Master Thesis

TITLE: **Fostering Climate Resilience in Cities: An analysis of adaptive policy strategies to mitigate urban flooding by utilizing multifunctional systems.**

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ABSTRACT

The climatic changes due to global warming include unpredictable and torrential precipitation. This has made cities built in delta and coastal areas more vulnerable to floods. There are various technological solutions to mitigate against urban flooding. These solutions are broadly categorized as retention or pumping options. The decision on which technology to employ and to what extent, requires cooperation between stakeholders with varied motivations, cognitions, resources and power. In instances where actors, resources and strategies are able to merge and result in sustainable policy, boundary spanning through linkages has taken place.

This research investigated how adaptive policy strategies can enhance flood mitigation activities that employ multifunctional methods such as ecosystem services. The study gives an analysis of the influence of policy on effective use of multifunctional opportunities availed by flood waters in urban areas. The research used comparative case study method to elucidate boundary spanning activities in five cities: Dordrecht and Rotterdam from The Netherlands, Nairobi and Kisumu from Kenya and Hoboken from New Jersey, USA.

The results showed that multifunctional mitigation strategies were applied in cities although not focused on the use of ecosystem services from flood water. In addition, the study found that cities that were able to span policy, actor and temporal boundaries were more likely to implement multifunctional strategies. Further, these cities were able to broaden their problem definition to include safety consideration in the event of a flood. The research recommends that cities re-evaluate their boundary judgments so as to identify opportunities and foster resilience. Learnings from the study can be applied to cities wit h similar characteristics to those in the case-studies.

Keywords: urban flood mitigation, adaptive policy making, Contextual Interaction Theory,

Boundary spanning, boundary judgments and multifunctionality.

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ACRONYMS LIST

CIT: Contextual Interaction Theory

OECD: The Organization for Economic Co-operation and Development

IPCC: Intergovernmental Panel on Climate Change

GHO: Global Health Organization

UN: United Nations

USA: United States of America

NGOs: Non-Governmental Organization

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CHAPTER 1. INTRODUCTION

1.1 Background and description of the problem

1.1.1 Soft versus Hard urban flood governance strategies

The global environmental and social changes experienced in cities have made it necessary for policy-makers to reconsider and perhaps re-conceptualize the policy making process. Specific to this research, climate change has made it difficult to predict the extent of extreme future weather conditions. The gravity of the situation increases in delta and coastal cities that are vulnerable to floods. For a long time strategies used to mitigate against floods exclusively involved hard-engineering approaches such as building and fortification of dykes due to the stability of weather conditions, essentially precipitation and global temperatures. The times have now changed and interventions to mitigate floods increasingly have to be flexible to adapt to weather uncertainties. In addition policies need to incorporate varied socio-economic aspects, so as to be sustainable and resilient. (The history of this change in water governance from hard to soft is described in Chapter 3 of this thesis). Thus flood mitigation policy now has to incorporate varied sectors, levels of administration and temporal scale. Invariably, new policy is to be soft and flexible, hence adaptive (Walker, 2001).The vital role of adaptive policy development and implementation is introduced in the succeeding sections of this introductory chapter, and thereby establishing the rationale leading up to this research.

1.1.2 Relevance of Climate Resilience in Cities

Climate change is happening now. The melting of the ice caps due to global warming has resulted in far reaching effects on both biodiversity and human settlement (IPCC, 2014). The World Health Organization estimated that in 2014, 54% of the world's population resided in cities (GHO, 2014). This number is expected to grow and cities are anticipated to be the centre of culture, economy and administration. The unpredictability of the weather changes necessitate holistic thinking in terms of planning of urban settlements. It is expected that 60% of the world population will reside in cities by 2030 (UN 2016). This underlines the importance of cities as a unit that can drive global reform. Further, the damage that is caused to property and lives due to periodic flooding of cities has local, regional as well as global socio-economic impact.

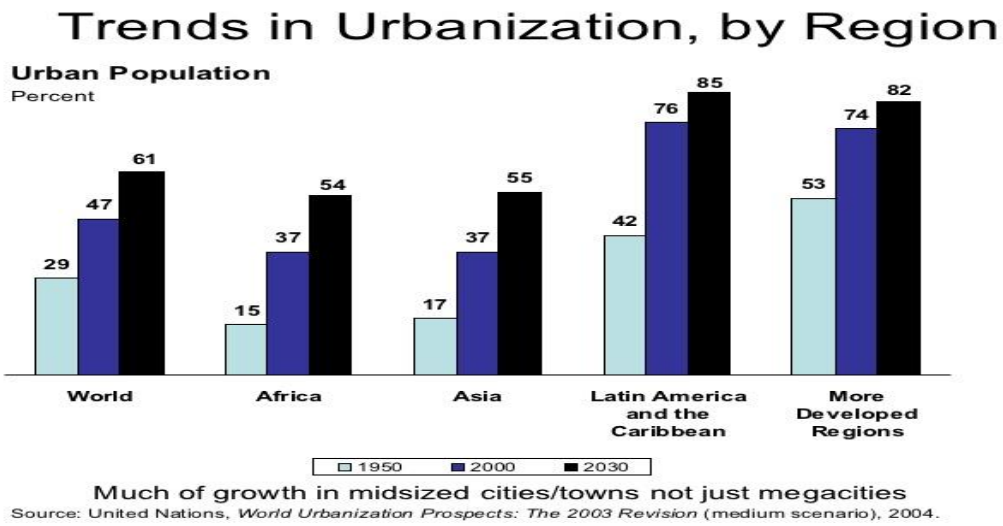

Figure 1: Showing that by 2030, over 60% of the world's population will be in cities. (UN 2004)

Therefore, the ability of cities to withstand climate anomalies such as, sea level rise, hurricane, storm and torrential rain, is an important component of climate resilience planning. It is also important for the cities to safe-guard fresh-water supplies further enhancing climate resilience. Cities have employed disaster management strategies such as early warning systems, fortification of dykes and increasing drainage infrastructure capacity to mitigate against floods in varied extents (Brikmann et al. 2010). It is therefore worthwhile to investigate how adaptive policy influences the strategies implemented to achieve resilience in different socio-economic contexts. This is because the varying magnitude of precipitation or flood waters (due to climate change) have meant hard engineering solutions are sometimes inadequate or quickly become obsolete when weather patterns change.

1.1.3 Influence of urbanization on flood occurrences

A key factor influencing flood resilience is the land use change driven by emergence of cities. Cities grow in areas that are rich in resources that play an important social, economic and transport role (Batty, 2008). In many instances, this resource is water. Water serves not only to sustain human life, but it is also used in agriculture, product manufacturing and also provides transportation of goods and people.

The OECD (2013) estimates that climate change combined with rapid population increase, economic growth and land subsidence could result in a nine-fold increase in flood risk in coastal cities by 2050. In addition, rapid growth of human settlement in delta regions (along waterways)

leads to overuse of water resource. An illustration is when waterways dry up, the settlement may shift to other economic activities and continue to grow (Jha et al. 2011). Notwithstanding, the now dried up historic water channels are built-over and the area of the river reduced. The system seems to adapt until it faces an unprecedented change such as increased precipitation. The water attempts to follow its natural gradient but instead of channels, it finds paved streets and buildings that are impermeable. The result is the water pools, its level rises and it builds up force and tries to make its own way through the city. The water becomes a destructive force that attempts to move any obstacle on its way to flatter ground. Thus the flood phenomena is experienced and water is viewed as the aggressor (Plate, 2002; Abhas et al. 2011). For a delta city vulnerable in this way (but not exclusively), it is necessary to develop a policy that is flexible to the flood risks it experiences now and in the future. As a result, urban water governance has evolved.

1.1.4 Evolution of urban water governance

The search for sustainable urban water management as brought to light various approaches towards achieving this. These approaches are described as integrated urban water management (Bahri, 2012) and sustainable urban water management (Van de Meene et al. 2011). Unpredictable climate change effects and thus future weather conditions make it unsustainable to continually raise dykes higher or simply divert water courses. These engineering accomplishments are being overtaken by climatic changes and are no longer as efficient both economically and functionally. A paradigm change to working with nature, rather than against it could provide a win-win solution to the seemingly inevitable changes in water level, brought about by global warming (Bressers, 2009). In this new era, nature, engineering and society need to work together interactively to provide solutions for threats to vulnerable urban areas, specifically by water. This has brought in the concept of building with nature (Van Slobbe et al. 2013) which involves multifunctional development design, using the forces of nature to optimize ecological systems for the benefit of urban areas. It presents a unique opportunity to investigate concepts related to implementation of working solutions. These concepts include boundary spanning, legal frameworks, uncertainty management, experimentation and public-private partnerships (Bressers and Lulofs, 2010).

The resilience of cities is measured by parameters outlined by economic, governance, society and environment topics. An adaptive policy making approach means that these four topics are effectively managed. It then follows that implementation of solutions would require relevant

policies, resources and actors to converge under a single strategy (Pahl-Wostl, 2015). The diversity in cities' geographical location, available resources and governance strategies give rise to different levels of success. Therefore in view of globalization and the far reaching effects of local disasters, it is relevant to formulate appropriate criteria for the development of sustainable policy. Such policy has been implemented in some vulnerable delta and coastal cities effectively, while not in others. Weather patterns have become more dynamic and so progressive and flexible solutions are on demand (Emori and Brown, 2005).

1.1.5 Purpose of the research

A commonly used phrase is 'water is life'. Taking this literally, water in all its forms is a resource. However, when flooding occurs, damage to property and loss of life contradict this notion. This is aggravated by the effects of climate change. Some of the effects presented by unpredictable weather patterns are torrential rain, storms, heat-waves and drought. Francesch-Huidobro et al. (2017) and Hallegate et al. (2013) predicate that cities in delta and coastal regions are most vulnerable. The rapid blockage of drains by fluvial deposits, increased amount of precipitation or overrunning of dykes results in flooding in urban areas. Further, increase in ambient temperature due to climate change and modern infrastructure in cities result in heat-waves, increased use of water and in some cases drought.

However, floods mean the availability of more water than a system can utilize at that instance. It is therefore logical that a solution to this would be to innovatively put the excess flood water to use. This would mean the development of soft and hard infrastructure to use as a means to utilize ecosystem services. The soft infrastructure is adaptive policies that are implemented through multifunctional strategies for mitigation of flood waters and multi-layer safety approaches to enhance safety in case of flooding.

A policy framework that considers varied social and economic contexts in delta and coastal cities is imperative. More so given the rapid and unpredictable weather changes. In order to develop such a framework, the influence of developing adaptive policy on the strategy that is eventually implemented requires investigation. The application of this framework can inform implementation of versatile flood resilience policy in delta and coastal cities globally. This research is a comparative study on how adaptive policy making is working in Dordrecht and Rotterdam in The Netherlands, Kisumu and Nairobi in Kenya and Hoboken in New Jersey, USA. Eventually, it may

provide a set of criteria for assessing the implementation of adaptive flood management strategies in cities.

1.2 Literature review: Flood Management in Cities

In this literature, links between the occurrence of climate change and rapid urbanization, to increase in urban floods are elucidated. It deduces the different approaches that lead up to adaptive flood governance policy strategies in urban areas. It also explores the use of flood water to gain social and economic benefits. The flexible governance of flood water is explored as an opportunity to improve the climate resilience of cities.

1.2.1 Vulnerability of coastal and delta areas to floods

As postulated by Maria et al. (2016), cities in delta and coastal areas are most susceptible to flooding due to dynamic climatic conditions such as higher temperatures and rising sea level. Balica et al. (2012) and Snoussi et al. (2008) further emphasize the vulnerability of coastal areas due to rise in sea levels, although Nicholls et al. (2010) attribute part of the vulnerability of coastal and delta areas to subsidence. De Bruijn et al. (2015) illustrate that these may occur suddenly in the form of hurricane storms, high tides and flash floods. Further, the threat to low-lying coastal areas was exemplified by Hurricane Sandy (2012) which made landfall off the coast on the coast of New Jersey (Elsey –Quirk, 2012). According to De Bruijn et al. (2015), delta areas are also threatened by rivers which drain vast hinterlands upstream, and intense rainfall. This risk is equally apportioned to cities built in these coastal and delta areas. The uncertainty of the effects of climate change also necessitate that a reverse scenario be considered whereby precipitation is reduced and drought occurs. Downstream areas may experience acute water shortages making low-lying delta areas again vulnerable. In consonance with Bressers et al. (2009) the above threats underline the need for a holistic approach to flood mitigation, which is the foci of this study, and urban water management in a broader sense.

1.2.2 Effect of urbanization on prevalence of floods

In urban areas, it is documented that flash floods have significant destructive/erosive force due to high velocity and depth. Huong et al. (2013), Suriya et al. (2012) and Wiles et al. (2002) elucidate the impact of urbanization on the severity of floods. In addition, Tingsanchali, (2012) advances that the consequences of urbanization include reduced infiltration into the ground due to concrete which means large volumes of water remain on the surface. Since storm drains are built for surface

runoff, the velocity of water is accelerated and transmitted faster. The drains are however designed to accommodate a specific flow-rate. Unanticipated precipitation may result in increase of the flow. This is known as increase in peak flow, it may reach up to six or seven times the normal flow-rate. Tucci, (2006) illustrates an example of change in peak flow-rate is the river Belem basin in Curitiba, Brazil. It had an impervious area of 42km^2, before urbanization, and impervious areas of about 60%, after urbanization, resulting in more frequent and violent floods in the settlements in the region.

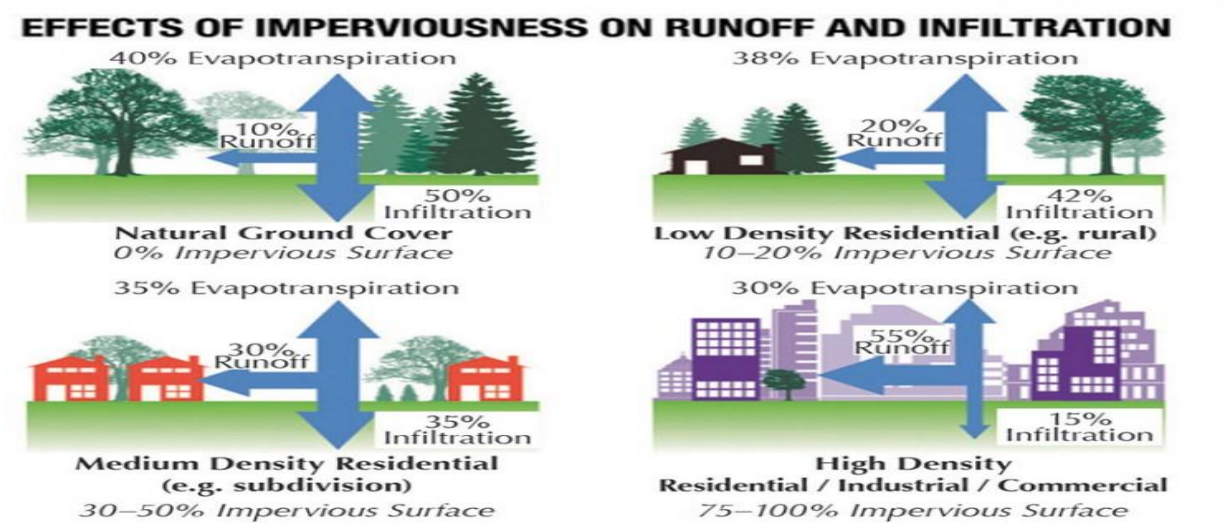

Figure 2: Showing the increase in run-off volume with increase in urban infrastructure. (Bay Journal 2015)

Urbanization also results in changes in the urban water cycle. As stated by Lamera et al. (2014) the urban water cycle refers to the journey of water from catchment areas into urban settlements, to be used for drinking, cooking and recreational uses, before returning to the natural water cycle as treated wastewater or run-off. An attempt to manage this change is through conventional means such as storm drains and sewer lines. The outcome of this strategy is presence of large volumes of poor quality runoff and reduced infiltration and wastewater discharge. According to Amores et al. (2013) there is more water going out of the cycle and compelling the system to take in more water through portable water and virtual water. It follows that in order for the water cycle to be sustainable in urban areas, the water managers have to ensure that the out flux balances out the influx. A representation of the changes in urban water cycle from natural water cycle is illustrated in figure 4 to underpin the influence of urban infrastructure on flood prevalence.

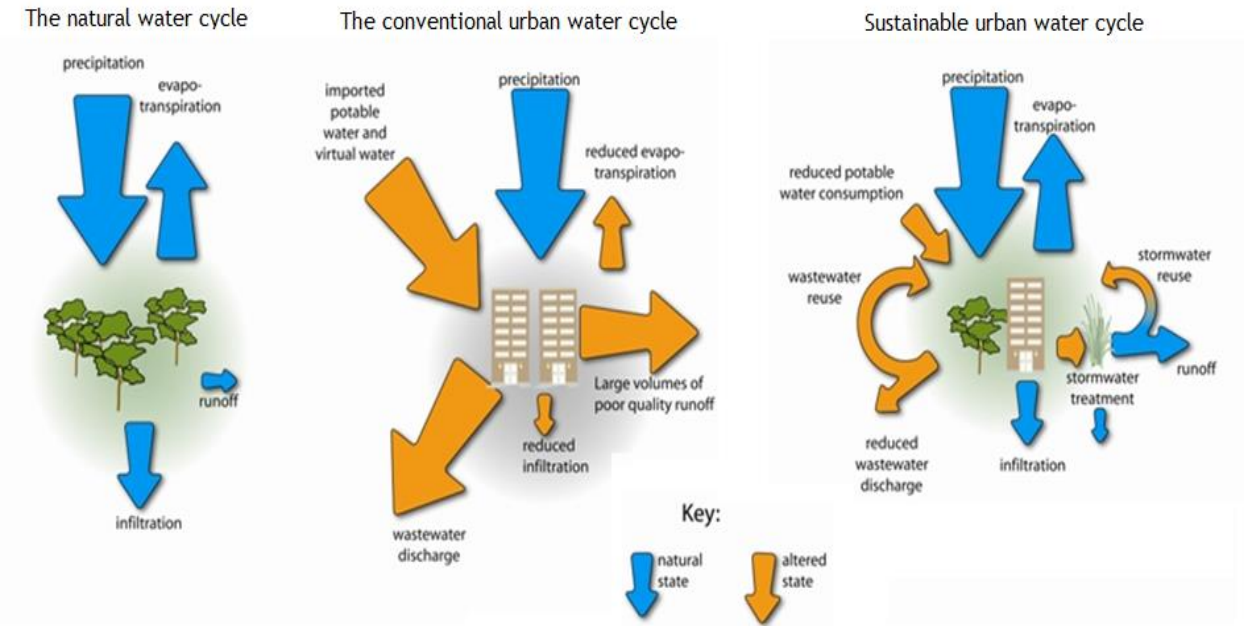

Figure 3: Major differences between the natural water cycle, the conventional urban water cycle and sustainable urban cycle. (Healthy Waterways, 2011)

Zevenbergen et al. (2008) found that urbanization, if not planned, will aggravate flooding disasters. This may be caused by one or a combination of the following factors: encroachment of floodplains and lowlands by 'greenfield' development, the inflexibility of urban infrastructure development even after flood disaster – striving to maintain *status quo* at the expense of innovation, the redevelopment of built-up areas 'brownfields' further disrupting natural drainage channels, and increased dependence on centralized infrastructure and utility services that enhances inflexibility. An example of the disadvantage of centralized utilities is illustrated by Pitt, (2008) who reports on the 2007 flooding in the United Kingdom. It led to loss of piped water for 350,000 inhabitants for 17 days.

1.2.3 Concept of Climate Resilient Cities

As per IPCC (2007), Climate Resilience is defined as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change." Zevenbergen et al. (2008) stated that enhancing resilience is a rational strategy to cope with uncertainty, therefore resilient systems have the ability to cope and recover from disturbances. This makes resilience an internal property of complex systems. The mechanisms that broadly outline resilience can be given as robustness and flexibility. As indicated by De Bruijn, (2005), there are three indicators to define

resilience: the amplitude of reaction to a disturbance, the graduality of increase of reaction with increasing disturbances and the recovery rate of a system. Mens et al. (2011) posit that a system is resilient when amplitude (apparent damage) is minimal, graduality is greater or recovery rate is high. The advent effect of climate change is increased frequency and severity of floods. Zevenbergen et al. (2008) suggest that due to rapid population growth, especially in the global south, urbanization is an uncontrolled process. Therefore vulnerability to flooding increases with the increase of population density. This points to an altering process. According to Godschalk, (2003), flexible management structure, inclusivity through stakeholder engagement and decentralization of systems are required for flood resilience in cities.

1.2.4 Genesis of Adaptive policy making

Due to the uniqueness of topography and hydrology for different cities, it follows that different policies should be designed and implemented to mitigate against floods. However, Pahl-Wostl et al. (2008) postulate that the rise in sea level and unpredictable and/or heavy precipitation dictate that these strategies be flexible. Other factors such as financial resources, technology and perception of the urgency of the need for protection introduce the elements of inclusivity and societal value system. Policy development in flood mitigation can therefore be viewed as a circular process. Current flood protection may be considered enough for a certain time, meeting the ecological demands of the river system and human society demands of flood protection. The increase in population of cities necessitates development of more structures, which, with the onset of climate change phenomena, results in unanticipated pressure on the ecological self-regulating system. The prevailing mitigation strategy becomes impaired and according to Plate (2002) society demands action to improve and/or change existing conditions. This process is illustrated in figure 5.

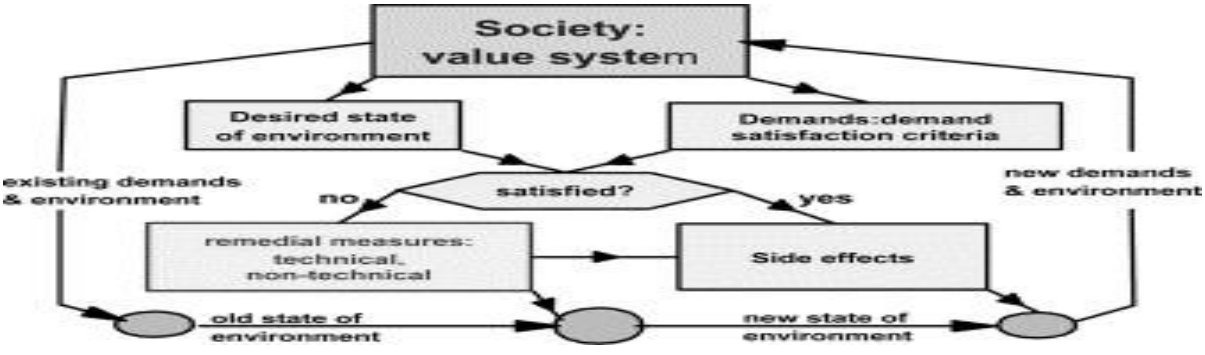

Figure 4: The cycle of responses to changing value systems and changing environmental conditions for water management. (Plate, 2002)

This brings into question the established practice of structural defences and a move to cheaper and sustainable alternatives becomes eminent. Werrity, (2006) stated that the trend is aided by regional legislation such as the EC Water Framework Directive (WFD, 2000) that has set high environmental standards for flood mitigation strategies. It (the WFD, 2000) underlines the importance of inclusivity in the policy formulation process. Alternatives to hard engineering strategies may be soft and hybrid engineering strategies, rain water capture and multiple use, as well as upstream measures. These are in essence multifunctional strategies.

1.2.5 Management of Flooding in Delta and Coastal Urban Areas: the Inception of Multifunctional strategy and Multi-layer approaches

As advanced by Brody et al. (2007) due to the suddenness of the occurrence of floods, preparation is key to limiting damage to property and preventing loss of lives. This unpredictability is demonstrated by experiences in the New Jersey coastline. Blake et al. (2013) illustrated that in this case (New Jersey coastline) the storm surge peak coincided with an uncharacteristically high tide (15cm above normal high tide) resulting in record storm tides and flooding. Just as De Angelis et al. (2016) and Sunday Nation (2016) showed in the instance of Nairobi, Kenya, the city lies downstream and bore the brunt of distributaries breaking their banks and flooding of roads in the incidence of excess rainfall.

The excess water, however, also presents an opportunity to harness eco-system services. De Groot (2006) put forward that in order to utilize these services, the governance regime needs to incorporate varied stakeholders, consider feasible eco-system services and manage resources and expectations so as to avert risks and foster urban resilience through multifunctional strategies. Multifunctional strategies were advanced by Vis et al. (2003 p.33) as a shift from traditional mitigation using dykes, etcetera (hard-engineering), to “resilience strategies”, De Bruijn et al. (2001) in Vis et al. (2003). These resilience strategies were given by Vis et al. (2003) as detention compartments and adapting land use to create green rivers during flooding. Since then, technology advancements have made multifunctional strategies socially and economically viable. This includes green infrastructure such as roof top gardens and blue infrastructure such as blue roofs for storage of rain water. A report by Kazmierczak and Carter (2010) evaluated case-studies of green and blue infrastructure implementation and their economic impact. It found that these multifunctional strategies made financial sense.

Another component of urban flood management is risk management. According to Terpstra and Gutteling (2008) this includes disaster preparedness and citizen participation. So as to foster resilience, more cities are looking into social involvement in preparation for and coping with floods. Studies by Baan and Klijn (2004) and Terpstra and Gutteling (2008) indicated that social responsibility of communities at risk of flooding is not clearly defined in the Netherlands. This situation is mirrored globally. Economic benefits of multi-layer safety systems are still not well understood. Tsimopoulou et al. (2013) depicted the economic value of implementing multi-layer safety through predictive cost-benefit analysis in a fictional coastal area.

The extent to which adaptive policy development contributes to multifunctional flood management strategies and the multi-layer safety systems varies in different contexts. The involvement of varied layers of government, varied stakeholders and extent of cooperation to implement said policy presents an area in which more investigation and learning is useful.

1.2.6 A multifunctional option: Upstream options for Ecosystem services for flood mitigation

Cities offer a variety of ecosystem services. By definition ecosystem services are; 'Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions' (Costanza et al. 1997 p.253). The technological advancements coupled with innovative design and implementation of flood water management strategies provide an avenue for use of these services in a city. These services are described by Barthel et al. (2010) and Dearborn and Kark, (2009) as parks and gardens. These are locations for recreation, food production and microclimate regulation, and education. In addition, Pankratz et al. (2007), DeNardo et al. (2005), and Sassen and Dotan, (2011) illustrate that from flood water there are options such as aquaculture, production of algal biofuels and small wetlands which improve hydrological quality by absorbing contaminants and buffering against flooding. Green rooftops reduce heating and cooling costs and reduce runoff from rainstorms. These emphasize the definition of ecosystem services as the benefits human beings get from ecosystems as stated by Costanza et al. (1997). The excess water from floods can be used to deliver a varied number of services depending on technology and resources to be employed. The ability of ecosystems to deliver services can be measured using both qualitative and quantitative methods; although this is not investigated in this study. Nevertheless, in order to do this, water managers

need to identify and evaluate ecosystem services available to them. According to Kohsaka et al. (2013), using this information, policy can then be formulated that encompass ecological, social, and economical concerns of a city.

1.3 Problem definition

Pursuant to the preceding literature, it is apparent that there is a wide range of strategies available that adaptive policies can utilize. Among these are multifunctional flood mitigation options and multi-layer safety approaches. However, there is no knowledge on how and to what extent adaptive policies influence the use of these strategies. So as to fill this research gap, in the context of urban areas, further research is necessary.

1.4 Contribution of this research

This research examines the development and implementation of flood mitigation policies in delta and coastal cities, in the advent of climate change and population growth. Specifically, it delves into the influence of adaptive policy in the application of multifunctional designs such as blue roofs. The study identifies the factors used to determine flood risk and damage in case-study cities although it does not quantify these indicators. The work evaluates the flood policies in place in Dordrecht and Rotterdam in The Netherlands, Kisumu and Nairobi in Kenya and Hoboken in New Jersey, USA, using the theoretical framework, which is elucidated in chapter 3, and assesses to which extent the policies are adaptive and influence use of multifunctional flood water management.

1.5 Problem Statement

The study will focus on the governance of flood risks in the five case-study cities, in the application of multifunctional strategies, multilayer safety approaches and resilience to flooding associated with climate change.

1.6 Research Objective

The research aims to assess the influence of flood governance strategies on utilization of diverse multifunctional strategies and multi-layer safety options; so as to distil lessons that will enhance climate resilience in cities.

1.7 Research Questions

1. What factors determine the flood risks and potential for flood damage in the selected five cities?

2. What are the flood policies developed in the selected five cities?
3. To what extent do the adaptive flood policies in the selected five cities adopt multifunctional goals, particularly addressing ecosystem services?
4. Based on the comparison of the assessments in five cities, what are lessons learned for the cities to improve their climate resilience?

1.8 Research Outline

In Chapter 2 the research framework used to assess the case studies is explained in detail. Chapter 3 describes the Contextual Interaction Theory applied in the assessment of the policies. The results of the research are derived presented in Chapter 4. In Chapter 5, the findings from Chapter 4 are elucidated through discussion and conclusion based on the theoretical framework. Chapter 6 gives the recommendations for improvements given results from the study.

CHAPTER 2. METHODOLOGY

This research evaluated boundary spanning activities in urban flood management of five cities in three parts of the world; East Africa, North America and Western Europe. The study analysed governance strategies used to manage these services. The Contextual Interaction Theory (CIT) was used as a basis to identify enablers and hindrances to effective and inclusive policy making in the five scenarios. The theory allows for the investigation of how interactions between actors of varying cognitions, motives and resources, within the structural context of governance, produce policy. The research provided recommendations on boundary spanning activities to consider while developing a governance strategy for a water vulnerable city, with the aim to utilize varied multifunctional strategies.

2.1 Research Framework

According to Verschuren et al. (2010), a research framework is a schematic presentation of the research objective that depicts activities that need to be done in order to achieve the objective. By applying step wise approach, the summary of activities was as follows:

Step 1: Characterizing the objective of the research project

The aim of this research was to identify and assess flood risks and the governance of flood risks, the strategies and policies and their implementation and effects in a comparative case study including five delta cities at five locations in Western Europe, USA and Africa.

Step 2: Determining the research object

The research object in this research was the five cities of Kisumu, Nairobi, Dordrecht, Rotterdam and Hoboken. The research aimed to assess the influence of flood governance strategies on utilization of diverse and multifunctional options; so as to enhance climate resilience.

Step 3: Establishing the nature of research perspective

The study identified and assessed flood risk policies in the five cities using secondary hydrological data and policy analysis models. It observed how the actors' characteristic of cognitions (boundary judgments) influence each other. The analysis was structured by CIT and elements of boundary spanning models.

The research used scientific literatures to develop a conceptual model. Theories and concepts used in this research were:

Table 1: Sources of the Research Perspective

Key concepts	Theories and documentation
• Climate resilience • Urban water governance • Adaptive policy making • Multifunctionality/Multi-layer safety • Strategies to mitigate floods in cities	Contextual Interaction Theory Adaptive policy making Boundary Spanning models Preliminary Research

Step 5: Making a schematic presentation of the research framework

The research framework was described using the flow chart below:

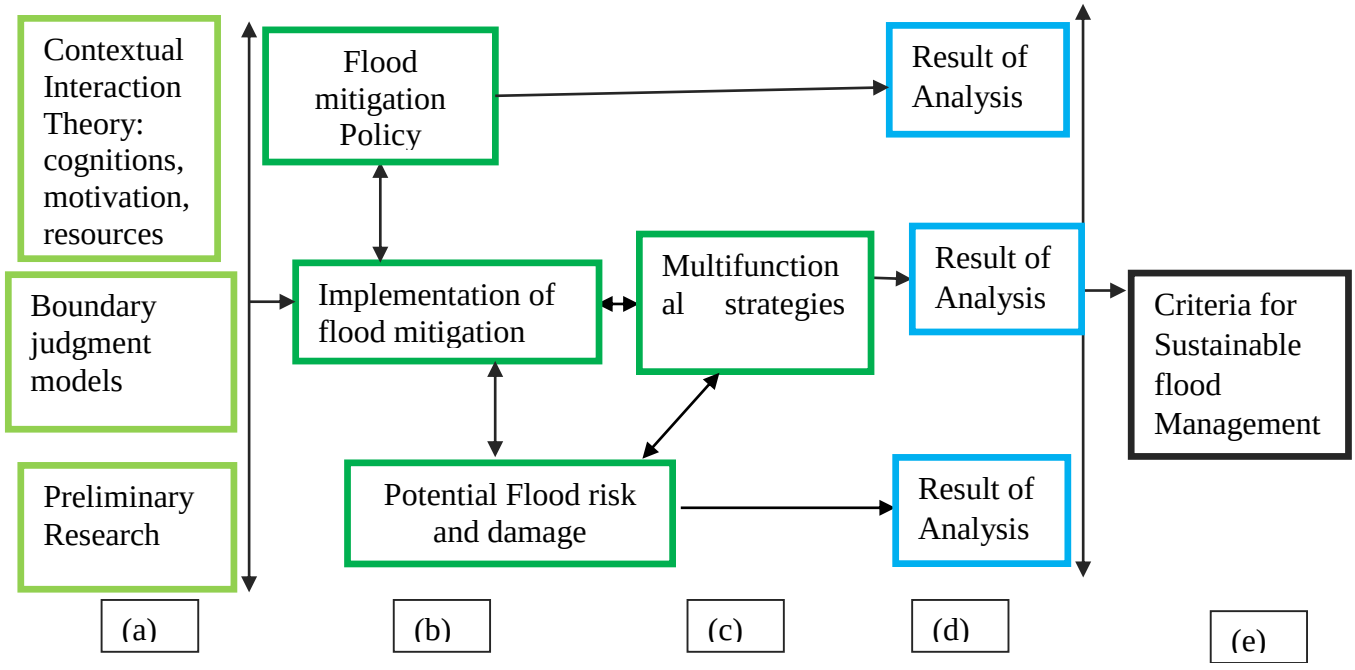

Figure 5: A Schematic Presentation of Research Framework

Step 6: Formulation of the research framework in the form of arguments is elaborated as follows:

(a) An assessment of flood management strategies based on CIT and preliminary data.

(b) Assessment of flood risk using hydrological data and literature.
(c) Assessment of effect of policy on utilization of multifunctional flood mitigation strategies.
(d) Analysis of boundary spanning activities using boundary judgment models.
(e) Formulation of criteria for sustainable management of flood water.

Step 7: Checking whether the framework requires any change

As research is an iterative process, minimal adjustments were made as data was gathered and analysed.

2.2 Defining Concept

For the purpose of this research, the following key concepts were defined as follows:

Climate resilience: ability of cities to withstand sudden change in rainfall/tide occurrence and intensity that lead to flooding (Park and Brooks, 2015).

Flood mitigation: this referred to both the structural and non-structural measures taken to minimize the adverse effects of floods (Andjelkovic, 2001).

Adaptive policy: the formulation of progressive strategies for governance of flood water in cities (Ward et al. 2013).

Boundaries: 'intersubjective constructed demarcations between different social worlds' (Bressers and Lulofs, 2010).

Boundary judgments: normative or cognitive perceptions of actors on the relevancy of specific actors, factors, issues for a domain (Bressers and Lulofs, 2010).

Boundary spanning: adaptive governance of activities by linking their sector, scale and timeframes to other previously independent sectors, scales and timeframes (Bressers and Lulofs 2010).

2.3 Research Strategy

The research investigated multiple cases in context. It used both qualitative data. The research focused on the area of flood mitigation strategy in the five cities. The study analysed the data in order to describe flood risk and governance in the cities, utilization of multifunctional strategies and the extent to which governance strategies influenced this activity.

2.3.1 Research Unit

The research unit of this research was the water managers in each city. The different actors of flood water management and individual city-level flood policy were used as observation units. Therefore each city functioned as independent loci of the research.

2.3.2 Selection of respondents

In this study, a combination of purposive and snowballing techniques was used in identifying participants. According to Cooper et al. (2006), these are both non-probability sampling methods. Therefore the researcher identified initial persons of interest in the specific area of study (city flood management). This was fulfilled by the purposive technique and a minimum of one respondent from each city water authority was interviewed. Initial selection of respondents depended on the organizational structure of the city water authority and the respondent availability. The initial participant then referred the researcher to new participants. The interviews were done in one siting except for Kisumu where three phone calls were made. The average duration of the interviews was forty-five minutes except for Hoboken where the interview took twenty-five minutes. The questions used are included in the appendices of the thesis. The study targeted:

- Personnel involved in city planning and infrastructure in relation to flood and water governance.

The interviewees in the different cities had varied expertise which are highlighted in the table below:

Table 2: Profile of interviewees who contributed to the research data

INTERVIEWEE	COUNTRY	PROFFESSIONAL PROFILE
Rik Hienen (MSc.)	The Netherlands	Policy adviser (water attention area) for the municipality of Dordrecht and the Drechtsteden Area (The Netherlands). He works on water safety, spatial planning and multi-layer safety. He also has experience in delta management, water policy and disaster risk reduction in Southeast Asia (Bangladesh, Vietnam, Australia).
drs. Nick van Barneveld	The Netherlands	Senior Policy Advisor, City of Rotterdam. He is involved in the national Deltaprogram as well as collaboration on (non) governmental level, design and consulting agencies and knowledge institutes. This is for management of current and uncertain future flood risk.
drs. Steven Krol	The Netherlands	Senior Policy Advisor Flood Risk Management in the Province of South Holland. He is currently the program manager EU Interreg project FRAMES. His specific interests are climate change, floods and crisis management. His project areas are crisis management, administrative decision making disaster management, multilayer security and spatial development.
Dr. Victor Ongoma	Kenya	Lecturer and Climate change expert. Worked at the Kenya Meteorological Department, HQ Nairobi. He is involved in weather forecasting, remote sensing and climate change.
Harun Guttah	Kenya	Environmental Officer at the county government of Kisumu. He is involved in development and implementation of policy concerning environment, disaster management, rural and urban flooding in the county of Kisumu.
Caleb Stratton, AICP, CFM	United States of America	Chief Resilience Officer at City of Hoboken. He is one of the Principal Planners of projects focussing on energy, security, climate change adaptation, community preparedness, sustainability, strengthening urban ecology, flood resistant urban design and transit security.
Nanco Dolman (MSc. BLArch)	The Netherlands	He is a leading professional in Urban Flood Resilience at Royal HaskoningDHV. His specialities include water management, spatial and urban planning, water assessment, effects of urbanization on water quality, water sensitive cities, sustainable water solutions and innovation and water sensitive urban design (WSUD)

2.3.3 Research Boundary

This was used to determine the limitation of study and its consistency. Hence, the goal of study was achieved within the specific time.

The following boundaries were used in this research:

- The study assessed in depth actor interaction with a bias on cognition in order to apply boundary judgment models.
- The study distinguished between city flood management policy and city water management policy and concerned itself with only the former.
- The number of informants and respondents vary in line with individual city flood management organogram

2.4 Research Material and Accessing Method

The following table gives a summary of research material required and the method used for collection of data.

Problem Statement: How does the governance of flood risks in the three case-study cities influence their resilience to flooding that is associated with climate change?

Table 3: Showing the data required for each of the research questions.

Research questions	Data/Information Required to Answer the question	Sources of Data	Accessing Data
RQ 1. What factors determine the flood risks and potential for flood damage in the five selected cities?	Structure of water management in the three cities Data on Hydrology of the cities, amount of rainfall, Infrastructure of the cities and capacity to retain water.	PD, SD, I, D, L PD, SD, I, D, L	Questioning using. Semi- structured individual interview. Content Analysis of interviews and literature
RQ 2. What are the flood policies developed in the five selected cities?	Flood mitigation policy in the three cities Implementation of flood mitigation strategy The actors and stakeholders in flood management	PD, SD, I, D, L , Strategy Reports	Questioning using. Semi- structured individual interview. Content Analysis of interviews and literature
RQ 3. To what extent do the adaptive flood policies in the five selected cities adopt multifunctional goals, particularly addressing ecosystem services?	Revenues allocation to environmental maintenance and sustainable management of water; Available infrastructure for utilization of multifunctional strategies (ecosystem services); Information flow between actors; City Population acceptance of multifunctional strategies (ecosystem services).	PD, SD, I, D, L	Questioning using. Semi- structured individual interview. Content Analysis of interviews and literature
RQ 4. Based on the comparison of the assessments in five cities, what are lessons learned for the cities to improve their climate resilience?	Flood mitigation policy documents from each city Written and verbal consultation on Actors' support to the management and adherence to policy.	PD, SD, I, D, L	Questioning using. Semi- structured individual interview. Content Analysis of interviews and literature
	Actors' understanding of flood mitigation policy (in content), the implementation of policy (process) awareness of ecosystem. Actors' responsiveness to concept of adaptive policy, opportunities and boundary spanning on flood mitigation strategy	PD, SD, I, D, L Interview, Feedback, Policy implementation Reports	Questioning using. Semi- structured individual interview. Content Analysis of interviews and literature
	Results of application of Contextual Interaction Theory and boundary judgment model on the policy/strategy in place in the three cities.	PD, SD, I, D, L	Content Analysis

KEY = PD: Primary Data, SD: Secondary Data, I: Interview, D: Policy Documents, L: Literature, RQ: Research Question

2.4.1 Type of data collected from information required.

The study, as mentioned earlier, employed a multiple case study research strategy. In line with characteristics of a case-study outlined by Yin (2013), Robson (1993), p.146, defined a case-study as 'A strategy for doing research which involves an empirical investigation of particular contemporary phenomenon within its real life context using multiple sources of evidence'. It therefore focused on the process of flood mitigation in the five cities and the outcome of the process in each scenario. It was an exploratory as well as explanatory study of flood mitigation in cities. The study will used qualitative and quantitative data to explore key concepts in the research and data analysis was in accordance to character of data obtained. Summarized below is data requirement to be effected:

Table 4: Data and Type of Data.

Data/Information Required to Answer the Question	Type of Data
Structure of water management in the three cities	Qualitative: input enabled description of flood management hierarchy/actors in cities
Flood mitigation policy in the three cities	Qualitative: descriptive data analysed current mitigation policy, written/legal documents
Implementation of flood mitigation strategy	Qualitative: data of an exploratory nature analysed with actor cognitions in mind.
The actors and stakeholders in the water management	Qualitative: data of a descriptive and exploratory nature analysed with actor cognitions in mind.
Information about the roles of each actor Information flow between actors in flood mitigation	Qualitative: analysed obligations and duties of actors in city water management
Data on Hydrology of the cities, amount of rainfall, Infrastructure of the cities and capacity to retain water.	Quantitative: data was used in appropriate formulas to estimate city flood risk, storage capacity and potential for multifunctional strategies
Revenues allocation to environmental maintenance and sustainable management of water; Available infrastructure for utilization of multifunctional strategies (ecosystem services); Information flow between actors; City Population acceptance of multifunctional strategies (ecosystem services).	Qualitative: data was used to identify flood risk and potential for ecosystem services from flood water in the city
Actors' understanding of flood mitigation policy (in content), the implementation of policy (process) awareness of ecosystem services and nature function that can be derived/potential value Actors' responsiveness to concept of adaptive policy, opportunities and boundary spanning on flood mitigation strategy.	Qualitative: data was used to describe the effectiveness of current policy and forecast the degree of effectiveness if adaptive policies are/were developed/ implemented

2.5 Data Analysis

According to Ritchie and Spencer (2002), qualitative data analysis involves a data evaluation process through logical and analytical framework. For the comparative case-study strategy the research used both explanation building and cross-case synthesis techniques, put forward by Yin,

(2003), to describe the policy situation in each of the three case-study locations. A case-study data base was developed for data from each city for future review if necessary

2.5.1 Validation of the study

The study used qualitative data. Qualitative data will be used in a 'modus operandi' detective paradigm to analyse concepts put forward in the research. The qualitative data in the form of interviews and experts with policy makers in the five case study cities. Internal validation of the study was established through iterative explanation building process in data analysis, construct validity was achieved through use of multiple sources of evidence during data collection and reliability of the study was given by use of a case study data-base (Data collected on Climate Adaptation in five cities, 2017), (Yin, 2003).

CHAPTER 3. Theoretical framework: Application of Contextual Interaction Theory in Urban Flood Management Strategies

3.1 Introduction

The development of *adaptive flood mitigation policies* can be attenuated to the progression of water management through three eras. This logical advancement is described by Lulofs and Bressers (2010) in the European context, although the process is similar in other areas of the globe albeit slower. The eras elucidated are bound by time and given as pre-1900 era, era between 1900-2000 and post-2000 era. The pre-1900 era was characterized by emergence of water planning as an important principle due to growth of urban (industrial) areas but lack of technology made floods, droughts and infectious diseases typical water problems. The era between 1900-2000 was characterized by the dominance of physical planning with water planning serving as a facilitating utility. The development of relevant technology meant that flood incidences were reduced by hard-engineering solutions (dykes, levees and storm drains). The overriding problems in this era were now ground water level and surface water quality. Further technological advancement and growth of urban areas led to interdependency between water and physical planning during the post-2000 era. The effects of climate change reversed some of the advancements made courtesy of hard-engineering. Floods, drought, water quality and ecological quality of water again became dominant issues during this era. Inadvertently, in the dawn of the new era, society came to play a vital role in the decision as to which approach was taken to tackle water related issues. This gave rise to *Integrated Water Management (IWM), Integrated Water Resource Management (IWRM) and Adaptive Water Management (AWM)* (Lulofs and Bressers, (2010) Chapter 1: p.5-7). This research draws parallels between Adaptive Water Management and Adaptive Flood Mitigation strategies. AWM explores the concepts of interaction between long-term and short-term solutions, experimentation and cooperation between previously isolated disciplines such as engineering and policy. The end goal being to maintain ecological resilience that allows system 'to react to inevitable stresses' and 'generating flexibility in institutions and stakeholders' (Johnson, 1999 from Lulofs and Bressers (2010) p. 1) in the event of a change. The sort of change occasioned by climate change. This kind of thinking in which strategy has to be flexible to the unpredictability of weather change and changing societal demands is what is referred to as *adaptive flood mitigation policy* in the context of this study. In order to assess the effect of *adaptive flood mitigation policy* on implementation of multifunctional strategies, this research applied aspects of

the Contextual Interaction Theory (CIT). The section 3.2 explains the reason for using this theory. Section 3.3 explains how the theory is applied in the context of boundary judgments and section 3.4 explains the framework of how learnings will be derived from the results of the study.

3.2 Rationale for application of Contextual Interaction Theory in analysis of adaptive flood mitigation

For the effective implementation of an *adaptive flood mitigation policy*, urban water managers need to interact with varied target groups such as building planners. This will need recognition of and cooperation with sectors previously ignored. The city planners may need to use hydrological, geographical and meteorological data to formulate and implement adaptive policy. Thus simultaneously increasing aesthetic and economical values of a city's commercial and residential areas (Niemczynowicz, 1999). This cooperation can be achieved if actors with varied characteristics interact in a process to formulate policy (Bressers and Klok, 1988; Bressers, 2004). A theory that explains the interaction process between actors is the Contextual Interaction Theory (CIT) (Bressers, 2009). The theory gives actor core characteristics as motivation, cognitions (information) and resources (power). These characteristics influence each other and are also influenced by external circumstances. This lends to the complexity of the interaction making the theory able to realistically predict result of relations between the core variables (motivation, cognitions and resources) and dependent variables (such as the governance context) in the actor interaction process (Mayntz, 1983; Bressers, 2004). This relationship is illustrated in figure 7. The assessment of flood management policy in the case-study cities is based on the interaction between actors using predictive models put forward by CIT. The predictive implementation models give an indication of 'what works, where, when and how' (Bressers, 2004 pp. 284).

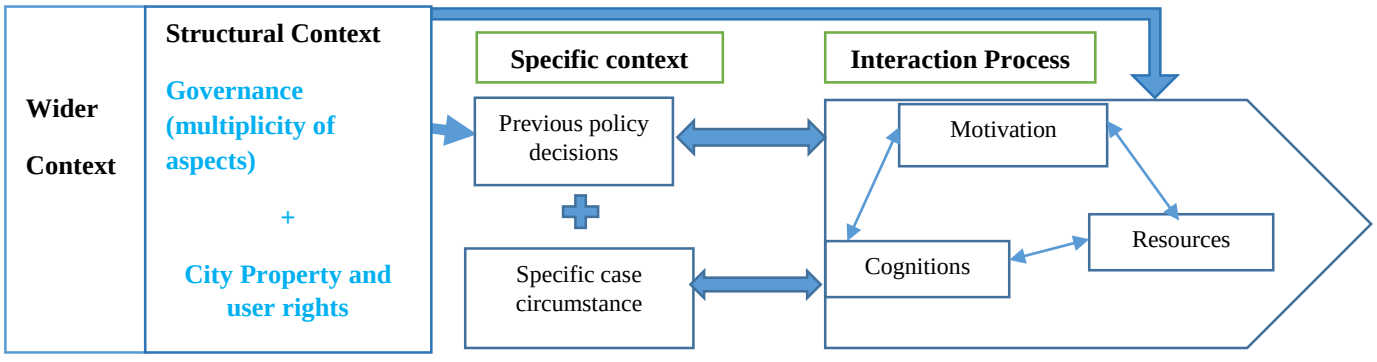

Figure 6: Showing the link between the governance context and the interaction process with the motivation, cognitions and resources of stakeholders involved. (Adapted from Bressers et al. 2013 Drop Report)

Therefore, to assess a city's flood governance strategies with respect to adaptability and sustainable management of flood water, CIT is adopted because it considers the key characteristics of actors, their - motivations, cognitions and resources- during policy formulation process. The study considers that the actor characteristics aforementioned influenced each other and are externally influenced during the actor interaction process. By focusing on the core actor characteristics, formulation of policy entails the input of internal factors (cognitions, motivation and resources) that interact in a process that involves actors and results in an output which is policy (Bressers, 2004). The relations are depicted in Figure 8 below, each of the three factors has bearing on the other and a cumulative influence on the interaction processes.

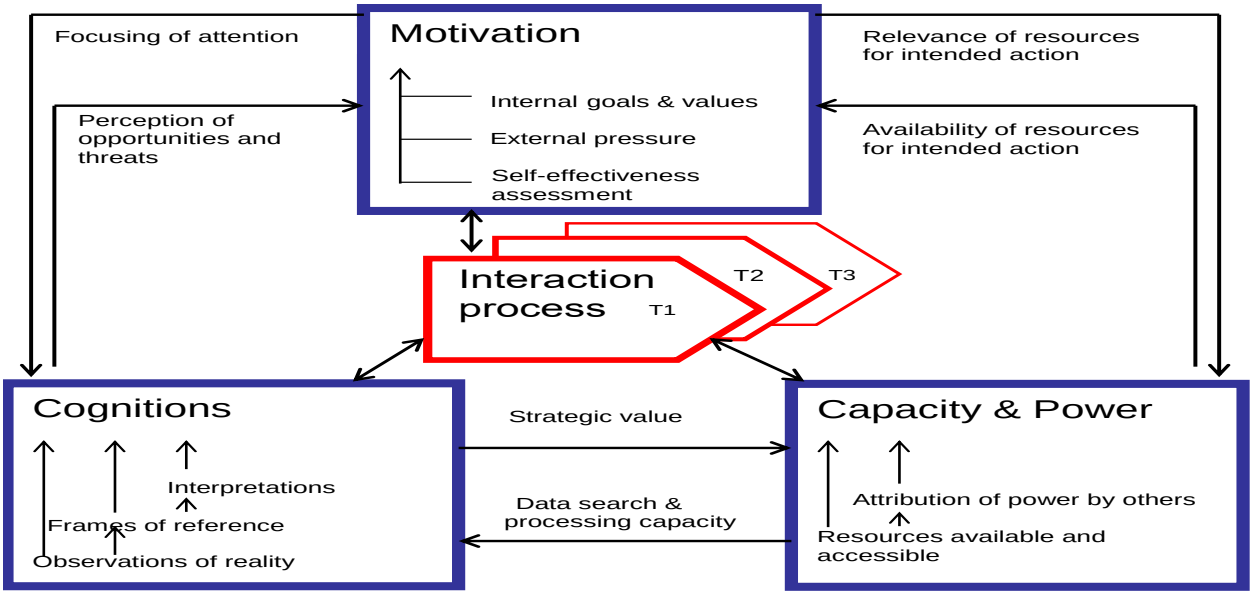

Figure 7: Showing in more detail the interaction process between actors with consideration of cognitions, motivation and power (resources). (Bressers, 2009)

The CIT specifies social-interaction of actor characteristics in the policy development process. In addition, it gives predictions on how these impact on the course and outcomes of the policy-making process.

This research lays emphasis on actor cognitions in relation to flood mitigation policy, and the concept of a multifunctional strategies to flood mitigation. In order to assess the extent to which the character of a policy (adaptive or not) influences adoption of multifunctional strategies; this

study will zoom into the cognitions box in figure 7. The cognitions box gives 'boundary judgments'. Boundary judgments at times defined as 'perimeters that protect a system from disturbances from outside disruptions, and frontiers to keep resources critical for survival' Yan and Louis, (1999) from Lulofs and Bressers, (2010) p.15.

In the issue of flood mitigation and broader, climate resilience of cities, the boundary judgments of actors influence the ongoing policy process. The cognitions prescribe the views actors hold regarding issues and other actors/stakeholders - concerning their relevance and necessity in the policy process. A new perspective may require traversing geographical, sector, spatial and administrative levels of authority. In addition, the continual nature of change due to global warming calls for innovation along time scales. The boundaries here are the cognitions (Figure 6) and the boundary judgments are previously held perceptions on issues, actors or aforementioned scales (Bressers and Lulofs, 2010). In order to enact progressive policy, allowance has to be made for new approaches and stakeholders. According to Bressers and de Boer (2013) CIT provides a framework to closely analyse interpretations made by actors and their influence on policy development and implementation.

3.3 Role of Boundary spanning in implementation of multifunctional flood mitigation strategy

The broadening of perspectives to include issues, sector scale, geographical scales and timescales hitherto disregarded is referred to as spanning boundaries (Bressers and Lulofs, 2010). In order to develop and implement policies that utilize ecosystem services provided by flood water, water managers may use the input and cooperation of city infrastructure planners and other relevant public servants as well as private sector players who own city buildings (Warner et al., 2010). Integrated water resource management and formulation of policies that are progressive thus requires new interactions of scales, actors, perspectives, strategies and resources (Bressers and Kuks, 2004). It brings to the fore the concept of 'boundary spanning' which Newell and Swan, (2000) describe as the process in which members of an organization participate in networks outside the usual mandate of the organization.

The actors in flood mitigation governance have to act in varying context with different interests and conditions influencing their decisions (Bressers and O'Toole, 2005). The intension to make a system multifunctional intrinsically means inclusion of sectors, geographical scales and timescales

previously overlooked. These scales are socially constructed dimensions that define interactive domains. The overcoming of previous prejudices leads to recognition of new stakeholders and initiation of boundary spanning activities across previously defined domains (Bressers and Lulofs 2010, p.17-32). The dimensions with aspects and sub-aspects are illustrated in table 1.

Table 1 gives the dimensions applied to outline the boundaries of a domain. The domain may be aligned to one scale and consequently one level of relevant actors. Urban areas often encompass wide geographical areas, therefore flood management involves varied sectors, over overlapping scales with different temporal considerations. More often, the domain in urban flood management involves more than one scale (different river basin and/or administration bodies/levels), more than one sector (different policies and actors) and stretching over a given (local level goal) or unknown (national/regional level goal) period of time.

Table 5: Adapted from Bressers and Lulofs (2010) p. Showing the aspects and sub-aspects over which boundaries need to be span.

Dimensions	Aspects	Sub – aspects
1. Sector dimension	Actors	Organizations Staff
	Resources	Authority Knowledge Budgets
	Policies	Problem definitions Solution strategies Process management
2. Scale dimension	Geographical (water basin) scales	
	Administrative levels	Global Supra national National Regional Local (city)
3. Temporal dimension	Time	Timing Time horizon
	Change	Speed

The three dimensions (sectors, geographical and time) form a tri-dimensional domain perspective for assessment of urban flood mitigation processes. This integration allows for processes from different sectors, geography and time horizons in a domain to combine in the actors' operations. This approach suggests a blurring of the boundaries between the processes. It allows actors involved to handle a multiplicity of issues, procedures, actors resulting in a 'coupling of strategies' (Bressers et al. 2008).

The extent to which the boundaries span and the strategies used to overcome prejudices vary from one context to another. Boundary judgment models will be used in the study to identify strategies used in governance of flood risks aiming at spanning boundaries in the five cities, during policy formulation and implementation.

3.4 Research Analytical Framework based on CIT

By using the dimensions highlighted in section 3.3, the boundaries in policy development and implementation will be analysed to determine the extent to which their adaptive character influences use of multifunctional strategies. The schematic presentation of analytical framework is shown in Figure 6 below:

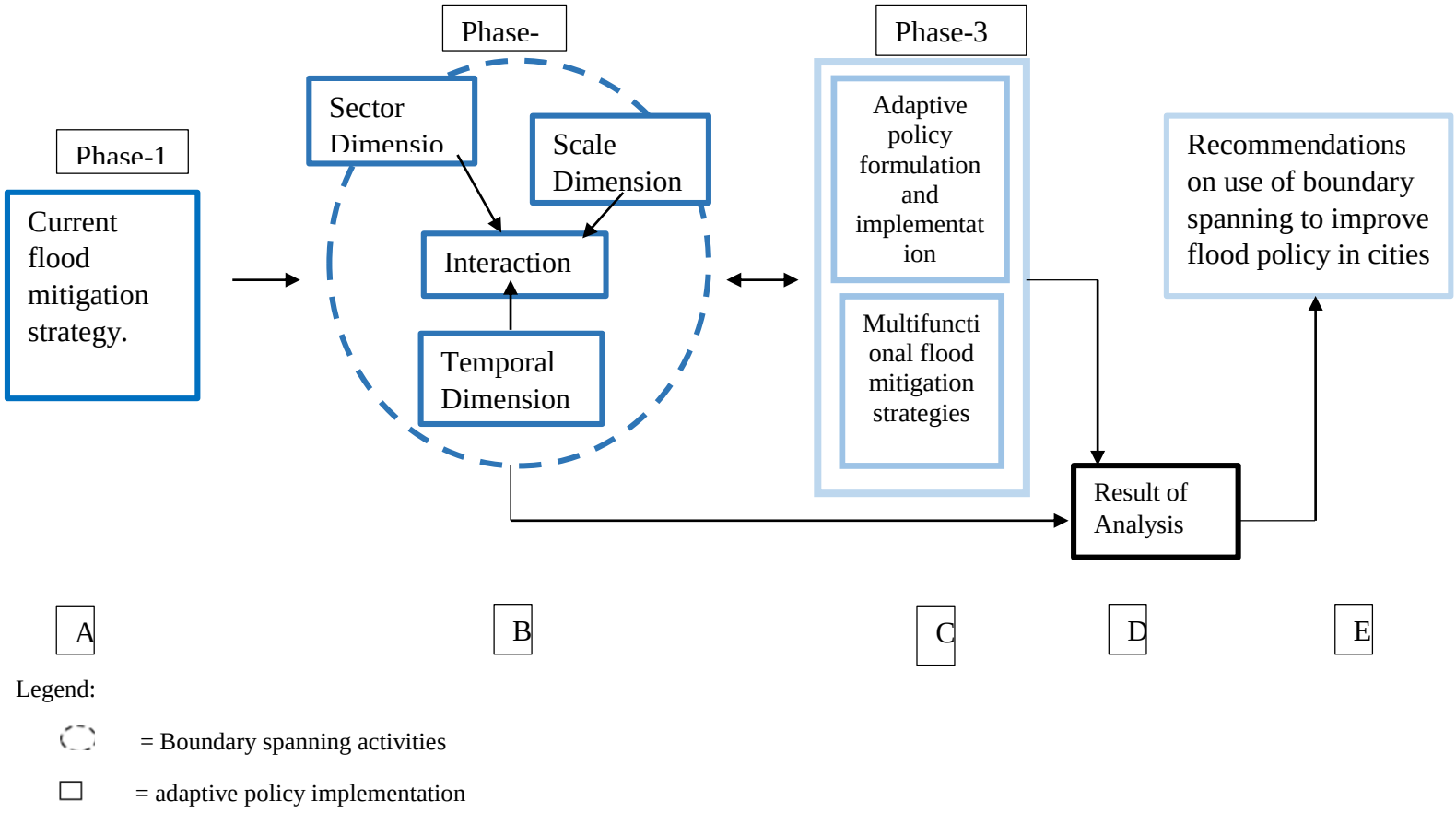

Figure 8: A Schematic Presentation of Analytical Framework for Policy analysis

3.4.1 Elaboration of analytical framework

The policy analysis was conducted with the following sequences:

a) Description of current flood mitigation policy

In this phase, the study analysed flood risk policy in by identification of actors and describing their interaction using the CIT.

b) Analysis of boundary spanning activities

In this phase, the study used boundary judgment models to describe the interaction of actors in temporal, scale and sector dimensions.

c) Analysis of likelihood and extent of implementation of flood risk policy

The phase used predictive models to evaluate the likelihood and effectiveness of current flood risk policy applied in each city.

d) Analysis of results

The results of analysis in c) enabled inference as to the influence of adaptive policy making, on use of multifunctional flood mitigation strategies such as ecosystem services in each city.

e) Criteria of adaptive policy for multifunctional utilization of flood water in cities

A cross-case analysis was conducted and recommendations were made based on results.

3.5 Potential for learning despite varied context

The administration of cities is often largely autonomous. City governors have the resources and legitimacy to implement policy changes at urban level. This is an advantage, especially in countries in the global south where bureaucratic processes greatly hinder policy implementation processes. Therefore a study of cities in different context presents an opportunity for global learning to occur. Borrowing from Wilbanks and Kates (1999) study on rethinking research of sustainable cities, this study provides a bottom-up paradigm by linking city management to larger regional and global policies. In addition, the case study approach allows for a more inclusive criteria, and layered framework to accommodate parties with disparate technologies and resources. In this way, local observations can be translated into a logical conceptual framework and inform decisions now, and in the future.

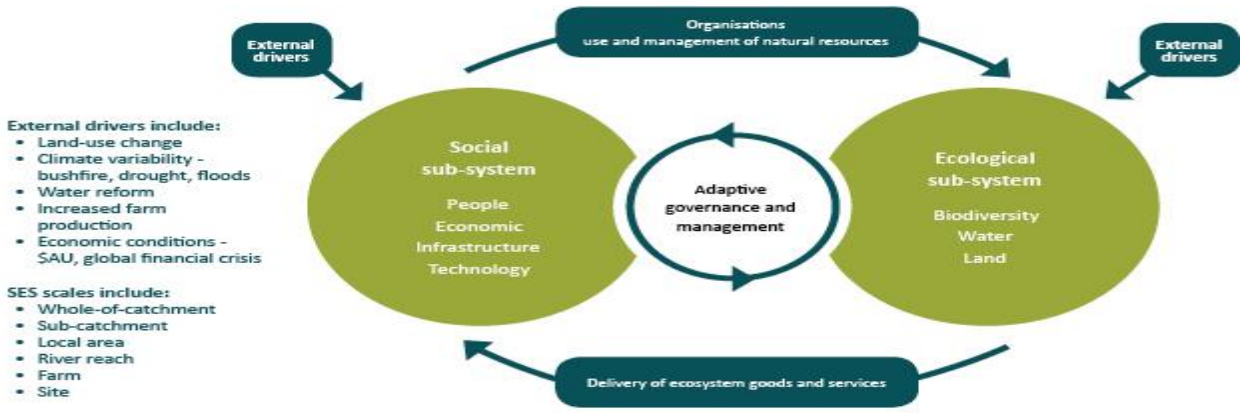

Figure 9: Depicting the relation between social and ecological sub-systems that yield multifunctional ecosystem services resilience through adaptive governance.

CHAPTER 4. DATA ANALYSIS

In this chapter the results of the study from the five cities are tabulated. The data has been analysed using themes generated from the theory. This was done using a deductive approach. A deductive approach is whereby the relationship between theory and data is investigated, Bryman and Bell, (2015). Specifically, the cognitions of policy makers were explored using CIT, Bressers, (2009) and further the boundary judgments and boundary spanning activities were depicted using domains put forward by Lulofs and Bressers, (2010). A table was developed incorporating elements of the theoretical framework of CIT as well as Mens et al. (2012) indicators of resilience. The data was collected between the period 1st June, 2017 and 17th August, 2017. The data from each city was then analysed using the standard table. Each city was analysed individually so as to keep the results in context.

4.1 Cognitions, boundaries, resilience and adaptation for Dordrecht

The table below depicts results from the city of Dordrecht. The data was gathered between 1st June and 31st of July, 2017. A semi-structured face-to-face interview of Rik Hienen, a policy advisor for the municipality of Dordrecht was conducted. He also completed the questionnaire in Appendix two. Additional data was gathered from Steven Krol Senior Policy advisor, Province of South Holland and Interviewee Two– Senior Policy advisor, City of Rotterdam, both of whom were guided by questions in Appendix one.

Table 6: Data Analysis for Dordrecht

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
COGNITIONS	Factors determining flood risk	Environmental	Interpretations	Recognition of effects of climate change: water level rising	Recognition of effects of climate change: increased rainfall	Recognition of effects of climate change: re-enforcement of dykes.
			Frames of reference	National flood mitigation policy: reliance on government overall objectives	National flood mitigation policy: reliance on government overall objectives	
			Observations of reality	Increased precipitation: increased river volumes		
		Hydrological	Interpretations	Most of Dordrecht is below sea level		

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
			Frames of reference	National flood mitigation policy: reliance on government overall objectives		
			Observations of reality	• Combination of threats from the river and the sea • Processes that occur in below-ground drainage systems for example sedimentation		
		Urbanization and population increase	Interpretations	• Admission of change in the way of thinking (for flood management) • Acknowledgement of rise in sea level •		Acknowledgement of rise in sea level
			Frames of reference	• National flood mitigation policy: reliance of government overall objectives		
			Observations of reality	• Development of areas not protected by the dyke ring • Change in land use from green to impervious surfaces • Management of green areas		
		Socio-economic	Interpretations	• Balancing the socio-economic factors with the observable flood risk		
			Frames of reference	• National flood mitigation policy: reliance on government overall objectives		
			Observations of reality	• Identification of vital infrastructure damaged by floods • Development of areas not protected by the dyke ring • Hazards: - Slight disruption of habitats and ecosystems - Rare disruption of transport services - Rare loss of jobs and businesses		
BOUNDARIES	Sector	Actors	Organisations	• Inter-city cooperation in multi-layer safety		
			Actors	• Municipal authority • Stakeholders: - Population – not well aware of vertical evacuation strategy - Population- take insurance on water damage by rainfall - Population- outside the dyke ring responsible for their own safety	• Water board • Provincial authority • Safety region	• National government: Delta programme • National Metrological Institute
		Resources	Authority	• No laws on spatial planning	• Water board: regulatory • Provincial authority: information monitoring/evaluation	• National government: - Development and maintenance of the dyke system - Policy-making and implementation

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
					• Safety region: policy making and implementation	• National Metrological Institute: - Information/monitoring evaluation
			Budget	• Restricted budget • Earmarked grants (EU) • Difficulties in mobilizing regular private sector contribution	• Taxation system funds water boards • From partners and E.U Interreg program	Finance dyke system, large budget
			Knowledge	• Urban infiltration needs to increase • Awareness on green areas • Awareness of contribution of urbanization to flooding • Hindrance: use of over technical information on non-experts		
		Policies	Problem definition	• Lack of adequate evacuation strategy • Hindrances to adaptive policy: - Lack of coordination of legislation on flood management. - Mismatch between hydrological and administrative boundaries - Lack of relevant scale of investment - Contradiction between different governmental level directives - Lack of incentives for cooperation	• Implementation of National policy • Hindrance to adaptive policy: - Lack of coordination of legislation on flood management.	• Protection from sea and river floods
			Solution strategies	• Safety Policy development • Determinants of policy development: - Climate change (major) - Economic constraints (moderate) - Growing population (moderate) - Crisis/emergency-driven management (moderate) - Urban infrastructure growth increase (minor) - Poverty and social inequalities (minor) • Factors that hinder performance of adaptive strategies: - Lack of staff and managerial capacity for policy implementation - Difficulties in ex post monitoring and evaluation	• National Flood Policy implementation • Areas influencing flood water governance: - Land use and spatial planning (moderate) - Energy (minor)	- Determinants of policy development: - National laws and regulations (major) - Increased attention to flood water in the political agenda (moderate) - Extreme events such as floods or heat waves. • Development of main flood mitigation policy • Flood mitigation using dykes
			Process management	• Safety Policy improvement • Safe-guard dykes - no building on the dyke • Mechanisms used to coordinate flood policy: - Inter-municipal collaboration on projects (no authority) • Tools for stakeholder engagement: - Focus groups and citizen committees - Media (traditional and web-based)	• Mechanisms used to coordinate flood policy: - Water boards (Waterschappen) – flood management - Shared databases and information systems	- Mechanisms used to coordinate flood policy: - Platforms for sub-national flood mitigation actors • Tools for stakeholder engagement: - Inter-ministerial consultations - Media (traditional and web-based) - Polls and referendum

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
				- Surveys - Consultation in regulatory processes - Workshops • Hindrances to stake-holder engagement: - Lack of time (major) - Clarity of information - Slightly misaligned objectives of stakeholders - Slight resistance to change - Complexity of issues	• Coordination with other sectors: - In flood water and spatial planning - Joint programmes/agencies at sub-national level - Partnerships and dialogue	
	Temporal	Time horizon		• Spatial adaptation: long-term plan		
		Time (Speed)				
RESILIENCE	Risk Assessment			• Strong trust in current flood mitigation infrastructure (dykes) • Hazard from flooding is frequent damage to homes and offices • Evacuate to the south high level faced by the constraint of only one bridge (only 10% evacuation of population) • Part of the old city is outside the dyke ring • Largest threat is in the event of combination of coastal and river flooding. • Use of both hazard and vulnerability analysis		•
	Coping capacity			• Spatial adaptation through water proof basements and increasing road height • Interaction of local authority with other stakeholders in flood water management: - Frequently with other municipalities. - Slightly frequent with service providers, civil society, consultancy and engineering, international organizations. - Rare interaction with business/industry, investors/donors • Vertical evacuation: upper levels of own house Community: understand level of threat from the flood water • Transnational cooperation on river level management • No flood insurance in the Netherlands • Well maintained urban drainage	• Interaction of local authority with other stakeholders in flood water management: - Frequent with regional and provincial authorities such as Safety region and Water boards.	• Interaction of local authority with other stakeholders in flood water management: - Rare with national authorizes such as National Metrological Institute.
	Indicators	Amplitude of reaction to disturbance		• Priorities in flood management considered very serious on highways, serious on buildings and homes then somewhat serious on flooding adjacent to properties.		

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
				• Risk assessment: No need for critical improvements but open for improvements		
		Graduality of increase of reaction with increasing disturbances		• Steps taken in monitoring flood risk: - Flood hazard mapping (applied) - Monitoring progress of storms (frequently applied)		
		Recovery rate of a system		•		• Government responsible for restoration of damage by flood within dyke ring
ADAPTIVE METHODS	Multifunctional Strategies			• Multifunctional building: may serve as a shelter during flooding. • System of storage of excess rainfall • Multifunctional use in terms of nature: develop ecosystem services through expansion of nearby wetland. • Green walls: urban greenery • Bio-retention: rain gardens • Wet proof structures, raised structures, floating structures and open drainage system	• Traditional mitigation strategies: - Maintenance of the dyke system - Channelization: diversion of streams, enhance drainage	• Traditional mitigation strategies: Development of dyke system (major)
	Multi-layer safety approaches			• Regulatory approaches: - Development of policy on multi-layer safety towards flood risk management - Flood zoning, building zones and mortgage limitations		

(Raw data available in page 1-27 and 38-42 of Data collected on Climate Adaptation in five cities, 2017)

4.2 Cognitions, boundaries, resilience and adaptation for Rotterdam

The following data was collected from the city of Rotterdam during the period 1st June to 31st July 2017. A face to face interview of Nick van Barneveld, Senior Policy advisor, City of Rotterdam was done. The data concerning Rotterdam from a phone interview with Steven Krol Senior Policy advisor, Province of South Holland was also included in this table. The results also incorporated secondary data on policy plans and implementation singled out by respondents. These plans/strategies were included in the policies-solution strategies section of the data analysis table.

Table 7: Data Analysis for Rotterdam

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
COGNITIONS	Factors determining flood risk	Environmental	Interpretations	• Recognition of effects of climate change: - Sea level rise - Lower river discharges - Long periods of heat - More intense rain events - Higher river discharges - Long periods of drought		
			Frames of reference	• National flood mitigation policy: Delta programme • Regional collaboration within the Rijnmond-Drechtsteden program • Rotterdam Climate Adaptation Strategy	• National flood mitigation policy: Delta programme • Regional collaboration within the Rijnmond-Drechtsteden program involving municipality, water boards and the province.	• National flood mitigation policy: Delta programme • Regional collaboration within the Rijnmond-Drechtsteden program
			Observations of reality	• Increased incidence of rainfall, Sea level rise • Heat stress		
		Hydrological	Interpretations	• Threat of storm surges • Water run-off •		
			Frames of reference	• Use of multilayered approaches.		• Increase in sea level
			Observations of reality	• It is a delta city, with - 400 kilometres of canals - 2800 km of sewers - 900 excess-water pumping stations • Urban flooding already occurring		

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
		Urbanization and population increase	Interpretations	• 49% of city service areas is above sea level (un-embanked area, harbour area) • Utilities like central station located below sea level: increased risk of flooding • Looking for alternative solutions to flood challenges as well as addressing social issues such as housing.		
			Frames of reference	• Spatial planning for un-embanked areas		
			Observations of reality	• Population increase: currently at 640,000 • Expanding port • A lot of architecture • New attractive residential areas		
		Socio-economic	Interpretations	• Scenarios depicted (used) to inform stakeholders such as businesses of the possible damage to property/economy due to floods		
			Frames of reference	• Using data from National Metrological Institute to inform stake holders and policy-makers.		
			Observations of reality	• 40 km port area: one of the largest in the world • Central station located below sea level: increased risk of flooding • Visualization using blue areas on maps to quantify economic damage		
BOUNDARIES	Sector	Actors	Organisations	•		
			Actors	• Municipality • Civilians • Companies	• Has 3 water boards • Safety region • Province	• National government • National Metrological Institute of Holland
		Resources	Authority	• Municipality: for spatial planning and influencing flood policy • Municipality: responsible for spatial planning in un-embanked areas.	• Province: for spatial planning, flood policy and delta program Climate change • Water board: maintain dyke system • Safety Region: responsible for evacuation, planning, crisis management – terrorism attack, cyber security, fires, alarm (warning systems)	• National government: spatial planning, flood policy and delta program Climate change • Emphasis on river system and sea • National Metrological Institute of Holland: give data and scenarios
			Budget	•	• From partners and E.U Interreg program	
			Knowledge	• Connecting delta cities worldwide (C40)		

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
				• Ready 4 climate change: quick check tool to activate stakeholders on their knowledge on climate change adaptation		
		Policies	Problem definition	• Identification of the following challenges: - Water challenges - Climate challenges - Urban challenges - Spatial development - Storm surge disasters: due to climate change • Climate adaptation is an opportunity for an attractive and economically strong city • Lack of spatial planning, critical infrastructure in the last decade	• Lack of spatial planning, critical infrastructure in the last decade	• Storm surge disasters: due to climate change
			Solution strategies	• Programs implemented (being) in the city: - Rotterdam Adaptation Programme - Rotterdam Climate Change Adaptation Strategy - Rijnmond –Drechtsteden program - Spatial planning/adaptation • Crisis management – evacuation/safe guard of critical infrastructure • Presentation of flood situations to civilians so they can take responsible action for themselves	• Spatial planning • Crisis management-evacuation/safe guard of critical infrastructure	
			Process management	• Admittance that there is more need to look at spatial planning and evacuation strategies. • Scenarios depicted (used) to inform stakeholders such as businesses of the possible damage to property/economy due to floods • New buildings need to be higher and climate proof	-	-
	Temporal	Time horizon		• Planning with mid and long-term projections: use of socio-economic growth/decline, moderate to rapid climate change scenarios • Setting 2080 as a milestone for new storm surge barrier		• Planning with long-term projections e.g. for the service of storm surge barrier and dykes
		Time (Speed)				
RESILIENCE	Risk Assessment			• Recognition of rainfall water run-off • City situated in and along the water: - Neighbourhood of 60.000 civilians along port area - 40.000 people living outside the dyke • Use scenario analysis to estimate risk • Use methodology to assess direct and indirect flood based economic losses		•

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
				• Use of standards such as 1:1000 to show likelihood of flooding • Confidence in dyke system		
	Coping capacity			• Use of multi-layered approach • Robust system, maintained and strengthened • Inter-city cooperation with Dordrecht, Amsterdam and Zwolle. • 900 excess-water pumping stations • Development of museum parks as parking and water storage, (10.000cubic meters) • Floating pavilions • Alternatives to elevation are: dry/wet proof buildings	• Inter-city cooperation with Dordrecht, Amsterdam and Zwolle.	• Storm surge barrier: Maeslant barrier- 22m high and 210 m long steel gate
	Indicators	Amplitude of reaction to disturbance		• Concerns about possible effects of flooding of for example chemical installations etcetera along un – embanked areas	• Involvement of Safety Region in awareness training to provoke cooperation on evacuation strategy.	
		Graduality of increase of reaction with increasing disturbances		• The scenario analysis allows for increase in reaction with increase in disturbances		
		Recovery rate of a system		• Responsibility for safety outside un-embanked area is a responsibility of owner (build at your own risk) • Due to large size of un-embanked areas, the municipality is thinking of ways to assist in mitigation –Building codes regulations		• Compensation for flooding within embanked areas is responsibility of National government
ADAPTIVE METHODS	Multifunctional Strategies			• Make use of public space: urban flood plains • Added value for environment, society, economy and ecology • Development of museum parks as parking and water storage (10.000cubic meters) e.g. water storage in Kleinpolderplein – 2,400 cubic metres in shells on roof of parking garage. • Green roofs: 160,000 square meters by 2014 • Water squares for water storage • Development of multifunctional dyke that serves as a road underground and a park on the surface need to be considered • Integrate multifunctional infrastructure to urban challenges for example multifunctional dyke consists of a dyke and a shopping centre	-	•

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
	Multi-layer safety approaches			• Cooperation with Safety region to formulate realistic evacuation plan in case of flooding		

(Raw data available in page 28-37, 38-42 and 43-51 of Data collected on Climate Adaptation in five cities, 2017)

4.3 Cognitions, boundaries, resilience and adaptation for Nairobi

The following table presents data collected from the city of Nairobi during the period 1st June to 31st July, 2017. The study used a structured interview via email and a Skype meeting to get information from Victor Ongoma, a climate expert and lecturer at a university in Kenya. The questions in Appendix two were applied in data collection. In addition, a content analysis of policies highlighted by the respondent (policies in solution strategies section of the table) were also carried out to get the results presented.

Table 8: Data Analysis for Nairobi

				Administrative Levels		
THEMES	SUB-THEMES			LOCAL	REGIONAL	NATIONAL
COGNITIONS	Factors determining flood risk	Environmental	Interpretations		• Climate change: increased precipitation	
			Frames of reference		• Environmental management and regulation	
			Observations of reality		• Occurrence of land-slides,	
		Hydrological	Interpretations		• Run-off; decreased infiltration	
			Frames of reference		• Historical data from the metrological department and disaster management.	
			Observations of reality		• Blockage of drainage systems	
		Urbanization and population increase	Interpretations		• Urban water course blockages and sedimentation	

					• Sewer conveyance blockages and sedimentation • Impact of external flooding on urban drainage systems • Deterioration of urban drainage assets	
			Frames of reference		• Data from disaster management	
			Observations of reality		• Change in land-use	
		Socio-economic	Interpretations		• Damage of private and public property	
			Frames of reference		• Data from the Red Cross	
			Observations of reality	-	• Damage to roads, transport services, homes, property such as cars and buildings • Damage to electricity and communication lines	
BOUNDARIES	Sector	Actors	Organisations		• Red Cross • Media (News agencies)	
			Actors	• Municipality • Hindrance to adaptive water governance: - Lack of relevant scale of investment - Multiplicity of flood mitigation agencies - Conflicts over water allocation - Lack of institution incentives for cooperation	• Regional government • Disaster management authority • Meteorological department • Obstacles to stakeholder engagement in decision-making: - No clarity on expected use of inputs in decision-making (moderate) - Lack of political will and leadership (moderate) - Stakeholder consultation fatigue (moderate) - Lack of transparency - Misaligned objectives of stakeholders • Hindrance to adaptive water governance: - Lack of relevant scale of investment - Multiplicity of flood mitigation agencies	• National government • Obstacles to stakeholder engagement in decision-making: - Consultation (lobbies over-representation of certain categories) – major - Weak legal framework to support stakeholders engagement - major • Political discontinuity – major • Hindrance to adaptive water governance: - Contradictions between government level recommendations/directives

		Resources	Authority	• Municipality: Policy-making and implementation	• Regional government: policy-making and implementation • Disaster management authority: information, monitoring and evaluation	• National government – responsible for financing
			Budget	• Municipality by laws: fines	• Sanction mechanisms to be used by municipal authority • Retail water tariffs (through regulation) • Central government transfers	• Incentives from National government • Sanction mechanisms to be used by regional authority
			Knowledge	-	• Competences of the metropolitan body on flood water management: - Information exchange - Provision of technical expertise - Operational management - Strategic management - Allocation of funding Use of legislative, regulatory and authoritative competences	
		Policies	Problem definition	• Flood management needs critical improvement	•	•
			Solution strategies	• Areas influencing flood water governance: - Solid waste management (plastics)- major - Building codes (moderate) Flood mitigation is guided by the following policy instrument: • Draft of National Disaster Management Policy (yet to be enacted by parliament) • Environmental Management Act of 2001	• Determinants of policy development: - Climate change (major) - Growing population (major) - Urban infrastructure growth increase (major) - Poverty and social inequalities (moderate) Fiscal consolidation measure (minor). • Flood related factors influencing policy development: - Obsolete, ageing and lack of infrastructure (major) - Extreme events such as floods (moderate) • Waterways pollution, obstruction of drainage and damage to levees/dykes (moderate)	

			Process management	• Factors that influence policy development: - National laws and regulations - Territorial reforms (mergers of regions, provinces and municipalities) - Decentralization/re-allocation of competences -	• Factors that influence policy development: - National laws and regulations - Territorial reforms (mergers of regions, provinces and municipalities) • Mechanism for coordination of water policy between levels of government: - Metropolitan sectoral authority - Expert panels - Ad hoc meetings • Coordination mechanisms with other sectors of government: - Planning: used by regional development and environment department. - Financial incentives: used by disaster management department - Coordination group meetings: used by disaster management and environmental department - Joint programs of agencies at sub-national level: Disaster management department	• Factors that influence policy development: - National laws and regulations • Hindrance to coherence and consistency to flood water management: - Overlapping, unclear allocation of responsibilities - Lack of coordination on legislation of flood management - Lack of strategic vision across flood water related sectors
	Temporal	Time horizon			• No current projections/planning on flood mitigation	
		Time (Speed)			• Reliance on international agencies on flood emergencies	
RESILIENCE	Risk Assessment			• Hazards due to floods are: - Disruption of electricity - Disruption of transportation services - Diversion of relief funds - Water damage to homes and offices (rare) • Floods are usually short in duration	• Assessment method used: vulnerability assessment – using historical data on topography, drainage and previous flood events	•
	Coping capacity			• Assistance from the general public when flood crisis occurs • City council mobilize resources	• Involvement of international aid agencies	

	Indicators	Amplitude of reaction to disturbance		• The most considered damage during floods are: - Flooding of highways, homes and adjacent property (serious). - Considered less serious is flooding of private buildings		
		Graduality of increase of reaction with increasing disturbances		•	• Determination of the areas susceptible to flooding when discharge of a stream exceeds the bank stage; using historical data on river stages, discharge from previous flood, topographical data	
		Recovery rate of a system		• Private individuals responsible for damage to property such as cars or houses	• Regional government responsible for restoration of damaged public property. • NGO's such as Red Cross concerned with delivery of food and health supplies to affected areas	• Responsible for damage to utilities such as electricity supply lines
ADAPTIVE METHODS	Multifunctional Strategies			•	• Strategies applied to mitigate urban floods: - Use of storm sewers - Use of retention ponds • Multifunctional Approaches: - Stream rehabilitation, restoration and daylighting - Open drainage systems such as street and extended channels, enlarged canal and check dams. • Challenges that hinder performance of multifunctional flood mitigation strategies: - Poor planning and not articulated with national objectives - Difficulties in ex ante evaluation - Difficulties in ex post monitoring and evaluation • Obstacles hindering transparency and accountability of	• Hindrance to financial sustainability of multifunctional flood mitigation: - Weak priotization of investment in flood water mitigation - Lack of multi-annual strategic plans and multi-annual budgets for flood mitigation • Obstacles hindering transparency and accountability of multifunctional flood water management policy: - Lack of publicly available data on flood risk. - Lack of bench-marking to evaluate flood water quality, management agencies and their performance • Obstacles that hinder effective use of information to guide decision-making: - Lack of independent data concerning flood occurrence and damage

					multifunctional flood water management policy: - Lack of publicly available data on economic and financial impact of floods including cost of recovery - Weak stakeholder engagement in flood water policy strategy and projects	
	Multi-layer safety approaches			• Multi-layer safety approaches are non-existent		

(Raw data available in page 52-73 of Data collected on Climate Adaptation in five cities, 2017)

4.4 Cognitions, boundaries, resilience and adaptation for Kisumu

This data was collected during the period 1st June and 5th August using phone interviews and applying structured and semi-structured questionnaires. Harun Guttah, an Environmental Officer at the Kisumu County Office (Regional Authority) gave three phone interviews and gave summarized answers by email to questionnaire in Appendix one.

Table 9: Data Analysis for Kisumu

				Administrative Levels		
THEMES	SUB-THEMES			LOCAL	REGIONAL	NATIONAL
COGNITIONS	Factors determining flood risk	Environmental	Interpretations		• Change in rain patterns	
			Frames of reference		• National Environmental Policy	
			Observations of reality		• Unprecedented amount of rainfall	
		Hydrological	Interpretations		• Marsh areas are prone to flooding • High water table due to close proximity to the lake	
			Frames of reference		• National Policy for Disaster Management (2009)	

			Observations of reality		• Flooding due to run-off incidences	
		Urbanization and population increase	Interpretations		• Rise in population within the city • Mushrooming of slum areas which lack utilities such as drainage and waste disposal	
			Frames of reference		• National policy on building in close proximity to a natural resource	
			Observations of reality		• Construction of houses on/close to river banks • Loss of lives and property due to flooding by rivers	
		Socio-economic	Interpretations		• Damage of property and displacement of population	
			Frames of reference		• National Poverty Eradication Policy	
			Observations of reality	-	• Damage to homes and business properties • Cutting off of transport networks	
BOUNDARIES	Sector	Actors	Organisations	• Red Cross		
			Actors	• Private corporations	• County government • Environmental department (county level) • Disaster management department (county level)	• National government •
		Resources	Authority	• Private corporations: involved through Corporate Social Responsibility (CSR) projects	• Environmental department: - draft on preparedness planning and policy making - Organization of stakeholder forums - Implementation of county and National policy •	• National government: - Policy making and regulation using agencies such as National Environmental Management Authority (NEMA)
			Budget	•	•	
			Knowledge	•		
		Policies	Problem definition		• Flooding from the rivers due to increased rainfall	•
			Solution strategies		• Restriction of building between 30m-60m away from the natural resources	

			Process management		• Mitigation strategies and policy are formulated and implemented by regional government	-
	Temporal	Time horizon			• Short to mid-term plans are made on how to evacuate and provide relief during flooding	
		Time (Speed)				
RESILIENCE	Risk Assessment				• Flooding and fires are environmental calamities • Effects of flooding: - Damage to infrastructure such as roads - Displacement of population - Destruction of vegetation	
	Coping capacity				• Creating water ways for run-off: flood channelization • Designating camping grounds to house populations displaced by floods	
	Indicators	Amplitude of reaction to disturbance		• Communities offer assistance to each other to build channels for excess water back to the river • Non-governmental programs financed by aid agencies to assist in recovery efforts		
		Graduality of increase of reaction with increasing disturbances			• Large flood disasters require regional government intervention.	
		Recovery rate of a system		• Private individuals responsible for damage to property from floods	• Camping sites for people displaced by flooding established • Regional government responsible for restoration of damaged public property. • NGO's such as Red Cross concerned with delivery of food and health supplies to affected areas	• Responsible for damage to utilities such as electricity supply lines

ADAPTIVE METHODS	Multifunctional Strategies			• Use of flood water by households • Use of flood water for subsistence farming such as the rice fields.		
	Multi-layer safety approaches				• Multi-layer safety approaches are non-existent	

(Raw data available in page 74 -77 of Data collected on Climate Adaptation in five cities, 2017)

4.5 Cognitions, boundaries, resilience and adaptation for Hoboken

The study collected data on Hoboken between the period 1st June and 3rd August, 2017.The data was obtained through phone interview with of Caleb Stratton, Principal Planner, City of Hoboken and a face to face interview with Nanco Dolman who was a climate adaptation expert who worked in flood mitigation projects for Hoboken. The questions in Appendix one were applied to both respondents. Additional information was collected through desk research on flood governance in the city.

Table 10: Data Analysis for Hoboken

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
COGNITIONS	Factors determining flood risk	Environmental	Interpretations		• Storm surge and high tides • Rising sea level	
			Frames of reference		• Preliminary Flood Insurance study of Hudson County	• 2014 National Climate Assessment
			Observations of reality		• Coastal flooding such as Hurricane Sandy	
		Hydrological	Interpretations	• Heavy rainfall • Naturally low topography and proximity to the Hudson river • Storm water run-off	•	
			Frames of reference		• "Water Body Advisory System" – monitory and reporting combined sewage overflows (level alert) • Advisory Base Flood Elevation (ABFE) maps	

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
			Observations of reality	• Stormwater flooding such as Hurricane Irene • Inadequate capacity of infrastructure such as sewer • Insufficient discharge capability due to high tide	•	
		Urbanization and population increase	Interpretations	•	•	
			Frames of reference			
			Observations of reality	• Impervious ground coverage	•	
		Socio-economic	Interpretations	• Economic damage due to hurricanes • Safety concerns due to hurricanes	•	
			Frames of reference		• Flood Insurance Study (FIS)	
			Observations of reality	• Hurricanes devastate wide-spread areas of the city	•	
BOUNDARIES	Sector	Actors	Organisations	•		
			Actors	• Hoboken County • Builders and Designers • Residents	• North Hudson Sewage Authority • Zoning Office • National Flood Insurance Program (NFIP) • Federal Emergency Management Administration	• Federal Emergency Management Agency (FEMA)
		Resources	Authority	• Hoboken county: drafting policy and plans to mitigate against floods • Builders and Designers – implement resilient building designs • Residents: involvement through social programs in park maintenance and giving information related to flood risk and insurance online	• North Hudson Sewage Authority: - owns and operates Hoboken's sewer infrastructure - manages water advisory system for alerting public on wet and dry weather • Zoning Office: provide flood maps determination to assist in locating properties/flood hazard areas	-

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
					• National Flood Insurance Program: Insurance of residents against floods • Federal Emergency Management Administration: ratings for insurance purposes •	
			Budget	• Funding from NJDCA Post Sandy planning grant program • Funding from DCA • National grants	•	
			Knowledge	•		
		Policies	Problem definition	• Reduce future storm vulnerability		•
			Solution strategies	• Re-aligning codes, standards and planning documents • Components of the Plan (policy/strategy): - Resilient Building Design Guidelines - Codes, Ordinances and Standards - Resilient Capital Improvement Plan - Hazard Mitigation Plan - Open Space, Recreation and Historic Preservation Plan • Green building and environmental sustainability master plan: Guidelines for strormwater management, utilities and infrastructure	-	• United States Department of Housing and Urban Development: Launched Rebuild by Design program with 5 components – Resist, Delay, Store and Discharge
			Process management	• Update of Flood Damage Prevention Ordinance • Storm water Flood Hazard Mitigation: reduce strain the strain on Hoboken combined sewer system during rainfall events • Coastal Flood Hazard Mitigation: for coastal floods in order to protect the city during high tide and storm surge events	-	-
	Temporal	Time horizon		• Long term control plan: will take 3-5 years to draft and decades to implement		
		Time (Speed)				
RESILIENCE	Risk Assessment			• Sewer system is over-taxed by intense rainwater events • Flooding exacerbated when rainfall occurs during high tide • Increase in precipitation (71%) on impervious surface (roof tops, streets, sidewalks and parking lots) lead to floods in the North east.		•

				Administrative Levels		
THEMES	SUB-THEMES			**LOCAL**	**REGIONAL**	**NATIONAL**
				• Rise in sea level predicted to increase severity of coastal flood events		
	Coping capacity			• Reliance on a 19th Century combined sewer and storm water drainage system • Alerts to inform residents of water/ sewage levels • Use of bulkheads as a protective barrier • Insurance for rebuilding and recovery efforts • Have a Community Emergency response team • Flood proofing critical buildings	•	
	Indicators	Amplitude of reaction to disturbance		• Development of new policy/plan and guidelines after Hurricane Sandy		
		Graduality of increase of reaction with increasing disturbances		• Measures put in place after Hurricane Sandy: - Energy Resilience: program designed to deliver uninterrupted electricity during disaster events (prevent blackouts and brown outs) - Shoreline protection: a flood barrier along southern edge to protect from storm surges - Flood mitigation using 3 shovel-ready wet weather pump stations (on-going) - Tracks of land to create open spaces to facilitate retention of storm water run-off - 'Resilience Task Force' – to develop ideas, policies, projects and programs		
		Recovery rate of a system		• Local government cooperate with regional and federal (National) to restore city property damage by flooding		
ADAPTIVE METHODS	Multifunctional Strategies			•	• Rebuild by Design Program • Restoration of wetlands for storm water detention such as Northwest Resiliency Park	•
	Multi-layer safety approaches			-		

(Raw data available in page 78-91 of Data collected on Climate Adaptation in five cities, 2017)

4.6 Delineation of boundary spanning results

The analysis tables depicts the dimensions and aspects that define domains in boundary judgements as outlined by Lulofs and Bressers (2010). By applying these domains to policy structure in all the cities, the study was able to infer the extent to which boundary spanning activities had taken place. Using the analytical framework in Chapter 2, figure 6 by zooming the tri-dimensional interaction of; sector, scale and temporal. The analytical process is summarised in figure 10, 11 and 12 below

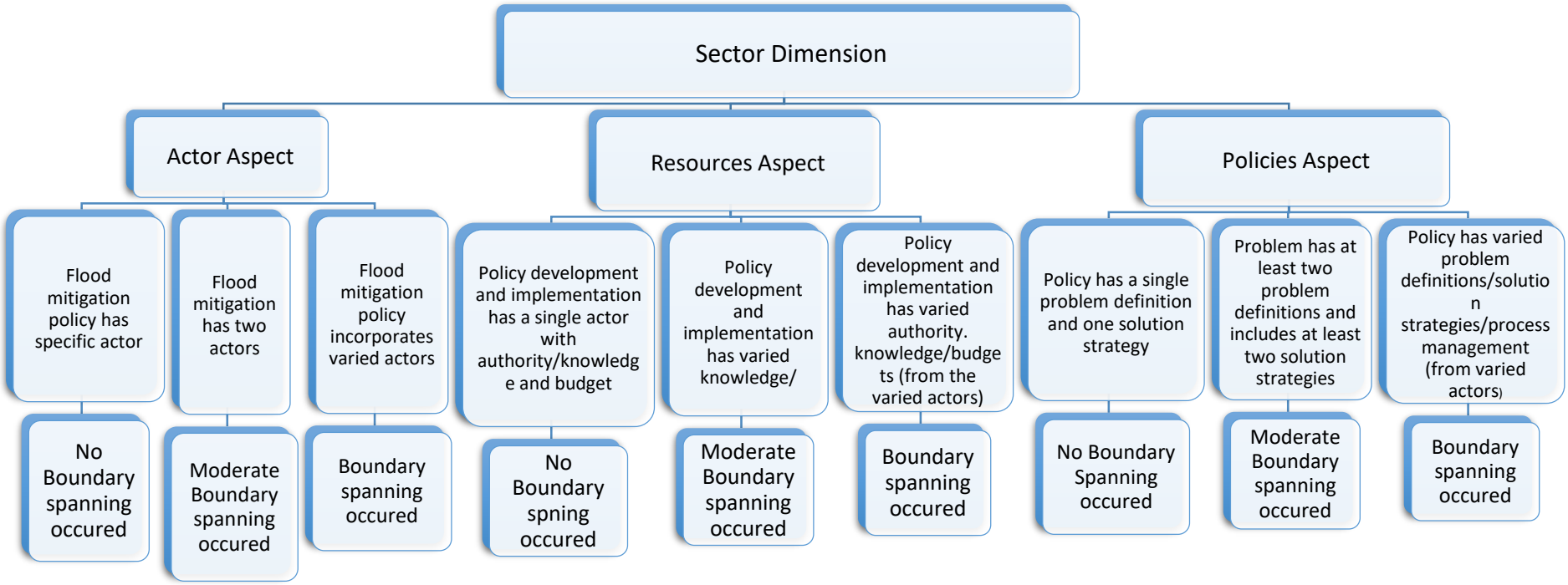

Figure 10: Outline of scheme for analysis of Sector Dimension

The scheme shows that the policy strategies implemented in the cities were analyzed considering the actor, resources and policies aspects. The occurrence or lack of boundary spanning was determined by answering the question under each aspect.

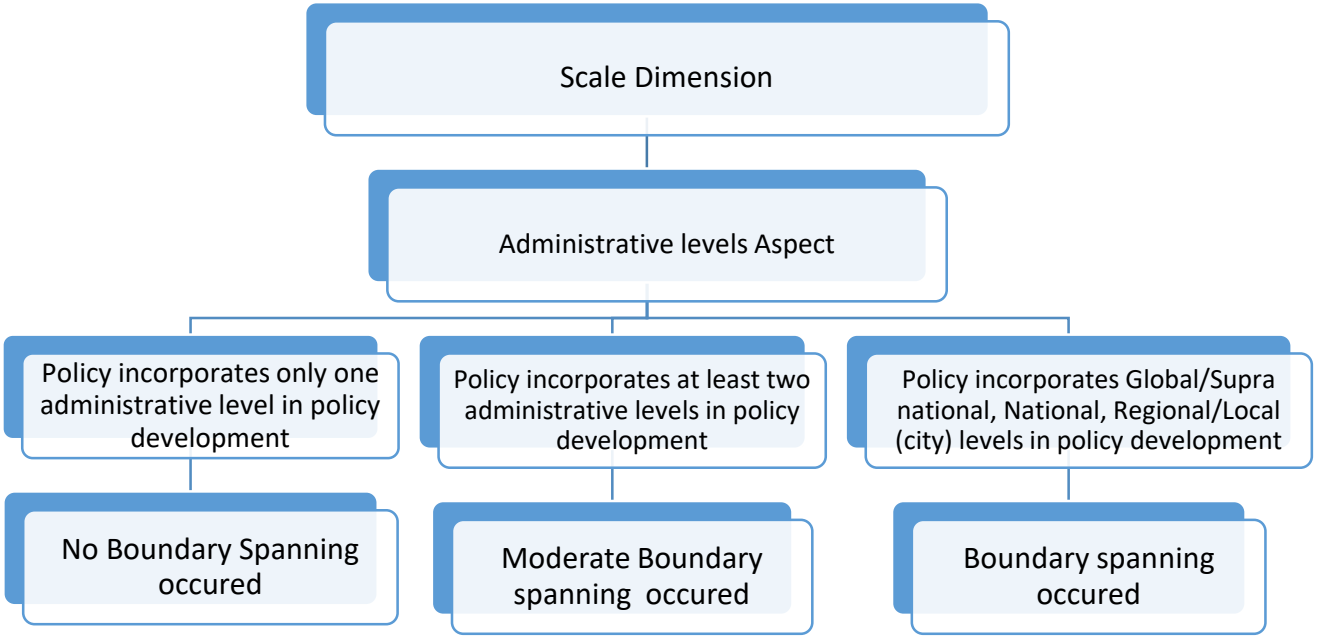

Figure 11:Outline of scheme for analysis of Scale Dimension

The scheme above elucidates how the information in the analysis table for each city was used to determine whether boundary spanning activity occurred in the scale dimension focusing on the administrative levels aspect. This was also determined by answering the question using information in the data analysis tables.

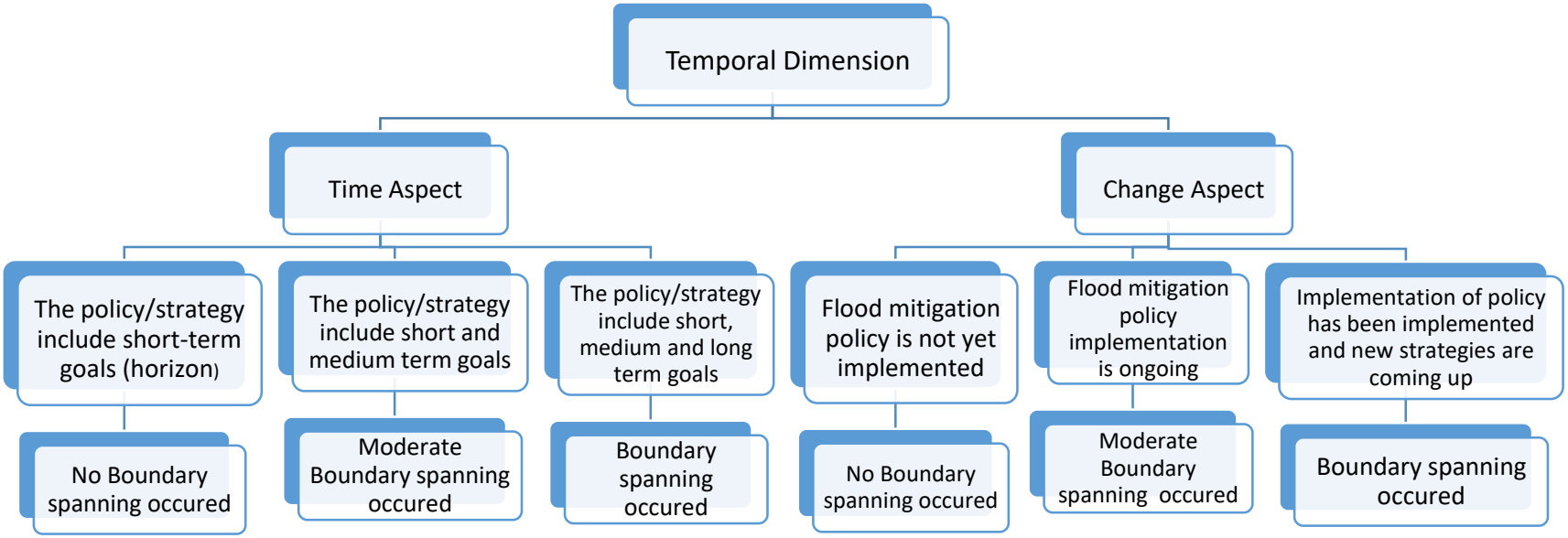

Figure 12: Outline of scheme for analysis of Temporal Dimension

The scheme above is similar to preceding schemes. It was applied in determining whether boundary spanning occurred with regards to the temporal dimension.

4.6.1 Summary of results from the case-studies:

By applying the schemes above a summary results table was developed. The extent to which boundary spanning activities took place in flood mitigation policy development and implementation is depicted in the table below. The presence or absence of multifunctional strategies is also indicated.

Table 11: Summary of boundary spanning results in the cities studied

		CITIES				
		Dordrecht	Rotterdam	Nairobi	Kisumu	Hoboken
BOUNDARY SPANNING ACTIVITIES BY DIMENSIONS AND ASPECTS						
Dimensions	Aspects					
Sector	Actors					
	Resource					
	Policies					
Administrative scale	Local					
	Regional					
	National					
Temporal	Time Horizon					
	Speed of Change					
EXTENT OF APPLICATION OF MULTIFUNCTIONAL STRATEGIES						
Having Multifunctional strategies		YES	YES	PARTIALLY	NO	YES

Key: Little or no boundary spanning.

Moderate boundary spanning

Boundary spanning takes place

4.7 Delineation of resilience results

In addition, the data analysis tables for the cities also had provision for resilience and used varied indicators to estimate the level of resilience in each city. Although the resilience indicators could not be precisely quantified to give a picture of the situation on the ground, the study used qualitative data, through analysis of statements made by respondents, to arrive at conclusions as to the approximate level of each resilience indicator. This is given in 4.7 Summary of results section of this thesis. The summary table also includes an adaptive methods component which

indicates presence (or absence) of either multifunctional strategies or multi-layer safety approaches (or both) in each the city. The schemes depicted by figure 13 and 14 were used to determine the level of resilience by examining indicators using the descriptions that were put forward in the literature review.

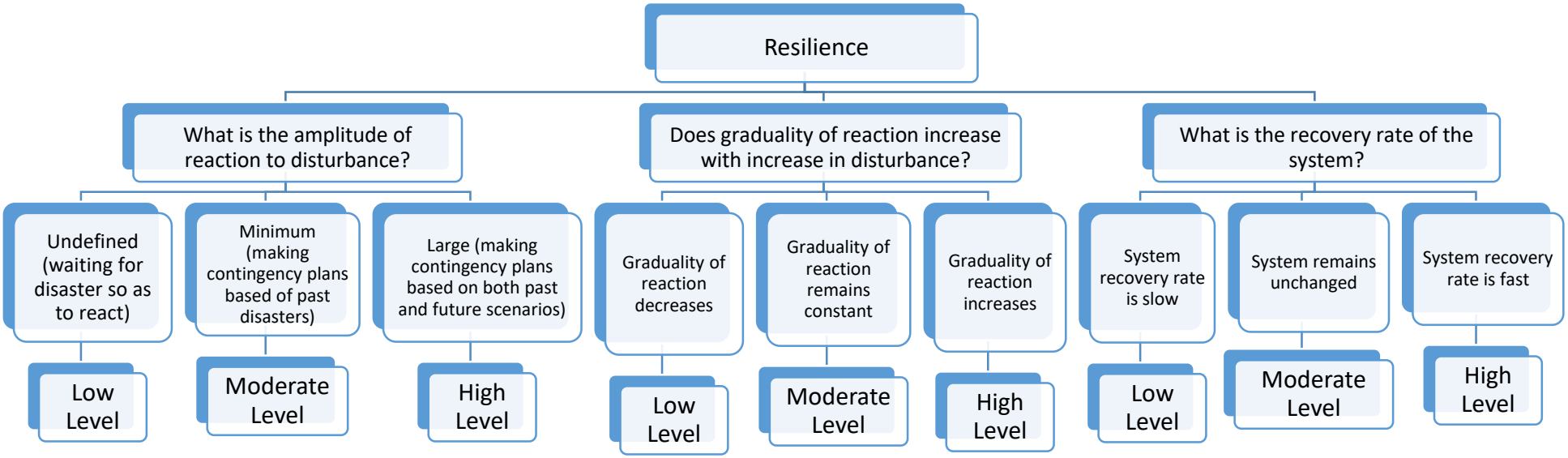

Figure 13: Outline of scheme for analysis of resilience indicators (Part 1)

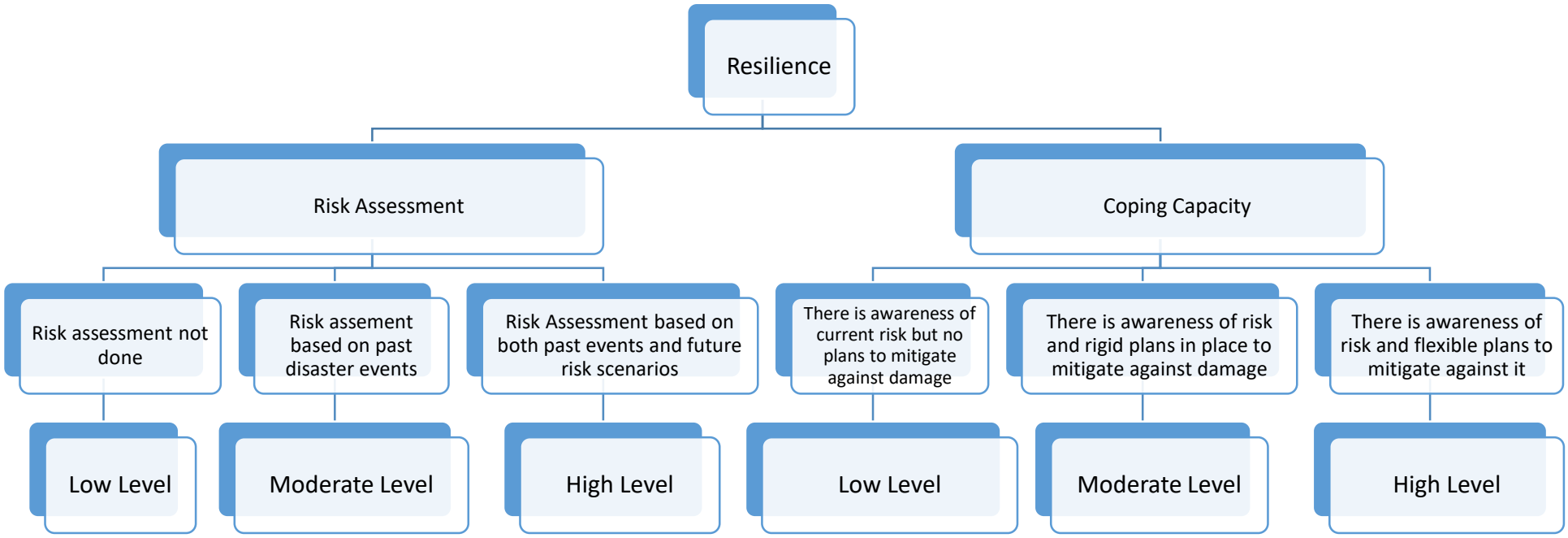

Figure 14: Outline of scheme for analysis of resilience indicators (Part 2)

The study applied a limited number of questions which were sufficient to determine the presence or absence of resilience in a city using the data acquired. The levels of low, moderate and high are estimates inferred, based on data collected. The estimates enabled the study to show the situation in a city which fulfilled the objective of the study. However, these levels are not absolutes and more data is necessary to adequately quantify the resilience indicators in each city.

4.7.1 Summary of results from the case-studies

Using the schemes in figure 13 and 14, the trend in resilience in the cities was determined. This is summarised in Table 12 below:

Table 12: Summary of resilience level results in the cities studied

LEVEL OF RESILIENCE PER INDICATOR						
		Dordrecht	Rotterdam	Nairobi	Kisumu	Hoboken
Resilience	Amplitude of reaction to disturbance	Moderate	Moderate	Low	Low	High
	Graduality of increase of reaction with increasing disturbances	Low	Moderate	Low	Moderate	High
	Recovery rate of a system	High	High	Moderate	Moderate	Moderate
	Risk Assessment	Moderate	High	Moderate	Moderate	High
	Coping capacity	High	High	Moderate	Moderate	Moderate

CHAPTER 5. DISCUSSION AND CONCLUSIONS

In this chapter, the results illustrated in the preceding chapter will be applied to answer the research questions. The answers are based on the data analysis tables and summary table results leading up to the research conclusions.

5.1 Question 1: What factors determine the flood risks and potential for flood damage in the five selected cities?

The study determined that there were numerous factors that influence flood risk and damage in the cities. These factors were classified into four broad categories namely environmental, hydrological, urbanization and population increase and socio-economic factors. As discussed in the literature several of these factors have been highlighted as contributors to the urban flooding phenomena. In addition, Smith (2013) also highlighted these four factors as determinants of flood risk in urban areas. The study determined that these four factors were considered by each of the city policy developers.

5.1.1 Environmental factors

The influence of climatic factors on level of water, heat stress and amount of precipitation was cited with varied emphasis in the cities. Dordrecht considered rise in water level as a major factor since most of the city is below sea level in elevation. Compared to Rotterdam, although most un-embanked areas were above sea level, the management of rainfall run-off was still an issue. As emphasized by Nicholls et al. (2010), low lying delta and coastal areas are at an increased risk of flooding. The increase in precipitation was also identified as a factor in as far as it led to increase of the volume of rivers draining into Dordrecht. In Nairobi and Kisumu the occurrence on heavy rainfall was cited as a major cause of recent flooding. Whereas in Hoboken, the occurrence of rainfall coupled with high tide resulted in storm water flooding, one of the prevalent type of flooding that occurred in the city.

5.1.2 Hydrological factors

The proximity of the cities to river systems, storms from the sea and water run-off were cited by several respondents as a factor that contributed to the flood risk. An example of Dordrecht is the city policy makers observed a combination of threats from the sea and the river as the biggest flood threat while Rotterdam identified storm surge as a major threat. The increase of river volume as a factor influencing flooding in delta areas was also illustrated by De Bruijn et al. (2015). All the

five cities concurred that the increase in rainfall put pressure on their water drainage systems. The problem was especially acute in Hoboken where a combined sewer system for waste water and storm water meant that in case of a hurricane (high rainfall) and a high tide, the system was overwhelmed and pumping water out became difficult. The high water table was cited in Rotterdam and Kisumu as a factor that reduced infiltration rates and increased urban flood risk.

5.1.3 Urbanization and population increase factors

The increase in population has led to development of areas formally not developed. The location of these new infrastructure such as housing and architecture were a major concern in terms of flood risk. It was observed that in Dordrecht, areas outside the dyke ring were being developed despite the flood risk contributing to increased risk. A similar situation was observed in the city of Rotterdam but on a much larger scale. The incidence of flood hazard (flooded streets) was observed to increase due to increase of paved areas in the delta areas.

The change in land use from green to impervious surfaces influenced flood risk in the five cities. For example, in Dordrecht this was cited as a contributing factor to reduced infiltration. The effect of reduced infiltration due to urbanization was put forward by Tingsanchali, (2012) and the effects were observed in all five cities albeit to varying extents. In Kisumu, the building of houses next to riparian areas led to regular displacement of population in the advent of heavy rainfall. While in Hoboken, urbanization meant clearing of coastal vegetation making the coastline more vulnerable to storms. The study found that population increase resulted in development of urban areas leading to a change in the water cycle due to decrease infiltration as outlined by Tucci, (2006) and change in land use as illustrated by Zevenbergen et al. (2008). Hence urbanization and population increase influenced flood risk in the cities.

5.1.4 Socio-economic factors

The socio-economic effects of floods were important in determining flood risk as they relate to how floods directly affect the residents of the five cities. In general, the larger the flood risk, the more severe the expected socio-economic effect. As advanced by Rojas et al. (2013), the social–economic consequences of floods in river areas due to climate change are real. The effect of floods on service infrastructure such as highways is considered very serious in Dordrecht. The effect on buildings and homes was considered serious while the effect on floods to areas adjacent to buildings was viewed as somewhat serious. The situation is different in Rotterdam with 49% of

the serviceable areas above sea level, the city may seem in a better position to cope with floods. In reality, with key utilities such as the central station below sea level, and major business installations such as oil refineries not fully aware of effects of floods on their processes, the city of Rotterdam considers itself to have a high flood risk. Rotterdam flood risk therefore is highly influenced by socio-economic factors. In Nairobi, damage to roads and business premises were cited as the major economic impact of urban floods experienced while in Kisumu, displacement of persons was a strong social factor that determined risk assessment. In Hoboken, the safety of energy infrastructure such as electricity transmission lines was a focus on coping with urban flood risk as was enforcement of building codes that promoted flood proof infrastructure. These observations led to the conclusion that socio-economic factors did determine flood risk in the five cities.

5.1.5 Conclusion on question 1

The climate related factors such as hydrology and environment continue to be the focus of flood risk assessment in the varied cities. However, the study found that there is an emergence of more socially oriented factors that were categorized as urbanization and social-economic factors. The increase in population has led to prominence of spatial planning as an element of flood resilience planning. Concurrently, the consideration of the safety of utilities such as electricity, energy, drinking water to prevent socio-economic damage through floods, has also gained importance. Flood mitigation policy hence has to consider the uncertainty occasioned by climate change effects on weather conditions, as well as social-economic considerations, population growth and urbanization. This can be ideally be achieved through boundary spanning on problem definition (policy), actor and stakeholder aspects.

5.2 Question 2: What are the flood policies developed in the five selected cities?

The flood mitigation policies identified from the five cities covered the following topics: safety, evacuation, risk assessment, infiltration, coping capacity and multifunctional strategies to mitigate against floods. The cities are the local level of government in the countries investigated. Thus, they have limited capacity in terms of funds at their disposal, and authority to develop policy. However, through involvement of the regional authority or independently, cities develop flood mitigation strategies in line with their perceived risks. By examining the case-studies it was found that

Dordrecht was developing a policy to govern evacuation of civilians in case of a flood as well as regulating development to remain within the dyke ring. In Rotterdam, the city authorities are trying to influence national policy processes to consider spatial planning and evacuation strategies during flood mitigation policy development. Rotterdam is also implementing the Rotterdam Climate Adaptation Strategy to govern effects of climate change in the city. The situation in Nairobi, Kenya was slightly different where focus was on coping with floods through environmental regulation and disaster management efforts by the regional government. Meanwhile, in Kisumu, Kenya the development of policy to prevent encroachment of land bordering rivers and enable coping with floods are the responsibility of the regional authority with input from city authority. In Hoboken, more was done on regulation of spatial planning by using building codes regulation set by the city authorities.

Although the policies varied in nature, an over-riding characteristic is that cooperation with the regional authority lead to implementation of strategies. For instance, in the Netherlands, the Rijnmond – Drechtsteden strategy that involved cities (among which were Dordrecht and Rotterdam) and the regional authority (water boards), carried out comprehensive flood risk assessment and solution strategies. In Kisumu and Nairobi, the direct involvement of regional authorities (county government) have meant availability of more funds to tackle floods, even though challenges in application of capacity remain major obstacles.

5.2.1 Conclusion on question 2

The cities' flood policy showed awareness of the increased threat of flooding effectuated by the uncertainties of climate change. Yet, despite this similarity, the study established that the cities have taken two varied approaches to mitigate against floods. The approaches can be broadly termed as either reactionary or progressive in character. Kisumu, Nairobi and Hoboken have experienced floods in the recent years and predominantly base their risk assessment and mitigation measures, to reflect lessons learned from these incidents. Thus the policies in these three cities lean towards reactionary character. On the other hand, although Rotterdam and Dordrecht experience street floods, the risk assessment and mitigation measures in these cities have a progressive (futuristic) character looking at best and worst case scenarios in the event of flooding, and using these scenarios to plan. What is engaging is that regardless of the character of the policy,

adaptive measures are feasible as exemplified by developments in both Hoboken (policy reactionary in character) and Rotterdam (policy progressive in character).

5.3 Question 3: To what extent do the adaptive flood policies in cities adopt multifunctional goals, particularly addressing ecosystem services?

For flood policies to adopt multifunctional goals, they need to be adaptive, Lulofs and Bressers (2010); Van Buuren et al., (2013). This means they are flexible, innovative and span boundaries, Lulofs and Bressers (2010). This study used boundary judgment assessments based on CIT to examine the extent to which flood policies applied in the cities span boundaries in order to adopt multifunctional goals. Therefore the dimensions of sector, administrative levels and time were applied to determine the character of flood policies in the cities. This was done on the premise that the more adaptive the policy, the more like it was to adopt multifunctional strategies including the use of ecosystem services.

5.3.1 Extent of Boundary spanning in city policy making

The results showed that Rotterdam had an adaptive strategy as the city incorporated large businesses, neighbouring cities, water boards and national government, spanning actor and administrative scales. Further, Rotterdam is looking into areas ignored by the National policy such as spatial planning regulation, evacuation strategy as well as safety of un-embanked areas, spanning problem definition, solution strategies and process management. The city has set milestones and scenarios bound by time thereby spanning temporal scales. Based on these findings, policy in Rotterdam may be said to be strongly adaptive.

Dordrecht applied regional inter-city collaboration mechanisms to span administrative scales. Dordrecht also actively engaged regional authorities to formulate a comprehensive multi-layer safety strategy (evacuation plan). The city however does not engage with non-governmental stakeholders. Dordrecht has applied risk assessment to develop evacuation strategies that go beyond current risks to envision worst case scenarios. For flood mitigation, the city relies on national and regional policy. The flood mitigation policy in Dordrecht is therefore adaptive with room for further boundary spanning.

In Kenya, both Nairobi and Kisumu cities rely on the regional authorities for flood mitigation policy. Within the regional authorities, collaboration between departments such as environment and disaster management takes place resulting in spanning of actors and resources. However, this sometimes leads to multiplicity of roles in the collaborating departments. Due to the condition of existing infrastructure, focus of policy in the cities is on repair, maintenance and expansion to manage flood occurrence, minimize damage to utilities and safe-guard lives. Flood mitigation policy in Kisumu and Nairobi is not adaptive as it does not incorporate time horizon and implementation of innovative solution.

In Hoboken, the flood mitigation policy uses structural and non-structural approaches. It spans boundaries in problem definition, solution strategies and process management. The city has collaboration with state and federal government therefore spanning administrative scales in policy development. Hoboken has issued new building codes since the occurrence of Hurricane Sandy and is implementing protection of its utilities. They have span knowledge and resources boundaries. The policy applied in Hoboken is adaptive with room for further boundary spanning.

5.3.2 Extent of adoption of multifunctional goals and utilize ecosystem services

Rotterdam and Dordrecht use multifunctional flood mitigation strategies. Rotterdam has a strategy for climate adaptation in which city water squares and parking garages are used for flood water storage within the city. In addition, ecosystem services such as green roofs and development of urban flood plains is a multifunctional strategy applied in Rotterdam. These strategies have enhanced Rotterdam's attractiveness as well as economic value. Dordrecht has also utilized ecosystem services by expansion of a wetland area national park neighbouring the city. This promotes conservation of biodiversity, enhances tidal flood coping capacity of Dordrecht while at the same time adding to its aesthetic. In Nairobi and Kisumu, an emphasis is given to policy that enhance coping capacity of the city such as improvements of drainage and designating of shelters in case of flooding. Multifunctional goals are not applied. In Hoboken, plans to utilize ecosystem services are being explored such as green infrastructure and development of urban parks. The city is aware of multifunctional strategies and plans to implement some.

5.3.3 Conclusion on question 3

The results of the study support the assertion that the more adaptive the flood mitigation policy, the greater the extent to which multifunctional goals are implemented in the city.

5.4 Question 4: Based on the comparison of the assessments in five cities, what are lessons learned for the cities to improve their climate resilience?

5.4.1 Adoption of ecosystem services for urban flood mitigation

All five city authorities recognised climate change as a contributor to increased rate of urban flooding. The cities as trying to build on their coping capacity using multi-layer safety measures and evacuation strategies. In Kisumu and Nairobi, the involvement of socially concerned non-governmental organisations such as the Red Cross has further enhanced their coping capacity and recovery rate. This is an indication of resilience. In Hoboken, recent building codes such as wet proofing enhance resilience. The protection considerations for utilities such as electricity supply in Rotterdam and energy installations in Hoboken are another way to strengthen resilience. Nevertheless, more than a reactionary stance needs to be taken. The need to actively seek out opportunities presented by heavy rainfall due to climate change is shrugged upon by the graduality of the impact of climate change. The use of ecosystem services from flood water presents an opportunity to abstract social as well as economic value from increased rainfall. This will at the same time mitigate against urban flooding.

With the exception of Rotterdam, the cities seemed reluctant to take up use of ecosystem services due to the perceived cost implications. The cost-benefit analysis on the additional value of ecosystem services in flood mitigation strategies are inconclusive. According to De Groot et al., (2010), this (inconclusiveness) is due to challenges such as integration with spatial planning and inclusion of ecosystem considerations in policy development. In some instances, such as those highlighted by Constanza et al., (2008), establishment of wetland ecosystems such as mangrove forests, have proved effective for hurricane protection. Further, Brauman et al., (2007), investigated the cost benefit analysis of ecosystem services and found them to have viable hydrological benefits.

5.4.2 Conclusion on question 4

The potential of use of ecosystem services to reduce effects of increased rainfall and enhance resilience of urban areas is downplayed. Nonetheless, the additional benefits with regards to achieving environmental conservation goals, social benefits such as providing leisure parks and economic benefits such as increasing the attractiveness of the city may be worth the effort in view

of resilience. The use of ecosystem services from rainfall would enable the cities to increase their capacity to cope with increased precipitation due to climate change effects. An example of this is the water squares in Rotterdam which serve as a basketball court and leisure area when the weather is dry, and provide aesthetic value and storage of rainwater when there is excess rainfall.

CHAPTER 6. RECOMMENDATIONS

6.1 Enhanced boundary spanning strategies

The research hitherto established the connection between boundary spanning activities and development of adaptive policy. The advantage of carrying out boundary spanning activities is that it would allow for development of innovative ideas, in fostering urban resilience to floods. A prevalent situation in each of the countries is that policy development was a responsibility of a specific level of administration. For instance, the regional level in Kenya, the national level in The Netherlands and local level in Hoboken. The research found that effective development and implementation of adaptive flood policy needed involvement of additional actors such as different levels of government, urban spatial planners, local/regional safety authorities, disaster management and knowledge institutes. This involvement requires new definitions of domains by current actors so as to include more actors in the policy process. The current actors are concerned municipalities, regional authorities and national level of government.

Although these actors cooperate to varied extents in terms of flood policy implementation. It is the spanning of problem definitions and solutions strategies aspects that will advance an adaptive policy making process. This means that actors need to formulate common goals and then work at implementing them. The common goal setting will also increase the level of motivation for implementation, and pool resources needed for the implementation. The advantage of boundary spanning is not limited to adaptive flood policy formulation. The spanning of interpretations is more likely to address the environment, hydrologic, urbanization and socio-economic factors determining flood risk across cities.

6.1.1 Reactionary policy also needs to span time boundaries

A common assumption is that policy of a reactionary character tends to be in the short-term time horizon. Therefore, flood policy-makers provide for temporary camps and relief supplies in addition to evacuation of residents affected by floods in delta areas. The study recommends that this is also the time to set more medium and long- term goals in urban flood mitigation. When the effects of flooding are fresh in the minds of actors and stakeholders, it will be easier to push for review of the short-falls of current strategy. During this reaction period, it is also easier to secure public funding, for implementation of adaptive strategies, which is determined by politicians who will be eager to sway positive public opinion as to their response to a flooding disaster. It is only

prudent that policy-makers take advantage of such opportunities to span the time boundaries in their flood mitigation strategies to include preventive (multifunctional) measures as well.

6.1.2 Caution in boundary spanning

Notwithstanding the benefits of boundary spanning to tackle varied policy aspirations. Care must be taken so that the boundary spanning process does not turn into a hindrance for adaptive policy making. The involvement of more actors can sometimes lead to a stale mate when actors fail to agree or worse a duplicity of functions due to misinterpreted authority levels. Therefore the boundary spanning arena should be clearly thought out in terms of what common interests actors share and can cooperate in, so as to set common goals. In addition, time limits to the negation process also help to improve focus. Further, clear designation of roles each actor plays to enhance development, and later ensure implementation of adaptive flood policy, need to be made to limit duplicity of functions as was observed in the policy making in cities in Kenya.

Here, however, a reversal to the caution above is that where the responsibility of actors already overlap, the common interest (goals) could serve as a point of cooperation and ease the boundary spanning process. This would inadvertently improve on flexibility and reduce redundancy during policy development and implementation process.

6.2 Opportunities to enhance fresh water supply in cities

Climate change creates uncertainty as to future rainfall amounts. For instance, in Kenya the effects include periods of heavy rainfall followed by prolonged drought. The importance of capture, treatment and storage of rainfall cannot be over-emphasized. In Rotterdam, the lack of fresh water supply in cities was cited as a possible future challenge. In these circumstances, the water from rainfall presents a possible source of fresh water supply for the cities. Already Nairobi experiences acute water shortage in the dry season resulting in rationing of tap water services, (Standard Digital, 2017). The use of multifunctional strategies such as rain capture on roof tops in urban areas may allay the fresh water challenge and at the same time mitigate against flooding of roads and streets. Policy-makers in the city need to re-think spatial planning so as to tap into this naturally availed resource so as to enhance resilience of cities by safe-guarding fresh water supply.

6.3 Involvement of non-governmental organizations to enhance coping capacity

Flood policy formulation and implementation is primary a function of the government albeit at different levels. However, a challenge faced by implementers of policy is the capacity to carry out certain tasks on a certain scale and at short notice. This is due to the usual suddenness of flood events. These tasks include but are not limited to evacuation of affected residents as well as raising awareness on potential flood risks and how to react when affected. An effective way in which these implementation goals can be achieved is by involving others stakeholders (apart from governmental authorities) in the planning phase. Socially oriented organizations such as the Red Cross and St. John's Ambulance already play a vital role in some cities' evacuation plans. Though plans to tap into these dormant social partners are being explored, this study would like to emphasize that this is an opportunity to build coping capacity with minimum input of government resources.

The media are also an enterprise which if approached could assist in raising awareness of communities that are resident in flood prone delta and coastal areas. The media can serve as an educational tool to reach a wide demographic of residents, even those previously not affected by floods.

6.4 Setting multifunctional goals in flood mitigation

The study proposes that in order to meet increasing societal and economic demands, policy makers need to set multifunctional goals in flood mitigation in order to 'kill two birds with one stone'. The birds referring to flood mitigation on one hand and socio-economic considerations on the other. The setting of multifunctional goals will also allow for saving of resources as effort will be made once to achieve varied results. An example of setting a multifunctional goal is the vision of a dyke that would serve as a road underground and a leisure park above ground. This kind of goal would alleviate flood threat using the dyke, provide public utility (road) and satisfy social demands (leisure park), all at the same time. The goal would in this way transverse varied societal needs such as safety and an aesthetic city, ergo saving money in the long run. Hence, policy makers should look into more solutions with multifunctional ends.

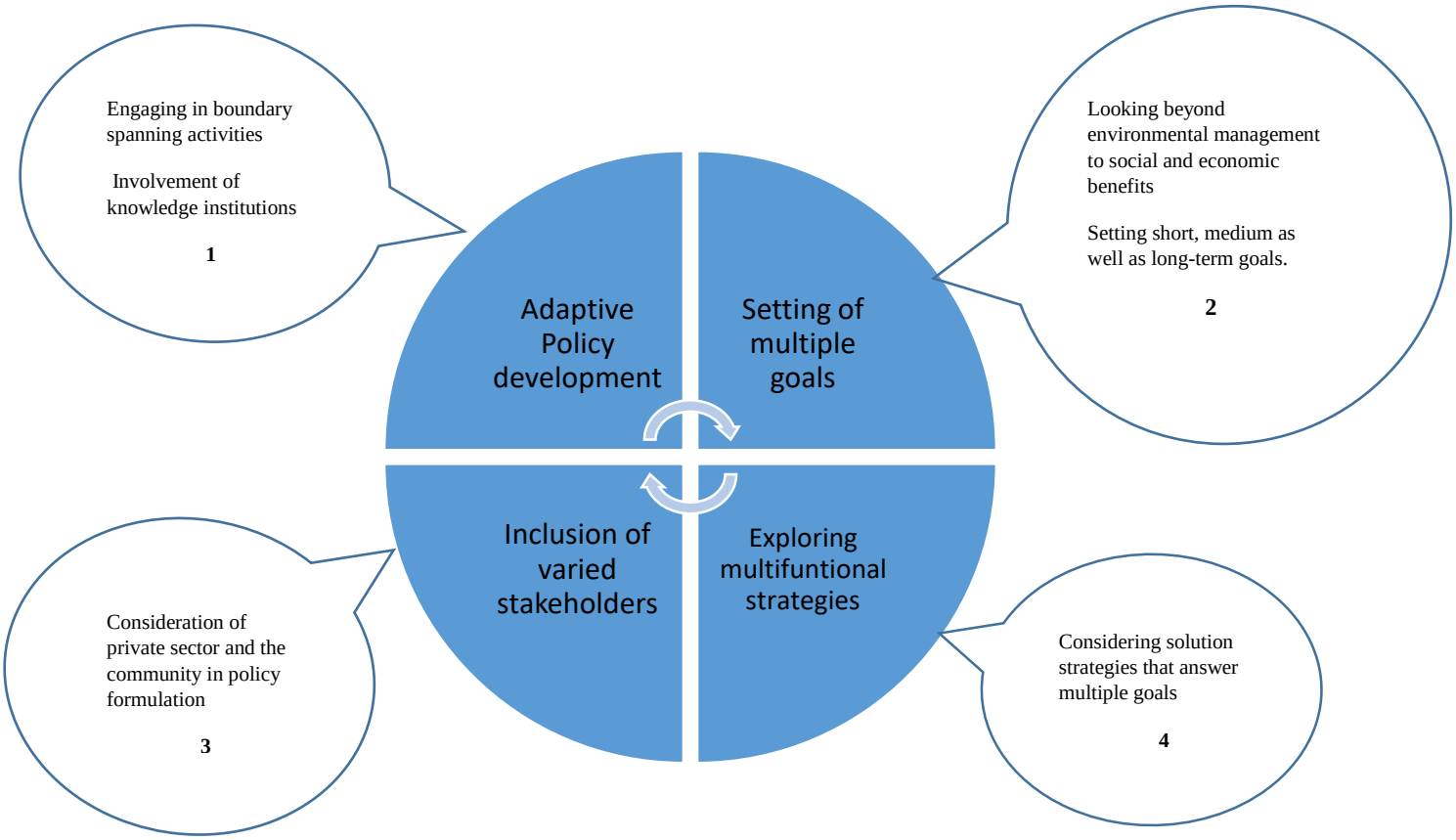

Figure 15: Summary of recommendations on adaptive flood mitigation strategies

The figure 15 above depicts the role in boundary spanning through activities in 1, 2, 3 and 4 in the development of adaptive flood mitigation policy. The enablers of adaptive policy have been explained in the preceding recommendations in section 6.1 to 6.4 of the thesis.

6.5 Recommendation for further research

The study gives an indication of the effect of boundary spanning on the development of adaptive flood policy. It focused on the local and middle (regional) level actors in policy development. This was to accomplish the research objective which was to assess the influence of flood governance strategies on utilization of diverse multifunctional strategies and multi-layer safety options; so as to distil lessons that will enhance climate resilience. However, further research on the cost and benefits of applying multifunctional flood mitigation strategies is required. In addition, the study focused on city level but it became apparent that more administrative levels are involved in flood mitigation policy development and implementation A study that incorporates views from all actors participating directly, and indirectly I urban water governance and flood mitigation is required.

In addition, although opportunities for adaptive flood mitigation through boundary spanning activities have been identified by this study, as shown in figure 15, the way in which these activities can be actualized was not investigated. Previous work by Lulofs and Bressers, (2010) has

identified varied types of linkages that can be applied in boundary spanning. The evaluation of how application of these linkages in the context of different cities around the globe would also provide insights on how to handle flood disaster. The recent floods by monsoon rains in South East Asia and rainfall due to Hurricane Harvey in Houston, Texas emphasize the importance and relevance of this area of study. The effects of climate change on weather patterns and intensity is real and informed policy development is the key to protecting property and saving lives.

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APPENDICES

Appendix one:

Interview Questions for city policy-makers, planners and experts in..... City.

SECTION 1 GOVERNANCE OF FLOOD RISK IN..... City.

1. Describe how flood risk is determined in..... (City).....?
2. A) How is flood mitigation organized in..... (City).....?
   B) What is your role in flood mitigation in..... (City).....?
3. What is the role of the local managers? What is the role of regional managers? What is the role of national managers? (In flood risk management of the Rotterdam Area)
4. Do the managers represent any special interests? If yes, which/who's interests?
5. What policy/ plan/ programme is currently implemented in ... (city).... to manage floods?
6. Is climate resilience addressed in this policies? How is it addressed?
7. How has the plan been implemented so far?
8. Who are the persons of responsibility/organizations (actors) recognized to be important in flood management in the..... (City).....?
9. Who are the other stakeholders in flood management? Which interests are important to each stakeholder? Are there any stakeholder interests that are similar to local government flood management interests?
10. Are there any conflicts in interests? How are these conflicts handled?
11. How does the municipality involve stakeholders in policy/plan/programmes?
12. How does current and future development plans affect each stakeholder?
13. How does municipality flood mitigation policy/plan/programme address maintenance of the measures in place for flood protection? (Sustainability – availability for future generations' use)
14. What development/change in policy is expected in the City to enhance flood mitigation?
15. What considerations have been made for multifunctional use of flood water?

SECTION 2 MULTIFUCTIONAL USE OF FLOOD WATER IN THE CITY OF.....

1. Which multifunctional services have been identified by the municipality? (from flood water)

2. Are there plans to develop the services above? Who develops these multifunctional services?
3. How does the multifunctional use of flood water benefit the providers/users?
4. Does the municipality (administration) benefit from this multifunctional use of flood water (ecosystem services)?
5. Do the beneficiaries (community) pay for the use of the ecosystem services from flood water?

Appendix two:

INTERVIEW/QUESTIONNAIRE CONSENT FORM

Fostering Climate Resilience in Cities: An analysis of adaptive policy strategies to mitigate urban flooding by utilizing multifunctional systems.

This form is given to protect the rights of the participant and fulfil ethical considerations in the above titled research. The purpose of the research are already explained in the introductory letter accompanying this consent form.

Dear participant, kindly read and reply to the declaration below:

I declare to be informed about the nature, method and purpose of the investigation. I voluntarily agree to take part in this study. I keep the right to terminate my participation in this study without giving a reason at any time.

My responses may be used solely for the purposes of this study. In its publications, they may *(please tick one of the options):*

O be cited with my name or function revealed

O be cited anonymously, thus without identifying context

O only used as information source

During the course of the interview I keep the right to restrict the use of (some of) my answers further than indicated above.

Name participant: …..…….....

Date: ……..……Signature participant: …...……

I declare to fully adhere to the above.

Name researcher: …….

Date: ……..…… Signature researcher: ……....……...

QUESTIONNAIRE

These questions have been prepared by Hellen Lillian Atieno Dawo, a master student conducting research in the course *Environmental and Energy Management* offered at the University of Twente. She is supervised by Dr. Kris Lulofs and Dr. Gül Ozerol. The research aims to assess the influence of flood governance strategies on utilization of diverse and multifunctional options such as ecosystem services in Drechtsteden, the Netherlands; Hoboken, New Jersey and Nairobi, Kenya; so as to distill lessons that will enhance climate resilience.

Target Audience

The questionnaire targets the primary authorities managing flood mitigation in the city. Depending on the country they may be municipal or metropolitan departments, regional authorities, service providers, regulators or de-concentrated bodies at the local, regional or national level.

BACKGROUND OF RESPONDENT

Government/City Department Name	
Respondent(s) name	
Position	
Email	
Telephone	
Website	

These following interview questions will enable the analysis of flood mitigation policy applied in participating cities. The questions will be in three sections:

Section 1- will address factors used to determine flood risks and potential for flood damage in the cities.

Section 2 - will address flood mitigation policies developed in the cities.

Section 3 - will address the extent to which the flood policies in cities adopt multifunctional goals such as utilization of ecosystem services.

All the information collected will be treated in confidence, however if the interviewee would like recognition for his/her input, this can also be effected. The questionnaire will take approximately two hours to complete, but comprehensive responses will be extremely valuable to the analysis. Kindly, only tick one level for each indicator per question.

Terminologies used in the questionnaire

Flood: The overflowing of the normal confines of a stream or other body of water leading to accumulation of water that are normally not submerged. These includes river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal and delta floods.

Levels of governments:

Local: municipalities

Regional: state, region, province, county or autonomous community government

National or Central: central or federal government

Supranational: formal legal authority, decision-making power, soft law (guidelines, recommendations) or conditional transfer from an institution (for example European Union) or international body (World Bank) to member states.

Urban Area: one or several central cities and surrounding areas that are socio-economically connected to central city/cities

Multilevel governance: explicit or implicit sharing of policymaking authority, responsibility, development and implementation at different administrative and geographical levels.

Stakeholder engagement: involvement of persons or groups having stakes in flood water management, being directly or indirectly influenced by flood water policy, and/or having the ability to influence the outcome either positively or negatively.

Flood water governance: it involves who does what, when and how. It circumscribes political, institutional and administrative rules, practices and processes through which stakeholders communicate their interests, concerns considered and decisions are taken and implemented, decision-makers are held accountable to development and management of flood mitigation strategies in the city.

Preamble

Kindly indicate the top 7 words you most often associate with managing flood water in cities, ranking from 1 to 7 the options from the list suggested below or your own consideration

1. *adaptive governance*
2. *awareness*
3. *bottom-up*
4. *Capacity*
5. *Climate change*
6. *Close loops/dependency*
7. *coherency*
8. *Coordination*
9. *Complexity*
10. *Conflicts*
11. *Costs*
12. *Crisis*
13. *Data/information*
14. *Decentralization*
15. *Demographic change*
16. *Drainage*
17. *Economy of scale/scope*
18. *Efficiency*
19. *Financing*
20. *Flexibility*
21. *Fragmentation*
22. *Green*
23. *Infrastructure*
24. *Innovation*
25. *Integration*
26. *Local*
27. *Opportunities for improvement*
28. *Partnerships*
29. *Pollution*
30. *Procurement*
31. *Public/private*
32. *Rainwater*
33. *Regulation*
34. *Resilience*
35. *Transport*
36. *Scarcity*
37. *Smart systems*
38. *Stakeholder*
39. *Tariffs*
40. *Top-down*
41. *Trust*
42. *Uncertainty*
43. *Urbanization*
44. *Water allocation*
45. *Water reuse*

W^0 1:
W^0 2:
W^0 3:
W^0 4:
W^0 5:
W^0 6:
W^0 7:

Section 1 Examination of factors used to determine flood risks and potential for flood damage in the city.

1.1. Which of the following hazards from floods are most prominent in your city/urban area?

Level of prominence / Effect of flooding	Always/ very frequently	Slightly frequent	Somewhat frequent	Neutral	Somewhat rare	Slightly rare	Never/ very rare
High water velocities may carry automobiles, houses, bridges and rocks	☐	☐	☐	☐	☐	☐	☐
Massive erosion may undermine bridges, levees and buildings	☐	☐	☐	☐	☐	☐	☐
Water damage to homes and offices	☐	☐	☐	☐	☐	☐	☐
Flooding of farm land resulting in crop loss	☐	☐	☐	☐	☐	☐	☐
Loss of human life	☐	☐	☐	☐	☐	☐	☐
Health hazard- Floodwaters may concentrate debris garbage and toxic pollutants	☐	☐	☐	☐	☐	☐	☐
Disruption of drinking water supply services	☐	☐	☐	☐	☐	☐	☐
Disruption of gas and/or electricity supply services	☐	☐	☐	☐	☐	☐	☐
Disruption of transportation services	☐	☐	☐	☐	☐	☐	☐
Disruption of food supply to urban area	☐	☐	☐	☐	☐	☐	☐
Loss of jobs and business due to flood damage	☐	☐	☐	☐	☐	☐	☐
Increase in insurance rate	☐	☐	☐	☐	☐	☐	☐
Corruption due to misuse of relief funds	☐	☐	☐	☐	☐	☐	☐
Disruption/destruction of habitats/ecosystems	☐	☐	☐	☐	☐	☐	☐

1.2. Which kind of risk assessment methodology is applied in your city?

Method in use	Type of analysis	Type of hazard	Outcomes/Products	Yes	No	Both
Hazard analysis process	For example, hazard modeling, use of historic data, expert judgment	Urban flooding	Maps, hazard zones, municipal hazard classification	☐	☐	☐
Vulnerability analysis process	For example use of past damage data for developing curves, mapping of buildings and/or infrastructure, mapping of socio-economic data such as income, age; use of vulnerability indices	Urban flooding	Vulnerable curves, vulnerability curves	☐	☐	☐

1.3 Which of the following factors influence flood risk assessment in your city?

Factor	Definition	Strongly disagree	Disagree	Disagree somewhat	Neutral	Agree somewhat	Agree	Strongly agree
Climate change; *precipitation-*	sudden change in duration, intensity, amount, location and seasonality	☐	☐	☐	☐	☐	☐	☐
Run-off; *urbanization* –	change in urban management with green field and pervious surfaces covered by less pervious materials	☐	☐	☐	☐	☐	☐	☐
Run-off; *management of peri-urban rural land* –	management of land adjacent to urban areas that influence run-off into urban area (e.g. mud floods)	☐	☐	☐	☐	☐	☐	☐
Urban conveyance systems and processes								
Environmental management and regulation-	management of green areas within urban landscape	☐	☐	☐	☐	☐	☐	☐
Urban conveyance systems and processes								

Factor	Definition	Strongly disagree	Disagree	Disagree somewhat	Neutral	Agree somewhat	Agree	Strongly agree
Urban watercourse conveyance, blockage and sedimentation-	process associated with above ground overland surface flow in natural watercourses and man-made systems	☐	☐	☐	☐	☐	☐	☐
Sewer conveyance, blockage and sedimentation –	process that occur in below-ground drainage systems	☐	☐	☐	☐	☐	☐	☐
Impact of external flooding on intra-urban drainage systems-	loss of conveyance and serviceability in below-ground drainage systems due to flooding from external sources	☐	☐	☐	☐	☐	☐	☐
Intra-urban asset deterioration –	change in performance, condition and serviceability of urban drainage assets	☐	☐	☐	☐	☐	☐	☐

Definition of factors courtesy of Future Flooding and Coastal Erosion Risks; Eds. Colin R. Thorne, Edward P. Evans, Edmund Charles Penning-Rowsell (2007). Thomas Telford.

1.4. To which extent are the flood damage types below, considered during flood risk assessment?

Types of flooding damage	Very serious	serious	Somewhat serious	Neutral	Somewhat unimportant	Unimportant	Very unimportant
Flooding of private buildings	☐	☐	☐	☐	☐	☐	☐
Flooding of public buildings	☐	☐	☐	☐	☐	☐	☐
Flooding of highways	☐	☐	☐	☐	☐	☐	☐
Flooding of homes	☐	☐	☐	☐	☐	☐	☐
Flooding adjacent to property	☐	☐	☐	☐	☐	☐	☐

1.5. How would you characterize the condition of your overall existing flood risk assessment system?

The flood assessment system:	Yes	No
Needs critical improvement	☐	☐
Needs significant improvement	☐	☐
Needs minor improvement	☐	☐
Is performing as designed	☐	☐
Is performing as designed but needs to be improved.	☐	☐
Needs no improvement	☐	☐

Section 2 Character of Flood mitigation policies developed in the city.

2.1. What is the level of influence of each of the following factors on flood mitigation policy development in your city now or in the future?

Factors	Extremely not important	Moderately not important	Slightly not important	Neutral	Slightly important	Moderately important	Extremely important (Critical)
Economic, social and environmental factors							
Climate change	☐	☐	☐	☐	☐	☐	☐
Economic constraints	☐	☐	☐	☐	☐	☐	☐
Fiscal consolidation measures	☐	☐	☐	☐	☐	☐	☐
Growing population	☐	☐	☐	☐	☐	☐	☐
Shrinking population	☐	☐	☐	☐	☐	☐	
Urban infrastructure growth (increasing artificial land with built-up cover or urban use)	☐	☐	☐	☐	☐	☐	☐
Poverty and social inequalities	☐	☐	☐	☐	☐	☐	☐
Crisis/ emergency –driven management	☐	☐	☐	☐	☐	☐	☐
Governance influence on flood mitigation policy	**Extremely not important**	**Moderately not important**	**Slightly not important**	**Neutral**	**Slightly important**	**Moderately important**	**Extremely important (Critical)**
International (hard and soft) laws and regulations (standards, recommendations, norms, guidelines)	☐	☐	☐	☐	☐	☐	☐
National (hard and soft) laws and regulations	☐	☐	☐	☐	☐	☐	☐
Territorial reforms (mergers of regions/provinces, municipalities)	☐	☐	☐	☐	☐	☐	☐
Decentralization/re-allocation of competences	☐	☐	☐	☐	☐	☐	☐
Liberalization/ privatization trends	☐	☐	☐	☐	☐	☐	☐

Factors	Extremely not important	Moderately not important	Slightly not important	Neutral	Slightly important	Moderately important	Extremely important (Critical)
Flood water associated influence							
Increased attention to flood water in the political agenda	☐	☐	☐	☐	☐	☐	☐
Ageing, obsolete infrastructure/Lack of infrastructure	☐	☐	☐	☐	☐	☐	☐
Competition over water allocation	☐	☐	☐	☐	☐	☐	☐
Extreme events such as floods or heat waves	☐	☐	☐	☐	☐	☐	☐
Water ways pollution (obstruction of drainage and damage to levees/dykes)	☐	☐	☐	☐	☐	☐	☐

2.2. What is the influence of the following policy areas on flood water governance in your city?

Sectors and issues related to flooding	Extremely not important	Moderately not important	Slightly not important	Neutral	Slightly important	Moderately important	Extremely important (Critical)
Land use and spatial planning	☐	☐	☐	☐	☐	☐	☐
Building codes and housing	☐	☐	☐	☐	☐	☐	☐
Transportation	☐	☐	☐	☐	☐	☐	☐
Solid waste management (e.g. plastics)	☐	☐	☐	☐	☐	☐	☐
Energy	☐	☐	☐	☐	☐	☐	☐
Agriculture	☐	☐	☐	☐	☐	☐	☐
Geospatial (rural, urban, regional) development	☐	☐	☐	☐	☐	☐	☐

2.3. Who is responsible for development and implementation of flood mitigation policy in your city?

Roles / Authorities in charge	Policy-making and implementation	Regulatory functions	Information/ monitoring evaluation	Financing	N/A
Central/national government	☐	☐	☐	☐	☐
State, Regional, Provincial government	☐	☐	☐	☐	☐
Local government (Municipality)	☐	☐	☐	☐	☐
Inter-municipal, supra-municipal, metropolitan body	☐	☐	☐	☐	☐
River basin organisation	☐	☐	☐	☐	☐
Disaster management department	☐	☐	☐	☐	☐
Metrological department	☐	☐	☐	☐	☐
Regional Water Authorities	☐	☐	☐	☐	☐
Other specific bodies(Please, name)	☐	☐	☐	☐	☐
Regulators (please specify,)	☐	☐	☐	☐	☐

2.4. Does your city/urban area belong to a metropolitan governance body?

Yes	☐
No	☐

2.4.1. If yes, does the metropolitan body have the following competences on flood water management?

Competences on water	Yes	No
Information exchange/ policy facilitation	☐	☐
Provision of technical expertise	☐	☐
Operational management of a service Provision	☐	☐
Strategic management of a service provision (for example setting of performance targets, the hiring of senior managers, calls for tenders or the supervision of sub-contractors)	☐	☐
Allocation of funding grants	☐	☐
Use of Legislative, Regulatory or other Authoritative Competencies	☐	☐
Other (kindly specify)	☐	☐

2.5.1 Which mechanisms, tools and institutions are used to co-ordinate flood water policy between your city and other levels of government (including other municipalities, regions and provinces)**?**

Mechanisms	Yes	No
Metropolitan sectoral authority (e.g. Metropolitan Water and Sewer Authority, Waterworks Authority and others .....)	☐	☐
Inter – municipal authority	☐	☐
Inter- municipal collaboration on projects (no authority)	☐	☐
Sub-national institution dealing specifically with flood management (water agency …….)	☐	☐
Multi-sectoral enterprises	☐	☐
Local Public Enterprises	☐	☐
Contractual arrangements (between levels of government)	☐	☐
Incentives from local/regional government (rules, rewards and sanctions mechanisms, earmarked funding …….)	☐	☐
Joint financing of projects by several sub-national authorities	☐	☐
Shared databases and information systems	☐	☐
Platforms for dialogue between sub-national flood water mitigation actors	☐	☐
Performance indicators	☐	☐

2.5.2 What does your city use to coordinate flood water management with other sectors of government?

Policy areas / Co-ordination mechanisms	Flood water and energy	Flood water and regional development	Flood water and disaster management	Flood water and agriculture	Flood water and spatial planning	Flood water and environment
Planning	☐	☐	☐	☐	☐	☐
Contracts	☐	☐	☐	☐	☐	☐
Financial incentivies	☐	☐	☐	☐	☐	☐
Co-ordination group/meetings	☐	☐	☐	☐	☐	☐
Legal requirements of co-ordination	☐	☐	☐	☐	☐	☐
Conditionalities	☐	☐	☐	☐	☐	☐
Joint programmes of ministries/agencies at sub-national level	☐	☐	☐	☐	☐	☐
Partnerships (e.g. ad hoc authority, platforms for dialogue .....)	☐	☐	☐	☐	☐	☐
Other(s) – Specify:	☐	☐	☐	☐	☐	☐

2.6. How frequently does your city flood governance actors interact with the following <u>stakeholders</u> in managing flood water?

Category of stakeholder	Always/very frequently	Slightly frequent	Somewhat frequently	Neutral	Somewhat rare	Slightly rare	Never/very rare
Central/national government	☐	☐	☐	☐	☐	☐	☐
State, Regional, Provincial government	☐	☐	☐	☐	☐	☐	☐
Local government (Municipality)	☐	☐	☐	☐	☐	☐	☐
Inter-municipal, supra-municipal, urban área governing body	☐	☐	☐	☐	☐	☐	☐
Disaster management department	☐	☐	☐	☐	☐	☐	☐
Metrological department	☐	☐	☐	☐	☐	☐	☐

Category of stakeholder	Always/very frequently	Slightly frequent	Somewhat frequently	Neutral	Somewhat rare	Slightly rare	Never/very rare
Regional Water Authorities	☐	☐	☐	☐	☐	☐	☐
Service providers	☐	☐	☐	☐	☐	☐	☐
Business/Industry	☐	☐	☐	☐	☐	☐	☐
Civil Society	☐	☐	☐	☐	☐	☐	☐
Financial actors (donors, international financial institutions, investors)	☐	☐	☐	☐	☐	☐	☐
Science, academia and research centres	☐	☐	☐	☐	☐	☐	☐
Customers and their associations	☐	☐	☐	☐	☐	☐	☐
Trade unions and workers	☐	☐	☐	☐	☐	☐	☐
Consultancy (e.g. private firms and engineering)	☐	☐	☐	☐	☐	☐	☐
International organizations	☐	☐	☐	☐	☐	☐	☐
Media	☐	☐	☐	☐	☐	☐	☐
Other specific bodies(Please, name)	☐	☐	☐	☐	☐	☐	☐
Regulators (please specify,)	☐	☐	☐	☐	☐	☐	☐

2.7. Which of the following instruments does your city use to engage stakeholders in flood water management related decision-making?

Mechanism	Yes	No
Sub-national institution dealing specifically with flood water governance (e.g. river basin organisation, disaster management, metrological department)	☐	☐
Water associations (associations of water utilities, water regulators, etc.)	☐	☐
Contractual arrangements	☐	☐

Mechanism	Yes	No
Decentralised assemblies (please specify which, ……..)	☐	☐
Survey/Polls/Referendum	☐	☐
Hotlines (to give information on probability of flood occurrence and/or damage caused)	☐	☐
Consensus conferences (provide dialogue between stakeholders and experts)	☐	☐
Shareholding (public, private, both)	☐	☐
Consultations in regulatory processes	☐	☐
Workshops (provide for discussions on Flood risk and mitigation strategy, information and answers to stakeholder questions)	☐	☐
Regular meetings (specify whether local or regional ……..)	☐	☐
Ad hoc meetings	☐	☐
Expert panels	☐	☐
Focus groups	☐	☐
Citizen committees	☐	☐
Inter-ministerial consultations	☐	☐
Traditional media- newspaper, newsletter, TV, Radio-	☐	☐
Web-based communication technologies (online platforms, email, social media, website, app, others …..)	☐	☐
Decentralised cooperation mechanisms	☐	☐

2.8. To which extent do the following obstacles hinder effective contribution of stakeholder engagement to decision making in relation to flood water mitigation in your city?

Category of stakeholder	Extremely not likely	Moderately not likely	Slightly not likely	Neutral	Slightly likely	Moderately likely	Extremely likely (Critical)
No clarity on the expected use of inputs in the decision-making process	☐	☐	☐	☐	☐	☐	☐
Consultation (lobbies, over –representation of certain categories)	☐	☐	☐	☐	☐	☐	☐
Lack of funding to support stakeholder engagement	☐	☐	☐	☐	☐	☐	☐
Lack of time	☐	☐	☐	☐	☐	☐	☐
Lack of political will and leadership	☐	☐	☐	☐	☐	☐	☐
Weak legal framework to support stakeholder engagement	☐	☐	☐	☐	☐	☐	☐
Stakeholder consultation fatigue (difficulty to maintain motivation)	☐	☐	☐	☐	☐	☐	☐
Information asymmetries and/or lack of transparency	☐	☐	☐	☐	☐	☐	☐
Political discontinuity (turnover of staff, shifting priorities)	☐	☐	☐	☐	☐	☐	☐
Misaligned objectives of stakeholders	☐	☐	☐	☐	☐	☐	☐
Resistance to change	☐	☐	☐	☐	☐	☐	☐
Difficulty to reach out to certain types of stakeholders	☐	☐	☐	☐	☐	☐	☐
Low capacity to engage in consultation (education, training)	☐	☐	☐	☐	☐	☐	☐
Complexity of issues at hand	☐	☐	☐	☐	☐	☐	☐
Geographical distance from decision-making cores	☐	☐	☐	☐	☐	☐	☐
Decision-makers' fear of losing influence and power	☐	☐	☐	☐	☐	☐	☐

Section 3 Extent to which the flood policies in city adopt multifunctional goals such as utilization of ecosystem services.

3.1. In your city/urban area what steps are taken to understand, monitor (location, frequency, and damages) and mitigate the flood risk?

Steps taken	Definition	Frequently not applied	Not applied	Somewhat not applied	Neutral	Applied somewhat	Applied	Frequently Applied
Flood hazard mapping	Determination of the areas susceptible to flooding when discharged of a stream exceeds the bank stage; using historical data on river stages, discharge from previous flood, topographical data	☐	☐	☐	☐	☐	☐	☐
Monitoring progress of storms	Using rainfall, degree of ground saturation, permeable soil and amount of vegetation is determined and these are correlated to give short-term prediction/forecast of possible floods	☐	☐	☐	☐	☐	☐	☐
Engineering Approaches								
Channelization	Diversion of streams to flow along specific path to control flood, enhance drainage, control erosion and increase access to floodplain for development	☐	☐	☐	☐	☐	☐	☐
Use of storm sewers	In order to collect run-off from streets, parking lots and buildings which are impermeable to provide underground drainage of the surface.	☐	☐	☐	☐	☐	☐	☐
Use of dams	Use to hold back waters so that discharge downstream can be regulated at a desired rate	☐	☐	☐	☐	☐	☐	☐
Use of retention ponds	Water held in retention ponds and released at controlled discharge to prevent flooding downstream.	☐	☐	☐	☐	☐	☐	☐
Use of levees, dykes, floodwalls, barriers, breakwaters, coastal defences	Structures built along side the channel to increase the stage at which the stream floods.	☐	☐	☐	☐	☐	☐	☐

Steps taken	Definition	Frequently not applied	Not applied	Somewhat not applied	Neutral	Applied somewhat	Applied	Frequently Applied
Use of flood ways	Areas that can be built to provide an outlet to a stream and allow it flood into an area that has been designated as a floodway	☐	☐	☐	☐	☐	☐	☐
Regulatory Approaches								
Floodplain zoning	Laws passed that restrict construction and habitation of floodplains; zoning could be for agricultural use, recreation or other uses wherein lives are not endangered when flood water re-occupy the plain	☐	☐	☐	☐	☐	☐	☐
Floodplain building codes	Structures allowed within floodplain are restricted to those that can withstand high velocity of flood waters or are high enough off the ground to reduce risk of water damage	☐	☐	☐	☐	☐	☐	☐
Floodplain buyout programs	Government buy the rights to the land rather than pay cost of reconstruction, subsidized flood insuarance or disaster relief in frequently flooded areas	☐	☐	☐	☐	☐	☐	☐
Mortgage limitations	Lending institutions refuse to give loans to buy or contruct dwellings or businesses in flood prone areas.	☐	☐	☐	☐	☐	☐	☐
Multifunctional Approaches								
Urban greenery	Green walls	☐	☐	☐	☐	☐	☐	☐
Urban furniture	Inverted umbrellas, Art Installations	☐	☐	☐	☐	☐	☐	☐
Rooftop detention of flood water	Green roofs Bluue roofs	☐	☐	☐	☐	☐	☐	☐
Reservoirs	Artificial detention basins, Water plazas, Underground reservoirs, cisterns	☐	☐	☐	☐	☐	☐	☐
Bio retention	Wet bioretention basins, Dry bioretention basins, Biowales, Bioretention planters, rain gardens,	☐	☐	☐	☐	☐	☐	☐
Permeable paving	Open cell pavers, Interlocking pavers, Porous paving	☐	☐	☐	☐	☐	☐	☐
Infiltration techniques	Infiltration trenches	☐	☐	☐	☐	☐	☐	☐
Multifunctional Approaches								

Steps taken	Definition	Frequently not applied	Not applied	Somewhat not applied	Neutral	Applied somewhat	Applied	Frequently Applied
Stream recovery	Stream rehabilitation, stream restoration, Daylighting streams	☐	☐	☐	☐	☐	☐	☐
Open drainage systems	Street channels, Extended channels, Enlarged canals,Check dams	☐	☐	☐	☐	☐	☐	☐
Floating structures	Floating pathway, Floating platform, Floating islands	☐	☐	☐	☐	☐	☐	☐
Wet proof	Submergible parks, Surbmergible pathways	☐	☐	☐	☐	☐	☐	☐
Raised structures	Cantilevered pathways, Elevated promenades	☐	☐	☐	☐	☐	☐	☐
Coastal defences (multifunctional)		☐	☐	☐	☐	☐	☐	☐
Other, specify	……)							

Steps adapted from Flooding Hazards, Prediction and Human Intervention (2015) Prof. Stephen A. Nelson. Tulane University.

3.2. Which of the following economic instruments are in place for managing floods in your city?

Sources of revenue for flood risk management	Yes	No
Bulk water tariffs[1]	☐	☐
Retail water tariffs[2]	☐	☐
Water abstraction charges	☐	☐
Water pollution (effluent) charges[3]	☐	☐
Fines and penalties	☐	☐
Levies	☐	☐
Payment for ecosystem services[4]	☐	☐
Tradable/Marketable permits[5]	☐	☐
Other (Please, specify)	☐	☐

3.2. Does your city have a role in water tariff regulation?

Yes	☐	If yes, please indicate which one(s)
No	☐	

[1] **Bulk water tariffs**: the wholesale price paid often for raw/ untreated water.
[2] **Retail water tariffs/user charges**: prices for the final consumer.
[3] **Pollution and abstraction charges or taxes**: they are based on the user-pays and polluter-pays principles. They include charges associated with non-tradable abstraction, consumption or pollution permits, and effluent or pollution charges. Aim to recover costs and internalize negative externalities associated with water abstractions or polluting activities.
[4] **Payments for ecosystem services (PES):** PES are agreements whereby a user or beneficiary of an ecosystem service provides payments to individuals or communities whose management decisions influence the provision of ecosystem services.
[5] **Tradable/marketable permits:** quotas, allowances or ceilings on pollution emission levels of specified polluters that, once allocated by the appropriate authority, can be traded subject to a set of prescribed rules

3.3. What types of financial input does flood mitigation in your city benefit from?

Type of Finance	Annual grant	Multi-annual grant	Earmarked grants	General grants	N/A
International (incl. EU) transfers/subsidies	☐	☐	☐	☐	☐
Central government transfers	☐	☐	☐	☐	☐
Regional government transfers	☐	☐	☐	☐	☐
Local input (e.g. intermunicipal transfers)	☐	☐	☐	☐	☐
Others, pleases specify	☐	☐	☐	☐	☐

3.4.1. Which obstacles related to the administrative and geospatial organization of your city hinder adaptive flood water governance?

Administrative gap	Extremely small obstacle	Moderately small obstacle	Slightly small obstacle	Neutral	Slight obstacle	Moderate obstacle	Extreme obstacle (Critical)
Mismatch between hydrological and administrative boundaries	☐	☐	☐	☐	☐	☐	☐
Municipal fragmentation (multiple authorities)	☐	☐	☐	☐	☐	☐	☐
Lack of relevant scale of investment	☐	☐	☐	☐	☐	☐	☐
Multiplicity of flood mitigation agencies	☐	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐	☐

3.4.2. Which obstacles hinder coherency of a multifunctional approach to flood mitigation in your city?

Objective gap	Extremely small obstacle	Moderately small obstacle	Slightly small obstacle	Neutral	Slight obstacle	Moderate obstacle	Extreme obstacle (Critical)
Intensive competition between different local authorities within the urban area (including political rivalries)	☐	☐	☐	☐	☐	☐	☐
Contradiction between different governmental levels recommendations/directives	☐	☐	☐	☐	☐	☐	☐
Lack of institutional incentives for co-operation (objectives, indicators)	☐	☐	☐	☐	☐	☐	☐
Conflicts over water allocation (across users)	☐	☐	☐	☐	☐	☐	☐
Interference of lobby groups	☐	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐	☐

3.4.3 Which obstacles hinder coherency and consistency on flood water management in your city?

Policy gap	Extremely small obstacle	Moderately small obstacle	Slightly small obstacle	Neutral	Slight obstacle	Moderate obstacle	Extreme obstacle (Critical)
Overlapping, unclear allocation of responsibilities	☐	☐	☐	☐	☐	☐	☐
Fragmentation of flood water related tasks	☐	☐	☐	☐	☐	☐	☐
Lack of strategic vision across flood water related sectors	☐	☐	☐	☐	☐	☐	☐

Unbalanced power between different interests	☐	☐	☐	☐	☐	☐	☐
Lack of co-ordination of legislation on flood management	☐	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐	☐

3.4.4 Which capacity challenges hinder the performance of multifunctional flood mitigation strategies in your city?

Capacity gap	**Extremely small obstacle**	**Moderately small obstacle**	**Slightly small obstacle**	**Neutral**	**Slight obstacle**	**Moderate obstacle**	**Extreme obstacle (Critical)**
Lack of staff and managerial capacities to implement policy	☐	☐	☐	☐	☐	☐	☐
Lack of knowledge on flood water management (technical, financial, policy development …….)	☐	☐	☐	☐	☐	☐	☐
Poor planning and not articulated with national objectives	☐	☐	☐	☐	☐	☐	☐
Difficulties in doing ex ante evaluation	☐	☐	☐	☐	☐	☐	☐
Difficulties in ex post monitoring and evaluation	☐	☐	☐	☐	☐	☐	☐
Others, please specify	☐	☐	☐	☐	☐	☐	☐

3.4.5 Which obstacles hinder the financial sustainability of multifunctional flood mitigation in your city?

Funding gap	Extremely small obstacle	Moderately small obstacle	Slightly small obstacle	Neutral	Slight obstacle	Moderate obstacle	Extreme obstacle (Critical)
Lack of financial guarantees for the city to borrow	☐	☐	☐	☐	☐	☐	☐
Limited decentralization of fiscal power and taxation	☐	☐	☐	☐	☐	☐	☐
Weak prioritization of investment in flood water mitigation	☐	☐	☐	☐	☐	☐	☐
Lack of multi-annual strategic plans and multi-annual budgets for flood mitigation	☐	☐	☐	☐	☐	☐	☐
Difficulties in mobilising private sector financial contribution	☐	☐	☐	☐	☐	☐	☐
Difficulties in collecting tariffs and charges from ecosystem services provided by flood water	☐	☐	☐	☐	☐	☐	☐
Affordability constraints requiring tariff adjustment	☐	☐	☐	☐	☐	☐	☐

3.4.6. Which obstacles hinder transparency and accountability of multifunctional flood water management policy in your city?

Transparency and accountability gap	Extremely small obstacle	Moderately small obstacle	Slightly small obstacle	Neutral	Slight obstacle	Moderate obstacle	Extreme obstacle (Critical)
Lack of publicly available data on flood risk	☐	☐	☐	☐	☐	☐	☐
Lack of publicly available data on economic and financial impact of floods, included costs of recovery	☐	☐	☐	☐	☐	☐	☐
Lack of accounting control through regular financial audits	☐	☐	☐	☐	☐	☐	☐
Lack of benchmarking to evaluate flood water quantity, management agencies and their performance	☐	☐	☐	☐	☐	☐	☐
Lack of competitive procurement process in implementation of flood mitigation strategies	☐	☐	☐	☐	☐	☐	☐
Weak judicial system for interpretation of the law/ weak regulation of existing policy plans	☐	☐	☐	☐	☐	☐	☐
Limited information sharing across local authorities	☐	☐	☐	☐	☐	☐	☐
Weak stakeholder engagement in flood water policy,	☐	☐	☐	☐	☐	☐	☐

strategy and projects							
Other, please specify	☐	☐	☐	☐	☐	☐	☐

3.4.7. Which obstacles hinder effective use of information to guide decision-making on urban flood mitigation strategies?

Communication/information gap	**Extremely small obstacle**	**Moderately small obstacle**	**Slightly small obstacle**	**Neutral**	**Slight obstacle**	**Moderate obstacle**	**Extreme obstacle (Critical)**
Absence or incomplete water users' registry	☐	☐	☐	☐	☐	☐	☐
Lack of data on the water balance and equity	☐	☐	☐	☐	☐	☐	☐
Inconsistencies in available data (e.g. variability of sampling and testing methods between water/weather and other concerned agencies etc.)	☐	☐	☐	☐	☐	☐	☐
Incomplete and irregular data collection (e.g. missing statistical units, missing values, no update etc.)	☐	☐	☐	☐	☐	☐	☐
Data dispersed across agencies making it difficult to track and compare	☐	☐	☐	☐	☐	☐	☐
Over technical information which does not allow non-water experts to understand the meaning of the indicators	☐	☐	☐	☐	☐	☐	☐
Lack of independent data concerning flood occurrence and damage	☐	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐	☐

3.5. Looking-forward, which of the following actions are important to cope with future flood water challenges in your city?

Strategies \ Ranking	Extremely unimportant	Slightly unimportant	Somewhat unimportant	Neutral	somewhat prioritized	Slight priority	High priority
Fostering co-operation across levels of governments	☐	☐	☐	☐	☐	☐	☐
Enhancing synergies with other policy areas	☐	☐	☐	☐	☐	☐	☐
Improving stakeholder engagement	☐	☐	☐	☐	☐	☐	☐
Raising awareness on flood occurrence, risk and damage	☐	☐	☐	☐	☐	☐	☐
Developing new laws or regulations	☐	☐	☐	☐	☐	☐	☐
Building/Operating/Maintaining flood water infrastructure	☐	☐	☐	☐	☐	☐	☐
Ensuring value for money (higher quality at lower cost)	☐	☐	☐	☐	☐	☐	☐
Increasing the willingness to pay of ecosystem services users	☐	☐	☐	☐	☐	☐	☐
Fostering capacity building, training and increase expertise	☐	☐	☐	☐	☐	☐	☐
Developing new flood information systems (e.g. apps, websites, interactive on line services, big data etc.)	☐	☐	☐	☐	☐	☐	☐
Developing technical and non-technical innovation	☐	☐	☐	☐	☐	☐	☐
Sharing information, commitments, actions (e.g. advertising campaign) for building trust and confidence	☐	☐	☐	☐	☐	☐	☐
Other, please specify	☐	☐	☐	☐	☐	☐	☐

Thank you for your time in answering this questionnaire!

In case you have any more comments, policy documents, links or other material you feel is relevant to this research kindly forward them to h.l.a.dawo@student.utwente.nl