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Integration of Interactions between Urban Water Management Transition and Spatial Dimension

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Summary

Climate change in recent decades has increasingly impacted on natural and human systems and caused extreme weather on cities. IPCC Fifth Assessment Report in 2014 posed the importance of dealing with the risk of water in cities. Hence, to adapt to such uncertainty, structural transformation in the urban water management and change of attitude toward water system are of significance. In other words, “radical change is needed in water management” (Pahl-Wostl, 2007). To address such an issue, a concept of transition is widely used in various academic fields. However, there is limited discussion on how socio-technical transition changes urban space and how the transition is influenced by urban space.

Therefore, this study aims to investigate the mechanism of urban space transformation due to climate change by testing the theories of the transition of urban water management and its interaction with urban space. two concrete water management projects in Agniesebuurt neighbourhood; Water Square Benthemplein and ZOHO Raingarden are used as study cases. Based on the interaction between transition and spatial dimension posed by Levin-Keitel, et al (2018), this research adds time axis and a concept of spatial solution to it for better understanding of the mechanism of urban space transformation due to climate change.

To analyse urban water management transition, the timeframe is defined as period based on the Rotterdam policy changes, institutional changes, technological development of multifunctionality, and behaviour of local people to the climate change adaptation projects. In each period, interactions between spatial dimensions and transition are found through interviews policy, reports and project documents analysis. Spatial dimensions are organized as location, physical environment, water system, actors, and institution. In particular, the transition of urban water management is spatially conditioned by spatial opportunity because a water retention facility physically requires space. Actor embedded in the area and local norms and values is also important for implementation because the functionality of reconfigured space needs to comply with their social norms.

As a result of the transition in each period, space is reconfigured by redistributing functionality, reshaping physically, reframing meaning, and innovating spatial typology. Because of climate change, water retention facility is the main function but space is integrated with other public functionalities preferred by local actors. Reconfigured space is also physically transformed by the transition. Shapes and materials of space reflect an influence from an institutional framework in large scale. The transition also reconfigures space’s meaning by building a vision of the area where the transition takes place or by reframing the collective meaning of space.

This paper indicates that differences in spatial solution are mainly caused by space’s multifunctionality reconfigured by the local transition. The variety of such functionality in reconfigured space is dependent on the local actors and their norm and water facility that is conditioned by a large-scale institutional framework. Therefore, reconfigured spatial solutions in Rotterdam has multiple functionalities that are constructed socially as well as work for more space for water. This poses some possibility that specific physical and social dimension of space would determine what spatial solution is used, but it would require an intensive dialogue between local actors and local space to discover their norm as well as a spatial opportunity.

Keywords

Transition, Spatial dimension, Urban water management, Climate change adaptation, Integration

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Abbreviations

IHS	Institute for Housing and Urban Development
IABR	International Architecture Biennale Rotterdam
RCP	Rotterdam Climate Proof
RCI	Rotterdam Climate Initiative
RAS	Rotterdam climate change Adaptation Strategy
WSUD	Water Sensitive Urban Design
NBW	National Administrative Agreement on Water
ZOHO	Zomerhofkwartier
HHSK	Het hoogheemraadschap van Schieland en de Krimpenerwaard
WFD	Water Framework Directive
KfC	Knowledge for Climate program

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Chapter 1: Introduction

1.1 Background

Climate change in recent decades has increasingly impacted on natural and human systems and caused extreme weather on cities. IPCC Fifth Assessment Report in 2014 posed the importance of dealing with the risk of water in cities by noting disastrous flooding events happened all over the world in recent decades. Urban water infrastructures and management are required to be able to adapt to this danger. In particular, storm water management and flood defence method need to change their attitude toward water. Since future climate events and fluctuation are hardly predictable, planning is based on its increasing uncertainty and its complexity (Katherine, et al., 2015; Daniell, et al., 2015; Pahl-Wostl, 2007). Traditional technology-oriented water management tried to predict and control water issue, which does not fit in dealing with the impacts of uncertain intense rainfall and complex water management system. Pahl-Wostl (2007) emphasizes its difficulty in predicting damages caused by extreme weather and notes that urban water management with adaptive capacity became a central issue.

One of such shifts to the improvement of adaptive capacity of the water management system is to physically increase the capacity of retention of water, rather than heighten walls (i.e. dike) against rivers and discharge water quickly. Another example of relatively new adaptations to climate change is introducing a de-centralized water management system and diversifying the system to reduce the impacts from extreme rainfall (Katherine, et al., 2015). Those examples, however, requires a change of physical urban water system but also its governance style "from purely publicly or locally operated water system to the increasing participation of the private sector" and "increasing citizen interests" (Katherine, et al., 2015, p.23).

Hence, in order to adapt to the risk of water issues in an urban area due to climate change, structural transformation in the urban water management and change of attitude toward water system are of significance in existing cities that would be heavily influenced by extreme weather. In other words, "radical change is needed in water management" (Pahl-Wostl, 2007). However, developed cities and their infrastructure have difficulty in re-designing its system, even though urbanization add their urgency due to its increasing volume of run-off and risk of flash-flood (Katherine, 2015). Then, how such structural change in the system of urban water management is possible in an established urban area is essential. It may require innovative ideas.

To address such an issue, a concept of transition is widely used in various academic fields. Urban transition research emerged as an interdisciplinary field to study in relation to adopting complex adaptive system thinking (Rotmans and Loorbach, 2009). The concept has been analysed for the last 20 years due to an increasing interest to identify the mechanism of long-term societal transformation, such as transition towards sustainability (Loorbach, Frantzeskaki, and Avelino, 2017). The transition can be understood as "the result of an interplay of a variety of changes at different levels and in different domains that somehow interact and reinforce each other to produce a fundamental qualitative change in a societal system" (Loorbach, Frantzeskaki, and Avelino, 2017, pp.605). According to Geels and Schot (2010), there are four characteristic concepts in the transition process; co-evolution, multilevel perspective, multiphase, and co-design and learning. Loorbash, et al., (2017) point out the complexity-related characteristics in addition to them; nonlinearity and emergence.

One of the well-known transition research is the energy transition from fossil energy to the renewable energy system. The transition is "much more than merely a technological shift; it is a power struggle and a socio-cultural change having a deep effect on incumbent institutions, routines, and beliefs" (Loorbach, Frantzeskaki, and Avelino, 2017, pp.601). This also applies to urban water management as it is discussed above. The transition of urban water management field includes technological, economic, environmental, institutional, and cultural dimensions (Pahl-Wostl, 2007).

Therefore, analysis of urban water management from a transition perspective is beneficial to understand the mechanism and process of necessary radical shift in the system due to climate change. Such a transition study has been paid attention to by researchers in recent decades, such as paradigm-shift from technical-oriented to more adaptive water management (Pahl-Wostl, 2007, Pearson, et al., 2010). Rutger van der Brugge, et al., (2005) argue that transition "from a technocratic scientific style to an integral and participatory style" can be seen in the Dutch water management since around 40 years ago by applying a model of multilevel perspective. By applying the concept of transition that can explain different level dynamics and complex social transformation, these show an implication for planning urban area facing water issues due to climate change.

1.2 Problem Statement

There is limited discussion on how socio-technical transition changes urban space and how transition is influenced by urban space. Although the relationship between socio-technical transition and space has been conceptually organized in recent studies, it remains conceptual and there is a room for exploring implications for urban spatial planning in concrete urban space.

Several researchers in economic geography realized and noted the lack of discussion about the relation between transition theory and space in the last decade (Coenen, et al., 2010; Roven, et al., 2012). The discussion comes from the fact that geographical unevenness of the transition process cannot be explained without an understanding of spatial dimension (Coenen, et al., 2010). Research on geographical sustainable transition has increased and added value on the existing studies through empirical cases (Elservier B.V., 2015). Another argument is that with regards to grassroots innovation, social innovation is considered as "institutionally and spatially embedded social struggles" (Castells, 1983; Moulaert, et al., 2005) so that urban space and institutional network within it in transition take a role in the transition process. Last but not at least, based on the concept of place, Urban Living Lab analysed the diffusion mechanism of socio-technical configurations that go beyond their physical boundaries of place (Wirth, V. T., 2018). This view shows the enlarging process of innovation would cause a certain spatial change in the urban area.

As mentioned above, several spatial aspects in transition are argued conceptually so far, that is; spatially embeddedness of the transition, inter-scale interactions, geographical relations (e.g. proximity), geographical unevenness, and shaping of urban space. Based on those arguments, Levin-Keitel, et al., (2018) conceptualize its interactive relationship between socio-technical transition and spatial dimension. However, its mechanism is still vague. Previous studies have not been able to mention clearly how real space has changed through socio-technical transition. Moreover, there is a possibility that the transition process and urban space transformation would be taken place at the same time. The conceptual framework has some room for development with the concrete spatial environment.

Another missing viewpoint in transition research derives from the trend that most of the transition research is mainly concerned with a normative reason (e.g. sustainability, innovation), its main interest is how to cause, enhance, and manage the transition. There is still lacking how concrete urban space has been reconfigured through transition, which is clearly a research gap. Especially in urban water management, socio-technical transition coincides with the development of actual urban space. For example, recent increasing precipitation enhance cities to increase space for water, such as surface water retention. This requires certain spatial intervention into existing built urban area for water. In other words, urban water management transition would also mean urban spatial transformation as well. Analysis of their dynamics in a long-term transition in concrete urban space is still necessary today.

1.3 Research Objective

The aim of this paper is to investigate the mechanism of urban space transformation due to climate change by testing the theories of socio-technical transition, urban water management, and its interaction with urban space. In particular, this research aim to understand the mechanism by appling the theoretical framework to two concrete water management projects in Agniesebuurt neighbourhood. This paper calls the current project site spatial solution and view it as a result of the interactions between urban water management transition and urban space conditions where the transition takes place. This paper aim at revealing the mechanism.

Agniesebuurt neighbourhood is currently one of the most transformative neighbourhoods in Rotterdam in the Netherlands. Rotterdam is a showcase of a climate-proof city in the Netherlands, which is the most vulnerable to water issues in the world due to its low-lying land. Nevertheless, its high vulnerability to water has cultivated their knowledge and technology of how to deal with water. There are several innovative adaptation projects conducted in the neighbourhood and now the neighbourhood is aiming at 100% climate-proof area in the project of Sponge 2020. Analysis on this area would enable to understand how such existing urban area has transform in relation to urban water management transition due to climate change.

1.4 Research Question

- ***Main Research Question***
  How do interactions between the transition of urban water management and spatial dimension explain the spatial solutions in the Agniesebuurt neighborhood?

- ***Sub Question1: indicate transition processes***
  How can each period of transition be defined in the timeframe?

- ***Sub Question2: identify spatial solution***
  How can the spatial solution in Agniesebuurt neighborhood be defined?

- ***Sub Question 3: clarify interactions***
  How do spatial dimensions affect transition in each period?
  How does transition in each period reconfigure spatial dimension?

1.5 Significance of study

Current study on the relationship between transition and space is conceptual development phase. The concrete spatial analysis would develop this research field and would cultivate not only water management transition but also another type of social transition e.g. urban sustainable transition. This study would play an important role in visioning how climate change will transform the urban built environment in a long-term perspective by the combination with a theoretical view of socio-technical transition and spatial view.

Such research viewpoint would be useful for policymakers when society faces a necessary transition. Especially due to climate change, policymakers in most of the countries need to deal with transition in a densified urban area where complex system transition is required.

This study would be also useful for spatial designers in urban area such as urban planners, urban designers, landscape architects, and architects. As climate change continues, they would become required to design urban space that performs as a part of the complex urban water management system as well as space with various other functions. Research on the relationship between space and adaptive urban water management would provide important clues to them.

1.6 Scope and Limitation

This paper focuses on the urban water management transition from technical-oriented to being more adaptive to extreme weather due to climate change in an existing urban area; in the neighborhood of Agniesebuurt in Rotterdam in the Netherlands. This concrete research with would useful for theoretical generalization.

Although Dutch water management is well-developed in its history, the topographical uniqueness of its flat land and water-oriented culture (i.e. polder model) would have difficulty in generalization for other research in other places. In addition, spatial context also put a limitation on the external validity of this study. Existing spatial structure, institutional situation, or incumbent water management would be local-specific context on the site.

To analyse the transition, this paper introduces a multilevel perspective model in section three. Multilevel perspective model (MLP) is widely used to understand the process and mechanism of socio-technical transition. This model is useful to understand how the transition path is created throughout interactions between three different levels in a long period (Geels. F.W., 2011). Each of three level; niches, socio-technical regimes, and socio-technical landscape, is "heterogeneous configuration of elements" (Geels. F.W., 2011). According to Geels, F.W., regime means socially established configurations that keep existing systems stable. Niches are defined as protected space where actors can conduct radical innovation oppose to domain regimes. The socio-technical landscape is long-term fluctuation that influences on niche and regimes. Transition in this model means the transformation of the socio-technical regime into another one through interaction between three levels (Geels. F.W., 2011; Loorbach, D en al. 2017). Besides, this model describes niche innovation is an essential role to change the incumbent system radically. As developed in the next section, this model, however, has some limitations, such as descriptive style, or lack of view on the role of agency. Those would put limits on the significance of transition process research.

For the data collection, this research analyses the process of transition and spatial interactions that had already happened based on the actors' recalling and secondary data. This would limit the precision of what was happening at the right moment because people do not always keep their perfect memory.

Chapter 2: Theory Review

2.1 State of the Art of the Theories/Concepts of the Study

This chapter fist reviews concept of transition to identify its nature. Then complex natuer of urban water management was reviewed for better understanding the mechanism of urban water management transition. Finally, reviewing framework of transition and spatial dimension. It is essential for discussion of urban water management transition and resulting spatial transformation.

2.1.1 Concept of transition

Studying the concept of transition can be seen in many scientific fields to understand the disruptive complex shift from one equilibrium to another condition (Loorbash, et al., 2017). Since the late 1990s, the necessity to learn such transition has risen as increasing focus on the normative concept, sustainability, which is thought of as a societal challenge. Researchers in those fields mainly learn about the complexity of the social system to address deep structural change in urban governance, economic development, or ecosystem. These system transitions within society are categorized in socio-technical transition at first, but its interest has extended to socio-economic, socio-institutional, or socio-ecological transition (Loorbash, et al, 2017;). Another aspect of interests in transition comes from innovation theory. Because innovation or experiment is thought to play an essential role to reconfigure the alternative social system, factors and management methods for the innovation is also main research fields to deal with social challenge (Bulkeley and Broto, 2012,).

Hence, arguing the nature of the transition is necessary to learn a shift of society in a long period of time. The definition is "the result of an interplay of a variety of changes at different levels and in different domains that somehow interact and reinforce each other to produce a fundamental qualitative change in a societal system" (Loorbach, Frantzeskaki, and Avelino, 2017, pp.605). Such interactive domains changing together for transition is visualized with geers by Martens(fig 1) and Rotmans (2005). They claim "sustainable transition requires such different domains work together but also "interlock with each other, in which, case developments can be reinforced, but when they block each other, developments can be inhibited" (Martens and Rotmans, 2005, pp.1138). Brugge, et al., (2005) notes "transition can therefore be described as a process of the co-evolution of markets, networks, institutions, technologies, policies, individual behaviour and autonomous trends"(pp. 166). As mention above, there are several widely-shared characteristics of transition in academic fields; long-term, non-linearity, emergence, multilevel, multiphase, (Loorbash, et al., 2017; Geels and Schot, 2010;). Rotmans, et al., (2001) define the transition into four phases in relation to how stable the societal system is. They are used by several researchers for analysis of transition process(e.g Brugge and Graaf, 2010). The four phases are;

- "A predevelopment phase of dynamic equilibrium where the status quo does not visibly change.
- A take-off phase where the process of change gets under way because the state of the system begins to shift.
- A breakthrough phase where visible structural changes take place through an accumulation of socio-cultural, economic, ecological and institutional changes that

react to each other. During the acceleration phase, there are collective learning processes, diffusion and embedding processes.

- A stabilization phase where the speed of social change decreases and a new dynamic equilibrium is reached"(pp.17).

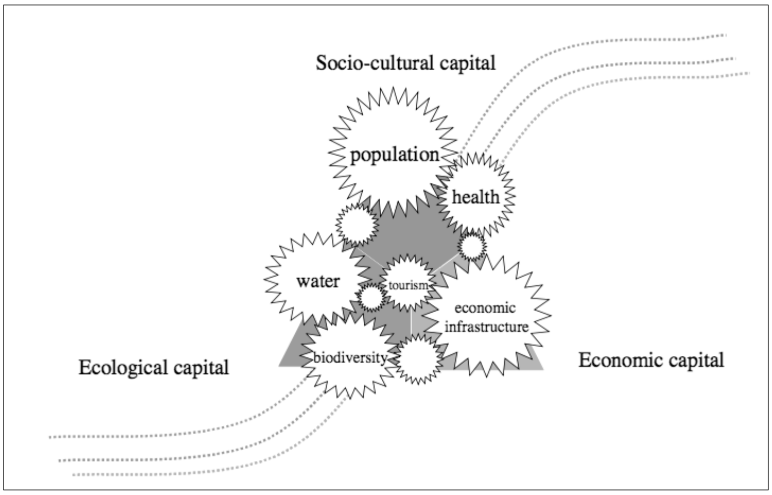


Figure 1 Transition takes place as a result of developments in several domains (source: Martens and Rotmans, 2005)

Those nature of transition has been analysed through a model of Multi-level Perspective (MLP). Geels (2002, 2010) and Geels and Schot (2007) argue and develop its use of the model of multi-level perspective to explain how socio-technical transition takes place. Three levels; niche-innovation, socio-technical regimes, and socio-technical landscape, are "not ontological descriptions of reality, but analytical and heuristic concepts to understand the complex dynamics of sociotechnical change" (Geels, 2002, pp.1259). Those levels are ordered in the degree of stability based on the number of actors and elements embedded in society(Geels, 2011). In the model, the transition is basically defined as a shift from incumbent socio-technical regime to another through the interaction of different levels, but there are several different types of sifting process (Geels and Schot, 2007). Such analytical lens of the three levels allows researchers to simply organize the complex large-scale structural shift (Smith, et al., 2010). Geels (2002) visualizes the transition dynamics between three levels by introducing various arrows and time axis (Fig.2).

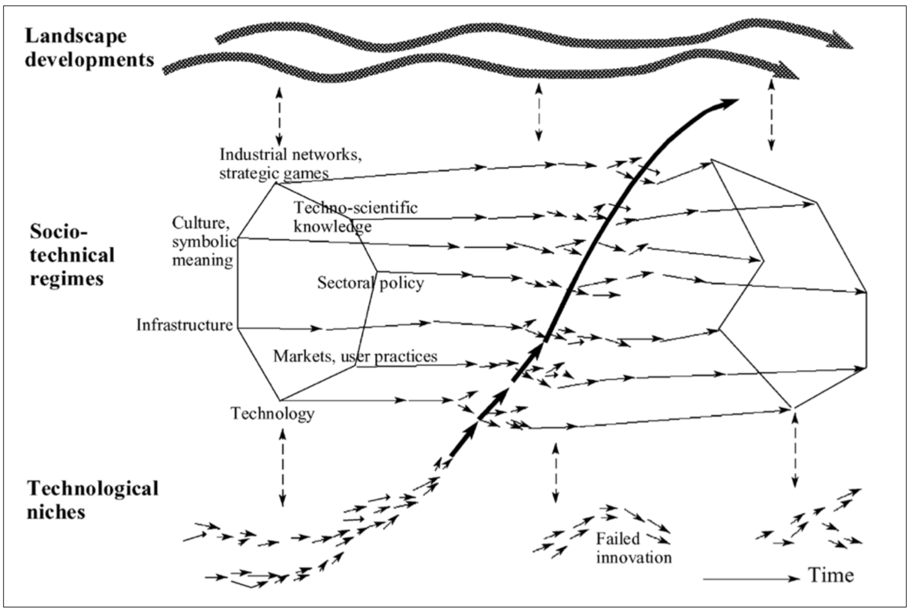


Figure 2 Dynamics of multi-level perspective (source: Frank W. Geels, 2002)

Several critics on the model, however, are posed by researchers. One of them is that because the definition of levels is conceptual, the relations are still vague and reality would be hard to represent its complex interactions (Smith, et al., 2010; Berkhout, et al., 2004). The abstract levels in the model also have difficulty in operationalization for empirical study(Smith et al, 2010). Another argument in this model is a lack of the role of agency and power relations that would be a central factor in transition (Smith, et al., 2005; Geels, 2011). Smith, et al., (2005) note too much attention on the descriptive and structural position. Most of those critics come from its conceptual level of the model and it is still lacking several aspects of transition, such as the geographical view or spatial dimension due to lack of discussion as mentioned above.

However, understanding such long-term social transformation from the different levels still has a potential for planners and policymakers who are concerned with how to deal with long-term planning. For instance, Bulkeley and Broto (2012) argue the importance of experiments for the governance of socio-technical system in the climate change context by noting the interactive relationship between niche innovation and regime transformation. With regards to such governance context, transition management has drawn researchers' attention in recent decades. Transition management is based on the notion that "(collective) understandings of the origin, nature, and dynamics of transitions in particular domains will enable actors to better anticipate and adapt to these dynamics so as to influence their speed and direction" (Loorbach, et al., 2015, pp.49). Analysis on the power relation in transition, governance experimentation, or participation of actors into the management process called transition arena, has been conducted to reveal a mechanism to manage transition (Wittmayer, Roorda and van Steenbergen, 2014; Loorbach, Frantzeskaki and Huffenreuter, 2015; Avelino and Wittmayer, 2016; Avelino, et al., 2017; Avelino, 2017; Hölscher, et al., 2017; Hölscher, Avelino and Wittmayer, 2018; Silvestri, et al., 2018).

Challenge for managing transition would be the nature of uncertainty, complexity, and interdependencies in the long-term (Loorbach, et al., 2017). The period is usually 25 years to 40 years so that social system transformation in such long-term would be difficult to control. In addition, because of its long-term feature, optimization in each short period does not mean long-term success to being normative society (Rotmans, et al., 2001).

Thus, through an overall review of the transition theory above, its emphasis is mainly on the complex nature of the systemic societal shift. Three different stability levels are introduced to explain complexity of the disruptive change through long period of time. Due to a potential in innovation from niche level, experiments and niche management are thought to take an important role for successful socio-technical transition. In terms of urban water management, climate change as landscape level fluctuation impact on regime levels and requires its shift. Next section reviews this urban water management transition.

2.1.2 Complexity in Urban water management

Increasing the necessity to deal with climate change impact requires a shift in several aspects of urban water management and pose some challenges. To understand urban water management transition, it is important to note characteristics of urban water management. Sapkota, et al., (2015), for example, visualize urban water cycle as fig. 3 and argue the increasing importance of hybrid water system (combining centralized and decentralized water system) to "generate more sustainable and resilient urban water systems" (pp.153). Without any adaptation to extreme weather, a large amount of precipitation in short time impacts on existing sewage infrastructure directly. However, the challenge is that change of urban water management, for instance introducing decentralized water management component, influences the overall urban water system. Such hybrid water system would increase the complexity of system management and requires institutional reform due to a variety of actors involved in the system (Sapkota, et al., 2015).

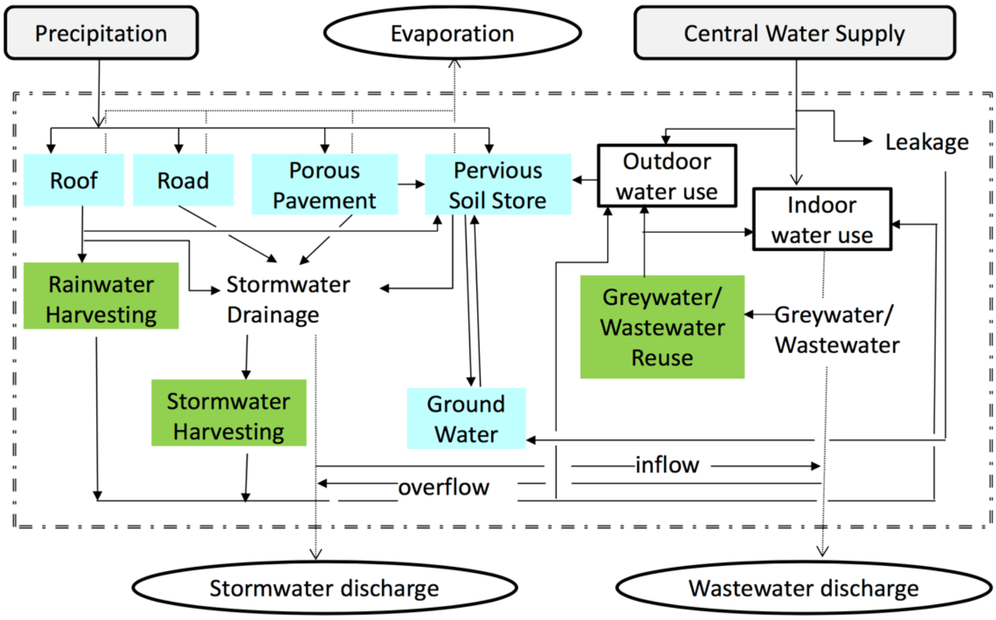


Figure 3 Urban water cycle's main components, pathways and novel technologies (Green colored boxes indicate decentralized components of water cycle) (source: Sapkota, et al., 2015)

Fratini, et al., (2012) focus on another nature of the complexity of urban water management in the decision-making process. They identify mainly two kinds of complexity; functional complexity and relational complexity, based on the physical and social domain of urban development. Functional complexity derives from necessary to arrange struggle of offering various societal needs in limited urban space, and relational complexity refers to addressing various actor involvement with different opinions in decision making in urban water management (Fratini, et al., 2012). Such complexity has been led by fact that not only engineers but also urban planners, citizens, or landscape architects attend to the process of dealing with urban water because of the changing view of water management from engineering field to social issue (Wong and Brown 2009; Fratini, et al., 2012).

Such complex nature in system, functionality, and actors' relations, means that urban water management transition does not change through only technical evolution but coevolve with those interactive elements; policy, institutions, technologies, and behavior. All of them needs to be addressed to cause transition. In addition, those complex aspects of urban water management include some important characteristics and conditions for transition. For instance, in the urbanized area, space for intervention would be an important factor. Or, to address functional complexity, multi-functionality come to be recognized as a solution (Fratini, et al., 2012). Institutional condition and water management system are obviously essential for understanding regime transformation. Based on them, the next section is reviewing which aspect of urban water management is focused on by several transition analysis so far.

2.1.3 Urban water management transition

The concept of transition has been adopted to changing issues faced in urban water management. Daniell et al (2015) elaborate such discussion and visualize its relations into the diagram below based on Brown, et al., (2009)(fig 4). According to them, drivers for transition in urban water management do not limit to fluctuation of climate, but includes urbanisation, environmental problem, or governance shift that have changed over the years.

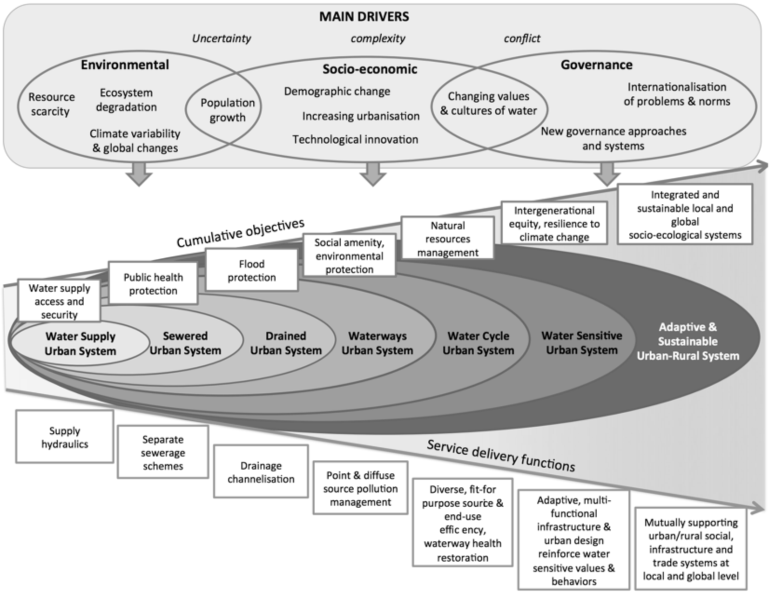


Figure 4 Drivers and resulting evolutions in urban water system (source: Daniell, et al., 2015)

Transition in urban water management to being adaptive to extreme weather from enduring by technological solution is a main issue that current cities face to due to climate change. Brugge, et al., (2005) characterize changing attitude to water in the recent history of Dutch water management as multiple levels interactions and multi-phases shift. By adopting multi-stage model developed by Rotmans, et al., (2001) to the Dutch water management (1975-2004), they note the transition process was still take off stage at that time and not acceleration stage due to the lack of operationalization. They argue increasing unpredictable water-related issues in the Netherlands and several policies and niche innovations have transform paradigm in urban water management from technocratic scientific style to an adaptive and participatory style. Introducing a side channel into a river rather than dike enhancement was an important shift to adapt to the uncertain water issue in urban water management. Such improvement of adaptive capacity for water by creating space for water becomes essential in recent urban water management, for instance, Sponge city (WangH, et al., 2018). Pahl-Wostl (2006) also highlights the importance of increasing adaptive capacity as a method for the water management transition toward adaptive water management.

Dunn, et al., (2017) , Brugge and Graaf (2010) are interested in policy innovation and policy-science interactions in urban water management transition in Rotterdam. Those interests derive from the unique fact that policies of urban water management in Rotterdam after 2000 has transformed dramatically and such policy transition emerged from architectural exhibition that accommodated niche innovative ideas for adaptation to climate change. Brugge and Graaf (2010) review its history in detail and note its innovative institutional change by linking of urban water management and urban development. Dunn, et al., (2017) argue influential factors of science and policy interaction for achieving water management goals that aim at "fostering climate resilience; improving liveability whilst fostering economic prosperity; and implementing solutions that offer multiple benefits" (2017).

Transition in urban water management due to climate change is often integrated with other urban issue. Another approach to urban water management transition comes from an urban design viewpoint. Climate change and related transition in urban water management are thought as an opportunity for urban development by "interlinking water infrastructural investments and ongoing urban developments" (Brugge and Graaf, 2010, pp.382). In this context, water sensitive urban design (WSUD) become known as the new method in urban water management transition since the 1990s. Based on the argument by Wong, Brown and Clarke (2007) notes that WSUD focuses on "synergies within and between the urban built form and landscape, and the urban water cycle, recognizing that community values and aspirations play an important role in urban design decisions and water management practices" (pp.1). Hence, water is thought of as a recreational element to improve urban amenity. In other words, transition in urban water management also aims at enhancing the attractiveness of urban space, for instance, in the degraded neighbourhood.

This view does not limit to such neighbourhood development scale but larger urban scale in the Netherlands. National water management program in the Netherlands aimed at not only improvement of discharging capacity in rivers but also creating new recreational space that can be used for urban amenity in dry periods. Room for the river program (2005-2015) was development of river basin and side channel in Rhine river in order to adapt to increasing precipitation in the Netherlands. What was unique in this case is not simply raising dyke for river flood management, but to realize such multi-functional space by spreading the river width sideways and embedding recreational functions. Frans Klijn, et al., (2013) notes that concept of spatial quality was introduced to evaluate planning for water management but more spatiality accomplished through the program.

Last but not least, another key issue in urban water management is focusing on the ecological viewpoint that is introduced in urban water management transition. Emphasizing on a nature-based solution, or blue and green infrastructure rather than gray one can be seen in sustainable transition studies (e.g. Frantzeskaki, et al., 2017). To address environmental challenges in specific places, "nature-based solutions have a transformative social impact since they mediate new social relations and new social configurations" (Frantzeskaki, et al., 2017, pp.65). Another rationale behind this trend is that blue and green infrastructure can "enhance ecosystem services in the management of water resources and increase resilience to climate risks" (Brears, 2018, pp.18). In this way, the aim of urban water management transition is also enhancing the ecological environment and biodiversity as well as configuration of social relations.

Therefore, urban water management transition has to deal with various water issues and multiple targets. Based on the discussion above, this paper defines three main directions that urban water management transition focus on; adaptive capacity for water, the attractiveness of space, and ecosystem. More precisely, three dimentoion of spatial quality that Room For The River project used is clear; (1) hydraulic effectiveness, (2) ecological robustness, and (3) cultural meaning and aesthetics (Frans Klijn, et al., 2013). Then, the urban water management transition does not occur only changing with policy framework for envisioning but also change of governance style to be more participant and de-centralized, technological improvement of multi-functionality, and local people's behaviour to achieve such de-centalized urban water management(fig 5).

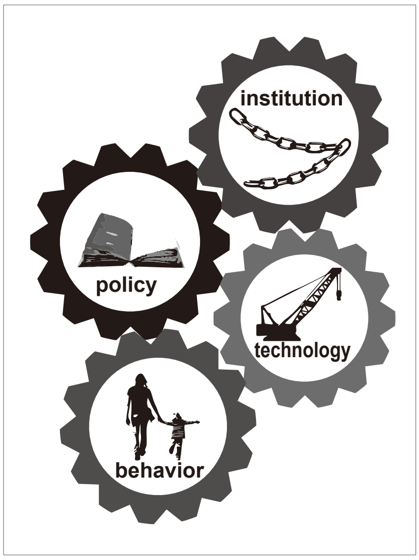


Figure 5 Transition mechanism of urban water management (source:author)

In addition, not only focusing on being adaptive to climate change but also on the importance of water-related urban amenities, and interests in materials derive from the fact that stormwater management has directly influenced urban space due to climate change. In other words, considering these issues comprehensively, it can be seen that urban water management transition toward being adaptive has a significant impact on urban space. So what kind of debate has been exchanged about transition and space so far?

2.1.4 Relationship between transition and space

As mentioned already, several articles note some spatial aspects in socio-technical transition. To address persistent contributions and research gaps through the reflection of that conceptual relationship between transition and space, identification of the role of spatial aspects in the socio-technical transition is of significance. Based on the arguments by Loorbash, et al., (2017), Geels and Schot (2010), Rotmans, et al., (2001), the characteristic natures of transition are; nonlinear transition process, multilevel interactions, coevolution, emergence, variation and selection, and multiphase. Those characteristic features are useful to gain insights about the spatial dimension of transition.

Emphasis on the geographical unevenness in transition has been shown by many geographical studies especially from economical geography viewpoint (e.g. Coenen, L., Benneworth, P. and Truffer, B., 2012; Lars Coenen, L., and Truffer, T., 2012). The rationale for focusing on this is the fact that certain transitions occur in a particular place and not in others. One of the reasons for this is that "place-specific norms and values have important influences on the geographically uneven landscape of sustainability transitions" (Hansen, Coenen, 2014). Because long-term transition process is a reconfiguration of incumbent regulations, rules, or customs, local norms and values have a heavy influence on the transition process. This also coincides with the explanation by many economic geographers that institutional difference of geography effects on the technology development process. Coenen, et al., (2012) focus on the institutional difference in places and introduced the notion of comparative institutional advantage and institutional thickness to explain geographical unevenness of transition. Another discussion is expressed that informal local institution plays an important role in grassroots innovations which tend to start from focusing on the place-specific problem. Hence, localized institutional frameworks are meaningful for transition experiments (Coenen, L., Raven, R., Verbong, G., 2010).

Geographical unevenness in transition sometimes derives from a variety of resource accessibility for certain industries. This Hansen and Lars Coenen emphasize the merit of geographical perspective in the transition process by mentioning that "[w]hen determining locational advantages for cleantech cluster formation, the availability of local natural resource endowments should also be noted as distinctive" (2014, p.102). They explain local technological and industrial specialization to address why the niche innovation emerges and form transition in a certain place. From such point of view, the formation of niches attributes the context of place because of the proximity of pre-existing industry or "related activities that have been historically present in a region" play an essential role in transition (Teis Hansen, Lars Coenen, 2014). Thus, these spatial contexts have been used to express the geographical unevenness of the transition process in various place, which implies the importance of spatial embeddedness of transition.

Coenen, et al., (2012) criticize transition theory for the lack of spatial dimension in the research and argue that transition process is spatially embedded in urban context. They emphasize the importance of "the institutional embeddedness of socio-technical development processes within specific territorial spaces" (2012). Noel Longhurs (2015) emphasizes the importance of urban place's role that allows and provides "protected space" for niche innovation. Such a role of grassroots initiatives is of significance for innovation and transition. To address socio-technical transition toward sustainability, Marc Wolfram (2018) emphasizes the importance of social innovation through "place-making activities that mutually engage citizens, local authorities and businesses in the transformation of the diverse socio-technical systems embedded in the urban fabric" (pp.12).

To understand the nonlinear nature of transition process especially happened from grassroots niches, some researchers focus on the mechanism of diffusion from place-based viewpoint (Wirth, et al., 2018, Marc Wolfram, 2018). The rationale behind this is that emphasis on the place-specific innovation has little attention to organize the contextual findings into broader context and that place-based diffusion process of innovation is essential to make a concrete strategies and practices in real space for transition. Wirth, et al., (2018) categorizes the process into three; embedding, translating, and scaling. This analysis on diffusion process tries to envision how transition would take place in urban planning, but focusing on the impact of experiment is lacking a view that diffusion is as a result of interactions with incumbent regime in transition process.

Another spatial argument in transition is that the levels in multi-level perspective model is not always the same as spatial or territorial scale (Raven, et al., 2012, Coenen, et al., 2012). Rave et al (2012) review the importance of scale in socio-technical transition in detail. Introducing relative spatial scale rather than absolute one, they develop the levels as "social constructs constituted by organizational and actor relationships that are multi-level" (pp.71). According to them, adopting relational spatial scales that "are socially constructed through networks of actors and cut across territories" (pp.70) enables to explain that transition "emerge out the tensions created in multi-scalar interactions between spatially distributed actors embedded in multi-level structures with different temporal dynamics" (pp.70).

Walfram (2018) reviews the mechanism of emergence and formation of grassroot socio-technical niche for sustainable transition. He argues that more influential role of place and place-making with which divers actors involved to reconfigure socio-technical system embedded in concrete urban space. In recent studies, the growing role of civic society actors in implementation of niche innovation for sustainable transition are highlighted because of "their proximity to local contexts, flexibility due to operating on the fringes of complex bureaucratic settings" (Frantzeskaki, et al., 2016, pp.44). Walfram (2018) notes that such experimentations based on urban place would be able to reconfigure not only socio-technical regime but also "values, identities, and governance relations" (pp.13) and reshape the urban place physically and culturally.

In the process of transition, such place-making or visioning for certain territorial area does not always mean to physically modify the city, but to redefine the urban space or reframe its meaning. Murphy (2015) focus on such a conceptual relation between socio-technical transition process and place-making. He reviews definition of place as relational; "phenomena constituted by web or constellations of external and internal relations which in effect "make" [places]". Based on the discussion by Pierce, et al., (2011), he notes place-making as "the process of reproducing, eliminating, and/or modifying the structures, identities, meanings, geographies, positionalities, and power relations associated with a given place" (pp.84) and it takes place "when interest groups, social movements, communities, political parties, states, firms, and/or other actors mobilize collective or shared place-bundles in order to achieve social and political ends" (pp.84). In the process, representations of a place or visioning its future are an essential part, that is, "place reframes" defined by Martin (2003). Such discussion address Elsevier notes the process of transition embedded in urban space can be seen as", in part, a place-framing and making process".

Discussion above shows current conceptual arguments about the relationship between space and socio-technical transition. Those can be divided into geographical unevenness, territorial embeddedness, multi-scales view and reshaping of urban space. Geographic interests in transition improve this academic fields about space and transition. However, there is still limited discussion about the interactive co-evolution process with space and socio-technical transition. In addition, current research on socio-technical transition does not put emphasis on evaluation of the space as a result of reconfiguration of socio-technical transition.

2.1.5 Definition of space and its dynamics with socio-technical transition

As it is mentioned in scale section, definition of space has several interpretations. One of them is that space is absolute physical entity in Euclidean geometrical view in modern era. This view defines urban space as an empty container that bounds activities in cities, and such object-oriented conceptualization is widely used still today (Graham & Healey, 1999). The absolute conceptualization of space is seen as “non-societal but environmental category” (Levin-Keitel, et al., 2018, pp.5). However, this view has been criticized by many sociologists in recent decades because they have claimed that space is “as a result of social thinking and action”(Levin-Keitel, et al., 2018, pp.6)

Based on discussion by Henri Lefebvre, Edward Soja and other sociologists and geographers develop the relational concept of space, which is called spatial turn. In their context, “space is also constructed space, created through physical, economic, and social network” (Roven, 2012, pp.68). and “the urban becomes an embedded and heterogeneous time-space process” (Graham & Healey, 1999, pp. 628). In this way, urban place is also understood as "articulated moments in networks of social relations and understandings” (Massey, 1993, p. 66).

Taking those spatial discussions about space into consideration, Levin-Keitel et (2018) visualize potential dynamics between socio-technical transition and spatial dimension (Fig.6). According to them, “socio technical innovation transform space directly, and actively but are, at the same time, dependent on space or spatial conditions, meanings that space and spatial condition also influence the emergence and spill over of technical innovations” (Levin-Keitel et, 2018, pp.7). They defines spatial dimensions into three; physical, social and relational to represents that the transition would transform space physically but also (re)produce space though “human intention”(pp.7) embedded in, and the spatial dimension is still a part of structuring social process.

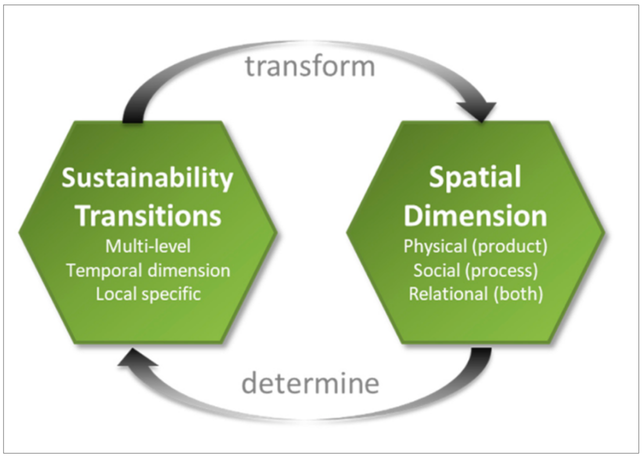


Figure 6 Fig Sustainability transitions and the spatial interface (Source: Levin-Keitel, et al., 2018)

Although this conceptual framework represents the relation between spatial dimension and socio-technical transition directly, it does not include time axis that is essential for understanding disruptive change in socio-technical transition and interactions with urban space. Time axis would be important for understanding how the interaction can be visualized and how its eventual solution would be. Moreover, what is spatial conditions for transition and how socio-technical transition transform spatial dimension is still unclear. Furthermore, non-spatial condition, such as economic situation, would impact on the transition, so that spatial dimension not always "determine" transition.

To develop the conceptual framework, this paper defines reconfigured space as spatial solution which is an integration of non-linear interactions with socio-technical transition and urban spatial dimension. Spatial solution is an existence of reconfigured socio-technical regime in reality. Setting such reconfigured urban space enables researcher to evaluate the transition result and process at the same time. Although evaluation of urban space is difficult because of its relational characteristics and number of variables, conceptualization of spatial solution would be important for coming urban planning that need to manage necessary socio-technical transition in real urban space, such as sustainable transition.

2.2 Conceptual framework

Hence, conceptual relations between socio-technical transition, spatial dimension, and spatial solution become clear. Translating those conceptual relations into urban water management transition due to climate change can be seen as below. In urban water management context, transition process would impact on spatial dimension through several aspects as mentioned above, such as functionality (for retention of surface and public space), physical dimension (blue and green material), or meaning of space (social relation). On the other hand, territorial location, availability of space (intervention-able space), or incumbent regime water system or institutional relations embedded in specific place are important conditions for urban water management transition process. Indicators that are mentioned above for condition and reconfiguration would not always affects transition processes or spatial dimension, but their existences prove the interaction. Finally, to understand spatial solution which is a result of the interaction between urban spatial dimension and urban water management transition process, evaluation indicators should be the one that the transition targets; hydraulic effectiveness, Ecological robustness, and cultural meaning and aesthetics

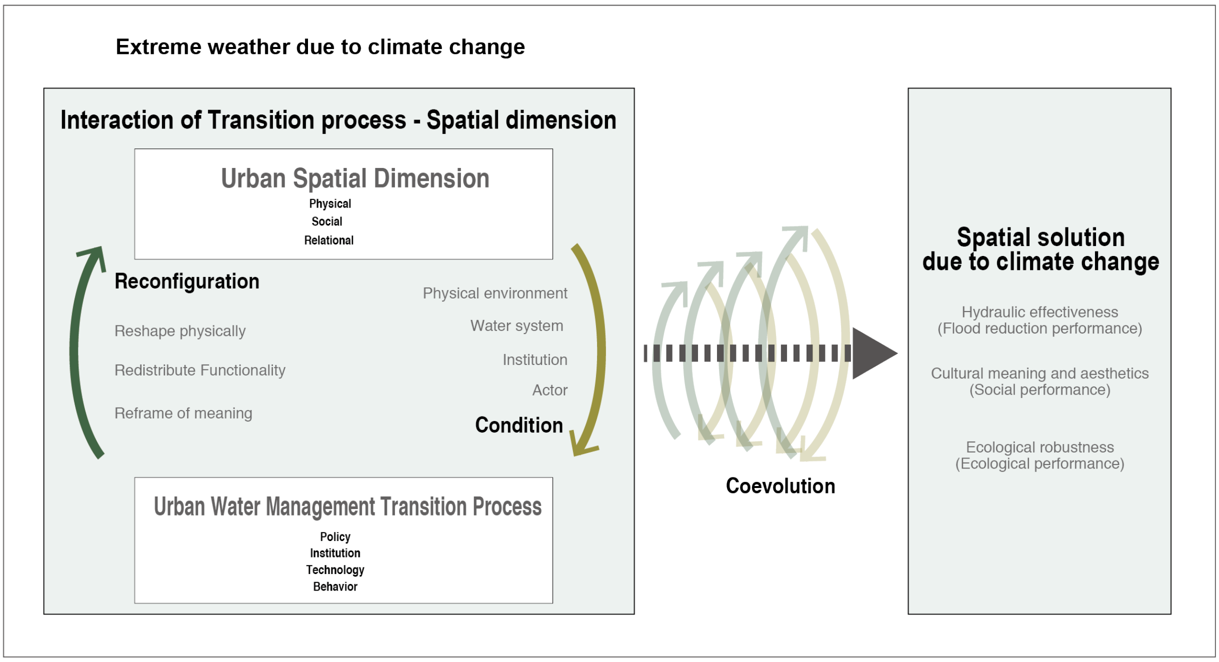


Figure 7 Conceptual framework (source: author)

Chapter 3: Research Design and Methods

3.1 Revised research question(s)

Bases on the theoretical review, research questions are revised as following.

- ***Main Research Question***
  How do interactions between urban water management transition and spatial dimension where transition takes place explain the spatial solution in the Agniesebuurt neighborhood?

- ***Sub Question1: indicate transition processes***
  How can each process of transition be defined in the timeframe?

- ***Sub Question2: identify spatial solution***
  How can the spatial solution in Agniesebuurt neighborhood be defined?
    How much is hydraulic effectiveness of the site for extreme weather?
    How much is the ecological robustness of the site?
    How much are the cultural meaning and aesthetics of the site?

- ***Sub Question 3: clarify interactions***
  How do spatial dimensions affect each process of transition?
  How does each process of transition reconfigure spatial dimension?

3.2 Research strategy

In this study, case study strategy, more specifically causal process tracing is the most appropriate in the four main research strategies. Although the number of the unit is relatively small, there is a large number of possibilities that cause the different spatial solution through interaction between urban water management transition and spatial dimension in the neighborhood of Agniesebuurt in Rotterdam. To trace the process to identify the causes of spatial solution, the process time frame should be divided into phases based on the transition process. Transition process is defined through changing of policies, institutions, technology and behaviors that are essential for urban water management.

More precisely, urban space of *Water Square Benthemplein*, and *ZOHO Raingarden*, are main case study projects in Agniesebuurt. They are projects that are part of CLIMATE-PROOF ZOHO program in Agniesebuurt. Water Square Benthemplein is an important showcase for water management throughout Rotterdam. This is because the project is an first official water square that realizes multifunctionality as an innovation stemmed from Rotterdam. ZOHO Raingarden is a project that emerged in a further flow after the realization of water square, and is one of the plans that clearly set Agniesebuur to become climate proof.

Before going deep into the case study research, desk research is conducted. In particular, existing literatures and reports about the site’ s water management transition would be analysed in detail. In addition, Rotterdam and Netherlands's water management transition is also analyse based on existing reports and literature because the site's transition is set within a part of Rotterdam urban water management transition as well as Netherlands.

3.3 Research methodology and data collection

In this research primary and secondary qualitative data collection method is used. Because tracing transition process and interaction with spatial dimension cannot be clearly defined by quantitative way. Rather, its descriptive way based on existing documents and actor's experiences is more important. In addition, secondary quantitative data is required to evaluate current spatial solution.

Primary qualitative data collection

- Semi-structured interview
  To define the interaction processes in transition, interview to actors about detail tracing the process. More precisely, identification is required about which spatial factor condition, and how urban water management transition process reconfigure spatial dimension in each process. Although several indicators are already identified, more variety of interaction would be introduced in conditions and reconfigurations thanks to the semi-structured interview.

- Observation
  To evaluate spatial solution in each site, observation on the site is needed. This is also useful to triangulate secondary quantitative data collection.

Secondary qualitative data collection

- Academic literature review:
  Necessary data are required to define transition process in time scale and multilevel perspective. Studies on the urban water management transition in Rotterdam or in the Netherlands is critically review. This would be useful to triangulate the primary qualitative data collected through interview

- Published documents review:
  Several books about the projects on the site, news articles, and report are published. In addition, establishing policies related urban water management are clear element of transition. Since 2000 several policies and official reports about Rotterdam water management are published.

Secondary quantitative data collection

To assess spatial solution as an integration of interaction between spatial dimension and the transition process, three variables; adaptive capacity, attractiveness of space, and ecosystem services are introduced. All of them can be calculated based on the quantitative geographical data published online which is needed to be triangulated through observation data.

3.4 Operationalization: variables, indicators

Table 1 indicators for urban water management transition

Concept		*Description*	*Sub-variables*	*Indicators*
urban water management transition process	**policy**	the way of dealing with storm water from technical-oriented to adaptive management	change of urban water management policy	policy/vision/strateg y
	institution (governance)	To adapt to climate change, water governance needs to be changed from centralized to de-centralized and participation	institutional change (regulation, rule, norm, value)	change of responsibility between agencies
				partnership to work together
				increasing recognition of necessity of climate change adaptation
	technology	discharge fast >>> retention and slowly (multifunctional)	change of infrastructure for water system	construction of adaptive water management infrastructure
	behaviour	stakeholder become willing to introduce green / blue infra for climate proof	increasing attention / participation / implementation	change of users' attitude toward extreme weather

Transition is a process of various societal aspects changing together. In terms of urban water management transition toward being adaptive to climate change, this paper focuses on transition of policy, institution, technology and behaviour based on the literature review. The time frame of transition in Rotterdam starts from the 1990s due to the policy analysis as follewed and incumbent research on urban water management in Rotterdam (Graaf and Brugge, 2010).

Table 2 indicators for interactions between transiton and urban spatial dimension

Concept		Description	Sub-variables	Indicators
Interactions between urban water management transition processes and urban spatial dimension	**Condition for the transition process**	Precondition for each process of urban water management transition. There would be divided into necessary condition and sufficient condition	physical environment (necessity / opportunity)	urbanization/ intervention-able space
			existing water system on the site	vulnerability / infrastructure
			institutions on the site	rules/ regulation / value/ norm
			actor embedded in the site	Distribution of stakeholders embedded in site
	Reconfiguration of urban spatial dimension	Re-arrangement of urban spatial aspect through each of the transition processes	Reshape physically (materiality / landscape)	ratio of green, blue, red, and gray / plan and section
			Redistribute Functionality	Variety of funcitionality
			Reframe meaning of space	collective image of space by actors

Table 3 Indicators for spatial solution

Concept	Description	Sub-variables	Indicators
Spatial solution	Integration of urban space transformation due to urban water management transition	hydraulic effectiveness	amount of retention rainwater and covering area
		cultural meaning and aesthetics	people's perception of the area
		Ecological robustness	based on ecological vulnerability defined by exposure, sensitivity, and adaptive capacity

The three sub-variables for spatial solutions are based on the indicators of spatial quality evaluation in Room For The River project.

3.5 Sample size and selection

This study employs so-called snowball sampling. That is one of the non-probable sampling methods for research. Because of the nature of causal process tracing, it is difficult to define possible causes in the process before research starts. Respondents are basically selected from actors that involved in the transition process. Identified main groups in the transition process are following.

Table 4 sample for semi-structure interview

Sector	position	No.
Rotterdam Municipality	project manager Water Square	1
	project leader of Raingarden	1
	project manager	1
	landscape designer	1
DE URBANISTEN	director of landscape architecture firm	1
Church	citizen	1
IHS	Involved in Zoiho workshop	1
De Kas nursery	Raingarden maintenance Botanist	1

Documents are used to make a basis of analysis.

Table 5 sample for secondary data

Year	document name	By
2000-2005	Rotterdam Waterplan1	Rotterdam municipality
2005	International Architecture Biennale Rotterdam 2nd catalog	IABR
2005	International Architecture Biennale Rotterdam 2nd report	IABR
2005	Rotterdam water city 2035	IABR,
2007	Rotterdam Waterplan2	Rotterdam municipality
2008-2014	Rotterdam Climate Proof(report)	RCP
2009	SUB-MUNICIPAL WATER PLAN Noord 2010-2015	Rotterdam Noord Sub municipality
2010	DE URBANISTEN AND THE WONDROUS WATER QUARE	DE URBANISTEN
2013	Climate Change Adaptation Strategy	RCP
2014	workshop report for Climate Proof ZOHO	DE URBANISTEN, RCP, Rotterdam Noord Sub municipality
2014	Climate Proof ZOHO DISTRICT	DE URBANISTEN
2015	Sustainability 2016-2018 program	Rotterdam municipality
2016	Rotterdam Resilient Strategy	Rotterdam municipality, 100 Resilient cities, Rotterdam Make It Happen

3.6 Data analysis methods

In this study, qualitative data analysis is applied because most of data collected are based on document-base data in case study. Especially, causal process tracing is focusing on "[t]emporal unfolding of situations, actions and events, traces of motivations (or other lower level mechanisms), evidence of (complex) interactions between causal factors, and/or information about restricting/catalyzing contexts/conditions, and detailed features of a specific outcome." (Blatter and Till Blume, 2008, pp.319). For such qualitative data analysis, Atlas TI is widely used software to unfold the hidden relationship.

3.7 Validity and reliability

Validity and reliability are essential aspects for academic research. There are two validity for academic research; internal validity and external validity. For internal validity, well-constructed theoretical review and flamework is necessary. In this research, main conceptual framework is developed from discussion about sustainable transition and spatial interface by Levin-Keitel, et al., (2018). The last chaptor critically review such spatial dimension and transition process in detail and add more concrete dimension of urban water management transition. Because causal process tracing is employed in this research, documentation of research processes is also important for keeping internal validity high.

The external validity in this research might not be high because it can be hard to generalize the outcomes of the case study research due to its dependence of context. Because transition process and spatial dimensions indeed depend the contextual dimension on the site, time, or society, findings from this research would not be always applicable to all the neighborhoods.

As for reliability, accuracy and consistency of research is of importance. In this analysis, identification of transition process in precise order in timeframe is of essential. This would be assured by triangulating secondary data. Process tracing sometimes depends on person's memory so that not all the data from inhabitants is always valid in the scientific context. As described above, triangulation by secondary research is essential to improve significance of this study. In this case, project documents, workshop reports, policy documents are used. In addition, detail recording of documentation process is also essential for consistency.

Chapter 4: Research Findings

This chapter is structured as follows. Chapter 4.1 describes the historical context of Rotterdam and Agniesebuurt as well as their water systems in the area. Chapter 4.2 mainly focuses on the transition of urban water management in Rotterdam and Agniesebuurt because of climate change. The transition is analysed in the aspect of policy, institution, technology, and behaviour and the transition's timeframe is defined. Chapter 4.3 shows the data and result of the spatial solution of Water Square Benthemplein and ZOHO Rain garden. The spatial solution is analysed based on hydraulic effectiveness, ecological robustness, cultural meaning, and aesthetics. Chapter 4.4 analses interaction mechanism of spatial dimension and transition in each period defined in chapter 4.2. More precisely, this chapter focuses on what spatial factor influences on transition and how the transition change urban space in each period. The last of this chapter argues the relation of such interactions and spatial solution in each site, and discuss the reason for differences in spatial solutions based on the interactions they went through.

4.1Context of study: Rotterdam and Agniesebuurt

History of Rotterdam and water system

Rotterdam is the second largest city in the Netherlands. According to the Rotterdam Partners' report "FACTS & FIGURES ROTTERDAM GENERAL", there are 634660 people, 50 % of them is Dutch, 170 nationalities in Rotterdam in December 2017. Total area is 324,16 km2 and 33% of which is water. Water system and urban design in Rotterdam are integrated, but its method is different in each place and age of development (Hooimeijer and Geldof, 2008).

Rotterdam is dam city as well as delta city. Rotterdam has developed from small villa with dam for River Rotte since the 13th century. The city developed its water infrastructure by constructing singles to keep open water clean from middle of 19th century. In 1872, Nieuwe Waterweg was constructed to connect Het Scheur and North Sea for ships, which opened its potential of industrial port of Rotterdam. Rotterdam is located in Rhine-Maas Delta, where it is a suitable transit hub to transfer products shipped from all over the world to the Europe. Such geographical location enables Port of Rotterdam to be the largest port in Europe now. Because the port needed to be close to the sea for efficiency of transhipping, industrial port moved to more downstream of Nieuwe Maas River.

Modern buildings and urban structure in the central area were constructed after World War Second, which differentiate from other Dutch cities. This is because the central area of Rotterdam was demolished by bombing during the war. After the war, Rotterdam had enlarged its size into suburban area to accommodate increasing number of inhabitants who seek to gain sufficient living space. The urban sprawl, however, led to deteriorate inner city during 1980s. In 1990s, Rotterdam has redeveloped the inner city and river side where there used to be an industrial port and its labours' neighbourhoods, such as Kop van Zuid. The city council made a vision in 2007 aiming at new identity changed from industrial port to knowledge economy and live-able place (Municipality of Rotterdam aaa)

In terms of geography, Rotterdam is divided into three territorial parts in relation to Nieuwe Maas River; Rotterdam Noord, Riverside, and Rotterdam Zuid. This division was adopted in official policy of Waterplan 2 Rotterdam in 2007(). Dykes along with riverside create the borders between riverside area and others (fig 8). Outer dike is riverbed elevated artificially up to avarage To keep the city dry, pump stations regulate water levels and discharge water from inner dike to outer-dike and that water eventually goes to the North Sea (fig8). Not only pumping station, water system in Rotterdam is “consists of storm surge barriers and dikes, of canals and lakes, outlets, sewers” stations that work together (Rotterdam climate adaptation strategy. pp.24). Such system shows that urban water management in Rotterdam has different role in relation to the place, for instance, whether in inner-dyke or outer-dike.

Due to climate change, Rotterdam is required to deal with more water from four different direction; from sky(precipitation), from underground (ground water), from the river, and from the sea. According to the Rotterdam Climate Change Adaptation Strategy (2013), Rotterdam is facing to four types of extreme weather caused by climate change; “more intense rainfall, higher sea and river levels, longer periods of drought, and longer hotter periods (heat wave)”. Sewage system in the city has been influenced by climate change. In the place where sewage pipes are combined with rain discharge system, a large amount of precipitation in short period overflows with dirty water into open water, such as canal, and degrade its quality (Waterplan2 Rotterdam). To prevent this, several solutions has been conducted in Rotterdam. One of them is introduce of separated sewage systems that enables to manage relatively clean rainwater and dirty waste water separately. However, reconstruction of all the sewage pipes takes decades and it is not effective from cost-benefit point of view. Rotterdam decided to apply this approach if the area was suitable (Water plan 2). Another is increase of water retention capacity by extra room for water, such as green roof, water square, or underground water reservoir. Most of them have multi-functionality, for instance, retention of water and public space. Increase of infiltration of storm water into ground by de-pavement is also another solution for reduction of intense rainfall impact on sewage system in Rotterdam.

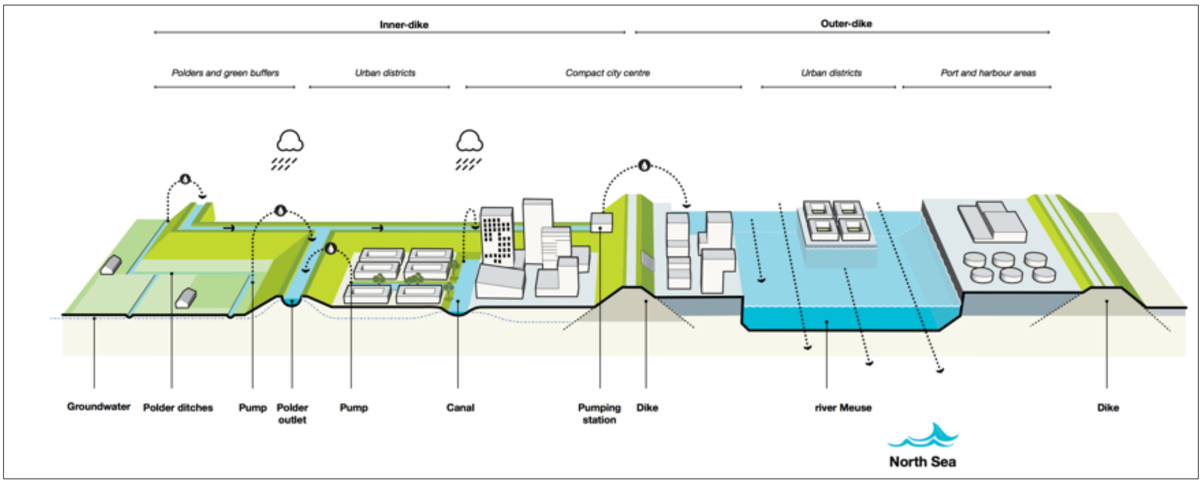


Figure 8 Diagram of water system in Rotterdam (source: RCP, 2013)

The neighbourhood of Agniesebuurt

Agniesebuurt (38ha) is a neighbourhood located in Rotterdam Noord district. There are around 4100 inhabitants living there (Municipality of Rotterdam). It was a place as high-dense residential area before WWII. After the war, Technicon complex and Zomerhofkwartier office area were constructed in the southern part, which is now used for education facilities and business district. One of the main structures characterizing this neighbourhood is former Hofplein station and Hofplein line used to connect Rotterdam to Scheveningen. Although both of them was closed in accordance with the changed place of Rotterdam central station, the station building and the elevated line still exist and create a micro space for small entrepreneurs.

The southern blocks named Zomerhofkwartier is also such a place for entrepreneurs, rather than large office buildings. This is due to what is called slow urbanism from 2013 initiated by Havensteder housing association and local initiatives(STIPO). Because of the economic crisis after the purchase of the block by the real-estate cooperation in 2007, they decided to develop the area more bottom-up way collaborated with various creative communities in ZOHO.

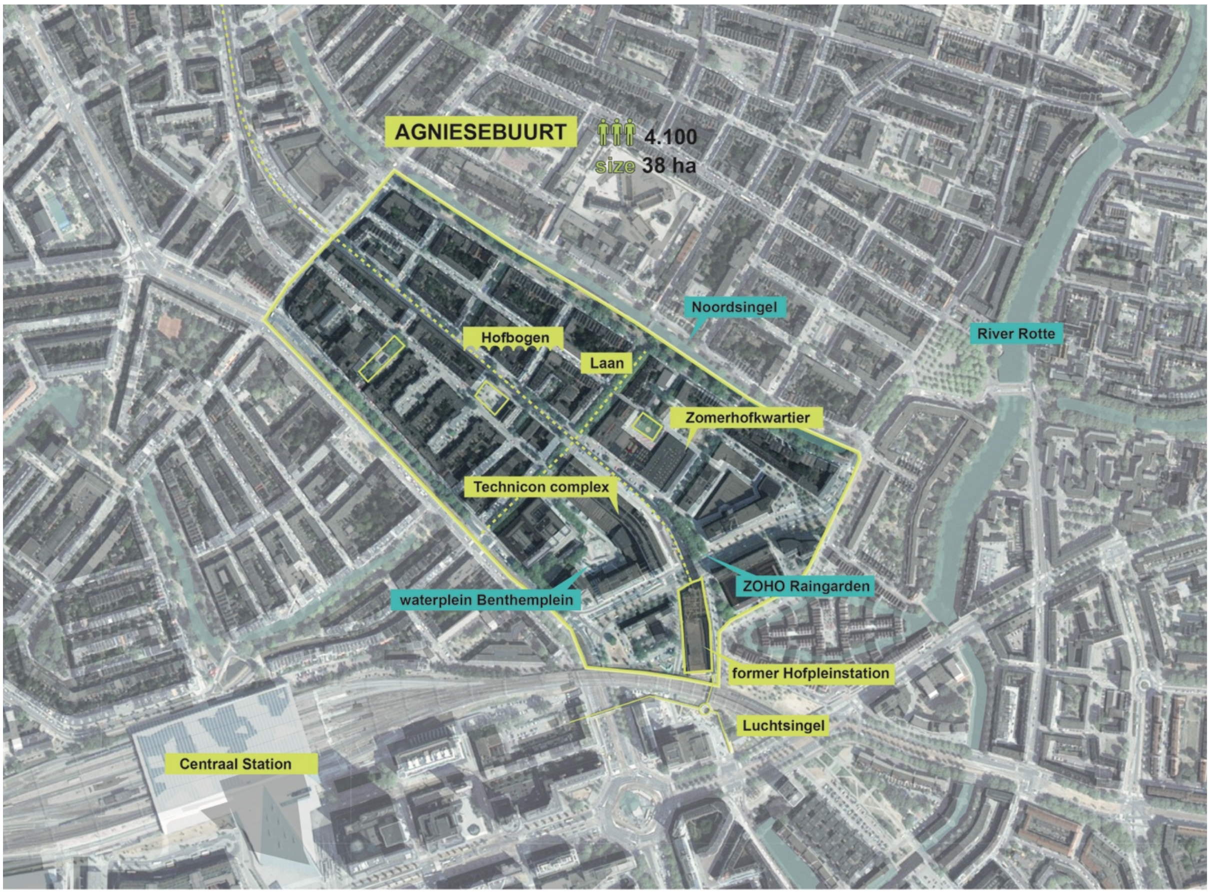


Figure 9 Agniesebuurt area map (Source: Aerial photo, 2018 edited by Author)

Figure 10 Agniesebuurt area photos (source: Author)

Het hoogheemraadschap van Schieland en de Krimpenerwaard (HHSK) is the district water board who is responsible for water level management in the entire area and maintenance in the main waterways in Rotterdam Noord, where Agniesebuurt is located. Rotterdam put what is called area committee to make local governance communication easy with residents. Agniesebuurt is belongs to Rotterdam Noord district and the sub-municipality of Rotterdam take charge in some of the water management in the city. The table and map show who is in charge of what kind of water management.

Table 6 responsibility of urban water management in Noord (Source: Rotterdam sub-municipality Noord, 2009)

	management	*agency in charge*
Surface water	level management	HHSK
	Dredging	HHSK
	cleaning	HHSK
	litter	Sub-municipality of Rotterdam Noord
	sheet	HHSK
	Maintenance of structures (divers, bridges, embankment)	Sub-municipality of Rotterdam Noord
	Maintenance ground and inlets	HHSK
Sewage	Maintenance and management of sewerage and sewage pumping stations	Rotterdam municipality water management department

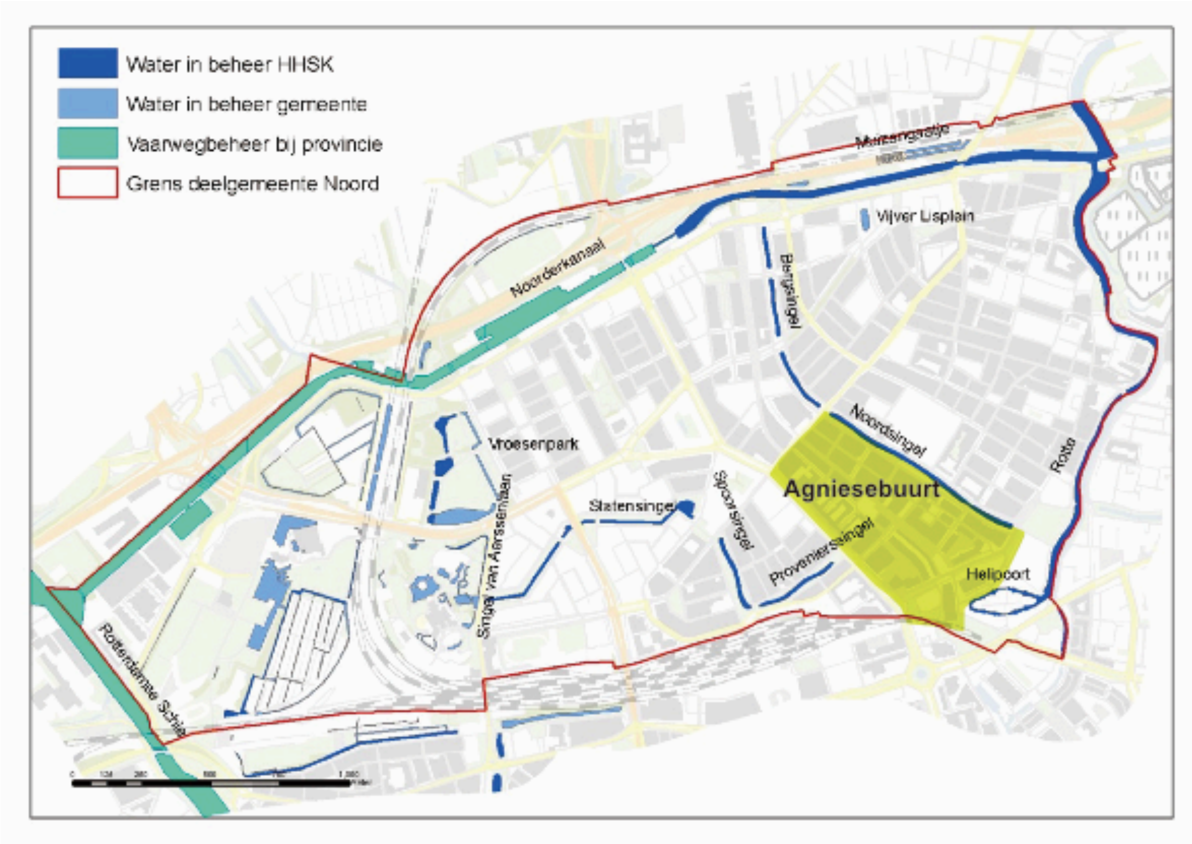


Figure 11 Duty area map of water management (source: Source: Rotterdam sub-municipality Noord, 2009)

4.2 Urban Water Management Transition in Rotterdam and Agniesebuurt

Transition in urban water management in Rotterdam has been analyzed in recent years because of its unique policy development process from 2000. In this paper, the transition in Rotterdam and Agniesebuurt is divided into four periods (period 1, period 2-1, period 2-2, period 3) based on the eoevolution of Rotterdam policy, institution of urban water management, technology of water square and rain garden, and behavior of citizens as follows. Before going to the explanation of each transition process, the followings are the summery of each period.

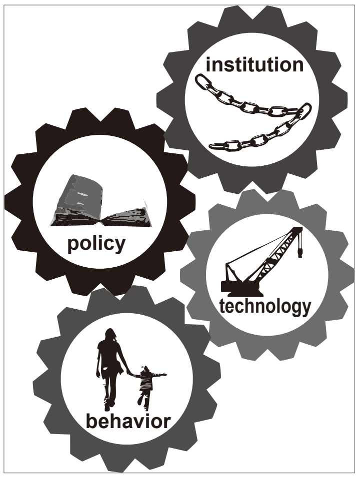


Figure 12 coevolution of transition (source: author)

Period1 (2000-2007)

Period 1 (2000-2007) is a phase of envisioning the direction of urban water management in Rotterdam. This period is defined as the first important transition of Rotterdam urban water management by the development of new policy and institution. In this period, the technological transition started from a niche but still a conceptual idea. From 2000, Rotterdam municipality started collaborating district water boards to enhance the quality of surface water with the city. As a result of niche innovation of International Architecture Biennale Rotterdam (IABR) and national institutional change as National Administrative Agreement on Water (NBW), Waterplan 2 Rotterdam was enacted in 2007. Waterplan 2 Rotterdam was the first official policy that envisions water-related climate change adaptations that focused not on reinforcing gray infrastructure but on being adaptive through creating retention capacity of water within the city. It also includes institutional framework that enhance transition in later period. During this period, the idea of water square was conceptualized in IABR and developed it typology for including an official policy.

Period2 (2008-2010, 2011-2013)

The period 2 (2008-2013) is the phase for implementation of pilot projects and development of clear strategy for climate change adaptation in Rotterdam. According to the interviewer, realization of the first large water square in Benthemplein in 2013 and publishing Rotterdam Climate Change Adaptation Strategy (RAS) in the same year were key moment of urban water management in Rotterdam. RAS is a key achievement of knowledge development programs about climate change from water plan2. The difference from Waterplan 2 is its changing focus from on water issue to more climate proof and extreme weather. In relation to the water square projects, the period 2 is divided into two periods; 2008-2010 (period 2-1), and 2011-2013(period 2-2).

After Rotterdam Waterplan 2, municipality tried to implement the idea of water square in concrete urban space in Rotterdam; Bloenhofplein. However, such a top-down strategy faced resistance from local residents and failed (2008-2010) (interviewers). Although the project stopped, the main landscape architect in the project, DE URBANISTEN, published a graphic book about the process that the idea of water square went through from IABR to the operational level in 2010(DE URBANISTEN, 2010). This period shows how the innovative idea from niche level grow up to the main streams but the idea was still not always accepted by local norm in Rotterdam. In addition, participation of such project was limited.

In 2011-2013, Rotterdam municipality and DE URBANISTEN worked on the implementation of water square in another place; Benthemplein. The local stakeholders were supportive to the idea and three participatory workshops adjust the idea into concrete local context and reflect their needs to the square design (workshop report, interviewees). Thanks to the technological development, the water square was realized in finally. 2013

Period 3 (20014-2018)

The period 3 is phase of diffusing climate adaptation in concrete urban space. After realization of Water Square Benthemplein and RAS, DE URBANISTEN collaborated with the municipality and planned to enlarge such climate adaptation from project scale to neighborhood scale by applying the scheme of RAS to Zomerhof district(ZOHO) in 2014. According to the interviewees, the workshop reports, and envisioning documents, municipality decided the district as pilot area of climate proof by series of bottom-up climate adaptation projects. By utilizing other urban development programs; sustainable outdoor improvement program and EU subsidy, the municipality realized a raingarden in the entrance of the district in 2018 as a part of Agniesebuurt district vision. This process ZOHO Raingarden went through from 2014-2018 was deeply elaborated by local entrepreneurs and initiatives who were willing to be involved in the climate adaptation and urban space improvements. However, not all the local residents in Agniesebuurt have positive attitude on other climate proof program in the district

The overall timeline can be shown as Fig 13.

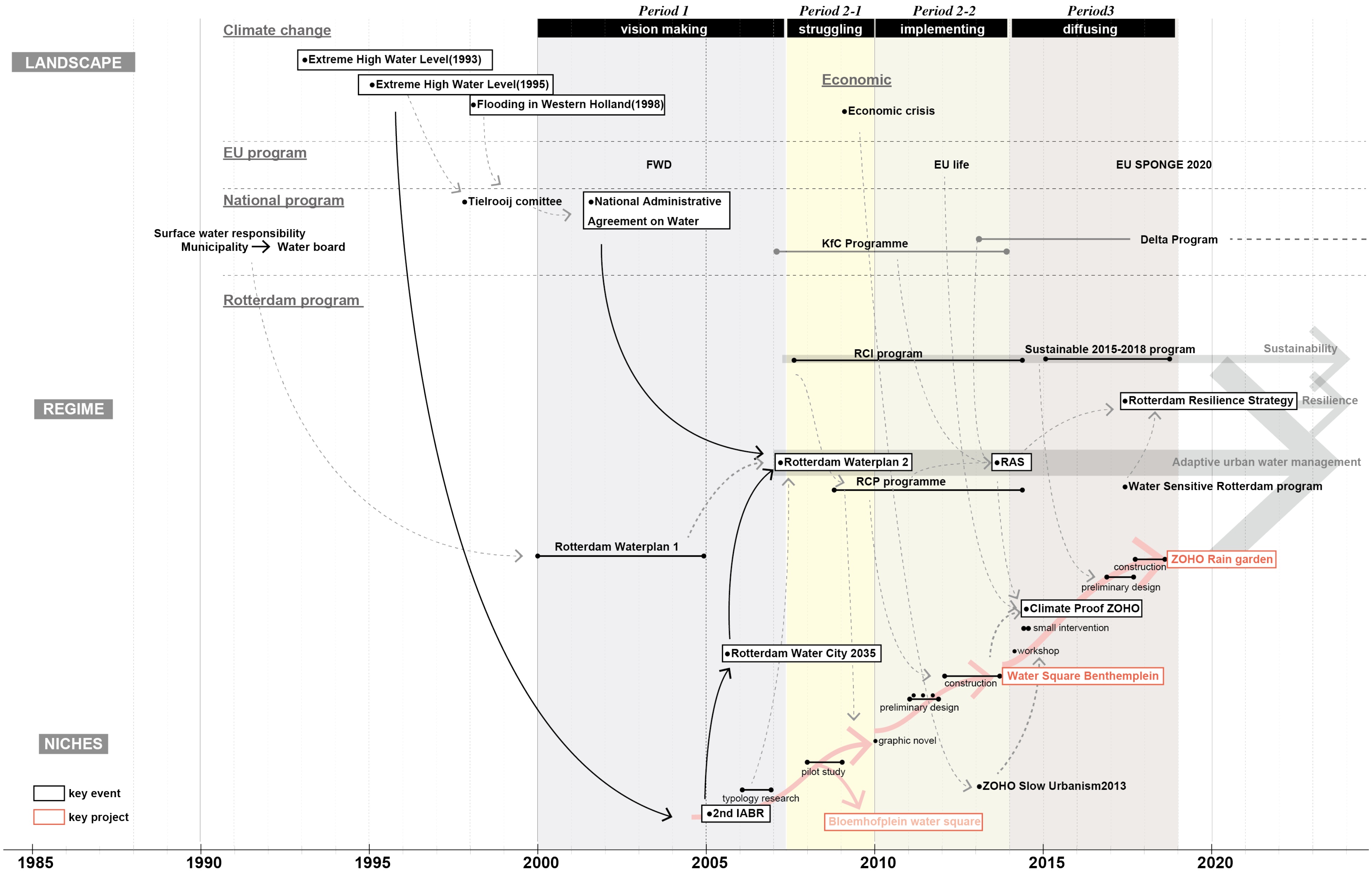


Figure 13 Timeline of transition in Rotterdam

4.2.1 Transition in policy level

Landscape, and regime fluctuation before start of transition

During the 1990s, several flood events encourage awareness on water issues and climate change in the Netherlands. Intense rainfalls in 1993 and 1995 had almost caused flooding in Maas river and Rhine river. Those events afterward required to reframe Delta works; national flood defense in Maas river and Rhine river basin. In addition, flooding happened in Western Holland in 1998, which "triggered parliamentary questions about the performance of the Dutch water system with respect to climate change" (Graaf and Brugge, 2010, pp.388). To deal with them, Tielrooij Committee was formulated. It argues that "the natural dynamics of the water system had been lost, and that this was the cause of many structural water management problems" (pp.212). Those discussion was realized as the 21st Century Water Policy Agreement. In 2003, National Administrative Agreement on Water (NBW) between the national government, the provinces, the municipalities and the water boards declared that Dutch water system needs to adjust to climate change by 2015. To reach its goal, Rotterdam was assigned to enlarge water retention capacity for more 600,000 m^3 by 2015 and 900,000 m^3 by 2050.

Policy innovation (2000-2007)

As mentioned in chapter 2, urban water management transition in Rotterdam has been analysed by several researchers. Graaf and Brugge (2010) analyze policy innovation in urban water management in Rotterdam. Their analysis shows how urban water management in Rotterdam and Netherlands had made huge turn from the 1990s because of increasing impacts of climate change. They especially emphasize the importance of a series of policy-related events; Second International Architectural Biennale Rotterdam (IABR) in 2005, its envisioning publication of *Rotterdam Water City 2035* in 2005, and an official policy of Rotterdam Waterplan 2 in 2007. This series represents how Rotterdam urban water management has started its transition from protected niche space; IABR 2005, to an official policy; Waterplan 2 Rotterdam.

IABR 2005 was a two-months exhibition in Rotterdam gathering knowledge and experiences in architecture, urbanism and landscape architecture. According to the exhibition catalogue (2005), the exhibition is intended to "make that tradition visible again and gauge its usefulness for the work that lies ahead" and "to demonstrate how the design acuity of architects, urban planners and landscape architects coupled with skills of hydraulic engineers can be used to tackle the interventions that water exacts without it being a burden, but sooner a unique opportunity to realize new landscapes, new cities and new buildings" (pp.8). It is important that this exhibition accommodated innovative ideas and insightful research for urban space that enable cities to adapt to a large amount of precipitation and to create attractive urban spaces. In the Water Cities section in IABR, several ideas of New Dutch Water Cities were proposed including Rotterdam Water City 2035. That part tried to show implications in sites in Rotterdam for future condition of the increasing volume of water. During the exhibition, physical model of Rotterdam was made to distribute spatial ideas for climate change adaptation and to show how the city would transform due to flood defense.

Rotterdam Water City 2035 played an important role in visioning the future of Rotterdam with water and in providing climate change adaptation strategies, such as water square. Especially, in relation to the water system embedded in the city, categorizing Rotterdam into three areas provides essential perspective on visioning the metropolis; river city, water network city, and canal city. Because of its non-official policy document, it was possible to work on cross-disciplinary collaboration, and to propose radical ideas and unusual long-term visioning (Graaf and Brugge, 2010).

In 2007, **Rotterdam Waterplan2**, official policy of city vision to 2030 with water, was published. This was a successor of Water Plan Rotterdam 2000-2005(Waterplan1), but included more insights on water potentiality for urban planning, legal necessity of integration with spatial planning and water management, and urgent significance of dealing with climate change impact. The structure of the document is facing problems, important principals of water, 2030 Rotterdam vision, strategies was on protection, clean water, attractive city, and sewers. By close linking with City Vision Rotterdam to 2030, this waterplan defined water as an essential role to improve urban attractiveness.

Graaf and Brugge (2010) regarded the path of Rotterdam water policy development as transition of urban water management thanks to the innovations in IABR, but the transition still had not completed, rather ongoing process at that time. This was because of lacking pilot project implementations, operations, and maintenances (Graaf and Brugge, 2010). In this period, however, urban water management in Rotterdam took a huge step to being adaptive to the impact of climate change by envisioning its direction. This transition resulted in the policy that put emphasis on not traditional Dutch style of dike reinforcement but on more adaptive water management. This is one of the reasons for definition of period 1 from 2000-2007.

Knowledge development and policy development (2008-2013)

After envisioning Waterplan 2 Rotterdam, three knowledge and policy development programs related to climate change adaptation in Rotterdam were taken place. One of them is Rotterdam Climate Proof program (RCP) (2008), a part of Rotterdam Climate Initiative (RCI). The other two programs that enhanced Rotterdam climate proof were national scale; the Knowledge for Climate research program (KfC) and the Delta Program.

Rotterdam Climate Change Adaptation Strategy(RAS) launched in 2013 by RCP, edition by the city of Rotterdam. This is an important achievement of RCP program because setting concrete strategy was "a vital step in the process of creating a climate proof Rotterdam" (strategy, pp.11). This is a guideline to become climate proof in area-specific way as well as framework of strategy for achieving robust system, adaptation, linkage, and adding values to the city (fig 14). Its basic foundation is scientific research conducted in RCP, KfC, and Delta Program and they were visualized clearly to bring necessary strategies.

Figure 14 Basic Scheme in RAS (source: RCI, 2013)

It defines four kinds of facing problems by climate change and set adaptation strategies for them in each site of Rotterdam. In terms of urban water management transition, one of the important things in this policy document is its emphasis not only on water issues, such as sea level rise and intense rainfall, but also on other types of extreme weather, such as drought and heatwave, to the same degree(fig, 15).

Official polity of Rotterdam Resilience Strategy launched by City of Rotterdam in 2016. In terms of climate adaptation, this official policy emphasizes RAS made huge contributions to this field by providing basis for how to deal with climate change impact and how to implementat projects. The research programs and implementations of climate change adaptation are also clearly included. This demonstrate that RAS made a huge contribution to defining the clear strategy of climate change adapation. In terms of transition, launching RAS in 2013 can be defined as a key moment of changing regime of urban water management from water-oriented to climate-proof oriented.

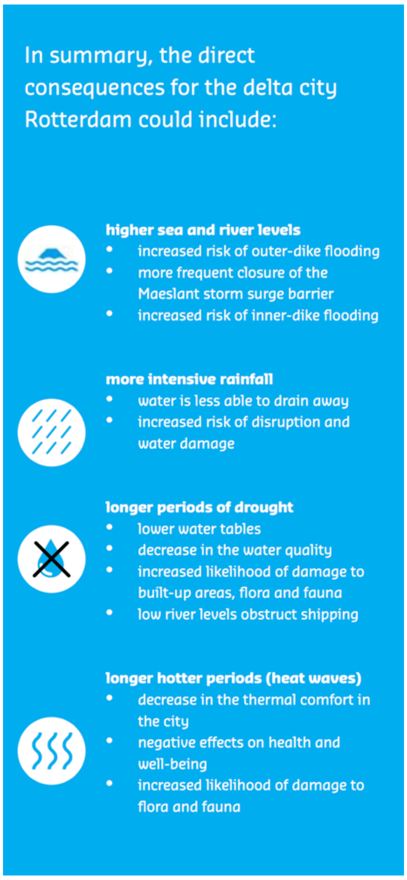


Figure 15 Four types of extreme weather Rotterdam faces (source: RCI, 2013)

BOX.1 knowledge development programs and collaboration platform

RCI (2007-2013) was set up as learning platform collaborated with the city of Rotterdam, Port authority, group of local employers, and the environmental protection agency. The aim is mitigation of climate change; to reduce CO2 emission in Rotterdam by 50% in 2025 compared with 1990. RCI realized increasing necessity to adapt to various risks caused by climate change and decided to work on new program (RCP) in 2008 to "build up the city's resilience to the impact of climate change"(pp.3), such as flooding, high temperature, or drought. This program was rectified by Rotterdam Council. The goal RCP set up was making Rotterdam climate-proof by 2025. Three pillars were set to realize such goal; developing knowledge, actions for implementing innovative pilots, and marketing communications to be a showcase for delta cities across the world. According to the report of RCP, successful results are reported in each pillar. In terms of knowledge, one of the most important achievements is publish of Rotterdam Climate Change Adaptation Strategy in 2013. This strategy defined the framework and principles for a future-proof development of Rotterdam. Not only this strategy, research on the issues in Rotterdam, instrument tools for climate change impact and international conferences were launched. Implementation section declares realization of innovative projects whose ideas were included in Rotterdam Water City 2035, such as multifunctional water square and green roof. Those implementations were embedded in Waterplan 2 Rotterdam. In the third pillar, international networks with delta cities were built up for knowledge export of climate change adaptation and for cooperative relationship.

National scientific research program, the **Knowledge for Climate program** (KfC) (2007-2014), was collaboration between the Dutch government, municipalities, the business community, water boards, and scientific research institutes. The objective was "timely and cost-effective climate proofing of the Netherlands, in an international context" (KfC, homepage). For Rotterdam, this program work as a basis for RCP program because Rotterdam was one of the national Hotspots in terms of climate change impact. This Hotspot was strategically chosen for making connection between knowledge and practical situation and provided financial support for research. According to RCP report, "[m]ost of the knowledge projects are included" in KfC program and international conference on delta cities was also organized together with KfC.

Delta Program (2010-) is a national program aiming at ensuring protection of the Netherlands from flooding, adaptations to climate change impacts, and fresh water supply. Every year, the program is carried out and updated by Delta Commissioner. Delta program, commission and its funding are legally constituted by the Delta Act. Under this program, the national government collaborates with provincial authorities, municipalities, water boards, companies, and knowledge institutes and civic-society organizations. Research in this national program provided insight into how vulnerable Rotterdam was and such measures were essential for making strategy of climate change adaptation (Rotterdam Climate Change Adaptation Strategy). Especially, sea level rising and increasing river flow would impact on outer-dike area in Rotterdam. Research in Delta program offered operation basis of Maeslant storm surge to optimize protection of flooding. Climate scenarios and delta scenarios in the Delta program were also adopted in the strategy as well.

After the RAS, **Water Sensitive Rotterdam** (2015-) was set up as a platform of climate change adaptation initiatives managed by management department of Rotterdam municipality. This program was established to diffuse small scale climate adaptation projects into bigger scale movement by connecting them. This program works not only for the platform of water sensitivity in Rotterdam but also for addressing local people working together and implementation.

Policy transition in Agniesebuurt

Water Square Benthemplein in Agniesebuurt opened in 2013. At the same time, RAS, which DE URBANISTEN deeply had been involved in, also was published. According to the interview of DE URBANISTEN, after the both key events in Rotterdam climate adaptation, they decided to enlarge the climate adaptation from project level to neighbourhood level; Zomerhofkwartier(ZOHO), southern part of Agniesebuurt. By collaborating with local entrepreneurs and Rotterdam municipality, they conducted research and implemented several practices based on the principal of RAS. The process and framework were organized and published in titled the **CLIMATE-PROOF ZOHO DISTRICT** (fig. 16), which aimed at climate proof in 2020. Thanks to the those efforts, municipality of Rotterdam receive a life + grant for implementation of climate proof of Agnieseburrt by European Union. This is a part of Urban Adapt Project to make Rotterdam climate proof and greener. The district now gains European grant SPONGE2020 to be100% climate-proof. It means that the district aims to manage all rainwater within the neighbourhood in coming years.

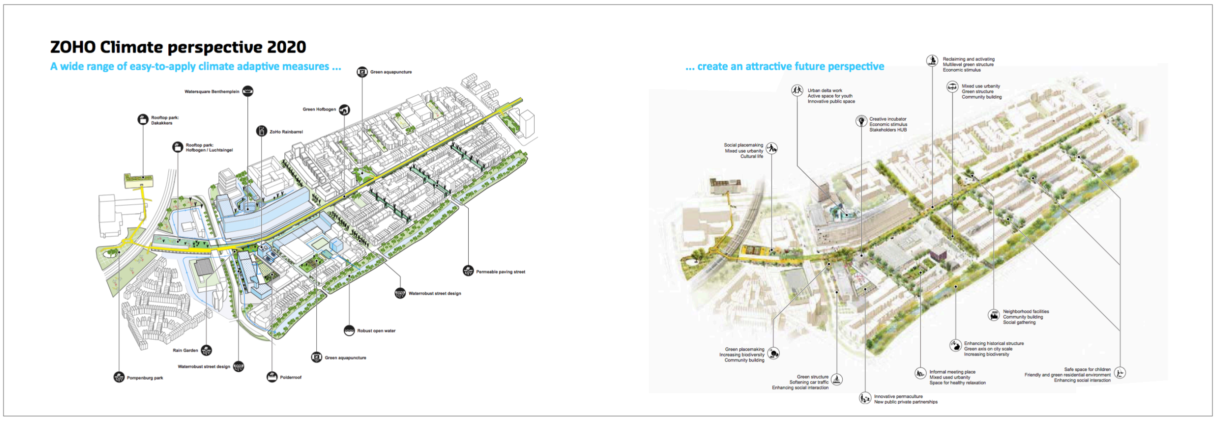


Figure 16 CLIMATE-PROOF ZOHO DISTRICT (Source: DE URBANISTEN, 2014-b)

Another key policy program enhancing climate-proof Agniesebuurt was **Sustainability 2015-2018 program** by Rotterdam municipality. This program aims at the implementation of a sustainable project within the city to increase awareness of sustainability concept with Rotterdam inhabitants. The program includes More Green program, aiming at increasing green especially in the central area of Rotterdam. HHSK, the district water board, applied ZOHO district to this program as a pilot climate-proof neighborhood and trying to enhancing outdoor space integrated with Waterplan 2 and RAS. By collaborating this program and gaining subsidy, ZOHO Raingarden, which is a part of CLIMATE-PROOF ZOHO DISTRICT, was realized in concrete urban space.

In terms of policy transition of urban water management in Agniesebuurt, movements occurred after realization of Benthemlplein and RAS in 2013. Envisioning CLIMATE-PROOF ZOHO DISTRICT with local initiatives is a representation of diffusion of transition from the water square to Agniesebuurt. Such vision worked with sustainability program and helped for the realization of ZOHO Raingarden.

4.2.2 Institution transition

Institution in urban water management is of importance for its governance. It is divided into formal and informal institutions. Formal institution is regulations and local rules. Informal institution is norm and value. Key institutional change for urban water management transition are picked up as follows.

Regulation

One of the key regulations in terms of urban water management transition is **National Administrative Agreement on Water (NBW)** in 2003. This national level agreement promises that urban areas should be protected from flooding more often than once every 100 years until 2015. Then, water authorities were required to calculate how much water needs to be storage in cities. This agreement obviously influenced on making Rotterdam waterplan2 by providing concrete amount of necessary extra water that each city was forced to retain. With regards to water quality, EU Water Framework Directive (WFD) (2000) set targets of ecological and chemical condition for the open water and subsurface water quality. NBW and WFD are mentions in times as a basic regulation Rotterdam needs to follow. This means that they are key drivers for envisioning in period1.

Rotterdam Waterplan 2 includes rules for implementation of its policy to its goal 2030. It is prioritization and phasing rules which address 2007-2012 implementation program. It was decided based on the urgency of implementation due to the necessity to meet NBW and WFD. In this context, Rotterdam needed to make extra 600,000 m3 water storage in the city by 2015. the policy distributed certain amount of retention water capacity into each neighborhood.

In waterplan 2, organization framework and collaboration of water-related issues for implementation are also mentioned. Before the plan, municipality and water boards work together for spatial plan and water management investment in the context of Rotterdam Waterplan 1. In Rotterdam Waterplan 2, two essential department of urban development were added to the working group in urban water management; Urban Planning and Housing Department (dS+V) and Rotterdam Develop corporation (OBR). This made it easy to integrate water management project with urban development.

Basic financial agreement between Dutch water-related parties and European Union is also mentioned in Rotterdam Waterplan 2. Basic principal is “the task owner pays”. For allocation of the cost, identification of the objectives the intervention would provide is an essential basis. To meet NBW, the water boards is responsible for the increase of water storage and it needed to joint with spatial development. The waterplan 2 recommends such all joint financing parties are involved as project teams from the very beginning. Not only intervention projects but also research and analysis on water issues also are also basically financed by municipality and district water boards in certain ratio.

Therefore, enactment of Waterplan2 Rotterdam in 2007was a key institutional change for urban water management. Especially, the distribution of extra water capacity was crucial for conducting implementations that would advance transition in progress.

Norm and value

Dunn, et al., 2017 visualize the basic events of Rotterdam urban water management transition (fig 17) and they argue the transition of urban water management developed with interaction of policy and scientific knowledge development. As their research shows, Rotterdam urban water management has updated their norm of what to solve and where to go.

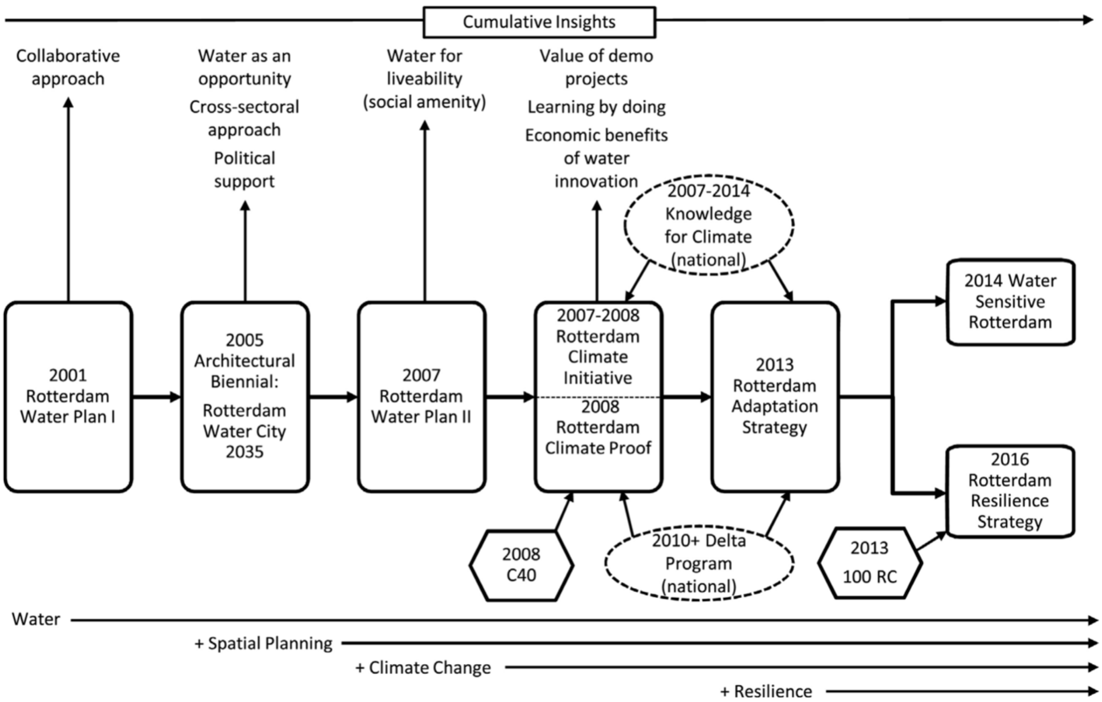


Figure 17 Key events in urban water transition in Rotterdam (source: Dunn, et al., 2017)

For instance, climate change became a facing problem in the Netherlands from 1990s. However, water became not a problem, but opportunity to work together with spatial planning in Waterplan 2. According to the interviewees from municipality, that was eye opening moment in urban water management. Waterplan 2 Rotterdam declered water took an essential role in increasing attractive in the city. Through knowledge development programs, water issue become one of the adaptation problems of extreme weather because of the climate change. As the diagram by G. Dunn, et al., (2017) shows, scientific knowledge programs (2008-2013) cultivated view of what Rotterdam is facing and their goal as a norm and organized as RAS. In this view, key transition moment of norm is Waterplan2 Rotterdam (2007) and RAS(2013).

However, the norm and value of the government and professional level is not always the same as citizen level. For instance, even though water square is an innovative and fascinating idea for Rotterdam municipality, the first attempt in Bloemhofplein in Rotterdam Zuid was failed in 2009 because the most of local neighbors disagreed with the idea (interviewees). On the other hand, people from Benthemplein had a positive attitude to the new water square and joined the design process actively in 2011-2013(interviewees). In other words, success in implementation with local people can represent the transition of local norm. In this context, realization of Water Square Benthemplein in 2013 and enlarged the scale of climate adaptation project with local initiative into ZOHO shows the sign of local norm transition. This is one reason for dividing period 2 into two periods.

4.2.3 Technological transition

Climate change adaptation requires realization of multifunctional space in densified urban space, such as in Rotterdam. To understand the process of technological development of such space, this study focuses on the path that idea of water square went through from IABR to being realized in Agniesebuurt and on the path of raingarden went through in ZOHO.

Water Square Benthemplein

The basic principle of water square is multifunctional space that can retain rain water when it is rain and can be used for public open space for people in a dry period. More precisely, technologies are needed for gathering rain water from surrounding area, for retaining it in open space, and for discharging it in certain period of time into ground or open water, such as singels or rivers. In addition, such water system needs to be integrated with public space.

The first idea of water square was elaborated for IABR 2005. It was product-oriented or visual-oriented at that time. Rotterdam Waterstad 2035 (2005) showed 10 sample types of water square, water system diagrams, and graphic image of its philosophy in case applying it into Rotterdam (fig 18, 19). To put the idea into the part of official policy of Waterplan 2, typological research on water square in some concrete squares within Rotterdam was conducted (DE URBANISTEN, 2010). The principal of water square; combining water retention space and public space, elaborated into varieties applicable to urban space typology. At this time, the typologies became more detailly elaborated into not only squares but also streets or pavements(DE URBANISTEN, 2010). It includes contextual research of Rotterdam, trying to visualize applicable and suitable place within Rotterdam. In the Waterplan 2 Rotterdam, the typological research is included.

Figure 19 Image of water square (source: Layout, 2007)

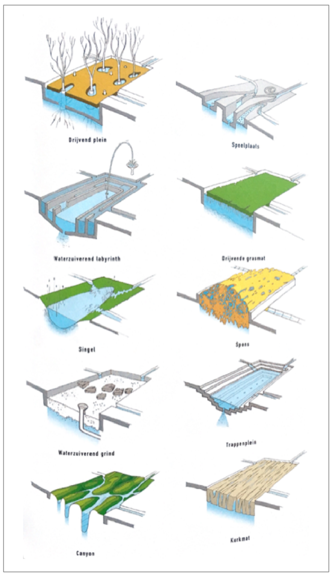


Figure 18 Rotterdam Watercity 2035 (source: Gemeente Rotterdam, et al, 2005)

Municipality of Rotterdam chose Bloemhofplein in Rotterdam Zuid as a first pilot water square although it was not implemented during 2007 to 2008 (interviewees). However, the drawings for this project (fig20, fig 21) shows how well-developed the water system in technological point of view was to an operation-able level and also to integration with park programs in public space.

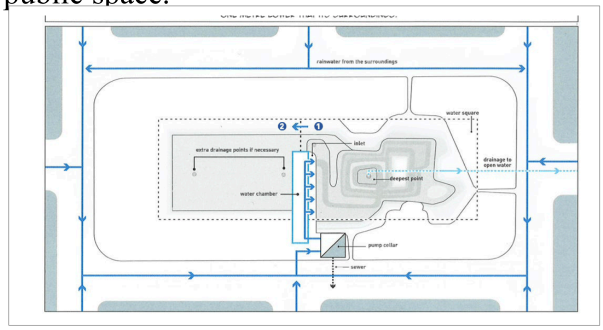


Figure 20 Water system in Bloemhofplein (Souece: DE URBANISTEN, 2010)

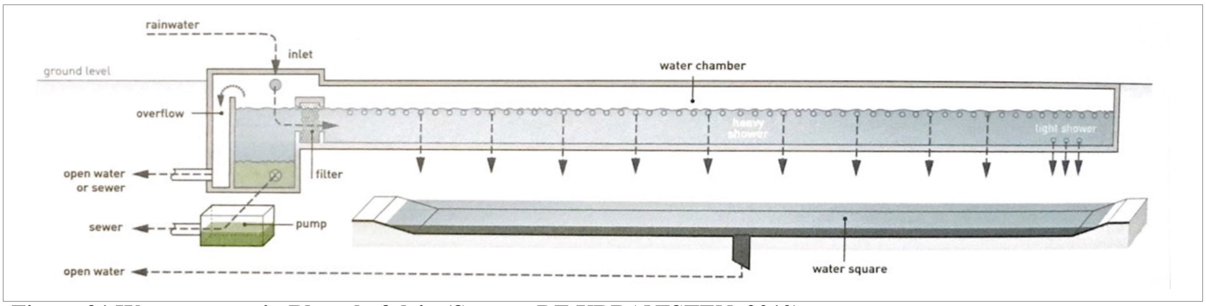


Figure 21 Water system in Bloemhofplein (Souece: DE URBANISTEN, 2010)

After the project of Bloemhofplein, Rotterdam municipality collaborated with DE URBANISTEN to realize water square in another plaza in Rotterdam; Benthemplein in Agniesebuurt. Through intensive workshops with stakeholders in 2011-2012, idea of water square was developed to integrate rain water retention and public square activities that neighbors wanted. As a result, in 2013, Water Square Benthemplein opened and started working as a rainwater retention basin as well as public space for the neighbourhood. The square collects storm water from surrounding buildings' roofs, streets, and neighborhood. Detail water system is explained in the next chapter

The idea of water square was conceptualized and developed with typology research until 2007. To operationalize it, the technology had been developed in the period of 2008-2010. The technology succeeded implementing in 2013. This is the trail and time period of technological transition happened.

ZOHO Rai garden

Compared with the idea of water square, ZOHO Raingarden had been developed locally with workshop and experiments. ZOHO Raingarden is composed of two water management technologies; rain garden and rain barrel. Rain garden works as a greenery garden in dry period as well as a rain water retention pool when it is rain. The retained water infiltrates into ground in certain period of time. Rain barrel is a retention tank of rain water from surrounding areas or roofs by connecting drainage pipes and is used for watering the garden when it is dry. Both technologies were not innovated for this project but elaborated through bottom-up process from 2014.

The first workshop for climate adaptation in ZOHO was in 2014 to create joint perspective. The workshop used the principles developed in RAS to evaluate each idea (DE URBANISTEN, 2014-a). Basic ideas participants came up with were illustrated in the workshop report; Hofbogen Ground Zero, ZoHo Buitenplaats, De-paving and greening, ZoHo Rain barrel(fig 22). Hofbogen is an elevated train truck without operation characterizing Aguniesebuurt as a main structure. It was under construction for new development and ideas of utilizing this structure for greening and system of rain water gathering were proposed during the workshop (fig 23). The de-pavement idea was come from in this workshop. Rain barrel idea came from team with Bas Sala who implemented variety of rain barrels after this workshop (interviewee).

Figure 22 proposed strategy in Workshop (source: DE URBANISTEN, 2014)

Figure 23 Ideas from workshop (source: DE URBANISTEN, 2014-a)

After the workshop, several pilot implementations were conducted. The small pop-up ZOHO Raingarden (fig24) was built in 2014 within two days by de-paving two parking spaces and sidewalk that was turned into a small garden in the north part of current ZOHO Raingarden(DE URBANISTEN, 2014-b). To gather rain water from Hofbogen roof, a drainage pipe was cut to drain into the garden. At the same time, Studio Bas Sala designed a rain barrel in ZOHO area which enabled people to retain rain water in a tank in intense rainfall and to use the retention water in dry period (fig 22).

Figure 24 pop up garden (source: DE URBANISTEN, 2014-b)

Figure 25 Rain barrel idea(source: DE URBANISTEN, 2014-b)

DE URBANISTEN put the bigger-scale design of ZOHO Raingarden in CLIMATE-PROOF ZOHO DISTRICT which visualize possible water system and gardening scheme in detail. In addition, because the site was entrance point of ZOHO district as well as was next to a car parking building, DE URBANISTEN took into account the integration of the raingarden with traffic, biking and walking systems (fig 26, 27).

Figure 26 Proposed water system by DE URBANISTEN (source: DE URBANISTEN, 2014-b)

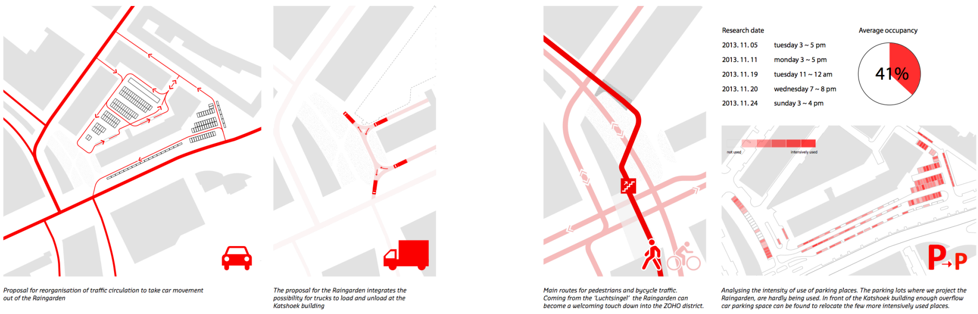


Figure 27 traffic system research in ZOHO (source: DE URBANISTEN, 2014-b)

After Rotterdam municipality decided subsidy for improvement of outdoor space in this district, municipality designed ZOHO Raingarden by themselves in 2016-2017. The garden gathers rain water from Hofbongen in the north pipe as the small pop up garden. In the south of the garden, Studio Bas Sala designed ZOHO letter as an icon of the district as well as rain barrels gathering water from Hofbangen as well. To make this raingarden work, balanced selection of plants and soil was essential. Because rain water kept in the garden would worsen plants' condition, planted greens need to be durable in such wet condition. In addition, the soil in the garden needs to be permeable for discharging rain water for at least one day to prevent growth of mosquitos. Hence, the plants need to be durable to drought due to such soil's permeability. Because of such difficulty, the municipality dig an additional hole in the garden for enhancing discharge after realization in 2018.

In terms of transition, technology development of ZOHO Raingarden started from first workshop in 2014 and reached to implementation in 2018. Although local initiatives and DE URBANISTEN engaged in experiments in first phase, the process was quite smooth compared to water square. Realization of ZOHO Raingarden represents that not only water square but such a different type of adaptive urban water system can be implemented in this period.

4.2.4 Transition of Behavior

As literature review section explains, transition of urban water management to being adaptive to climate change needs to change local people's participation. In the project of water square in Bloemhofplein, municipality and landscape architectual firm did not have workshop for participatory design and failed (interviewee). In the design process of Water Square Benthemplein, project team succeeded in gathering local stakeholders and worked tto develop the water square design together (interviewee). This can be said that transition of people's behaviour occurred in this period.

The development phase of ClIMATE PROOF ZOHO DISTRICT also shows a lot of local initiatives's participation (DE URBANISTEN, 2014-a). Their active involvement was essential for the visioning (interviewee). In addition, conducting pop-up garden as an experiment was iconic because participants built it without any governmental budget(fig 28) (DE URBANISTEN, 2014-b). This represents people's active involvement not only design on paper but also implementation level.

Figure 28 planting pop up garden (source: DE URBANISTEN, 2014-b)

However, interviewee from DE URBANISTEN mentions that it is still under development. He mentions that even though ZOHO district has been improved by local initiatives from urban water management point of view, those initiatives are still small group of initiatives in agniesebuurt district. In addition, another interviewee from municipality mentioned that they met with some opporsition from residents about climate proofing of whole agniesebuurt area by sewage pipe improvement and by increasing infiltration area as rain garden is. To achieve the goal, it is important for municipality to work with residents. Nevertheless, not all of them have a positive attitude on the plan (interviewee). Transition of behaviour is limited in 2018.

4.2.5 definition of periods in Transition.

Because of the impacts from climate change, urban water management in Rotterdam has transformed into being adaptive to extreme weather from 2000 to 2018. Based on the discussion above about transition in policy, institution, technology and behaviour, this paper defines 4 periods from 2000 to 2018 as summerized as the introduction of this chapter 4.2. Analysis on them shows that the transition in Rotterdam and Agniesebuurt is divided into four periods.

The period 1 (2000-2007) is the first important transition of Rotterdam urban water management for envisioning its direction. From 2000, Rotterdam municipality started collaborating district water boards to enhance quality of surface water with the city. As a result of niche innovation from IABR and Rotterdam Watercity 2035, as well as large scale institutional framework of NBW, Waterplan2 Rotterdam was enacted in 2007. Waterplan2 Rotterdam is the first official policy as well as formal institution that envision adaptive urban water management by creating retention capacity of water within the city. During this period, the idea of water square was conceptualized in IABR and developed.

The period 2 (2008-2013) is the phase for implementation of pilot projects as well as for development of concrete adaptation strategy for climate change in Rotterdam. Because Rotterdam municipality promoted water square, realization of the first large water square in Benthemplein in 2013 was a key moment. Additionally, RAS was also launched in the same year, which shows the key period of urban water management transition in Rotterdam. RAS enlarged institution of its focus from on water-issue to drought and heat iseland phenomenon. In relation to the technological development of water square, the period 2 is divided into two periods; 2008-2010(period 2-1), and 2011-2013(period 2-2). In the first half, municipality tried to implement the idea of water square in Bloenhofplein in Rotterdam, but they faced resistance from local residents and and stoped. No participation style was planed in this project. This period shows how the innovative idea from niche level grow up to the main streams but the idea was still not always accepted by local residents in Rotterdam. In 2011-2013, Rotterdam municipality and DE URBANISTEN worked on Benthemplein together with active local neighbors. The local stakeholders were supportive to the idea and three participatory workshops adjust the idea into concrete local context and reflect their needs to the square design. Finally, the water square was open in 2013.

In the period 3 (2014-2018), Rotterdam succeeded in diffusing climate adaptation in concrete urban space into neighbourhood scale. After realization of Water Square Benthemplein and RAS, scope of such climate adaptation was enlarged to neighborhood scale with the scheme of RAS in ZOHO district. With help of other public programs, the municipality realized a raingarden in 2018 as a part of CLIMATE PROOF ZOHO DISTRICT vision. This process from 2014 to 2018 was deeply elaborated by local entrepreneurs and initiatives who were willing to be involved in the climate adaptation and urban space improvements. Urban water management transition in Rotterdam made a progress in each of four periods through policy changes, institutional change, technological development and behaviour of local people to the climate change adaptation.

4.3 Evaluation of Spatial Solution

Basic data of Water Square Benthemplein and ZOHO Raingarden is as follows. Each indicator of spatial solution is scored 0-5.

	Water Square Benthemplein	*ZOHO Raingarden*
Activity	**PLAIN:** playing sports in the field, skateboarding in slope, community events, sitting in stairs or benches	**GARDEN:** passing through the greenery on foot, by biking or cars
Water system	gather rain water from surround buildings, block and streets, retain certain period of time and discharge to north singel or ground	gather rain water from Hofbogen, retain in the garden and infiltration into ground water, some of water is kept in barrel
space design	DE URBANISTEN	Municipality of Rotterdam
Year	2013	2017
Total area	9.500 m2 (incl. street and parking) square: 5.500 m2	4.070m2 (incl. street and parking) garden :1.410m2

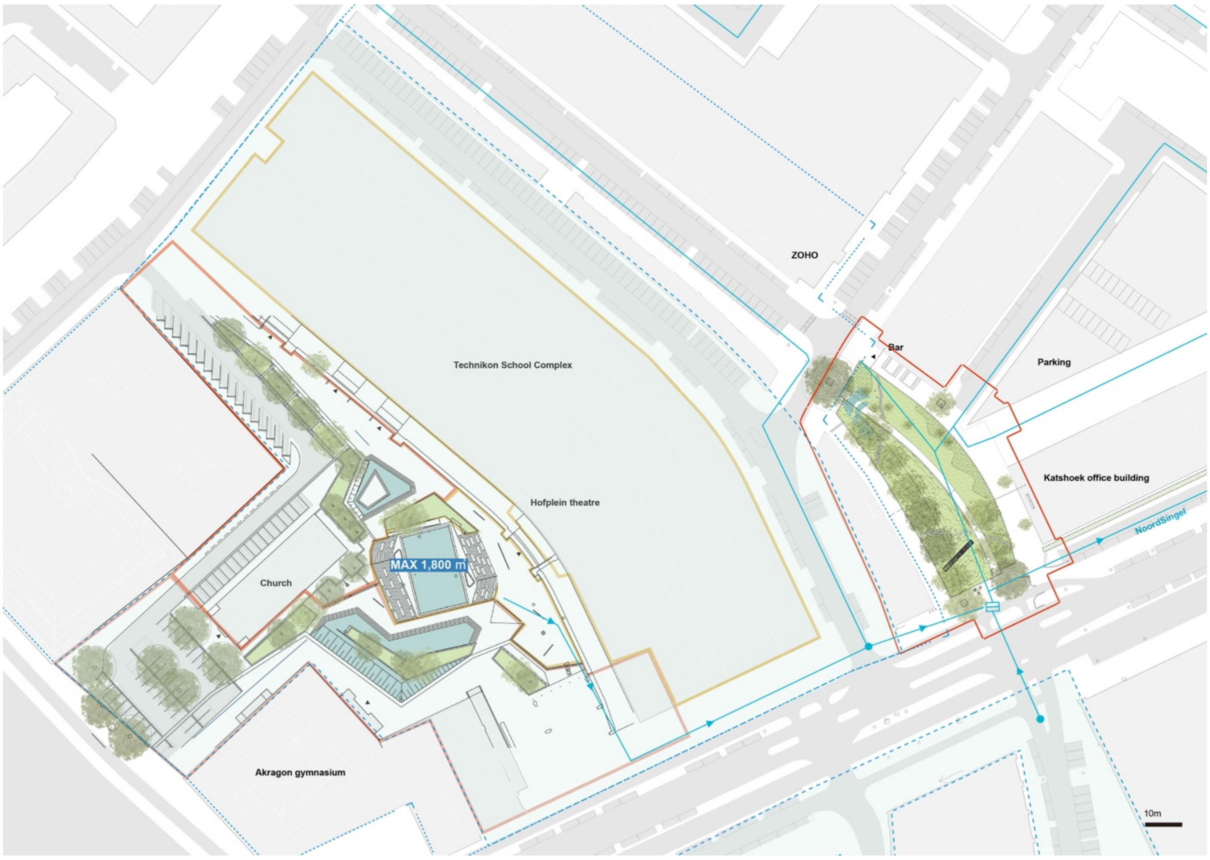


Figure 29 Plan of the two sites (source: author)

4.3.1 Water retention capacity

Water Square Benthemplein

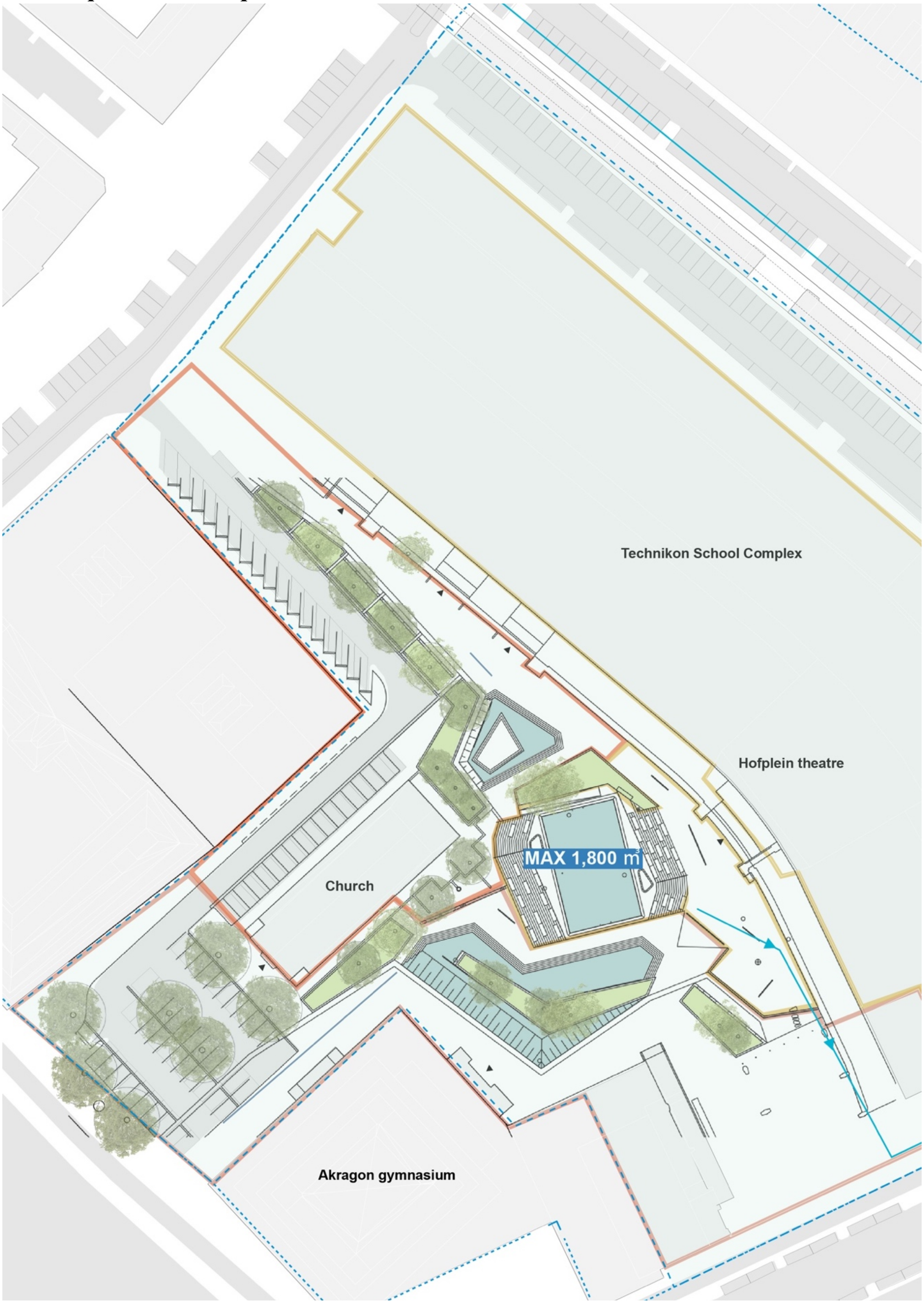
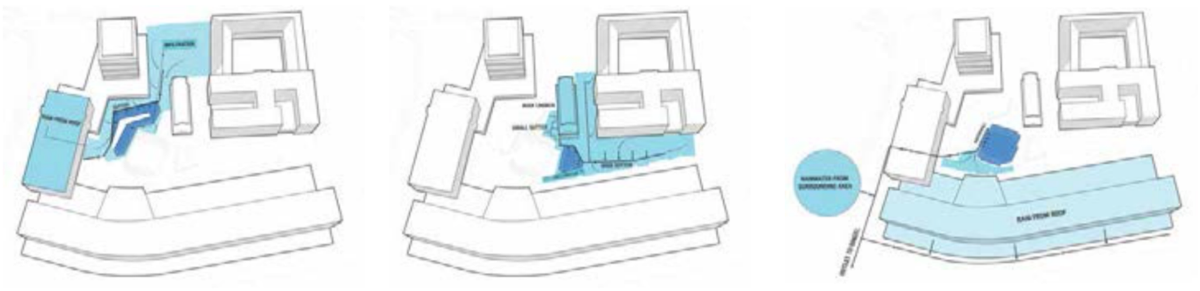


Figure 30 plan of Water Square Benthemplein (source:author)

There are three rain basins in Water Square Benthemplein and they work in different ways(fig31). Two boomerang-shape ponds gather precipitation from surround roof and streets (area in orange) and discharge slowly into ground. The biggest basin in the center with a basket court retains rain water from Zadkine school roof and surround neighborhoods (area in yellow) and discharges it to Noord Singel. The water of the central basis discharge into the singe after a maximum of 36 hours to ensure public health. Total amount of water for retention is 18,000m3.



Catchment area of basin 1 *Catchment area of basin 2* *Catchment area of basin 3*

Figure 31 water system in Water Square Benthemplein (Source: DE URBANISTEN,2014-c)

By creating new temporary ponds to retain storm water, impact on sewage system and risk of mix waste water overflow was reduced. Not only basis, but channels for rain water are designed to represents its flow to users. This was intended to make people enjoy water itself as well as to increase awareness that this square(DE URBANISTEN, 2014-c)

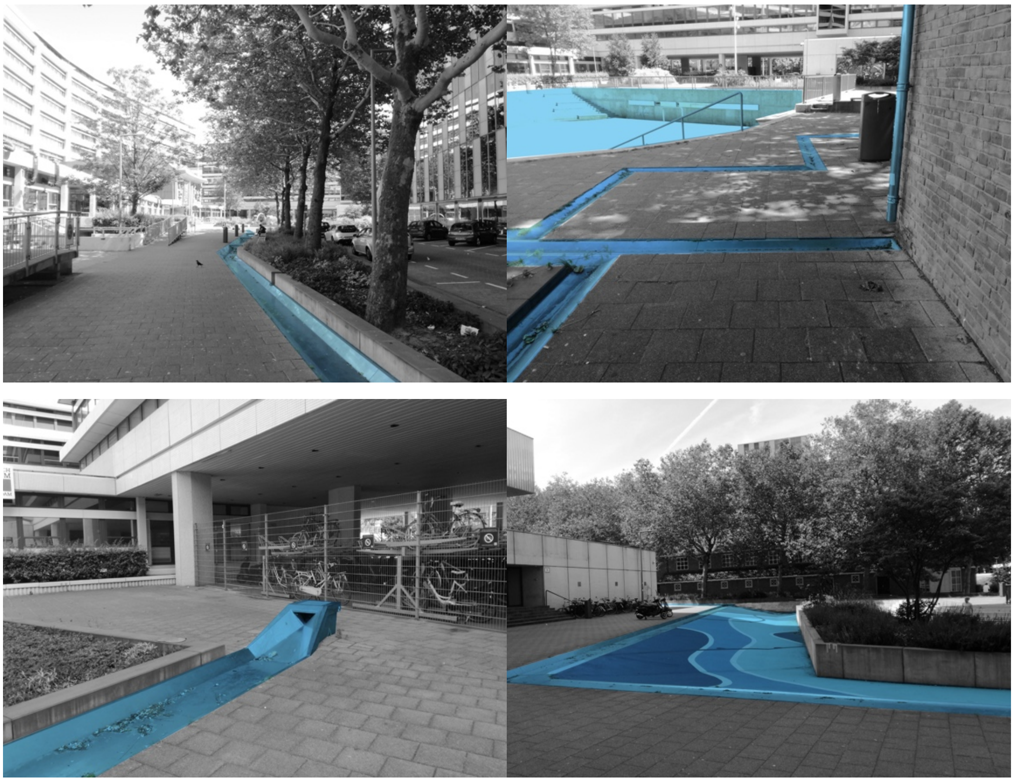


Figure 32 water system in the plein (source: author)

ZOHO Raingarden

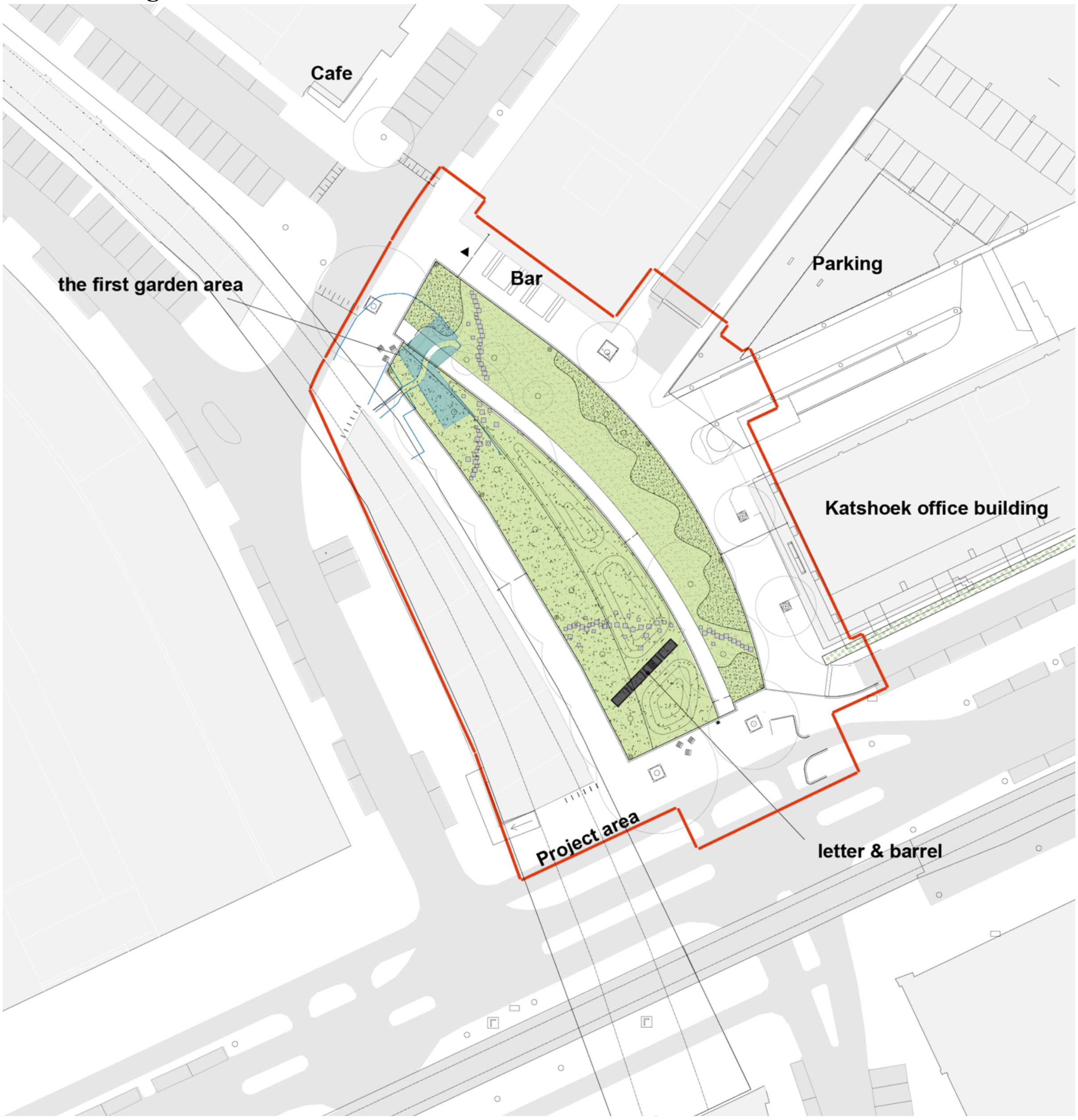


Figure 33 Plan of ZOHO Raingarden (source: Author)

ZOHO Raingarden gathers rain water mainly from Hofbogen, former elevated railway truck that is now converted into a flower shop and green roof. There are two discharge pipes along with the garden and northern pipe discharges storm water into the west part of garden. The garden has a small hollow to retain water for about one day. ZOHO letter in the south of garden was designed by Studio Bas Sala. This letter is intended to show the entrance of the district as well as to hold retention tank inside the letter and retained rainwater used for green maintenance. Fig 34 diagram shows how it works. Inside of the garden works for infiltration of rainwater into ground. Estimated retention capacity in the hollow and tank is 180m3.

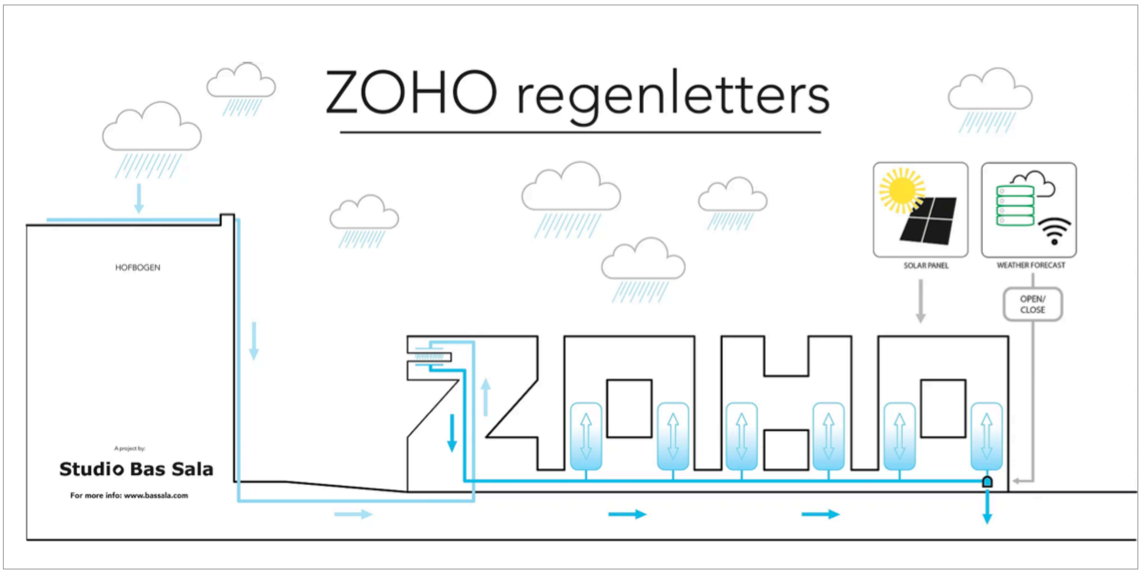


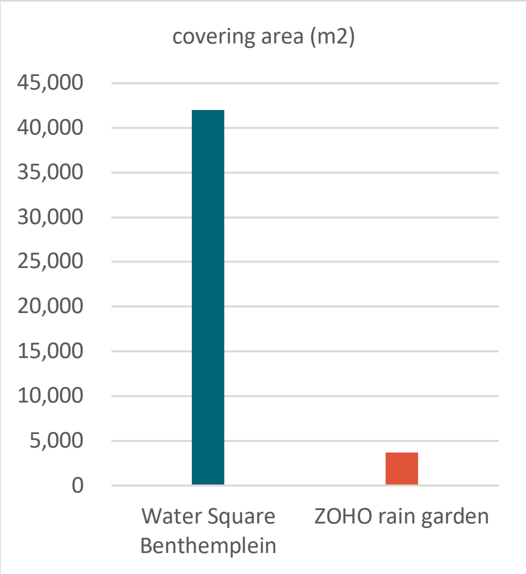
Figure 34 Water system in the ZOHO letters by Studio Bas Sala (source: Studio Bas Sala, 2019)

Figure 35 site photos (source: author)

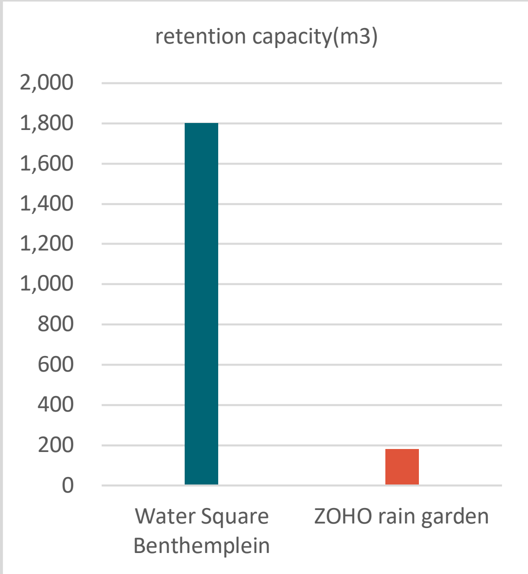
Evaluation of hydraulic effectiveness

To evaluate hydraulic effectiveness in each site, a following simple formula is adopted. Retention capacity and covering area from where each project gather storm water are essential to reduce the risk of flooding. For comparing analysis, the hydraulic effectiveness score in Water Square Benthemplein put five. Then, the score of ZOHO Raingarden is relatively decided based on that.

$$\text{hydraulic effectiveness} = \frac{\text{retaintion capacity} \times \text{covering area}}{\text{project area(=project scale)}}$$



graph 1 covering area



graph 2 water retention capacity

Table 7 result of hydraulic effectiveness

	Water Square Benthemplein	*ZOHO Raingarden*
retention capacity(m3)	1,800	180
covering area (m2)	42,000	3,650
project area (m2)	9,500	4,070
hydraulic Effectiveness	5	0.10

4.3.2 Ecological robustness

Water Square Benthemplein

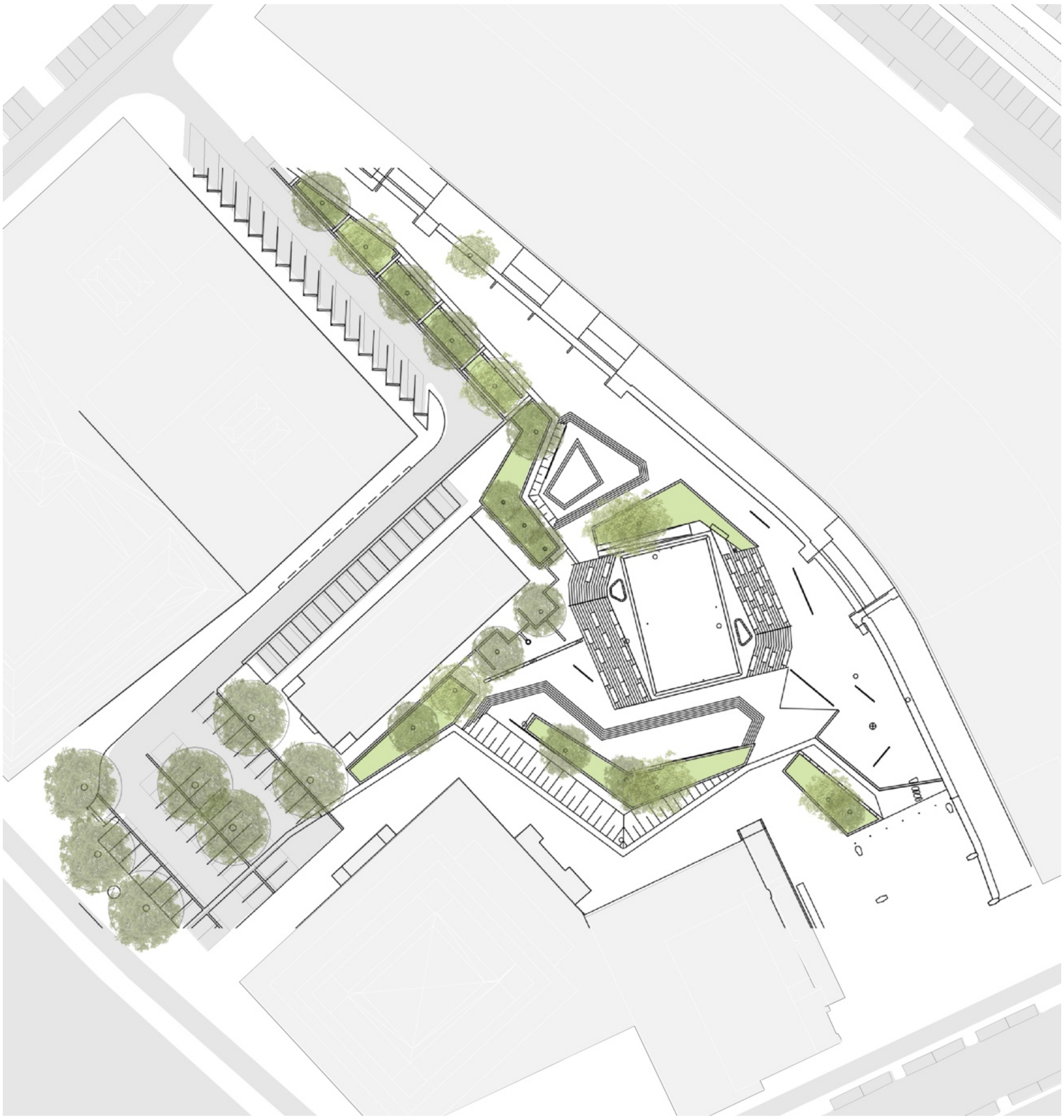


Figure 36 plan of green in Benthemplein (source: author)

Figure 37 photo of green in the Benthenplein (source: author)

There are five linear-shape plants area integrated with water basis and streets in the park. Because the square was mainly designed for outdoor activities, green materials area is relatively limited compared to water basin. Landscape designer DE URBANISTEN plan the distribution of plants and flowers based on the exposure of each place, height of plants and color schemes (fig. 38). The green areas are not integrated with water retention system but more works for aesthetics.

beplantingsplan *samenstelling, opbouw en soortkeuze van de centrale plantvakken*

Figure 38 plants planning (source: DE URBANISTEN, 2014-c)

ZOHO Rain garden

Figure 39 plan of green in ZOHO Rain garden (source: author)

Figure 40 photo of green and maintenance in ZOHO Raingarden (source: author)

As its name, ZOHO Raingarden was planned to work as a garden as well as retention of rain water. A large amount of green space, which is more than double of that in Benthemplein, was built thanks to the project. In the planning phase, planners intended the place as a garden rather than wadi, which also works for water retention with plain grass.

According to the maintenance worker and project developer's interviews, the rain garden, however, required more professional efforts on maintenance. One of the reasons is that water kept in the garden would worsen plants' condition. Another reason is a difficulty in balancing permeability of soil and plants. On the one hand, the soil in the garden needs to be permeable for discharging rain water for at least one day to prevent growth of mosquitos. On the other hands the plants need to be durable to drought due to the soil's permeability. These difficulties show the garden requires special maintenance compared to other public green in Rotterdam.

Currently, it is maintained by local botanist group. Rotterdam offer unique administrative system to communicate with citizen for their work. Municipality receives citizen's opinion on their work and then if possible, citizen can take over the municipality's duty in the same salary as municipality workers does. Marja Versteeg from Stadskwekerij De Kas knew this system and was willing to take over maintenance as a professional botanist. The municipality decided to consign the maintenance of this raingarden to this local botanist initiative because of its win-win relationship. As a result, the raingarden, works well thanks to the professional' maintenance.

Evaluation of ecological vulnerability

Ecological robustness is essential for climate proof of the site. However, to evaluate it, this paper adopts ecological vulnerability because the concept is suitable for "[s]ocio-ecological system analysis when a loss of recovery is a consideration" (Mumby, et al., 2014). Vulnerability is assessed based on three indicators; exposure, sensitivity, and adaptive capacity. To what each site is exposed is extreme rainfall, drought and heatwave in terms of climate change. In this paper, both sites are so close to each other that the exposure has the same value. According to McCarthy, et al., (2001), sensitivity is defined as "the degree to which a system is affected, either adversely or beneficially, by climate related stimuli (pp.982). In this study, shaded area, land cover, each site's permeability are essential for the site's ecosystem. Adaptive capacity is "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (McCarthy, et al., 2001, pp.982). In this paper, water retention capacity, amount of greens, maintenance frequency, and preparation for extreme weather.

$$\text{ecological vulnerability} = \text{exposure} \times \text{sensitivity} \times \text{adaptive capacity}$$

To assess vulnerability, the formula (Fritzsche, et al,. 2014, pp.110) is used to score 0-1 in each indicator.

Formula 1:

$$X_{i,\,0\ to\ 1} = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

where

X_i represents the individual data point to be transformed,

X_{Min} the lowest value for that indicator,

X_{Max} the highest value for that indicator, and

$X_{i,0\ to 1}$ the new value you wish to calculate, i.e. the normalised data point within the range of 0 to 1.

Figure 41 culculation formula (source: Fritzsche, et al,. 2014)

Figure 42 map of shadow by tree (source: DE URBANISTEN, 2014-b)

Table 8 basic area data

	Water Square Benthemplein	*ZOHO Raingarden*
green material area (m2)	620	1265
shaded area (m2)	6300	3130
permeable area(m2)	9310	1265

Table 9 result of sensitivity and adaptive capacity indicator in Water Square Benthemplein

	Water Square Benthemplein							
	Sensitivity Indicators	*Description*	*Data Sources*	*Unit*	*Measurement*	*Min*	*Max*	*0-1*
sensitivity	pavement and green(land cover)	Percentage of unpavement in the site	observation, planning document	percentage (%)	31	0	100	0.31
	shaded area by tree	percentage of unshaded area	document by DE URBNIISTEN	percentage (%)	23	0	100	0.23
	permeability	Percentage of area where precipitation goes into sewage	planning documents	percentage (%)	10	0	100	0.10
adaptive capacity	maintenance frequency (institution)	how often the maintenance is conducted	interview	times	3	0.5	4	0.71
	water retaintion capacity (technology)	how much the area can retain water	planning documents	m3	3	1	5	0.50
	preparation for extreme weather (institution)	whether prepartion of water or maintenance rules exsit	interview, observation	number of methods	4	1	5	0.75
	amount of green area	percentage of green in the site	observation	percentage (%)	1265	0	2000	0.63

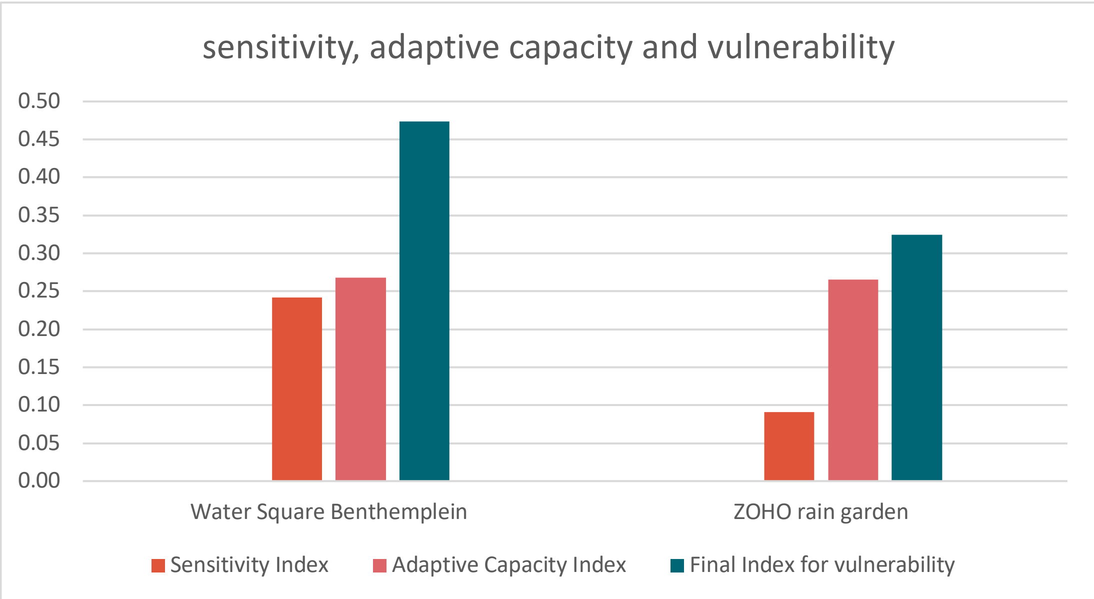
Table 10 result of sensitivity and adaptive capacity indicator in ZOHO Raingarden

	ZOHO Raingarden							
	Sensitivity Indicators	***Description***	***Data Sources***	***Unit***	***Measurement***	***Min***	***Max***	***0-1***
sensitivity	pavement and green(land cover)	Percentage of unpavement in the site	observation, planning document		93	0	100	0.93
	unshaded area by tree	percentage of unshaded area	document by DE URBNIISTEN		40	0	100	0.40
	permeability	Percentage of area where precipitation goes into ground	planning documents		12	0	100	0.12
adaptive capacity	maintenance frequency	how often the maintenance is conducted	interview		2	0.5	4	0.43
	water retention capacity	how much the area can retain water	planning documents		4	1	5	0.75
	preparation for extreme weather	whether prepartion of water or maintenance rules exsit	interview, observation		3	1	5	0.50
	amount of green area	how much the area has green area	observation		620	0	2000	0.31

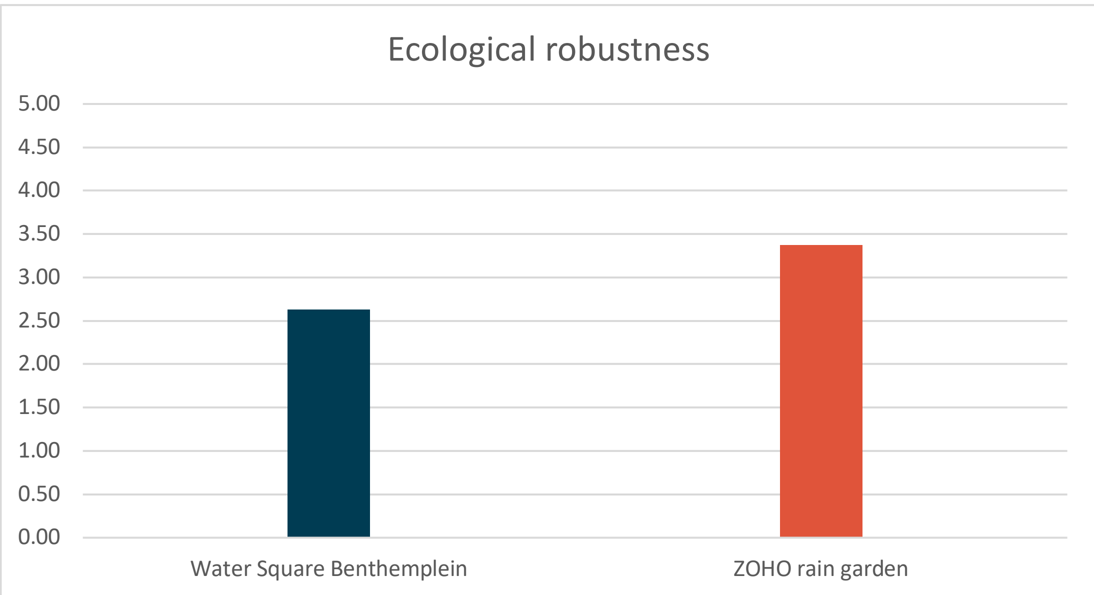
Final results are followings. Final ecological robustness is scored as a following formula. Ecological robustness = 5*(1-final vulnerability index)

Table 11 final scores of index for ecological robustness

	Water Square Benthemplein	*ZOHO Raingarden*
Exposure Index	-	-
Sensitivity Index	0.24	0.09
Adaptive Capacity Index	0.27	0.27
Final Index for vulnerability	0.47	0.32
Ecological robustness	2.63	3.38



graph 3 index of sensitivity, adaptive capacity and vulnerability



graph 4 result of ecological robustness

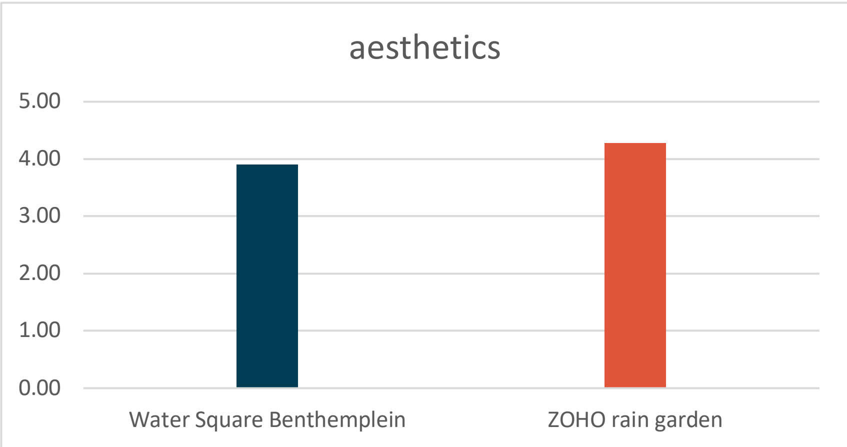
4.3.3 Aesthetics and Cultural meaning

Aesthetics

Aesthetics and cultural meaning of space is quality that is hardly quantified. In this study, scores are based on the spatial design experts' interviews. Most of interviewees put high score in both projects.

Table 12 result of aesthetics score

Water Square Benthemplein		*ZOHO Rain garden*	
expert1	4	expert1	5
expert2	4	expert2	5
expert3	4	expert3	4.4
expert4	4.5	expert4	4
expert5	3	expert5	3
aesthetics	3.90	**aesthetics**	4.28



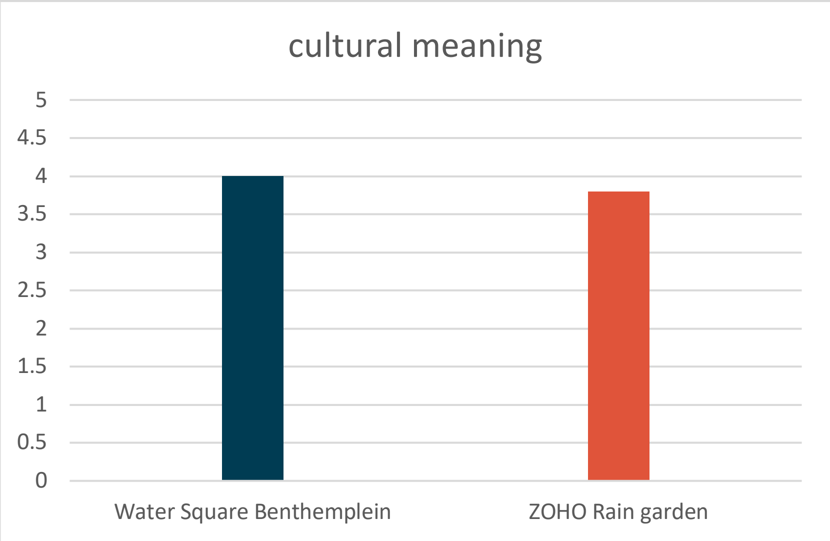
graph 5 result of aesthetics score

Cultural meaning

Cultural meaning in this case is defined as an evaluation of how well the multifunctional space works for users around the area. This is also based on the experts' interviews and users' opinions.

Table 13 result of cultural meaning score

Water Square Benthemplein		*ZOHO Raingarden*	
expert1	4	expert1	4
expert2	5	expert2	4
expert3	3	expert3	4
expert4	4	expert4	3
expert5	4	expert5	4
cultural meaning	4.00	**cultural meaning**	3.80



graph 6 result of cultural meaning score

4.3.4 Evaluation of Spatial Solution

Overall index of spatial solutions are as follows. Hydraulic effectiveness has huge difference between two projects. This comes from the scale difference; retention capacity index and covering area index. For flood risk reduction, Water Square Benthemplein focuses on reducing the impact of intense rainfall on sewage system by increasing amount of temporary open water. The water in the basins comes from surrounding blocks streets, and building roofs. On the other hand, the raingarden is intended to infiltrate rainwater from Hofbongen and the garden itself into the ground and to utilize the water for harvesting. Therefore, the purpose of urban water management in each site would explain this result.

ZOHO Raingarden has better score in ecological robustness compared with Water Square Benthemplein. This is because of large difference of greenery area, pavement, and amount of trees that create shaded space. Especially, although Benthemplein is much bigger than the raingarden, the raingarden has more than two times as many areas of green as the water square. Such difference would come from each site's functionality. Benthemplein offers space for sports activities and community events as well as water retention basins. The raingarden has functionality of garden, rain water retention, and path for cars, bikers and pedestians.

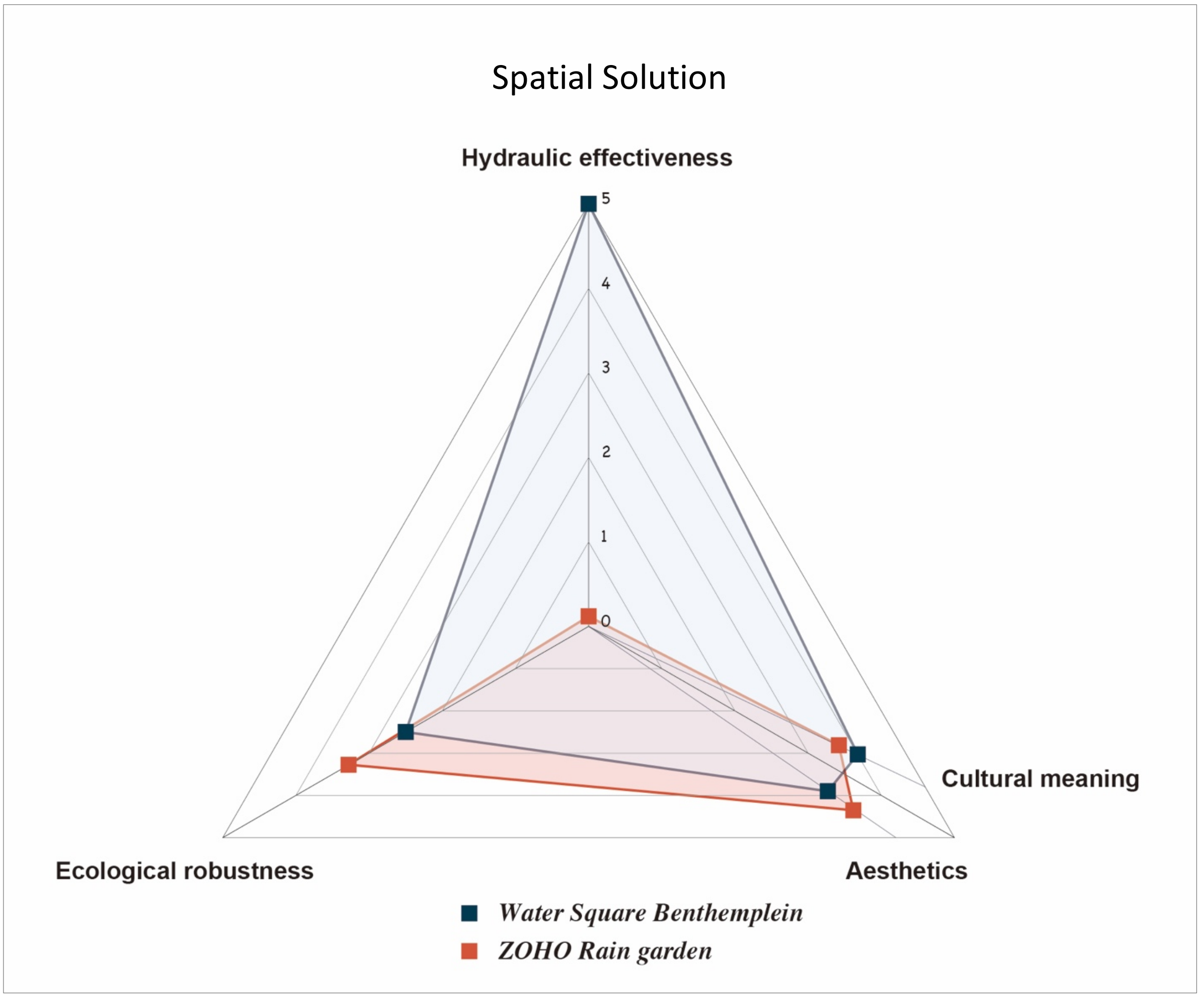
In terms of aesthetics, three interviewees mentioned about a problem of garbage and cleaning maintenance in Water Square Benthemplein. This is because the square gathers rain water which carry trashes as well. The municipality project leader mentioned because of the good spatial design for people meeting, there are sometimes too much people in the square. Two of them claimed more natural material is needed rather than pavements. In the ZOHO Raingarden, all interviewees have a positive attitude to the maintenance by local botanist group as an expert.

In terms of cultural meaning, one interviewee from municipality put score 4 to the Water Square Benthemplein. This is because the students, church community, theatre group and surrounding inhabitants use the park not only for playing sports but for cultural activities. On the other hand, trashes in the park shows their relatively low involvement in the place maintenance even though the municipality is in charge of it. Another expert mentioned that because of the surrounding large buildings, the park does not have a spatial connection to the north part of Agniesebuurt, which reduces access by inhabitants in the area.

ZOHO raingarden gets positive score for its cultural meaning. Thanks to position of the garden, the ZOHO letter and rain water retention in the garden, the project work as creating awareness of climate change adaptation (interviewee from municipality). On the other hand, the way of integration of traffic system on the street with the garden addressed some local complaints. Three experts mentioned about the steps in the edge of the garden. They were made to prevent bikes from entering to the garden but they make uneasy access by wheel chairs to the garden. Another complaint comes from the bar next to the garden. Because of the bikes going through in front of the bar, its terrace could not connect directly to the garden even though the first planning had the connection (interviewee from DE URBANISTEN and other experts).

Table 14 final index of spatial solution

	Water Square Benthemplein	*ZOHO rain garden*
hydraulic Effectiveness	5	0.10
Ecological robustness	2.63	3.38
aesthetics	3.90	4.28
cultural meaning	4	3.8



graph 7 final index of spatial solution

4.4 Interactions through transition

Reviewing interviews, policy documents, and project reports identifies urban spatial dimension as a condition for each process of urban water management transition. Then, those documents mention that such transition also re-configurates urban space. The following matrix shows what kind of urban spatial dimension conditioned in each period and what kind of reconfiguration was seen in each transition. The number indicates how many times interviewees and documents mentions about the topics in each period.

Table 15 spatial conditions in each period

		Period1	*Period2-1*	*Period2-2*	*Period3*
location	**location**	4	4	2	6
	traffic system	0	0	0	8
physical environment	**ground condition**	0	0	0	4
	spatial opportunity	0	2	9	31
	built environment	8	3	2	18
water system	**water system**	6	3	3	18
actor	**actor**	0	7	16	31
institution	**local norm and value**	2	7	10	16
	responsibility for management	0	0	0	2

Table 16 spatial reconfiguration in each perido

	Period1	*Period2-1*	*Period2-2*	*Period3*
redistribute functionality	3	0	12	8
reshape physically	0	0	5	9
reframe meaning (place-making)	0	0	12	3
reframe meaning (envisioning)	8	0	4	6
innovate spatial typology	5	2	0	6

Fig 43 illastrate overall interactions between spatial dimensions and transition in periods based on the theoretical framework of this research. Yellow arrow represents conditioning of transition by spatial dimesion based on following analysis. Green arrow shows reconfiguration of space as a result of transition in each period. Boxes in upper side are urban spaces that condition transition or reconfigured urban spaces. Box in down side indicates transition in each period. The timeline clearly indicates how the interaction happened and reach to spatial solutions, Water Square Benthemplein, and ZOHO Raingarden.

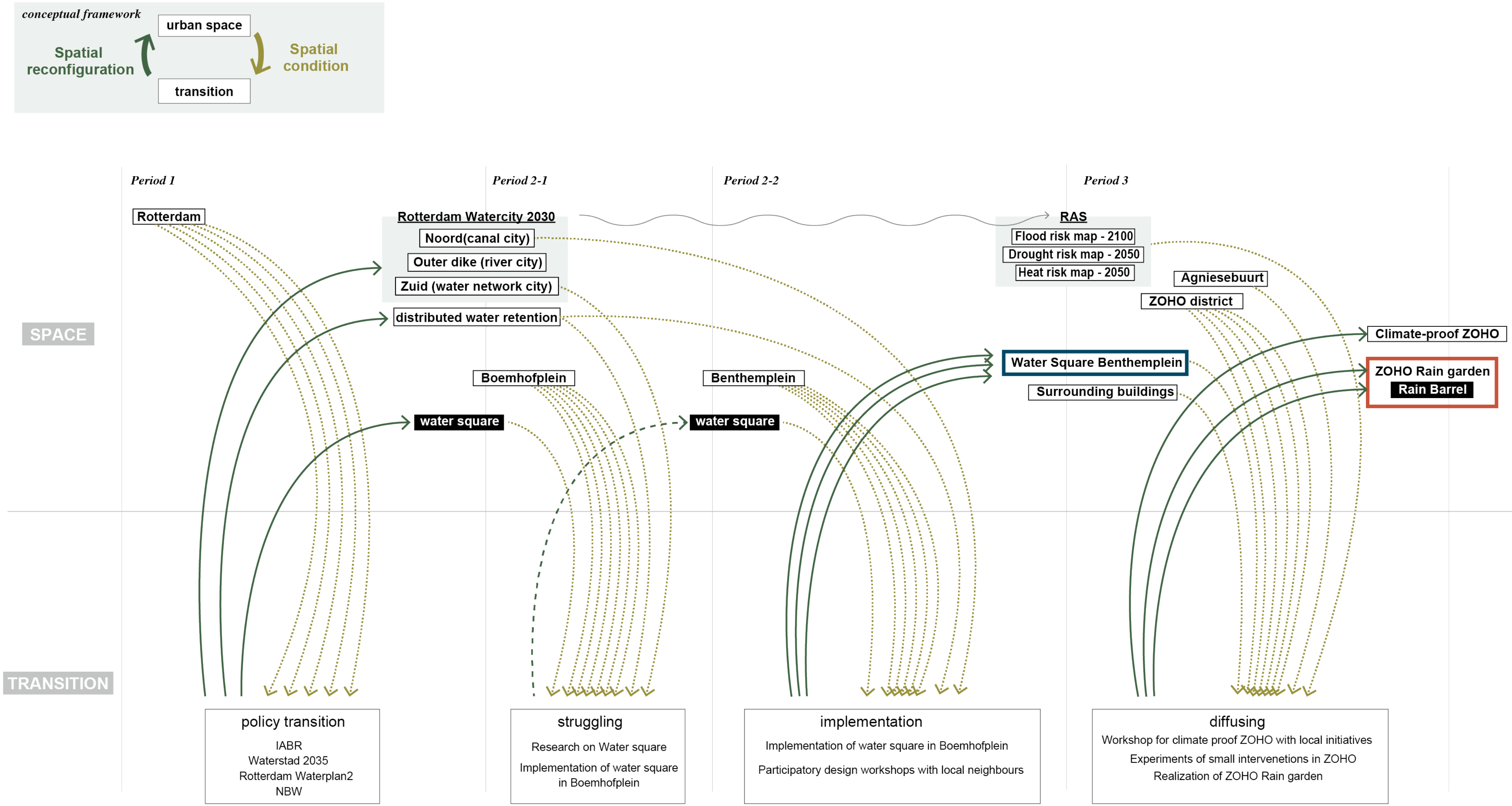


Figure 43 Timeline of interaction between transiton and spatial dimension (source: author)

4.4.1 Period 1 (2000-2007)

Condition

In this period, transition is conditioned mainly by spatial dimension of Rotterdam as follows. The findings clearly show how urban water management transition is spatially defined by large scale context (location and national spatial regulation) and by physical characteristics of the city which relates to water system and urbanized built environment. Transition of urban water management to being adaptive to climate change started from around 2000. Niche innovations proposed in IABR 2005 became an official policy; Rotterdam Waterplan2 in 2007 based on Rotterdam Water City 2035. Additionally, idea of water square was conceptualized and developed at the same time.

IABR 2005 offered an opportunity to consider water-related issues and possibility to realize "new landscapes, new cities and new buildings" by utilizing it (IABR, 2005, pp.8). Such focus came from the awareness that "the water thrusts itself upon us, and compels administrators, designers, contractors and scientists to treat it as a priority on their agendas" (IABR, 2005, pp.6). On the other hand, IABR 2005 was an eye-opening event for the Rotterdam municipality, district water boards, and local architects working together for envisioning. They share the same view on water; water becomes a threat but offers an opportunity to improve urban space (Interviewee from municipality). As a result, Rotterdam Waterplan2 mentioned Rotterdam needs to be protected from water as well as to use it to achieve strong economy and live-able environment that Rotterdam urban vision aimed at.

In this context, Rotterdam Water City 2035 was developed to visualize such threat, possibilities it offered, and the whole city's vision on water. It clearly declared that climate was changing and it would impact on Rotterdam. Because "Rotterdam is built in a delta"(pp.142), this would become a huge problem without anything changed (interviewee also mentioned). Although Rotterdam have developed their port industry thanks to such location, they also realized delta area was vulnerable to sea level rising and extreme weather due to climate change.

To concern about the urban water management in such situation, physical characteristics of Rotterdam were emphasized during this transition period. One of them is Nieuwe Maas River/ On the one hand, Nieuwe Maas River goes through the center of Rotterdam and offers various type of opportunities for metropolis (IABR, Rotterdam Waterplan2). On the other hand, because of the climate change, water from sea and the river put flooding risk on Rotterdam. To adapt to the threat, existence of dikes along with the river work for the flood defence.

In addition, the dikes characterize city's structure and water management method (fig 45). The dikes and its topographical difference divide the city into inner dike area and outer dike area (Rotterdam Waterplan2, Graphic novel, Interviewees). Due to changing climate, the inner dike areas mainly face to the threat from intense rainfall rather than river and sea level rising. Furthermore, difference exists between water systems of north bank and south bank. In the north bank of Rotterdam, singels and rivers in different levels are used for drain water and groundwater control. In the south bank, water network that is all the same level defines the area's water management method. Spatial vision of Rotterdam Water City 2035 was designed based on this division by dikes and existing water systems (fig. 45). Rotterdam Waterplan 2 adopted the same scheme.

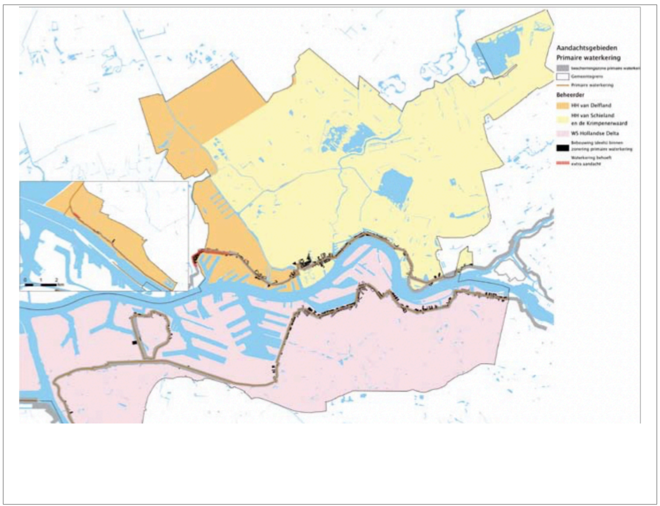


Figure 44 primary dikes (source: Gemeente Rotterdam, et al., 2007)

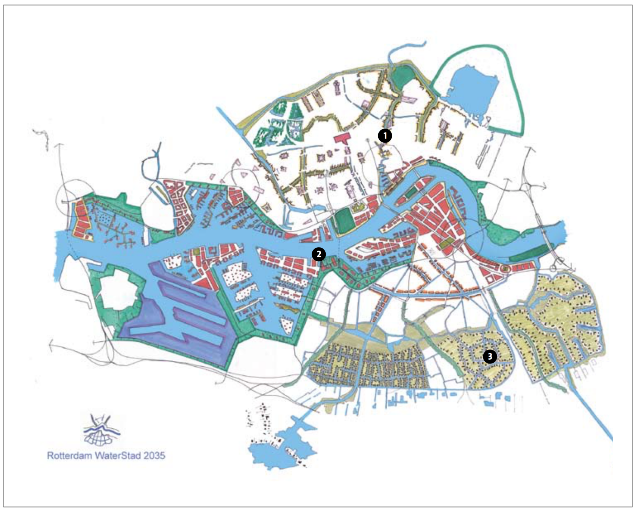


Figure 45 Rotterdam Water City 2035 (source: Gemeente Rotterdam, et al., 2005)

Another spatial condition concerned in this period was high-density of buildings within the city of Rotterdam. In other words, there were lack of space for open water (Rotterdam Waterplan2, Interviewee). Based on NBW, Rotterdam at that time was assigned to create 600,000 m3 of extra water retention capacity by 2015 and 900,000 m3 by 2050 (Rotterdam Waterplan2). This spatial requirement has an influence on transition because "[e]specially in the densely built-up urban area, it is almost impossible to dig the necessary open water" (Rotterdam Waterplan2, pp.47). Such high-dense built environment and institution of the water retention requirement needs innovative solution. During the visioning process, the idea of water square had been conceptualized and elaborated because of such physical condition; lacking space for water in the city.

Therefore, during 2000-2007, urban water management transition was conditioned by following spatial dimensions of Rotterdam; its location, characteristics of its physical environments, water system working in each area, and institution embedded in the metropolis. Basically, a scale of spatial dimensions mentioned in this period is Rotterdam, rather than neighbourhood or project level. Because of its location and its physical environments, spatial requirement by climate change significantly influenced on the regime urban water management. The imminent necessity of spatial reconfiguration encouraged its transition from niche innovations. To envision policy, the physical characteristics and existing water systems provided basic structure of the transition. To conceptualize water square, high-dense built environment was an important spatial condition. In addition, an interviewee from DE URBANISTEN mentioned that "the end purpose is to add value to the city" by integrating water with the city. This local norm became a principal of water square and visualized new spatial typology.

Location

- Rotterdam is located in delta city close to the river and sea, (interviewee from DE URBANISTEN, report from Studio Marco Vermeulen, IABR). Delta area is vulnerable to sea level rising and extreme weather due to climate change.

Physical environment

- Nieuwe Maas River goes through the center of Rotterdam(IABR, Waterplan2 Rotterdam).
- Existence of dikes along with the river characterizes city's topography and divides the city into inner dike area and outer dike area (Waterplan2 Rotterdam, Graphic novel, Interviewees).
- High-density of building in the city lack of space for open water (Waterplan2 Rotterdam, Interviewee).

Water system

- Rotterdam's main water system is "bath tab" that is composed of rivers, dikes, canals, water ways working together to discharge storm water to the elevated river and sea (Waterplan 2 Rotterdam, Interviewees, graphic novel).

Institution

- Rotterdam was assigned to increase water retention capacity within the city by NBW until 2015 and 2050.
- Climate change has increased its impact on the city and Municipality, water authorities, and private sectors realized the necessity and opportunity to work on the issue together (Waterplan2 Rotterdam, two Interviewee).

Reconfiguration

In this period, IABR, Rotterdam Water City 2035, and Waterplan2 Rotterdam were the main series of visualizing Rotterdam's spatial vision in relation to climate change impacts. Although the concrete urban space in Rotterdam was not transformed physically in this period, the transition reframed Rotterdam in three different parts, and distributed new water functionality in each neighbourhood in conceptual level. In addition, new spatial typologies; water square, was conceptualized by landscape architects through this period. Rotterdam municipality included this innovation into an official policy and kept emphasizing on its necessity in later documents (RCP, RAS, Rotterdam Resilience Strategy) to adopt it to a concrete public space in Rotterdam. This shows how huge the impact of the new spatial typology was on regime policy.

It is important to mention that a lot of ideas from IABR and Rotterdam Water City 2035 became an essential part of Waterplan 2 Rotterdam. Especially, structuring Rotterdam into three areas and innovating ideas of multifunctional space are essential achievement during the transition. The vision to 2030 clearly defined the three principal areas in accordance with urban condition and water system; The River City, North, and South. This division was based on the Rotterdam Water City 2035, but was more elaborated with Rotterdam city vision to 2030 (fig 46). Each area has different methodologies of urban water management and they were intended to contribute to strong economy and attractive living environment by spatial transformation (Water plan 2 Rotterdam). Providing new perspective on the city succeeded in reconfigurating the image of Rotterdam into three water cities. That is reframing the meaning of space.

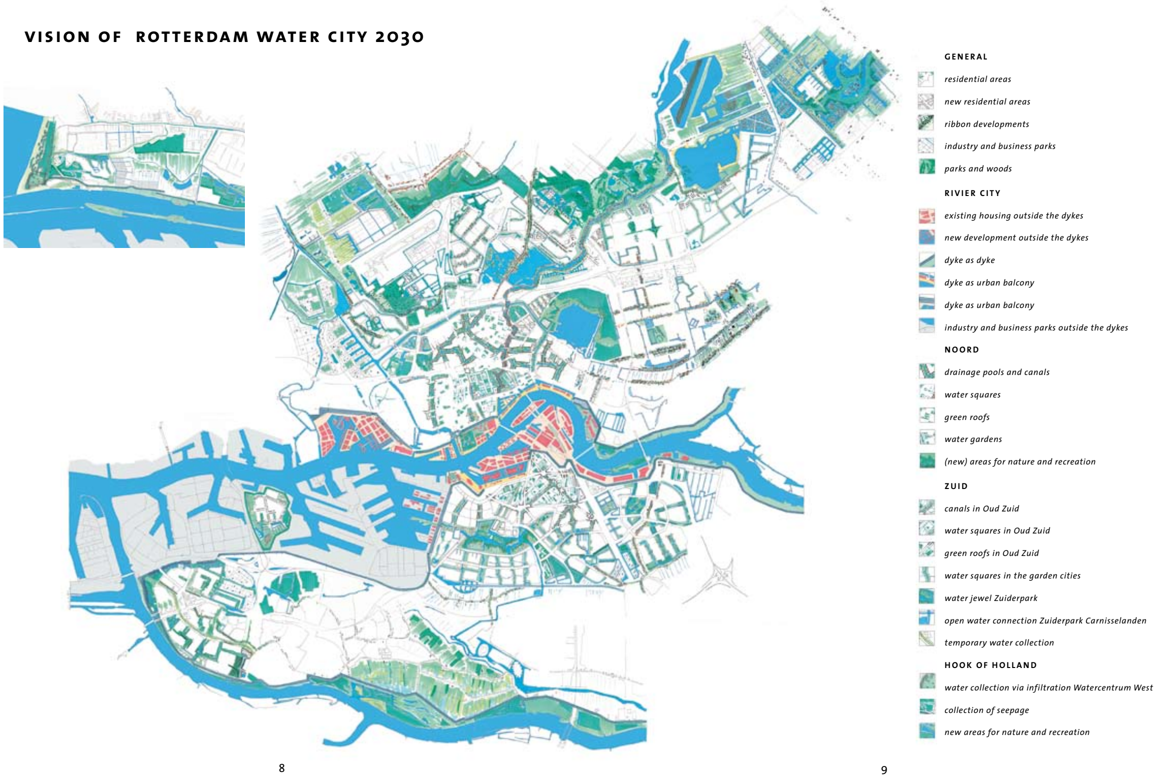


Figure 46 Vision of Rotterdam Water City 2030 (source: Gemeente Rotterdam, et al., 2007)

Rotterdam was required to increase additional water retention capacity for more 600,000 m3 by 2015 and 900,000 m3 by 2050 at that time (Waterplan2 Rotterdam, 2007). To achieve it, necessary amount of retention water in each neighborhood and projects for additional water was distributed(fig 47, 48). In the high-density area, such as city center and old district, this cannot be reached with only improving existing water infrastructure because of lack of space for open water. Innovative solutions elaborated in IABR were in that sense suitable and essential in the vision.

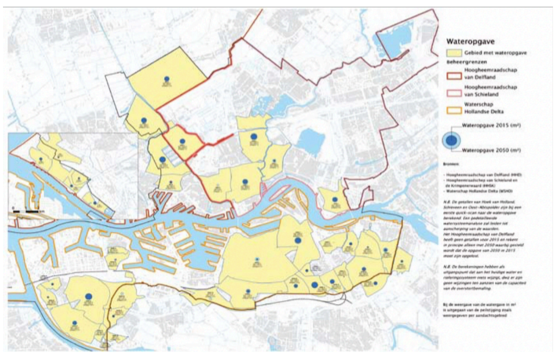


Figure 48 Water distribution (source: Gemeente Rotterdam, et al., 2007)

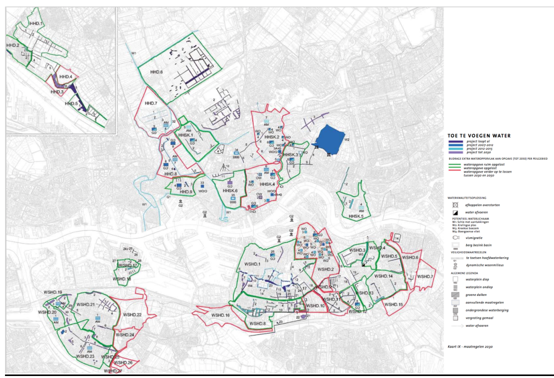


Figure 47 water retention projects (source: Gemeente Rotterdam, et al., 2007)

Innovate ideas of new spatial typology for water management were developed for IABR; green roof, water square, multifunctional dike, or tidal park (IABR, Interviewee). To adopt the idea of water square in official policy document, the landscape architects developed its typology and conducted research on the city for ideal implementation place. Basic principle of the water square was shown as the sketch(fig 49); 95% of the year, it is used for ordinal plaza and 5% of the year, it works for water retention basin.

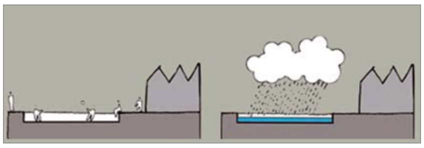


Figure 49 Water Square principle (source: Gemeente Rotterdam, et al., 2007)

The research showed the location of water square was an important for gathering water from surroundings and discharging it properly by sewage system. Research on topography, sewage system, possible square, and flood prone area was visualized on map to assist square selection (fig 50). However, the idea of water square is basically anonymous to the context. Such invention of spatial typology is new type of reconfiguration of space in transition. In this paper, this type of spatial reconfiguration is called as innovating spatial typology.

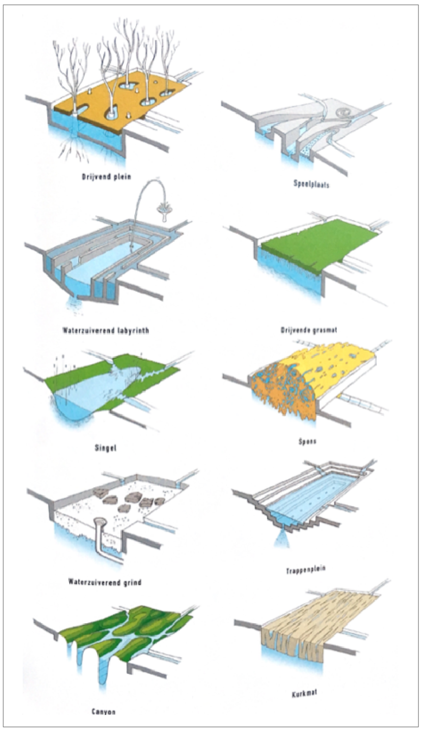


Figure 50 Typology of water square (source: Gemeente Rotterdam, et al., 2005)

Reframe meaning (envisioning)

- More precisely, Rotterdam is divided into Noord (canal city), River city, and Zuid(water network) and distribute vision in each area(IABR, Rotterdam Waterplan2).
- Water is defined as an essential element in urban development for strong economy and good residential environment (interviewee, Rotterdam waterplan2)

Redistribute functionality

- Rotterdam Waterplan2 distributes certain amount of retention water in each neighbourhoods in relation to the characteristics of each site (Rotterdam Waterplan2)

Innovate spatial typology

- Innovate idea of spatial typology that did not exist before in urban space. green roof, water square, multifunctional dike, tidal park that are integrated with city to benefit for the living environment (IABR, Interviewee)
- Especially, water square was elaborated into several typologies to able to apply to the concrete city space (IABR, interviewee, Rotterdam Waterplan2, graphic novel)

4.4.2 Period 2-1 (2008-2010)

Condition (2008-2010)

In this period, transition in Rotterdam entered phase of technological development for implementation of adaptive urban water management. Municipality tried to implement pilot project of water square. Typological research before this period developed several condition of built environment, water system, or location that need to be taken into consideration. (Waterplan 2 Rotterdam, Graphic Novel).

The following maps show the spatial conditions that decides position of water square within the city. Three water collection strategies were elaborated; the enclosed basin, the open basin and the open network. the enclosed basin needs to be large enough to retain discharged water as well as to be close to the main sewage system because the stored water in this type of water square (graphic novel). Open water basin needs to be located in the lower level in the city to catch rainfall by the height difference (Waterplan2 Rotterdam). Position of existing dikes are of importance in this case. In case of location with low height difference, small water square network would be useful to collect a large amount of precipitation. Flood prone area is suitable for this type of solution. Such typological research illustrated such spatial conditions of water square implementation.

The municipality decided Boemhofplein in Rotterdam Zuid area as the pilot project site based on the research (interviewees). The neighbourhood area needed to increase 30,000m3 of water assigned at that time. The municipality was intended to use this project to create 750 m3 of water retention capacity (waterplan2 Rotterdam). The project documents from graphic novels shows surrounding dikes, canals and sewage system defined the square's type; the enclosed water square. In addition, the area was typical type of "densely populated urban neighbourhood". Those physical characteristics of the neighbourhood was also suitable for project implementation.

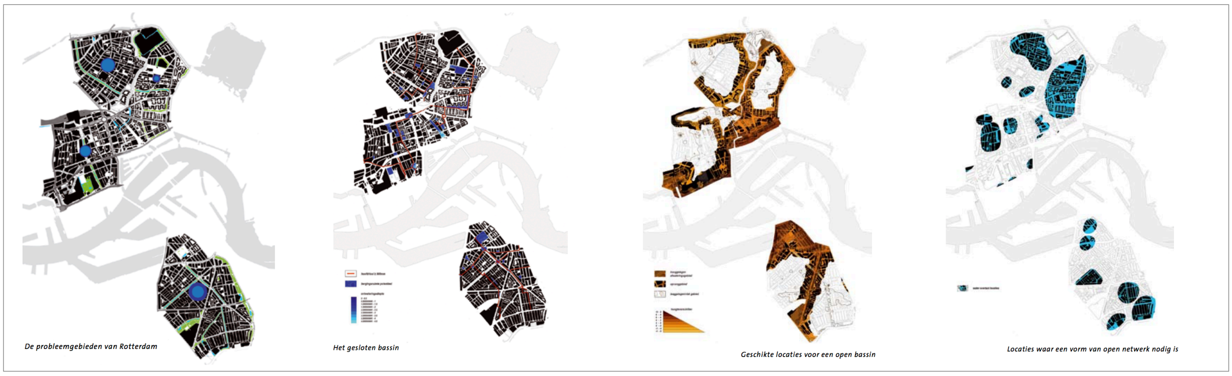


Figure 51 built environment and water system condition research (source: Gemeente Rotterdam, et al., 2007)

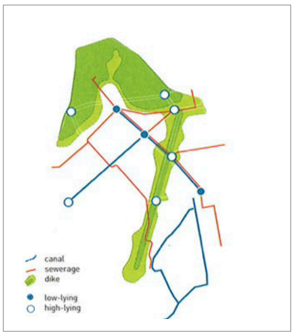


Figure 53 surrounding area topography, canals, and and sewage system(source: DE URBANISTEN, 2010)

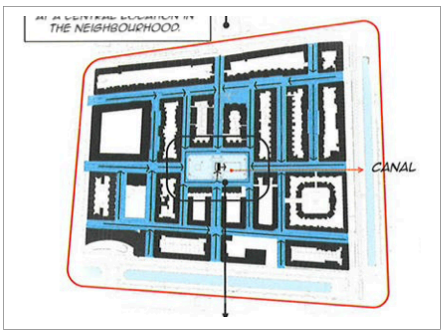


Figure 52 surrounding buildings and canals (source: DE URBANISTEN,

However, because the idea of water square was relatively anonymous to the context, its adoption process to real urban space was top-down approach. As a result, the municipality and the landscape architect faced to a big resistance from local neighbours and stopped the project (interviewees). The interviewee from DE URBANISTEN said that the local actors were happy with the existing square because it was refurbished with the help of the community two years before. In addition, parents in the area concerned about water filling with the square if project would implemented. In the neighbourhood, the square was the only place where their children were playing (interviewee). As a result, this project was cancelled.

From the planners' point of view, the square was a spatial opportunity and suitable location for a water square. Physical environments of surrounding neighbourhood were also good condition for the innovative idea. However, the struggling process with local people shows that local actors and their norm and value embedded in the area are of significance for realization of innovative idea. In this period, the scale of spatial conditions mentioned from interviews and project documents was site area and surrounding neighbourhood level.

<u>Location</u>

- Bloemhofplein is located in flood prone area and close to the main sewage pipes and canals (graphic novel, Rotterdam waterplan2)
- the square was the center of the neighborhoods and surrounded by community who was satisfied with it already(interviewees)

<u>Spatial opportunity</u>

- There is a lack of spatial opportunity in the area. Boemhofplein is an only square where a lot of children are playing even thought the large space is needed for water retention (interviewee, Graphic novel).

<u>Built environment</u>

- Topographically low area (Graphic novel)
- densely populated urban neighborhood (Graphic novel)

<u>Water system</u>

- Water system in the area is defined by main sewage system canals and dikes(Graphic novel).

<u>Actor</u>

- neighbors were happy with the square because it was refurbished with the help of the community two years ago(interviewees)
- Parents in the area objected against water square because they concerned about water filling with the square, their children's playing area, when it rains.
- municipality wanted to conduct a pilot project in the site

<u>Institution</u>

- 30,000m3 of water was assigned for the neighbourhood
- Local norm is that no need for water square/ concern about the square filled with water

Reconfiguration (2008-2010)

As a result of struggling of planner's views and local norms, there was no spatial reconfiguration occurred in this period except for technical development of water square. This process was an important lesson for the municipality and the landscape architect (interviewees). Even though spatial condition was physically perfect, local actors, their norm and value embedded in the urban space are essential condition for transition.

Develop spatial typology
• Water square developed the idea to an operation-able level (graphic novel) as mentioned in chapter 4.2

4.4.3 Period 2-2 (2011-2013)

Condition (2011-2013)

In this period, the municipality, DE URBANISTEN and local stakeholders worked together through three workshops to design new square in Agniesebuurt. Realization of Water Square Benthemplein in 2013 is an important transition moment because it clearly demonstrates the possibility and reliability of an innovative adaptation idea from niche level. In addition, although the policy level transition occurred in period 1, this project also shows the technological development of adaptive urban water management from idea level to operational level.

One of the key conditions in this period was a spatial opportunity that offered intervention possibility to the project team from municipality and the landscape architect. Local students visited to the city council to ask improvement of Benthemplein in Agniesebuurt. Benthemplein was surrounded by school complex, sports gym and church in one block. Because it was just covered with plane concrete before the project, students and neighbours had nothing to do there (interviewees). Such problematic space was a suitable opportunity for intervention of new project(interviewee).

In addition, existing water system in the area had problems. Combined sewage system was under planning to renewal to separate system at that time, which provided an opportunity to integrate both projects together (interviewee). The neighborhood also had a flooding problem in building basements and overflow (interviewee). At that time, the landscape architect from municipality notes that building a singel was the first choice for increasing water retention, but it was difficult to find a space in existing city. Agnieseburrt was one of such high-dense city areas and building the water square was desirable for this district.

Not only students and teachers from schools, but also church community members, people from gym, theatre, and inhabitants from Agniesebuurt joined workshops. Local users of the area were well-organized and had a positive attitude to the idea of water square. According to the project manager from municipality and the landscape architect from DE URBANISTEN such support from local people was of significance for realization of the project because they had not got that in previous project.

During the workshops, participants were asked and discussed their preference of activities, atmospheres and water by using various cards (Interviewees, workshop report) (fig55). Those inputs were distributed within the square in relation to the existing buildings and were integrated with water basins in later workshop(fig 54). For instance, in front of the church, a small plaza was layouted for their community event (interviewee). This process shows that not only their attitude toward water issue, but their values on the plaza was developed and visualized during the workshop and eventually organized as a concrete site plan.

Figure 55 activity cards for workshop(source: DEURBANISTEN, 2014-b)

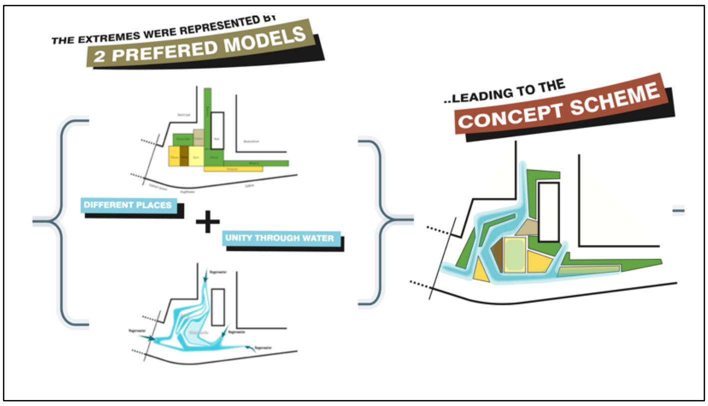


Figure 54 Basic functionality distribution (source: DE URBANISTEN, 2014-b)

<u>Location</u>

- the square was surrounded by neighbours who were willing to change it

<u>Spatial opportunity</u>

- building new singels in existing city is difficult due to lack of space
- sewage renewal plan that offer intervention chance
- unused concrete flat square that people really wanted to improve and several student asked to do that to the municipality

<u>Built environment</u>

- dense urban area
- existing buildings church entrance

<u>Water system</u>

- because overflow happened in the district, water retention is needed in the area

<u>Actor</u>

- well-organized community around the square (students, church group, theater group, gym, and inhabitants) had nothing do with the square / they are open to realize the idea of water square / took an essential role in designing the square by inputting their desired activities
- municipality wanted to conduct a pilot project in the site

<u>Institution</u>

- water storage is needed in the area from planning point of view
- no value for existing square / water square would improve the space

Reconfiguration (2011-2013)

The idea of water square from 2005 IABR was finally realized as multifunctional space in 2013 in Benthemplein. Through participatory design workshops with local stakeholders, the concrete flat square was transformed physically, functionally as well as socially.

Figure 56 Activities in the square (source: author)

As mentioned above, the square's design reflected local users' preference but integrated with water system necessity (interviewees). Based on the workshop, three active programs were lay-out in each of the three basins that work for water retention space as well (fig57, 58). A depth difference in each basin due to its structural reason is used for design of public activities. The basin called wheel slope is linear-shape so that it is enjoyable for skate boarding. The largest basin is named sports theatre that includes a basket court in the center and sitting stairs in two long sides. This place is also used for theatre activity (interviewee). The last basin, dancing stage, is relatively small stage event surrounded by the steps similar to audience seats.

Calm programs are put in the site in relation to the green cluster and existing buildings. Small plaza in front of the church is now an important place for their members' communication after the service on Sunday (interviewee). Before going to the design, they refered to meaning of the water in the bible. As a result, they ask for small fountain in the small plaza as a baptismal font and sometimes they use the square to baptize a person (interviewee). Benches under the trees are layout along with the street to the north. As chapter 4.3 explains, water system in the Benthemplein organized as the three different basins. Network of stainless gutters are spread for carrying rain water from the square, surrouding buildings and streets.

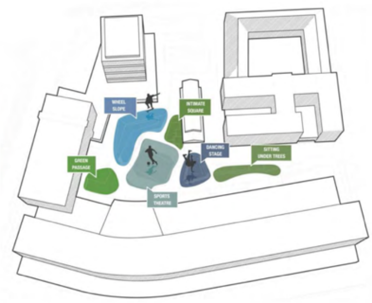


Figure 57 program for public space (source: DE URBANISTEN, 2014-c)

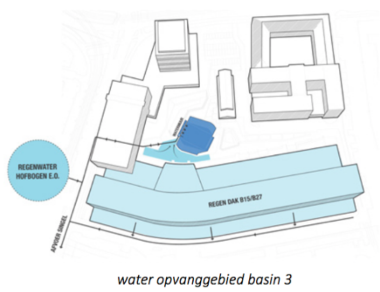


Figure 58 water system on the site (DE URBANISTEN, 2014-c)

Interviewee from the church and local architect mention that thanks to the realization of the water square, local community activities that had not existed previously are seen in the square. From flat concrete square, it was really improvement for local community (interviewee). Now a wide variety of user groups uses the square (children, students, theatre group, church community, gym group, and inhabitants). This means that the space was socially reconfigured as a result of transition.

In addition, realization of the water square influence on surroundings. For instance, the church decided to renovate the building to change the entrance from opposite side to the small plaza. Within the neighbourhood, Project manager from municipality mentioned that realization of this climate adaptation space influenced its near district due to its huge scale of project (interviewees). Moreover, Water Square Benthemplein became a showcase of internationally well-known climate adaptation practice because of its first large water square (interviewees from municipality, Rotterdam Resilient Strategy).

Redistribute functionality

- Through discussion of the preferred activities between stakeholders, public space functionality (e.g. sports, small square for community activities, having a lunch in quiet space) were distributed (intended activities) in the square.
- water retention basin that connects surrounding water systems for gathering substantial amount of water and discharge into ground or into the open water of Noord single
- Small fountain in front of the church was constructed for their ritual meaning of water

Reshape physically

- three basins were built for water retention as well as public activities
- Stairs and slopes due to the height difference of basin are used for public activities
- Water flow is highlighted with stainless steel gutters
- large flat square was divided into human scales (e.g. small square for church)
- from flat concrete square, it was really improvement

Reframe meaning (place-making)

- different groups use the squares (children, church, theater, students, skateboarders)
- small fountain in front of the church was constructed for their ritual meaning of water
- international attention as the first large scale water square realization
- because of its scale, water square Benthemplein impacted on surrounding development as catalyst

4.4.4 Period 3 (2014-2018)

Condition (2014-2018)

In this period, transition of urban water management diffused their project scale into the neighbourhood. The process is interveined with envisioning climate adaptation in ZOHO and implementing of ZOHO Raingarden. After opening of Water Square Benthemplein in 2013, DE URBANISTEN intended to enlarge their climate adaptation project into neighbourhood scale by suggesting it to the municipality and local initiatives (interviewee). At the same time, RAS was launched as a result of knowledge development programs from 2008. DE URBANISTEN was deeply involved in this document as well. Key difference from Waterplan 2 Rotterdam is that its focus is on the strategy to adapt to not only water-related extreme weather but also heat wave and drought. As a result of several workshops and small pilot projects based on RAS, the district was chosen as a pilot neighbourhood of implementation of this climate-proof strategy. Project of ZOHO Raingarden was intended as a part of this neighbourhood perspective and Water Square Benthemplein was included as well.

One of the key spatial condition in this transition is location of Water Square Benthemplein. Realization of the square worked as a catalysis for this neighbourhood transition due to its proximity and its scale of the project (interviewee, CLIMATE-PROOF ZOHO DISTRICT). In addition, Agniesebuurt is "typical high-density district of 19c neighbourhood and modernist structures of the city center". DE URBANISTEN chose ZOHO district as their next step from the water square and RAS. ZOHO area is a place where large number of small entrepreneurs gather. This is because of the unique development style going on the area due to economic crisis from 2009; slow urbanism. Grassroots initiatives and creative agencies in the area share the same interest in outdoor space improvement by themselves (interviewees).

Another key issue in this period is publish of RAS. Research in RAS reframed what Rotterdam is facing to due to climate change from Waterplan 2 Rotterdam. RAS shows three different maps that shows the risk; Flood risk map – 2100, Drought risk map – 2050, and Heat risk map – 2050.

Organized by DE URBANISTEN, workshops were held in 2014 for building joint perspective of climate proof in ZOHO district and Agniesebuurt based on the scheme in RAS. put a basis on the workshop about climate adaptation in ZOHO. Influence maps of heat, rain water and ground water visualized the area's physical characteristics(workshop report). Participants from municipality, local initiatives, neighbours and researchers from a knowledge institute had to take into account the increasing intense rain fall, longer periods of drought and heat stress. This means that idea was needed not only for water retention or infiltration but also for greenery.

Such different types of spatial necessity enabled to joint with non-climate adaptation program; outdoor space improvement program for building sustainability. Sewage replacement plan due to the existing old pipes also provided joint project possibility, such as public space improvement (interviewee). Elevated rail truck, Hofbongen, was under construction.

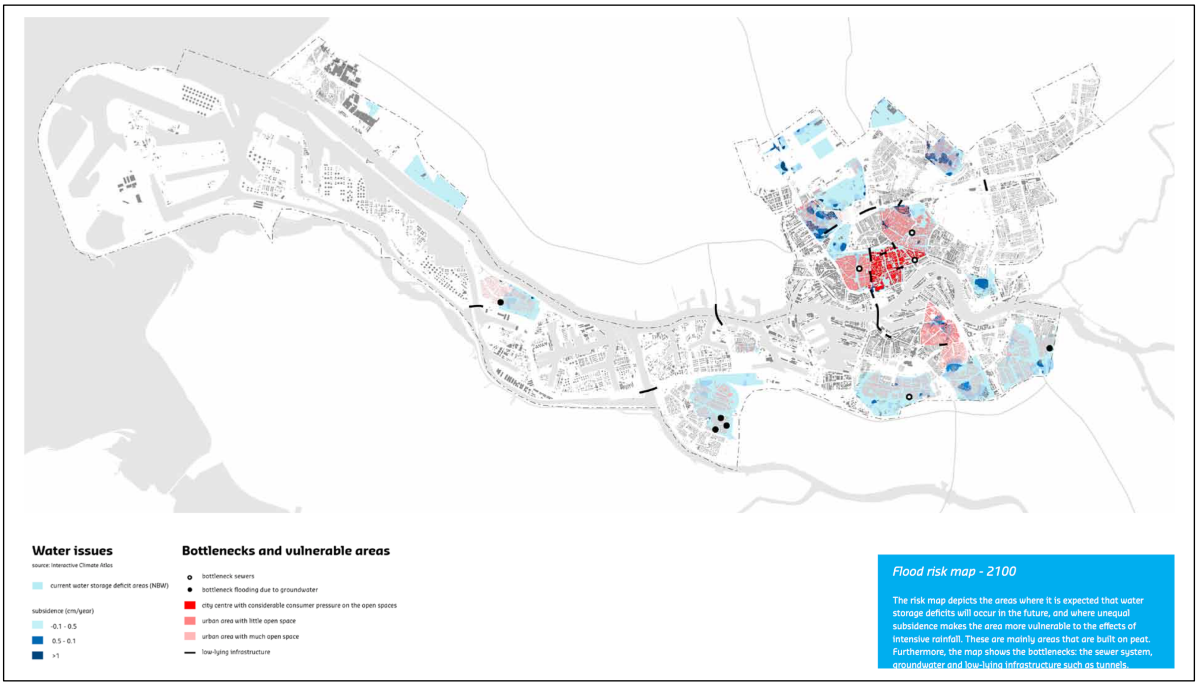


Figure 59 Flood risk map-2100 from RAS (source: Gemeente Rotterdam, et al., 2013)

Research in RAS shows that the neighbourhood has little open space, little infiltration capacity, no open water(fig 59). During the workshops, it was found that 50% of the parking space was not in use in the area. Based on the RAS, such an abundance of hard surface (pavement) in ZOHO or Teilingerstraat was spatial opportunity (workshop report). 75% of the ZOHO area was non-permeable at that time (workshop report). Stone pavement gave negative and empty impression on the site and people in the area wanted to change the place (workshop report, CLIMATE-PROOF ZOHO DISTRICT). A lot of spatial intervention possibilities was mentioned in Hofbongen roof, facade, and sidewalk through the workshop (workshop report, interviewee). In addition, Traffic system in Agniesebuurt was analysed to Through the workshop, participants visualized characteristics of physical environment and spatial opportunities of the area and organized strategies for interventions.

Several projects were conducted as experiment. The unused parking space was turned into a pop-up garden as an experiment by removing pavements of the two parking and cutting a drainage pipe in Hofbongen. Within two days, new garden was built up, which convinced municipality to subsidise the area greening project. Studio Bas Sala, who elaborated Rain barrel idea, implemented variety of rain barrels after the workshop(CLIMATE-PROOF ZOHO DISTRICT, interviewee). As a result, CLIMATE-PROOF ZOHO DISTRICT was published by DE URBANISTEN as the area's climate proof framework (fig 60). The spatial vision was composed of six basic projects and one of them was raingarden. By collaborating with the area's water board, this project gained subsidy from European Union.

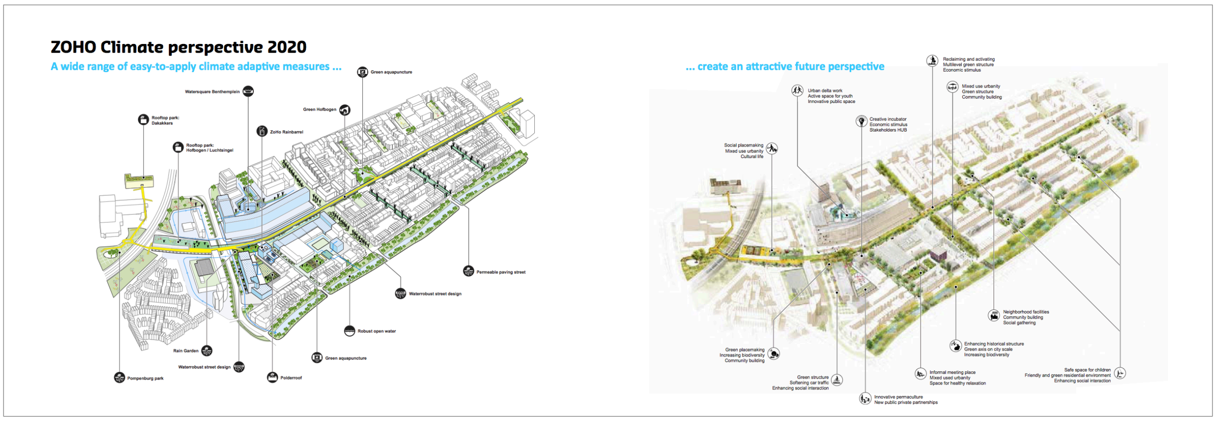


Figure 60 ZOHO Climate perspective (source: DE URBANISTEN, 2014-b)

To realize ZOHO Raingarden, location was an important condition. Traffic system within the area was needed to consider because the garden was proposed to be built by reducing car parking lots and a road for cars. The research was conducted "[on the current zoning plan and on the arrival of a raingarden in the southwest corner. The starting point is that this raingarden is as much as possible remains free from through traffic and that the parking garage, Schoterboshof, remains easily accessible]" (Raamwerk Buitenruimte, 2016, pp.21). Such blind spot in local traffic system was a suitable location for new intervention (fig 61). In addition, The ZOHO area was surrounded by not residents but business companies and Hofbongen under development. This also made the intervention easy for the municipality(interviewees). Furthermore, since the site was located in the entrance of ZOHO district, it was intended to took a role in making welcoming atmosphere to the ZOHO (CLIMATE-PROOF ZOHO DISTRICT).

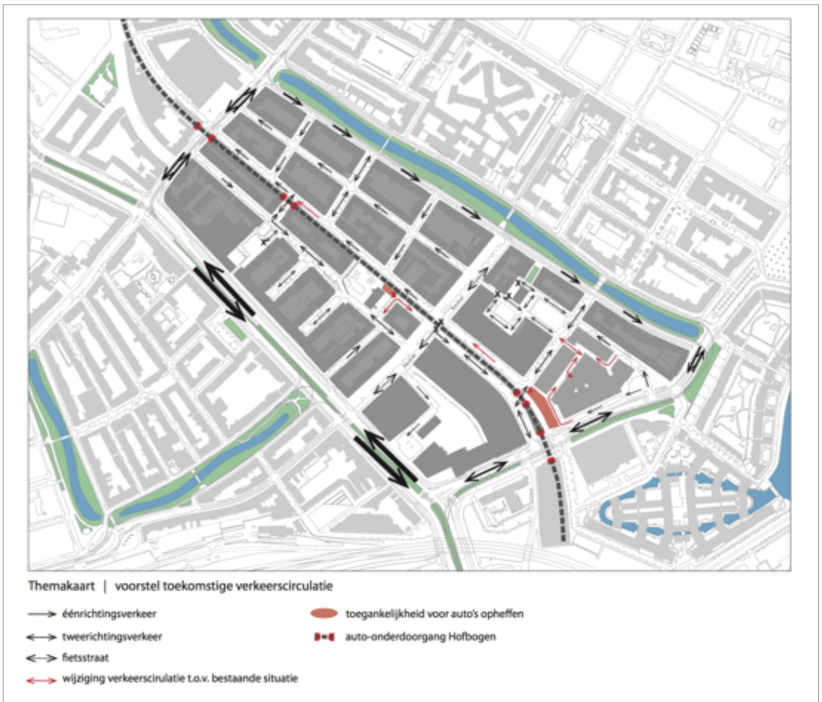


Figure 61 traffic system research in Agniesebuurt(source: Gemeente Rotterdam, 2016)

Existing water system was also mentioned in the interviews. For the district water board, increasing unpaved area would work for reducing impact on the sewage system and for enabling them to keep open water quality. In terms of water retention functionality, the existing Water Square Benthemplein worked well enough so that building a new retention facility was not necessary (interviewee from landscape department of the municipality). Rather, they viewed this opportunity as an implementing chance for different type of water retention; raingarden, within the same neighbourhood.

To design the infiltration garden, ground water and soil conditions in the site were took into consideration (interviewee from landscape department of the municipality). In addition, design is needed for gathering rain water from surrounding buildings. The first design by DE URBANISTEN was intended to gather rain water from Hofbongen and the other side buildings. However, drainage pipes was within the buildings structure, the final design by municipality gather water from only Hofbongen, whose drainage pipes were exposed to outside.

As it is explained above, local grassroots initiatives and creative agencies in the area took an important role in the transition. They shared the same interest in outdoor space improvement by themselves (interviewees). Creative local entrepreneurs involving in place-making, DIY, or public activities joined the ZOHO climate proof project from the beginnings and turn climate measures into new values for the district(interviewees). They build up pop-up garden by themselves together with local community. With their help, workshop was held to determine climate adaptation project and its spatial vision in the area. Initiatives group, ZOHO CITIZEN, was open and constructive to the raingarden project as well(interviewees). Contributions to the design of the ZOHO letter by Studio Bas Sala, one of such entrepreneurs, demonstrates the importance in transition in the area. Such local coalition and their involvement result in greenery raingarden.

Compared with transition period 2, the process was bottom-up approach. Although the municipality and the landscape architect supported coordination, local participants discovered spatial opportunities and characteristics of local built-environment by themselves. Because of the economic crisis, the area accommodated entrepreneurs and grassroot initiatives in the area. Thanks to the climate adaptation workshop, those local initiatives were encouraged and actively involved in the transition process. Another key condition in this process is realization of Water Square Benthemplein. By integrating the project into the neighborhood climate-proof perspective, transition of urban water management succeeded in diffusing. For designing rain garden,

Location

- Water square as a climate adaptation showcase was there, and it set a series of related interventions as a catalysis
- Hofbogen, next to the raingarden, has been under development.
- The ZOHO area was surrounded by business companies (not residents) which makes intervention easy for the municipality.
- Traffic system, car parking in the neighbourhood
- ZOHO raingarden is a suitable location for entrance to the area

Ground condition

- ground water level, peat and sand layer is suitable for infiltration
- sewage pipes have cracks which unintentionally work for balancing groundwater level. old housings' wooden piles in the area

Spatial opportunity

- housing company owned the blocks in ZOHO but could not developed due to economic crisis. They did what is called slow urbanism. A lot of interventional opportunities created because ZOHO was dynamic district where a lot of development going on.
- During the workshops, it was found that 50% of the parking space is not in use. The unused parking space was allowed to turn it into a pop-up garden.
- Sewage replacement plan provided joint project possibility such as public space improvement
- stone pavement gave negative and empty impression on the site and people wanted to change the place
- Hofbongen was under redevelopment. This provides flexible water management intervention due to an easily connection of drainage pipe. In addition, a lot of spatial intervention possibilities existed in roof, facade, and sidewalk

Built environment

- Agniesebuurt is typical high-density district of 19c neighbourhood and modernist structures of the city center
- There were an abundance of hard surface(pavement) in ZOHO or Teilingerstraat. The concrete landscape of the ZOHO is 75% non-permeable
- Hofbogen is a main structure of the area and provides various development possibilities to the whole area but poor social coherence due to Hofbogen as a barrier
- The neighbourhood has little open space, little infiltration capacity, no open water.(RAS)

Water system

- increasing amount of infiltration influence on surface water
- Sewage pipes there have cracks so that groundwater leak into the sewage system
- Position of drainage pipes condition of raingarden design. Pipes from Hofbongen were easy to connect because they were open to outside. But Pipes from the other side buildings could not connect to the garden because the pipes were inside of the building.
- in terms of water retention, raingarden did not have to be built, but good for different way of water storage in relation to Water Square Benthemplein

Actor

User group

- ZOHO CITIZEN (not inhabitants in the area) was open and constructive with the raingarden project
- They build up pop up garden by themselves together with local community

Local initiatives

- municipality, stipo and housing association Havensteder work together for slow urbanism that enables for small entrepreneurs to get together
- such people from different backgrounds worked on grassroots developments in ZOHO, which made it easy to build a coalition to develop buildings and outdoor space
- creative local entrepreneurs involving in place-making, DIY, or public activities joined the ZOHO climate proof project from the beginnings to turn climate measures into new values for the district. With their help, workshop was held to determine climate adaptation project and spatial vision in the area
- Studio Bas Sala, one of the local designers, innovator for design of rain barrel
- DE URBANISTEN convinced municipality and noord councils. They also were interested in the Climate proof project in neighbourhood scale and Municipality also wanted to take a next step for RAS

Institution

- There were local initiatives with creativity involving in grassroots developments, place-making, DIY. They were willing to such a bottom-up project. They did not have a question on the climate adaptation, willing to add value by this climate adaptation
- not all the inhabitants are willing to change the sewage system due to the risk of their basement
- There was water storage deficit based on NWB
- In the context of RAS, Agniesebuurt was chosen as a pilot area
- outdoor space improvement program for building sustainability

Reconfiguration

In this period, Rotterdam succeeded in addressing diffusion of their implementation into neighbourhood scale (Interviewee). ZOHO area and later Agniesebuurt were chosen as a pilot climate-proof district officially. As a result of workshops, small scale interventions, envisioning, and designing, ZOHO Raingarden was open in 2018. Such transition in this period reframe the meaning of the ZOHO and Agniesebuurt as climate-proof district. In addition, building raingarden reconfigure the space functionally, physically as well as socially. It became from paved parking lots to a new green space with water retention facility for neighbours.

Building a joint perspective in ZOHO district and Agniesebuurt reframe the area as a dynamic district to be climate-proof (CLIMATE-PROOF ZOHO DISTRICT). The vision was admitted by European Union and the project gained subsidy for increasing greeneries, water collection and water infiltration (Urban Adapt Homepage). Projects and research have been conducted in not only ZOHO area but northern residential area of Agniesebuurt.

However, because of the ground condition, it becomes clear that it is difficult to implement all the proposed projects for the vision of climate-proof neighbourhood. Because current sewage pipes have cracks through which ground water leaks (interviewee). In case of replacing whole sewage pipes in the area or creating further infiltration areas, ground water level would be hard to keep balanced and basements of old buildings in the neighbourhood would get a negative influence. Interviewee from landscape department of Municipality mention that not all the residents agree on the perspective and discussion between stakeholders is still needed.

ZOHO Raingarden project transformed the space functionality from paved car parking lots and a car road into a raingarden and foot path, bike and car road. In that mean, this project reconfigured a multi-functionalities of traffic system, water system and raingarden within the site. The new garden with variety of plants works for water infiltration layer, reduction of heat wave impact, as well as provision of green space for people in the area (interviewee). Detail water system and variety of green are explained as chapter 4.3. Although the retention capacity is low compared with the water square, precipitations in Hofbongen and the street are infiltrated into ground or stored in rain barrel, rather than going to sewage system before.

Rain barrels designed by Studio Bas Sala can store water from Hofbongen and it is used for watering plants in the garden. Through the workshops and experimental projects, the idea had developed and realized in such a large scale (workshop reports, interviewee). The barrels are covered by large letter of wooden ZOHO. The large letter with rain barrels in the raingarden becomes as an iconic entrance for the district and works for creating awareness of climate proof to the pedestrians (interviewees). As a result, ZOHO Raingarden currently is a showcase of the different type of water retention system from that of Water Square Benthemplein (interviewees).

A foot path goes through the center of the garden. Because it is not intended for bikers but for pedestrians only, both edges of the path have step to prevent bikers from entering (interviewees). This makes it difficult for wheel chairs to access to the garden(interviewees).

Bike uses path in the east side that goes through in front of the bar, which also makes it difficult for bar owner to create direct access from the bar to the garden.

Redistribute functionality

- Pop up garden was built in 2014 by de-paving two parking lots into a garden that infiltrates rain water from Hofbongen. By reducing more parking space and car path, this garden was enlarged to the current ZOHO Raingarden in 2016-2018.
- Rain water from Hofbongen comes to the garden through their drainage pipe. Water was retained in the garden within one-two days. Rain barrel designed by Studio Bas Sala store water that can be used for watering plants in the garden
- reconfigure traffic system of walking, biking, and cars. Optimum course for walkers was built for enjoying sceneries
- there are some spaces for stepping or sitting to have a lunch
- the new ZOHO letters work for water retention as well as iconic entrance of the district
- ZOHO letter creates inviting view to people

Reshape physically

- a new walking path in the center of the garden wad designed. Steps were there in the path so that wheel chair can not access easily
- instead of stone pavements, greens materials were used. They grow up to wild , not just plane grass field.

Reframe meaning (envisioning and place-making)

- Area vision of being climate-proof in the ZOHO district was built up widely shared with local initiatives through workshop.
- In the making vision process, raingarden is in its one part by linking several water-related projects such as water square. Raingarden now is showcase of the different type of water retention system compared with Water Square Benthemplein.
- Globally students and professionals recognize the area as actively climate-proof district
- letter creates invitation to the district
- neighbours around the garden enjoy the green space for having a lunch

Innovate spatial typology

- raingarden and rain barrel enables to catch the rain water and infiltrate slowly in different types. This mechanism is new translation of polder system that is water management tradition in the Netherlands.
- rain barrel was identified in the workshop and realized in a large scale in ZOHO Raingarden

4.4.5 Spatial solution and Interactions between urban spatial dimensions and urban water management transition

To understand the interaction mechanism, reminding nature of urban water management is important. Literature review in chapter 2 shows that urban water management has a complex nature in water system, functionality, and actors' relations. This is the essential driver of interactions.

Water is physical three-dimensional object as well as is embedded in large urban water system. Hence, urban water management needs to discover intervention-able space for retention of additional water to adapt to climate change. At the same time, urban water management needs to make the system where the water is embedded work in extreme weather condition. Relations to the existing water system needs to be consider.

In the dense built environment, such space for water is hardly found. Adding extra functionality (water retention) to public space becomes a solution for this. Although such idea of multifunctional space is suitable for climate change adaptation, local residents are the main actor using the public space. There would be a variety of stakeholders to be considered. Their value and norm on the space are essential condition for design of the space's functionality. In addition, the multifunctional space is also required to work for adaptation to heat wave and drought due to climate change. In this way, transition of urban water management is process of integration of those complex relations in water system, functionality, and actors. And such complexities are spatial dimensions.

Period 1 is the phase of deciding direction of Rotterdam urban water management due to climate change. IABR, Rotterdam Water City 2035, and Waterplan 2 Rotterdam focused on the impact from climate change on existing water system of Rotterdam. Rotterdam's spatial dimention; location of the city, its build environment and existing water system, addressed how to re-organize the water system in city scale to make it adaptive to climate change as well as to fit them into existing urban space. In this period, Rotterdam space was reconfigured not physically but conceptually as Vision of Rotterdam Watercity 2030 and distribution map of water retention. Both of them are visual image of integration of complexity in water system and functionality in city scale.

In period 1, architects in IABR found space with a possibility for water retention in dense urban area, water square. It was conceptualized and developed from IABR. Water square was a spatial typology that would succeed in integration of the complexity in water system and functionality in project scale. Typological research developed the variety of integration pattern but at this period, difficulty and importance of complex actor's view was not concerned.

In period 2-1, the spatial typology was tried to implement in the concrete site. Existing water system and related physical characteristics were analysed for designing water square. However, local norm and value on the site were not taken into account so that project team faced to the resistance from local residents.

In period 2-2, model of water square proved its value in climate change adaptation in Rotterdam by succeeding in integrating three types of complexity in urban water management. Thanks to the spatial opportunity the site provided, municipality was able to conduct intervention for new water management facility. Communities around the square (students, church group, theatre group, gym, and inhabitants) had different type of opinions about the future square but they were open to realize the idea of water square and took an essential role in designing the square by inputting their desired activities Through workshops with the local stakeholders, the idea of water square got such local inputs. With help of landscape architect, they made a decision of the relations of public space functionalities and water retention facilities as well as urban water system within Benthemplein and surrounding blocks.

Therefore, Water Square Benthemplein is an integration of complexity in urban water management into one spatial solution through interactions between spatial dimension and transition. Scale of spatial dimensions that conditioned the process was building blocks level. The envisioned Rotterdam Watercity 2030 and distribution of retention capacity in period1 provided large scale framework for this project. Spatial typology innovated in period 1 was contextualized and materialized through decision making process with local users successfully. This is the lesson from period 2-1.

In period 3, ZOHO Raingarden was realized as a part of ZOHO climate proof district. Realization of the water square offered possibility for landscape architect and municipality to enlarge climate adaptation in neighbourhood scale. Through workshops based on the scheme of RAS, participants of local intiatives, landscape architect, and municipality discovered spatial opportunities by themselves and conducted pilot projects. Because of the slow urbanism in ZOHO, there were many local initiatives sharing their interest on public space improvement and placing value on creativity. This local condition of people and their norm addressed the envisioning the climate proof district.

At this time, RAS updated Waterplan 2 Rotterdam in its aim; Rotterdam face not only to water issue but also to longer drought and intense heat wave due to climate change. This influenced on the expected multifunctionality. Not only water retention and infiltration functionality for flood risk reduction but also increase of greenery for cooling the city is required. In this context, unused parking lots and roads with stone pavements in the area were the intervention-able space and the suitable space for achieving the climate proof district. To transform those urban facilities, reconfigurated space needs to function as a part of local traffic system.

Based on those discussion, local stakeholders and the landscape architecture firm organized the district vision; CLIMATE-PROOF ZOHO DISTRICT. This is a result of integrating local stakeholders' views and relations of water system as well as various functionalities for climate proof in the neighbourhood. Municipality took a role in designing ZOHO Raingarden, which needed to work as a garden of water retention and infiltration into ground, adaptative place to heat wave and drought by rain barrel and greeneries, traffic and foot path, iconic entrance to the district, and enjoyable green space for neighbours.

Several problems arise after realization of ZOHO rain garden as the previous chapter mentioned. Those problems come from the fact that because of the subsidy deadline, municipality had little time to communicate with local neighbours and to cultivate their design of the garden (four interviewees). Although they conducted hearings from ZOHO CITIZEN and other stakeholders, the bar owner did not notice such design. This shows the design process of the garden did not get enough input from local norm and value even though the envisioning process of ZOHO area had good collaboration with local initiatives. Although all the interviewees mentioned that people walking the garden are basically satisfied with greenery garden, it is inevitable to mention that municipality was too optimistic to implement this green increasing project.

Therefore, transition of urban water management in concrete space is a process of integration of such complexity into one spatial solution. In Rotterdam, this process started from city level. After conceptualization of water square, the process became local building block scale. Water Square Benthemplein is the first integration through interactions between spaces of such different scales and transitions of urban water management. After realisation of Benthemplein, the scale was diffusing to neighbourhood. ZOHO Raingarden is integration through interactions between transition and spatial dimensions of such large scale and surrounding built environment scale.

The interactions between spatial dimensions and transition does not occur automatically. In other words, suitable spatial conditions (location, spatial opportunity, built environments, actors, and institution) does not encourage transition and decide reconfiguration of space simultaneously. Interviewees mention that a coordinator who are eager to change the circumstances is essential for driving interactions. In addition, to integrate complexity in one spatial solution, spatial design professionals, such as a landscape architect, takes an important role in the process. They have a skill to discover a spatial opportunity, as the conceptualization process of water square in IABR. Last but not least, financial support is an important institutional driver in case of Rotterdam. Interviewees and project documents mention the subsidy from the municipality, water boards, national government or European Union. Especially, because of the subsidy for ZOHO Raingarden, the project was able to start implementation but needed to finished before the deadline. Such financial framework had a significant influence on its realization process.

4.5 Comparison of Spatial Solutions and Interactions

This chapter focuses on the difference of spatial solution between two projects and explain the reasons for such difference from the interaction process each project had experienced. As fig 64 shows, spatial solution is a reconfiguration of local space in each of final transition period (period 2-2, or period 3). Therfore, difference in spatial solution derives from the difference of reconfiguration of space between two projects. Reconfiguration is redistribute multiple functionalities, reshape the space physically and reframe meaning of space. Based on that, difference in three dimention of spatial solution is analysed as follows.

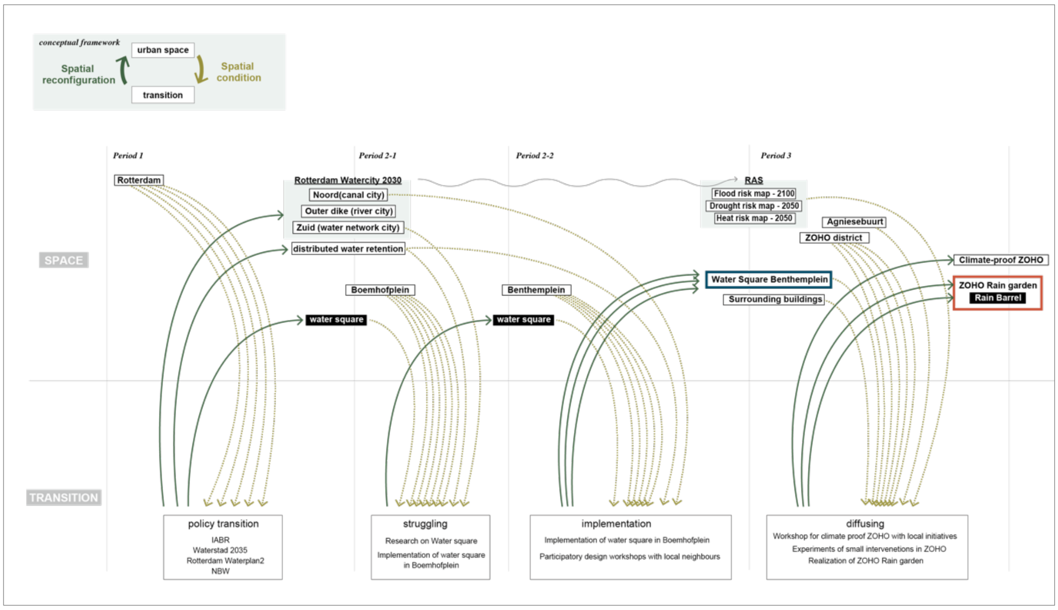


Figure 62 interaction between spatial dimensions and transition (source: author)

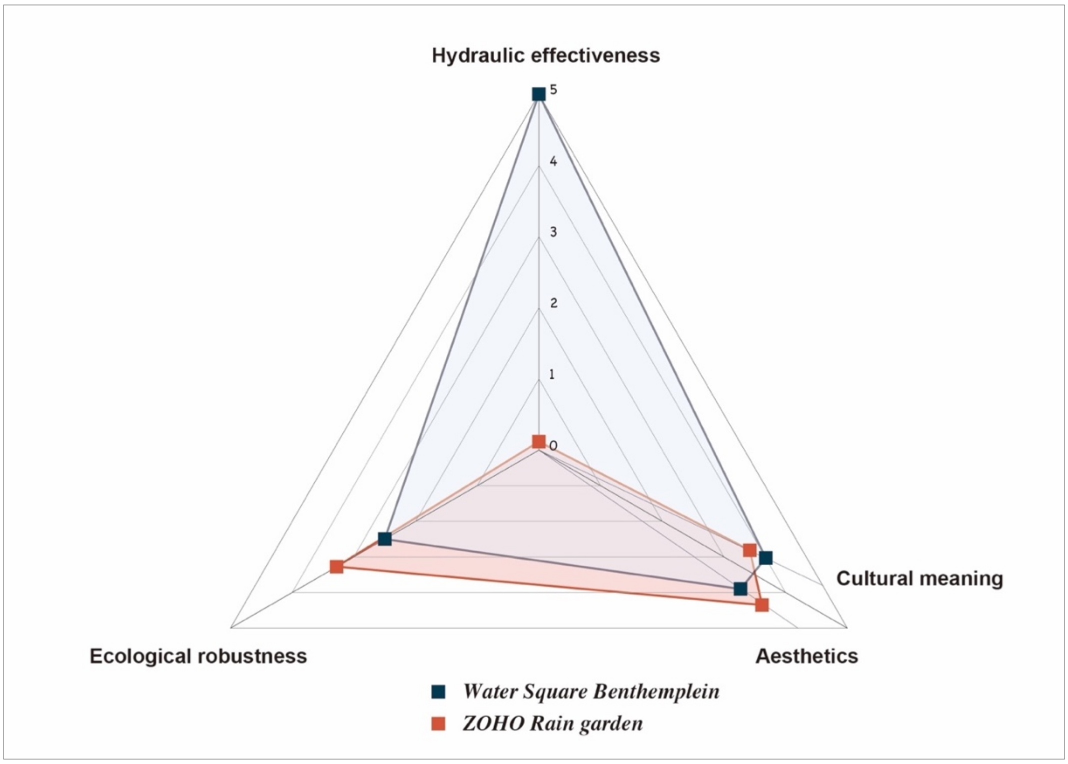


Figure 63 Spatial solution index (source:author)

4.5.1 Hydraulic effectiveness

As explained in chapter 4, the difference between two projects comes from the scale difference; retention capacity index and covering area index. Difference in such project scale derives from each project's reconfigured functionality with regards to water.

Water Square Benthemplein's function is "water square" ; increasing amount of temporary open water for flood risk reduction. The water in the basins comes from surrounding blocks streets, and building roofs. On the other hand, ZOHO Raingarden is intended to infiltrate rainwater from Hofbongen and the garden itself into the ground and to utilize the water for harvesting.

Water Square Benthemplein's functionality is one of the reconfigurations of local square in period 2-2. However, water square was elaborated before the period. The idea was innovated in period 1 as a solution of water retention facility in dense urban area and was elaborated through period 2-1. In other words, Water Square Benthemplein's functionality was decided previously but it needed to adjust to the site for realization as spatial solution.

Existing water system with low capacity and high-dense built environment required large retention capacity in the area. Existing concrete square was not used by local people, which means that large spatial opportunity was in the square. These were important condition for transition. In addition, the transition was conditioned institutionally in local scale as well as city scale. Because local users were positive to a square with open water basin, functionality of water square was accepted. In city scale, the transition was conditioned by Rotterdam's institutional framework that assigned to build up large amount of water retention facility.

Interestingly, such Rotterdam's institution was also reconfigured in previous periods as an idea of water square. In period 1, NBW assigned Rotterdam to increase retention capacity because of climate change. Waterplan2 Rotterdam redistributed water retention functionality in each neighbourhood of the whole city. In relation to water issue, Rotterdam Watercity 2030 visualized the spatial vision and strategy of Rotterdam and Noord area where Benthenplein is located. Such regulation and vision were important institutions embedded in the Benthemplein and surrounding area. Besides, such regulation and vision was a result of transition in period 1 that was conditioned by spatial dimensions of Rotterdam.

On the other hand, functionality of ZOHO Raingarden was reconfigured from bottom up approach in transition during period 3. In the period, workshop with local initiatives was held to enlarge the climate adaptation project to district level and to discover ideas and opportunities. Through the workshop, the rain garden idea grow up from existing spatial opportunities. The paved car parkings were not so large as the water square but suitable for gathering water from surrounding buildings. In this case, local institutions were built up through interactions with physical spatial dimentions in the workshop and they reconfigured the space's functionality as a garden that can retain water for infiltration and green harvesting.

In addition, because of realization of Water Square Benthemplein, ZOHO garden did not have to follow the regulation of water retention capacity as water square. In turn, RAS was an important large scale institutional framework for deciding function of raingarden in this period. During the workshop, ideas were tested for adaptation to not only intense rainfall but also heat wave and drought. Raingarden was suitable for this large scale institution.

Therefore, functionality of space for water decides spatial solution in hydraulic effectiveness. Such functionality is one of the reconfigurations of local space by transition. The last transition for spatial solution is deeply conditioned by local institution, local spatial opportunity, local physical environments but largely conditioned by Rotterdam's institutions. Such interactions is not limited within one period but previous phases and different scales.

4.5.2 Ecological Robustness

ZOHO Rain garden has better score in ecological robustness than Water Square Benthemplein. As chapter 4.3 explains, this is because of large difference of greenery area, pavement, and number of trees that create shaded space. Such physical difference of space is a result of reconfiguration of space physically by transition, but also functionally with respect to green area's role.

Benthemplein is a multifunctional space designed for retaining rain water as well as sports activities, community events, or staying under the trees. The active programs and water basins are suitable for being paved with hard materials. Green areas are distributed in the square but not work for water system. They are used for separation of each basins and creating calm space. Green in the square is not a main functional material for this space. On the other hand, ZOHO Raingarden has functionality of garden, water retention and infiltration, and path for cars, bikers and pedestrians. The green material has the main functionality of space because it is a "garden" that can infiltrate rain water into ground. The water system is integrated to green for harvesting plants in the garden.

Public space functionality in Benthemplein were reconfigurated in transition period 2-2 and clearly reflected local norms embedded in the space through workshop. Because large number of participants in the workshops were from schools, theater and gym, they asked for active programs. Those are integrated with water basins as explained in chapter 4.4.3. In terms of physical reconfiguration of space, attention was paid to large water basins because the realization of water square was a main condition in this transition. Green materials was not emphasized in the report and interviews.

Functionality of ZOHO Rain garden was reconfigured through workshop for climate proof of ZOHO district. Because the workshop was based on RAS, attentions were paid for adaptation to intense rain fall, heat waves and drought. In this context, greenery material was expected to take an essential role in the space. Another key condition was realization of Water Square Benthemplein. Thanks to such a large water retention facility within the area, different type of climate adaptation measure was expected in the site. Spatial conditions of local built environment was suitable for rain garden. Water system of Hofbongen was easily connected to the space.

Therefore, greenery as physical element of space has a different functionality in each space, and the green's functionality determines ecological robustness in spatial solution. Such green's functionality was reconfigurated through transition. Different large scale institution(water retention or climate proof) and local norm was essential condition for reconfiguration of space by transition.

4.5.3 Aesthetics and Cultural meaning

First of all, each project gets high score in aesthetics and cultural meaning of space. In terms of aesthetics, maintenance and trash are main factor for difference between two sites. Maintenance difference derives from each space's functionality. Water Square Benthemplein work for public space so that cleaning maintenance is conducted as an ordinal park. Although ZOHO Raingarden work as "rain garden" that needs professional and careful maintenance, the space is maintained in addition to the municipality's cleaning duty. Such functional difference can be explain as above chapter.

In terms of cultural meaning of space, difference arises from variety of functionality in each site and how well such multiple functionalities are integrated in each site. Each project area has a space for collective meanings of the area. In Water Square Benthemplein, water basins or small green plaza in front of the church are used for cultural activities by students, church community, theatre group and surrounding inhabitants. In ZOHO Raingarden, the ZOHO letters and rain water in the garden work for creating awareness of climate change adaptation to passengers, thanks to the location of the garden. Both of such space with social meaning is a reconfiguration of local space through transition. And both trainsition reflected local people's norms on the place through participatory workshops.

In terms of integration of multifunctionality, Water Square Benthemplein succeeded in distribute public space activity and water basins. On the other hand, the raingarden has problems about the way of integration of traffic system on the street with the garden. The steps in the edge of the garden and bike lane which interrupts bar with access to the garden even though the first planning had the connection. As argued in chapter 4.4.5, this is because lack of discussion between municipality group and local users in the final design process of ZOHO Raingarden. In other words, their norm and value was not completely materialized in the space.

Therefore, aesthetics and cultural meaning of space also depends on the functionality of each space, its variety, and its integration of them. Such multiple functionalities was reconfigured by transition that especially influenced by local norms. In other words, aesthetics and cultural meaning of spatial solution depends on how well the local norm was integrated in the last part of transition.

4.5.4 Overview of Spatial Solutions and Interactions

Spatial solution is a reconfiguration of local space in each of final transition period. This means that differences in spatial solutions are mainly caused by differences in the reconfiguration of local space. Based on the discussion above, different spatial solutions are caused by variety of functionality of space with its physical elements, collective meaning of space and its integration way of multifunctionality. These are reconfigured by transition and such transition is deeply conditioned by the local actors and their institution, but also by local spatial opportunity, by local physical environments and largely conditioned by Rotterdam's institutions.

Such interactions are not limited within one period but previous phases and different scales, but in the final phase, local actors and their norm take an important role to reconfigurate local space into certain spatial solution. In other words, such interactions between spatial dimensions and transition of urban water management lead to a preference for certain multifunctional spatial solutions that are socially embedded in the place and offer more space for water in Rotterdam. This poses some possibility that specific physical, social dimension of space would determine what solution is used, but it requires process of dialogue between local actors and local space to discover their norm as well as a spatial opportunity.

Chapter 5: Conclusions and recommendations

5.1 Research Objective

The aim of this paper is to investigate the mechanism of urban space transformation due to climate change by testing the theories of transition of urban water management and its interaction with urban space. In particular, this research aim to understand the mechanism by appling the theory of interaction to two concrete water management projects in Agniesebuurt neighbourhood; Water Square Benthemplein and ZOHO Raingarden. Based on the conceptual framework of interaction between transition and spatial dimention by Levin-Keitel, et al (2018), this research adds to time axis to the interactions to understand the mechanism of urban space transformation due to climate change.

5.2 Sub-Question1:

How can each period of transition be defined in the timeframe?

Because of the impacts from climate change, urban water management in Rotterdam has transformed themselves into being adaptive to extreme weather from 2000 to 2018. Based on transition in policy, institution, technology and behaviour, analysis of them shows that the urban water management transition in Rotterdam and Agniesebuurt is divided into four periods.

The period 1 (2000-2007) is the first important transition of Rotterdam urban water management for envisioning its direction to being adaptive to climate change. From 2000, Rotterdam municipality started collaborating district water boards to enhance quality of surface water with the city. As a result of niche innovation from IABR and Rotterdam Watercity 2035, as well as large scale institutional framework of NBW, Waterplan2 Rotterdam was enacted in 2007. Waterplan2 Rotterdam is the first official policy as well as formal institution that envisions adaptive urban water management by creating retention capacity of water within the city. During this period, the idea of water square was conceptualized in IABR and developed.

The period 2 (2008-2013) is the phase for implementation of pilot projects as well as for development of knowledge for adaptation strategy to climate change. Realization of the first large water square in Benthemplein in 2013 was a key milestone of technological transition from niche idea level to operational level. Additionally, RAS was launched in the same year. RAS enlarged its focus on not only water-issues to drought and heat island phenomenon, which shows the key update of policy of urban water management in Rotterdam. With the technological development of water square and people’s behaviour, the period 2 can be divided further into two periods; 2008-2010(period 2-1), and 2011-2013(period 2-2). In the first half, municipality tried to implement the idea of water square in Bloenhofplein in Rotterdam, but they faced resistance from residents and stopped. No participation style was planned in this project. This period shows how the innovative idea from niche level grew up to the main streams but the idea was still not accepted by residents’ norm. In 2011-2013, Rotterdam municipality and DE URBANISTEN worked on Benthemplein together with active local neighbors. The local stakeholders were supportive to the idea and participatory workshops adjusted the idea into concrete local context and reflect their needs to the square function.

In the period 3 (2014-2018), Rotterdam succeeded in diffusing climate adaptation in a concrete project into neighbourhood scale. After realization of Water Square Benthemplein and RAS, scope of such climate adaptation was enlarged to neighborhood scale with the scheme of RAS in ZOHO district. With help of other public programs, the municipality realized a raingarden in 2018 as a part of CLIMATE PROOF ZOHO DISTRICT vision. This process from 2014 to 2018 was deeply elaborated by local entrepreneurs and initiatives who were willing to be involved in the climate adaptation and urban space improvements.

Urban water management transition in Rotterdam made progress in each of four periods through policy changes, institutional change, technological development and behaviour of local people to the climate change adaptation.

5.3 Sub-Question2:

How can the spatial solution in Agniesebuurt neighborhood be defined?

In this study, spatial solution is evaluated by indicator of hydraulic effectiveness, ecological robustness, and aesthetics and cultural meaning based on the spatial quality adopted in Room for the river program (Frans Klijn, et al., 2013). Water Square Benthemplein has quite high quality of hydraulic effectiveness, relatively low ecological robustness, and high score in aesthetics and cultural meaning. ZOHO Raingarden has very low hydraulic effectiveness compared to water square, relatively high ecological robustness, and high score of aesthetics and cultural meaning. Those preference is mainly because of functionality the space has for water and green as well as for social activities.

Hydraulic effectiveness score in Water Square Benthemplein has 50 times larger than ZOHO Raingarden. This is because each space has different role in urban water management. There is a large difference in retention capacity and rain capture area. For flood risk reduction, Water Square Benthemplein focuses on increasing amount of temporary open water capacity for gathering precipitation from surrounding blocks. On the other hand, the raingarden is intended to infiltrate rainwater from surroundings into the ground or to utilize the water for harvesting. Therefore, the functionality of urban water management in each site explains this result. On the other hand, ZOHO Raingarden has better score in ecological robustness compared with Water Square Benthemplein. This is because of large difference of greenery area, pavement, and shaded area that trees create. Such material difference is related to each space's functionality of green. Benthemplein offers space for water retention basins, sports activities and community events as well as small green space. The raingarden has mainly functionality of garden with rain water retention.

In terms of aesthetics, problem of garbage and cleaning maintenance arises in Water Square Benthemplein. This is because users' low involvement in the place. In the ZOHO Raingarden, positive opinions are made to the garden maintenance. Because it needs professional knowledge, local botanist group is in charge of it as well as municipality is in charge of basic cleaning. As a result, functionality for local people's involvement is key factor for the aesthetics. In terms of cultural meaning, Water Square Benthemplein gets high score because local uses use the park not only for playing sports but for cultural activities. ZOHO raingarden also gets positive score for its cultural meaning because the project function as creating awareness of climate change adaptation thanks to the location of the garden and ZOHO letters. On the other hand, low integration of traffic system with the garden addressed some local complaints about bad access by wheel chair users and bad connection to the bar next to the garden. Cultural meaning depends on the variety of functionality and how well-integrated the multifunctionality is in space.

5.4 Sub-Question 3:

How do spatial dimensions affect transition in each period?

How does transition in each period reconfigure spatial dimension?

Analysis illustrates that spatial dimensions influence on transition as a condition in every period. What kind of spatial conditions in each period is dependent on the scale that the transition deals with and the type of transition occurs in the period (policy, institution, technology and behaviour). Spatial conditions for the transition are found as follows: location, physical environment, water system, actors, and institution. Location is where the site is located in a large-scale context. In transition process, water system's relation, street and traffic system are needed to be concerned. Transition is spatially conditioned by physical environments; ground condition, spatial opportunity, and characteristics of built environment. Existing water system embedded in the area influences on transition of urban water management because climate change cause problems in existing system and that new interventions influence on the water system. Nieuwe Maas River, canals, singels, sewage system, drainage pipes are found as condition for transition in Rotterdam. Actor, who is in the area, is also an important condition in implementation. Formal institution and local norms and values is essential for transition of urban water management.

As a result of such transition in each period, space is reconfigured. Reconfiguration types are as follows; redistributing functionality, reshaping physically, reframing meaning, and innovating spatial typology. Reconfigured space in Rotterdam by urban water management transition has multiple functionalities that reflect local norms and values. Because of climate change, water retentition facility is a main function but the space is integrated with other public functionalities preferred by local actors. Reconfigured space is physically transformed by transition, especially shape and materials of space. Transition also reconfigure space's meaning by reframing vision of the area that transition occurs or by reframing collective meaning of space.

In Rotterdam, this interaction process started from city level. Rotterdam's spatial dimensions conditioned envisioning urban water management transition. Transition in this period reconfigured Rotterdam not physically but conceptually by reframing it and distributing water retention. In addition, new spatial typology was innovated by such transition. After conceptualization of water square, the process became local building block scale. Thanks to the spatial opportunity the site provided, municipality was able to conduct water square that was needed due to large institutional framework. Local actors addressed functionality of the square by inputting their norm. Benthemplein was reconfigured as integrated public space functionalities and water retention facilities. It was integration through interactions between space of such different scales and transition of urban water management into one spatial solution. After realisation of Benthemplein, the scale was diffusing to neighbourhood. The local condition of people and their norm addressed transition of the envisioning the climate proof district. RAS added new institutional framework for not only water issue but also longer drought and intense heat wave. Unused parking lots and roads with stone pavements in the area were the intervention-able spatial opportunity. Based on such spatial conditions, transition reconfigured space of ZOHO Raingarden that functioned for climate proofing and for local traffic system. ZOHO Raingarden is integration through interactions between transition and spatial dimensions of local neigbourhood and surrounding built environment.

5.5 Main Research Question:

How do interactions between urban water management transition and spatial dimension where the transition takes place explain the spatial solution in the Agniesebuurt neighborhood?

To understand the interaction mechanism, reminding the nature of urban water management is important. Literature review in chapter 2 shows that urban water management has a complex nature in the water system, functionality, and actors' relations. Water is a physical three-dimensional object as well as is embedded in a large urban water system. Hence, urban water management needs to discover intervention-able space for retention of additional water to adapt to climate change. At the same time, urban water management needs to make the system where the water is embedded work in extreme weather condition. Relations with the existing water system needs to be considered. In the densely built environment, such space needs to work for other functionality, such as public space. Although multifunctional space is suitable for climate change adaptation, residents are the main actor using public space. There would be a variety of stakeholders to be considered. Their value and norm on the space are an essential condition for the design of space's functionality. In this way, the transition of urban water management is a process of integration of those complex relations in a water system, functionality, and actors. And such complexities are embedded in local space. To deal with such complexity(water system, functionality, and actors) for a new regime, a transition of policy, institution, technology, and behaviours are needed. In this context, a spatial solution is an integration of the complexities into one space through the interaction of transition and urban spatial dimension.

In timeframe, the spatial solution is a reconfiguration of local space in each of final transition period. This means that differences in spatial solutions are mainly caused by differences in the reconfiguration of local space. Differences in spatial solutions are caused by a variety of functionalities of space with its physical elements, collective meaning of space and its integration way of multifunctionality. These are reconfigured by transition and such transition is deeply conditioned by the local actors and their institution, but also by local spatial opportunity, by local physical environments and largely conditioned by Rotterdam's institutions. Such interactions are not limited within one period but previous phases and different scales. However, in the final phase, local actors and their norms take an important role in reconfiguring local space into certain spatial solution. In other words, such interactions between spatial dimensions and transition of urban water management lead to a preference for certain multifunctional spatial solutions that are socially embedded in the place and offer more space for water in Rotterdam. This poses some possibility that specific physical, the social dimension of space would determine what solution is used, but it requires an intensive process of dialogue between local actors and local space to discover their norm as well as a spatial opportunity.

5.6 Recommendation

Transition of urban water management in Rotterdam toward being adaptive to climate change has not accomplished completely. Even Agniesebuurt, chosen neighbourhood as pilot place for climate proof, faces problems on local resistance because of difficulty in balancing ground water condition and sewage system. Further and more detailed research on the process would be beneficial for understanding interactions between transition of urban water management and spatial dimensions. Analysis on this topic in another site, such as Spangen for instance, would reveal more spatial conditions for the transition.

This study shows transition of urban water management by climate change has interactive relations with urban space in Rotterdam. In such a dense-built environment, Rotterdam has been required to increase space for water. Those spatial dimensions resulted in encouragement of urban space reconfiguration by local people. In some countries, urban water management is still limited to engineering department of infrastructure and not integrated with urban space. Although successful reconfiguration of multifunctional space would require long process of intense dialogue with local people, such transition can regenerate local area and would be efficient for urban land use, for instance.

Not only spatial conditions but drivers of such transition is worth for further analysis. Interviewees mentions several possibilities on this topic. One of them is coordinators who are eager to change the circumstances because their effort would make it possible to gather local norms and values. Spatial design professionals also takes an important role in the process. They have a skill to discover a spatial opportunity and integration of space with multifunctionality. Last but not least, financial support is an important institutional driver in case of ZOHO Raingarden. The project was able to start implementation thanks to a subsidy but needed to finished before the deadline. Such financial framework had a significant influence on its realization process. More analysis on this topic would be beneficial.

In this study, spatial solution is analysed based on hydraulic effectiveness, ecological robustness and aesthetics and cultural meaning. These are essential space indicators evaluating multifunctional space reconfigured by urban water management transition. However, there are some room for improving the definition, especially, aesthetics and cultural meanings of space. Although spatial quality is difficult to be quantified, placing value on the quality of space in transition would definitely improve a city "thanks to" climate change.

Bibliography/References

Ashley, R. M., Balmforth, D. J., Saul, A. J. and Blanskby, J. 2005. Flooding in the future–predicting climate change, risks and responses in urban areas. Water Science and Technology, 52 (5), pp. 265-273.

Ashley, R. M., Blackwood, D. and Jowitt, P., 2004. Sustainable water services. IWA publishing.

Avelino, F., 2017. Power in Sustainability Transitions: Analysing power and (dis) empowerment in transformative change towards sustainability. Environmental Policy and Governance, 27 (6), pp. 505-520.

Avelino, F. and Wittmayer, J. M. 2016. Shifting power relations in sustainability transitions: a multi-actor perspective. Journal of Environmental Policy & Planning, 18 (5), pp. 628-649.

Avelino, F., Wittmayer, J. M., Pel, B., Weaver, P., et al., 2017. Transformative social innovation and (dis) empowerment. Technological Forecasting and Social Change, .

Berkhout, F., Smith, A. and Stirling, A. 2004. Socio-technological regimes and transition contexts. System Innovation and the Transition to Sustainability: Theory, Evidence and Policy, 44 (106), pp. 48-75.

Berndtsson, J. C. and Hyvönen, I. 2002. Are there sustainable alternatives to water-based sanitation system? Practical illustrations and policy issues. Water Policy, 4 (6), pp. 515-530.

Blatter, J. and Blume, T. 2008. In Search of Co‐variance, Causal Mechanisms or Congruence? Towards a Plural Understanding of Case Studies. Swiss Political Science Review, 14 (2), pp. 315-356.

Brears, R. C., 2018. Blue and Green Cities The Role of Blue-Green Infrastructure in Managing Urban Water Resources 1. Palgrave Macmillan UK.

Brown, R. R. and Clarke, J. M., 2007. Transition to water sensitive urban design: The story of Melbourne, Australia. Facility for Advancing Water Biofiltration, Monash University Melbourne.

Brown, R., Ashley, R. and Farrelly, M. 2011. Political and professional agency entrapment: an agenda for urban water research. Water Resources Management, 25 (15), pp. 4037-4050.

Brown, R. and Farrelly, M. 2009. Challenges ahead: social and institutional factors influencing sustainable urban stormwater management in Australia. Water Science and Technology, 59 (4), pp. 653-660.

Castells, M., 1983. The city and the grassroots: a cross-cultural theory of urban social movements. Univ of California Press.

Coenen, L., Benneworth, P. and Truffer, B. 2012. Toward a spatial perspective on sustainability transitions. Research Policy, 41 (6), pp. 968-979.

Coenen, L. and Truffer, B. 2012. Places and spaces of sustainability transitions: Geographical contributions to an emerging research and policy field. European Planning Studies, 20 (3), pp. 367-374.

Deelgemeente Rotterdam-Noord. Hoogheemraadschap van Schieland en de Krimpenerwaard. 2009. Deelgemeentelijk waterplan Rotterdam Noord 2010-2015

DE URBANISTEN. 2010. DE URBANISTEN AND THE WONDROUS WATER SQUARE. 010 Publishers, Rotterdam

DE URBANISTEN. 2014-a. [workshop report for Climate Proof ZOHO]. homepage of Wijkcommunity Agniesebuurt, [Online] Available: https://www.aanpakagniesebuurt.nl/downloads/. [June 6. 2019]

DE URBANISTEN. 2014-b. Climate Proof ZOHO District. homepage of Wijkcommunity Agniesebuurt, [Online] Available: https://www.aanpakagniesebuurt.nl/downloads/. [June 6. 2019]

DE URBANISTEN. 2014-c. WATERPLEIN BENTHEMPLEIN Project documentation. [Online] Available: https://www.rotterdamarchitectuurprijs.nl/2014/waterplein.html [June 20. 2019]

Frantzeskaki, N., Borgström, S., Gorissen, L., Egermann, M., et al., 2017. Nature-based solutions accelerating Urban Sustainability Transitions in cities: Lessons from Dresden, Genk and Stockholm cities. Nature-based solutions accelerating Urban Sustainability Transitions in cities: Lessons from Dresden, Genk and Stockholm cities. 2017. Nature-Based Solutions to Climate Change Adaptation in Urban Areas. Springer, Cham. pp. 65-88.

Frantzeskaki, N., Dumitru, A., Anguelovski, I., Avelino, F., et al., 2016. Elucidating the changing roles of civil society in urban sustainability transitions. Current Opinion in Environmental Sustainability, 22 pp. 41-50.

Fratini, C. F., Elle, M., Jensen, M. B. and Mikkelsen, P. S. 2012. A conceptual framework for addressing complexity and unfolding transition dynamics when developing sustainable adaption strategies in urban water management. Water Science and Technology, 66 (11), pp. 2393-2401.

Gemeente Rotterdam, Waterschap Hollandse Delta, Hoogheemraadschap van Schieland en de Krimpenerwaard, Hoogheemraadschap van Delfland, 2007. Rotterdam Water Plan 2: Working on water for an attractive city.

Gemeente Rotterdam, Waterschap Hollandse Delta & Hoogheemraadschap van Schieland en de Krimpenerwaard, 2005. Rotterdam Waterstad 2035. Episode Publishers, Rotterdam.

Gemeente Rotterdam, 100 RESILIENT CITIES, Rotterdam Climate Initiative, Rotterdam Make it happen. 2016. Rotterdam Resilient Strategy.

Gemeente Rotterdam, 2015, Sustainability 2016-2018 program

Graham, S. and Healey, P. 1999. Relational concepts of space and place: Issues for planning theory and practice. European Planning Studies, 7 (5), pp. 623-646.

Hansen, T. and Coenen, L. 2015. The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. Environmental Innovation and Societal Transitions, 17 pp. 92-109.

Hölscher, K., Avelino, F. and Wittmayer, J. M. 2018. Empowering actors in transition management in and for cities. Empowering actors in transition management in and for cities. 2018. Co-creating Sustainable Urban Futures. Springer. pp. 131-158.

Hölscher, K., Wittmayer, J. M., Avelino, F. and Giezen, M. 2017. Opening up the transition arena: An analysis of (dis) empowerment of civil society actors in transition management in cities. Technological Forecasting and Social Change, .

Hussey, K. and Kay, E. 2015. The opportunities and challenges of implementing 'water sensitive urban design': Lessons from stormwater management in Victoria, Australia. The opportunities and challenges of implementing 'water sensitive urban design': Lessons from stormwater management in Victoria, Australia. 2015. Understanding and Managing Urban Water in Transition. Springer. pp. 593-614.

International Architecture Biennale Rotterdam. 2005-a. De Zondvloed Catalogus, Internationale Architectuur Biënnale Rotterdam

International Architecture Biennale Rotterdam. 2005-b. De Zondvloed Report, Internationale Architectuur Biënnale Rotterdam

Lay-Out, Waterpleinen. 2007. platform voor recent ontwerpend onderzoek,

Longhurst, N., 2015. Towards an 'alternative'geography of innovation: Alternative milieu, socio-cognitive protection and sustainability experimentation. Environmental Innovation and Societal Transitions, 17 pp. 183-198.

Loorbach, D., Frantzeskaki, N. and Huffenreuter, R. L. 2015. Transition management: taking stock from governance experimentation. Journal of Corporate Citizenship, (58), pp. 48-66.

Massey, D., 2012. Power-geometry and a progressive sense of place. Power-geometry and a progressive sense of place. 2012. Mapping the futures. Routledge. pp. 75-85.

Maurer, M., Pronk, W. and Larsen, T. 2006. Treatment processes for source-separated urine. Water Research, 40 (17), pp. 3151-3166.

Maurer, M., Pronk, W. and Larsen, T. 2006. Treatment processes for source-separated urine. Water Research, 40 (17), pp. 3151-3166.

Moulaert, F., MacCallum, D. and Hillier, J. 2013. Social innovation: intuition, precept, concept. The International Handbook on Social Innovation: Collective Action, Social Learning and Transdisciplinary Research, 13 .

Pahl-Wostl, C., 2007. Transitions towards adaptive management of water facing climate and global change. Water Resources Management, 21 (1), pp. 49-62.

Pearson, L. J., Coggan, A., Proctor, W. and Smith, T. F. 2010. A sustainable decision support framework for urban water management. Water Resources Management, 24 (2), pp. 363.

Rijke, J., Ashley, M. and Sakic, R. 2016. Adaptation mainstreaming for achieving flood resilience in cities. Socio-Technical Flood Resilience in Water Sensitive Cities—Adaptation Across Spatial and Temporal Scales, .

Rotmans, J., Kemp, R. and Van Asselt, M. 2001. More evolution than revolution: transition management in public policy. Foresight, 3 (1), pp. 15-31.

Rotmans, J. and Loorbach, D. 2009. Complexity and transition management. Journal of Industrial Ecology, 13 (2), pp. 184-196.

Rotterdam Climate Initiative, 2013, Rotterdam Climate Change Adaptation Strategy

Rotterdam Climate Initiative, 2013, Rotterdam Climate Proof report : ADAPTATION PROGRAMME[Online] https://sdr.gdos.gov.pl/Documents/Wizyty/Belgia%20i%20Holandia/Program%20adaptacji%20do%20zmian%20klimatu%20w%20Rotterdamie.pdf [June 29. 2019]

Sapkota, M., Arora, M., Malano, H., Moglia, M., et al., 2015. An Overview of Hybrid Water Supply Systems in the Context of Urban Water Management: Challenges and Opportunities. Water, 7 (1), pp. 153-174.

Silvestri, G., Wittmayer, J., Schipper, K., Kulabako, R., et al., 2018. Transition Management for Improving the Sustainability of WASH Services in Informal Settlements in Sub-Saharan Africa—An Exploration. Sustainability, 10 (11), pp. 4052.

Smith, A., 2005. The alternative technology movement: an analysis of its framing and negotiation of technology development. Human Ecology Review, 12 (2), pp. 106.

Truffer, B., Murphy, J. T. and Raven, R. 2015. The Geography of Sustainability Transitions: Contours of an Emerging Theme, .

Van der Brugge, R. and De Graaf, R. 2010. Linking water policy innovation and urban renewal: the case of Rotterdam, The Netherlands. Water Policy, 12 (3), pp. 381-400.

Wang, H., Mei, C., Liu, J. and Shao, W. 2018. A new strategy for integrated urban water management in China: Sponge city. Science China Technological Sciences, 61 (3), pp. 317-329.

Wittmayer, J., Roorda, C. and van Steenbergen, F. 2014. Governing urban sustainability transitions–inspiring examples. International Journal of Sustainable Development, 15 (1), pp. 19-36.

Wolfram, M., 2018. Cities shaping grassroots niches for sustainability transitions: Conceptual reflections and an exploratory case study. Journal of Cleaner Production, 173 pp. 11-23.

Wong, T. H., 2006. Water sensitive urban design-the journey thus far. Australasian Journal of Water Resources, 10 (3), pp. 213-222.

Wong, T. H. and Brown, R. R. 2009. The water sensitive city: principles for practice. Water Science and Technology, 60 (3), pp. 673-682.

Annex 1: Research Instruments and Time schedule

Interview Guideline

I am Takashi Obase. I am a student of IHS, Erasmus University Rotterdam. This interview guideline is used as an instrument for research on "Spatial Solution for Climate change: Integration of Interactions between Urban Water Management Transition and Spatial Dimension". This interview will be used only for academic purposes.

Date and Time of the Interview:
Respondent:

• Name:	•Email:
• Position:	• Institution:

Questions

-Transition process

Your position in relation to the municipality or client
Is there any missing event in the timeline in relation to water management transition in Rotterdam?
Is there any force influencing on the process? (Key driver, Key agency/actor, Key institution)

-Project of Water Square Benthemplein

How were you involved in the project?

How the relationship between the pilot studies in other plein and Benthemplein? and
Why the place was chosen as the first water square? (Was there any potential/opportunity at that time?)

Policies are supportive? Role of policies and influence on policies

(water plan 2, climate proof program, Rotterdam adaptive strategy, resilient city)

What was discussed in each workshop and when were they?

Agenda / Aim / challenge / research beforehand?

Process / who join

Result / What was changed through WS? What did people find through WS?

Through ws, what did people find / learn ?*]*

-ZOHO Climate proof project and ZOHO Raingarden

What was the relation between water square and ZOHO area development?

Why the area was chosen?
There are two development periods, how did they develop?

How were you involved in that?

What was discussed in each period?*]*

Agenda / Aim / challenge / research beforehand?

Process / who join

Result / What was changed through WS? What did people find through WS?

Opinion on current situation.

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