these challenges?*
9. *Do you think that the "network approach" of Amsterdam Rainproof is in line with the traditional idea of network governance, or is it something different?*
10. *Do you think then that awareness, in terms of education, would be a trigger for changing behaviour?*
11. *Do you think that in the future it would make more sense (in terms of climate adaptation) to decentralise the urban water system (e.g., water retention roof that also purifies wastewater, which can be used again by households) or to keep it centralised?*
12. *Do you think that in the future, the relation between utility companies and government actors will change? (In regard to ownership, activities carried out, responsibilities)*
13. *Do you think that in the next 10 years citizens will be more directly involved in the management of the urban water infrastructure?*
14. *Today, to what extent are residents involved in the formal policy-/decision-making process?*

2. *Interview with KWR, 28/01/19*

1. *How would you describe the responsibilities and main tasks that you have in your organisation?*
2. *Could you tell me about the vision of KWR regarding the urban water infrastructure?*
3. *Could you give me an example of an important result that you achieved so far?*
4. *In your opinion, how could (Amsterdam) residents contribute to the achievement of your vision and overcoming of the related challenges? For example, is it more related to changing behaviour or to the development of modes of co-provision?*
5. *In your opinion, what would be the major challenges for KWR to achieve its vision? (next 10 years)*
6. *10 years from now, do you think that urban utilities will be more decentralised (e.g., co-provision with end-users) or more centrally managed (e.g., district heating)?*
7. *How would you describe the relationship between the utility companies (water, waste, energy) and the Gemeente? Do you think that in the future, the relation between utility companies and government actors will change? (In regard to ownership, activities carried out, responsibilities)*
8. *Do you think that in the next 10 years the Municipality will strengthen its relationship with Waternet or increase its collaboration with external actors?*
9. *Do you think that in the next 10 years there will be a change in the relationship between citizens and the urban water system? Talking about e.g., awareness, involvement...*

10. *In your opinion, when citizen participate to the policymaking process (for the urban water system, like for use or standards), what is the main contribution that such participation process brings (in a practical standpoint) for managing the urban water infrastructure?*
11. *Why did you decide to launch the Freshness of Water project and Clean Water Experiment?*
12. *Do you think citizen-science can be applied to other public utility sectors?*
13. *What is your opinion on the Amsterdam Rainproof programme?*
14. *Do you think that citizen participation would still be linked to economic concerns?*

3. Interview with Amsterdam Rainproof, 30/01/19

1. *How much is the vision of Amsterdam Rainproof, of community engagement and embedding "rainproof measures" in policy, is oriented towards changing the urban water governance spectrum?*
2. *Do you think that, in the next 10 years, the relationship between Waternet and citizens will change? Meaning, do you think that citizens will be able to directly participate to the policymaking process in the matters related to water management?*
3. *Another interviewee from the Municipality of Amsterdam told me that there's a huge difference between climate adaptation in public vs. private spaces, because as Gemeente they deal a lot with public spaces but can only indirectly affect private spaces. Could you tell me more about what Rainproof is achieving by making people adopt voluntary adaptation measures in their private spaces and by making them aware of these issues and accept the risk?*
4. *Do you think that higher citizen participation will have an impact on the design/architecture of the institutions that regulate and manage the urban water systems, namely Waternet and the RWA? Or do you think that participation will only be used with the same purposes it has today? (namely, data-gathering, increasing awareness, and implementation of small-scale measures in private areas)*
5. *Do you think that, 10 years from now, co-creation will become institutionalised as the new paradigm of urban infrastructure development?*
6. *In this respect, do you think that co-creation mechanisms could serve even more purposes (as well as more urban utility sectors) than what they do today?*
7. *What is the relationship between different organisation under the same "Rainproof" name? (Are they part of the same organisation or are they two separate organisations that share the same philosophy/modus operandi?)*

4. Interview with Waternet, 30/01/19

1. *How would you describe the responsibilities and main tasks that you have in your organisation?*
2. *Daniel Goedbloed mentioned this piece of recent legislation called Omgevingswet, could you tell me a bit more about that?*
3. *In your opinion, what would be the major challenges for Waternet to achieve its vision? (next 10 years)*
4. *In your opinion, how could (Amsterdam) residents contribute to the overcoming of these challenges?*
5. *How would you describe the relation between Gemeente Amsterdam and Waternet?*
6. *Do individual residents participate in the policy-/decision-making process? Are there (more or less) formal spaces for citizen participation?*
7. *So in the next 10 years, in your opinion, do you think that there is going to be a higher overlapping of responsibilities and functions between the Gemeente and Waternet? Or do you think that there is going to be more clear differentiation in who does what?*
8. *Could you give me an example that symbolises this new type of relationship between the municipality and Waternet?*

9. *Does this new collaborative approach also impact the way Waternet or the RWA is organised?*
10. *Are you acquainted with the projects Amsterdam Rainproof, Freshness of Water, and/or the Clean Water Experiment?*
11. *Do you think that these projects could be a way to change behaviour with water, energy, waste, more than just increasing awareness?*

5. Interview with Waternet, 18/02/19

1. *How would you describe the responsibilities and main tasks that you have in your organisation?*
2. *I guess you are already acquainted with the Clean Water Experiment and the project behind it, the Freshness of Water project from KWR. I would like to ask in general what is your opinion, your evaluation of the projects.*
3. *Do you that increasing public participation can be done on topics that are not entirely in the normal discourses of people, something that is quite technical or engineering like water management or the infrastructure? Do you think the discourse on public participation is still valid? I am thinking for example about the vision of Waternet and the Waterboard, do you think this discourse fits in this respect?*
4. *Do you agree with the fact that awareness is the first step in changing the behaviour of end-users, or do you think that increasing awareness would not be enough?*
5. *In your opinion, what would be the major challenges for Waternet and the Waterboard to achieve their vision(s)?*
6. *Many of these investments in circular solutions require high-tech infrastructures or massive investments for remaking the whole system of the infrastructure. Do you think that in the next 10 years this is going happen?*
7. *Do you think that in the next 10 years we're going to move towards a more decentralised water management, more multi-level?*
8. *Do you think that there's going to be a mainstreaming, institutionalisation of co-production, as a process? Referring specifically to the involvement of citizens in the co-design and co-decisions for infrastructural development, and evaluation of the project, while the public administrator has to respond to citizens. I wonder if such process of co-creation is going to be more used in the future, or if it is going to be "the new normal."*
9. *Talking about the Omgevingswet, I saw there were some concerns regarding the capacity of municipalities to implement climate adaptation strategies. I would like to ask you what your opinion on the Omgevingswet is, in general, and on this issue of allocating resources in the hands of municipalities themselves.*
10. *Do you think this idea of defining a new role, also maybe a new political role, would require a sort of restructuring of Waternet and the RWA? In terms of architecture of the organisation.*

6. Interview with AGV Waterboard , 18/02/19

1. *How would you describe the responsibilities and main tasks that you have in your organisation?*
2. *I guess you are already acquainted with the Clean Water Experiment and the project behind it, the Freshness of Water project from KWR. I would like to ask in general what is your opinion, your evaluation of the projects.*
3. *Do you that increasing public participation can be done on topics that are not entirely in the normal discourses of people, something that is quite technical or engineering like water management or the infrastructure? Do you think the discourse on public participation is still valid? I am thinking for example about the vision of Waternet and the Waterboard, do you think this discourse fits in this respect?*
4. *Do you agree with the fact that awareness is the first step in changing the behaviour of end-users, or do you think that increasing awareness would not be enough?*
5. *In your opinion, what would be the major challenges for Waternet and the Waterboard to achieve their vision(s)?*
6. *Many of these investments in circular solutions require high-tech infrastructures or massive investments for remaking the whole system of the infrastructure. Do you think that in the next 10 years this is going happen?*

7. *Do you think that in the next 10 years we're going to move towards a more decentralised water management, more multi-level?*
8. *Do you think that there's going to be a mainstreaming, institutionalisation of co-production, as a process? Referring specifically to the involvement of citizens in the co-design and co-decisions for infrastructural development, and evaluation of the project, while the public administrator has to respond to citizens. I wonder if such process of co-creation is going to be more used in the future, or if it is going to be "the new normal."*
9. *Talking about the Omgevingswet, I saw there were some concerns regarding the capacity of municipalities to implement climate adaptation strategies. I would like to ask you what your opinion on the Omgevingswet is, in general, and on this issue of allocating resources in the hands of municipalities themselves.*
10. *Do you think this idea of defining a new role, also maybe a new political role, would require a sort of restructuring of Waternet and the RWA? In terms of architecture of the organisation.*

Annex 3: Selected questionnaire results

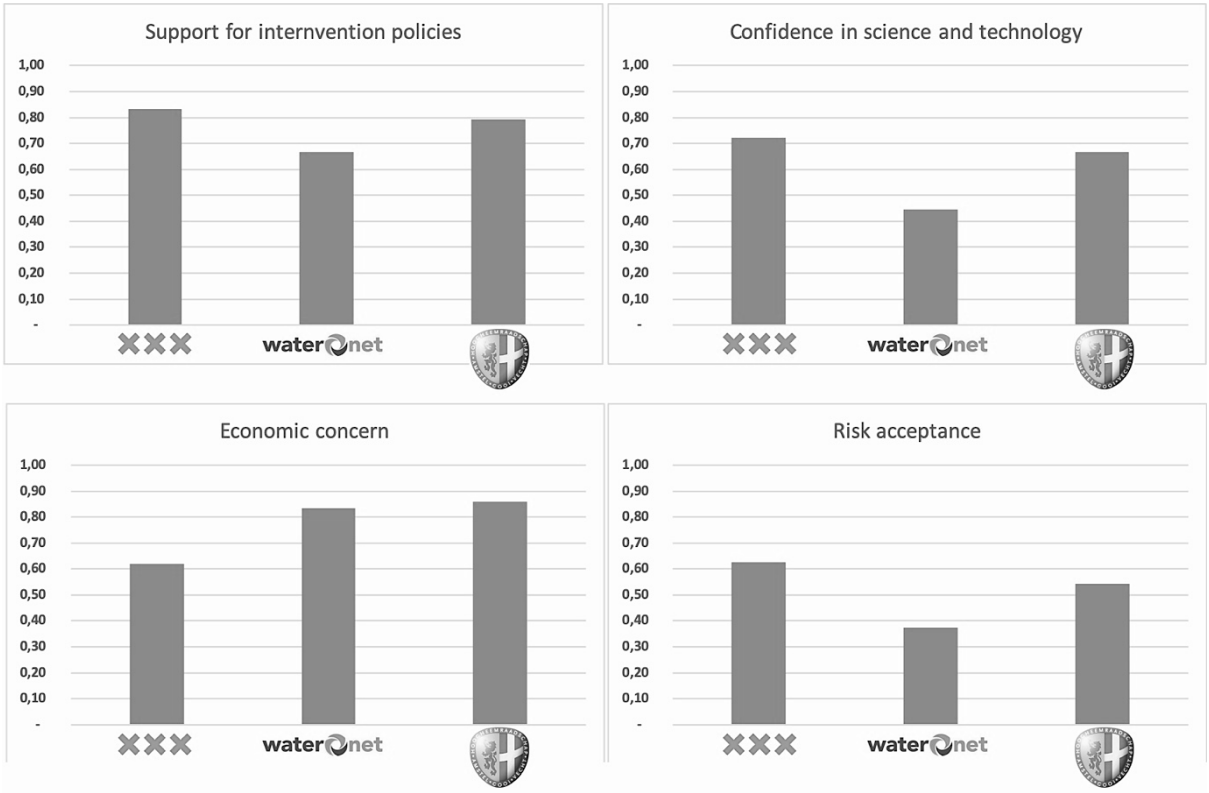


Figure 11: Questionnaire results for selected categories: support for intervention policies, confidence in science and technology, economic concern, and risk acceptance (logarithmic scale).

The four graphs show the responses of the representatives of regime actors (i.e., interviewees from the Municipality of Amsterdam, Waternet, and AGV Waterboard) in the four categories that presented the major differences.