Master's Thesis Internship – master Water Science and Management

RAINPROOFING UTRECHT

The adequacy and possible improvements of water governance concerning extreme rainfall events in the Utrecht region

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Summary

Extreme rainfall events can lead to enormous economic damage on real estate in densely built-up areas of cities. On July 28th, 2014, Hoogheemraadschap De Stichtse Rijnlanden (HDSR) experienced problems caused by an extreme rainfall event in Kockengen, a small village in the province of Utrecht. Such an event in the densely populated city of Utrecht could cause severe problems.
The situation of Kockengen has been an eye-opener to HDSR, which led to a certain sense of urgency. The problem of extreme rainfall events can be counteracted by implementing blue-green adaptation measures. These measures must be implemented by various stakeholders and this requires adequate governance. Therefore, a research project is started based on the following research question:

To which extent is there adequate water governance concerning the implementation of blue-green adaptation measures by stakeholders in order to cope with extreme rainfall events in the Utrecht area?

In order to answer this research question, data was gathered by performing an in-depth case-study, including desk research, interviews with respondents of stakeholders and participative observations during meetings. Furthermore, an extensive consultation of experts in the field of water management, especially the efficiency of policy instruments, has been conducted.

I first concluded that in the Utrecht area, there is a higher risk on calamities caused by extreme rainfall events in the future. Subsequently, I found that according to the consulted experts, the most efficient blue-green adaptation measures are: water storage in green areas; wadi's; water infiltrating green areas; open gutters to surface water or green areas; polder roofs; green roofs; and raise doorsteps, thresholds in front of houses, garages and parking-lots. Furthermore, it was concluded that the responsibilities to execute blue-green adaptation measures rest with the municipality of Utrecht and the citizens. The other stakeholders, namely central government, Province of Utrecht, Water Board HDSR, CRA and Winnet, have a facilitating, stimulating, regulatory and/or informative role. This means that these stakeholders are dependent on the municipality of Utrecht and/or citizens with respect to the execution of blue-green adaptation measures.

Next, the adequateness of water governance in the Utrecht area was analysed on the basis of an evaluation framework which consists of structure, management and policy requirements. There were strong and weak points observed on all domains (structure, management and policy). These weak points in governance are considered so-called 'governance barriers' for the successful implementation of blue-green adaptation measures. An important governance barrier is the absence of a regional body which possesses formal decision-making power to implement blue-green adaptation measures concerning extreme rainfall events.
Besides governance barriers, there are also other barriers that hamper the implementation of blue-green adaptation measures. The public space is limited and it will therefore be necessary to consider how to use it. The application of blue-green adaptation measures is sometimes at the expense of other options for spatial development. Furthermore, the budgets from the Province of Utrecht, Water Board HDSR and the municipality of Utrecht allocated for blue-green adaptation measures can not be utilized for other public services.

To overcome these barriers it is recommended, among others, to present blue-green adaptation measures in such a way that it becomes clear that these measures not only prevent damage due to extreme rainfall events, but also contribute to other public interests, such as reducing heat stress and air pollution and improving biodiversity.

Table of Content:

1 Introduction

Extreme rainfall events can lead to enormous economic damage on real estate in densely built-up areas of cities. In 2011, there was an extreme rainfall event in Copenhagen, with an estimated material damage of 1 billion euro (Uittenbroek, Janssen-Jansen and Runhaar, 2013). In 2014 a big rainfall event in Amsterdam took place, causing big losses on real estate. More recently in May 2018, there were severe rainfall events in Southern Limburg. Central and local government were alarmed. These rainfall events are societal and scientific problems that demand for further examination.

In this chapter the issue of climate change and extreme rainfall events will be discussed (section 1.1). Subsequently, the responsibilities and actions of government bodies concerning extreme rainfall events are introduced (section 1.2). Up to now only limited research has been done into the way the government is reacting to extreme rainfall events and whether their reaction is appropriate (section 1.3). This is leading to the aim and central research question of this study, which is focused on the current state of water governance in Utrecht region (section 1.4). Next, the way of data gathering and analysis is described (section 1.5). Finally, the relevance of the study is discussed (section 1.6).

1.1 *Climate change and extreme rainfall events*

Climate change is one of the most pressing global problems of our time. Two major responses have emerged to deal with this issue: mitigation and adaptation. In general, climate policy has mostly focused on mitigation. While there is a wide consensus amongst climate experts and policy makers that mitigation of climate change is and should remain the primary focus of climate policy, it is increasingly recognized that adaptation to climate change has become unavoidable. The IPCC has shown that even under optimistic assumptions for the success of present-day mitigation efforts and policies, human activity is likely to lead to further climate change with severe impacts (IPCC, 2014).

Both climate and socioeconomic processes are leading to a higher risk and impacts on society. One of the most urging aspects of climate change is the increase in extreme weather events. Risks caused by extreme weather events, such as extreme rainfall events, are already moderate (high confidence) and high with 1°C additional warming (medium confidence) (IPCC, 2014). The occurrence of an extreme rainfall event on urban areas can have severe impacts. Extreme rainfall events are a climate feature which globally have increased in number and are causing extensive damage, especially in densely populated areas (Cuevas, 2011).

Climate change in the Netherlands is expected to result in a temperature increase of 1,0 to 2,3 °C in 2050, depending on the future emissions of greenhouse gasses (KNMI, 2014). A warmer climate may cause an increase in economic losses and more people affected by flooding in river basins and coasts, driven by increasing sea levels and peak river discharges (IPCC, 2014). Climate change results in bigger extremes; extreme rainfall events are therefore likely to become more extreme and will occur more often in the future. An increase of 1°C in temperature may lead to an increase of the amount of rainfall of 14 percent and an increase of 14-32.2 percent in occurrence of extreme rainfall events (KNMI, 2014).

The severity of current and anticipated impacts depends both on recent severe weather events and societal changes such as urbanization, and are therefore most pressing in urban areas due to dense settlements and economic activity, as well as high pressure on existing infrastructure (Glaas and Jonsson, 2014). In most urban areas the capacity of the sewage system is insufficient to discharge the rainwater during such extreme events, resulting in flooded streets, cellars and districts. Ongoing urbanisation, densification of cities and the amount of increased paved surfaces have dramatically decreased the surface infiltration capacity within cities. Important risks and common impacts emerging from these events with heavy precipitation over a short period of time include foremost various types of urban flooding and water leakage (Nie et al., 2009).

On the individual house scale, the risks that are found most commonly occurring are similar as for increased annual precipitation, i.e. water leakage due to plugged or broken gutters/pipes and cracks or openings in roofing felts, basement walls or facades (IPCC, 2012). However, risks are anticipated to be high for flooding in basements and low situated houses without basements due to increased rainfall-runoff, among others leading to high water levels in nearby water courses and ground recesses (Nikolowski et al., 2013), and backwater inflow (water pushed up through floor drains, toilets, etc.) as a result of deficient or poorly managed storm water drainage or sewage overloading (ten Veldhuis et al., 2011).

The consequences of the effects of climate change and ongoing urbanisation make it necessary for government bodies to interfere, but many solutions are too costly. Due to the high replacement costs, replacing the sewage system to increase the capacity is not an option. Therefore, governmental bodies need to search for other solutions.

1.2 *Responsibilities and measures of government*

Since the cultivation of the Netherlands, people have always struggled with water management resulting in a complex governance system where several responsible authorities try to manage water problems in the best way possible (Lazaroms and Poos, 2004). Nowadays, The Netherlands can be characterized as a low lying and densely populated country, in which a delta has formed the actual landscape. In fact, 26 percent of the Netherlands is even below sea-level, which is prone to flooding (PBL, 2016). After the disastrous floods of 1916 and 1953, the Zuiderzeewerken and the Dutch delta works have resulted in a robust system protecting the Netherlands against flooding from the sea. Besides the risk of floods from the sea, river flooding is another risk for the Netherlands. Recent examples of river flooding are the exceptional high-water levels in the river Meuse in 1993 and 1995 nearly resulting in dike breaches in several provinces. These incidents led to two new water management plans: Deltaplan Large Rivers and the project Room for the River (Van Heezik, 2007). Starting in 2010, the new Delta program is anticipating the effect of climate change on expected flood risks. Trends such as the increase of global temperature, sea level rise, the amount and intensity of rainfall periods, are addressed as risks for the Netherlands.

The Dutch government is taking large scale actions against possible flooding from the sea and rivers. However, a clear national strategy to cope with problems caused by extreme rainfall events is currently lacking. As stated in the Delta program of 2017 the Dutch government intends to prevent water hindrance by adapting the spatial environment.

The yearly amount of precipitation (851mm) in the Netherlands is not causing water hindrance. Rijkswaterstaat, the Dutch water boards and municipalities have set up a system which can discharge such amounts (<30mm/day) of rainfall (Gemeente Utrecht, 2016). However, precipitation does not fall on an average basis, precipitation rates are irregular and can exceed 50mm/day (KNMI, 2014). According to the KNMI (2014) climate variations and climate change is likely to result in even larger amounts of maximum precipitation and more extreme rainfall events. An increase of extreme rainfall events has been seen over the last decades in the Netherlands (Figure 1).

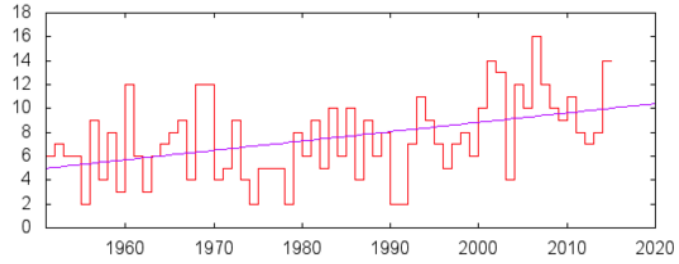

Figure 1: Amount of days that exceed the amount of 50mm of precipitation (KNMI, 2014).

In the Netherlands, every municipality has the legal obligation to prevent water hindrance for its inhabitants. This so called "*Hemelwaterzorgplicht*" implies that a municipality has the duty to take maximum effort in order to prevent water hindrance from rainfall to its inhabitants. This obligation is not specified into a concrete norm but can be characterized as an effort obligation ("*inspanningsverplichting"*).

1.3 *Water governance concerning extreme rainfall events*

Most literature concerning extreme rainfall events consist of technical analyses of the problem. The given solutions are therefore mainly from a technical point of view. In the literature, a number of blue-green measures that are suitable for dealing with extreme rainfall events are mentioned. Think for instance of wadis, green roofs and permeable roads. These instruments are implemented by various stakeholders. Some of the relevant stakeholders are for instance: central government, the province, the water board, the municipality and the citizens.

For a successful implementation of the blue-green adaptation measures, it is necessary that the stakeholders collaborate well and take care of their responsibilities and tasks. In other words, there must be good water governance. However, governance is often not addressed in current studies. There is hardly any specific scientific literature available about water governance concerning extreme rainfall events. One of the few exceptions is the study of Mees (2014), that discusses the role of governance concerning climate change adaptation.

According to Mees (2014), the impacts of extreme precipitation events are expected to increase in the near future. Consequently, public actors, such as city governments, and private actors, such as developers and citizens, are planning for and taking action on adaptation to climate change. In the climate adaptation practice, however, the implementation of adaptation plans and actions is hampered because the division of responsibilities for adaptation to climate change between public and private actors remains fragmented and ambiguous. Mees (2014) argues that a clear and deliberate allocation of responsibilities, based on a conscious weighting of different considerations underlying this allocation of responsibilities, is necessary to get adaptation planning and action off the ground. Moreover, the allocation of responsibilities to certain public and private actors has implications for the effectiveness, legitimacy, and fairness of the subsequent governance arrangements. It therefore matters to study the issue of public and private responsibilities for climate adaptation. Nevertheless, the issue of public versus private responsibilities is underexplored in the adaptation literature, despite a substantial increase of work on the governance of climate adaptation. A systematic analysis and evaluation of emerging arrangements between public and private actors, based on multiple cases and on multiple theoretical perspectives, has been lacking.

As stated before, there is a lack of specific scientific literature about water governance concerning extreme rainfall events. However, in order to derive requirements that are needed for adequate water governance, general governance literature is abundantly available. According to this general governance literature three aspects are important for adequate governance, namely structure, policy and management (Bovard and Löffler, 2009; Peters and Pierre 2007). Moreover, there are specific governance studies on different areas, such as the publication of Boesveldt, Van Montfort and Boutellier (2017) concerning homelessness, from which requirements for appropriate (water) governance can be derived.

The study by Boesveldt, Van Montfort and Boutellier (2017) presents a general governance framework based on literature in the field of public administration and governance studies. This general framework is applied by the authors on the issue of homelessness. There are indications that the general governance framework is also applicable to the issue of water governance concerning extreme rainfall events. The issues of homelessness and extreme rainfall events are comparable for three

reasons. In the first place, in both issues there are several stakeholders, including a number of government bodies. Secondly, in both issues various instruments are implemented to reduce the problem at stake. Thirdly, there is a lot of collaboration between the stakeholders who aim to reduce the problem at stake. All in all, it can be concluded that the general governance framework applied to the issue of homelessness is also applicable to the issue of extreme rainfall events.

In this thesis I use the requirements as derived from the general literature and the specific literature on other areas to develop a framework to assess the quality of water governance concerning extreme rainfall events. Subsequently I will apply this assessment framework on a concrete study case, namely water governance in the Utrecht region.

1.4 *Aim and research question*

This study focuses on water governance concerning extreme rainfall events within the Province of Utrecht, in which Utrecht is the largest city and the water board Hoogheemraadschap De Stichtse Rijnlanden (HDSR) is an important actor.

HDSR experienced problems caused by an extreme rainfall event on July 28th, 2014, particularly in Kockengen. For several days inhabitants had to cope with flooded waterways, streets, public areas and houses. HDSR and the municipality Stichtse Vecht were held responsible for the damage by the inhabitants of Kockengen. The event was characterized as a 1:1000 event, but in October 2013 inhabitants of Kockengen also experienced hindrance due to flooding. Explanations that such extreme events are beyond management capacities of both authorities were not accepted by the citizens (Blekemolen and Schwarz, 2014).

The situation of Kockengen has been an eye-opener to HDSR, which led to a certain sense of urgency. It became clear to them that there were no clear governance arrangements and that responsibilities were ambiguous, regarding the implementation of adaptation measures. Taking responsibility for adaptation measures is a shared responsibility by multiple agents. The implementation of blue-green adaptation measures is sometimes over and above the statutory requirements. For HDSR it is not clear who has to govern the implementation of blue-green adaptation measures. Moreover, not only from a practical perspective the lack of a governance framework is acknowledged, also in scientific literature there is no consensus about this matter (Driessen et al., 2012). This conflict of ambition to implement blue green adaptation measures by the relevant stakeholders without adequate water governance, is the key problem in this research. Therefore, the main research question reads:

To which extent is there adequate water governance concerning the implementation of blue-green adaptation measures by stakeholders in order to cope with extreme rainfall events in the Utrecht area?

It is important to find out whether the expected future development of extreme rainfall events implies an increased risk of damage in the Utrecht area. Therefore, the first sub-research question reads:

1. **Is there an increased risk of damage as a result of future extreme rainfall events in the Utrecht region?**

In order to cope with this potential increased risk a number of blue-green adaptation measures are implemented by the stakeholders in the Utrecht area. This leads to the second and third sub-research questions:

2. **Which green-blue adaptation measures are efficient to reduce the risk of damage due to extreme rainfall events?**

3. **Which responsibilities, roles and ambitions do stakeholders in the Utrecht region have in implementing the blue-green adaptation measures?**

According to the general governance literature and some specific governance studies in other fields, three elements of water governance may be crucial: structure, management and policy (Peters and Pierre, 2007; Bovard and Löffler, 2009; Boesveldt, Van Montfort and Boutellier, 2017). This leads to the following three sub-research questions:

4. **Is there an adequate structure among stakeholders in Utrecht concerning water governance on extreme rainfall events?**
5. **Is there currently adequate water management at stake concerning the water problems resulting from extreme rainfall events?**
6. **Is there an adequate policy concerning the issue of extreme rainfall events in Utrecht?**

The last sub-research question reads:

7. **Which governance barriers and other types of barriers can be identified per blue-green adaptation measure and per stakeholder in the Utrecht area?**

1.5 *General approach and methods*

This thesis is based on a single case study. The case study focusses on water governance concerning extreme rainfall events in the Utrecht area. Within this case study four methods of research are applied. The first one is desk research; several documents of the municipality of Utrecht, the water board HDSR, the Province of Utrecht and the national State are analysed. Furthermore, interviews are performed with key figures from the municipalities of Utrecht, Houten, the water board HDSR, the Province of Utrecht and researchers from the University of Utrecht. The third research method consists of participating observation in several networks' meetings of the Coalitie Ruimtelijke Adaptatie (CRA), this coalition is constituted by several municipalities in the province of Utrecht, the water board HDSR, the Province of Utrecht and several NGO's. Finally, the fourth research method consist of consultation of experts in the field of the effectiveness of water management instruments.

2 Extreme Rainfall Events and Governance

In line with the four sub-research questions, I will first explore several scenarios provided by the KNMI about the future development of extreme rainfall events (section 2.1). Subsequently, I will describe a number of blue-green policy instruments derived from the water management literature (section 2.2). Next, the stakeholders in the Utrecht area which are involved in the implementation of blue-green policy instruments are introduced (section 2.3). Furthermore, I will describe the requirements for adequate water governance concerning extreme rainfall events with respect to structure (section 2.4), management (section 2.5) and policy (section 2.6). A schematic summary of all requirements for adequate water governance concerning extreme rainfall events will be presented in a table (section 2.7). Finally, two types of barriers can be distinguished that stakeholders can be confronted with when implementing blue-green adaptation measures: governance barriers and measure-related barriers (section 2.8).

2.1 *Future extreme rainfall events according to climate scenarios*

In most studies and policy plans an extreme rainfall event and a cloudburst are actually the same, a heavy amount of rainfall in a short time. In this thesis, I speak of an extreme rainfall event when the amount of rainfall happens in such a short period, that it leads to a calamity. We speak of a calamity when there is excessive rain which flows horizontally towards real estate and is causing damage. The amount of damage depends on the magnitude of the rain shower and the resistance of the water system in a city.

According to the KNMI, climate change has as a consequence that extremes will become bigger in the future. These future climate change predictions apply for the whole Netherlands but are based on the results of de KNMI station in de Bilt (KNMI, 2014). The KNMI has developed the KNMI' 14 climate scenarios, which consist of four new scenarios for climate change in the Netherlands (Figure 2). Every scenario covers 12 variables that include temperature, precipitation, sea level, and wind. They are based upon the combination of the two options for global temperature increase ('Moderate' and 'Warm) and air circulation pattern ('Low value' and 'High value'). The climate scenarios project two different time horizons: 2050 and 2085.

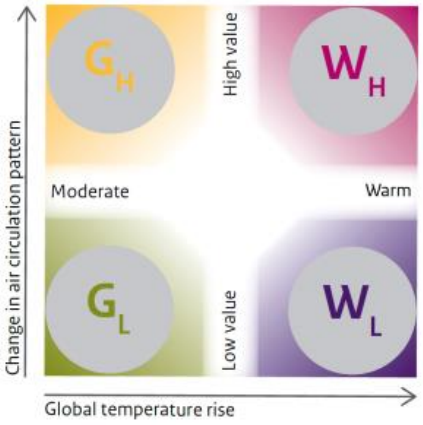

Figure 2: KNMI '14 Climate scenarios (KNMI, 2014)

For now, it is still uncertain which KNMI' 14 scenario is likely to become reality, but cities have to adapt their water system in order to become capable of sustaining heavier rainfall. All four scenarios show an increase in the maximum hourly precipitation sum per year. The W_h scenario is the scenario with the highest increase, namely 13-25%, resulting respectively in 17.1 mm/h or 18.9 mm/h (Table 1).

Table 1 Projected change in precipitation due to climate change in the Netherlands (KNMI, 2014)

Season	Variable	Indicator	Climate 1981-2010 = reference period	Scenario Change of climate in 2050 (2036-2065)			
				G_L +1 °C Low value	G_H +1 °C High value	W_L +2 °C Low value	W_H +2 °C High value
Global temperature increase:							
Change vanair circulation pattern:							
Winter	Precipitation	mean amount	211 mm	3%	8%	8%	17%
		10-day sum precipitation exceeded once in 10 year	89 mm	0.06	0.1	0.12	0.17
		number days ≥ 10 mm	5,3 days	+9,5%	19%	20%	35%
Spring	Precipitation	mean amount	173 mm	+4,5%	+2,3%	0.11	0.09
Summer	Precipitation	mean amount	224 mm	+1,2%	-8%	+1,4%	-13%
		10-day sum precipitation exceeded once in 10 year	44 mm	+1,7 to +10%	+2,0 to +13%	+3 to +21%	+2,5 to +22%
		maximum hourly precipitation sum per year	15,1 mm/uur	+5,5 to +11%	+7 to +14%	+12 to +23%	+13 to +25%
		number days ≥ 20 mm	1,7 days	+4,5 to +18%	-4,5 to +10%	+6 to +30%	-8,5 to +14%
Autumn	Precipitation	mean amount	245 mm	7%	8%	3%	+7,5%

Table 2 from the KNMI' 14 scenarios shows the average recurrence time of certain rainfall events with its corresponding amount of rainfall. It shows that when the W_L becomes our future climate, we can expect larger amounts of rain per 24 hours. This means that if our climate shifts towards the W_L scenario, a city has a bigger necessity to invest in better water governance.

Table 2 Precipitation amount of 24-hour sum of the Bilt (in mm) on a yearly basis, based on various recurrence times and among different climate scenarios in 2050 (KNMI, 2014).

Repetition (years)	G_L +1 °C Low value			G_H +1 °C High value			W_L +2 °C Low value			W_H +2 °C High value		
	lower	centre	upper	lower	centre	upper	lower	centre	upper	lower	centre	upper
0,5	30.4	30.9	31.4	30.1	31.1	31.9	30.5	32.4	33.6	30.4	31.7	33.2
1	36.5	37.2	38.0	36.2	37.4	38.6	36.7	39.1	40.9	36.4	38.2	40.3
2	42.9	43.9	44.9	42.5	44.1	45.6	43.1	46.2	48.5	42.6	45.1	47.8
5	51.9	53.2	54.6	51.4	53.5	55.5	52.2	56.1	59.2	51.4	54.6	58.3
10	59.1	60.7	62.3	58.5	61.0	63.4	59.4	64.1	67.8	58.5	62.3	66.7
20	66.6	68.6	70.5	66.0	68.9	71.7	67.1	72.5	76.9	65.9	70.4	75.6
25	69.2	71.2	73.2	68.5	71.5	74.5	69.6	75.3	79.9	68.4	73.1	78.6
50	77.3	79.6	82.0	76.5	79.9	83.4	77.8	84.2	89.5	76.3	81.7	88.0
100	85.8	88.4	91.2	85.0	88.8	92.7	86.4	93.7	99.7	84.7	90.8	98.0
200	94.8	97.7	100.8	93.8	98.2	102.6	95.4	103.6	110.4	93.4	100.4	108.5
500	107.3	110.8	114.4	106.3	111.3	116.4	108.0	117.5	125.4	105.8	113.8	123.2
1000	117.4	121.3	125.3	116.3	121.8	127.5	118.2	128.6	137.4	115.6	124.5	135.0

The relation between temperature and rainfall events is also shown in Figure 3. This figure shows the relation between the exceeding chance and the intensity of the rainfall event at different dew point temperatures. A higher dew point temperature causes a higher chance of exceeding the chance that a certain intensity in mm/h is reached.

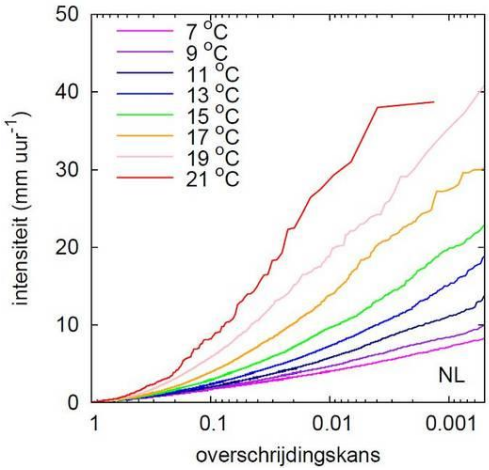

Figure 3: precipitation divisions (in exceeding chances) of hourly precipitation sums, occurring at different dew point temperatures at 27 weather stations in the Netherlands (KNMI, 2014)

Most of the data about precipitation extremes of the KNMI presented so far are based on the data provided by the observations from the weather station De Bilt. In general, we can say that the distribution of precipitation is equally distributed above the Netherlands and only small deviations in the distribution occur. Figure 4 shows these deviations for the different regions within The Netherlands. Based on this figure we see that the Utrecht area lies within the green area, which means that the statistics and predictions for De Bilt also apply for the Utrecht area. This is not really a surprise, because De Bilt lies within the Utrecht area. However, if the same study would be repeated in for instance the city of Rotterdam, the data as presented in Table 1 and 2 should be multiplied with a multiplication factor because of the geographical location.

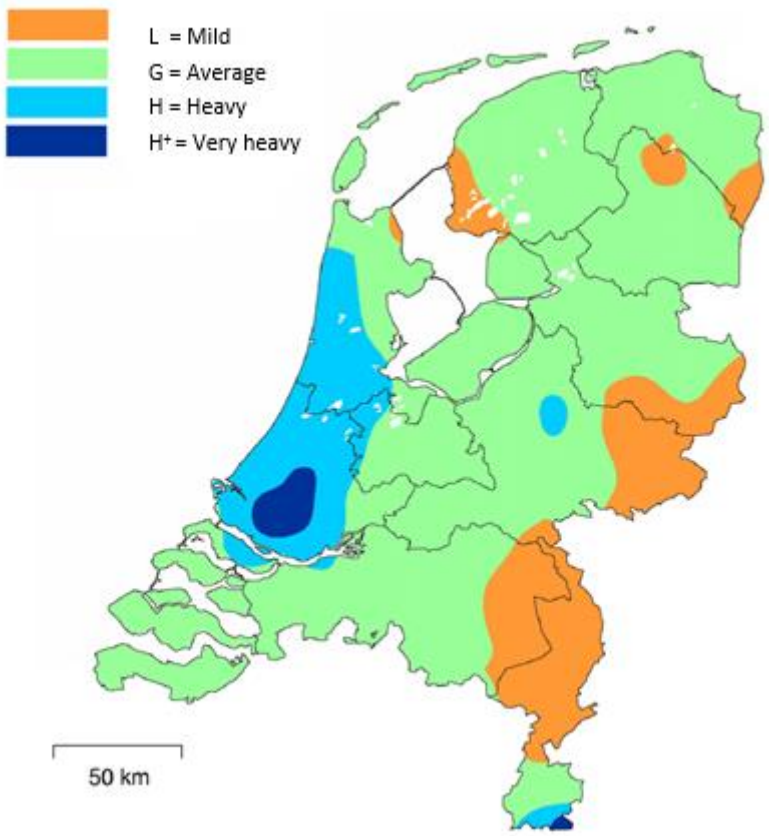

Figure 4 Four precipitation categories showing precipitation events with a period of 1 to 9 days, with each a unique extreme value

Table 3 Multiplication factor for the amount of precipitation in the extreme value statistic of De Bilt addressed in the four precipitation categories in Figure 4.

Precipitation category	Multiplication factor in comparison to De Bilt
L	0,93
G	1
H	1,08
H+	1,14

2.2 *Blue-Green adaptation measures*

To cope with the future increase in extreme rainfall events, blue-green adaptation measures must be implemented. In the literature (Voskamp and Van de Ven, 2015; Locher and Dekker, 2016), the following blue-green adaptation measures are mentioned that can be used to limit damage caused by extreme rainfall events (table 4).

Table 4 Blue-Green adaptation measures divided in four categories (storage, discharge, infiltration and robust building)

Rainwater storage measures:	Rainwater discharge measures:	Rainwater infiltration measures:	Rainwater Robust Building:
Hollow Roads	Disconnection sewage system	Permeable roads and pavement	Raise doorsteps, thresholds in front of garages and parking-lots
Green roof	Open gutters to surface water or green areas	Unpavement of parking places, sidewalks, squares etc.	Remove vulnerable (public) utility (like ICT) from first floor
Polder roofs	Efficient road thresholds that prevent streams to low lying places	Water infiltrating green area, such as gardens	Usage of rainproof materials and constructions
Rain barrel		Removal of pavement stones, and insertion of green and infiltration boxes	
Wadi			
Water storage in green areas			
Water square (grey/blue)			
Storage bassin			

2.3 *Stakeholders*

The blue green adaptation measures presented in Section 2.2 are implemented by various stakeholders. I will now introduce these stakeholders:

- The first stakeholder is central government. This actor is responsible for formulating national policy in the field of water management. Central government has, for example, established the Delta Program and the Water Law ('Waterwet').
- The second stakeholder is the province of Utrecht. This government layer is responsible for formulating regional water policy. That policy is documented in, among other things, the provincial water regulation ('Provinciale Waterverordening').
- The third stakeholder is water board (HDSR). This government agency is responsible for maintaining the water system in the Utrecht region. In that context, it must ensure that there are sufficient options for storing and discharging rainwater.
- The fourth stakeholder is the municipality of Utrecht. This local government is responsible for constructing and maintaining the local sewerage system. It is also responsible for designing the public space in such a way that flooding caused by extreme rainfall events is limited as much as possible. Like all other Dutch municipalities, the municipality of Utrecht has a duty of care in the area of storing and draining rainwater ('hemelwaterzorgplicht').
- The last stakeholder is the citizens of Utrecht. Although these have no formal responsibilities in the field of rainwater storage, citizens are an important actor for successfully implementing blue-green adaptation measures.

The regional and local authorities, namely the province of Utrecht, the water board (HDSR) and the municipality of Utrecht, collaborate in two networks. The 'Coalitie Ruimtelijke Adaptatie' (CRA) is one of those networks. The CRA consists of: Water Board (HDSR), Safety Region Utrecht, Province of Utrecht and the municipalities of Utrecht, Nieuwegein, Houten, Stichtse Vecht, Woerden and Bunnik. This network makes plans in the field of spatial planning and climate adaptation. Coordination between the various stakeholders takes place in this network. The network has no formal powers. The other network is Winnet (WaterINnovatieNETwerk). This network consists of: 14 municipalities in the Utrecht area and Water Board (HDSR). In Winnet, research activities take place and ideas for water innovation are developed. This network also has no formal powers.

2.4 *Structure requirements for water governance*

In order to implement the various blue-green adaptation measures as efficiently as possible by the various stakeholders, there must be adequate water governance. Adequate governance consists of three elements, namely structure, management and policy (Boesveldt, Van Montfort and Boutellier, 2017). Based on the computer metaphor, structure, management and policy can be considered the hardware, software and output of governance respectively.

The first element of adequate water governance concerning extreme rainfall events is an adequate structure. The structural element of water governance comprises the following aspects: the extent to which responsibilities and budgets in a policy sector have been decentralized to the right governmental level (Fleurke, Hulst and De Vries, 1997; Fleurke and Hulst 2006); the extent to which government bodies collaborate with private companies and non-profit organizations (Jessop 2004; SER 2010; WRR 2000) and the presence of a network with a well-structured division of tasks (Koppenjan and Klijn, 2004; Mees, 2014). In case of a network, the following two aspects are also relevant: the presence of clear arena rules, clear interaction rules (Koppenjan and Klijn, 2004), and the presence of a process manager (Koppenjan and Klijn, 2004; De Bruijn and Ten Heuvelhof, 2018).

Decentralisation of decision-making power to the regional level

The first aspect of an adequate structure of governance pertains to the decentralization of responsibilities and budgets in the policy sector to the right level. When a problem is governed within a centralized structure, the advantage is a concentration of money and professional expertise. However, often specific knowledge of the local situation is missing and this hampers the desired customization. If a problem is governed within a very decentralized structure, there is the advantage of situation specific knowledge, but a disadvantage of lacking enough professional expertise and financial resources to tackle the problem at stake (Fleurke, Hulst and De Vries, 1997; Fleurke and Hulst 2006).

Complex problems, such as extreme rainfall events, should therefore be governed within a moderate form of decentralization. The responsibilities should be located at the regional level. At this level, there is enough professional expertise, enough financial resources and sufficient local specific knowledge available to address the problem.

Collaborative arrangements between all relevant stakeholders

Complex problems demand for a good collaboration between all stakeholders, because collaboration between stakeholders ensures substantive enrichment. The quality of policy and decisions is improved by the input from different stakeholders (Edelenbos and Klijn, 2005) Furthermore, the legitimacy, i.e. societal acceptance, of policy and decisions is increased by the participation of stakeholders in the policy making and decision-making process (Edelenbos and Klijn, 2005).

A clear division of tasks between all relevant stakeholders

With an independent institute or a network with a clear division of tasks it is ensured that nobody does the same job twice or that different organizations do not work on the same task, which would be inefficient. Moreover, it also prevents that tasks are avoided because it is not clear whose responsibility it is. This contributes to the efficiency of the performance of the tasks (Mees, 2014).

In case of a network: clear interaction and arena rules

In the case of a network there is also a requirement for clear arena- and interaction rules. Arena rules indicate who is allowed to join the network. These arena rules include official, written rules and unwritten and rules that originate from practice. A network operates better as the arena rules are clearer (Koppenjan and Klijn, 2004).

Moreover, there must be clear interaction rules within the network. Interaction rules indicate in which way decisions should be prepared and how to make them. Are decisions only valid when there is unanimous agreement or is it based upon a majority of the votes? Interaction rules can also have a written or unwritten character (Koppenjan and Klijn, 2004).

In case of a network: presence of a process manager

Finally, the last requirement for an adequate structure in a network is the presence of a process manager. A process manager has the task to organise regular meetings, to put the relevant topics on the agenda, and to make sure that decisions about these topics are made within the time constraint. In other words, the process manager has the task that within the network a policy is developed and that decisions about this policy are taken (Koppenjan and Klijn, 2004; De Bruijn, 2008; De Bruijn and Ten Heuvelhof, 2018).

2.5 *Management requirements for water governance*

The second element of adequate water governance concerning extreme rainfall events is appropriate management. From literature regarding policy implementation can be concluded that adequate management comprises the following aspects: stimulating the development of a communal vision between stakeholders, ensuring sufficient knowledge, capacities, competences and motivation within

the collaborating stakeholders and executing sufficient supervision on the collaborating stakeholders (Hoogerwerf, 2008; Coolsma, 2008).

Stimulating the development of a communal vision between stakeholders

A communal policy vision indicates what the different stakeholders want to reach with the policy and why they find it necessary that policy is performed (Van Heffen, 2008; Vandoninck, Brans, Wayenberg and Fobé, 2017). A communal policy vision has multiple advantages. Firstly, it helps to get all stakeholders on the same page. Secondly, it helps to adjust the expectations on attainability and desirability. Lastly, it helps to increase the understanding of the different perspectives (Vandoninck, Brans, Wayenberg and Fobé, 2017).

In case of a network: monitoring knowledge, competences and capacities within the network

Stakeholders should have sufficient knowledge to be able to structure the problem, to design goals that associate well with the problem, to choose instruments that are evidence based and to realize that an evaluation afterwards is needed. Several forms of knowledge have to be present: knowledge for relevant legal regulation or current policy, and hydrological knowledge. Moreover, there has to be enough budget, material and FTE's. Even when there is enough knowledge within the network, the possibility that the competences of the employees are not sufficient remains. A lack of certain competences can lead to insufficient collaboration or an incorrect prioritisation of goals (Coolsma, 2008).

In case of a network: monitoring processes and activities within the network

The last aspect of adequate management is sufficient monitoring on the processes and activities within the network (Coolsma, 2008; De Ridder, 2008). History shows that without adequate monitoring organizations do not fulfil their tasks and duties in a proper way. In this aspect reference can be made to the quite recent debacles of housing corporations, health organisations and education institutes, where a lack of monitoring was evident (Commissie Behoorlijk Bestuur, 2013).

2.6 *Policy requirements for water governance*

A third element of adequate water governance concerning extreme rainfall events is appropriate policy. This element comprises the following aspects: extensive problem structuring; SMART formulated policy goals; clear relations between policy instruments and policy goals and efficient policy instruments.

Extensive problem structuring (i.e. clarification of the nature, extent, causes and consequences of the problem that should be solved)

Adequate policy demands for extensive problem structuring. Extensive problem structuring means that the actual problem, wherefore policy is being developed, should be thoroughly analysed. This means that the nature, extent, causes and consequences of the problem in question should be clarified. An extensive problem structuring ensures prevention of making wrong policy for a non-occurring or incorrect examined problem (Dunn, 2003; Hoogerwerf, 2008; Bressers and Klok, 2008).

SMART formulated policy goals

SMART is an acronym, giving criteria guidance in the setting and assessment of objectives. Smart formulated goals are specific (i.e. what do we want to realize?), measurable (i.e. how are the goals measured?), achievable (i.e. is this a realistic goal?), relevant (i.e. is the goal clearly related to the problem?) and time bound (i.e. when should the goal be reached?) (Bovend'Eerdt, Botell and Wade, 2009).

Clear relations between policy instruments and policy goals

For adequate water governance policy, it needs to be clear how the policy instruments are related with the policy goals. Policy makers should ensure a clear connection between each policy instrument and the goal it should realize (Hoogerwerf, 2008; Bressers and Klok, 2008).

In the literature, four types of policy instruments are distinguished: juridical, economic, communicative and physical policy instruments (Hoogerwerf, 2008; Fenger & Klok, 2008).

Efficient policy instruments

Efficient policy instruments should realize as much as possible with the lowest possible costs. Therefore, an efficient measure implicates an effective measure with respect to the water capacity in m^3. Moreover, an efficient measure also scores high on side effects (Bressers, 2008).

2.7 *Evaluation model: criteria for the quality of water governance*

The evaluation criteria for assessing the quality of water governance are summarized in Table 5.

Table 5 Framework: Evaluation criteria for the quality of water governance

Structure	1) Decentralization of decision-making power to the regional level 2) Collaborative arrangements between all relevant stakeholders 3) A clear division of tasks between all relevant stakeholders 4) In case of a network: clear arena rules (who is allowed to join the network) and clear interaction rules (decision procedures) 5) In case of a network: presence of a process manager
Management	1) Stimulating the development of a communal vision between stakeholders 2) In case of a network: monitoring knowledge, competences and capacities within the network 3) In case of a network: monitoring processes and activities within the network
Policy	1) Extensive problem structuring 2) SMART formulated policy 3) Clear relations between policy instruments and policy goals 4) Efficient policy instruments

2.8 *Barriers regarding an efficient implementation of blue-green adaptation measures*

When stakeholders implement the measures available to them, they can be confronted with various barriers. On the one hand, there are barriers that have to do with water governance in the Utrecht area. For example, it is possible that the governance structure, management and / or policy in the Utrecht region are not adequate. Such shortcomings in water governance hamper an optimal implementation of the measures. On the other hand, there may be barriers that have to do with the characteristics of the blue-green adaptation measures themselves. For example, the fact that for a number of measures it applies that the implementation thereof requires a lot of money and / or a lot of public space, which are scarce resources.

3 Methodology

This chapter describes the methodology used to achieve the objective of this research. It describes what research methods and databases are used in relation to the problem (section 3.1), blue-green adaptation measures (section 3.2), stakeholders (section 3.3), water governance (3.4) and barriers regarding an efficient implementation of blue-green adaptation measures (3.5).

3.1 *Research methods concerning future extreme rainfall events*

With respect to the first sub-research question (concerning future extreme rainfall events) two research methods are applied within the case study: desk research and interviews.

Desk Research

During the desk research, I used a topic list containing the topics that I needed to explore to answer the first sub research question. This topic list consisted of: current precipitation regimes (in Utrecht), future precipitation regimes (in Utrecht) and current flood damage in Utrecht.
Sufficient information about these topics are found in the public accessible database of the KNMI, which is used to find scientific meteorological and climatological publications. The most important source is the publication with the KNMI'14 scenarios. These scenarios contain meteorological information about future extreme rainfall regimes. Another source obtained from desk research is a 2D damage model of Utrecht. This model estimates the inundation depth as a result of virtual rain showers that vary in intensity.

Interviews

Another research method that I used to collect information about future extreme rainfall events is by interviewing experts. To obtain more information about the regional occurrence of extreme rainfall events in the Utrecht area, I interviewed Janette Bessembinder. She is working as an advisor/project leader at KNMI (03-2017, Appendix A). In this semi structured interview, I discussed the following subjects; future rainfall patterns under different scenarios in the Utrecht area, background information about the KNMI'14 scenario's and the application of these scenarios. Moreover, a semi structured interview with Michiel Rijsdijk, (policy officer of the municipality Utrecht, 02-2017, Appendix A) also gave information about the use of damage models as a result of extreme rainfall events in the municipality Utrecht.

3.2 *Research methods concerning blue-green adaptation measures*

With respect to the second sub-research question (concerning blue-green adaptation measures) two research methods are applied within the case study: desk research and expert consultation.

Desk Research

A selection of blue-green adaptation measures is retrieved from the articles of Lot Locher and Gert Dekker (2016) and Kennis voor Klimaat (n.d.), and from numerous examples on http://www.groenblauwenetwerken.nl/.

The blue-green measures are classified by the way they cope with extreme rainfall events. The first classified group of measures can store a surplus of rainwater and is therefore called; Rainwater storage measures. The second classified group of measures can discharge a surplus of rainwater and is therefore called; Rainwater discharge measures. The third classified group of measures can let a surplus of rainwater infiltrate to the groundwater and is thus called: Rainwater infiltration measures. The fourth classified group of measures makes sure that a surplus of rainwater does not affect buildings. This group of measures is called: Rainwater robust building.

All the presented blue-green adaptation measures are in a way able to reduce the problems that arise due to extreme rainfall events. Nevertheless, some measures can store more water (m3), some measures are expensive, other are cheap but might be inefficient. In order to make scoring of the blue-green adaptation measures possible, all measures are characterized on certain factors e.g. effectiveness (amount of storage in m3/m2), costs (per m2), Additional effects (Cooling effects, positive effect on ecology/biodiversity), creating sustainability and improvement of rainwater awareness.

Expert consultation

To check whether blue-green adaptation measures are efficient, the consulted experts have been asked to assess a list of measures. In the final two columns of Table 6, the experts could give other advantages or disadvantages of any measure. Appendix B in Chapter 8 contains the names and affiliations of the consulted experts.

Table 6 Overview of blue-green measures and characterized factors of these measures.

		Effectiveness in water storage m3	Costs (€)	Additional effects (cooling effects, ecology/biodiversity, and improvement of air quality)	Creating sustainability	Improvement of rainwater awareness	Total Score	Other Advantages	Disadvantages
Rainwater storage Measures	Hollow Roads								
	Green roof								
	Polder roofs								
	Rain barrel								
	Wadi								
	Water storage in green areas								
	Water square (grey/blue)								
	Storage bassin								
Rainwater Discharge Measures	Disconnection sewage system								
	Open gutters to surface water or green areas								
	Efficient road thresholds that prevent streams to low lying places								
Rainwater Infiltration Measures	Permeable roads and pavement								
	Unpavement of parking places, sidewalks, squares etc.								
	Water infiltrating green area, such as gardens								
	Removal of pavement stones, and insertion of green and infiltration boxes								
Rainwater Robust Building	Raise doorsteps, thresholds in front of garages and parking-lots								
	Remove vulnerable (public) utility (like ICT) from first floor								
	Usage of rainproof materials and constructions								

To find out which measures score best on the described factors (Table 6), six experts from the water board and municipality have scored every measure on each factor. These experts could choose between 0 = no/minimal effect (or very expensive in the case of costs), 1 = insignificant effect (or expensive in the case of costs), 2 = medium effect (or medium in the case of costs), 3 = big effect (or cheap in the case of costs). However, in this case all factors are equally important. In fact, some users will argue about the importance of the beneficial effect of a certain factor. To acknowledge this, a set of scenarios is provided.

- **Scenario 1**: Effectiveness (35%), Costs (35%), Additional effects (Cooling effects, positive effect on ecology/biodiversity) (10%), Creating sustainability (10%), Improvement of rainwater awareness (10%).
- **Scenario 2**: Effectiveness (20%), Costs (20%), Additional effects (Cooling effects, positive effect on ecology/biodiversity) (20%), Creating sustainability (20%), Improvement of rainwater awareness (20%).
- **Scenario 3:** Effectiveness (50%), Costs (50%), Additional effects (Cooling effects, positive effect on ecology/biodiversity) (0%), Creating sustainability (0%), Improvement of rainwater awareness (0%).
- **Scenario 4:** Effectiveness (25%), Costs (0%), Additional effects (Cooling effects, positive effect on ecology/biodiversity) (25%), Creating sustainability (25%), Improvement of rainwater awareness (25%).

In the end, the overall scores of the experts are averaged and this results in a top 5 of blue-green measures including all 4 scenarios. The result of the scoring based on expert judgement of professionals in water management working within the water board or municipality is verified with data sets provided by Amsterdam Rainproof and the municipality of Rotterdam.

3.3 *Research methods concerning stakeholders*

With respect to the third sub-research question (concerning stakeholders) three research methods are applied within the case study: desk research, interviews and participating observation.

Desk Research

In order to get a good understanding of the responsibilities, roles and ambitions of the various stakeholders, concerning the issue of extreme rainfall events and the implementation of blue-green adaptation measures, a number of policy documents and legal provisions are researched. The desk research is based on the documents presented in Appendix D in Chapter 8.

Interviews

With respect to the stakeholder analysis I have conducted interviews with Michiel Rijsdijk (policy officer municipality Utrecht), Erik Groenland (policy officer municipality Houten, Wouter Egas (policy officer Province of Utrecht), Goos Boelhouwer (policy advisor HDSR and representative in CRA) and Marian Booltink (Calamity Coordinator HDSR) (Appendix A, Chapter 8). These interviewees are all affiliated with the relevant stakeholders.

Participating observation

During my internship at Water Board HDSR I attended a number of meetings in which the relevant stakeholders participated. This gave me insight in their responsibilities, roles and ambitions with respect to the issue of extreme rainfall events and the implementation of blue-green adaptation measures.

3.4 *Research methods concerning water governance*

With respect to structure, management and policy aspects of water governance (sub-research questions 4-6), four research methods are applied within the case study: desk research, interviews and participating observation.

Desk Research

During the desk research concerning water governance I tried to find information about water governance aspects in the Utrecht area. Therefore, I researched policy documents of the municipality Utrecht and Houten, province of Utrecht and water board HDSR. The names of these policy documents can be found in Chapter 6 Appendix D (policy documents).
For each aspect of the water governance criteria, Table 7 indicates which research method is used.

Interviews

Concerning water governance aspects 9 interviews were performed with Michiel Rijsdijk (policy officer municipality Utrecht), Erik Groenland (policy officer municipality Houten, Wouter Egas (policy officer Province of Utrecht), Irene Poortinga (community manager Amsterdam Rainproof), Tjerron Boxem (community manager Water board Delfland), Goos Boelhouwer (policy advisor HDSR and representative in CRA), Marian Booltink (Calamity Coordinator HDSR), Dries Hegger (Assistant professor Copernicus Institute of Sustainable Development Utrecht) and André van Montfort (associate professor of public administration VU, Amsterdam) (Appendix A).

These interviews have had variable durations and frequencies and were often performed in an informal setting and with an open character. The following topics are discussed in the interviews:
- Decentralization of decision-making power to the regional level
- Collaboration between all stakeholders
- A clear division of tasks between all relevant stakeholders
- In case of a network: presence of a process manager
- Stimulating the development of a communal vision between stakeholders
- In case of a network: monitoring knowledge, competences and capacities within the network
- In case of a network: monitoring processes and activities within the network
- Smart formulated policy goals
- In case of a network: monitoring knowledge, competences and capacities within the network
- Clear relations between policy instruments and policy goals

Table 7 depicts if there was, for each aspect of governance, information obtained by interviews.

Participating observation

During several meetings concerning extreme rainfall events with experts from the field of water management and climate adaptation, I could obtain several insights about water governance aspects via observation. Two of these meetings were intended for participants of the Coalition Spatial Adaptation (CRA) (Appendix C). Table 7 depicts if there is, for each aspect of governance, information obtained by participating observations.

Table 7 Evaluation criteria concerning the quality of water governance and research methods

Evaluation criteria concerning the quality of water governance		Research Methods
Structure	1) Decentralization of decision-making power to the regional level	Desk research and interview
	2) Collaboration between all stakeholders	Desk research and interview
	3) A clear division of tasks between all relevant stakeholders	Desk research and interview
	4) In case of a network: clear arena rules and clear interaction rules	Interview and participating observation
	5) In case of a network: presence of a process manager	Interview
Management	1) Stimulating the development of a communal vision between stakeholders	Desk research, interview and participating observation
	2) In case of a network: monitoring knowledge, competences and capacities within the network	Interview
	3) In case of a network: monitoring processes and activities within the network	Interview
Policy	1) Extensive problem structuring	Desk research
	2) Smart formulated policy goals	Desk research and Interview
	3) Clear relations between policy instruments and policy goals	Desk research and interview
	4) Efficient policy instruments	Desk research

3.5 *Research methods concerning barriers regarding an efficient implementation of blue-green adaptation measures*

With respect to the last, seventh sub-research question (barriers), the same four research methods are applied as have been used for gathering information about governance in the Utrecht area: desk research, interviews, participating observation and expert consultation.

4 Results

In this Chapter I present the results of the research that are needed to subsequently answer the research and sub-research question in Chapter 6. The results of are ordered based on the seven sub-research questions. First, I describe how extreme rainfall events will develop in the future in the Utrecht area (section 4.1). Secondly, it is explained what blue-green adaptation measures are the most efficient according to the experts consulted (section 4.2). I continue with a description of the responsibilities, roles and ambitions of the stakeholders (section 4.3). Subsequently, the research results concerning the different elements of water governance in Utrecht area are presented, namely the adequacy of structure (section 4.4), of management (section 4.5) and of policy (section 4.6). The Chapter continues with an overall picture of the quality of water governance concerning extreme rainfall events as a whole in the Utrecht area (section 4.7). Finally, I describe a number of governance barriers and measure-related barriers regarding successful implementation of the most efficient blue-green adaptation measures (section 4.8).

4.1 *Future extreme rainfall events in Utrecht area*

The first sub-research question reads: Is there an increased risk of damage as a result of future extreme rainfall events in the Utrecht region? If we look more specific to the Utrecht area, we see an erratic distribution of the rainfall events in the period 2008-2016 (Figure 5). This figure shows that 7 rainfall events, with an intensity of at least 25mm/h, happened above the small village Kockengen (located at the black part in Figure 5), while large parts of the Utrecht area did not deal or only had to deal once with such an event for the entire 8 years (STOWA, 2018).

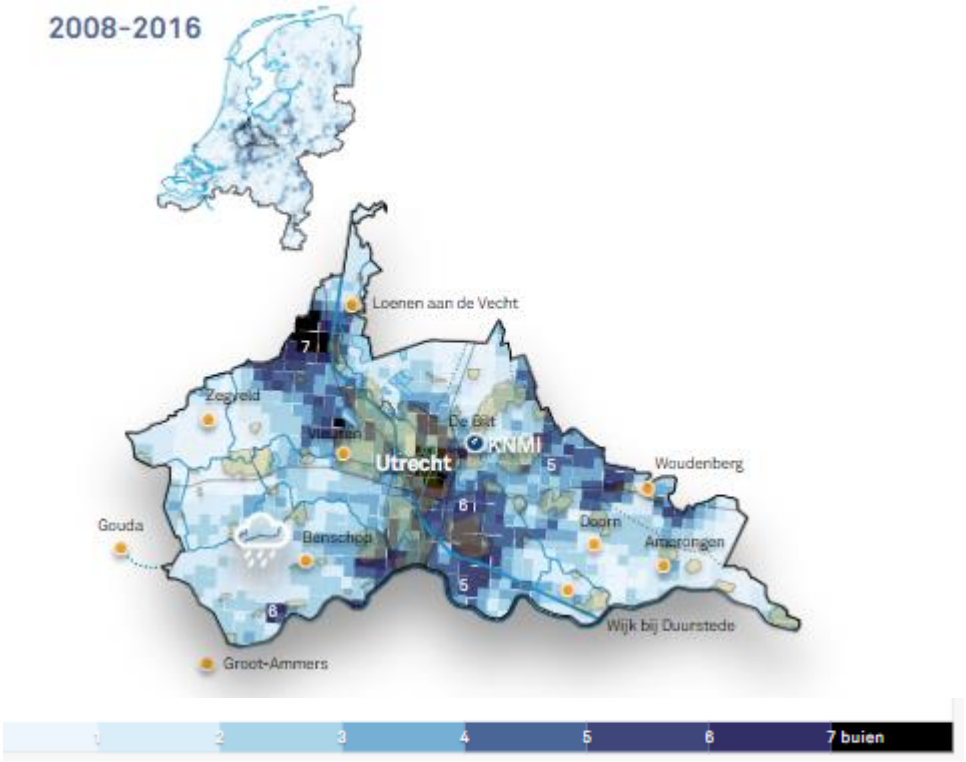

Figure 5: Number of precipitation events exceeding an intensity of 25mm/h in 2008-2016 (STOWA, 2018)

Figure 5 shows that during the 2008-2016 period there were quite often heavy rain showers in the Utrecht region. As has been shown in Section 2.1, in the Netherlands there will be an increase the intensity of heavy rain showers in the future. This information is based on KNMI research regarding the situation in de Bilt. Therefore, it also applies to the situation in the Utrecht region, which implies that there will be more frequent cases of extreme rainfall events in the future as well (Figure 4).

Knowing that extreme rainfall events occur more often in the Utrecht area in the future, there is a possibility for an increase in risk on calamities. This increase in risk depends on the chance and on the possible consequential damage (Kinney and Wiruth, 1976). The municipality of Utrecht researched this increased risk and the results can be found in Figure 6. This figure shows the inundation depths that occur during a 60mm/h event.

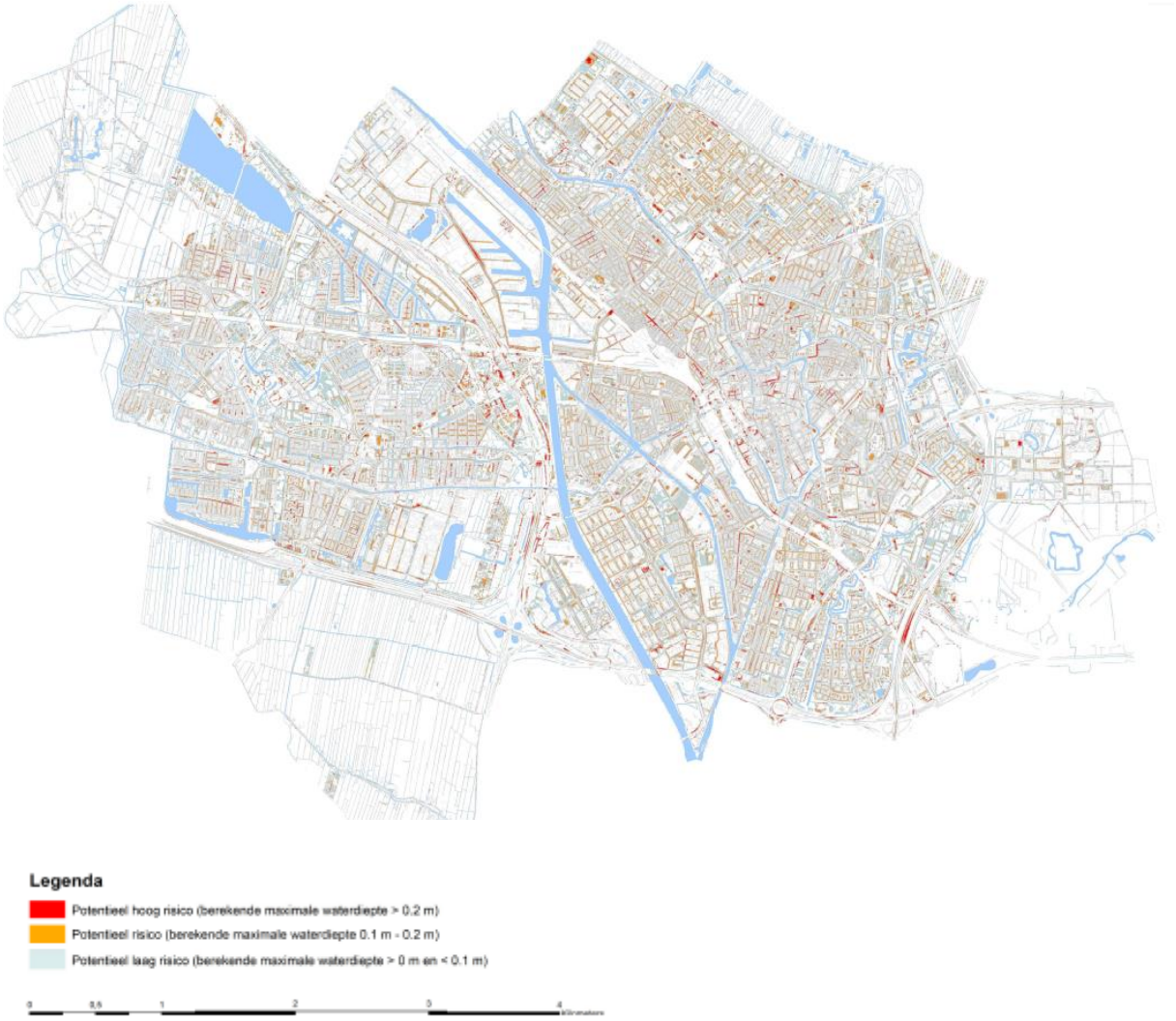

Figure 6 Potential inundation of Utrecht with precipitation amount of 60mm/h (Municipality of Utrecht, 2015)

Figure 6 shows that during an extreme rainfall event with an intensity of 60mm/h, several places within Utrecht inundate with depths more than 20cm. In general, houses in the Netherlands are obliged to have a threshold of 30cm. However, in practice not all houses within Utrecht have this threshold and some houses ('souterainwoningen') even have rooms below street level. These houses are prone to severe water damage if lateral flows from the street reaches them. All in all, it is evident that in Utrecht area there is a higher risk on calamities caused by extreme rainfall events in the future.

4.2 *Most efficient blue-green adaptation measures*

The second sub-research question reads: which green-blue adaptation measures are efficient to reduce the risk of damage due to extreme rainfall events? As explained in Chapter 3, a list of 18 policy instruments (rainproof measures) based on scientific reports and results from engineering firms was presented to experts. Table 8 shows the average score of each policy instrument (row) on each aspect (column). The first group (8 rows) of policy instruments consists of water storage measures, the second

group (3 rows) consists of water discharge measures, the third group (4 rows) consists of water infiltration measures and the fourth group (3 rows) consists of rainwater robust building measures. The experts scored each aspect (column) with a score ranging from 0-3. The total score shows the average score of all aspects and this total score differs per scenario. These scenarios variate in the importance of each aspect, as is explained in Chapter 3.

The results of the expert consultations are depicted in Table 8. The rankings in the last column of Table 8 show what measures are most efficient according to the assessment of the experts. The most efficient measures are: water storage in green areas; wadi's; water infiltrating green areas; open gutters to surface water or green areas; polder roofs; green roofs; and raise doorsteps, thresholds in front of houses, garages and parking-lots.

Table 8 Blue-green adaptation measures evaluated by experts on various aspects.

	Effectiveness in water	Costs (€)	Additional effects (cooling effects, ecology/biodiversity, and improvement of air quality)	Creating sustainability	Improvement of rainwater awareness	Total Score (scenario 1)	Total Score (scenario 2)	Total Score (scenario 3)	Total Score (scenario 4)	Average Score	Rank
Hollow roads	2,8	1,5	0,8	1,3	1,3	1,8	1,5	2,1	1,5	1,7	9
Green roofs	1,3	2,1	2,8	2,0	2,5	1,9	2,1	1,7	2,1	2	6
Polder roofs	1,8	1,8	3,0	2,0	2,5	2,0	2,2	1,8	2,3	2,1	5
Rain barrel	0,0	3,0	0,5	0,5	2,5	1,4	1,3	1,5	0,9	1,3	17
Wadi	2,8	1,8	2,8	3,0	2,8	2,4	2,6	2,3	2,8	2,5	2
Water storage in green areas	2,6	2,7	2,8	3,0	2,5	2,7	2,7	2,6	2,7	2,7	1
Water square (grey/blue)	2,5	0,5	0,5	1,5	2,5	1,5	1,5	1,5	1,8	1,6	13
Storage bassin	2,3	1,0	0,0	0,8	0,3	1,2	0,9	1,6	0,8	1,1	18
Disconnection sewage system	2,3	0,9	0,5	1,3	1,5	1,4	1,3	1,6	1,4	1,4	16
Open gutters to surface water or green areas	2,5	2,5	1,0	2,0	2,5	2,3	2,1	2,5	2,0	2,2	4
Efficient road thresholds that prevent streams to low lying places	2,3	2,4	0,0	1,0	1,5	1,9	1,4	2,3	1,2	1,7	9
Permeable roads and pavement	2,0	1,3	1,3	1,8	1,3	1,6	1,5	1,6	1,6	1,6	13
Unpavement of parking places, sidewalks, squares etc.	2,0	1,5	1,8	2,3	2,0	1,8	1,9	1,8	2,0	1,9	8
Water infiltrating green area, such as gardens	2,5	2,4	2,4	2,5	2,3	2,4	2,4	2,4	2,4	2,4	3
Removal of pavement stones, and insertion of green and infiltration boxes	2,0	2,0	1,0	1,5	1,5	1,8	1,6	2,0	1,5	1,7	9
Raise doorsteps, thresholds in front of houses, garages and parking-lots	2,5	2,8	0,0	1,0	2,0	2,1	1,7	2,6	1,4	2,0	6
Remove vulnerable (public) utility (like ICT) from first floor	2,3	2,0	0,0	1,5	0,8	1,7	1,3	2,1	1,1	1,6	13
Usage of rainproof materials and constructions	2,8	1,5	0,3	1,3	1,5	1,8	1,5	2,1	1,4	1,7	9

4.3 *Stakeholder analysis*

The third sub-research question reads: which responsibilities, roles and ambitions do stakeholders in the Utrecht region have in implementing the blue-green adaptation measures? This sub-research question is answered on the basis of the 7 most efficient blue-green adaptation measures.

The seven most efficient policy instruments can be obtained from the last column of Table 8. Some of these policy instruments demand for the same type of action from the stakeholders. The implementation of the policy instruments "*water storage in green areas*" and "*water infiltration in green areas*" demands the same type of action from the stakeholders, namely the creation or extension of green areas. A similar situation arises with the application of the policy instruments "*green roofs"* and "*polder roofs"*, namely the creation of urban gardens on rooftops. Therefore, the aforementioned blue-green adaptation measures are coupled in Tables 9 and 12.

Tables 9 to 13 comprise seven stakeholders who all have a responsibility, role and/or ambition regarding the implementation of policy instruments in the field of extreme rainfall events. These tables relate to the most efficient policy instruments. Whereas Table 9 relates to the most efficient (couple of) policy instrument(s), namely the creation or extension of green areas, Table 13 pertains to the relatively least efficient policy instrument, namely raising thresholds.

Table 9 Creation or extension of water storage in green areas and water infiltration in green areas analysed in terms of responsibilities, roles and ambitions for each stakeholder.

Creation or extension of water storage in green areas and water infiltration in green areas			
	Responsibility	Role	Ambition
Central Government	No specific responsibility regarding this measure.	Stimulating and informative role via Delta Program and information on www.ruimtelijkeadaptatie.nl.	General support to include this instrument in the water policy.
Province of Utrecht	No specific responsibility regarding this measure.	Facilitating, regulatory and stimulating role reflected in their activities regarding sustainable spatial development.	General support to include this instrument in the water policy.
Water Board (HDSR)	The Water Board has to eveluate whether the creation or extension of green areas meets the criteria of the Watertest ("Watertoets") and to provide water permits ("watervergunning") for the realisation of water storage in green areas.	Stimulating, regulatory, facilitating and informative role.	Specific support, this policy instrument fits well in the principle of retainment, storage and disposal ('Vasthouden-Bergen-Afvoeren'). However, no concrete target (amount).
Coalitie Ruimtelijke adaptatie	Due to the absence of legal competences, the CRA has no specific responsibility regarding this measure.	Stimulating, facilitating and informative role.	Specific support, however no concrete target (amount).
Winnet	Due to the absence of legal competences, Winnet has no specific responsibility regarding this measure.	Informative role.	Specific support, however no concrete target (amount).
Municipality Utrecht	The municipality has the executive responsibility to realize this measure in the public space.	Stimulating, regulatory, facilitating, informative and executive role.	Specific support for this policy instrument, the municipality aims at an increase of the amount of green areas in the city, to enhance the quality of the living environment. However, no concrete target (amount).
Citizens	No responsibility.	Executive role.	No ambition on this matter.

Table 10 Creation of Wadi's analysed in terms of responsibilities, roles and ambitions for each stakeholder.

Wadi's			
	Responsibility	Role	Ambition
Central Government	No specific responsibility regarding this measure.	Stimulating and informative role via Delta Program and information on www.ruimtelijkeadaptatie.nl	General support to include this instrument in the water policy.
Province of Utrecht	No specific responsibility regarding this measure.	Facilitating, regulatory and stimulating role reflected in their activities regarding sustainable spatial development.	Specific support to include this instrument in the water policy. However, no concrete target (amount).
Water Board (HDSR)	Evaluate whether the design of the Wadi meets the criteria of the "Watertest" (Watertoets) Provide water permit ("watervergunning") for the realisation of the Wadi.	Stimulating, regulatory, facilitating and informative role.	Specific support, this policy instrument fits well in the principle of retainment, storage and disposal ('Vasthouden-Bergen-Afvoeren'). However, no concrete target (amount).
Coalitie Ruimtelijke adaptatie	Due to the absence of legal competences, the CRA has no specific responsibility regarding this measure.	Stimulating, facilitating and informative role.	Specific support, however no concrete target (amount)
Winnet	Due to the absence of legal competences, Winnet has no specific responsibility regarding this measure.	Informative role.	Specific support, however no concrete target (amount)
Municipality Utrecht	The municipality has the executive responsibility to realize this measure in the public space.	Stimulating, regulatory, facilitating, informative and executive role.	Specific support for this policy instrument, the municipality aims at an increase of the amount of green areas in the city, to enhance the quality of the living environment. However, no concrete target (amount).
Citizens	No responsibility.	No role.	No ambition on this matter.

Table 11 Creation of open gutters to surface water analysed in terms of responsibilities, roles and ambitions for each stakeholder.

Open gutters			
	Responsibility	Role	Ambition
Central Government	No specific responsibility regarding this measure.	Stimulating and informative role via Delta Program and information on www.ruimtelijkeadaptatie.nl	No explicitly stated ambition.
Province of Utrecht	No specific responsibility regarding this measure.	Facilitating, regulatory and stimulating role reflected in their activities regarding sustainable spatial development.	No explicitly stated ambition.
Water Board (HDSR)	Evaluate whether the design of open gutters meets the criteria of the "Watertest" (Watertoets)	Stimulating, regulatory, facilitating and informative role.	No explicitly stated ambition.
Coalitie Ruimtelijke adaptatie	Due to the absence of legal competences, the CRA has no specific responsibility regarding this measure.	Stimulating, facilitating and informative role.	No explicitly stated ambition.
Winnet	Due to the absence of legal competences, Winnet has no specific responsibility regarding this measure.	Informative role.	No explicitly stated ambition.
Municipality Utrecht	The municipality has the executive responsibility to realize this measure in the public space.	Stimulating, regulatory, facilitating, informative and executive role.	No explicitly stated ambition.
Citizens	No responsibility.	No role.	No ambition on this matter.

Table 12 Creation of green and polder roofs analysed in terms of responsibilities, roles and ambitions for each stakeholder.

Green and polder roofs			
	Responsibility	Role	Ambition
Central Government	No specific responsibility regarding this measure.	Stimulating and informative role via Delta Program and information on www.ruimtelijkeadaptatie.nl	General support to include this instrument in the water policy.
Province of Utrecht	No specific responsibility regarding this measure.	Facilitating, regulatory and stimulating role reflected in their activities regarding sustainable spatial development.	Specific support to include this instrument in the water policy. However, no concrete target (amount).
Water Board (HDSR)	No specific responsibility regarding this measure.	Stimulating, regulatory, facilitating and informative role.	Specific support, this policy instrument fits well in the principle of retainment, storage and disposal ('Vasthouden-Bergen-Afvoeren'). However, no concrete target (amount).
Coalitie Ruimtelijke adaptatie	Due to the absence of legal competences, the CRA has no specific responsibility regarding this measure.	Stimulating, facilitating and informative role.	Specific support, however no concrete target (amount).
Winnet	Due to the absence of legal competences, Winnet has no specific responsibility regarding this measure.	Informative role.	Specific support, however no concrete target (amount).
Municipality Utrecht	Provide the subsidy for green/polder roofs.	Stimulating (subsidy provider), regulatory, facilitating, informative and executive role. Moreover an exemplary role regarding public buildings.	Specific support for this policy instrument, the municipality aims at an increase of the amount of green roofs in the city, to enhance the quality of the living environment. However, no concrete target (amount).
Citizens	No responsibility.	Executive (paying) role.	No ambition on this matter.

Table 13 Raising doorsteps and thresholds in front of houses, garages and parking-lots analysed in terms of responsibilities, roles and ambitions for each stakeholder.

Raise doorsteps and thresholds in front of houses, garages and parking-lots			
	Responsibility	Role	Ambition
Central Government	No specific responsibility regarding this measure.	Stimulating and informative role via Delta Program and information on www.ruimtelijkeadaptatie.nl	No explicitly stated ambition.
Province of Utrecht	No specific responsibility regarding this measure.	Facilitating, regulatory and stimulating role reflected in their activities regarding sustainable spatial development.	No explicitly stated ambition.
Water Board (HDSR)	No specific responsibility regarding this measure.	Stimulating, regulatory, facilitating and informative role.	No explicitly stated ambition.
Coalitie Ruimtelijke adaptatie	Due to the absence of legal competences, the CRA has no specific responsibility regarding this measure.	Stimulating, facilitating and informative role.	No explicitly stated ambition.
Winnet	Due to the absence of legal competences, Winnet has no specific responsibility regarding this measure.	Informative role.	No explicitly stated ambition.
Municipality Utrecht	The municipality has the executive responsibility to realize this measure in the public space.	Stimulating, regulatory, facilitating, informative and executive role.	No explicitly stated ambition.
Citizens	It is mandatory to have the threshold of the front door at least 30 centimetres above ground level.	Executive (paying) role.	No ambition on this matter

4.4 *Quality of water governance structure in Utrecht area*

In order to answer the fourth, fifth and sixth sub-research question the quality of water governance in Utrecht area is assessed Sections 4.4 to 4.6. The present Section describes only the evaluation of the structure aspects concerning water governance. It provides answers on the fourth sub-research question: is there an adequate structure among stakeholders in Utrecht concerning water governance on extreme rainfall events?

4.4.1 Decentralization of decision-making power to the regional level

To find out on which level the policy is established, the responsibilities of the stakeholders must be clear, which have already been described in Section 4.3. Formally, most of the legal decision-making power on the terrain of extreme rainfall events is vested within the municipality Utrecht (Municipality of Utrecht, 2015). Only a small part of the legal powers concerning extreme rainfall events resides with the water board (HDSR) and Province of Utrecht (HDSR, 2016; Province of Utrecht, 2015). The formal decisions concerning this subject are mostly made on a local level within each of the municipalities.

In practice, the coordination of the implementation of the municipal legal powers takes place on a regional level, within the networks CRA and Winnet (CRA, 2016; Winnet, 2013). The Province of Utrecht and the water board (HDSR) operate on a regional level and adjust their policy implementation with the municipalities on the same regional level (province of Utrecht, 2015; HDSR, 2016; and personal communication, Goos Boelhouwer, 7-3-2017). All in all, most legal powers are formally situated on a local level. However, in practice all policy decisions are coordinated on a regional level.

4.4.2 Collaborative arrangements between stakeholders

There are collaborative arrangements between all governmental stakeholders, mostly expressed in the networks CRA and Winnet. Both networks consist of stakeholders from municipalities (e.g. Utrecht), water board HDSR and the province of Utrecht (CRA, 2016). However, to cope with extreme rainfall events there is a need to also include private parties, NGO's and residents' organizations. Within the CRA, private parties are allowed to join the network, as stated in the statement of principles. In practice, these stakeholders are only included in both networks to a very limited extent (CRA, 2016).

According to policy administrator of the municipality of Utrecht, Michiel Rijsdijk (personal communication, 10-3-2017), there is almost no active approach from the governmental stakeholders towards the private parties and residents. Only in the neighbourhoods with severe sewage problems (Zeeheldenbuurt), there are cooperative arrangements with residents.

4.4.3 A clear division of tasks between stakeholders

In the Utrecht area, there are two networks, CRA and Winnet. First, I will describe whether there is a clear division of tasks between these networks. Subsequently, I will describe if there is a clear division of tasks between the stakeholders that are part of these networks, namely the Province of Utrecht, water board HDSR and the municipality of Utrecht.

Task division between the networks CRA and Winnet

The goals of CRA and Winnet concerning extreme rainfall events are quite similar. The networks are both willing to prevent damage from extreme rainfall events as much as possible. Based on interviews with Goos Boelhouwer (personal communication, 7-3-2017), there is probably no clear task division between CRA and Winnet and both networks are discussing extreme rainfall events. Broadly can be stated that when the issue of extreme rainfall events concerns spatial planning this issue is discussed within CRA. More innovative, technical details are elaborated within Winnet. The circumstance that both networks consist for a large extent of the same persons decreases the risk of an overlap in tasks between the networks.

Task division between province of Utrecht, HDSR and municipalities

As can be derived from policy documents (province of Utrecht, 2015; HDSR, 2016; municipality of Utrecht, 2015) and the legislation concerning extreme rainfall events, the legal responsibilities are well divided between the Province of Utrecht, Water Board HDSR and the municipality of Utrecht. As shown in Table 14, there is however a difference between the legal responsibilities and the perceived responsibilities (roles).

Table 14: Legal and perceived responsibilities of stakeholders

	Legal responsibilities	*Perceived responsibilities (role)*
Province of Utrecht	The Province is responsible to supervise the water boards and municipalities, as documented in the "provinciale waterverordening". They operate as directing body that develops development plans, they have to consider and adjust the interests of other stakeholders and are responsible to improve the complementarity between cities and rural areas within the province. The province formulates the frame or standards for the regional water system. An example: the chance for inundation of urban areas from waterways is 1/100y.	The province provides the regulations for the other governmental bodies such as water boards and municipalities. The province has sector exceeding and connection role on a regional level.
Water Board (HDSR)	The task of a water board is lawfully limited to the water state care ("waterstaatzorg"). The Water Board (HDSR) is responsible to manage the (regional) water system and the purification of urban wastewater. The water system includes the embankments and groundwater. Norm: flooding may occur less than once in a hundred years due to inundation of the waterways.	Create awareness among citizens about the level of protection (norm) and the possibility that future extreme rainfall events can exceed these norms more often. The role of water boards concerning extreme rainfall events; Knowledge sharing, stimulating and facilitating rainproof measures.
Municipality of Utrecht	The responsibility of the municipality in spatial planning in cities and rural areas covers the domain in a wide range of aspects concerning: mobility, environment, nature, water, economics and living. The municipality has to address these aspects in development plans when spatial planning is involved. Concerning water issues the municipality has certain specific duties to live up to assigned by the Province. 1) A safe collection of transport and wastewater, without risks for public health and environment, 2) the collection and process of rainwater without problems with flooding, 3) the prevention and reduction of structural groundwater nuisance, 4) The cooperation with water boards in order to create safe, healthy and attractive surface water bodies where	Their role is (together with the Province) to create a safe and liveable live- and work-environment. The municipality should also come up with plans to adapt to climate change including all stakeholders. That starts with making all stakeholders aware of the problems concerning extreme rainfall events. The municipality has a role as a first point of contact for citizens. Citizens with problems concerning for example rainwater issues, will contact the municipality at first.

	people can live, work and recreate in a pleasant way. The rainwater duty only addresses the municipality if the duty cannot be performed reasonably by the owner of the property (a citizen). If the owner cannot sustain this, the municipality should organize a facility in order to distribute the excessive rainwater from the property of the citizen. The municipality is owner of and responsible for the public space and sewage system and is accountable if houses are flooded. In a case that flooding due to inundation from water coming from public spaces or the sewage system leads to damage, this will be settled by the private law (civil law).	

When we look to the perceived responsibilities (role) of each stakeholder, it becomes clear that all stakeholders tend to expand their activities. The involved stakeholders expand their formal responsibilities and associated tasks in order to have a larger remit, causing overlap. Sometimes this overlap may lead to better results. For example, if both the municipality and HDSR try to create awareness for green gardens, the message will reach more people and its impact might therefore be greater.

This overlap is understandable from a substantive point of view. For example, the water board benefits when less rainwater ends up in the sewage system. The rainwater in the sewage system ultimately ends up (polluted) in the storage areas belonging to the Water Board. The overlap is, however, not in all cases based on clear agreements, which can result in inefficient use of resources. Without proper agreements, an overlap in tasks could lead to inefficient 'double' work.

4.4.4 In case of a network: clear arena rules and clear interaction rules

Arena rules

The consulted documents made clear that the CRA has clear arena rules (about who is allowed to join the network). The statement of principles of the CRA is clear about the fact that the CRA should invite new parties in the CRA. These parties could be other governmental institutions, regional corporations, NGO's, private parties and residents (CRA, 2016). According to HDSR policy advisor Goos Boelhouwer (personal communication, 12-10-2017), also member of CRA and Winnet, the arena rules for Winnet are not documented, but are clear for the members of the network. If other municipalities in the Utrecht area want to join Winnet they are accepted.

Interaction rules

Formally there are no clear interaction rules (about decision procedures) but based on personal communication with Goos Boelhouwer (12-10-2017) and personal observation during meetings both networks strive to consensus when a decision must be made. However, this is not a strict rule. It is not clear what happens when one of the members has a dissent opinion and is not willing to adapt his or her opinion to those of the other members.

4.4.5 In case of a network: presence of a process manager

Within the CRA there is a specific person, Enrico Moens from SWECO, who is responsible for the agenda and progress of the CRA. However, no specific person has the task of managing the development and decision-making concerning extreme rainfall event measures. Therefore, the function of process manager is only present to a limited extent.

Within Winnet there is a process manager on the terrain of extreme rainfall events. Annemarie ter Schure (Winnet and municipality of Utrechtse Heuvelrug) has the task to assure that within Winnet the issue of extreme rainfall events is addressed. Moreover, she is responsible that measures concerning extreme rainfall events are discussed and decisions about them are made.

4.5 *Quality of water governance management in Utrecht area*

This section pertains to the fifth sub-research question: is there currently adequate water management at stake concerning the water problems resulting from extreme rainfall events? The management aspects concerning water governance in the Utrecht area are evaluated.

4.5.1 Stimulating the development of a communal vision between stakeholders

Based on the information found in policy documents of the province of Utrecht, water board HDSR and the municipality of Utrecht, these stakeholders try to cooperate and they join forces to come up with a strategy to cope with extreme rainfall events. These stakeholders form together the Coalition Spatial Adaptation in which they spoke out the intention (in the statement of principles) that they want to continue working on spatial climate adaptation (including extreme rainfall events) by making climate challenges intelligible and to use a shared framework for this purpose (Coalitie Ruimtelijke Adaptatie Regio Utrecht, 2014 and 2016).

Within the two networks, CRA and Winnet, the stakeholders can discuss their opinions. During a meeting of the CRA on June 8th, 2017 about extreme rainfall events I participated in several workshops about extreme rainfall events. During these workshops there often was an open debate with all stakeholders about extreme rainfall events. The stakeholders (Province of Utrecht, HDSR and the municipality of Utrecht), were clearly trying to understand the real problem of extreme rainfall events. Sometimes the stakeholders had different opinions about the possible solutions for the problem. Some of the discussed solutions were: other norms, more responsibility for the citizens and improvement of the sewage system capacity.

Not only during this meeting of the CRA, but also in different interviews with employees of the municipality of Utrecht and the water board HDSR, I strongly had the impression that the development of a communal vision is stimulated by all stakeholders. All in all, it is evident that the stakeholders are stimulated to create a communal vision.

4.5.2 In case of a network: monitoring knowledge, competences and capacities within the network

The policy documents of CRA do not contain information about knowledge, competences and capacities. Therefore, the impression is that the networks do not monitor on these aspects. During my participation of meetings of the CRA, I also did not notice that the network pays attention to the question whether the network parties possess sufficient knowledge, competences and capacities. This is an indication that there is almost no monitoring of this issue. In addition to the policy documents and personal observations during the CRA meetings, HDSR employee Goos Boelhouwer also confirmed this statement to a large extent. According to him, the CRA is not monitoring the knowledge, competences and capacities of the members of the network. There is also nobody directly responsible for this task. However, projects and activities are evaluated (personal communication, 12-10-2017).

For Winnet applies more or less the same. The impression from the reviewed documents and the interviewed members of Winnet is that almost no attention is payed to the knowledge, competences and capacities available within the network. This is also confirmed by interviewed members of Winnet from HDSR (personal communication Goos Boelhouwer, 12-10-2017).

4.5.3 In case of a network: monitoring processes and activities within the network

Concerning the monitoring of processes and activities the impression is more nuanced. The policy documents of both networks, CRA and Winnet, show that the processes and activities are evaluated. They both provide information about the progress of projects, the follow-up of meetings and the outcomes of other activities. For example, Winnet provides on its website several documents about their actions, results of activities and plans for the future. Both meetings from the CRA which I attended were evaluated afterwards and all participants could give feedback on the meeting. The CRA uses this feedback to improve their meetings and activities. However, this requirement also asks for an evaluation of the functioning of the network as a whole. Based on the consulted documents and interviewed persons it is not evident that both networks monitor themselves in such a way.

4.6 Quality of water governance policy in Utrecht area

This section pertains to the sixth sub-research question: is there an adequate policy concerning the issue of extreme rainfall events in Utrecht? The policy aspects concerning water governance in the Utrecht area are evaluated in the sections below.

4.6.1 Extensive problem structuring

The problem of extreme rainfall events within the Utrecht area has the attention of all governmental institutions. Especially the municipality of Utrecht and water board HDSR did a thorough risk analysis of extreme rainfall events. The municipality of Utrecht performed a model study that led to a map with possible water inundation depths in the city (Figure 6). The water board (HDSR) also performed a model study with a virtual 1:1000 rain event, to see where inundation occurs (HDSR, 2016).

An adequate structuring of the problem of extreme rainfall events, requires information about its nature, extent, causes and consequences. Concerning the nature of the problem, this problem has climatological, political and governance aspects. Most of the research concerning the nature of the problem has been done on the climatological aspect (Municipality of Utrecht, 2015). There is a research gap concerning the governance and political aspects of this problem. Concerning the extent of the problem, most of the finished studies also focussed on the climatological aspect. The extent of the problem in the field of governance and politics is only researched to a limited extent. The causes of the problem of extreme rainfall events are very clear for all stakeholders. They are all aware that extreme rainfall events will occur more often in (near) future. Moreover, the densification of cities due to urbanisation causes extra paved areas within cities, leading to less rainwater infiltration and rainwater storage places (Glaas and Jonsson, 2014). The consequences of extreme rainfall events are clear to a limited extent. Most research has been accomplished about the inundation depth of the water in the city (Municipality of Utrecht, 2015). The economic and social consequences of an extreme rainfall event with water damage is however still uncertain.

All in all, the problem is structured to a large extent concerning the climatological aspects. The governance aspects and social and economic consequences are however less explored and demand for a more complete problem structuring by the stakeholders.

4.6.2 SMART formulated policy goals

SMART formulated policy goals must be Specific, Measurable, Achievable, Relevant and Time bound. The policy goals of the province of Utrecht, water board HDSR and municipality of Utrecht can be found in their policy documents (province of Utrecht, 2015; HDSR, 2016; municipality of Utrecht, 2015). Each policy goal is assessed on the SMART-criteria (Table 15).

The goal of the province of Utrecht is to make the city's environment energy neutral and climate robust in 2050 (Province of Utrecht, 2018). The water safety, freshwater facilities and the spatial design are climate proof and water robust, in order to cope with the large extremes of the climate in a resilient

way (Province of Utrecht, 2018). The policy goal is fairly specific ("large extremes"), measurable to a very limited extent ("climate proof" and "water robust"), relevant to a high extent ("water safety") and time bound ("2050"). Its achievability cannot be assessed due to too many uncertainties about future developments.

The goal of the water board HDSR is to make sure that, together with the province and municipalities, climate proof and water robust spatial design is completely integrated in 2020. HDSR wants to create awareness about extreme rainfall events among other stakeholders. Within cities, HDSR has the legally defined task and goal to maintain the waterways in such a way that inundation from within the waterways only happens once in 100 years (HDSR, 2015).

The policy goal of the water board HDSR is fairly specific ("extreme rainfall events" and "climate-stress test"), measurable to a very limited extent ("climate proof", "water robust spatial design" and "completely integrated"), relevant to a high extent ("extreme rainfall events" and "risks") and time bound ("2020" and "coming years"). Its achievability cannot be assessed due to too many uncertainties about future developments.

The goal of the municipality of Utrecht is to ensure that Utrecht is still an attractive city to live in, because the city is resistant against extreme rainfall events, periods of drought and high temperatures in 2050 (municipality of Utrecht, 2015. Regarding rainfall events (>20mm/h), the municipality has the goal to prevent lateral flow from rainwater towards real estate, prevent hindrance on streets for traffic and emergency services, prevent safety or health risks due to sewage water that backflows to the streets, prevent blockages of all components of the sewage system (municipality of Utrecht, 2015).
The policy goal of the municipality of Utrecht is specific to a high extent (">20mm/h and "prevent"), measurable to some extent ("attractive city" and "resistant"), relevant to a high extent ("extreme rainfall events") and time bound ("2050"). Its achievability cannot be assessed due to too many uncertainties about future developments.

In Table 15, the scores of all SMART criteria are depicted and are based on the above evaluated policy goals. Whereas there are positive scores on the criteria Relevant and Time Bound, there is a negative score on Measurable. It is remarkable that the municipality of Utrecht shows higher scores on the SMART-criteria than the other stakeholders.

Table 15: Scores on SMART criteria of policy goals of the stakeholders (Province of Utrecht, water board HDSR and Municipality of Utrecht) on SMART

	Province	Water board	Municipality of Utrecht	Total
Specific	+/-	+/-	+	+/-
Measurable	-	-	+/-	-
Achievable	not evaluable	not evaluable	not evaluable	not evaluable
Relevance	+	+	+	+
Time bound	+	+	+	+
Total	+/-	+/-	+	+/-

4.6.3 Clear relations between policy instruments and policy goals

The policy goals of the province of Utrecht, water board HDSR and municipality of Utrecht can be found in Section 4.6.2 and the various policy instruments can be characterized as juridical, economic, communicative or physical (section 2.6).

The most important policy instrument of the province of Utrecht has a juridical character. The province must set the norms (waterverordening) for other governmental bodies, such as municipalities and water boards (Province of Utrecht, 2015). The province of Utrecht tries to achieve their goal concerning

water management on extreme rainfall events with these norms. The relation between the policy instrument (norms) and policy goal (i.e. climate robust 2050) is therefore clear.

Water board HDSR uses all types of policy instruments. The signing of the statement of principles of CRA is a juridical policy instrument that is clearly related to the policy goal (i.e. integration of climate proof a water robust spatial design in 2020) (HDSR, 2016). In the coming years, together with the municipalities, the water board HDSR wants to assess the water system with a stress test. This test gives insights on concrete action perspectives and allows the water board to give customized advice on spatial design. Climate stress tests increase the knowledge of the risks of extreme rainfall events and is a communicative policy instrument, which is also related to the policy goal (i.e. raising awareness) (HDSR, 2016). Physical policy instruments are also applied by the water board HDSR. To make sure that waterways only inundate once every 100 years in cities (policy goal), more water retention areas and nature friendly shores are created (HDSR, 2016). The BBI (Blauwe Burger Initiatief) is an economic policy instrument taken by water board HDSR. Citizens, neighbourhood associations and companies with a good plan to improve the water system receive subsidy from HDSR (HDSR, 2016). This policy instrument is not directly related to the policy goal of HDSR and also goes beyond the legal responsibility of HDSR.

The municipality of Utrecht also uses all types of policy instruments. The statement of principles of CRA is also signed by the municipality of Utrecht. This signing means that the municipality has a juridical policy instrument that is clearly related to the goal to make Utrecht an attractive city that is able to cope with extreme rainfall events in 2050 (Municipality of Utrecht, 2015). Economic policy instruments are also applied by the municipality of Utrecht, namely subsidies on green roofs for residents. The municipality of Utrecht clearly indicates the relation of green roofs with the previously mentioned policy goal in the 'Plan municipal water tasks' (Municipality of Utrecht, 2015). Furthermore, the municipality of Utrecht uses policy instruments of a communicative character. They advertise on their website to encourage citizens to use more plants in their private gardens and to unlink drainage tubes from the sewage system directly into the garden (Operatie Steenbreek and De Watervriendelijke Tuin). Creating awareness about extreme rainfall events among citizens is not mentioned in the 'Plan municipal water tasks' and is therefore not clearly linked with a policy goal (Municipality of Utrecht, 2015). Physical policy instruments are on a large scale implemented in the city of Utrecht by the municipality. Physical measures such as creating wadi's, green areas, permeable pavement and other are also clearly linked by the municipality of Utrecht with the aforementioned policy goal.

All in all, it becomes clear that all government bodies rather clearly indicate the relations between their policy instruments and policy goals.

4.6.4 Efficient policy instruments

Efficient policy instruments are blue-green adaptation measures that are effective in water storage (m3) and low in costs (€). Moreover, these blue-green adaptation measures must score high on side effects that fulfil other goals such as; sustainability, improving air quality, biodiversity and rainwater awareness.

In the Utrecht area, stakeholders implement the following 7 blue-green adaptation measures: green roofs, wadi's, water storage in green areas, disconnection of the sewage system, permeable roads and pavements, water infiltrating green area, removal of pavement stones and insertion of green and infiltration boxes (Table 8). These blue-green adaptation measures can be perceived as policy instruments.

Are the seven policy instruments used in the Utrecht area efficient? Four policy instruments that are used in the municipality of Utrecht score high according to the experts, namely: wadi's; water storage in green areas; open gutters to surface water or green areas; water infiltrating green areas, such as gardens. Furthermore, two of the policy instruments used in the municipality of Utrecht score

moderate, namely: permeable roads and pavements; removal of pavement stones and insertion of green and infiltration boxes. There is only one policy instrument which scores a low score in most scenarios, and used by the municipality of Utrecht, namely: the disconnection of the sewage system. All in all, most of the policy instruments utilized in the Utrecht area are efficient.

However, there is still some room for improvement with respect to the criterium efficient policy instruments. The stakeholders in the Utrecht area do not use all instruments which are positively evaluated by the consulted experts. They do not utilize the policy instruments hollow roads, and open gutters to surface water or green areas.

4.7 *Overall picture of the quality of water governance in Utrecht area*

The water governance in the Utrecht area has been evaluated in the sections 4.4-4.6. The scores on the various evaluation criteria are included in the overview given in Table 16. In this table, the symbol '–' means that the evaluation criterion is only slightly met. The symbol '+/-' means that the evaluation criterion is met to a reasonable extent, but that there is still considerable room for improvement. The symbol '+' implies that the evaluation criterion is met to a large extent. In the Sections 4.4-4.6 can be seen why the symbol '-', the symbol '+/-' or the symbol '+' has been allocated to each of the concerned evaluation criteria in Table 16.

Table 16: Scores on the evaluation criteria concerning water governance within the Utrecht area

Structure	1) Decentralization of decision-making power to the regional level	+/-
	2) Collaboration arrangements between all stakeholders	+/-
	3) A clear division of tasks between all relevant stakeholders	+/-
	4) In case of a network: clear arena rules (about who is allowed to join the network) and clear interaction rules (about decision procedures)	+/-
	5) In case of a network: presence of a process manager	+/-
Management	1) Stimulating the development of a communal vision between stakeholders	+
	2) In case of a network: monitoring knowledge, competences and capacities within the network	-
	3) In case of a network: monitoring processes and activities within the network	+/-
Policy	1) Extensive problem structuring	+/-
	2) SMART formulated policy goals	+/-
	3) Clear relations between policy instruments and policy goals	+
	4) Efficient policy instruments	+/-

4.8 *Governance barriers and measure-related barriers hampering the implementation of the top 5 blue-green adaptation measures per stakeholder*

This section pertains to the last, seventh, sub-research question: which governance barriers and other types of barriers can be identified per blue-green adaptation measure and per stakeholder in the Utrecht area?

4.8.1 Barriers and opportunities for each top 5 blue-green adaption measure per stakeholder

Governance barriers are a result from shortcomings in water governance in the area of extreme rainfall events in the Utrecht region. These barriers are indicated in Sections 4.4-4.6 and summarized in Section 4.8. They hamper successful implementation of blue-green adaptation measures. Besides barriers related to the shortcomings in the water governance, there are also other barriers that hamper the implementation of blue-green adaptation measures. Think for instance of barriers that are related to specific characteristics of blue-green adaptation measures, such as the scarcity of the public space available to embed these measures. Contrary to these two types of barriers, there are also opportunities that are conducive to the implementation of blue-green adaptation measures. An example of such an opportunity is that the realisation and maintenance costs of such measure can be spread over several stakeholders.

In the Tables 17 to 21, the following question is answered per blue-green adaptation measure:
What are the governance barriers, other barriers and opportunities for each stakeholder given the responsibilities and roles of the stakeholder? For each blue-green adaptation measure attention is paid to the governance barriers, other barriers and opportunities of every stakeholder. However, no attention is paid to Winnet, because this network is not involved in the implementation of any blue-green adaptation measure.

In the Tables 17 to 21, reference is made to the governance criteria (i.e., structure, management and policy criteria) mentioned in the previous Section in Table 16.

Table 17 Creation or extension of water storage in green areas and water infiltration in green areas analysed in terms of governance barriers, other barriers and opportunities for each stakeholder.

	Governance barriers	Other barriers	Opportunities
Central Government	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	None	The creation of (the amount of) green areas could be prescribed in the Water Law ('Waterwet').
Province of Utrecht	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	The importance of good water drainage must be weighed against other public interests such as adequate housing, parking spaces and other spatial developments.	The creation of (the amount of) green areas could be prescribed in the 'Provinciale Waterverordening'
Water Board HDSR	The most important governance barriers are: no collaboration with private parties (Structure criterium 2), a lack of SMART formulated goals (Policy criterium 2) and no clear relationship between policy instruments and policy goals (Policy criterium 3).	No clout in the public space.	Reduce the Water Board tax for citizens who own a green garden ('belastingdifferentiatie').
Coalitie Ruimtelijke Aaptatie	This stakeholder on the regional level is not authorized to make decisions on this issue due to the absence of the decentralization of	None	Ensure that the CRA receives legal decision power on this issue.

	legal powers to the regional level (Structure criterium 1). There are no clear interaction rules within this network (Structure criterium 4) and there is no adequate monitoring of processes and activities (Management criterium 3).		
Municipality of Utrecht	The most important governance barriers are: no collaboration with private parties (Structure criterium 2), no clear division of tasks (Structure criterium 3) and no efficient usage of policy instruments (Policy criterium 4)	It is not possible to execute this measure on privately owned areas. Capacity of space in urban areas is limited, so creating more green areas has a consequence for other services. Costly measure (m3/m2), which only becomes effective when large areas are turned into green or polder roofs.	Reduce the Sewage System taxes ('rioolwaterheffing') for citizens who own a green garden. Start an awareness campaign about the impact that green gardens can have on the problems caused by extreme rainfall events.
Citizens	There are no governance barriers.	Designing a green garden means investment and maintenance (costs).	If citizens are aware of their role and feel a shared responsibility, they can have a big impact on a water robust city, since they possess a lot of private ground.

Table 18 Creation of Wadi's analysed in terms of governance barriers, other barriers and opportunities for each stakeholder.

	Governance barriers	Other barriers	Opportunities
Central Government	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	None	The creation of (the amount of) wadi's could be prescribed in the Water Law ('Waterwet').
Province of Utrecht	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	The importance of good water drainage must be weighed against other public interests such as adequate housing, parking spaces and other spatial developments.	The creation of (the amount of) wadi's could be prescribed in the 'Provinciale Waterverordening'
Water Board HDSR	The most important governance barriers are: no collaboration with private parties (Structure criterium 2), a lack of SMART formulated goals (Policy criterium 2) and no clear relationship between policy instruments and policy goals (Policy criterium 3).	No clout in the public space.	Possible contribution to the maintenance costs of wadi's.
Coalitie Ruimtelijke Aaptatie	This stakeholder on the regional level is not authorized to make decisions on this issue due to the absence of the decentralization of legal powers to the regional level (Structure criterium 1).	None	Ensure that the CRA receives legal decision power on this issue.
Municipality of Utrecht	The most important governance barriers are: no collaboration with private parties (Structure criterium 2), a lack of SMART formulated goals (Policy criterium 2) and no clear relationship between policy instruments and policy goals (Policy criterium 3).	Public space is scarce, so it has consequences for other services. (parking spaces etc.)	Try to reduce maintenance costs by asking for cooperation from the water board and the citizens.
Citizens	None	None	Citizens could help with the maintenance of wadi´s.

Table 19 Creation of open gutters to surface water analysed in terms of governance barriers, other barriers and opportunities for each stakeholder.

	Governance barriers	Other barriers	Opportunities
Central Government	No ambition formulated regarding this measure.	None	Development of a specific ambition regarding this measure.
Province of Utrecht	No ambition formulated regarding this measure.	None	Development of a specific ambition regarding this measure.
Water Board HDSR	No ambition formulated regarding this measure.	No clout in the public space.	Development of a specific ambition regarding this measure.
Coalitie Ruimtelijke Aaptatie	No ambition formulated regarding this measure.	None	Development of a specific ambition regarding this measure.
Municipality of Utrecht	No ambition formulated regarding this measure.	This measure demands a 3D flow model, which is currently lacking.	Could be performed if streets have to be repaved or when neighbourhoods are restructured.
Citizens	None	None	None

Table 20 Creation of green and polder roofs analysed in terms of governance barriers, other barriers and opportunities for each stakeholder.

	Governance barriers	Other barriers	Opportunities
Central Government	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	None	The creation of (the amount of) green/polder roofs could be prescribed in the Water Law ('Waterwet').
Province of Utrecht	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	None	The creation of (the amount of) green/polder roofs could be prescribed in the 'Provinciale Waterverordening'
Water Board HDSR	No barriers, the very limited responsibilities and role are fulfilled sufficiently.	No clout in the public space.	Intensivation of the cooperation with Winnet and CRA. Exposure of their exemplary role by creating green roofs on public buildings.
Coalitie Ruimtelijke Aaptatie	This stakeholder on the regional level is not authorized to make decisions on this issue due to the absence of the decentralization of legal powers to the regional level (Structure criterium 1).	None	Ensure that the CRA receives legal decision power on this issue.
Municipality of Utrecht	The most important governance barriers are: no collaboration with private parties (Structure criterium 2), a lack of SMART formulated goals (Policy criterium 2) and no clear relationship between policy instruments and policy goals (Policy criterium 3).	Green roofs are in most cases located on private area that belongs to citizens. The municipality has no ownership in the private area and they are therefore dependent on the effort of citizens.	Intensivation of the cooperation with Winnet and CRA. Exposure of their exemplary role by creating green roofs on public buildings. Replace subsidies on green roofs by a discount on the Sewage System taxes ('rioolwaterheffing'), for citizens who own a green roof. Include citizens to design polder roofs in densely build urban areas to recreate.
Citizens	None	Costs and maintenance of a green roof	Use crowdfunding as a possibility to create polder roofs.

Table 21 Raising doorsteps and thresholds in front of houses, garages and parking-lots analysed in terms of governance barriers, other barriers and opportunities for each stakeholder.

	Governance barriers	Other barriers	Opportunities
Central Government	No ambition formulated regarding this measure.	None	None
Province of Utrecht	No ambition formulated regarding this measure.	None	None
Water Board HDSR	No ambition formulated regarding this measure.	No clout in the public space.	Provide more information about the beneficial effects of higher thresholds.
Coalitie Ruimtelijke Aaptatie	No ambition formulated regarding this measure.	None	Ensure that the CRA receives legal decision power on this issue.
Municipality of Utrecht	No ambition formulated regarding this measure.	This measure demands a 3D flow model, which is currently lacking. This 3D flow model helps to find the right places for these thresholds.	Provide more information about the beneficial effects of higher thresholds. When a flow model is available, it is possible to prevent streams causing damage to houses or parking garages.
Citizens	None	Some citizens are not aware that they are responsible to raise their thresholds when these are less than 30cm above ground level. Furthermore, thresholds cost money.	When citizens are aware of the beneficial effects of this measure, they are more willing to invest in raising thresholds in front of their houses.

4.8.2 Summative remarks considering the barriers and opportunities for stakeholders

The information from the Tables 17 to 21 can be summarized as follows. With regard to most blue-green adaptation measures and *most stakeholders* there is a lack of cooperative relationships with private parties and NGO's. The government often needs the cooperation of private individuals for the implementation of the blue-green adaptation measures. Consider, for example, the construction of green roofs. The municipality of Utrecht can encourage the implementation of this measure, but the final decision as to whether green roofs will actually be realized, is made by citizens and/or private companies. As stated in the statement of principle of the CRA, private parties are allowed to participate in this network. This is a promising opportunity to overcome this governance barrier.

For two out of the most efficient blue-green adaptation measures, namely for the measures 'open gutters' and 'raising doorsteps', *none of the stakeholders* have formulated an ambition. Furthermore, with respect to all blue-green adaptation measures, *none of the stakeholders* has formulated concrete targets. For instance, no desirable number of the amount of green roofs is explicated. A similar situation applies to the desirable number of wadis in the Utrecht area. All in all, it can be concluded that there are serious barriers with respect to the governance evaluation criterium 'SMART goals'.

In addition to these governance barriers, there are also a few other barriers. First, for the measures "Open Gutters" and "Raising Doorsteps and Thresholds" no 3D-flow model has been developed yet commissioned by the *municipality of Utrecht*. Such a model is necessary to efficiently implement these two measures.

Secondly, measures in the field of water management in the public space must always be balanced against other interests that play a role in the public space. The public space is limited and it will therefore be necessary to consider how to use it. The application of water management measures is

sometimes at the expense of other options for spatial development. Furthermore, the budgets from *the Province of Utrecht, Water Board HDSR and the municipality of Utrecht* allocated for water management instruments can not be utilized for other public services.

Finally, some measures have to be implemented to a large extent on private territory, over which *government bodies* have no control. This means that the costs must be paid by citizens and private organizations. One of the barriers for citizens and private organizations are the investment and maintenance costs of the measures. An opportunity to overcome this barrier, is that citizens and private organizations are stimulated to execute these measures by reducing the *municipal taxes* on sewage system and *Water Board taxes* ('waterschapsbelasting').

Partly based on these summative remarks, in Chapter 6 recommendations are made on how governance and other barriers that hamper successful implementation of blue-green adaptation measures in the Utrecht region can be reduced.

5 Discussion

In this chapter, the case-study in the Utrecht region is associated with earlier research in the field of water governance with regard to extreme rainfall events and other aspects of climate change. Subsequently, attention is paid to strengths and limitations of the case-study in the Utrecht area.

5.1 *Relationship with previous research*

As stated in the introductory chapter of this thesis, there is hardly any specific scientific literature about water governance concerning extreme rainfall events. One of the few exceptions is the study of Mees (2014), that discusses the role of governance concerning climate change adaptation. According to Mees, the implementation of adaptation plans and actions is hampered because of the fragmented and ambiguous division of responsibilities for adaptation to climate change between public and private actors. A clear and deliberate allocation of responsibilities, based on a conscious weighting of different considerations underlying this allocation of responsibilities, is necessary to get adaptation planning and action off the ground.

Nevertheless, the issue of public versus private responsibilities is underexplored in the adaptation literature (Mees, 2014). In addition, little attention has also been paid to other governance aspects that are important for society to be well prepared for extreme rainfall events. There was, therefore, a need for further research in this field.

The present case-study within the Utrecht area tried to meet this need. This study investigated to which extent there is adequate water governance concerning the implementation of blue-green adaptation measures by stakeholders in order to cope with extreme rainfall events in the Utrecht area. In accordance with the advice of Mees (2014), I examined, among others, to what extent there is a clear division of tasks between all stakeholders and to what extent not only public parties but also private parties are involved in implementing blue-green adaption measures.

The conclusions of the case-study will be presented in Chapter 6. Prior to that I will now first pay attention to the strengths and limitations of this research.

5.2 Strengths and limitations of the study

Strengths

A strength of this study is that I developed an original governance assessment framework on the basis of literature in the field of public administration and water management. This governance framework is valid in all regions of the Netherlands and possibly abroad as well. It consists of 12 criteria in the three domains of structure, management and policy, offering a well elaborated evaluation framework. This framework is practically applicable, gives direct consequences, and future improvements when applied to governance arrangements. The assessment framework can be reapplied in several years as a form of self-evaluation, to assess if the recommendations from this research have reduced the weaknesses in water governance in the Utrecht area.

Another strength of this study pertains to the in-depth case study design within the Utrecht area, which made it possible to give a highly detailed representation of the water governance concerning extreme rainfall events in this region. Therefore, multiple practical recommendations are given for the Utrecht area. Within this study, various types of data collection were executed, such as a studying policy documents, performing interviews with nearly all relevant stakeholders, collecting personal observations during meetings and the consultation of experts with respect to the policy instruments.

Moreover, for each of the 5 most efficient blue-green adaptation measure attention is paid to the governance barriers, other barriers and opportunities of every stakeholder. This makes it possible to make specific recommendations for each stakeholder, which will be done in Chapter 6.

Limitations

A first limitation of this study is that within the subject of water governance concerning extreme rainfall events, I could only give insight in the situation of the Utrecht area. Therefore, I could only make recommendations which are applicable to this area and no general recommendations for other areas. Nevertheless, the governance assessment framework can be used again in other regions and could give specific recommendations for these regions.

Another limitation is that only a limited number of employees of the involved stakeholders were interviewed. Of each relevant stakeholder, only one or two employees were interviewed. A larger number of interviewees might have led to more and more profound insights into governance in the Utrecht region.

Moreover, only a limited number of experts in the field of blue-green adaptation measures were interviewed. When it comes to the implementation of blue-green adaptation measures, these experts may be biased due to their own work experience as policy advisors in the field of water management. Consulting one or more experts from the private sector might have led to a different list of most efficient blue-green measures.

6 Conclusion

In this chapter, the conclusions on the sub research questions based on the research material of Chapter 4 will be presented. Subsequently, I describe the conclusion on the main research question. Finally, I will give some suggestions for future research.

6.1 *Conclusions on sub-research questions*

The first sub-research question reads: **Is there an increased risk of damage as a result of future extreme rainfall events in the Utrecht region?** Due to climate change extreme rainfall events will intensify in frequency and amplitude in the Utrecht area (KNMI, 2014). Knowing that extreme rainfall events occur more often in the Utrecht area in the future, there is a possibility for an increase in risk on calamities. This increase in risk depends on the chance of extreme rainfall events and on the possible consequential damage. During an extreme rainfall event with an intensity of 60mm/h, several places within Utrecht inundate with depths more than 20cm. Therefore, it is evident that in Utrecht area there is a higher risk on calamities caused by extreme rainfall events in the future.

The second sub-research question reads: **Which green-blue adaptation measures are efficient to reduce the risk of damage due to extreme rainfall events?** According to the consulted experts, the most efficient blue-green adaptation measures are: water storage in green areas; wadi's; water infiltrating green areas; open gutters to surface water or green areas; polder roofs; green roofs; and raise doorsteps, thresholds in front of houses, garages and parking-lots.

The third sub-research question reads: **Which responsibilities, roles and ambitions do stakeholders in the Utrecht region have in implementing the blue-green adaptation measures?** In general it can be concluded that the responsibilities to execute blue-green adaptation measures rest with the municipality of Utrecht and the citizens. The other stakeholders, namely central government, Province of Utrecht, Water Board HDSR, CRA and Winnet, have a facilitating, stimulating, regulatory and/or informative role. This means that these stakeholders are dependent on the municipality of Utrecht and/or citizens with respect to the execution of blue-green adaptation measures.

The fourth sub-research question reads: **Is there an adequate structure among stakeholders in Utrecht concerning water governance on extreme rainfall events?** An adequate water governance structure concerning extreme rainfall events meets the following 5 criteria: 1) decentralization of decision-making power to the regional level, 2) collaboration arrangements between all stakeholders, 3) a clear division of tasks between all relevant stakeholders, 4) clear arena rules and interaction rules and 5) presence of a process manager.

The first requirement regarding an adequate structure (i.e. decentralization of decision-making power to the regional level) is only partly fulfilled. In practice, the decision-making has been decentralised to a regional level, since the regional networks of CRA and Winnet do cover the topic of extreme rainfall. Legally, the authority remains in hands of the province, the water board and the municipalities. The regional networks CRA and Winnet do not have the legal authority to make the final decision.

The second requirement (i.e. collaboration arrangements between all stakeholders) is not completely met. Good collaborative arrangements between the governmental stakeholders (province, water board and municipality of Utrecht) do exist. However, there is a lack of collaborative arrangements between these governmental bodies on the one hand and NGO's, companies and citizens on the other. The statement of principles of the CRA states that it is possible for these private parties to join the CRA. Therefore, collaborative improvement in the future is possible.

The third requirement (i.e. a clear division of tasks between all relevant stakeholders) regarding an adequate structure is also partly fulfilled. The task division concerning the legal responsibilities is clear. However, concerning the perceived responsibilities there is a lot of overlap between the stakeholders. This overlap is -as appears from interviews- not based on clear arrangements. The involved institutions tend to expand their responsibilities, in order to maximize their tasks and influence.

The fourth requirement (i.e. clear arena rules and interaction rules) is also partly fulfilled. The arena rules have been clearly defined, by means of the statement of principles for the CRA and by means of oral agreements of the members of Winnet. There are no clear interaction rules in both networks.

The fifth requirement (i.e. presence of a process manager) is partly fulfilled. Winnet has appointed a process manager regarding extreme rainfall events. At CRA, there is a general process manager whose tasks do not only cover extreme rainfall events. However, no decisions have been made regarding the authority and responsibilities of this process manager within the field of extreme rainfall events, which indicates that there is no fully adequate structure concerning this aspect.

With respect to the requirement concerning the water governance structure it can be concluded that all requirements are partly fulfilled.

The fifth sub-research question reads: **Is there currently adequate water management at stake concerning the water problems resulting from extreme rainfall events?** Adequate management concerning extreme rainfall events entails the following 3 criteria: 1) stimulating the development of a communal vision between stakeholders, 2) monitoring knowledge, competences and capacities within the network and 3) monitoring processes and activities within the network.

The first requirement regarding of adequate water management (i.e. stimulating a communal vision) is completely fulfilled in the Utrecht area. The stakeholders are stimulated to create a communal vision on coping with extreme rainfall events.

The second requirement (i.e. monitoring knowledge, competences and capacities) is not fulfilled. In the networks CRA and Winnet, the knowledge, competences and capacities of the stakeholders are not monitored.

The third requirement (i.e. monitoring processes and activities) is partly fulfilled. In both aforementioned networks, the implementation of agreements made during meetings is evaluated afterwards. However, the functioning of the whole network is not monitored.

Overall, the requirements regarding adequate water management are met to some extent.

The sixth sub-research question reads: **Is there an adequate policy concerning the issue of extreme rainfall events in Utrecht?** An adequate water policy concerning extreme rainfall events meets the following 4 criteria: 1) extensive problem structuring, 2) SMART formulated policy goals, 3) clear relations between policy instruments and policy goals and 4) efficient policy instruments.

The first requirement (i.e. extensive problem structuring) is partly fulfilled. An extensive problem structuring has been performed by all stakeholders. Studies of rainwater models, fictive rain showers and pilot projects give information about the problems caused by extreme rainfall events. However, at this moment it is not entirely clear at which level of intensity extreme rainfall events cause damage.

The second requirement (i.e. SMART formulated policy goals) is partly fulfilled. The SMART-criteria Relevance and Time Bound are covered in all the policy documents from the stakeholders. They all clearly link the problem to their policy goal and indicate a realisation date. Regarding the other SMART-

criteria (Specific and Measurable) the stakeholders show lower scores. Concerning the SMART-criterium Achievable no assessment was possible.

The third requirement (i.e. clear relations between policy instruments and policy goals) is completely fulfilled. All government bodies rather clearly indicate the relations between their policy instruments and policy goals.

The fourth requirement (i.e. efficient policy instruments) is partly fulfilled. Most policy instruments utilized in the Utrecht area are efficient. However, there is still some room for improvement. Not all the policy instruments which are positively evaluated by the consulted experts are used.

Overall, the requirements regarding adequate water policy are partly fulfilled.

The last sub-research question reads: **Which governance barriers and other types of barriers can be identified per blue-green adaptation measure and per stakeholder in the Utrecht area?** With regard to most blue-green adaptation measures and *most stakeholders* there is a lack of cooperative relationships with private parties and NGO's. The government often needs the cooperation of private individuals for the implementation of the blue-green adaptation measures. Furthermore, for two out of the most efficient blue-green adaptation measures, namely for the measures 'open gutters' and 'raising doorsteps', *none of the stakeholders* have formulated an ambition. Moreover, with respect to all blue-green adaptation measures, *none of the stakeholders* has formulated concrete targets.

In addition to these governance barriers, there are also a few other barriers. First, for the measures "Open Gutters" and "Raising Doorsteps and Thresholds" no 3D-flow model has been developed yet commissioned by the *municipality of Utrecht*. Secondly, measures in the field of water management in the public space must always be balanced against other interests that play a role in the public space. The application of water management measures is sometimes at the expense of other options for spatial development. Furthermore, the budgets from *the Province of Utrecht, Water Board HDSR and the municipality of Utrecht* allocated for water management instruments can not be utilized for other public services. Finally, some measures have to be implemented to a large extent on private territory, over which *government bodies* have no control. This means that the investment and maintenance costs must be paid by citizens and private organizations.

6.2 *Conclusion on central research question*

The central research question reads:

To which extent is there adequate water governance concerning the implementation of blue-green adaptation measures by stakeholders in order to cope with extreme rainfall events in the Utrecht area?

Adequateness of water governance in the Utrecht area

The research findings presented in Section 6.1, indicate that there is only partially adequate water governance present for implementing blue-green adaptation measures by the stakeholders in the Utrecht area. On all three governance elements (structure, management and policy) there are strong and weak points. To overcome the shortcomings in water governance as presented in Section 6.1, several recommendations can be made. These shortcomings in water governance imply that the various stakeholders are only able to a sub-optimal extent to implement these efficient blue-green adaptation measures successfully.

General recommendations for improvement of water governance in the Utrecht area

The research results make it possible to make a number of recommendations to improve water governance in the Utrecht area. These improvements will ensure that the various stakeholders can successfully implement the most efficient blue-green adaptation measures as well as possible.

It can be recommended that the legal responsibility and the decision-making competences need to be transferred to the regional level, preferably to the network CRA. A better collaboration between all relevant stakeholders is indispensable, which entails including the private parties. Winnet and CRA will have to make well-defined agreements on the tasks they are responsible for, as there now are conflicting load balances. The interaction rules of both Winnet and CRA should become clear for members of the networks and other interested stakeholders.

Concerning the management aspect, it can be recommended that the process managers within these networks should monitor the knowledge, competences and capacities within the network. Moreover, they should also monitor the processes and activities of the network itself.

With respect to the policy aspect, a recommendation concerning the formulated policy goals of all stakeholders, is to make them SMART and especially more measurable. The stakeholders within the Utrecht area should also carefully look at the efficiency of the policy instruments used and take lessons from it. On the one hand, sometimes it is better to invest in blue-green adaptation measures that are only effective in solving one issue instead of partly solving several issues. On the other hand, sometimes it is advisable to apply measures that not only prevent damage from extreme rainfall events but also contribute to different goals within climate adaptation in the Utrecht area. The presented scenarios can help to make a deliberate choice between the policy instruments presented in Table 8. The scenario's show which measures are cheap but less effective, or on the other hand are effective but rather expensive. I recommend investment in policy instruments that also take care of other effects (i.e. increasing biodiversity, cooling or air quality). These instruments score high in scenario 2 or 4.

Specific recommendations to overcome (governance) barriers by stakeholders

The current stakeholders should implement the most efficient policy instruments as well and as quickly as possible. The five (couples of) most efficient policy instruments are: 1) Creation or extension of water storage in green areas and water infiltration in green areas, 2) Wadi's, 3) Open gutters, 4) Green and Polder Roofs and 5) Raise doorsteps and thresholds in front of houses, garages and parking-lots.

Furthermore, relevant stakeholders should formulate specific ambitions for the policy instruments 'open gutters' and 'raising doorsteps'. The lack of specific ambitions of the stakeholders with respect to these two policy instruments explains why the beforementioned policy instruments are currently not applied. Moreover, specific targets should be formulated for all policy instruments. Formulating SMART objectives promotes efficient policy implementation. For instance, the desirable number of the amount of green roofs should be explicated.

Moreover, citizens and private organizations should be stimulated to execute the implementation of the measures 'green and polder roofs' and 'green gardens'. To create a financial incentive for citizens and private organizations, the municipal taxes on sewage system and Water Board taxes ('waterschapsbelasting') should be reduced by the relevant stakeholders.

A last recommendation pertains to the fact that measures in the field of water management in the public space must always be balanced against other interests that play a role in the public space. The application of water management measures is sometimes at the expense of other options for spatial development. Furthermore, the budgets from the Province of Utrecht, Water Board HDSR and the municipality of Utrecht allocated for water management instruments can not be utilized for other public services. This situation makes it necessary to present blue-green adaptation measures in such a

way that it becomes clear that these measures also contribute to other public interests, such as reducing heat stress and air pollution and improving biodiversity.

6.3 *Suggestions for further research*

The framework in Table 5 could be used in other regions within the Netherlands to give insight on the state of the water governance concerning extreme rainfall events. I suggest that policymakers within different regions apply the framework by themselves. If multiple regions use the framework, it will give a national insight on this issue.

The evaluation of the water governance in the Utrecht area is based on the evaluation criteria from Table 16. However, it is not certain whether all relevant aspects are mentioned in the framework in Table 5 (and 16). A thorough literature analysis would contribute to a more elaborate framework including a larger number of relevant aspects of water governance.

As described in the recommendations (section 6.1), shifting decision-making powers to a regional level regarding extreme rainfall events is a way to improve the governance structure. Amsterdam Rainproof is an example of such a regional body with formal decision-making powers. It is interesting to investigate how this regional body originated and what the biggest failure and success indicators were.

Recommendations have been made to successfully implement the 5 most successful blue-green measures in the Utrecht region (section 6.1). Some of these blue-green adaptation measures are already implemented in other regions. It is advisable to investigate how stakeholders in these regions implement these blue-green adaptation measures. Lessons can perhaps be learned from this for the Utrecht region.

The recommendations made to successfully implement the blue-green adaptation measures (section 6.1) can first be tested in a pilot study. The pilot study could be executed in a neighbourhood in the Utrecht area in which rainwater problems are most severe. In this neighbourhood, for example, the sewage tax could be reduced as an experiment. Citizens then pay less sewage taxes if they retain a certain percentage of rainwater by creating green roofs or green gardens. If this recommendation proves to be successful in this neighbourhood, the recommendation can be performed throughout the whole Utrecht area in order to reduce possible problems caused by extreme rainfall events.

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8 Appendix

A

List with interviewed persons:

André van Montfort, associate professor of public administration VU, Amsterdam, interviewed on 15-05-2018.
Dries Hegger, Assistant professor Copernicus Institute of Sustainable Development Utrecht, interviewed on 10-01-2017
Erik Groenland, policy officer municipality of Houten, interviewed on 28-2-2017
Goos Boelhouwer, policy advisor HDSR and representative in CRA, interviewed on 7-3-2017, 12-10-2017, 14-03-2018
Irene Poortinga, community manager Amsterdam Rainproof, interviewed on 23-2-2017
Janette Bessembinder, advisor/project leader at KNMI, interviewed on 8-3-2017
Marian Booltink, Calamity Coordinator HDSR, interviewed on 1-6-2017
Michiel van Rijsdijk, policy officer municipality of Utrecht, interviewed on 10-3-2017
Tjerron Boxem, community manager Water board Delfland, interviewd on 09-11-2017
Wouter Egas, policy officer Province of Utrecht, interviewed on 22-2-2017

B

List with consulted experts:

Astrid van Veldhoven, program manager 'omgaan met wateroverlast' HDSR
Erik Groenland, policy officer municipality of Houten
Goos Boelhouwer, policy advisor HDSR and representative in CRA
Michiel van Rijsdijk, policy officer municipality of Utrecht
Nico Admiraal, policy advisor HDSR
Wouter Egas, policy officer Province of Utrecht

C

List with attended meetings:

Werkconferentie Coalitie Ruimtelijke Adaptatie on 8-6-2017
Vakbeurs Klimaat EXPO Houten on 9-11-2017
Numerous weekly meetings with policy advisors from HDSR.

D

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