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Managing flood risks caused by torrential rainfalls, while contributing to the spatial quality.

A comparison between the cities of Rotterdam and Groningen.

Water retention square ''Benthemplein'' in Rotterdam. Source: De Urbanisten (2011).

By: M. van der Goot
Supervisor: B.J. Kuper, MSc.
University of Groningen, Faculty of Spatial Sciences
BSc. Spatial Planning and Design

m.van.der.goot@student.rug.nl
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Summary

Increase in torrential rainfalls is one of the negative effects of climate change that urban areas have to deal with. Becoming climate resilient includes mitigating to the risks that come with growing chances of such intense rainfalls. Dealing with these risks can be done in various ways. First of all, institutional changes, such as raising awareness by the municipality and citizens is needed. Secondly, spatial implementations that contribute to the spatial quality, such as using softer pavement materials and water retention squares help to capture, store and drain excessive rainwater are needed. There are big differences in how different cities handle this problem. This study compares the policies of the city of Rotterdam and the city of Groningen to answer the research question: What lessons can Groningen learn from Rotterdam on management of flood risks due to torrential rain, when integrating urban planning and water management? Qualitative data about the policies of both cities was collected by interviewing policy makers of both municipalities. In addition to this a set of policy documents of both municipalities is analysed. After analysing both policies, differences were identified and suggestions of lessons that mainly the municipality Groningen could learn from the municipality of Rotterdam were provided in this paper. Rotterdam has a further developed policy than Groningen. First of all, Rotterdam has a more extended spatial analysis than Groningen in respect to both quality and quantity. Secondly, differences in awareness about the problem of flood risks due to torrential rain are recognised. Groningen strives for internal awareness of the problem, while this is to a sufficient extend already achieved in Rotterdam where they seek for more awareness among the citizens. Differences in spatial concepts that have been implemented in both cities are contributed to the fact that the city of Rotterdam is willing to experiment with innovative solutions, where the city of Groningen choses for safe solutions that already turned out to be successful.

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1) Introduction

Extreme weather events occur more and more frequently in the present day. Not only problems of drought, which were obviously present in the summer of 2018 (KNMI, 2018), but also heavy rainfalls bring up concerns (Runhaar et al., 2012). Climate change has led to a rise in rainfall of approximately 26% between the years 1910 and 2013 (KNMI, 2014). The biggest problem of this rise in rainfall is the increase in torrential rains, to be more specific torrential rains in urban areas. Especially these areas will have to endure the negative effects of the scenario, due to use of hard pavement materials with a low permeability, such as asphalt and concrete, streets easily flood (Lui & Cheng, 2014). In addition, Dutch city centres tend to be built in a high density (Gemeente Rotterdam, 2011), which make it hard to change the water infrastructure, and makes these areas vulnerable (Gemeente Groningen, 2018). The sewerage systems do not have the capacity to cope with extreme amounts of inflowing water. This results in flooded streets with waste water, which is very bad for public health and causes damage on buildings. (Dai et al., 2018). These problems result in rise of awareness of the risks that are caused by torrential rains, and policy makers tend to seek for solutions (Gemeente Rotterdam, 2011).

Obvious solutions seem to be extending the capacities of existing water infrastructures by introducing new, innovative systems, or by completely renewing the existing systems. Nonetheless, these strategies are really high in their costs and do not immediately contribute to the spatial quality of the urban areas (De Graaf & Van der Brugge, 2010). These disadvantages are reason enough for municipalities to seek more sustainable solutions which do contribute to spatial quality by having a multifunctional character (Gemeente Rotterdam, 2011). To come to such solutions, both spatial and organisational innovations need to be developed (Mukheibir, 2017).

An observation of 25 Dutch cities has shown that there are great differences in the extent to which these cities succeed in developing sophisticated policies that attack the problem of pluvial flooding in a sustainable and integrated way (Den Exter et al., 2015). Big cities, such as Amsterdam, Rotterdam and Utrecht already developed successful projects that are the result of organisational developments (Den Exter et al., 2015). To look deeper in the case of Rotterdam, projects such as the water square at the ''Benthem plein'' and the ''Museum park garage'' - which function as a buffer for excessive water during torrential rainfalls - (Rotterdam climate initiative, 2018) are made possible because there is a strong collaboration between a group of important stake holders in the city (Kruip, 2016) and a high ambition for creating innovative solutions (Gemeente Rotterdam, 2011).

The earlier discussed implemented concepts can be seen as successful results of making the city climate resilient by integrating water management into urban planning, but it is not clear whether the city is developing this strategy further and if it does, in what ways it does.

Groningen did develop some implementations to address the problem of flooding due to torrential rainfalls, such as replacing regular paving with water-passing paving in some areas (Gemeente Groningen, 2016). Nonetheless, in contrast to the city of Rotterdam, following Den Exter et al. (2015), Groningen lacks a central climate coordination office, ''to highlight that

climate strategies are important for, and should be addressed by, everyone in the municipal organisation''. These findings raise the question whether the municipality of Groningen is actually aware of the risks of climate change and whether the municipality is developing policies that will attack the problem in the future, in addition, to do this in a way where not only the risks will be managed, but also to contribute to the spatial qualities of the city.

Research questions

The aim of the research is to develop a comparison between the cities of Rotterdam and Groningen of how these cities integrate urban planning and water management to address the problem of flooding due to torrential rains. The fact that it is safe to say that the city of Rotterdam has already developed a sophisticated concept on this subject in the past, leaves the question what the planned strategy for the future is.

Groningen did not develop such a strategy in the past and it is hard to say whether the municipality is working on one to manage the problem in the future. Both these uncertainties make this study socially relevant

The comparison made in this research could lead to the discovery of lessons that could be learned by one city from another, demonstrating the academic relevance of this study.

As the municipality of Rotterdam is ahead of Groningen on this subject, the research may take lessons for the city of Groningen from Rotterdam's experience. This leads to the central question:

What lessons can Groningen learn from Rotterdam in management of flood risks due to torrential rain, when integrating urban planning and water management?

To answer this question, answers to a number of secondary questions is needed:

-To what extent has Rotterdam developed a concept on integrating urban planning and water management to find solutions for flood problems caused by torrential rainfalls?

-To what extent has the Groningen developed a concept on integrating urban planning and water management to find solutions for flood problems caused by torrential rainfalls?

-To which degree can policies and measures to manage flood risk by torrential rain be transferred from Rotterdam to Groningen.

Reading guide

This study is built up in the following structure. After the introduction follows chapter two wherein the theoretical framework is presented. Theories and concepts relevant to this study are presented and explained in this chapter, after which a conceptual model is set up. In chapter three the methodology is stressed out, in which is explained which research methods were used and which considerations were taken into account. In chapter four the results are presented, and comparisons are made between the two cases on three different subjects. In chapter five the conclusions, recommendations, discussion and reflections are presented.

2) Theory

Theoretical framework

To understand the academic relevance of this study a theoretical framework is set up. Theories and concepts that are relevant to this study are elaborated in this chapter to indicate the position of this study among other academic studies.

Torrential rain

Increase in temperature of the air due to climate change results in the air being capable to contain more water. As this warm, moist air rises and cools down, rain is the result. This leads to more and heavier rainfalls, not only in the winter, but also in summertime (Feng et al., 2007). This phenomenon of intense rainfalls, for example 70 millimeter rain per hour, is referred to as torrential rainfalls (Easterling et al., 2000).

Torrential rain is a big threat for urban areas. Firstly, because urban areas consist of hard materials with low permeability. In case of an intense rainfall, places where water can infiltrate into the soil tend to be scarce. This results in city centres flooding easily (Lui & Cheng, 2014). Secondly, urban areas tend to be built in a high density. The fact that cities consist of high concentrations of buildings with all sorts of functions, makes it vulnerable. Intense rainfalls can flood the streets, with financial and material damage as result (Jha, Bloch & Lamond, 2012). Thirdly, the sewerage systems of Dutch cities are not designed with the capacity to manage high quantities of water in short periods. Torrential rainfalls force sewerage systems to use their overflows, which result in unhygienic water in the surface waters in the cities, with health risks as result (Kruip, 2016). A counter argument for the statement that torrential rain is a true risk for Dutch cities is the fact that rainfalls of such scale are very scarce and do not occur often in the Netherlands (Lenderink et al., 2008). Nonetheless, the fact that something did not occur in the past is not a guarantee that it will not happen in the future, especially concerning torrential rainfalls, given the fact that the cause of this problem, global warming, is increasing (Lenderink et al., 2008).

Climate resilience

Cities that understand how to cope with impacts of potential natural disaster (which can be devoted to climate change) through urban planning are referred to as ‘’climate resilient cities’’ (Prasad, 2008). Climate resilience is, in other words, the capability of a municipality to cope with the changes of climate (Næss et al., 2005). In this research the most important aspect of climate change is the increase of torrential rainfalls. Being resilient to this increasing threat means that an urban area is capable to adapt to the consequences of these risks (Næss et al., 2005).

Integration

Climate adaptation is in this research an important concept. Rather than climate mitigation, which refers to measures that have to lead to prevention of consequences of climate change, climate adaptation tends to cope with the consequences in a way that does not lead to a decrease in spatial quality (Bosch et al., 2013).

Resilient cities adapt to potential risks by increasing the spatial quality. Implementing solutions meant to manage flood risks caused by torrential rainfalls, combined with improving public space, should be the result of integration of water management with other policy making sectors, especially with urban planning (Kruip, 2016).

The municipality of Rotterdam acknowledges that urban water infrastructure should gradually transform by integrating water infrastructure investments with urban revitalization programs (De Graaf & Van der Brugge, 2010). To let this transformation become a success, integration of multiple policy fields (planning department and water management department) is necessary. Although this might seem to be a successful way to achieve such a policy area, it asks for great amounts of effort and money. Both tend to be scarce in municipalities, given that many Dutch municipalities lack in having enough man power, and that the major income source is through taxes, which are hard to raise without getting into conflict with the citizens of the municipality (Van Bommel & Kuindersma, 2008). To actually develop such an integrated policy, a carefully considered transition is needed, which will be set out in the next paragraph.

Transition theory

To break down the transformation set out above, the transition theory can be used (De Graaf & Van der Brugge, 2010). This theory breaks a transition down in four phases: the pre-development phase, the take-off phase, the acceleration phase and the stabilization phase. It might be interesting to investigate in which perspective is used in both Rotterdam and in Groningen and in what phase these cities currently are developing. Although the transition theory might seem to be a helpful tool differentiate the phases of the development of a municipality, it is a quite abstract theory (Robinson & Carson, 2016). In practice it is hard to observe in what phase a transition actually is, mainly because all different phases overlap in fact, but also because different sectors work apart and the one develops itself faster than the other, which leads to the fact that not all sectors move in the same phase (Robinson & Carson, 2016). Nonetheless, the transition theory helps an institution to structure its development.

Citizen-participation

The tools that are mentioned above that helped the municipality of Rotterdam to come about a successful policy do not provide an answer to the earlier mentioned problems of lack in labour and financial resources that most Dutch municipalities meet. The solution to this is participation of local citizens (Kruip, 2016). First of all, because work is taken out of hands of the municipality. By only providing the possibility for locals to have their involvement in, for example, brainstorm sessions, a top-down structure is created. The municipality shifts towards a more mediating role, instead of an all determining authority, which saves labour

and money (Wallner et al., 1996). Furthermore, dissatisfaction of local stakeholders is prevented. By involving the local inhabitants and other stakeholders into the decision-making process, everyone's desires are considered. This can prevent the development of action groups, which makes the transition towards new implementations more efficient (Kruip, 2016). Despite these benefits, working towards a bottom-up decision-making structure makes a municipality dependent on its local stakeholders (Chan, 2013).
To ensure a successful decision-making environment, locals need to be willing to participate. This makes the process vulnerable. Nonetheless, the municipality needs to see this problem as a challenge that is part of the whole transition that is to be made. It is the job of the municipality to create a situation wherein it is easy to participate and stimulate local stakeholders to be part of the process (Wallner et al., 1996).

Spatial concepts
Eventually these organisational concepts need to lead to spatial concepts that both manage the risks of flooding as result of torrential rainfalls, as well as contribute to the spatial quality. Concepts that are mentioned frequently are, among others, water squares, green roofs and paving materials with high permeability (Kruip, 2016). First, water squares are multifunctional area's which function as recreational area's under dry circumstances and during intense rainfalls as buffer zones (Boer et al., 2010). Secondly, by referring to green roofs, the concept of adding green structures to the roofs of buildings is meant. In this way excessive rainfall can be stored on top of buildings instead of immediately discharging it to the sewerage systems on ground level (Mentens et al.). Thirdly, replacing existing paving materials with low permeability by newer materials with higher permeability rainwater can infiltrate easier into the soil (Gemeente Rotterdam, 2011). This lowers the quantities of water that needs to be discharged to sewerage systems in case of torrential rainfalls (Kruip, 2016).

Water retention, storage and discharging
What these three spatial concepts have in common is the concept of water retention, storage and discharging. This plays a great role in the management of flood risks due to excessive rainfall in the city of Rotterdam (Gemeente Rotterdam, 2011). Applying this strategy is done by implementing solutions such as water retention squares, ''softening'' parking areas (to improve infiltration) and retaining water in green roofs. This approach of capturing, storing and draining rainwater is referred to as the three-step method (Dai et al., 2018). What it actually means is that rain water is locally captured, rather than being discharged immediately to the sewerage systems with overflow as negative result (Mentens et al.). After capturing, the water is stored until it can slowly be discharged, partly through infiltration and partly towards the sewerage systems. This strategy decreases stress on the sewerage system and can be beneficial in times of drought.

Conceptual model

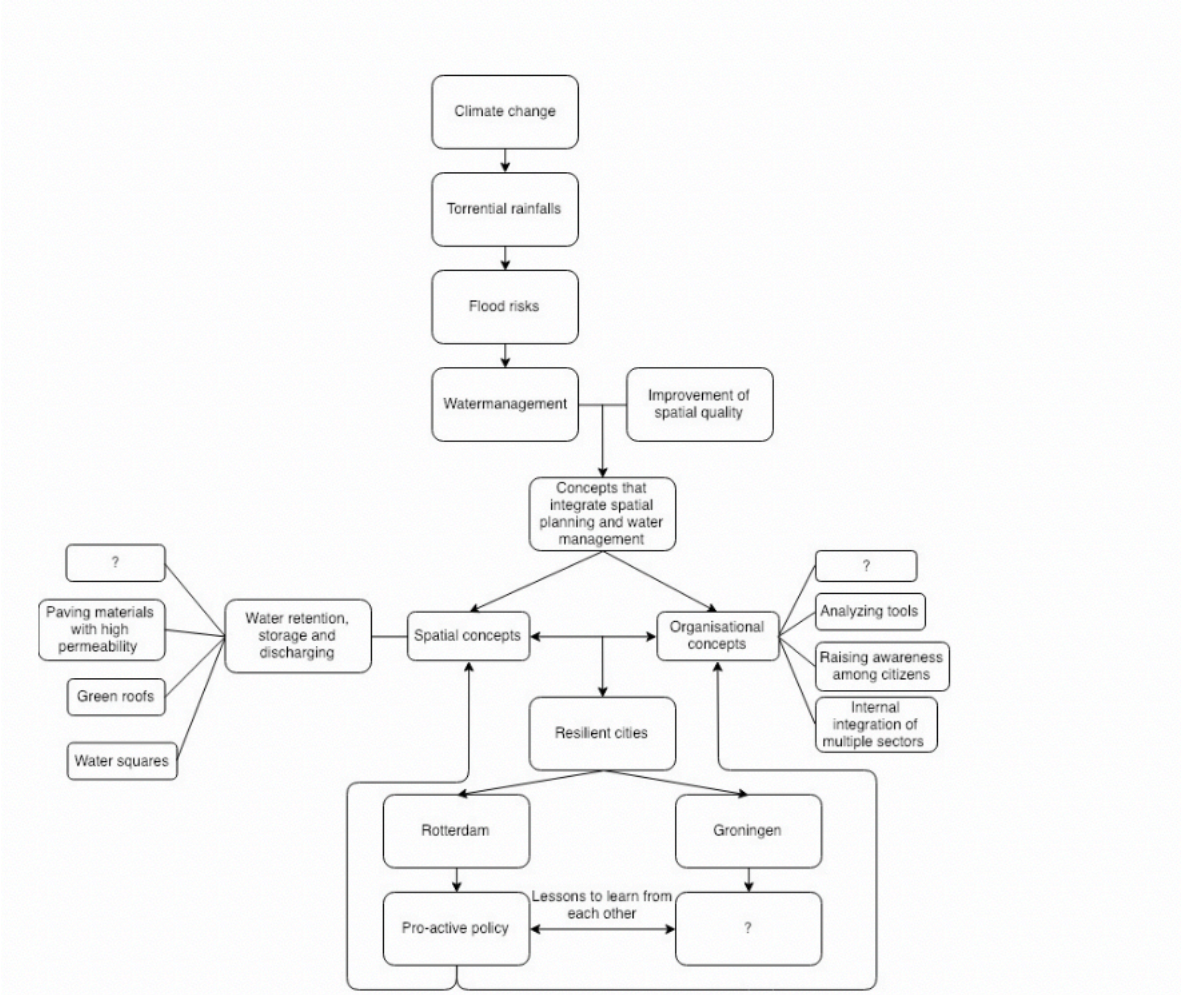


Figure 1: Conceptual model.

This conceptual model (figure 1) is used to visualize the most important concepts discussed in this paper, presented along with the research gap. Due to climate change all sorts of negative effects occur on our environment. One of these is the increase of torrential rainfalls in both the summer and in the winter. Shortly explained is this the result of increase in warm air, which contains more water and after rising and cooling down, resulting in rain. To adapt to this problem through water management while contributing to spatial quality concepts that integrate both policy sectors are needed. In this paper we distinguish between spatial and organisational concepts. When executing such concepts is done successfully cities can be classified as being resilient to the problem of flooding due to torrential rainfalls. The city of Rotterdam has, as discussed earlier, developed a pro-active policy that consists of both spatial- and organisational concepts to attack the problem of torrential rainfalls while contributing to the spatial quality, where such a policy is not yet developed in Groningen. This is where the research gap of this study is to be found: to what extent has Groningen developed such a policy and what lessons can both cities learn from each other.

3) Methodology

This research began with determining the cases that would be analysed and compared. First of all, the city of Rotterdam was selected. Reason to choose Rotterdam was because this city is nationally and internationally known for its innovating implementations to address the problem of flooding due to excessive rainfalls. For this study a city which was not particularly well-known known for its policy to address this problem, being Groningen, was chosen as second case. A comparison between cities with a more developed and a lesser developed policy on this subject could lead to conclusions wherein lessons are taken from one case and let the other case learn from this.

Considerations

When designing the research strategy, a set of considerations was created (Clifford et al., 2010). The first consideration is the choice between either qualitative, or quantitative research methods.

A comparison of policies of two municipalities calls for in-depth research. This means that qualitative research methods are most suitable for conducting this research. By interviewing policy makers from different sectors within the municipalities of both cities, it is possible to make a proper analysis of both municipality's policies (Clifford et al., 2010). After determining that qualitative data would be collected by conducting interviews, the consideration what type of interviews would be conducted arose. The choice whether a structured, a semi-structured, or an unstructured interview would be conducted was considered. Semi-structured interviews were chosen to be done, because this would allow respondents to provide their answers in their own words and to address subjects that are in their eyes relevant to the interview (Clifford et al., 2010). Each interview was conducted following the same interview guide, which is added to the appendix (1).

After the decision was made that the primary data would be collected through semi-structured interviews, respondents were approached to participate in this research. Two respondents of the municipality of Groningen and three of the municipality of Rotterdam were willing to participate in this research. An overview of the respondents is provided in the appendix (3).

Method and analysis

A total amount of five interviews is sufficient to draw conclusions about both policies, nonetheless a policy document analysis was added to the research. Reason for this was to verify statements of the respondents and to search for additional information that could contribute to this research.

Each interview was recorded and afterwards transcribed. An analysis was made up by coding the transcribed interview. In addition, also parts of collected policy documents were coded. Coding was done in Atlas.ti8.1. Before coding was done the choice whether deductive, or inductive coding should be conducted. In case of a deductive coding method, a pre-set of codes is made up, based on literature research and the conceptual model. Inductive coding is a system wherein the codes are derived from the collected data, while analysing the collected data, the code book is made up (Clifford et al., 2010). For this research inductive coding was chosen, reason for this is the fact that this is a more appropriate form of coding in the case where the policies of two municipalities are compared. An overview of the code tree is added to the appendix (2).

Ethics

While conducting semi-structured interviews a couple of ethical issues were considered (Clifford et al., 2010). First, the privacy of the respondents was a point of consideration. None of the respondents objected to publishing their names in this study, this is why their identities are not hold anonymous.

Secondly transparency was an issue to consider. Before each interview was conducted, the respondent was asked whether the interview could be recorded. At the end of each interview, the respondent was asked whether there were any notes on subjects addressed during the interview and if anything had to be removed from the interview.

After each interview was transcribed, the transcript was e-mailed to the respondent, final version of this research paper was e-mailed to each respondent.

4) Results

To create a decent overview of the policies of both municipalities, to compare them, this section will be divided into themes being: spatial analysis, organisational structures and spatial concepts.

Spatial Analysis: Rotterdam

The municipality of Rotterdam modelled the city using a calculation package, this package is called 3Di (Waterboards & Province Zuid-Holland, 2014). Not only ground level was included, but also sewerage systems and the surface water systems. Eventually a stress test was executed on this model. Three scenarios were put to the test, being 50 millimetres rain in one hour, 100 millimetres rain in two hours and 70 millimetres in one hour (Pieneman, personal communication, 25-10-18). The model visualised the spots which would gain flood problems in these scenarios. The model showed which buildings would risk flooding, which roads would become impassable and which vulnerable objects would come into danger. With vulnerable objects are meant objects such as hospitals and elderly homes, objects which would cause problems if they became impassable (Van Dijk, personal communication, 19-11-18) (Waterboards & Province Zuid-Holland, 2014).

Given the fact that this is not the first time that the municipality calculated the sewerage systems, they had been doing this for a long time, raised the question whether this new method would actually give new results. Eventually by identifying the lowest spots in the region, the wettest spots are identified, concerning that these are (most of the time) inherent to each other (Pieneman, personal communication, 25-10-18).

Nonetheless, the benefit of the 3Di model is that the interaction between systems is made visible. Like most cities, the sewerage system and the open water system are strongly dependent to each other (Pieneman, personal communication, 25-10-18). In cases of high quantities of water, the overflows of sewerage systems can be used. This leads to having polluted sewerage water mixed with the surface water systems in the inner city Thus, analysis of the connection of both water systems is of utmost importance (Van Dijk, personal communication, 19-11-18).

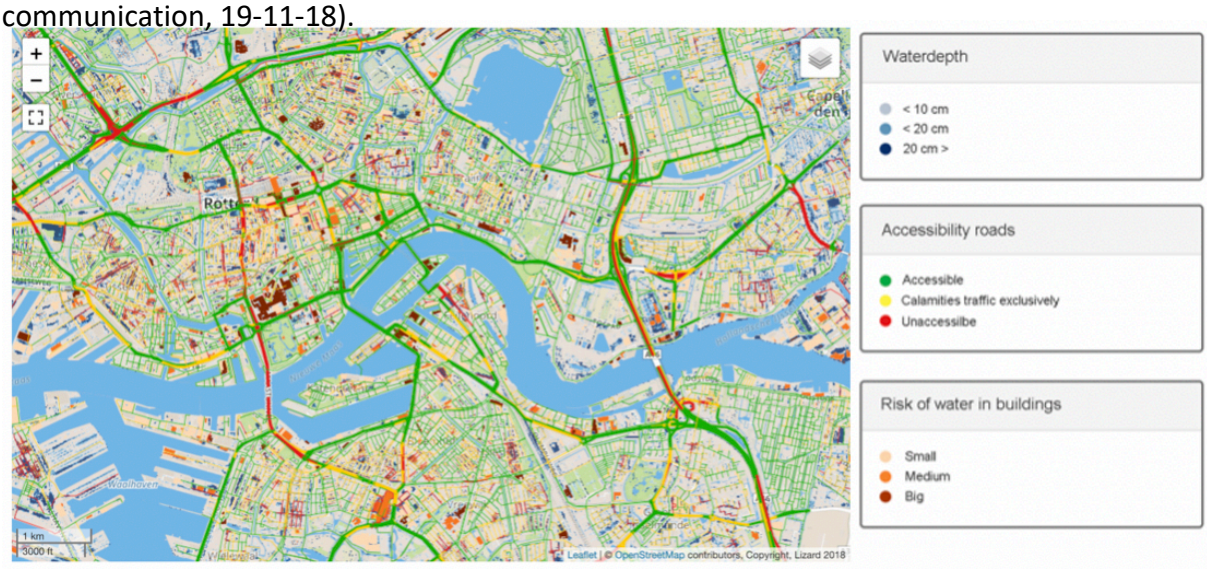


Figure 2: Stress test 100mm rain in two hours in Rotterdam. Source: Provincie Zuid-Holland (2014).

Spatial Analysis: Groningen

Commissioned by the national government, the municipality of Groningen also did a stress test (Jansma, personal communication, 24-10-18). Rain falls of 58 and 73 millimetres in one hour were put into model to visualize problematic areas (Gemeente Groningen 2018). The municipality chose not to put a rainfall of bigger size into model, because the probability of a rainfall such as in Denmark (150 millimetres in two hours (Gemeente Groningen, 2018)) is very low. In case that such a cloud break would occur, the municipality would consider this as very bad luck (Jansma, personal communication, 24-10-18).

Just as in Rotterdam the stress test in Groningen made visible which roads would become impassable and which vulnerable objects would become problematic. This was of use when analysing which areas had priority with implementing solutions for flood problems (Jansma, personal communication, 24-10-18). When analysing this, not only the objects itself had priority but also its surroundings. To illustrate this an example: When the university hospital (UMCG) is above flooding level it sounds positive, but when all surrounding roads are flooded, it is still problematic (Gemeente Groningen, 2018).

The next step is determining a base effort. This is done together with the water boards. This base effort consists of maintaining and managing the sewerage systems. Thereafter, possibilities to go further are explored. With the knowledge that torrential rainfalls will increase in frequency, the municipality is aware that the sewerage systems themselves do not have enough capacity to keep the city free from flooding during excessive rain falls, so alternative solutions are needed (Jansma, personal communication, 24-10-18).

Figure 3: Stress test 73mm rain in one hour in Groningen. Source: Gemeente Groningen (2018).

Spatial Analysis: Comparison

Both municipalities recognise torrential rain falls as (future) threats for their cities. In Rotterdam as well as in Groningen an analysis with help of a stress test was done, nonetheless the one executed in Rotterdam was more extensive and focussed on the relation between surface water and sewerage systems than the one in Groningen. It can be advised to the city of Groningen to run such a model as well, given the fact that a scenario wherein sewerage water and surface water mix in the inner city, hygiene problems may occur.

A discussion may rise about the fact whether it is fair to compare the way the municipalities analyse the connection because the physical situation in both cases is different (Rotterdam has the Meuse which flows through the city, while Groningen does not have such a river flowing through the city) (Pieneman, personal communication, 25-10-18).

Nonetheless it may be helpful for the city of Groningen to analyse this connection, to mitigate the risk of having polluted sewerage water in the canals around the inner-city centre. In addition to this it also may be of use to execute a test wherein a rainfall over a longer period (70mm in two hours) is put into the model. For this research such maps are provided (Figure 4 and 5). Figure 5 shows a scale which makes visible that during a rainfall of 70mm in two hours, important objects in the city centre, such as the roads connected to the UMCG hospital, the railway and the Gedempt Zuiderdiep become problematic.

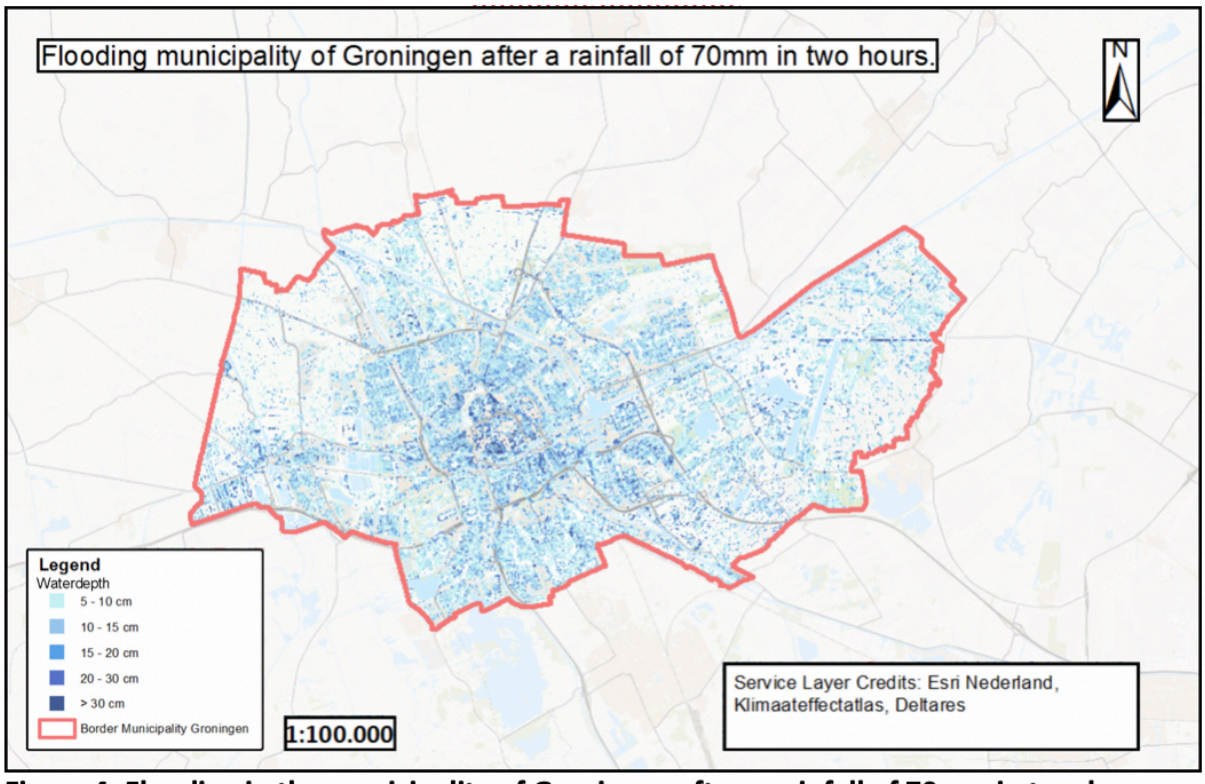


Figure 4: Flooding in the municipality of Groningen after a rainfall of 70mm in two hours.

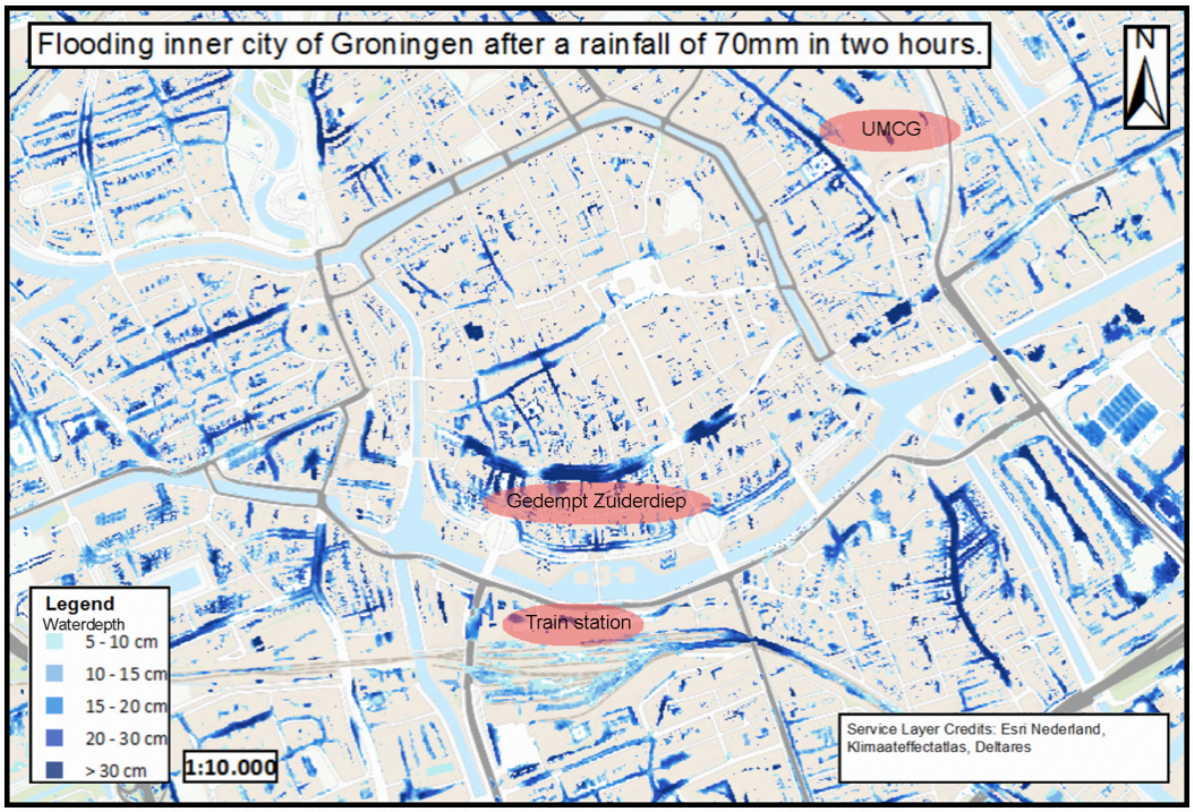


Figure 5: Flooding in the inner city of Groningen after a rainfall of 70mm in two hours.

Organisational structures: Rotterdam

In the process of creating and implementing solutions for flood risks due to torrential rain, the municipality of Rotterdam wants to shift from working for the citizens, to working with the citizens, to eventually having the citizens doing the work (Pieneman, personal communication, 25-10-18). To explain this, historically, the municipality of Rotterdam planned and developed spatial implementations in a top down way in the past. Most decisions concerning the public space were made for the citizens, but not by, or together with the citizens (Pieneman, personal communication, 25-10-18). The water plaza at the 'Benthem plein', which opened in 2013, was designed together with the surrounding stakeholders so that everyone's needs were meet to some extent. This project was led by a project developer called ''De Urbanisten'' (Van Dijk, personal communication, 19-11-18). Although this way of improving the quality of the public space together with local stakeholders proved successful (Water Sensitive Rotterdam, 2018, see below), the municipality acknowledge the problem that by only making use of the public space, the risks will not be mitigated enough. According to the municipality it is essential that eventually citizens themselves start to change the structures of their private properties (Pieneman, personal communication, 25-10-18).

The first step in achieving this is raising awareness for the risks of torrential rainfalls. By having citizens participate in creating solutions for storing rain water instead of discharging it citizens become more aware. Water Sensitive Rotterdam is an initiative to make citizens enthusiastic to participate in water projects (Mesu, personal communication, 12-11-18). It consists of a network of people from inside and outside the municipality, who organise meetings in areas

where there are plans of starting projects such as water gardens. Water Sensitive Rotterdam mainly focusses on making the public space water and rain proof (Water Sensitive Rotterdam, 2018). There is also an educative package that can be used by elementary schools to raise awareness for children. This package consists of coatings with which children can paint water adaptive relevant designs on streets and squares (Van Dijk, personal communication, 19-11-18).
These developments do not directly lead to privately owned properties becoming more water proof, but it must lead to more awareness (Van Dijk, personal communication, 19-11-18). This rise of awareness can lead to people starting to think about putting more greenery in their gardens or to choose for getting green roofs (a subsidy scheme was developed for this, but this jar is empty, nonetheless, the municipality is working on a new subsidy scheme).
It is important to mention that all of these projects, structures and plans are developed in a ''pilot-sphere''. The city of Rotterdam likes to present itself as an experimental garden for spatial concepts that integrate water management. This is, in fact, also part of their marketing strategy (Mesu, personal communication, 12-11-18). By experimenting with concepts, lessons can be learned, and concepts can be developed further to be implemented elsewhere. To conclude this, the red line through the policy of the municipality of Rotterdam on adapting to the risks of torrential rainfalls is learning by doing in the form of experimenting with all sorts of spatial concepts.

Organisational structures: Groningen
The municipality of Groningen sets out three different scenarios in which awareness is raised for redeveloping public space to become more water adaptive. These are citizens taking initiative, a combination of hydraulic calculations and depreciation of sewerage systems, and redevelopment of neighbourhoods (Jansma, personal communication, 24-10-18). First, citizens can make the municipality aware of problems of flooding in their neighbourhood. This is an important source, because not all problematic areas are highlighted in the stress test analyses (Jansma, personal communication, 24-10-18). In the second scenario, the outcomes of hydraulic calculations done in the stress test are analysed. After this, sections of the sewerage system that come to depreciation are highlighted. If area's that turn out to be problematic according through the stress test and the sewerage system in that area is almost depreciated, the municipality starts making plans for renovating the sewerage system as well as rearranging (green) structures on ground level (Jansma, personal communication, 24-10-18). In the third scenario, when redeveloping a neighbourhood, there is thought about how these neighbourhoods can become more water adaptive. This can be done by giving conditions such as using new paving materials with higher permeability or implementing more green structures (Gemeente Groningen, 2018).
These three scenarios all lead to large scale solutions. In addition, the municipality also pays attention to include citizens in managing the risks of flooding due to torrential rain. The municipality of Groningen was, 10 years ago, the first to provide a subsidy scheme for green roofs for their citizens (Gemeente Groningen, 2018). Small symbolic policies, such as a period

wherein people can buy a rain barrel for a low price are also part of raising awareness about this problem (Schuit, personal communication, 14-11-18).
Yet the greatest challenge for the municipality of Groningen is raising awareness about the risks of climate change internal (Schuit, personal communication, 14-11-18). Following the two respondents who were interviewed, awareness on this subject is something that lacks in many sectors of the municipality. It is important that the subject of being climate resilient becomes an integrated subject through all policies, such as water management and urban planning. The problem of flood risks needs to be managed together with other negative effects of climate change, such as heat stress.
The main ambition currently for the municipality of Groningen lays in raising awareness internally about the negative results of climate change. This must be done by including different sectors in (re)development projects and organising events, such as seminars (Schuit, personal communication, 14-11-18). By succeeding in this, the subject of climate change will be an integrated subject in each policy field, which will have as result that the currently traditional way of managing the risks of flooding will shift to a more integrated way, in which water management is integrated with other policy fields, such as urban planning and green structure management (Schuit, personal communication, 14-11-18).

Organisational structures: Comparison
Both municipalities have some kind of policy that addresses the risks of rain flooding. Nonetheless they differ in multiple ways. The city of Rotterdam explicitly points out its ambition for having citizens participating in developing solutions, through for example initiatives such as Water Sensitive Rotterdam (Mesu, personal communication, 12-11-18). Groningen has some solutions to do this as well, but not on such a large scale. The fact that the municipality of Rotterdam works together with stakeholders has as result that innovative ideas come to the table. In addition, Rotterdam wants to be known as a city that likes to experiment with new ideas, which allows for these innovative ideas to actually be implemented. The municipality of Groningen still is looking for ways to make the negative results of climate change an integrated subject in the municipality's policies, which makes it hard to actually develop integrated concepts.
The differences in degree of development of having a policy that addresses this subject can be attributed to the differences in capacities. The city of Rotterdam counts approximately 3000 kilometres of sewerage, with 21 people working on risk management. The city of Groningen counts approximately 1000 kilometres of sewerage and half of one person's function is to address this subject, which is out of proportion. This illustrates the differences in awareness and capacity to handle this problem (Jansma, personal communication, 24-10-18).
A solution to this could partially be to outsource projects, which was done by the municipality of Rotterdam in the case of designing the Benthem plein. The next problem then would be financing such projects. By raising awareness, which is done in Rotterdam with Water Sensitive Rotterdam and educative packages, citizens become more aware about the risks and

chances may increase that they accept higher taxes on water management (Jansma, personal communication, 24-10-18).

Spatial Concepts: Rotterdam

As is discussed earlier in this paper, the municipality of Rotterdam developed numerous examples of spatial implementations that address the problem of flood risks. A selection will be stressed out in this section.

An interesting concept to start with is the underground water basin in the area of Spangen which also functions as water source for the football stadium of Sparta. Excessive water during heavy rainfalls can be stored underground and eventually be pumped up when needed for watering the football field for example (Mesu, personal communication, 12-11-18).

A second example of implementing a water storage with a multifunctional character is the underground carparking at the Museum park. This carparking functions as a buffer zone for excessive water during torrential rainfalls, taking off stress from the sewerage system resulting in the fact that overflows do not need to be used and sewerage water does not need to mix with the surface water close by at the Westersingel. The Museum park-parking has a capacity of 10.000m^3, which is 50 percent of the pre-existing capacity, being of great value for water management of Rotterdam (Pieneman, personal communication, 25-10-18).

These two examples contribute to the spatial quality of the local area by having a multifunctional character, but as was discussed earlier, working with public space is not enough to manage the risks. The challenge for the municipality is to find possibilities to upscale the assessment of managing flood risks (Mesu, personal communication, 12-11-18).

Adding more green structures is one of the solutions which helps in this respect. Because of the high permeability of green places, water can be retained, stored and infiltrated locally. The city of Rotterdam has set a target to add 20 acres of green structures instead of hardened paving (Mesu, personal communication, 12-11-18). An important concept in this ambition is the use of green roofs, because of the lack of room on ground level. Here is where participation of citizens and other stakeholders come to play a part. By encouraging them to soften their private property citizens can contribute to achieving the target set by the municipality (Mesu, personal communication, 12-11-18).

Spatial Concepts: Groningen

The city of Groningen has developed a set of spatial concepts to address the problem of flooding as well.

First, train station Europapark is a good example of a climate resilient, durable public space. Under the station there are two basements that can function as rain water storage. In addition, the outside area has parts that function as public gardens that not only function as water buffer, but also address the heating effect of climate change (Gemeente Groningen, 2016).

Secondly, in the period between 2010-2015 more than 20.000m^2 of green roofs were implemented because of the subsidy scheme that was developed in 2009. Green roofs can be multifunctional, such as the one on the school building of the Werkman College. On this roof, native herbs were planted. The roof does not only function as water retention place, but also allows for native herbs to grow, which otherwise would not be possible anymore (Gemeente Groningen, 2016).

These implementations show that the city of Groningen is developing in becoming (more) climate resilient. Nonetheless, the municipality still struggles with having water management integrated in urban planning. Dries Jansma, a policy maker from the Water Management Department in Groningen, refined the fact that the urban planning department does not often incorporate the problem of flood risks in the first stage of their design processes. When this would be done in a more pro-active way the problem can be assessed on a higher scale (Schuit, personal communication, 14-11-18).

Spatial Concepts: Comparison

Both cities have developed spatial concepts that both contribute to the spatial quality and the flood risks caused by rain. It is observable that successful concepts are higher in their quantity and larger in scale in Rotterdam than in Groningen, but this can be attributed to the fact that the municipality of Rotterdam is on many fronts a larger organisation than the municipality of Groningen (Jansma, personal communication, 24-10-18).

Differences in character of the implementations of both cities are to be found in the extent of being innovative. The city of Rotterdam is with many implementations one of the first to develop, such as the three concepts that were stressed out earlier. The concepts implemented in Groningen consist mainly of small-scale concepts that are known to be effective.

Specific targets such as those in Rotterdam to achieve a certain amount of soft paved surface are not found in the city of Groningen. When the organisational structure to reach such targets is lacking or underdeveloped, such targets might seem ineffective. Nonetheless by setting targets such as those in Rotterdam, the municipality of Groningen would force the development of solutions to reach them.

Lessons Groningen can derive from Rotterdam's experience on this subject are not specifically to be the first to implement a certain spatial concept. But by thinking out of the box and try to be innovative in integrating water management into urban planning, efficient and interesting ideas can come up, as is proven in Rotterdam

5) Conclusions

Conclusion

This paper focussed on answering the following central question: What lessons can the City of Groningen learn from the City of Rotterdam on management of flood risks due to torrential rain, when integrating urban planning and water management? To answer this, the policies of both cities were defined and eventually compared.

To do this, three aspects of the policies of both cities were reviewed being: Spatial analysis, organisational structures and spatial concepts. From each aspect conclusions were drawn.

First of all, the municipality of Rotterdam executed a spatial analysis of in more plural form and of a greater extent than the analysis executed in Groningen. The latter also executed an analysis, but it lacks in showing connections between systems and diversity of types of rainfalls. Groningen could take Rotterdam as an example in developing a more sophisticated analysis. This could lead to becoming more resilient to the effects of climate change (Bosch et al., 2013).

Secondly, other than in Groningen, the internal awareness of the problem of torrential rainfalls is (to some extent) achieved in Rotterdam. This was essential for the municipality of Rotterdam to develop the pro-active policy described in the conceptual model. The next step is to raise awareness among the citizens and let them participate in helping to become as climate resilient as possible. The way in which Rotterdam invites citizen participation could be a lesson for Groningen, especially because the municipality Groningen lacks sufficient resources inside the municipality to assess the subject of water risk management. By using tools such as increasing internal and external awareness, the municipality of Groningen may create an organisational environment which encourages becoming a climate resilient city (Van Bommel & Kuindersma, 2008).

The third conclusion is that both cities implemented concepts to both improve spatial quality and manage flood risks. The difference is to be found in the fact that Rotterdam experiments with innovative and new kinds of implementations, where Groningen walks the beaten track by implementing proven concepts. The strategy of Groningen cannot be valued as wrong, but Rotterdam proved that experimenting with innovating concepts and working together with third parties and stakeholders can have successful results. Fact that Rotterdam is successful in developing innovative concepts could be accounted for by the fact that the city is further developed in the transition theory of de Graaf and van der Brugge (2010) than Groningen.

Recommendations

Follow-up research could explore the potentiality of successful physical implementations in other cities. Such research could be initiated by the municipality of Groningen, or organisations such as the university to consult the municipality. Furthermore, policies of other cities which are analysed in various studies (Restemeyer et al., 2015) can be added to such a study. Eventually this could lead to a universal set of successful implementations to manage flood risks caused by torrential rainfalls, while contributing to the spatial quality.

Discussion

This paper shows a comparison between two cities on their policies. The fact that the policy of Rotterdam is used to draw lessons from for the city of Groningen does not mean that the policy of Rotterdam is perfect, and the policy of Groningen is weak.

The fact that concepts implemented in Rotterdam worked out in a positive way does not mean that these concepts would also work in Groningen.

The mindset of the municipality of Rotterdam and its citizens has led to its successful approach, but which implementations would be most successful in the city of Groningen has not become clear yet.

Reflections

Reflecting on the theoretical research done in this study, a sufficient amount of theories was collected to create a theoretical framework that embedded the subject of the study. Especially finding overarching theories and concepts that describe the subject were not hard to find, given the fact that results of climate change are topics that gain a lot of attention in academic literature. Finding a sufficient amount of theory about both the cases required more effort, especially, there was little academic research on the case of Groningen.

The research method of choice, semi-structured interviews, allowed respondents to point out subjects which they thought would contribute to the research. Although the interviews provided enough information to draw conclusions, the quantity of five seemed low. To make the analysis of the data stronger, an analysis of three policy documents was added to the research to draw extra conclusions and to confirm statements of the respondents

Parts of the data turned out not to be relevant for this research, mainly consisting of information about technical aspects of the (robust) sewerage systems. Nonetheless, the fact that all the respondents gave answers to the same interview questions, comparisons and conclusions were able to be made.

6) References

Boer, F., Jorritsma, J., Pijpe, D van. (2010). *De Urbanisten and the woundrous water square.* Rotterdam: 010 publishers.

Bommel, S. van, Kuindersma, W. (2008). *Policy integration, coherence and governance in Dutch climate policy : a multi-level analysis of mitigation and adoption policy.* Report no. 1799. Wageningen: Alterra.

Bosch, P. R., Broeke, H ten. M., Gjaltema, J. G., Pasztor, A. E., & Rovers, V. (2013). De synergie van stedelijke klimaatadaptatie en-mitigatie maatregelen; een vijftal maatregelen uitgewerkt voor Rotterdam. Report no. 102/2013. Utrecht: TNO.

Carnicer, J., Coll, M., Ninyerola, M., Pons, X., Sánchez, G., Peñuelas, J. (2011). Widespread crown condition decline, food web disruption, and amplified tree mortality with increased climate change-type drought. *Proceedings if the National Acadamy of Sciences of America* 108(4), pp 1474–1478.

Chan, E. Y. Y. (2013). Bottom-up disaster resilience. *Nature Geoscience,* 6, pp 327-328.

Clifford, N., Cope, M., Gillespie, T., French, S. (2010) *Key Methods in Geography.* 2nd Edition, London: SAGE.

Dai, L., Wörner R. &. Rijswick, H. F. M. W. van (2018). Rainproof cities in the Netherlands: approaches in Dutch water governance to climate-adaptive urban planning. *International Journal of Water Resources Development*, 34(4), pp 652-674.

Easterling D. R., Meehl G. A., Parmesan C., Changnon S. A., Karl T. R., Mearns L. O. (2000). Climate Extremes: Observations, Modeling, and Impacts. *Sience,* 289(5487), pp 2068-2074.

Exter, R. den, Lenhart, J., Kern, K. (2015). Governing climate change in Dutch cities: anchoring local climate strategies in organisation, policy and practical implementation. *Local Environment,* 20 (9), pp 1062-1080.

Feng, Q., Wang, A., Zhang, W. (2007). Research Work on Torrential Rain and Typhoons. *Data Science Journal*, 6, pp 581–588.

Gemeente Rotterdam (2011). *Vasthouden van regenwater in de openbare ruimte van Rotterdam.* Rotterdam: Gemeente Rotterdam.

Gemeente Groningen (2016). *Groningen klimaatbestendig.* Groningen: Gemeente Groningen.

Gemeente Groningen (2018). *Stresstest Klimaatadaptatie Groningen-Ten Boer.* Groningen: Gemeente Groningen.

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

Grant, G. (2006). Extensive green roofs in London. *Urban Habitats*, 4 (1), pp 51-65.

Jha, A. K., Bloch, R., Lamond, J. (2012). *Cities and flooding: a guide to integrated urban flood risk management for the 21st century*. Washington, D.C.: World Bank.

Kaufmann, M., Doorn-Hoekveld, W.J., Gilissen, H.K. van, Rijswick, H.F.M.W. van (2015), *Drowning in safety. Analysing and evaluating flood risk governance in the Netherlands*. Report no. D3.3. Utrecht: STARFLOOD Consortium.

KNMI. (2014). *Klimaatscenario's voor Nederland*. Applied at 14-10-2018 through http://www.klimaatscenarios.nl/scenarios_samengevat/. De Bilt: Royal Dutch meteorological institute KNMI.

KNMI. (2018). *Uitleg over droogte.* Applied at 02-01-2019 through: https://www.knmi.nl/kennis-en-datacentrum/uitleg/droogte. De Bilt: Royal Dutch meteorological institute KNMI.

Kruip, M. (2016). *Hemelwateroverlast in de stad, het adaptatiebeleid van Amsterdam en Rotterdam.* Nijmegen: Radboud University, faculty of Management Sciences

Lenderink, G., Meijgaard, E. van, Selten, F. (2008). Intense coastal rainfall in the Netherlands in response to high sea surface temperatures: analysis of the event of August 2006 from the perspective of a changing climate. *Climate Dynamics,* 32 (1), pp 19-33.

Lui, Y. C. & Cheng, C.L. (2014). A Solution for Flood Control in Urban Area: Using Street Block and Raft Foundation Space Operation Model. *Water Resources Management,* 28(14), pp 4985–4998.

Mentens, J., Raes, D., Hermy, M. (2006). Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landscape and urban planning,* 77(3), pp 217-226.

Mukheibir, P. (2017). Shifting to Urban Sensitive Water Design – One Water: Urban Water Management. *Water Wheel*, 16(2), pp 29–31.

Næss, L. O., Bang, G., Eriksen, S., Vevatne, J. (2005). Institutional adaptation to climate change: Flood responses at the municipal level in Norway. *Global Environmental Change,* 15 (2), pp 125-138.

Prasad N., Ranghieri F., Shah F., Trohanis Z., Kessler E., Sinha R. (2008). *Climate Resilient Cities: A Primer on Reducing Vulnerabilities to Disasters.* Washington D.C.: World Bank.

Restemeyer, B., Woltjer, J., Brink, M. van den (2015). A strategy-based framework for assessing the flood resilience of cities–A Hamburg case study. *Planning Theory & Practice,* 16 (1), pp 45-62.

Robinson, G. M., Carson, D. A. (2016). Resilient communities: transitions, pathways and resourcefulness. *The Geographical Journal,* 182 (2), pp 114-122.

Rotterdam climate initiative (2018). *Rotterdam climate initiative.* Applied at 29-09-2018 through http://www.rotterdamclimateinitiative.nl/. Rotterdam: Rotterdam climate initiative

Runhaar H., Mees H., Wardekker A., Sluijs, J. van der, & Driessen P. (2012). Adaptation to climate-change related risks in Dutch urban areas: stimuli and barriers. *Regional Environmental Change*, 12 (4), pp 777-279.

Runhaar, H. A. C., Mees, H. L. P., Sluijs, J van der., Wardekker, A., & Driessen, P. P. J. (2011). Omgaan met hittestress en wateroverlast in de stad. *Milieu*, 2, pp 22-25.

Smith, A., Stirling, A. (2010). The Politics of Social-ecological Resilience and Sustainable Socio-technical Transitions. *Ecology and Society,* 15 (1): 11. [online] URL: http://www.ecologyandsociety.org/vol15/iss1/art11/.

Urbanisten, De (2011). *Water Square Benthemplein.* Applied at 20-01-2019 through: http://www.urbanisten.nl/.

Visschedijk, P.A.M., Vries, E.A de. (2014). *Groen en gemeenteraadsverkiezingen: aandacht voor groen in de partijprogramma's voor de gemeenteraadsverkiezingen van 2014.* Report no. 79. Wageningen: Alterra.

Wallner, H. P., Narodoslawsky, M., & Moser, F. (1996). Islands of Sustainability: A Bottom-up Approach towards Sustainable Development. *Environment and Planning A: Economy and Space*, 28(10), pp 1763–1778.

Water sensitive Rotterdam (2018). *Rotterdam in 2050: Harde regenbuien en grote droogte wisselen elkaar af, maar de stad kan het aan,* Applied at 11-01-2019 through https://www.watersensitiverotterdam.nl/. Rotterdam: Water Sensitive Rotterdam.

Waterboards & Province Zuid-Holland (2014). *Klimaat atlas Zuid-Holland.* Applied at 11-01-2019 through https://zuid-holland.klimaatatlas.net/. The Hague: Provincie Zuid-Holland.

Woert, N. D. van, Rowe, D. B., Andresen, J. A., Rugh, C. L., Fernandez, R. T., & Xiao, L. (2005). Green roof stormwater retention*. Journal of environmental quality*, 34(3), pp 1036-1044.

7) Appendix

1) Interview guide

Introductory questions
1.1) Are you okay with recording this interview?

1.2) Can you introduce yourself and can you explain shortly what your function is in the organisation you work for.

Research questions
2.1) What are the problems as result of climate change, that the city of Rotterdam/Groningen has to deal with?

-Are you acquainted with the term ''climate resilient''?
-To what extend is this part of the municipality's policy?

2.2) Does the municipality of Rotterdam/Groningen focus on managing flooding risks as result of torrential rainfalls?

-What concepts or projects are developed?
-What projects are currently being developed and planned to develop?
-What strategies are being used when developing projects to manage pluvial flood risks?

2.3) When implementing these idea's, how are these projects organisationally structured?

-What role does the municipality play in organising concepts and ideas to attack the problem?
-Is there integrated collaboration between different departments?
-Who initiates the ideas and projects?
-Is there influence from higher (or lower) governments?

2.4) How does the municipality of Rotterdam/Groningen recognize regions or spots which have high flooding risks during torrential rainfalls.

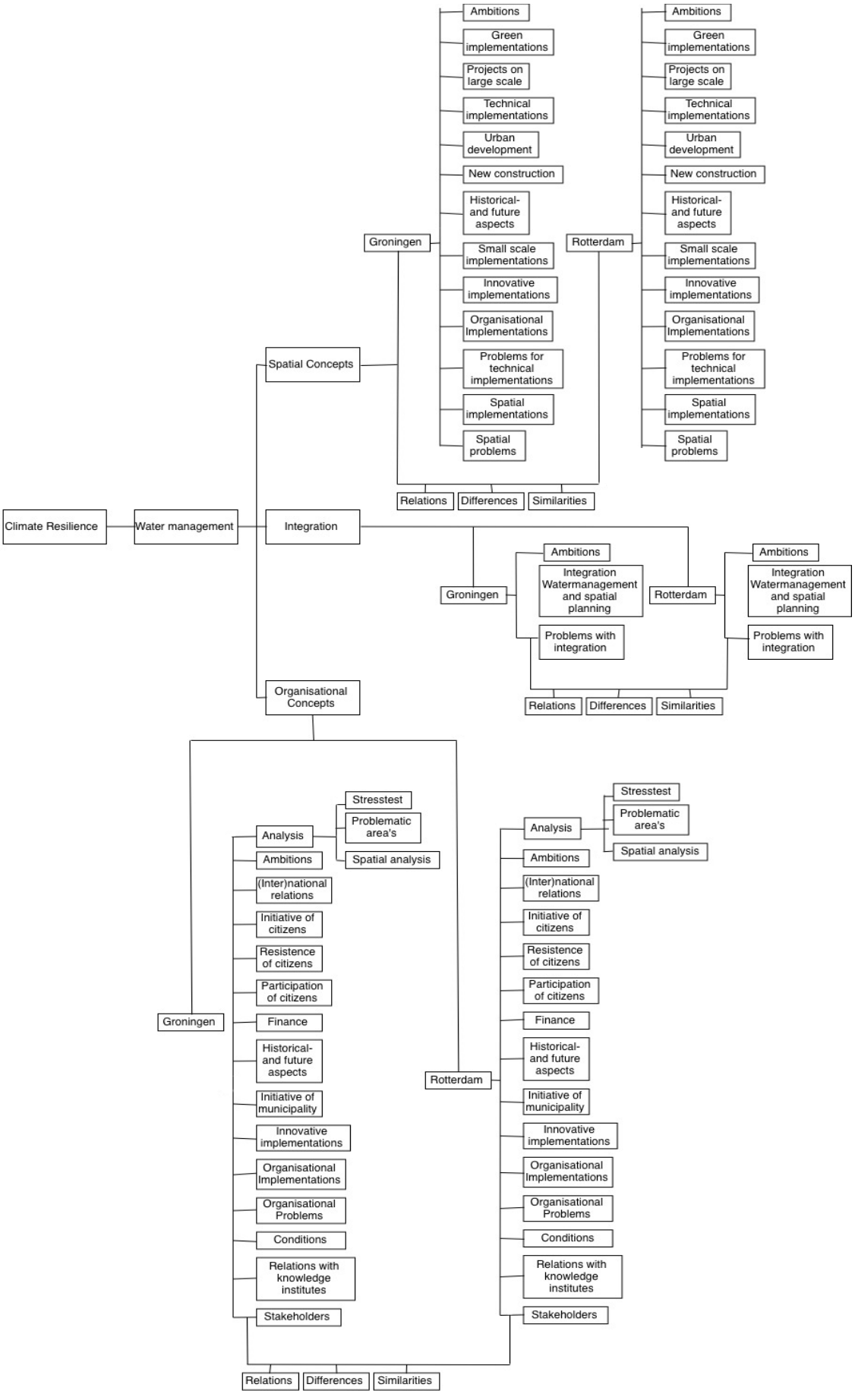
-How is decided whether an area is suitable for any kind of implementation?
-To what extend are citizens consulted?

2.5) Does the city of Rotterdam/Groningen work together with other regions and knowledge institutes to develop solutions for pluvial flood risks?

-Does the city have examples that are intended to follow.
-How does the municipality concern itself in managing flood risks, in terms of successfulness?

Closing questions
3.1) Do you have any feedback on the interview?
3.2) Do you have any remarks to anything you have said, or do you want to add something?
3.3) Do you have any recommendations for other people to interview?

2) Code tree


Climate Resilience
Water management
Integration
Spatial Concepts
Groningen
Ambitions
Green implementations
Projects on large scale
Technical implementations
Urban development
New construction
Historical- and future aspects
Small scale implementations
Innovative implementations
Organisational Implementations
Problems for technical implementations
Spatial implementations
Spatial problems
Rotterdam
Ambitions
Green implementations
Projects on large scale
Technical implementations
Urban development
New construction
Historical- and future aspects
Small scale implementations
Innovative implementations
Organisational Implementations
Problems for technical implementations
Spatial implementations
Spatial problems
Relations
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Groningen
Ambitions
Integration Watermanagement and spatial planning
Problems with integration
Rotterdam
Ambitions
Integration Watermanagement and spatial planning
Problems with integration
Relations
Differences
Similarities
Organisational Concepts
Groningen
Analysis
Stresstest
Problematic area's
Spatial analysis
Ambitions
(Inter)national relations
Initiative of citizens
Resistence of citizens
Participation of citizens
Finance
Historical- and future aspects
Initiative of municipality
Innovative implementations
Organisational Implementations
Organisational Problems
Conditions
Relations with knowledge institutes
Stakeholders
Rotterdam
Analysis
Stresstest
Problematic area's
Spatial analysis
Ambitions
(Inter)national relations
Initiative of citizens
Resistence of citizens
Participation of citizens
Finance
Historical- and future aspects
Initiative of municipality
Innovative implementations
Organisational Implementations
Organisational Problems
Conditions
Relations with knowledge institutes
Stakeholders
Relations
Differences
Similarities

3) List of respondents

Date of interview	Respondent name	Organisation	Function	Correspondence through
24-10-18	Dries Jansma	Municipality of Groningen	Technical Policy Officer Water and Sewerage Systems	Dries.jansma@groningen.nl
25-10-18	Jorg Pieneman	Municipality of Rotterdam	Senior Advisor Urban Water and Sewerage Systems	Jn.pieneman@rotterdam.nl
12-11-18	Liselotte Mesu	Municipality of Rotterdam	Urban Planner	Lj.mesu@rotterdam.nl
14-11-18	Martijn Schuit	Municipality of Groningen	Technical Policy Officer Spatial Planning and Design	Martijn.schuit@groningen.nl
19-11-18	Rokus van Dijk	Municipality of Rotterdam	Landscape Architect	Rg.vandijk@rotterdam.nl