rijksuniversiteit groningen

CARL VON OSSIETZKY universität OLDENBURG

Master-Thesis:

Towards flood resilient cities

- Assessing the adaptive capacity of water safety institutions in Bremen and Hamburg (Germany) -

Written by: Fenja Kügler

Double Degree Master Program:

„Water and Coastal Management“ & “Environmental and Infrastructure Planning”

(Student ID Groningen: S2719843 & Student ID Oldenburg: 2601097)

1st supervisor: Dr. M.A. Margo van den Brink; Rijksuniversiteit Groningen

2nd supervisor: Leena Karrasch; Carl von Ossietzky Universität Oldenburg

Faculty for Spatial Sciences

August 2015

"Floods are an act of god - but flood losses are largely an act of man"

Gilbert White (1945)

Acknowledgements

This study is the concluding research project of the double degree master program "Water and Coastal Management" and "Environmental and Infrastructure Planning" at the Universities of Groningen (The Netherlands) and Oldenburg (Germany).

Writing this thesis was an interesting period where new insights were won regarding the consequences of climate change and the adaptation to the increasing risk of floods as well as the challenges faced for adequate adaptation.

Besides this interesting character of the topic itself, data collection and writing this thesis was also a tough task. This is why I want to thank my Family and Mats for the support and motivation during this time.

Second, I would like to thank my supervisors Dr. M.A. Margo van den Brink and Leena Karrasch for the advice, insights and guidance along the process.

Last, as research has been performed through interviews in the region of Bremen and Hamburg special thanks also go to all the interview-partners, not only for spending their time on answering various questions but also for the really nice and interesting discussions we had.

Fenja Kügler

Abstract

Adequate adaptation to climate change is crucial for those consequences that cannot longer be hindered, like the increasing risk of floods in future. As resistance towards flooding is seen as inadequate in dealing with the growing threat, flood resilience seems to be promising in reducing the cities vulnerability to floods. Such a less vulnerable system is characterized by a high adaptive capacity which demands further capacity building in society. For the assessment of these capacities the modified Adaptive Capacity Wheel was developed and used as the conceptual framework of this thesis.

The results show that both cities scored rather high in the supporting qualities while the main barrier for adequate adaptation seems to be the missing political willingness. This thesis proofs that Bremen and Hamburg are both still relying on the resistance approach and its idea of holding the line and none of the cities can be characterized as flood resilient.

Based on these insights various recommendations are given, which emphasize the importance of risk awareness in society as well as the broadening of responsibilities. Additionally, it is assumed that a change in the political willingness can be the impulse for a transition. This transition should result in a flood resilient future, where living with floods is appreciated and the public takes an active role in the management of floods. As there are currently no indications that this becomes possible in the near future this thesis ends with an advice for further research on the topic.

Keywords: Climate change, Flood resilience, Adaptive Management, Adaptive capacity, Adaptive Capacity Wheel, Hamburg, Bremen

Zusammenfassung

Anpassung an den Klimawandels ist wichtig, wenn dessen Folgen nicht mehr verhindert werden können, wie beispielweise das wachsende Überschwemmungs-Risiko. Der Management-Ansatz der Hochwasser-Resistentz scheint inadäquat zu sein, um auf die Komplexität des Klimwandels reagieren zu können. Vielmehr scheint die Idee der Flut-Resilienz vielversprechend zu sein, um die Verwundbarkeit gegenüber Hochwassern zu verringern. Solch ein weniger verwundbares System ist von einer hohen Anpassungskapazität gekennzeichnet. Dies bedarf zusätzlichen Kapazitätsaufbau in der Gesellschaft. Für die Erfassung dieser benötigten Kapazitäten wurde das „modifizierte Anpassungskapazität-Rad“ (modified Adaptive Capacity Wheel) entwickelt und als Rahmenkonzept dieser Arbeit benutzt.

In den Resultaten ist zu erkennen, dass beide Städte hohe Werte in den „unterstützenden Dimensionen“ aufzeigen, dem jedoch ein mangelnder politischer Wille gegenübersteht. Diese Arbeit bestätigt, dass Bremen und Hamburg weiterhin an dem Ansatz der Flut-Resistenz festhalten und keine der Städte als flut-resilient bezeichnet werden kann.

Aufgrund dieser Einblicke werden in dieser Arbeit Empfehlungen gemacht, wobei besonders die Wichtigkeit der Risikokommunikation, sowie die Erweiterung der Verantwortlichkeiten betont werden. Zudem wird vermutet, dass ein Wandel des politischen Willens eine Transition in Richtung Flut-Resilienz verursachen kann, wo „Leben mit dem Überschwemmungs-Risiko“ ermöglicht wird und die Bevölkerung aktiver Teil des Hochwasserrisikomanagements ist. Da jedoch bisher keine Anzeichen für solch eine Transition zu erkennen sind, wird zudem weitere Forschung in dem Bereich empfohlen.

Stichworte: Klimawandel, Flut-Resilienz, Adaptives Management, Anpassungskapazität, Anpassungskapazität-Rad, Hamburg, Bremen

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List of Abbreviations

BIS: „Behörde für Inneres und Sport“
Municipal Office for the Interior and for Sport

BSH: „Bundesamt für Seeschifffahrt und Hydrographie“
Federal Maritime and Hydrographic Agency

BSU: „Behörde für Stadtentwicklung und Umwelt”
Authority for Urban Development Environmental Affairs (Hamburg)

DWD: „Deutscher Wetterdienst“
German Meteorological Service

GAK: „Gemeinschaftsaufgabe zur Verbesserung der Agrarstruktur und des Küstenschutzes“
Joint Task for the Improvement of Agricultural Structures and Coastal Protection”

GMLZ: „Gemeinsames Melde- und Lagezentrum“
German Joint Information and Situation Centre

HPA: „Hamburg Port Authority“

LSBG: „Landesbetrieb Straßen, Brücken und Gewässer“
Agency for Roads, Bridges and Water

LAWA: „Bund/Länder-Arbeitsgemeinschaft Wasser“
German Working Group of the Federal States on Water Issues

NLWKN: „Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz“
Lower Saxony Water Management, Coastal Defense and Nature Conservation Agency

SUBV: „Senator für Umwelt, Bau und Verkehr“
Senator for Environment, Construction and Traffic

Chapter 1 Introduction

1.1 Introduction

Climate change challenges planning practice with various unknown consequences, the so called known and unknown unknowns (Termeer and van den Brink, 2013). Known unknowns are rather certain events where no exact numbers exist (Termeer and van den Brink, 2013), like sea level rise, more intense rainfall and an increase in storm surges in winter (IPCC; 2007). All of these factors contribute to an increasing flood probability in the future. Besides, unknown unknowns are those consequences that are currently not realized (Termeer and van den Brink, 2013). It is for example known that the sea level is not only rising because more water is floating into the oceans due to melting ice shields, but also a thermal expansion of water is happening due to increasing temperatures over the last decades (IPCC, 2007). This may result in the fact that the whole water cycle will be disrupted in future and wind and water currents will change. Considering these changing and unknown variables, the predictability of future flood events is challenging.

Besides increasing flood probability and increasing uncertainty, also the impact a flood can have is globally rising. Due to the global predominant resistance approach (Vis et al., 2003; Oosterberg et al., 2005) where technical measures like dikes, dams and storm surge barriers (Meijerink and Dicke, 2008) are used to prevent the inland from being flooded, people feel safe in flood prone regions. This result in growing development and increasing economic value of flood prone regions, which makes them even more attractive to further settlement and development in future (Kabat et al., 2005).

Regarding the definition of flood risk, which is the probability of a flood event times its potential impact (Helm, 1996), the conclusion can be drawn that the risk of being flooded in the future is globally increasing. As the resistance approach focuses on probability reduction only it seems inadequate in dealing with the growing flood risk (Vis et al., 2003). Rather, dealing adequately with the growing risk of floods demands a risk based approach. Flood resilience is such a risk based approach and can therefore be described as the new normative aim in flood management (e.g. Restemeyer et al., 2015; Davoudi, 2012).

1.2 Problem Statement

As the German North Sea Coast, which incorporates areas of Lower Saxony, Bremen, Hamburg and Schleswig-Holstein, is prone to floods, flood protection is a crucial task in these Federal States. Here, static defense measures, mainly in form of dikes protect the inland from being flooded (Sterr, 2008). The standing of the dike can be seen in the following saying: "Wer nicht will Deichen, der muss weichen"

(Tranlastion: "who does not want to dike, has to move"). Every child in the northern parts of the county knows this saying, which shows the German attitude as a protective state. As seen by the saying the safety-discourse became institutionalized in informal institutions, but it is also written down in formal institutions, like the Masterplan Coastal Protection (NLWKN, 2007) and the paper "Hochwasserschutz in Hamburg" (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). These historically grown institutions that strive for safety characterize the resistance approach, while flood resilience asks for flexibility and a risk based approach (Lange and Garrelts, 2007). A transformation from the safety towards the risk discourse is therefore challenging.

Hartmann and Albrecht (2014) state this shift is already happening in Germany and current planning practice is characterized by a mixture of both approaches (Hartman and Albrecht, 2014). This is also given in Lange and Garrelts (2007) which add to this coexistence that German responsibilities reduce the risk discourse to make it compatible with the historically grown safety discourse (Lange and Garrelts, 2007).

It is therefore questionable to what extent the two City states at the German North Sea Coast, namely Bremen and Hamburg, already incorporate the idea of flood resilience, which results in the central question of this paper: "Do the historically grown water safety institutions in the northern City-States of Bremen and Hamburg allow these cities to adequately deal with the increasing flood risk faced in times of climate change?"

1.3 Theoretical approach

The concept of resilience was originally used in physics, where it explains the "bouncing-back" of materials after being bent or stretched (Galderisi et al., 2010). But over the last decades it diffused into other fields, like flood management. Here, it is used to describe a cities capacity to withstand a flood event (robustness), to keep functioning in case of a flooding (adaptability) and transform to a less flood prone state, when necessary (transformability) (Galderisi et al., 2010). While robustness and adaptability describe the original meaning of resilience and the capacity to "bounce back", transformability incorporates the system's capacity to "bounce forward" to a more favorable state, when necessary (Davoudi, 2012). This continuous process of adaptation and learning is important in times of climate change, because unknowns get known over time. When there are new insights and new knowledge available the robust and the adapted measures need to change in response to the new conditions, until a new transformation becomes necessary. This means that a flood resilient city is able to adequately deal with unknown climate changes and an increasing flood risk.

But flood resilience only describes a normative aim. For reaching this aim further capacity building is needed (Pahl-Wostl, 2007; Folke et al., 2005; Restemeyer et al., 2014). Capacities needed for adequate climate adaptation, are given in the Adaptive

Capacity Wheel from Gupta et al. (2010). While the original wheel is focusing on climate adaptation in general, the wheel used in this study has been modified. This means that the definitions of the criteria used were linked to the normative aim of flood resilience. Moreover, a psychological dimension was added as recommended in Gorthmann et al. (2013). This modified Adaptive Capacity Wheel is used for assessing the adaptive capacity of water safety institutions in Hamburg and Bremen separately. The two resulting wheels are then used to answer the aforementioned research question.

1.4 Research strategy

The City States of Bremen and Hamburg were chosen due to their similar characteristics. Both densely populated cities are located in the North-Western part of Germany. They represent the biggest cities in this area and are both influenced by the North Sea and consequently prone to floods. As the responsibility for flood protection in Germany is given to the Federal States both have their own strategy in dealing with floods (Lange and Garrelts, 2008). A comparison therefore offers the opportunities to not only recommend general fields of improvement but also draw lessons from each other (Nadin and Stead 2013; Dolowitz and Marsh 1996).

As capacity building is the precondition for the shift towards flood resilience, the modified Adaptive Capacity Wheel represents an assessment tool that tells strengths and areas of concern regarding this capacity building. For the assessment of the two wheels a document analysis, using peer-reviewed scientific papers, books and policy documents is done. As these only tell about formal institutions this analysis has been completed by eleven telephone interviews that deliver information about formal and informal institutions. The resulting two wheels, one for Bremen and one for Hamburg, represent the basis for the analysis of strengths and areas of concern as well as for recommendations where to improve and what to learn from whom.

1.5 Relevance of research

1.5.1 Scientific relevance

As there are consequences of climate change that can no longer be hindered using mitigation measures only, like the increase in global flood events, adequate climate change adaptation is crucial these days. Referring to various authors the shift towards a flood resilient city seems promising to deal with the increasing risk of floods (e.g. Davoudi, 2012; Galderisi et al., 2010; Scott, 2013; White, 2010; Hooijer et al., 2004; Vis et al., 2003). Other authors recommend increasing the adaptive capacity of society to deal with the unknown future. There are two concepts with their own literature that are both dealing with the ability to adequately deal with the growing uncertainty in

times of climate change. Only few authors focus on the interconnectedness of these concepts, but without finding agreement. For example Béné et al. (2012) conceptualized resilience as absorptive, adaptive and transformative capacity which would imply that the pillar of adaptability is a synonym for adaptive capacity. Contrasting Folke et al. (2002) state that adaptive capacity and transformability mean the same. But as adaptive capacity incorporates adaptation and learning (Gupta et al., 2010) this thesis assumes that adaptive capacity does neither expresses adaptability nor transformability, but both.

Additionally, the definition of the flood resilience concept differs in scientific literature. Various authors (e.g. de Bruijn, 2005; Douven et al., 2012; Vis et al., 2003) differentiate between the resistance and the resilience approach, where resilience is characterized as impact reduction. But according to Davoudi (2012) and others (Godschalk, 2002; Restemeyer et al., 2015, Folke et al., 2010; Galderisi et al., 2010) resilience and resistance are no opposing strategies. Rather, resistance is an inherent part of the flood resilience concept (Davoudi, 2012).

This thesis not only tries to identify the similarities and interactions of the concepts used, it also comes up with a new assessment tool that can be used make the normative aim of flood resilience practicable. The modified Adaptive Capacity Wheel can be used to formulate strengths and areas of concern in capacity building that is needed for a flood resilient future for various regions across the globe. This new assessment tool therefore contributes to the understanding of the flood resilience concept and how to get there in scientific literature as well as in local organizations.

1.5.2 Societal relevance

Next to better understanding the concept of flood resilience, in-depth case information can be extracted from this research. The findings represent an objective reflection of the local status quo, which visualizes strengths and areas of concern. These insights can be used to improve local flood management. Moreover, as institutions are socially constructed (Kim, 2011) and therefore a local phenomenon a comparison, which is pending, shows whether or not the water safety institutions in Hamburg and Bremen differ. As both societies were challenged differently from past flood events, a distinction in institutions seems plausible. If there is this distinction, it is also interesting to see where and to what extent the institutions differ.

Institutions restrict and enable society (Sharpf, 1997) which means that institutional redesign can contribute to a societal change (Alexander, 2005). This thesis can give valuable insights where institutional redesign should focus on in turning towards a flood resilient future. This thesis therefore can and hopefully will be used, for institutional reforms, which allows these two City-States to adequately deal with the threat of an unknown climate change and increasing flood risk.

1.6 Outline of this thesis

The outline of this thesis can be seen in figure 1. As the introduction into the problem statement and the resulting question are given in chapter one, the following chapter two gives an insight into the theoretical concepts used in this thesis. Here, the presentation of the current approach in dealing with floods, the resistance approach, is given first. Regarding its critiques the shift towards flood resilience is explained and flood resilience conceptualizing as robustness, adaptability and transformability (Davoudi, 2012). As the shift towards flood resilience needs further capacity building the link towards adaptive capacity is explained. After presenting the Adaptive Capacity Wheel invented by Gupta et al. (2010), the wheel is modified to better suit the problem statement of this thesis. This modified wheel is the conceptual framework of this thesis and is presented in the last section of chapter two.

The methodological strategy for the assessment of the modified Adaptive Capacity Wheel is presented in chapter three. Referring to the research protocol of the Adaptive Capacity Wheel given in Gupta et al. (2010) the selected cases Hamburg and Bremen are presented first. Next, the methods for data collection and data analysis are given.

In chapter four the case of Bremen is presented. Next to a general introduction into its vulnerability, important organizations and documents regarding the management of floods are introduced. Moreover, the results for each assessment criteria and its resulting scores are explained in detail. Finally, all the results are presented in the modified Adaptive Capacity Wheel for Bremen (Figure 12).

In chapter five a general introduction into Hamburg's vulnerability, as well as into the flood management legislation is given. Moreover, the results for each assessment criteria and its resulting scores are explained in detail. Finally, all the results are presented in the modified Adaptive Capacity Wheel for Hamburg (Figure 17).

In chapter six the results are discussed by assessing strengths and areas of concern for each city separately. Second, a comparison of the results is done and recommendations for institutional redesign are given. Last, a conclusion is drawn.

In chapter seven a reflection on the thesis as well as an outlook for further research are presented.

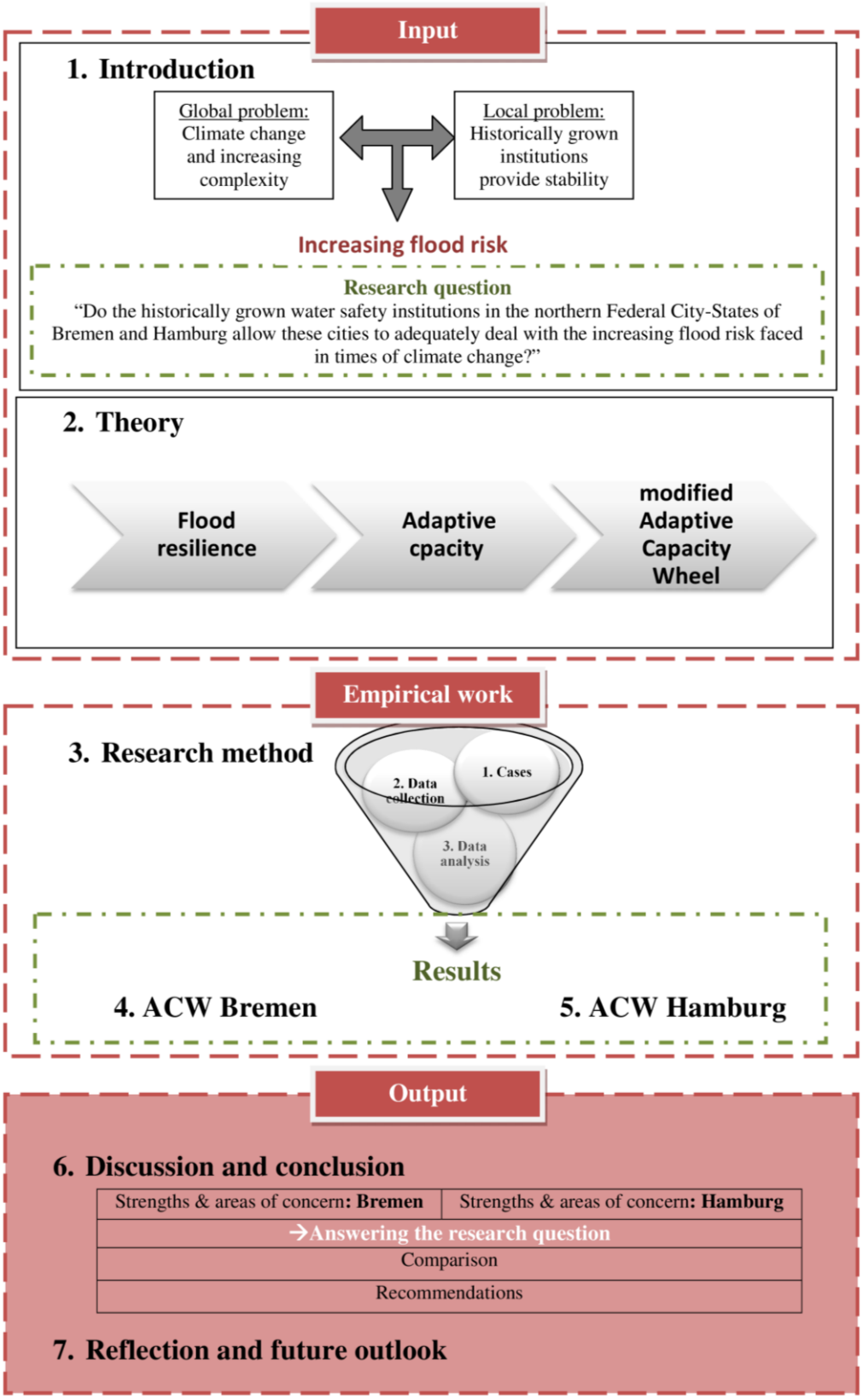

Figure 1: Outline of this thesis (Source: Author)

Chapter 2 The paradigm shift in flood management

The following presents the key concepts used n this thesis. Next to the limitations of the resistance approach the concept of flood resilience is presented. As the shift towards flood resilience demands further capacity building the modified Adaptive Capacity Wheel is developed which represents the conceptual framework of this thesis.

2.1 The risk of being resistant

The resistance approach focuses on hard defense measures, like dikes, dams and storm surge barriers (Meijerink and Dicke, 2008) to reduce the local flood probability and protect the inland from disturbance and damage (Burrell et al., 2007). The size of measures used is based on calculations of the flood probability that incorporates different parameters, like expected height of storm surges and wave run up (NLWKN, 2007). Structural measures and especially its visibility result in a common sense of safety (Kundzewicz, 2000; Vis et al., 2001) behind the measures. This increases the cities attractiveness which affects urbanization and economical development in flood prone places (Robert et al., 2003).

This sense of safety is risky, because structural measures can fail in function. Dikes can for example break or water can overtop the height of dikes. In case structural measures fail in function a flooding can have damaging effects, because the safety discourse incorporates equal levels of safety along the coastline (Lange and Garretls, 2007). This implies that all areas behind structural measures are equally vulnerable to floods. The location for a failure and also the flow of water are therefore uncertain (Rasid and Paul, 1987) and as the water body cannot be controlled a catastrophe seems plausible. This is further perpetuated because the sense of safety also affects that little attention is given on how to behave during a flooding. This results not only in unpreparedness of society but also increases the recovery time of a flooded area (Kundzewicz, 2000; de Bruijn, 2005). Here, kind of a vicious circle develops when flood resistant systems are flooded, because infrastructure that is not prepared for a flooding can further slow down the pace of recovery and may even result in a breakdown of the whole infrastructure network. For example a failure of power and communication lines can further perpetuate the problem and disrupt the process of recovery. Consequently, the potential damage and the number of casualties might increase (de Bruijn, 2005). Another point for criticism on structural measures can be seen regarding climate change, because structural measures are inflexible (Few, 2003). In times of unknown consequences of climate change structural measures will be challenged, as it is not possible to adapt them to fast changing conditions. Rather, it takes years to adapt the exiting defense-line.

All in all, hard defense measures create a risky sense of safety, because a failure is possible due to wrong calculations, misuse, mismanagement, poor maintenance or rapidly changing conditions. Thus, the trust in hard defense measures increases the potential impact of floods, which is also meant by White (1945) saying that man created flood losses.

2.2 Two dueling approaches

As seen above, the resistance approach reduces the flood probability, while it also increases the impact of a flood event. This connection of probability and impact of a flood event can also be seen in the definition of flood risk based on Helm (1996). Here, flood risk is expressed as the product of the probability of a flood event and the impact it can have.

Flood risk = probability of a flood event * potential impact of a flooding

Table 1 presents these two approaches of hazard and impact reduction that are often seen as opposing views (e.g. Douven et al., 2012; Hooijer et al., 2004). A flooding can either be hindered by using technical or non-technical, spatial measures that reduce the probability of a flooding which is the idea of the resistance approach, or focusing on impact reduction by preparing urban environments for floods. Some Authors label this impact reduction approach as resilience (e.g. de Bruijn, 2005; Vis et al., 2003).

Table 1: Strategies in dealing with floods (Source: Author, Source data: Meijerink and Dicke, 2008)

Strategy	Probability/Hazard reduction	Impact/Vulnerability reduction
Measures	Technical or spatial measures	Early warning, Evacuation, or infrastructure adjustments

2.3 Beyond dualism: The resilience approach

Shifting the focus away from the products of the equation and choosing between those, another opportunity for flood management occurs - a flood risk approach. Focusing on the overall flood risk allows incorporating both, probability and impact reduction. This shift towards a more holistic, risk related approach goes hand in hand with meaning of resilience explained by Scott (2013) and others (Davoudi, 2012; Galderisi et al., 2010; Restemeyer et al., 2015).

The resilience concept evolved over time from a once clear physical meaning to an interdisciplinary field of research (Galderisi et al., 2010). In the field of physics

resilience is used to describe the capacity of materials and objects to bounce back to its former status after being bent or stretched. Later, the word diffused into other fields of research like ecology (Holling, 1973), where it describes the ecosystem's capacity to recover from disturbance. In the case of water management resilience focuses on the systems theory and its social-ecological systems (Davoudi, 2012). Here, it is no longer about only bouncing-back to its original form after being stressed but also about bouncing-forward. This means that resilient social-ecological systems are able to not only absorb but also to learn and adapt to changes via a self-organizing behavior. Flood resilience therefore means a state beyond equilibrium (Davoudi, 2012).

Davoudi (2012) further conceptualize the flood resilience concept using three pillars to explain its functioning: Robustness, adaptability and transformability. These pillars are applied to the idea of flood resilient cities in Restemeyer et al. (2015). Here, a flood resilient city is described as being able to withstand and absorb an occurring flood. This city's robustness which reduces the local flood probability is realized using structural or non structural measures (Mejerink and Dicke, 2008). Adaptability means that the hinterland is adjusted to a flooding which does not imply that a flooding is not hindered (de Bruijn, 2005; Douven et al., 2012; Vis et al., 2003). As resilience means the coexistence of robustness, adaptability and transformability a variety of flood management measures are used in the flood management strategy. Adaptability therefore means that in case the robust measures fail in function the city will not be flooded, because the hinterland is already adapted (Restemeyer et al., 2015). Adaptability can be referred to vulnerability reduction (Meijerink and Dicke, 2008). This means that not only a physical but also a social adaptation takes place, where infrastructure is adjusted and people are prepared for a flood event, because early warning systems and evacuation plans exist (Meijerink and Dicke, 2008). This social dimension is not only important for adaptability, but also for transformability. Transformability "implies a capacity [of the cities society and institutions] to change based on new insights, searching for the most appropriate way to deal with flood risk" (Restemeyer et al., 2015, p.4). Transformability therefore characterizes the capacity to foster societal change to make the city less flood prone (Restemeyer et al., 2015).

Regarding the three pillars of resilience and the flood risk definition given in Helm (1996) resilience can be seen as an advancement of the resistance paradigm. It still incorporates the idea of holding the line by being robust. But by taking adaptability and transformability into account the focus is not longer on hazard reduction only but also on impact reduction, learning and self organizing as well as the aforementioned capacity to bounce forward (Davoudi, 2012). Thus, resilience incorporates all aspects of the flood risk definition and can be characterized as a flood risk management approach.

This flood risk management approach has various advantages compared to the idea of holding the line. By also taking impact reduction into consideration the damaging effects on a particular region are limited in a resilience approach, because the level of

preparedness is high (Godschalk, 2002). The failure of a structural measures is already incorporated into the plan and the water hits prepared ground (Godschalk, 2002), where crucial infrastructure is adjusted to high water levels (Restemeyer et al., 2015). Additionally, communities are able to react during the flood event because plans exist about how to behave. Moreover, they are not only more aware of the threat of being flooded but are also educated and part of the flood risk management concept (Restemeyer et al., 2015). Additionally, infrastructure that is already adjusted, will not fail in function. Hence, the recovery time and the overall damage of an occurring flood are lowered which is why a flood resilient community is safer from being harmed (Chan and Parker, 1996). Another positive aspect of flood resilience is that there is not one perfect, fixed balance between its three pillars that need to be achieved. Rather, the most effective balance is based on the environmental conditions and socio-economic characteristics and context dependent (Green et al., 2000).

All in all, flood resilience means to not longer repress the possibility of failure of structural measures and overcomes the dualism of hazard and impact reduction by combining all strengths into one holistic flood risk management strategy which makes a flood resilient city able to deal with uncertainty (Godschalk, 2002).

2.4 From resilience towards adaptive institutions

Flood resilience is a normative aim explained by various authors (e.g. Davoudi, 2012; Scott, 2013; Galderisi et al., 2010). But climate change challenges planning practice with multiple non-linear and complex effects that cascade through various scales (Patwardhan et al., 2009), which increases the unpredictability of its outcomes. A resilient city therefore needs to be in a constant way of flux and should be able to adapt to changing circumstances. A resilient city needs to be able to learn from the experiences made and change when preferred (Godschalk, 2002) which calls for an adaptive management approach (e.g. Folke et al., 2005; Holling, 1973; Pahl-Wostl, 2007; Geldorf, 1995). Such an approach that incorporates flexibility challenges the historically grown institutions that provide stability (Pollitt and Bouckaert, 2000). This stability is given in form of a top-down approach which creates institutional path dependence, because it focuses little on local knowledge or innovative ideas (Gupta et al., 2015). The shift towards an adaptive management approach, where flexibility and learning is appreciated, therefore calls for the rise of bottom-up initiatives. But as bottom-up approaches are characterized by a lack of authority, they need the shadow of law (Segerson and Miceli, 1998) to be effective (Gupta et al., 2015). A good mixture of top-down and bottom-up approaches is therefore crucial. These bottom-up approaches call for further capacity building in society. These capacities for an adaptive management approach are given in Restemeyer et al. (2014) focusing on aspects of governance as well as techniques and tools. Regarding governance adaptive

management needs a variety of actors involved, where various forms of knowledge are combined to an "outside-in" approach where societal learning is stimulated. Regarding the tools and techniques, various futures need to be anticipated to hinder a lock-in which also incorporates diversity of solutions and experimentation. This broad focus allows incorporating emergent processes and innovations. Monitoring these processes can lead back to learning and adaptation, when necessary (Restemeyer et al., 2014). These capacitates of an adaptive management approach can be assessed using the Adaptive Capacity Wheel from Gupta et al. (2010) which 'refers to the inherent characteristics of institutions that empower social actors to respond to short- and long-term impacts either through planned measures or through allowing and encouraging creative responses from society, both ex ante and ex post' (van den Brink et al., 2011, p.273). Assessing the adaptive capacity of local water safety institutions can therefore be used to draw conclusions about the extent these institutions allow for or even foster the flexibility and adaptability of local organizations, people and networks (Gupta et al., 2010) which is crucial for a transition towards flood resilience.

2.5 The Adaptive Capacity Wheel

As seen in Figure 2 the Adaptive Capacity Wheel from Gupta et al. (2010) is made out of three rings. The inner ring represents the overall adaptive capacity of the institutions under research. Its assessment is done using the ring in the middle, where six dimensions are presented. These six dimensions are assessed using 22 criteria which are also defined by Gupta et al. (2010). The various criteria of the Adaptive Capacity Wheel need to be scored first, before the assessment of the dimensions and later the overall adaptive capacity in society is assessed (Gupta et al., 2015).

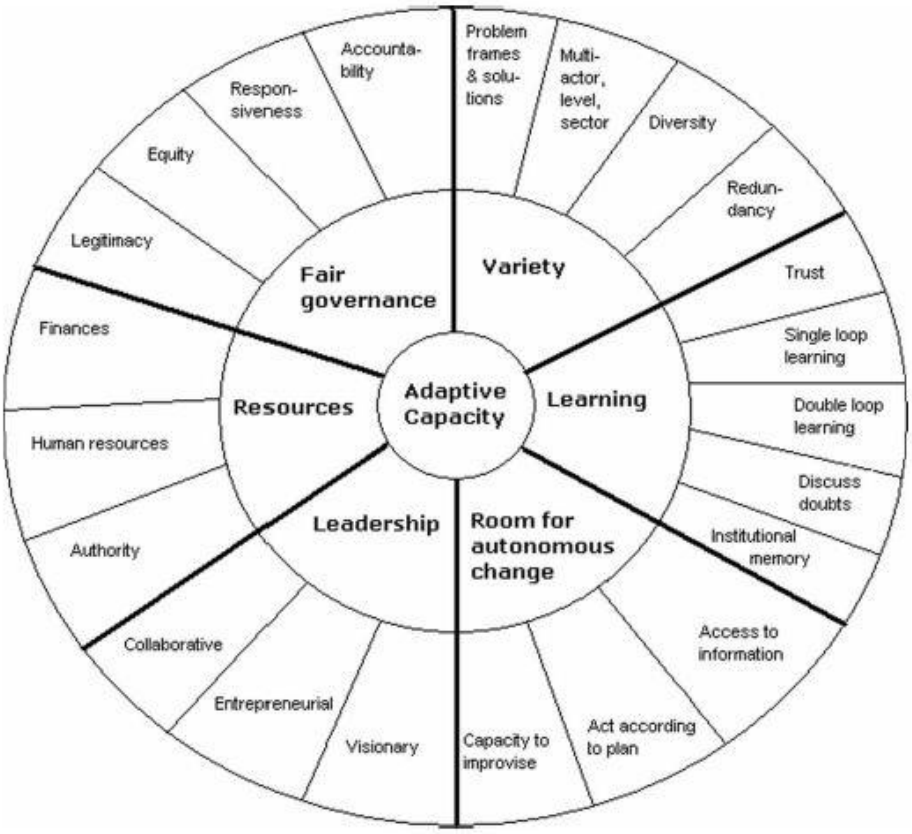

Figure 2: The Adaptive Capacity Wheel as developed by Gupta et al. (2010)

The dimensions of variety, learning and room for autonomous change directly contribute to the adaptive capacity in society which is why Gupta et al., (2010) characterize them as key dimensions. As simplification leads to a reduction of uncertainty, adaptive institutions need to provide variety in form of a variety of problem frames and solutions and the involvement of various actors, sectors and levels in policy making (Gupta et al., 2010). Additionally a diversified field of policy options and redundant measures further reduce the risk of being affected by something unknown or surprising, as there are various possible paths for future (Gupta et al., 2010). Moreover, adaptive institutions are characterized by a well functioning learning atmosphere, where trust and the discussion of doubts between the actors involved is given (Gupta et al., 2010). As no routines exist about how to tackle future problems (van den Brink et al., 2011) a system needs to be able to learn from past experiences (Folke et al., 2005) by improving routines (single-loop learning) but also questioning underlying assumptions (double loop learning) (Gupta et al., 2010). Additionally, monitoring and evaluation of experiences made can help to contribute to an institutional memory (Gupta et al., 2010). Furthermore, adaptive institutions leave room for autonomous change. This means society has a continuous access to information and is able to act according to plan

(Gupta et al., 2010). But society is also able to adjust its behavior and improvise, when needed (Gupta et al., 2010).

Additional contextual dimensions that indirectly contribute to adaptive capacity are leadership, resources and fair governance. Leadership is a driver for change (Gupta et al., 2010) which is why institutions should provide room for reformist leaders and those who stimulate actions or collaboration (Gupta et al., 2010). Besides, the access to resources contributes to the success of adaptation efforts (Biermann, 2007). This is why financial resources as well as human resources and the availability of authority are crucial for effective adaptive management (Gupta et al., 2010). Moreover, adaptive capacity in society is supported when institutions meet fair governance criteria (Gupta et al., 2010). This implies that legitimacy is given and institutional rules are fair. Additionally, institutions need to provide responsiveness as well as accountability procedures to foster adaptive capacity in society (Gupta et al., 2010).

2.6 Towards a modified Adaptive Capacity Wheel

The Adaptive Capacity Wheel developed by Gupta et al. (2010) is an assessment tool that can be used for the assessment of both, formal and informal institutions. Moreover, it has a strong communicative value, especially when using the traffic light scheme in the resulting wheel (Gupta et al., 2015). As it represents a standardized assessment tool it can be used to compare different contexts (Gupta et al., 2015), which is why the definition of the criteria used is rather general. This rather general formulation is, on the one hand, the reason why the Adaptive Capacity Wheel can be applied to various sectors (Gupta et al., 2015), but on the other hand as the assessment of the Adaptive Capacity Wheel is not independent from its context (Gupta et al., 2010) the criteria and dimensions used can differ in importance, depending on the topic under research. Consequently, tailor-made solutions are possible (Gupta et al., 2015).

As this thesis wants to assess the adaptive capacity of water safety institutions in two cases in Germany, the wheel from Gupta et al. (2010) is modified. Here, the criteria stated in Gupta et al. (2010) are redefined and adjusted, first. These new definitions are based on the insights from various scientific peer-reviewed articles that are dealing with the idea of flood resilience. Due to the definitions that refer to the concept of flood resilience some of the criteria stated in Gupta et al. (2010) are also added, linked together or excluded in the modified Adaptive Capacity Wheel (Figure 4). Second, as inspired by Grothmann et al. (2013) a psychological dimension is added to the wheel. Here, the dimensions used in Grothmann et al. (2013) are modified as well for making the psychological dimension also more problem-centered.

2.6.1 Modifying and redefining the criteria

Variety

Variety is achieved when institutions give room to many *problem frames and solutions* (Gupta et al., 2010). The problem which is central to this thesis is the increasing risk of being flooded. A variety of problem frames and solutions is therefore directly connected to the flood risk definition (flood risk is the product of its probability and its potential impact (Helm, 1996)). When there are many problem frames regarding the threat of being flooded the focus is on all parts of the equation, rather than on probability reduction only. Instead of one optimal policy strategy, or a set of mutually consistent solutions, namely probability reduction, there is a broader focus which allows tackling the problem via various solutions of probability reduction and vulnerability reduction. When a risk based approach is considered flood resilience can be guaranteed.

Variety also calls for the involvement of various *actors, sectors and administrative levels* in policy making (Gupta et al., 2010). While the resistance approach is characterized by a strong water management sector which cooperates with spatial planners on specific projects (Restemeyer et al., 2015) a resilient system involves various actors. Especially the pillars of adaptability and transformability require a broadening of responsibilities where spatial planners, water- and disaster-managers are involved in policy making and implementation (Woltjer and Al, 2007). This allows incorporating various forms of knowledge, and results in better preparation of flood events which reduces the vulnerability of the city (Woltjer and Al, 2007) and its flood risk. Additionally, a resilient city is characterized by well-informed citizens that understand their role in flood risk management (Woltjer and Al, 2007). In a flood resilient city people know how to behave during a flooding which results in less damage (Knieling et al., 2009).

A *diversity of solutions* also contributes to variety. Here, a wide range of policy options means a broad set of adaptation measures dealing with all pillars of resilience. For example robustness is about structural and non-structural measures, like dikes, flood walls, or room for the river (Meijerink and Dicke, 2008). Adaptability can include warning systems, evacuation plans, or flood proof infrastructure (Meijerink and Dicke, 2008), and transformability incorporates risk communication and awareness rising (Restemeyer et al., 2015). Variety calls for many proactive strategies, measures and instruments (Noteboom, 2006). This is especially important in dealing with the unknown, because a failure of one measure is damped by other measures. It is no longer about trial and error but a coexistence of various solutions and paths for future, because variety allows for adequate adaptation when external conditions change (van den Brink et al., 2013). Thus, society is still able to handle the problem, even in times of changing climate.

Even if resilience is about a diversified filed of flood management instruments referring to its pillars of robustness, adaptability and transformability which coexistence

is already assessed under the criterion diversity, the criterion *redundancy* can also contribute to a flood resilient city. As redundancy implies "more of the same" (van den Brink et al., 2011; Gupta et al., 2010), it can be assumed that for example focusing on impact reduction early warning systems alone would result in a higher flood risk than having early warning systems, evacuation plans and an adjusted infrastructure. This is why a variety of redundant measures can also contribute to a flood resilient city.

Learning capacity

Trust regarding Gupta et al. (2010) means that institutional patterns promote mutual respect and trust while the discussion of doubts also indicates that institutions are open towards uncertainties (Gupta et al., 2010). These criteria are assessed separately in the wheel from Gupta et al. (2010). But as trust and respect between actors is also needed to discuss doubts (Weick and Sutcliffe, 2001), it is assumed that trusting each other and discussing doubts cannot be separated from each other. Furthermore, it may sometimes be better to distrust each other, to be skeptical about what others do to start up a discussion about doubts, because a high score in trust can also indicate that one is less watchful and careless or blind about what others do. As these two criteria can influence or even reinforce each other they are merged and scored together in the *good relations* criterion. In a flood resilient city good relations between water managers, spatial planners and disaster managers (Restemeyer et al., 2015) are needed. This allows the involved actors on the one hand to act as effective as possible in case of a hazard, because actors that trust each other can concentrate on their strengths when facing a threat. On the other hand actors show openness towards uncertainty by discussing doubts which reduce the chance of being surprised.

As resilience is a continuous process of adaptation and learning actors need to be willing to scrutinize their underlying assumptions, ideologies, frames, claims, roles, rules and procedures that dominate current policy making (Gupta et al., 2010). This can make society able to develop new habits and norms when external conditions change. The ability to learn from past experiences and improving existing routines (*single loop learning*) that better fit to the new situation, as well as to challenge basic assumptions and norms (*double loop learning*) (Argyris and Schön, 1978) by unlearning routines (Pahl-Wostl et al., 2011) are therefore crucial in flood resilient city.

Besides these forms of leaning, it is also crucial to monitor and evaluate the experiences made to create an *institutional memory* (van den Brink et al., 2013). This institutional memory can be seen as the toolbox in problem solving that can help to better and adequately deal with threats in future.

Room for autonomous change

To make social actors adequately response to a flooding awareness raising and empowerment are crucial (Restemeyer et al., 2015; Kuhlicke and Steinführer, 2013).

For more awareness in society all individuals need to have *continuous access to information* (Gupta et al., 2010). This does not imply that people are generally able to find information on the internet which represents a more passive way of informing people. Rather, access to information is actively informing people via general risk communication (Knieling et al., 2009). This can for example happen in form of brochures, public campaigns (Restemeyer et al., 2015) as well as early warning systems in case of a flooding (Folke et al., 2005).

But only informing people is not enough to make them less vulnerable to flooding. Empowerment indicates that people are able to *act according to plans*. Orgnizations need to come up with such plans that tell the society how to behave during a flooding (Gupta et al., 2010; Restemeyer et al., 2015).

But as the external context is changing continuously the actors also need to be able to respond to unforeseen circumstances by having the *capacity to improvise* when facing a flood (Gupta et al., 2010). When, for example an evacuation path fails due to the occurred flooding, social actors need to seize opportunities and self-organize to help themselves (van den Brink et al., 2013). As time to react is running short during a flooding improvisation is crucial. Indicators for the societal ability to improvise are the awareness of the risk in society and their willingness to become an active part in flood risk management (Restemeyer et al., 2015). It is assumed that people who are not aware of the flood risk and unwilling to become active are unable to improvise when facing a flood. Next to early education in school (Restemeyer et al., 2015), the access to information but also and the availability of plans can contribute to the society's capacity to improvise.

Leadership

Regarding the pillar of transformability resilient cities need creativity and openness towards new ideas (Restemeyer et al., 2015) which makes *visionary leadership* crucial in a flood resilient system. Here, institutions need to provide room for long-term visions and reformist leaders (Gupta et al., 2010), the so called change agents. Those are able to convince others to anticipate potential future threats and create innovative long-term visions (Young, 1991) which are necessary to transform to a less flood prone state.

Creating those long-term visions is not enough to get those visions done. Here, *entrepreneurial leadership* can help to realize visions and adaptation measures by helping to gain access to necessary resources (Termeer, 2009). Institutions should therefore provide room for actors that stimulate entrepreneurial actions and undertakings (Gupta et al., 2010).

As transformability also asks for interdisciplinary networks (Restemeyer et al., 2015) it is important that flood resilient cities make actors collaborate. Institutions should therefore allow for leaders who encourage *collaboration* between different actors (Gupta et al., 2010).

Resources

Regarding the definition of human resources in Gupta et al. (2010) both, manpower as well as knowledge and capacitates are described. But in this thesis the criterion human resources is split up into the two separated resources of manpower and knowledge. This is done because it is assumed that it is an important difference if there is a lack of manpower or of knowledge. While manpower describes the availability of workers in general, the knowledge describes the availability of qualified persons. In case manpower is missing the implementation of plans may become a problem, while the absence of knowledge bares problems for developing plans. This is why a distinction between manpower and knowledge resources is done in this research.

Resources in form of *knowledge* and expertise are needed to think about and develop effective and efficient adaptation strategies (van den Brink et al., 2013). While robust measures need a high amount of expert knowledge in technical engineering and planning the shift towards flood resilience asks for additional knowledge about adaptation options found in the hinterland of the robust measures to reduce the cities vulnerability (Restemeyer et al., 2015).

Additionally *manpower* is needed to make the adaptation strategies and plans work (Gupta et al., 2010). Without enough manpower comprehensive plans can hardly be created and barely be realized.

For the realization also *financial resources* are crucial. Those cannot only help implementing but also allow for experimentation with various measures (van den Brink et al., 2013). While robust measures require high public funds for the construction and maintenance of the primary defense line, adaptability calls for investments in adaptation measures and a risk based approach (Restemeyer et al., 2015). Additionally, people in a flood resilient city are willing to invest money in private adaptation measures (Restemeyer et al., 2015).

Regarding the resources needed it is also crucial to embed institutional rules in constitutional laws. This contributes to *authority* in form of an accepted and legitimate form of power which can help to successfully implement the decisions made (Gupta et al., 2010).

Fair governance

Adaptive capacity and the shift towards flood resilience are fostered when the criteria of fair governance are met (Gupta et al., 2010). Fair governance is met when institutional patterns provide *accountability* (van den Brink et al., 2013).

Moreover, institutions that give feedback to society and are transparent (Biermann, 2007) can increase the adaptive capacity in society. But for realizing *responsiveness* an interested society is needed first. If society is not aware of the risk or not interested into flood risk management institutions cannot adequately response to society.

This public interest is also needed for realizing *legitimacy*, because a precondition for public support is public interest. When public interest is given institutions should show response to societies demands which can also result in public support.

Gupta et al. (2010) also state that institutional rules should be fair. But while the safety-discourse deals with equal safety levels along the coastline (Lange and Garrelts, 2007) and therefore same flood probabilities, the resilience concept considers the risk of being flooded (Vis et al., 2003). This risk, which incorporates both the probability of an occurring flood and the impact it can have (Helm 1996), does not need to be the same in every region. The flood risk of farmland for example could be way higher than the flood risk in a densely populated city. This implies that equity is not directly wanted and therefore excluded from this research.

2.6.2 Adding a psychological dimension

Grothmann et al. (2013) reflect on the Adaptive Capacity Wheel from Gupta et al. (2010) saying that actors would not adapt to climate change without the perception that adaptation is necessary and possible. This is why Grothmann et al. (2013) created an Adaptive Capacity Wheel which is extended by the dimensions of "adaptation motivation" and "adaptation belief" as seen in Figure 3.

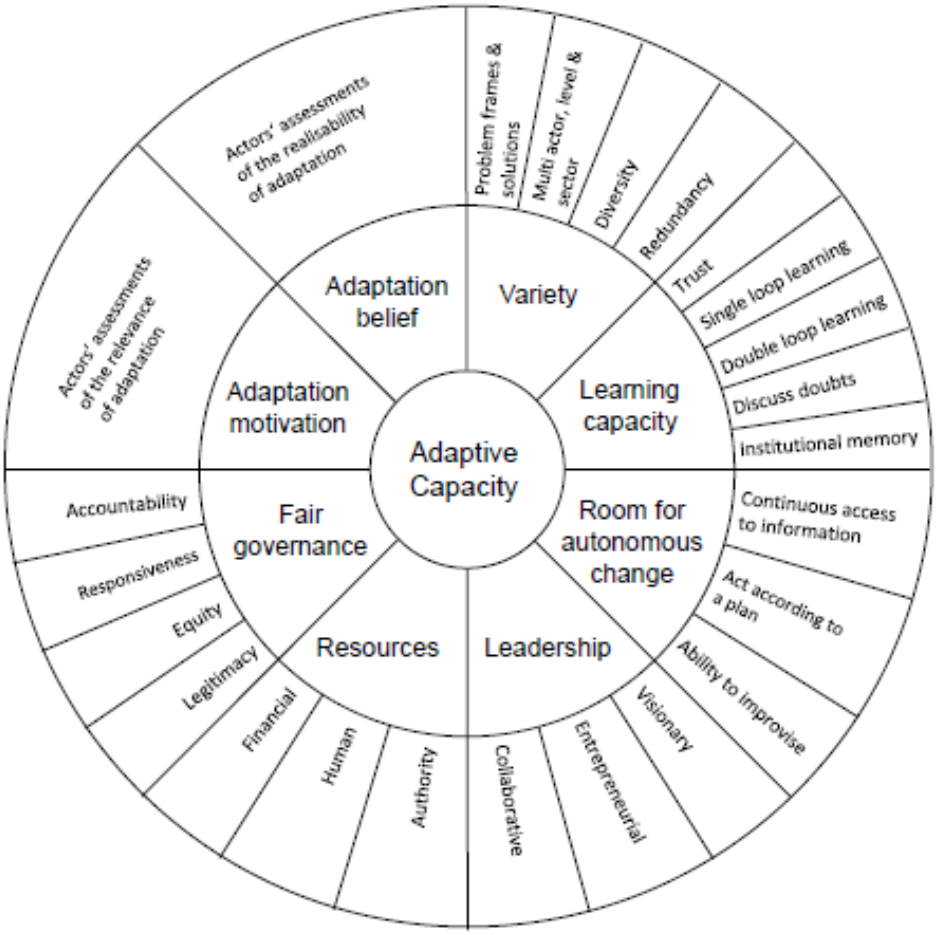

Figure 3: The extended Adaptive Capacity Wheel used in Grothmann et al. (2013)

Grothmann et al. (2013) state the importance of the psychological focus saying that scoring high in the psychological dimension is needed for policy intervention. But scoring high in this psychological dimension does not indicate that adaptation takes place, but increases the probability of adaptation, while low scores in the psychological dimensions can indicate an important barrier to climate adaptation (Grothmann et al., 2013). But Grothmann et al. (2013) do not determine the exact location of the two dimensions. Rather, depending on the topic under research they recommend the addition of a new psychological dimension, and using adaptation motivation and adaptation belief as its assessment criteria (Grothmann et al., 2013).

As a flood resilient city is characterized by political support in a risk based approach (Khakee, 2002; Restemeyer et al., 2015) such a psychological dimension is added to the modified Wheel of this thesis. It is assumed that next to a high adaptive capacity the shift towards flood resilience and adaptive management requires a political willingness that enables adaptation action (Levina, 2007). The assessment criteria for this new dimension "political willingness" are inspired by Grothmann et al. (2013) but as those

are again focusing on climate adaptation in general they were replaced by more problem centered criteria.

Adaptation belief as stated in Grothmann et al. (2013) indicates whether or not the actors think they can successfully adapt to climate change (Grothmann et al., 2013). This belief refers to the external effect, or spill-over effects of climate change that can make actors feel powerless (APA, 2010) and therefore restrict local willingness (Zuidmea, 2013) for adaptation. This adaptation belief seems unimportant in turning towards flood resilience, because even if climate change is a global phenomenon, local adaptation to the increasing risk of being flooded is crucial. Even if one can do nothing about the issue of climate change one needs to adapt to its consequences. The idea of adaptation belief is therefore not considered in this thesis.

According to Grothmann et al. (2013) adaptation motivation refers to the risk perception or awareness of climate change and its impacts (Moser and Ekstom, 2010). This goes hand in hand with the weak profile of environmental concerns (Zuidema, 2013). This means that ecological parameters cannot be expressed in financial terms and are not direct cause and effect issues but take years to become known and visible. This influences the sense of urgency to adapt in policymaking (Zuidema, 2013). The sense of urgency expresses the degree of necessity to adapt now and not in the future. The criterion of adaptation motivation is therefore relabeled to *sense of urgency*. This sense of urgency goes hand in hand with the shift towards flood resilience and the willingness to change the current way of adaptation. If there is a high sense of urgency policymakers are aware of the fact that probability reduction only is not enough to tackle the problem of climate change. It is assumed that with a high sense of urgency the willingness to take the risk based approach of flood resilience into account is higher. The sense of urgency is therefore a trigger for the shift towards flood resilient cities.

Additionally, another criterion was added to the political willingness dimension of the modified Adaptive Capacity Wheel. It is assumed that there is only little political willingness to consider flood resilience when there is no acceptance that a flooding is possible. As done in the resistance paradigm the reduction of uncertainty allows for the calculation and the development of models. But as climate change represents a wicked problem where non-linearity and complexity do not allow for cause and effect predictions institutions need to allow for or *accept uncertainty*. Regarding the known unknowns and especially the unknown unknowns that result out of unforeseen non-linear effects, a resilience approach is the only approach that can handle this complexity. The acceptance of uncertainty is key to rethink the resistance approach and be motivated and willing to build up further capacities to become flood resilient.

2.6.3 The resulting conceptual framework

Based on the reflections on the original wheel and the focus on flood resilience a modified wheel is used as the conceptual framework of this study. This wheel, which is shown in Figure 4, consists out of 7 dimensions and 23 criteria which are summarized in Table 2.

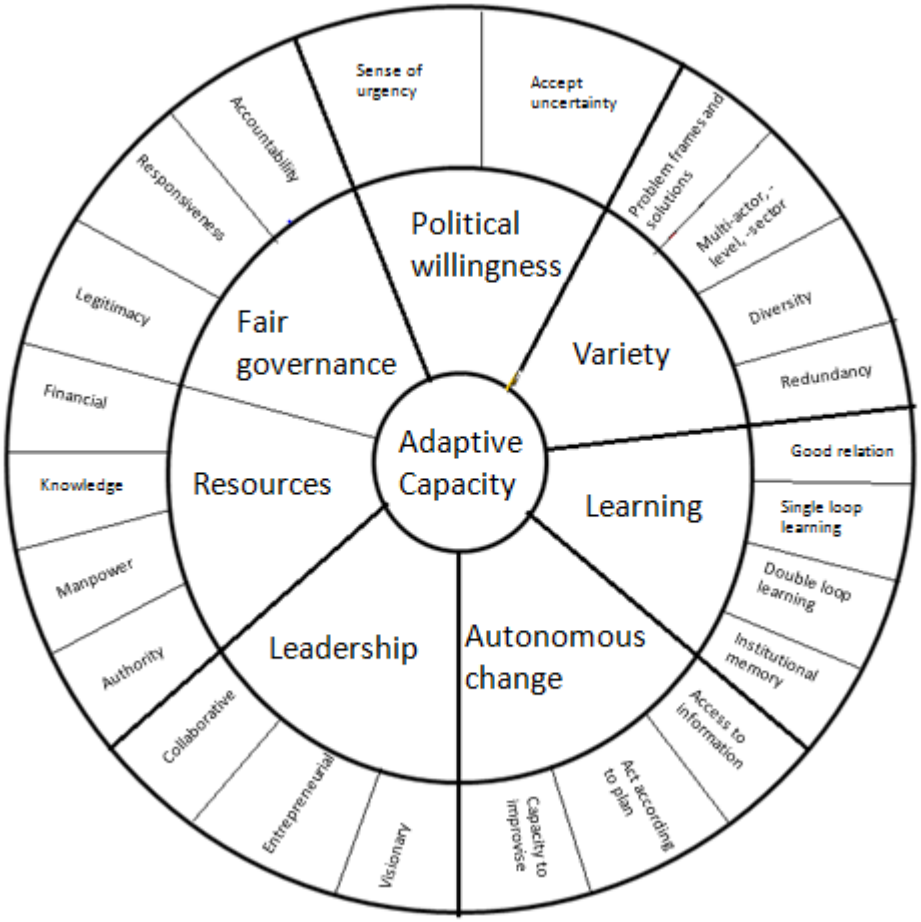

Figure 4: The modified Adaptive Capacity Wheel (Source: Author; Source Data: Gupta et al., 2010; Grothmann et al., 2013)

Table 2: Criteria definitions of the modified Adaptive Capacity Wheel (Source: Author)

Dimension	Criteria	Definition
Variety	Problem frames and solutions	The focus is on flood risk and its products and no longer on probability reduction only
	Multi actor, sector, level	Actors from various sectors as well as local people are involved in flood risk management
	Diversity	Availability of various adaptation measures reflecting all three pillars of resilience
	Redundancy	"More of the same" – Various measures for each of the resilience pillars coexist
Learning capacity	Good relations	Actors mutually trust each other but also discuss doubts
	Single loop learning	Society is able to learn from experiences made and consequently improves routines
	Double loop learning	Society challenges basic norms and underlying institutional patterns when necessary and is able to develop new and unlearn old routines
	Institutional memory	Monitoring and evaluation of experiences made
Room for autonomous change	Continuous access to information	Data is continuously accessible within institutions as well as for the public
	Act according to a plan	Plans about how to behave during a flooding exist, for example evacuation plans or scripts about how to behave
	Capacity to improvise	Society is able to self-organize during a flooding
Leadership	Visionary	Room for reformist leaders that stimulate creative solutions, for example change agents
	Entrepreneurial	Room for leaders that stimulate actions and undertakings
	Collaborative	Room for leaders who encourage collaboration
Resources	Authority	Provision of accepted and legitimate forms of power
	Knowledge	Availability of expertise and knowledge about technical engineering, vulnerability reduction and adaptation options
	Manpower	Availability of manpower to make plans work
	Finances	Availability of financial resources to support policy measures and its investment into a risk based approach
Fair governance	Legitimacy	There is public support for flood related institutions

	Responsiveness	Feedback is given to society which makes policy making more transparent
	Accountability	Responsibilities are assigned to different parties
Political Willingness	Sense of urgency	There is an urgency felt which leads to political willingness to shift from probability reduction towards a risk related resilience approach
	Accept uncertainty	Acceptance of uncertainty, non-linearity and complexity

This chapter showed how the concepts of flood resilience and adaptive capacity are interrelated. These insights are used for the development of the modified Adaptive Capacity Wheel (Figure 4) which is used for the assessment of the adaptive capacities of water safety institutions in Hamburg and Bremen. How the assessment is done is explained in the next chapter.

Chapter 3 Research method

The assessment of the modified Adaptive Capacity Wheel is based on judgment and interpretation of the author of this thesis. To guarantee as much objectivity as possible the assessment of the wheels in this research is based on the protocol from Gupta et al. (2010). Here, the selected cases are stated, first. Second, the methods of data collection, namely interviews and document analysis are explained (Gupta et al., 2010). Third, the methods used to analyze the gathered data are given and the data interpretation is explained using the seven steps of the evaluative qualitative content analysis explained in Kuckartz (2012).

3.1 Case selection

The cases of Hamburg and Bremen were selected because of their similar characteristics. As seen in the Figure 5, the cities of Bremen and Hamburg are both located in the north-western part of Germany. The coastal areas found in this part of the country are mostly characterized by low laying marshes.

Figure 5: Map of Northern Germany showing the locations of the case studies (Source: Googlemaps, 2015, adapted by the Author)

Moreover, both cities can be found along rivers, namely Weser (Bremen) and Elbe (Hamburg) and are influenced by the North Sea and its tides which make them vulnerable to floods. In Hamburg nearly one third and in Bremen around 85% of the cities area are located in flood prone regions (Lange and Garrelts, 2008). As both are

already vulnerable to floods and flood risk is increasing in future, both cities will be challenged by similar consequences of climate change.

Next to these similarities both cities show differences in their flood history. Regarding the storm surge of 1962, which is one of the most important dates in German flood history Hamburg was affected by a huge flooding. Due to the failure of 50 dike one sixth of the area of Hamburg was under water and the infrastructure collapsed. Hence, about 60.000 inhabitants lost their homes and 315 people died (Lange and Garrelts, 2008). Bremen was also affected by dike failures and consequently flooded in 1962. Next to minor damages seven people, who lived in the garden plots found in the dike foreland, lost their lives (Lange and Garrelts, 2008).

3.2 Data collection

Data needed for this study is gathered via two qualitative research methods, namely a document analysis and semi-structured interviews. The documents used to gather the needed information mainly represent policy documents, which gives information about the formal institutions of the two cases. For further data, especially about informal institutions, semi structured interviews were made. These allow not only answering questions regarding both formal and informal institutions but also deliver more up to date information as well as insider knowledge about the process of developing the documents. As the interviews are semi structured participants are free in answering the questions. These open questions allow the interviewee to add further aspects into the discussion. Moreover, the interviewer can add further explanations in case the answer does not fit well to the meaning of the question. But as data is only collected in this stage, no value or meaning is added to the answers. To formulate the questions as neutral as possible and do not influence the answer given by the interviewees a guideline was developed first.

The guideline, which can be found in Appendix I, consists out of six groups that represent the original dimensions of the Adaptive Capacity Wheel. For the new psychological dimension no questions were formulated, because those represent more the attitude of the actors involved. The assessment of the political willingness is therefore based on the general way of answering the other six groups of questions. Here, the criteria of each dimension are used as the basis for each specific question. The group of variety questions for example consists out of four questions, one for each criterion. Gupta et al. (2010) add to these six groups of questions a warm-up and a concluding question. In this thesis, the warm-up question also represent a group of questions to get into the topic and to get information about the person who is interviewed, while only one concluding question is given that is used to find out prospects for the future. At the end of the questionnaire one additional question is formulated to find out who else

should also be interviewed during the research, which represents the use of the snowball principle.

All interviews were done in May and June 2015. Due to problems in finding interview partners in the beginning and as a result of this a lack of time all interviews were done in form of telephone-interviews. On the one hand interviewees were more willing to spend time, as an appointment was more flexible and could also been done more spontaneous. On the other hand the interviewer was able to conduct more interviews per day and as the lack of time was compensated, it was possible to return to the original schedule. All in all, eleven interviews were done which took in general more than an hour which results in more than 600 minutes of interviews.

The interviewees have been chosen due to their relevance in the field of flood protection in Hamburg and Bremen. All of them represent responsible professionals in the organization they are working in which is why they are not considered as individuals but as representatives of their organization (Meuser and Nagel, 1991; Flick 2005; Lamnek 2002).

As both cases represent a City and a Federal State at once they can be characterized as City States. Normally, Germany is divided into three administrative layers. The first layer is represented by the Federal Government that is the highest level of legislation. The second layer of German legislation is build out of the Federal States and administrative regions. As Germany represents a Federal State most of the regulations given by the national level need to be implemented at this level of legislation. Finally, the third and lowest level of legislation is represented by the districts and municipalities (Lange and Garrelts, 2008). But as seen in Figure 6 the second and third layers of legislation overlap in a City State which means that local organizations also built up the second layer in legislation.

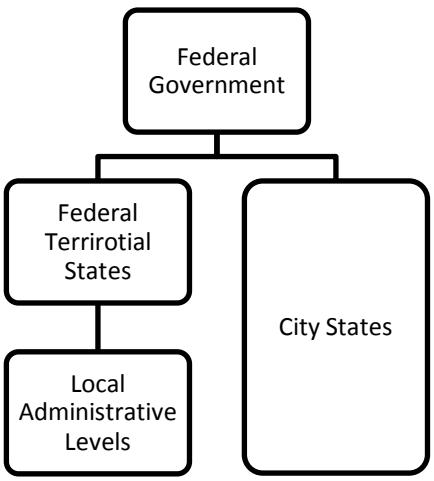

Figure 6: Simplified hierarchical structure of the Federal State of Germany (Source: Author)

At this administrative level, various sectors coexist on a horizontal axis, focusing on disaster control, climate adaptation and flood protection. Additionally the flood protection sector is further separated on a vertical axis where different layers of responsibilities exist (Lange and Garrelts, 2008). Besides these administrative levels and sectors the Federal Ministry of Education and Research in Germany (German abbreviation: BMBF) funded the research project "KLIMZUG – Managing climate change in the regions for the future" between 2008 and 2014. This project aims to analyze local consequences of climate change and promotes local climate adaptation actions and measures. In total there were seven sub-projects, and two of them dealt with the selected cases of this thesis. The project KLIMZUG-NORD focused on the metropolitan region of Hamburg and while nordwest2050 dealt with the metropolitan region Bremen-Oldenburg (Umweltbundesamt, 2015a).

As seen in Table 3 and 4 interviews were made with responsibilities from each of these layers mentioned above. Besides the date of interview the tables show the organization the interviewee belongs to, as well as their field of responsibility. As the interviews were treated anonymously the tables also include the acronym used in the following chapters where the results are presented. CP1 for example indicates that the interviewee is working at the highest level of organization (1) and is responsible for coastal protection (CP), while DC indicates that the interviewee is responsible for disaster control. The abbreviation CA indicates that the interviewee is involved in the development of the climate adaptation strategy and CP/CA shows the interviewee is a member of the KLIMZUG research project. Additionally, the city the interviewee belongs to is stated (B for Bremen and HH for Hamburg).

Table 3: List of interviews made in Bremen (Source: Author)

Bremen			
Date	**Organization**	**Interviewee responsible for**	**acronym**
21.05.2015	Senator for Construction, Environment and Traffic (SUBV)	Coastal Protection	CP1_B
22.05.2015	Senator for Construction, Environment and Traffic (SUBV)	Climate Adaptation	CA_B
02.06.2015	Senator for the Interior and for Sport	Disaster Control	DC_B
22.05.2015	Dike Association	Coastal Protection	CP2_B
02.06.2015	Research-Project nordwest2050	Coastal Protection/ Climate Adaptation	CP/CA_B

Table 4: List of interviews made in Hamburg (Source: Author)

Hamburg			
Date	**Organization**	**Interviewee responsible for**	**acronym**
02.06.2015	Department of Civil Engineering and the Environment (BSU)	Coastal Protection	CP1_HH
27.05.2015	Department of Civil Engineering and the Environment (BSU)	Climate Adaptation	CA_HH
26.05.2015	Municipal Office of the Interior (BIS)	Disaster Control	DC_HH
20.05.2015	Agency of Roads, Bridges and Water (LSBG)	Coastal Protection	CP2_HH
28.05.2015	Dike Association	Coastal Protection	CP3_HH
29.05.2015	Research-Project KLIMZUG-NORD	Coastal Protection/ Climate Adaptation	CP/CA_HH

All of the interviews were recorded and later transcribed. This allows documenting the information collected. Here, the following elements, given by Gläser and Laudel (2004) and Meuser and Nagel (1991) were considered. The transcript uses the standard-orthography. Non-verbal statements are only used when they are meaningful for the statement. Linguistic features, disruptions, and unknowable words are noted. Moreover, no notation systems is used. Due to the transcripts the interviews represent authentic texts that minimize the room left for interpretations and increase the objectivity of this study. The anonymized transcripts can be found in Appendix II.

3.3 Data analysis

In order to analyze the transcribed interviews and documents gathered during data collection an evaluative qualitative content analysis (Evaluative Qualitative Inhaltsanalyse) described in Kuckartz (2012) is made with the help of the computer software ATLAS.ti version 7.5.6. This helps not only to compress and sum up the collected data, it also allows to estimate, grade and evaluate its content (Kuckartz, 2012). Kuckartz (2012) describes seven phases of the analysis.

Step 1

First, the assessment criteria are determined. As the criteria are already developed by Gupta et al. (2010) and adapted to the problem statement of this thesis in the paragraph of the contextual framework (see Chapter 2.6.3), the assessment criteria are

already given. Thus, the 23 assessment criteria used and their definitions can be found in Table 2. Table 5 gives an example of the room for autonomous change dimension.

Table 5: Definition of the assessment criteria for the "room for autonomous change" dimension (Source: Author)

Dimension	Criteria	Definition
Room for autonomous change	Continuous access to information	Data is continuously accessible within institutions as well as for the public
	Act according to a plan	Plans about how to behave during a flood exist, for example evacuation plans or scripts about how to behave
	Capacity to improvise	Society is able to self-organize during a flooding

Step 2

Second, the text passages needed for the assessment of the criteria were identified and coded. Here, a list with coding hints was created first, which allows for a transparent coding of the gathered data. This list can be found in Table 6.

Table 6: List with hints for coding (Source: Author)

	Criteria	Definition of the criteria	Hints for coding
Variety	**Problem frames and solutions**	The focus is on flood risk and its products and no longer on probability reduction only	How is the problem of increasing risk of being flooded solved? What is the plan? What do they focus on?
	Multi actor, sector, level	Actors from various sectors as well as local people are involved in flood risk management	Who is involved when planning for adaptation measures and who not?
	Diversity	Availability of various adaptation measures reflecting all three pillars of resilience	What types of measures exist so far?
	Redundancy	"More of the same" – Various measures for each of the resilience pillars coexist	What specific types of measures exist regarding robustness/ adaptability/ transformability?

Learning capacity	**Good relations**	Actors mutually trust each other but also discuss doubts	How do the actors work together? Do they sit together?-When yes, how often? Is their work separated from the work of others? How do they talk about each other?
	Single loop learning	Society is able to learn from experiences made and consequently improves routines	Are actors willing to learn and to improve routines? Did they learn from past experiences? How does learning take place?
	Double loop learning	Society challenges basic norms and underlying institutional patterns when necessary and is able to develop new and unlearn old routines	Did actors talk about mistakes taken in the past? Did they do more than improving what is already given? Are actors willing to 'unlearn' routines?
	Institutional memory	Monitoring and evaluation of experiences made	Do actors monitor their actions and undertakings? Do they evaluate what they monitor?
Room for autonomous change	**Continuous access to information**	Data is continuously accessible within institutions as well as for the public	Do actors have a continuous access to information? Does this information also reach the public? Is there an active flow of information between organizations/ actors/ public?
	Act according to a plan	Plans about how to behave during a flooding exist, for example evacuation plans or scripts about how to behave	Are there plans that tell how to behave in case of a flooding? Is the public part of those plans? Is the public able to act autonomously in case of a flooding?
	Capacity to improvise	Society is able to self-organize during a flooding	Does the public play a role in flood risk management? Is the public aware of the risk? Is the public educated? Could the public rescue themselves during a flooding?
Leadership	**Visionary**	Room for reformist leaders that stimulate creative solutions, for example change agents	Are creative solutions wanted/ accepted? Are those leaders heard? Do those leaders already exist?
	Entrepreneurial	Room for leaders that stimulate actions and undertakings	Are actors able to stimulate actions? Are those leaders heard? Are there already actors who stimulate actions?

	Collaborative	Room for leaders who encourage collaboration	Is collaboration wanted? How does collaboration takes place (is it really a form of collaboration)? Are there already leaders that encourage collaboration?
Resources	**Authority**	Provision of accepted and legitimate forms of power	Is there a hierarchy that indicates who has what forms of power? Are institutional rules embedded in constitutional rules?
	Knowledge	Availability of expertise and knowledge about technical engineering, vulnerability reduction and adaptation options	Is there enough knowledge available to handle the problem/to find solutions?
	Manpower	Availability of manpower to make plans work	Is there enough manpower to realize the plans?
	Finances	Availability of financial resources to support policy measures and its investment into a risk based approach	Is there enough money available for the problems faced? What amount of money has been spent or is planned to spend on measures taken?
Fair governance	**Legitimacy**	There is public support for flood related institutions	Are the undertakings legitimized? When yes, how are they legitimized?
	Responsiveness	Feedback is given to society which makes policy making more transparent	Is the planning process transparent? Is the public heard? Do the public have a saying?
	Accountability	Responsibilities are assigned to different parties	Are the responsibilities clear?
Political willingness	**Sense of urgency**	There is an urgency felt which leads to political willingness to shift from probability reduction towards a risk related resilience approach	Is climate change seen as an issue that needs actions now? Are the limitations of technical measures seen?
	Accept uncertainty	Acceptance of uncertainty, non-linearity and	Is climate change seen as an uncertain/non-linear/complex issue?

The transcripts and policy documents used were scanned for answers that fit to the questions found in the Table 6. An example is given below in Figure 7. It represents an extract from a transcript showing quotes referring to the codes "act according to plan" and "access to information" in the city of Bremen. As seen in Figure 7 the marked text passage (blue) answers the question "*Is the public part of those plans? Is the public able to act autonomously in case of a flooding*?" by telling that the public is not part of the tutorials. This text is therefore labeled with the code "act according to plan".

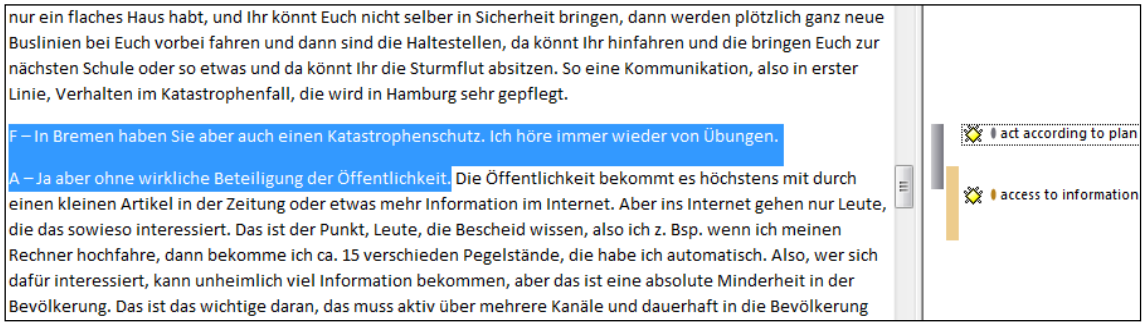

Figure 7[1]: Extract from a transcript, showing quotes for the codes "act according to plan" and "access to information" (Source: Author)

Step 3

In a third step all text passages for each criterion are ordered to the persons saying those. Consequently a list of codes results with all the quotes identified in the previous step, as seen in Figure 8. This list of quotes is the basis for the next steps of the analytical work.

[1] Translation of the original marked quote (blue) into English:
F (Question) - In Bremen there is also a disaster control team. I keep hearing of tutorials.
A (Answer) - Yes, but without real public participation.

Kode: act according to plan {31-0}

P 2: CP1_B - 2:22 [Es gibt gewisse Dinge, die auc..] (38:38) (Super)
Kodes: [act according to plan]
keine Memos

Es gibt gewisse Dinge, die auch zu Papier gebracht worden sind. Zum Beispiel haben wir einen Kalender, da steht drin, ab einem gewissen Wasserstand müssen die und die informiert werden, die Türen müssen zu. Da darf man nichts vergessen. Das hat sich über die Jahre so entwickelt und das wird auch immer wieder angepasst. Und da ist ein Tor verschwunden oder da ist eins kaputt. Das wird jährlich fortgeschrieben.

P 2: CP1_B - 2:27 [Werden zum Beispiel Flugblätte..] (55:56) (Super)
Kodes: [act according to plan]
keine Memos

F – Werden zum Beispiel Flugblätter verteilt? Gibt es das in Bremen?

A – Bislang nicht. Das haben wir aber vor. Aber da ist auch das Thema Sammelpunkte. Wo sind hohe Punkte im Gelände, wo wir wissen, die gehen nicht unter Wasser, da können wir die Leute erst einmal hinstellen. Da können sie nicht ertrinken. Oder – wie verhalte ich mich? Das gibt es zurzeit nicht.

P 4: CP2_B - 4:10 [F – In Bremen haben Sie aber a..] (21:22) (Super)
Kodes: [act according to plan]
keine Memos

F – In Bremen haben Sie aber auch einen Katastrophenschutz. Ich höre immer wieder von Übungen.

A – Ja aber ohne wirkliche Beteiligung der Öffentlichkeit.

P 9: DC_B - 9:3 [Es gibt keine festen. Wenn sie..] (23:23) (Super)
Kodes: [act according to plan]
keine Memos

Es gibt keine festen. Wenn sie sowas meinen, wie fertig, vorgefertigte Evakuierungspläne, die haben wir nicht. Die entwickeln wir dann in der Zeit.

Figure 8[2]: Extract from the original codes for Bremen showing parts of the criterion "act according to plan". (Source: Author)

[2] Translation of the original Figure 8 into English:
Code: act according to plan {31-0}
P 2: CP1_B - 2:22 [There are certain..] (38:38) (Super)
Code: [act according to plan]
no memos
There are certain things that are also noted on paper. For example, we have a calendar that tells at which water level who needs to be informed and which gates need to be closed. In such a situation nothing should be forgotten. This has evolved over years and is also adjusted continuously. When for example a gate has disappeared or one is broken. This is updated annually.
P 2: CP1_B - 2:27 [F – Are there for..] (55:56) (Super)
Code: [act according to plan]
no memos
F – Are there for example flayers handed out? Does this exist in Bremen?
A – Not yet. But this is planned. But this is also connected to the issue of assembly points. Where are high points in the area that do not go under water where people can wait for further instructions. Here, they cannot drown. Or, how to behave? That does currently not exist.
P 4: CP2_B - 4:10 [F - In Bremen there ..] (21:22) (Super)
Code: [act according to plan]
no memos
F - In Bremen there is also a disaster control team. I keep hearing of tutorials.
A - Yes, but without real public participation.
P 9: DC_B - 9:3 [There is nothing..] (23:23) (Super)
Code: [act according to plan]
no memos
There is nothing fixed. If you think of completed, prefabricated evacuation plans, those do not exist. Those will be developed, when needed.

Step 4 and 5

In step four the data analysis (Gupta et al., 2010) starts, where each criterion is scored. First, a preliminary score is given to each of the assessment criteria (Kuckartz, 2012). Here, various text passages are needed to underline the decision made. For the scoring the definitions and the list with the hints for coding (Table 6) are used. The findings from the previous step are analyzed and a decision is made if the quotes show a positive, slightly positive, slightly negative, or negative effect on the adaptive capacity of the water safety institutions. For each of the assessment criteria one out of these four scores is given. Having four scores means that no middle score exists. This is done, because a middle score neither show strength nor an area of concern. Contrasting, when only positive or negative scores are given this directly shows where to improve and what is actually quite good. While Gupta et al. (2015) use five main categories for scoring this thesis only uses the fifth "unknown" score in case there is not enough data available for a valid scoring or in case the statements are unambiguously (Kuckartz, 2012).

After the preliminary score the gathered data and the degree of compliance with the definitions is checked again which results in a final score. This final score represents the fifth step explained in Kuckartz (2012).

Table 7: Scores and color schemes of the modified Adaptive Capacity Wheel (Source: Author)

Effect of institutions on adaptive capacity	**score**	**Aggregated scores for the seven qualities and overall the adaptive**
Positive effect	+2	(+1.01) to (+2.00)
Slightly positive effect	+1	(+0.01) to (+1.00)
Slightly negative effect	-1	(0.00) to (-1.00)
Negative effect	-2	(-1.01) to (-2.00)
unknown	-	-

As seen above in the Table 7 each of the criteria from in the conceptual framework were scored using a scale from (-2) to (+2), where (-2) indicates a negative effect and is colored in red, (-1) means a slightly negative effect and is colored in orange, (+1) shows a slightly positive effect and is colored in yellow, and (+2) indicates a positive effect and is colored in green.

A dimension is assessed by adding up its criteria and then dividing it by the number of criteria used (Gupta et al., 2010). As it is also possible that these aggregated scores (Gupta et al., 2010) achieve decimals in between the scores of (-2) and (+2), all calculated scores between (-1.01) and (-2.00) are colored red, scores between (0.00) and (-1.00) are colored orange, scores between (+0.01) and (+1.00) are colored yellow and

scores between (+1.01) and (+2.00) are colored green. For example: Diversity=(-1); Redundancy=(-1), Variety of problem frames and solutions=(+2); Multi actor, level sector=(+1) → the overall Variety is ((-1)+(-1)+(+2)+(+1)/4)=0.25 and consequently yellow. In case of an unknown effect this criterion is ignored in the following calculation. For example: Diversity=(-1); Redundancy=(0), Variety of problem frames and solutions=(+2); Multi actor, level sector=(+1) → the Variety is ((-1)+(+2)+(+1)/3)=0.5 and consequently yellow.

For the assessment of the overall adaptive capacity the decimal scores for each dimension is added up and later divided by its total number, namely 7. The coloring of the overall adaptive capacity follows the same categories as for the dimensions and criteria, seen in Table 7.

Besides the colors of a traffic light, also different shades of grey could have been used (Gupta et al., 2010). Those represent a more neutral way for the presentation of the scores. But the traffic light colors are more communicative, as the scores become directly visible. Even if they are not value free in our society, because red is always connected to "warning" and "caution" while green represents "everything is fine", "go on" the colors were chosen, because this is also what this thesis is about. It should raise awareness where the cities of Hamburg and Bremen should put more emphasis on and different shades of grey would not have the effect that this thesis wants to achieve.

Step 6 and 7

The data interpretation as described in Gupta et al. (2010) represents the sixth and seventh step of Kuckartz's (2012) content analysis. The sixth phase is a descriptive analysis (Kuckartz, 2012), where a verbal representation of the criteria and its scores is given, without any value or judgment. Lastly, in-depth interpretations are made (Kuckartz, 2012) and the given scores get a meaning, which allows to talk about strengths and area of concern as well as to come up with recommendations for improvement.

This chapter showed which cases were selected for what reasons. Moreover, the methods used for data collection and analyzed were given in this chapter. The results of this analysis and the resulting scores are presented in the next chapters. The results for Bremen are given in chapter 4 while the results of Hamburg can be found in chapter 5.

Chapter 4 The case of Bremen

This chapter first introduces the city of Bremen, its vulnerability as well as the responsible organizations and leading documents regarding flood protection and climate adaptation in Bremen. Second, the results of the evaluative qualitative content analysis and the resulting scores for each dimension are presented. Lastly, the results of this chapter are visualized in the modified Adaptive Capacity Wheel for Bremen (Figure 12).

4.1 Bremen's vulnerability to floods

The city of Bremen has about 548.500 inhabitants (Freie Hansestadt Bremen, 2014) and a size of 325km² which lies mainly on flat marshes (NLWKN, 2007). As seen in Figure 9 Bremen is not directly located at the North Sea. But due to its location at both banks of the river Weser, which flows into the North Sea, it is still influenced by the tides (Below, 2010).

Figure 9: Map of Bremen (Source: Googlemaps, 2015a)

In Bremen Hemelingen, which can be found in the south eastern parts of the city, a weir stops the influence of the tides. Moreover, it represents the border between the Middle and the Lower Weser (Below, 2010). Downstream the weir storm surges threaten the city, while upstream the weir fluvial floods are possible (Freie und

Hansestadt Bremen, 2003). All areas in Bremen are therefore protected by a closed line of structural measures. Only some garden plots and the Weserstadion (the local soccer stadium) are located in the dike foreland. The total length of the dikes in Bremen is about 74km (NLWKN, 2007).

Even if a closed line of defense measures exists, a flooding of the city is possible. The areas at risk are shown in Figure 10. The blue color shows areas that are not protected by any measures and therefore regularly flooded. Light colors indicate lower water levels while dark colors indicate high water levels in these areas. Additionally, red colors indicate those areas that are protected but would be flooded when all measures fail. Here, dark colors also show deeper water levels while light colors indicate lower water levels.

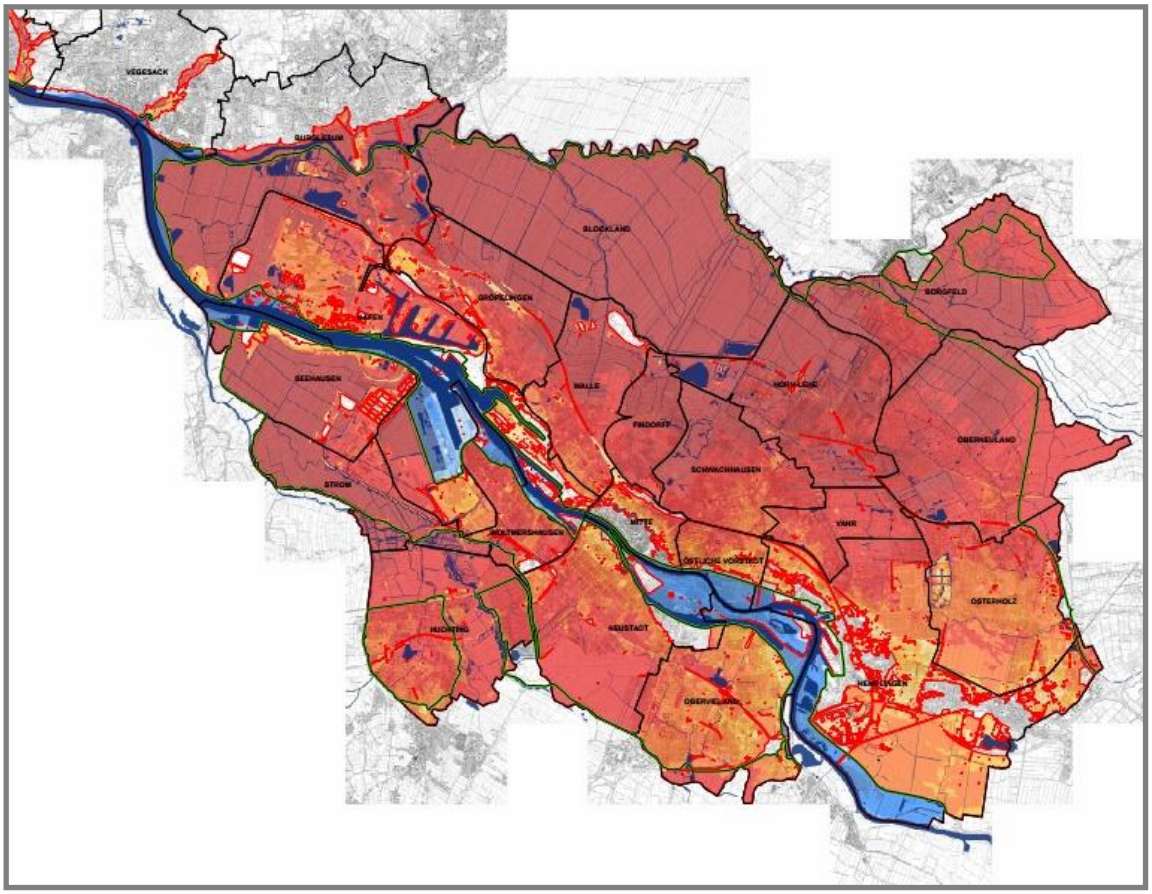

Figure 10: Extract from the flood risk map of Bremen (Source: Der Senator für Umwelt, Bau und Verkehr, 2015)

4.2 Flood management in Bremen

Flood protection is crucial in Bremen. As seen in Figure 11 various administrative levels are part of the flood management organization.

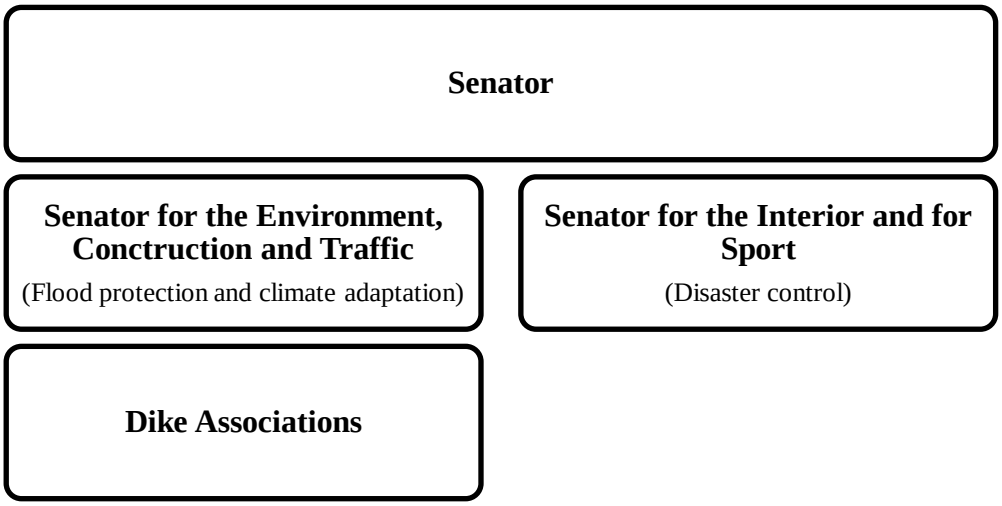

Figure 11: Simplified organigram of the administrative layers involved in flood management in Bremen (Source: Author)

The operation and maintenance of the existing measures, as well as the expansion and maintenance of the water routes and the drainage of the inland is done by the local dike associations. Here, two organizations exist. Both represent self-governing public cooperations that act on behalf of the city of Bremen and are supervised by the Senator for the Environment, Construction and Traffic (German abbreviation: SUBV) (Lange and Garrelts, 2008). In case the existing measures fail in their function the lead is given to the Senator for the Interior and for Sport, where the disaster control is done and for example evacuations planned (Lange and Garrelts, 2008). But normally, the SUBV is the leading organization for flood protection in Bremen. It is responsible for the implementation of various regulations concerning the management of floods (Lange and Garrelts, 2008).

One of these documents is the "Generalplan Küstenschutz" (Translation: Masterplan Coastal Protection) (NLWKN, 2007) which was published by the SUBV in 2007. It was developed in cooperation with the Lower Saxony Water Management, Coastal Defense and Nature Conservation Agency (German abbreviation: NLWKN) which is the responsible water management organization in the Federal State of Lower Saxony. The Masterplan represents the guiding document for flood protection along the Lower Weser. Thus, it tells how the inland is protected from storm surges, namely via structural measures, and how these measures are built and financed. For example the

current construction program, where 74 % (55 km) of the existing protection line are adapted to climate change costs about 100 Million Euro (NLWKN, 2007).

The document "Hochwasserschutz im Land Bremen" (Translation: Flood protection in the Federal State of Bremen) (Freie Hansestadt Bremen, 2003) informs about the threat of being flooded and the measures used to handle the problem. Moreover, it tells about the importance of flood protection regarding storm surges and fluvial floods, as well as climate adaptation (Freie Hansestadt Bremen, 2003).

Another document that also deals with the issue of adequate climate adaptation is called "Anpassung an die Folgen des Klimwandels in den Zuständigkeitsbereichen des Senators für Umwelt, Bau und Verkehr" (Translation „adaptation to the consequences of climate change regarding the responsibilities of the Senator for the Environment, Construction and Traffic"). This document was published by the SUBV in 2013 and tells about future visions for adequate climate change adaptation. This document therefore completes national adaptation strategies, like the German Climate Adaptation Strategy and the recommendations made by the German Working Group of the Federal States on Water Issues (German abbreviation: LAWA). Moreover, it acknowledges the findings of the nordwest2050 project (Der Sentor für Umwelt, Bau und Verkehr, 2013).

Next to these policy documents the "Sektorale Roadmap Küstenschutz" (Translation: sectoral roadmap coastal protection) (Sustainability Centre Bremen, 2013) presents the findings of the nordwest2050 project, which is the KLIMZUG project for the metropolitan region Oldenburg-Bremen. This document tells about local climate changes and the vulnerability to climate change in the field of flood protection. Based on these findings it tells about future visions and gives recommendations how to get there.

Besides the research done in form of the project nordwest2050 and the various documents that deal with the issue of adequate adaptation, Bremen is currently developing a climate adaptation strategy. The lead for the development of this strategy is given to the SUBV.

4.3 The adaptive capacity of water safety institutions in Bremen

Below the results for Bremen are presented. Based on the data gathered via interviews and document analysis the findings for each criterion and its scoring are presented separately, before all scores are visualized in the resulting Adaptive Capacity Wheel for Bremen (Figure 12).

4.3.1 Variety

Problem frames and solutions

In Bremen 89% of the city is protected by one main defense line which consists out of various technical measures. Due to climate change sea level is expected to rise and also storm surges may increase which is why the main defense line was already adapted to a new design water level (NLWKN, 2007). Additionally, an expansion potential was incorporated into the new construction which means that in case sea level rise is faster or stronger than expected, the technical measures can be easily heightened (NLWKN, 2007). Besides, there also exist retention areas along the Weser (Freie Hansestadt Bremen, 2003) which may be expanded in future due to dike relocations (Der Senator für Umwelt, Bau und Verkehr, 2013). Those non-structural measures seem especially important under the aspect of missing space in a densely populated city as well as the increasing technical difficulties for further adaptation of the main defense line (Der Senator für Umwelt, Bau und Verkehr, 2013). Another vision for future is also the construction of a storm surge barrier at the Weser estuary (Sustainability Centre Bremen, 2013). But currently, other solutions are not considered as all of them seem to be more expensive than the heightening of the existing defense line (CP1_B). As long as it is financially feasible the main defense line will be continuously heightened in future (Sustainability Centre Bremen, 2013), because the SUBV wants to keep the existing level of protection also in future to ensure living in Bremen (Freie Hansestadt Bremen, 2003).

All these measures of dikes, barriers and also retention areas and dike relocations focus on probability reduction. Even if the paper from the SUBV (2013) states that Bremen needs to strengthen its robustness, adaptability and transformability in future, there are no measures stated. Additionally, a risk based approach seems to be financially not feasible and not reconcilable with current legislation, like the dike law (Sustainability Centre Bremen, 2013). The problem frames and its solutions are narrowed on probability reduction which seems not to change in the near future. This focus on probability reduction is also the reason why disaster control on Bremen only plays a minor role in flood management. Here, plans are only predefined (DC_B) which is why the public seems to be unaware of the flood risk. Vulnerability reduction is therefore missing in Bremen which is why the score for "variety of problem frames and solution" is not sufficient (-2).

Multi actor-, sector, -level

In Bremen the SUBV takes the lead in flood protection issues. It creates plans and guides the action of the dike associations (CP2_B). The dike associations take care of the dikes and organize the measures, and are therefore involved in policy making even if they do not directly decide about the actions taken (CP2_B). In 2007 the SUBV

developed the Masterplan Coastal Protection (NLWKN, 2007) together with the responsible ministry from Lower Saxony (CP1_B). This is the leading document regarding flood protection in Bremen. The dike associations are informed about these plans (CP1_B). Additionally, the plans are agreed with the sector of disaster control, because the plans influence their work (DC_B). The lead for disaster control is given to another ministry, the Senate for the Interior and for Sport (CP1_B; DC_B). Here, the dike associations are the consultants of the disaster control sector, because they are responsible for the dike protection. (CP1_B). Disaster control members coordinate the actions during a flooding but also administration members and private companies are invited to this management group (DC_B).

There are two different hierarchically organized sectors which cooperate, when necessary. The criterion multi-sector is given, but it is more a coordination and exchange of information rather than creating plans together. Additionally, in shifting towards flood resilience cooperation with the spatial planning sector is still missing. Moreover, it can be seen that lower levels of administration are involved, like the dike associations. Even if plans are guided by the highest level, flood protection tasks are separated across various levels. Lower levels like the dike associations represent the interests of the locals. As those have a certain degree of power to influence the decisions taken it can be concluded that the public is partly involved in policy making. But generally there are only few members in at each level responsible. Regarding all of these issues the criterion multi-actor, -level, -sector is scored with (+1).

Diversity of solutions

In Bremen 160km of dikes can be found (CP1_B). But dikes also have their own "infrastructure-system" which exist out of toe erosion protection measures, flotsam removal paths, dike ditches, dike protection paths (NLWKN, 2007; Freie Hansestadt Bremen 2003) and pumping stations (CP2_B). Besides the dike also other structural measure, like bulkheads, floodwalls and quays can be found along the Weser as well as barriers at its tributaries (CP2_B). Despite these structural elements, also dike forelands can be found in Bremen (Freie Hansestadt Bremen, 2003). Those give room to the river and can also take up water in case of a storm surge which reduces the overall peak water level (Freie Hansestadt Bremen, 2003). But in Bremen these forelands are small and do only contribute little to the reduction of the water level (Freie Hansestadt Bremen, 2003). At the Weser's tributaries bigger retention areas can be found (Freie Hansestadt Bremen, 2003).

In case of a flooding of the hinterland the population is warned via TV, radio or a warning-App. Additionally, the police is driving around and is doing loudspeaker warnings. But no area-wide warning system exists. The old hooter-system was disposed in 1989 and no compensation was given (DC_B).

Bremen focuses on the main defense line and its technical measures which reduces the probability of a flooding. Due to climate change this line of defense is heightened by about 1m (CP1_B; CP2_B; NLWKN, 2007) which means that technical measures are also the solution for the near future. People behind the dike are and will be protected from floods and only few plans for disaster control exist. But neither infrastructure adjustments nor education or information of the locals take place. The diversity of measures is rather little and does not contribute to a flood resilient city which is why its score is (-2).

Redundancy

All of the aforementioned technical flood protection measures build one closed line of defense (CP2_B; NLWKN, 2007).

For disaster control there are four types of warning measures: TV, Radio, Warning-App and police activities (DC_B). All of them need electricity and, besides the police activities, all of them need people who are aware of the risk of flooding. In case none of the people living in Bremen is watching TV or listening to the radio in that moment nor has a warning App the system is really much depended on the police activities.

Regarding the closed line of defense measures, there is no redundancy and measures taken for warning are only slightly redundant. As there are still various possibilities left the redundancy is scored with (-1).

4.3.2 Learning capacity

Good relations

Regarding flood protection the SUBV takes the lead but some responsibilities are also given to the dike associations (CP2_B; CP1_B). Therefore, the dike associations have a say in policy making and are also heard by the upper levels.

In the field of disaster control, actors meet after the event and discuss where and what to improve (DC_B). Additionally, there is a working group disaster control where all actors who are involved in the field of disaster control are part of, like dike associations, the SUBV and aid organizations. This group meets two to three times a year and talks about important issues, changes and needs (DC_B).

Due to the fact that the responsibilities are separated the discussion of doubts seems to be limited, while trust in each other's competences seems to be high. For the discussion of doubts the dike associations seem to play a crucial role, because they are involved into both sectors and have the position to raise doubts. As the trust in each other's expertise seems to limit the discussion of doubts the score for good relations is (+1).

Single-loop learning

Dikes are being built and maintained for 900 years (CP2_B). In this time a lot of experience has been made. For example the shape of the dike changed tremendously. Today, dike construction is an own field of technical engineering, where loads are simulated and models used (CP2_B). When new knowledge and new insights are available, those are added to the existing plans and systems (CA_B; CP1_B). Therefore, also climate change is not a new issue. Climate changes are known and its adaptation done for years (Der Senator für Umwelt, Bau und Verkehr, 2013).

Regarding disaster control in Bremen single-loop learning is also given due to the fact that tutorials, where a disaster is simulated and performed among the involved actors, are done regularly. Due to these tutorials the involved sectors of disaster management and flood protection can experience where improvement is needed to adequately deal in case of a real threat (CP1_B).

Leaning is also not always based on own mistakes done in the past, but it is also about learning from the mistakes of others (CP2_B). For example, the flooding of New Orleans in 2005 was analyzed and based on these insights pumping stations in Bremen were sealed to keep them dry during a flooding. Thus, they will not fail in function during a flooding as it was the case in New Orleans (CP2_B).

Improvement and learning are central in Bremen (CP1_B; CP2_B; NLWKN, 2007), especially because of its geographical location adaptation and learning are crucial (Der Senator für Umwelt, Bau und Verkehr, 2013). Single-loop learning is given in form of improvement and adaptation regarding new knowledge and past experiences which is why it is scored with (+2).

Double-loop learning

As stated by a responsibility for disaster control in Bremen the settlement and the cultivation of flood plains, which reduces the room for the river and increases peak water levels, is today seen as a mistake. It is stated that flood plains should no longer be reduced in future (DC_B; Freie Hansestadt Bremen, 2003).

The unlearning of routines which leads to changes in underlying assumptions is rather limited. The reduction of flood plains is the only indicator for double-loop learning in Bremen. The methods therefore seem to be always the same. Therefore, double-loop learning seems to be rather weak which is why its score is (-1).

Institutional memory

In Bremen tutorials, where a hazard is simulated and performed among the involved sectors, are made regularly (CP1_B; DC_B; CP2_B). Those are evaluated and discussed afterwards (DC_B). Moreover, monitoring of climatic factors takes place. Here, it was mentioned that the sea level rose about 15-20cm during the last 100 years (Freie Hansestadt Bremen, 2003). This can contribute to an institutional memory. But it is not known to what extent the gathered information is evaluated. If this information is not evaluated institutional memory can get lost when the few responsible actors in an organization change over time (CP/CA_B; CP2_B). This is also the fact regarding the dike associations. As mentioned that dikes are being built for 900 years, also dike associations exist for that long time (CP2_B). It is possible that the whole organization is characterized by a great knowledge based on various experiences made. But also here, actors are replaced over time. To what extent the experiences are noted is unknown.

As there is only little information about the evaluation of monitored issues it is assumed that evaluation is barely done. As there are possibilities in Bremen where monitoring took place, but only monitoring is not enough to build an institutional memory its score is low (-1).

4.3.3 Room for autonomous change

Access to information

The involved organizations have no own data sources. Both, the flood protection and disaster control responsibilities are informed about water levels and threatening storm surges via the Federal Maritime and Hydrographic Agency (German abbreviation: BSH) (CP1_B; DC_B; Freie Hansestadt Bremen, 2003). Additionally, the flood protection sector also has access to the information from Lower Saxony (CP1_B) who has a measuring station on Norderney which tells about water levels and wind directions that are needed to predict a storm surge. In case a storm surge is expected in Bremen the responsibilities will give the information to the lower levels of administration as well as to the public (DC_B) via press release (CP1_B; CP2_B) The public has also access to general information about the water level, the wind direction as well as the hydrographic curve of the Weser via the homepage of the BSH (CP1_B; CP2_B). Moreover, in case of a flooding and an evacuation the public is informed via the aforementioned warning measures, TV, radio, loudspeaker warning, police activities and in near future also a warning-App that can be downloaded on every Smartphone (DC_B).

While the organizations themselves are well informed about the data they need and want to have, the public access to information is limited. Generally the public has access to some data, but all of these types of information require public awareness of the risk itself. As it is assumed that local risk awareness is low it remains questionable if the public knows where to find the data and how to interpret it. Even if the organizations have a good access to the needed data, local access to information is passive which is why the criterion continuous access to information is scored (-1).

Act according to plan

In Bremen the "Katastrophenschutzkalender" (Translation: disaster control calendar) tells who needs to be informed and what needs to be done when a certain water level is reached (CP1_B; DC_B). Besides this general information the "Katastrophenschutzkalender" also tells where emergency accommodations can be found across the city and how to transport people to these locations, namely flipping public transport routes to these locations (DC_B).

But this plan is not publically accessible. Moreover, those plans are only predefined (DC_B) and the final decisions are taken when necessary. Consequently, locals cannot act according to plans, because no real plans exist. It is for example unknown where the meeting points or emergency accommodations are in case of a flooding. Additionally, locals are not informed about general behavior and the risk is also not communicated (CP1_B; CP2_B). This information is planned for the future (CP1_B) but currently the capacity to act according to plans in society is low and scored with (-1).

Capacity to improvise

In Bremen there are professionals involved in disaster control, like the fire brigade, which are experts in what they are doing. They are educated in dealing with chaos and critical situations and it is their job to turn a chaotic event into order (DC_B). Those professionals are not only working in case of a flooding but are also part in everyday life and have a wealth of experience and act slick (DC_B).

Improvisation in society is to some extent possible, because these experts can autonomously guide actions in case of a flooding. But due to the fact that locals are not educated about the risk of floods at all, the probability for panic and chaos seem to be quite high. In case a flooding affects Bremen, where people do not know what to do, the capacity to improvise seems to be limited (-1).

4.3.4 Leadership

Visionary leadership

While a strong water management sector can create path dependence, bottom-up arrangements can bring new knowledge and innovative ideas (Gupta et al., 2015). For example the work done by researchers is independent from the administrative level. But actors in Bremen argue that research outcomes are often abstract (CA_B), not practicable (CA_B), or economically not feasible (Sustainability Centre Bremen, 2013; CP1_B). Future visions, like a second dike line or the implementation of soft measures are seen critically by the responsible authorities, because space in Bremen is limited (CP1_B; Sustainability Centre Bremen, 2013). All new ideas are appreciated, observed and sometime the administrative level also participates in projects (CP1_B). For each project it therefore needs to be seen what the useful insights are (CP1_B) and to what extent these can be used (CA_B). But sometimes also more research is needed or ideas are still not practicable (CA_B).

In the research project nordwest2050 a "Klima-Pakt" (Translation: climate-treaty) was signed by some of the involved actors, which shows that they identify themselves with the recommended measures (CP/CA_B) and are open these future visions. Those mainly focus on flood resilience which means the robust measures need to be kept, but the system should be extended by a second dike line where possible as well as risk communication and the idea of working with nature not against it needs to be considered (Sustainability Centre Bremen, 2013). But these ideas are not unlimited shared by the involved actors (Sustainability Centre Bremen, 2013). Rather, other actors mention that a second dike lines as well as soft measures are not feasible due to limited space and too high costs. Moreover, these measures are not in line with the current legislation as they would reduce the level of protection. Risk communication is also seen critically (Sustainability Centre Bremen, 2013). Rather, there is no urgency to change the existing flood protection system.

The Roadmap (Sustainability Centre Bremen, 2013) does not tell which actors are open-minded towards the recommendations made and who are not. But regarding the interviews made, it is not planned to realize any of these ideas or other alternatives in near future. Even if the responsible actors give reasons why rejecting the ideas the organizations are generally rather critical about innovating the system. To sum up visionary leadership is accepted and appreciated but not really considered in policy making. Its score is therefore low (-1).

Entrepreneurial leadership

Due to the hierarchical structure clear responsibilities exist in Bremen. It is given who is doing what and the implementation of adaptation plans and measures is no problem. While the adaptation plans are formulated by the responsible persons for flood

protection in the SUBV, the dike associations do the implementation of the adaptation plans (CP1_B). Additionally, the disaster control team is preparing plans for a disastrous event, like evacuation plans (DC_B).

All actors are accepted leaders who stimulate actions and undertakings to get the climate adaptation of flood protection measures done. This is why entrepreneurial leadership is scored with (+2).

Collaborative leadership

Collaboration takes place across Germany via the "Bund/Länder-Arbeitsgemeinschaft Wasser" (Translation. German Working Group of the Federal States on Water Issues) (German abbreviation: LAWA). Here, all Federal States, as well as the Federal Government are represented (CP1_B). Next to the LAWA also other forms of cooperation take place, for example there are working groups for various rivers (CP1_B). Besides this national cooperation there is also cooperation on the European level as well as on regional level, like the cooperation with the Federal State of Lower Saxony (NLWKN, 2007; Freie Hansestadt Bremen, 2003; CP/CA_B). Regarding the issue of climate adaptation there is also cooperation between the northern Federal States, as those are affected by similar climate change consequences (Der Senator für Umwelt, Bau und Verkehr, 2013). Additionally, the climate adaptation strategies in the northern Federal States will also be created with the help of the KLIMZUG research projects for these regions, namely RADOST, KLIMZUG-NORD, and nordwest2050. With partners who joined these projects as well as representatives from the northern Federal States and the Federal Government a regional conference is done regularly (Der Senator für Umwelt, Bau und Verkehr, 2013).

How these forms of cooperation are stimulated is unknown, but as it is fact that there are various forms of cooperation there must also be people who encourage these networks. To what extent this cooperation is used to collaborate is also unknown. It seems to be more an exchange of information. Furthermore, as mentioned earlier, cooperation takes place within and across the responsible sectors for water safety in Bremen. Even if tasks are divided within these local networks, co-management seems to be limited due to the separated sectors and the hierarchical structure. But networks for possible co-management exist, which is the reason why the criterion collaborative leadership is scored (+1)

4.3.5 Resources

Authority

For flood protection the responsible senate is the SUBV, for disaster control the Senate for the Interior and for Sport takes the lead. Moreover, there is a given hierarchy in policy making which results in the fact that for each problem a person can be found who has the power to decide upon the issue. In a senate there are for example responsibilities for various issues, like flood protection and water quality, as well as nature conservation. For each sector superiors and clerks can be differentiated. The lead of all sectors is given to the corresponding senator (DC_B) that is the one who can take the final decision. In the senate also laws and regulations are adopted and published (CA_B) which are guiding for the actions taken.

In Bremen the provision of accepted and legitimate forms of power can be seen which results in a high score of the authority resource (+2).

Manpower

The development of the climate adaptation strategy needs to be done next to the everyday work (CA_B). This results on the one hand in the fact that the strategy is really much integrated into planning practice. But on the other hand actors may not have enough time for both, which can slow down planning processes. As manpower is already quite limited (CP1_B; CA_B) on the administrative level, this can result in planning problems in the near future, because missing manpower means that plans for adequate adaptation can only hardly be created due to limited capacities and barely be realized on time.

In case of a flooding, manpower from lower levels of authority outside the administrative levels can be used. These people, mainly represented by the local aid organizations, are around 2000 people that can be mobilized to manage a disaster (DC_B). In case this is not enough additional manpower can be recruited from the German Armed Forces or other regions in Germany, like from the Harz Mountains. The demand and supply of this additional staff outside the city is coordinated by the "Gemeinsames Melde- und Lage Zentrum" (German abbreviation: GMLZ) (DC_B).

Regarding the development of strategies, laws and regulation the manpower seems to be a limiting factor which may hinder adequate climate adaptation in future. But in case of a flooding there is enough manpower available to prevent the city from damage. At the moment manpower therefore seems to be sufficient which is why its score is (+1).

Knowledge

Today, flood protection is an own field of research, where own study programs exist (CP2_B). This is why there is well educated junior staff available. Additionally, the plans created in the field of flood protection can also be outsourced to engineering offices which means that in case there is enough money available additional knowledge can be bought (CA_B). Moreover, in case of a flooding, professional aid organizations can be recruited which are educated well (DC_B). Therefore, they do not only represent manpower but a source of knowledge. Furthermore, the involvement of local knowledge is mainly given by the dike associations who also take part in policy making in Bremen.

The availability of knowledge is given and also seems to be no problem for future planning practice. The knowledge available mainly incorporate expert knowledge in engineering and to some degree also knowledge about vulnerability reduction. Only knowledge about adaptation options seem to be missing, which is why its scored is damped to (+1).

Financial resources

From 1955-2006 Bremen invested 180 million Euro on the maintenance and heightening of the defense line (NLWKN, 2007). The new Masterplan was implemented in 2007 (NLWKN, 2007) and states measures will last until 2015 with overall costs of 240 million Euro (Der Senator für Umwelt, Bau und Verkehr, 2013). Regarding the next ten years it is assumed the flood protection sector will spend about 200 million Euros (CP/CA_B). Generally all this money is coming from the Federal Government and the Federal State itself. Due to the so called Joint Task for the Improvement of Agricultural Structures and Coastal Protection (German abbreviation: GAK) around 70% of the costs for coastal protection are taken by the Federal Government. The rest (30%) needs to be paid by the Federal States themselves (CP1_B).

In case of a flooding manpower are recruited from various aid organizations, which is why disaster control does not cost much money. The available staff is not part of the disaster control office and does not need to be paid by them. They are only recruited in case of a flooding. This is also the fact for the transport systems and the emergency accommodations used for an evacuation. Here, the existing infrastructure, like schools and the public transport system, especially the buses, will be used. There are no extra costs for disaster management.

But it is said that soft measures do cost too much money and as long as current measures are economically feasible the system will not change (Sustainability Centre Bremen, 2013). As stated in Restemeyer et al. (2015) resilient measures do not need to be more expensive than technical measures. For example risk communication is cheap.

The price seems to be an excuse to not invest in resilient measures. Sufficient amounts of money seem to be available, but they are not invested in flood resilience. The score for financial resources is therefore (-1).

4.3.6 Fair governance

Legitimacy

In Bremen a law was published which states that the development of a climate adaptation strategy is obligatory (CA_B). Consequently, all parties, like the coastal protection actors have to come up with a future outlook. This legal basis is also given for the dike constructions, where a planning permission is needed before measures can be realized (CP2_B). Here, a risk based approach did not had any legitimacy in policy (Sustainability Centre Bremen, 2013), as by definition there was no need for actions in areas behind the dike as this land was protected by the exiting measures. This changed with the implementation of the European flood directive, which is about the idea of a risk based approach. With its implementation into German law in 2009 (Lange and Garrelts, 2008) there is a legal basis for a risk based approach given.

In Bremen there is a legal basis for the actions taken which represents a legitimate form of policy making. When the public does not support the plans, it is possible to show resistance. But here a problem occurs. On the one hand people are not aware of the risk which is why they are not interested into the topic at all. On the other hand, due to the missing risk awareness, people show resistance regarding the planned measures as those reduce their owned land or disconnect the locals from the water. Public support is therefore limited, but there is a legal basis for the actions taken. Moreover since 2009 legitimacy is also given for a risk based approach, but it is still not incorporated into any flood protection plans in Bremen. Legitimacy is therefore damped to (+1).

Responsiveness

Transparency is given, because the public is informed about the flood protection plans via newspapers or the internet (CP1_B). Due to this information and the needed planning permission, locals can become active in the planning process. In case there is local resistance the arguments will be proven and either trade-offs are made or the arguments are rejected (CA_B). This will also be the case regarding the climate adaptation strategy. Here, it is decided that the public will be involved in the policy making but to what extent participation takes place will be decided in future (CA_B). Only in disaster control management the public is not informed about the actions taken (DC_B).

Regarding disaster control plans the local property is not directly affected, which is why it is assumed that no response to society is needed. Regarding other plans society has the possibility to become active during the planning permission process. Here, the organizations need to show response in case of local resistance. But the argument that the public is not aware of the risk (CP2_B) or not interested into the topic is influencing the criterion responsiveness. How should the institutional patterns show response to society when those are not even aware of the risk? Responsiveness of institutional patterns in Bremen is given but limited (+1).

Accountability

Regarding the challenges faced in climate change the responsibilities amongst the involved organizations are clear (CA_B). The sectors have their field of responsibility and within the sectors a hierarchical structure provides clear responsibilities. In case situations show a cross sectional character there is one person who officially takes the lead (CA_B).

The hierarchical structure and the division of sectors results in clear responsibilities which is why its score is high (+2).

4.3.7 Political willingness

Sense of urgency

Generally, a storm tide in Bremen is never unexpected. Due to Bremen's geographical location upstream the Weser lead times are up to 12 hours (DC_B; Freie Hansestadt Bremen, 2003). Additionally, as written in the Masterplan (NLWKN, 2007) the new heights of the main defense line in Bremen are already adapted to the expected consequences of climate change. The height of the measures was adapted to a new design water level that is expected for the year 2050 (NLWKN, 2007). As it is known that the data used is characterized with uncertainties, bonus heights were already incorporated into the adapted heights. Future heightening therefore seems to be no problem, which results in the persuasion that Bremen is characterized by a "proactive consideration of climate change when compared nationally and internationally"[3] (Der Senator für Umwelt, Bau und Verkehr, 2013, p.10).

As stated in the Roadmap (Sustainability Centre Bremen, 2013) from the project nordwest2050 it is assumed that the lower extremes of calculations will not challenge the existing system, but that the upper extremes and a fast rising sea level needs further adaptation (Sustainability Centre Bremen, 2013; CP/CA_B).

3 Original quote: „Bremen hat sich damit, auch im nationalen und internationalen Vergleich, für eine sehr vorausschauende und anpassungsfähige Berücksichtigung des Klimawandels im Hinblick auf den Küstenschutz entschlossen"

Regarding the climate adaptation strategy, Bremen is currently in its beginnings to anticipate future visions. But it is already noted that the most threatening consequence of climate change will be the changing heat balance and the intense rainfall but also the limited space and too heavy loads of dikes for further adaptations (Der Senator für Umwelt, Bau und Verkehr, 2013). Communication and flood retention areas are considered (Der Senator für Umwelt, Bau und Verkehr, 2013).

As the main defense line was already adapted there is no urgency seen in the organizations to further adapt to climate change. This was also proven by the nordwest2050 project (Sustainability Centre Bremen, 2013). Additionally, the roadmap (Sustainability Centre Bremen, 2013) stated that actor's motivation to participate in the nordwest2050 project was low. This can also be seen in the fact that not all of the members who joined the working group did sign the "climate-treaty" (Sustainability Centre Bremen, 2013). Those cannot identify themselves with the recommendation made (CP/CA_B; Sustainability Centre Bremen, 2013). All of these facts show that local actors do not show any sense of urgency to change the system for adequate climate change adaptation, which is why its score is low (-2).

Accept uncertainty

It is recognized that the exact consequences of climate change are unknown (DC_B; Der Senator für Umwelt, Bau und Verkehr, 2013). As stated in the document of climate adaptation from the SUBV the amount of future greenhouse gas emissions are not known and the extent and the speed of sea level rise are unknown (Der Senator für Umwelt, Bau und Verkehr, 2013). Therefore, there are not only models used (Freie Hansestadt Bremen, 2003; NLWKN, 2007) but also a bonus height and a future adaptation are already incorporated (CP2_B; Der Senator für Umwelt, Bau und Verkehr, 2013; NLWKN, 2007) into the measures taken today.

Bremen's actors are aware of the uncertainties faced. But having a closer look on their statements and also the documents published, it can be seen that they are only aware of known unknowns, like the rising sea level and increasing storm surges. The non-linearity and complexity of climate change and the resulting unknown unknowns seem to be disregarded in the plans and not even realized by the actors in charge. Rather, bonus heights are given to reduce the uncertainties left. The score for accepting uncertainty is therefore low (-1).

The previous sections explained the scores for each criterion of the modified Adaptive Capacity Wheel. All of these findings regarding the adaptive capacity of water safety institutions in Bremen are visualized in the modified Adaptive Capacity Wheel for Bremen (Figure 12).

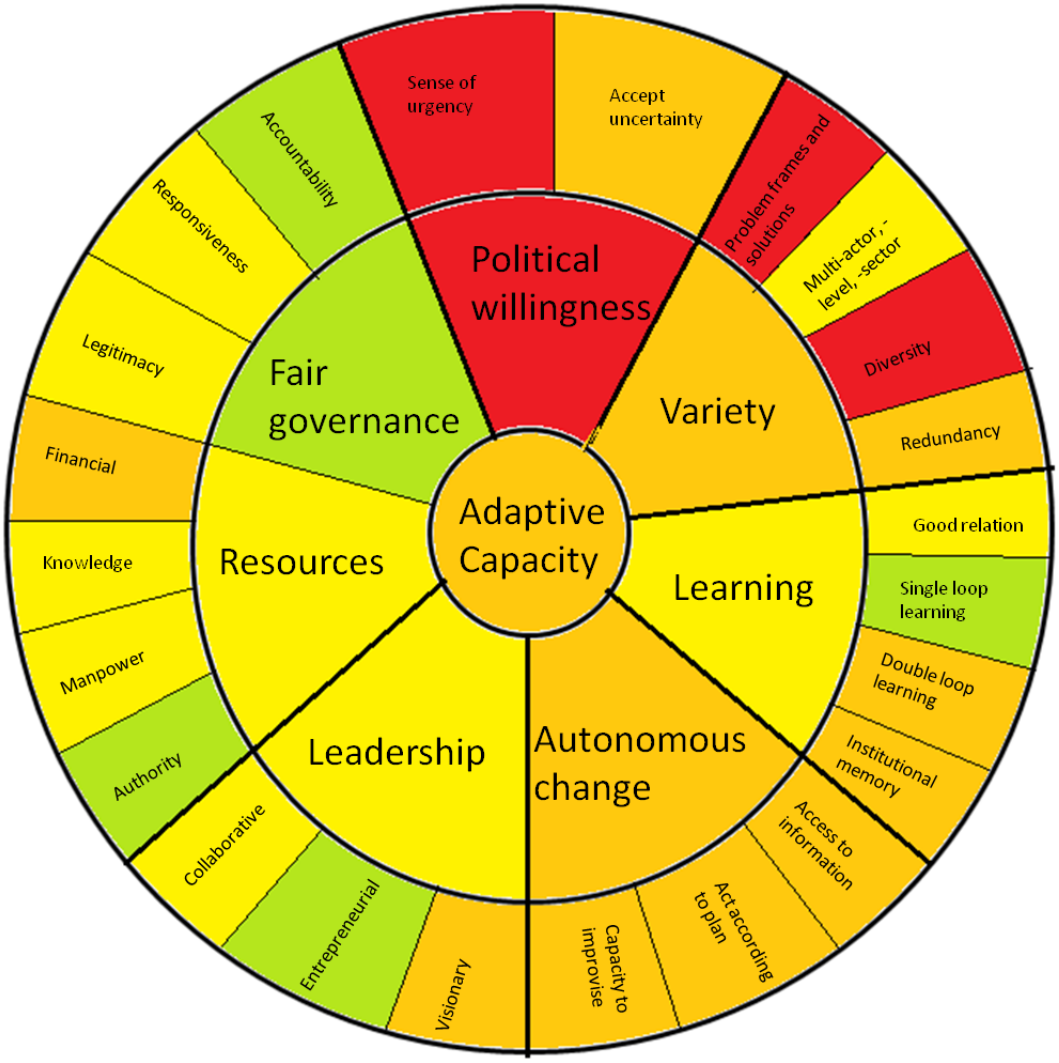

Figure 12: The resulting modified Adaptive Capacity Wheel for Bremen (Source: Author)

This chapter dealt with the findings from the case of Bremen. The results from the interviews and documents were given for each criterion separately. Based on the findings a reasoned score is given to each of the assessment criteria. All scores are visualized in the resulting modified Adaptive Capacity Wheel for Bremen (Figure 12). The findings for the other case study under research, namely the water safety institutions in Hamburg, are presented in the next chapter.

Chapter 5 The case of Hamburg

This chapter first introduces the city of Hamburg, its vulnerability as well as the responsible organizations and leading documents regarding flood protection and climate adaptation in Hamburg. Second, the results of the evaluative qualitative content analysis and the resulting scores for the local adaptive capacity are presented. Lastly, the results of this chapter are visualized in the modified Adaptive Capacity Wheel for Hamburg (Figure 17).

5.1 Hamburg's vulnerability to floods

Hamburg is one of the biggest cities in Germany. It has about 1 746 342 inhabitants (Statistisches Amt für Hamburg und Schleswig-Holstein, 2014) and is located on flat marshlands (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). As seen in Figure 13 Hamburg is not located at the North Sea, but as the Elbe is floating into the North Sea, Hamburg is still affected by the tides. Additionally, Hamburg is located in a bifurcation area which means that some districts are surrounded by the river.

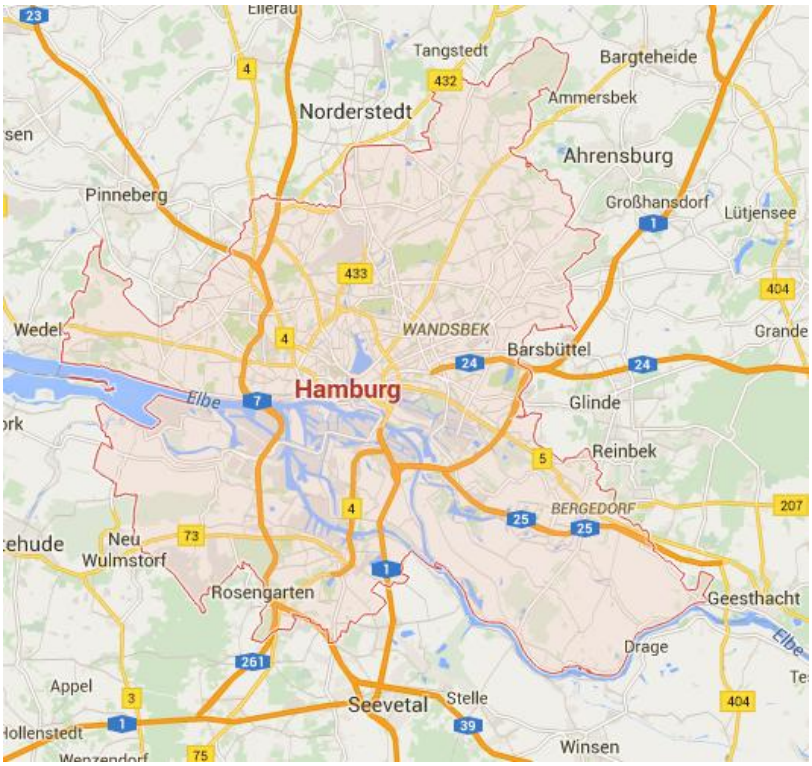

Figure 13: Map of Hamburg (Source: Googlemaps, 2015b)

The area at risk of being flooded can be seen in Figure 14. Here, small squares with blue color indicate areas at risk of being affected by a fluvial flood, while the two big squares with pink color show areas prone to storm surges. The overall area at risk has a size of about 324km² which is nearly 45% of the city. In these flood prone region about 325.000 people are living which is about 20% of the total population. Moreover, 165.000 working places and goods with an overall value of about 30 billion Euro can be found in this region (Bürgerschaft der Freien und Hansestadt Hamburg, 2012).

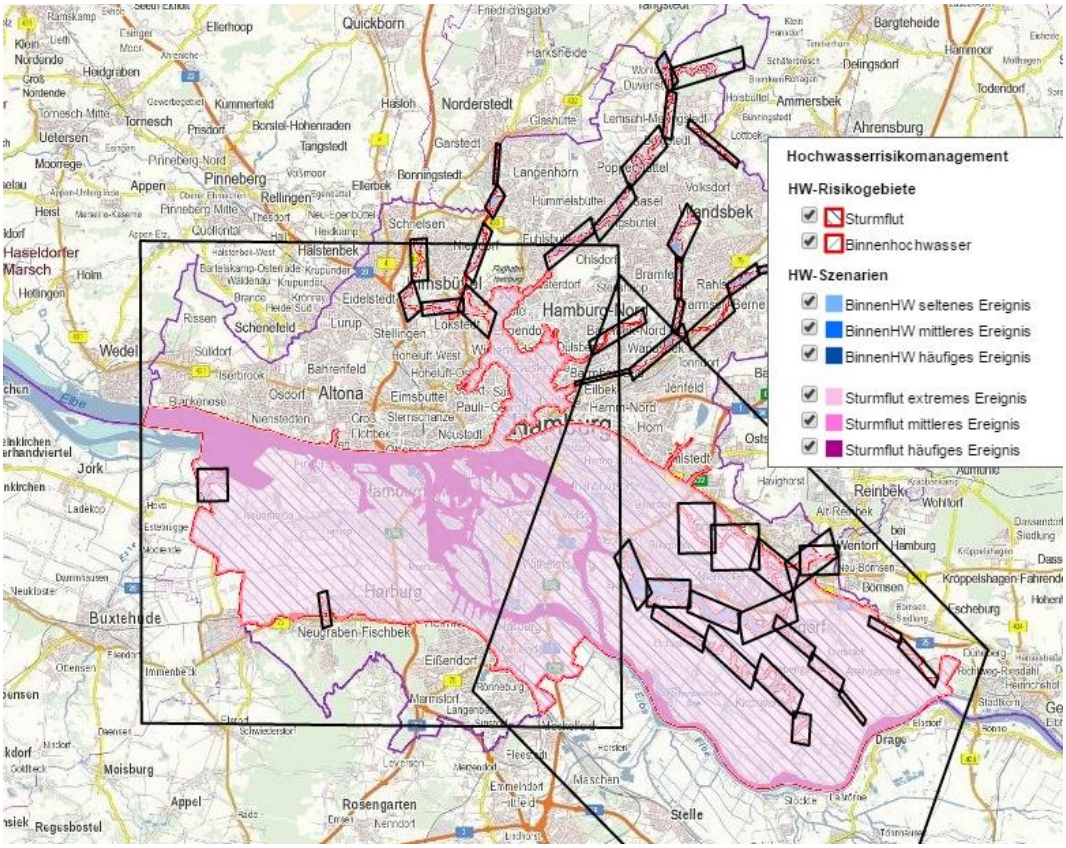

Figure 14: Areas in Hamburg prone to fluvial floods (small squares with blue color) and storm surges (big squares with pink color) (Source: hamburg.de GmbH & Co. KG, 2015a)

5.2 Flood management in Hamburg

In the past Hamburg was already affected by the huge storm surge in 1962. Here, a flood affected 50 dike failures and consequently one sixth of the area of Hamburg was flooded. The extent of the flooding (colored blue) can be seen in Figure 15.

Figure 15: Map of Hamburg showing the extent of the flooding in 1962 (blue) (Source: hamburg.de GmbH & Co. KG, 2015b)

Due to this flooding the infrastructure collapsed and about 60.000 inhabitants lost their homes and 315 people died. The biggest damage was affected in Wilhelmsburg and Georgswerder which are located in the middle of the bifurcation area. After the flood event, huge faults in flood management were considered (Garrelts and Lange, 2008) which is why this storm flood can be seen as the initiator for many extensive changes in flood protection in Hamburg (Garrelts and Lange, 2008).

After 1962 flood protection became task of the city administration, which is why the local dike associations play only a minor role in today's flood management (Lange and Garrelts, 2008). The planning, construction and maintenance of the flood protection infrastructure is mainly done by the Agency of Roads, Bridges and Water (German abbreviation: LSBG) that represents a service provider of the Authority for Urban Development and Environmental Affairs in Hamburg (German abbreviation: BSU) (LSBG, 2015). The BSU takes the lead for flood protection and climate adaptation in Hamburg. Amongst other issues, it is responsible for the development of various regulations, concerning flood protection and climate adaptation (Lange and Garrelts, 2008). Only in case of a flooding the lead shifts to another sector, namely the Municipal Office of the Interior (German abbreviation: BIS) which is responsible for disaster management in Hamburg. In case of a hazardous event the BIS is able to empower, stimulate and coordinate measures (Lange and Garrelts, 2008). A simplified version of the administrative organization can be seen in Figure 16.

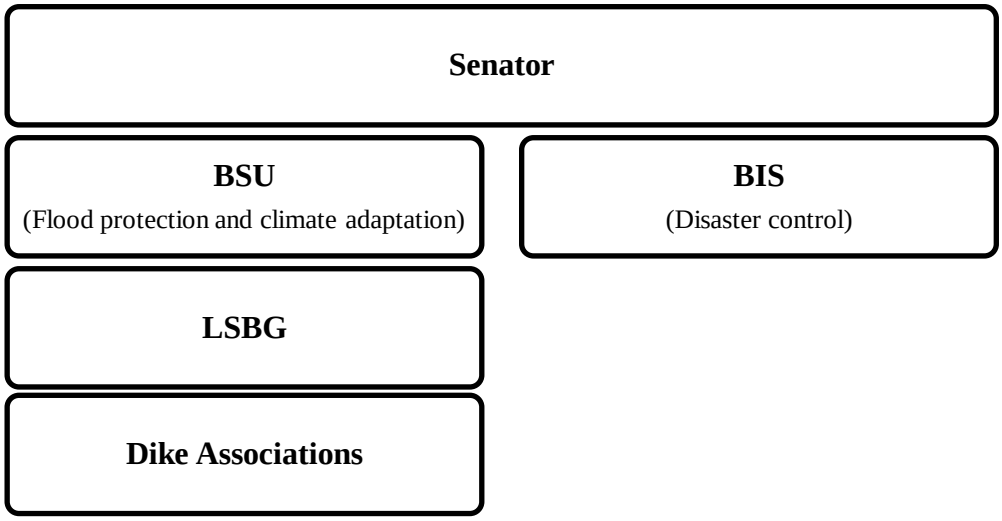

Figure 16: Simplified organigram of the administrative layers involved in flood management in Hamburg (Source: Author)

The leading document for flood protection in Hamburg is called "Hochwasserschutz für Hamburg" (Translation: flood protection for Hamburg). It was published in 2012 by the „Bürgerschaft der Freien und Hansestadt Hamburg". This document tells about the local vulnerability und existing measures, namely structural measures in form of dikes, flood walls and flood gates as well as public information (Bürgerschaft der Freien und Hasestadt Hamburg, 2012). Moreover, impact reduction measures can be found in the so called "HafenCity" which is a district located in the dike foreland. Instead of the protection via structural measures, houses and important infrastructure are adjusted to high water levels. They are built on mounds (Bürgerschaft der Freien und Hasestadt Hamburg, 2012). Besides these existing measures the document Hochwasserschutz für Hamburg (Bürgerschaft der Freien und Hasestadt Hamburg, 2012) also tells about possible solutions for future.

These visions for future are also given in the "Masterplan Klimaschutz" (Translation: Masterplan climate protection), which is also published by the Bürgerschaft der Freien und Hansestadt Hamburg (2013b). It sketches a plausible future path and sets the agenda needed for this future vision (Bürgerschaft der Freien und Hansestadt Hamburg, 2013b).

Direct measures for adequate climate change adaptation can be found in the "Aktionsplan Anpassung and den Klimawandel" (Translation: Action Program Adaptation to climate change). This document is also published by the Bürgerschaft der Freien und Hansestadt Hamburg (2013a) and tells about climate changes that happened so far, as well as the changes that are expected until 2050 and assumed until 2100. Based on these findings it tells about measures needed for adequate adaptation. Here, the different sectors of port industry, costal protection, water management, health, urban

planning, transport, protection of nature and soil, agriculture and forestry, civil protection and education are considered (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a).

Additionally, Hamburg is currently developing a monitoring for the consequences of climate change (Umweltbundesamt, 2015) that should help to analyze not only the exact local consequences but also the effectiveness of the taken measures (hamburg.de GmbH & Co. KG, 2015c). Moreover, the Senate of Hamburg decided upon the 'Development of a Climate Adaptation Strategy for Hamburg' at the end of 2011, which should be used as an action framework for local climate adaptation (hamburg.de GmbH & Co. KG, 2015c). The publication of this adaptation strategy is planned for the year 2015 (Umweltbundesamt, 2015; hamburg.de GmbH & Co. KG, 2015c).

Besides these actions taken at administrative level research for adequate climate adaptation is also done by the project KLIMZUG-NORD. This project is one of the German-wide KLIMZUG projects focusing in the metropolitan region of Hamburg. The output of this project is the so called Kursbuch Klimaanpassung (KLIMZUG-NORD Verbund, 2014). It tells about various areas of improvement for climate adaptation in the metropolitan region of Hamburg.

5.3 The adaptive capacity of water safety institutions in Hamburg

Below the results for Hamburg are presented. Based on the data gathered via interviews and document analysis the various criteria of the modified Adaptive Capacity Wheel are scored. The findings for each criterion and the resulting score is explained, first, before all scores summarized and visualized in the resulting modified Adaptive Capacity Wheel for Hamburg (Figure 17).

5.3.1 Variety

Problem frames and solutions

During the last 50 years Hamburg concentrated on the adaptation of the technical measures. For example the dikes were heightened by about 2.5m (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). In 1933 an adaptation program was adopted which includes aspects of technical adaptation of the existing measures as well as public information (CP2_HH). The construction program from 1993 is nearly finished, but a new construction program was already decided in 2012 (CP1_HH). Here, various alternative ideas were considered, like dike relocations (CP2_HH), a barrier, or another adaptation of the defense line (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). But no alternative to the heightening of dikes seemed sufficient. Soft measures were seen as difficult to implement in the densely populated city and they are economically not feasible (CP1_HH). Moreover, a barrier cannot be built in Hamburg and therefore

needs the agreement of the neighboring states. Furthermore, it would need lot of investment as ships need to be able to pass this barrier. Consequently, the adaptation of the defense line was decided.

For future adaptation Hamburg already developed an action program (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a) which tells that future dike constructions need to consider climate changes and need to incorporate an expansion potential. In this document it is also written that next to technical measures more soft measures are needed in future. The storage capacity, infiltration and discharge of water should be increased in future by creating retention areas. Additionally, further risk communication is needed in future (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a), because even if the technical measures in Hamburg have a high protection level, society needs to be aware of the risk which is increasing due to climate change (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a). Here, warning systems for fluvial floods and heavy rainfall are planned to reduce the potential damage. Moreover, the project "Deichpark" should make water perceptible for the public (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a). Additionally, the action program suggests house adjustments and building permissions for Hamburg's future development. For example new house constructions should incorporate a certain height and a building permission is recommended, because building limitations should be given to flood prone areas along the tributaries. Only along the Elbe exceptions should be made when other flood protection measures are realized (Bürgerschaft der Freien und Hansestadt Hamburg, 2013b).

Due to the fact that active information of society is taking place flood protection in Hamburg is not only about probability reduction, but also about impact reduction. This is also given in the future outlook where a comprehensive flood risk management plan is presented that already incorporates the shift towards resilience and living with floods. But due to the interviews made and the decision taken in 2012 where alternative solutions were considered but later rejected which resulted in an other construction program the score for problem frames and solutions is damped to (+1).

Multi actor-, sector, -level

After the damaging storm flood in 1962 the legislation in Hamburg changed. Before 1962 the dike associations took an active part in the management of floods. But after 1962 all tasks were given to the public administration (BSU) who still takes the lead for flood protection today.

The BSU is responsible for the planning, the construction, the maintenance as well as the financing of measures (CP1_HH). For the plans and their realization most actions were outsourced to the LSBG, but those work on behalf of the BSU (CP1_HH). In the policy making also other actors are involved who advice the BSU, like the Hamburg

Port Authority (German abbreviation: HPA), various dike associations as well as disaster control managers (CP1_HH; CP3_HH; DC_HH). The decisions taken are coordinated between these actors (CP2_HH). The HPA for example achieved that the flood protection measures at the harbor are excluded (CP1_HH) from the new construction program. These private flood protection measures found at the harbor are consequently not heightened.

In case a flooding occurs, the responsibility shifts from the BSU to the disaster control management in the BIS (CP1_HH; DC_HH). Here, the BSU gets an advisory function (CP1_HH).

After the storm flood in 1962 the dike associations were disempowered and the lead for flood protection was given to the BSU. In today's flood protection various organizations only have an advisory function which means that the BSU is independent in its decisions. Moreover, the public is informed about the risk and how to behave, but they are not part of the local policy making. The interest of the public is only represented by the dike associations, who only play a minor role in local flood management. The criterion multi-level is therefore rather limited. The part multi-actor is also limited, as there are only few actors responsible at each planning level. Only multi-sector is given in Hamburg, but also to a limited extent, because the sectors exchange information but are still separated from each other. Additionally, the sector spatial planning is not part of the flood management. The overall score for multi-actor, -level-, -sector is therefore low (-1).

Diversity of solutions

Flood protection in Hamburg can be divided into three parts: technical flood protection, operative flood protection and preventive flood protection (DC_HH). Technical flood protection is realized via various technical measures, like the dike line, flood walls and other single structures (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). Preventive flood protection means to reduce the consequences of a flooding, which is done in form of risk communication and awareness rising (DC_HH). Here, people are not only informed about the risk itself, but also know what to do in case of a flooding. Next to general adequate behavior also evacuation routes with signs and barriers exist that can be activated in case of a flooding (DC_HH). Moreover, people know where to go and are familiar with the assembly points in their surrounding area (DC_HH). All this information is regularly given to the inhabitants living in flood prone areas in form of brochures and flayer (DC_HH). In this information sheets there is also information about the warning system which is part of the operational flood protection. Here, various forms of warning measures exist, like a hooter system, gun salute and a warning-app as well as SMS-service, TV, radio, police loudspeaker warnings and in some cases even telephone calls (DC_HH).

For future also soft measures should be considered, like retention areas and house adjustments (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a). Both types of measures can already be found across Hamburg. But the dike relocations were done for nature conservation and not for flood protection reasons (CP2_HH) and the housing adjustments that can be found in the HafenCity are labeled as exception from the normal flood protection strategy (CP2_HH).

As seen above, there are still possibilities left to make the system even more diverse. But it must also be appreciated that the current measures are already differentiated. For this reasons the score of the diversity criterion is (+1).

Redundancy

In Hamburg the technical measures build one line of defense (CP3_HH). There are no other measures taken that reduce the probability of a flood. Regarding the preventive flood protection a redundancy in evacuation paths can be seen. In case one of the planned paths can for any reasons not be used in case of a disaster other paths are already incorporated into the plans (DC_HH). This is also seen regarding the operative flood protection where various types of warning measures coexist. In case one fails, various alternatives exist (DC_HH).

Redundancy is mostly given regarding the impact reduction of a flooding. For probability reduction no redundant measures exist, which is justified due to the limited space in a densely populated city. The score for redundancy is therefore (+1).

5.3.2 Learning capacity

Good relations

As mentioned earlier the lead for flood protection in Hamburg is given to the BSU. But even if the BSU takes the lead there are various actors, like the LSBG, the HPA, the dike associations, and the disaster control managers who advice the BSU in policy making processes (CP1_HH). Here, cooperation takes place (CP2_HH) and there is also the opportunity to raise doubts (DC_HH).

But the sectors of flood protection and disaster control are more separated than integrated. As cooperation takes place in form of informing each other, also room for the discussion of doubts is given. But this discussion seems limited while trust in each other's know how and competences seems to dominate the relation between actors. Only the dike associations (CP3_HH) showed skepticism about some decision made. It seems that trust surpasses the discussion of doubts which is why the score for good relations is damped to (+1).

Single-loop learning

The calculation of the design water level is based on up to date models and methods (CP1_HH). Generally, even if dike construction is a traditional method (CP2_HH) a lot of improvement took place (CP3_HH) over the years.

Furthermore, the warning systems adapts continuously to technical improvements, like the implementation of a satellite system for warnings which allows feeding all the warning systems with the wanted information at once. Additionally, directly steering the TVs and smoking detectors in houses was not possible in the past, but may be used in near future (DC_HH). Additionally, the tutorials of a disastrous event, like a flooding, and its debriefings, allow for continuous improvement of routines among all the involved administrative levels and the local aid organizations that join these tutorials (DC_HH; CP3_HH).

All of these advancements include an update of methods, models and data as well as routines which can be directly referred to the criterion single loop learning. The ability to learn from past experiences and improve routines is therefore scored high (+2).

Double-loop learning

As mentioned earlier, the past and especially the flooding in 1962 influenced the flood protection in Hamburg. In 1962 police and fire brigades were responsible for disaster control, but after the damaging flood a coordinating sector was implemented, the disaster control sector (DC_HH). Furthermore, it was realized that warning messages need to be predefined, and more than just one warning system is need in case of a flooding (DC_HH). Consequently, today's flood protection system feeds various warning systems with predefined warning messages. Furthermore, Hamburg developed its own storm surge warning service, which provides more detailed knowledge than the data from the BSH (DC_HH).

These significant consequences for flood management represent more than an improvement of existing routines; they are changes in the system and can be titled as double-loop learning. But as the final shift towards "living with water" is not yet done the unlearning of the old paradigm is still not given. This is why the score for double-loop learning is (+1).

Institutional memory

Climate change is not a new issue in Hamburg's policy making. The sea level rise is for example monitored for years. It is therefore known that the sea level rises about 25cm in 100 years (Bürgerschaft der Freien und Hansestadt Hamburg, 2012; CP2_HH). Besides, there is also a monitoring for future climate change consequences in progress in Hamburg which allows to not only monitor future changes, but also to evaluate the

effectiveness of the measures taken today (CA_HH). Furthermore, the "KlimaCampus" is doing research about climate development and its consequences for Hamburg (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a).

Next to this monitoring system the flooding of 1962 and its evaluation afterwards as well as the debriefings of the tutorials made contributed to an institutional memory. Especially the flooding in 1962 influenced and stamped flood protection system in Hamburg. Even if the event is already 50 years ago and the direct concernment in society is getting more and more lost (CP3_HH), the insights won during this flooding are still seen today, like the active risk communication. This results in a high score for the criterion institutional memory (+2).

5.3.3 Room for autonomous change

Access to information

Regarding the access to information about climate change and its consequences, Hamburg's responsibilities do collaborate with th German Meteorological Service (German abbreviation: DWD). Moreover, Hamburg is doing own research about climate change and its consequences in the "KlimaCampus" project (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a).

In case of a storm surge, warnings are done by the BSH. Here, the public administration is informed from the BSH that a storm surge is expected (CP2_HH). For Hamburg the lead times are 9-12 hours. In this time the "Katastrophenstab" (Translation: disaster management group) meets and decides what to do. Additionally, all other agencies like the LSBG but also the public are then informed by the local administration (DC_HH). But generally, the data from the BSH can also be found on the website of the BSH. Local people know about this website, because on the flayers that are handed out each year it is written where information can be found (CP2_HH). But also public campaigns are made to generally inform the society and raise the risk awareness (CP3_HH).

In case a flooding is expected, the public is informed via various ways, like the media, hooter or loudspeaker warnings (DC_HH).

Information about storm surges is not only reaching the responsible organizations, but also directly given to the local people in Hamburg. It is not only "passive" information available on the internet, but also "active" information in form of brochures and campaigns are made. Moreover, as the flyers are given to the households regularly, information is also continuously given. Next to the threat of storm surges there is also good access to climate change data which results in the conclusion that the criterion continuous access to information is scored high (+2).

Act according to plan

In case the BSH informs the responsible organizations about an expected storm surge there exist plans what to do. As the lead times before the events affects the city are up to nine hours, the first two hours will be used to coordinate and plan the measures needed (DC_HH). What to do depends on the expected water level. There are various escalation levels (CP2_HH). From an escalation level of 4 a so called blocking and steering process will be activated (DC_HH). This means that the gates are closed (CP2_HH) and traffic for specific areas will be steered via flood barriers and signs to prevent people reaching the area at risk (DC_HH). The size of the area that is steered and blocked depends on the expected water levels. For worst case scenarios a supra-regional area will be affected, which means that traffic will be steered out of Hamburg (DC_HH).

In case the public needs to be evacuated, the first two hours of the lead time are needed to coordinate accommodations and transport vehicles. Such an evacuation is already prepared, because daybeds, accommodations, transport systems, staffs and food are already organized and therefore available when needed (DC_HH). After these first two hours, the warning message which is already prepared will be given to the public via various ways. Moreover, policeman will be positioned around the city to tell people what to do and those will also check if the evacuated areas are empty (DC_HH).

Besides these coordinated actions from the administrative level, locals can also become active in case of a flooding. Via the given brochures the locals are informed about what to do in case of a flooding (CP2_HH). The brochures include a checklist about the things to do but also inform about where to go and what to take in case of a flooding (CP2_HH; DC_HH).

Regarding this variety of detailed plans within the organizations as well as tailored plans for the inhabitants of the flood prone areas the capacity to act according to a plan in Hamburg is high (+2).

Capacity to improvise

The plans do not represent blue-prints that need to be fulfilled (CP3_HH). Rather, there is the possibility to decide differently, in case unforeseen things change the situation. Improvisation is therefore acknowledged by the involved actors.

Due to the checklist handed out in society, it is assumed that locals can autonomously act in case of a flooding. But even if the public is informed, there is only little risk awareness in society (DC_HH; CP3_HH).

Generally, information is available and the public is educated about how to behave in case of a flooding. But it remains unknown if the locals take the brochures seriously

and are really able to improvise in case of a flooding. This is why the capacity to improvise is damped to (+1).

5.3.4 Leadership

Visionary leadership

In Hamburg there are various research projects done concerning climate change and flood protection. Those projects are considered at administrative level (CP2_HH), but as the administrative level has the task to protect the people, the room for experimentation is seen to be limited. Here, some interviewees argued that the recommended strategies need to be financially feasible, but research projects seldom do a calculation about the budget needed for implementation (CP1_HH). Moreover, research projects can on the one hand bring interesting insights (CP1_HH), but on the other hand some projects are seen as far away from reality (CP1_HH) or there is either nothing new about them (DC_HH). The responsible actors therefore recommend taking part in research project, so that their experience can help to find more feasible outcomes (CP1_HH).

This pessimistic attitude towards research outcomes seems to leave no room for reformist leaders and innovative ideas. But actors also state that the strategy until 2050 is concentrated on the technical measures, for actions after 2050 there is no predefined path, it is rather open and flexible (CP1_HH). Here, the HafenCity can play a crucial role, as it represents an important innovation in Hamburg (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a). This district which can be found in the dike foreland where the existing infrastructure as well as houses are adjusted to high water levels is flooded regularly. Here, mounds and flood gates prevent any damage. Furthermore, inhabitants of the HafenCity are actively involved into the flood risk management, as they are responsible for closing the flood gates (Restemeyer et al., 2015). This shows that there already exist a place where living with water and also alternative measures are realized which can be seen as an experiment that may guide future actions. But Restemeyer et al. (2015) also state that the public living in the HafenCity is not more aware of the flood risk than other people living elsewhere in Hamburg (Restemeyer et al., 2015).

The HafenCity shows an innovative flood management approach in Hamburg which can influence future visions for Hamburg. But generally, responsible actors seem to be rather pessimistic about innovative ideas which results in the conclusion that room for reformist thinking in Hamburg is rather limited (-1).

Entrepreneurial leadership

The BSU takes the lead in flood protection, while the BIS is the leading senate regarding disaster control (CP1_HH). This shows that nearly all actions are controlled

and also initiated at the senate level, which represents a top-down approach. Besides, the dike associations that are part of the flood commission in Hamburg can put pressure on the administrative levels. Dike associations are formed out of local people (CP3_HH) which means they can steer bottom-up approaches.

There are leaders available from both directions that can make things done and this is why entrepreneurial leadership is scored with (+2).

Collaborative leadership

Hamburg also cooperates with the Federal States, as well as the Federal Government via the LAWA as well as other working groups for various rivers (CP1_H). Besides this national cooperation there is also cooperation on the regional level, like cooperation with the northern Federal States Lower Saxony and Schleswig-Holstein regarding flood protection in general as well as the climate adaptation strategy (CP2_HH; CA_HH; CP1_HH). Additionally, the climate adaptation strategies in the northern Federal States will also be created with the help of the KLIMZUG research projects for these regions, namely RADOST, KLIMZUG-NORD, and nordwest2050. With partners who joined these projects as well as representatives from the northern Federal States and the Federal Government a regional conference is done regularly (Der Senator für Umwelt, Bau und Verkehr, 2013).

Additionally, across sectors as well as within sectors cooperation takes place. As tasks are divided across various levels and sectors collaborative leadership is given. For example the flood protection sector from the BSU collaborates with the LSBG, the HPA as well as the districts and the dike associations. But as the BSU as well as the BIS takes the lead for their sector, they not only stimulate this collaboration, they also direct it which limits the overall co-management capacity. Moreover various networks exist where cooperation can also be realized. To what extent these networks are used for co-management is unknown which is why the score for collaborative leadership is damped to (+1).

5.3.5 Resources

Authority

In Hamburg a hierarchical system exists, where the Senate is the highest level of authority, followed by the various departments which are again authorized against the lower agencies and others. The department for flood protection from the BSU takes the lead in flood protection and is guiding the actions of the LSBG, the dike associations and also the local districts. This is the same for the BIS and the disaster control department which has its own hierarchical structure (CP1_HH). Additionally, there

exist various policy documents that were adopted by the senate and are legally binding (CA_HH).

Actions taken regarding disaster control and flood protection in Hamburg are embedded in institutional laws and regulations. There exist legitimate forms of power which is why the criterion authority is scored (+2).

Manpower

At the administrative level few people are responsible for the issues of flood protection and disaster control (CP1_HH; DC_HH; CA_HH). This means people already have various remits and due to the climate adaptation strategy, which needs to be incorporated in every day work (CA_HH), the workload is getting higher. In case enough money is available new staff can be recruited (CP2_HH) but money is saved which results in limited manpower (CP1_HH). If climate is changing rapidly manpower may be not enough (CA_HH).

The missing manpower will also become a problem in future, because junior staffs in the aid organizations are also limited due to demographic change (CP3_HH).

Currently, there is enough manpower available that can become active when a flooding occurs (CP3_HH; DC_HH). Here, Hamburg can also be supported by the German Armed Forces which further increases the amount of manpower available (DC_HH).

At the moment, the availability of manpower seems to be sufficient. But in future, especially when climate is changing more rapidly, the limited amount of manpower available can reduce the capacity to adapt plans at administrative level. Moreover, execution of plans may become difficult due to the missing junior staff in local aid organizations. In case climate is changing fast, which means huge changes until 2050, not only plans but also executive manpower will be missing. As it remains unknown if manpower will become a problem in future as it seems to be sufficient at the moment, its score is still (+1).

Knowledge

Besides the qualified employees found in the administrative levels themselves (CP1_HH), various planning, engineering or construction offices can be charged for developing or realizing plans (CP2_HH) that represent forms of external accessible knowledge. Furthermore, in Hamburg cooperation takes place within and across sectors. Here, not only expert knowledge concerning various sectors, but also local knowledge is given by the local dike associations. Moreover, cooperation with universities and the storm surge research group takes place (CP2_HH), which means that not only various forms but also up to date knowledge is available. Additionally, new study programs

were elaborated at the University of Applied Sciences Hamburg, like rescue-engineering and hazard control (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a).

The amount of knowledge available is currently enough and even in future it seems to be kept. The types of knowledge available are focusing on vulnerability reduction and engineering knowledge while the knowledge about adaptation options seems to be missing in Hamburg. This is why the score for the knowledge criterion is damped to (+1).

Financial resources

Hamburg spends about 20 million Euros per year on flood protection (DC_HH; CP1_HH). Normally, 70% are given from the Federal Government due the GAK and 30% are spent by the Federal State itself. Hamburg's GAK subsidies are limited to 6.7 Euro per year, but in the past Hamburg got more money on average, because other Federal States could not scoop their subsidies. The average money received per year from the GAK is about 10.2 million Euros (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). Additionally, flood protection is also subsidized by the European Union (CP1_HH).

Future flood protection actions are expected to cost about 550 million Euros (CP2_HH). Even if there are subsidies available for flood protection in Hamburg, money is a limiting factor (CP2_HH). Financial resources are also the reason why other alternative solutions, especially soft measures, are not realized in practice. Many of them seem to be financially not feasible (CP1_HH; CP2_HH). But as Restemeyer et al., (2015) state, resilient measures are not automatically more expensive, which is proven by the case of the HafenCity (Restemeyer et al., 2015), the argument "financially not feasible" seems to be an excuse why not implementing alternative measures.

As seen above, huge funds are available which could have been invested elsewhere. But as stated in the action program "too early adaptation ties resources unnecessarily"[4] (Bürgerschaft der Freien und Hansestadt Hamburg, 2013a, p.3) which seems to be the reason why not investing in flood resilience now. Financial resources are available but not used for becoming flood resilient. Thus, the score for financial resources is (-1).

5.3.6 Fair governance

Legitimacy

Due to the fact that no damaging flood happen for more than 50 years, societal trust in flood protection agencies is high (CP1_HH). This acceptance of flood protection is

[4] Original Quote from the text: "Zu frühe Anpassungsmaßnahmen binden unnötig Ressourcen"

further perpetuated by the fact that dikes are multifunctional, today (CP2_HH). They are no longer seen as a barrier but as room for recreation (CP3_HH). New adaptation does not longer only focus on flood probability reduction but also on visually appealing measures (CP1_HH) which is better accepted by the locals.

But public resistance can be seen regarding the identification of flood prone regions (CA_HH). This is why administrative members feel the support for coastal protection measures is higher than for fluvial flood protection measures (CP1_HH).

Public support for water safety institutions is generally given. Of course, there are always disagreements and resistance but this seem to be limited in Hamburg, which is why the score for legitimacy is (+1).

Responsiveness

Plans and calculations are publically accessible, so that interested people can inform themselves about the taken decision (CP3_HH). Due to the planning permission that is done for each section of measure taken, the public has the possibility to show resistance and can even go to court (CP2_HH; CP3_HH). But resistance does not always result in a lawsuit (CP2_HH). Rather, the dike associations as well as the ground- and water association are not only representatives of the locals, they are also part of the advisory group for flood protection (CP1_HH; CP2_HH) and can also become active during the planning process.

This shows the plans and decision taken at administrative level are transparent. But the local's power to take part in flood risk management seems to be reduced. Thus, responsiveness is scored with (+1).

Accountability

In the hierarchical structure within as well as between the flood protection sector and the disaster control sector the responsibilities are clear (CP1_HH; CP2_HH; DC_HH). For example the BSU is setting the framework conditions for flood protection while the BIS coordinates the disaster control management and the LSBG is doing the needed calculations (CP1_HH). Responsibility and accountability seem to be divided clearly.

But, as stated in an interview, the responsibilities in Hamburg argue that there is no alternative than heightening the existing structural measures, because the city is densely populated. Therefore measures like a barrier or retention areas can only be realized in the neighboring states of Lower Saxony and Schleswig-Holstein (CP1_HH; CP2_HH) which is why actors recommend shifting flood protection responsibility to the Federal Government, as those are the only ones who could initiate these measures (CP2_HH).

Even if the responsibilities within Hamburg seem to be clear, accountability for missing alternative measures seem to be shifted to the Level of the Federal Government. As flood resilience can also be achieved within Hamburg without shifting the responsibility to the Federal Government, this seems to be an excuse for not changing the status quo. Therefore, accountability is reduced to (+1).

5.3.7 Political willingness

Sense of urgency

The new adaptation program that will start in 2017 (CP2_HH; DC_HH) will adapt the flood protection measures to expected water levels of the year 2050 (CA_HH; CP1_HH; Bürgerschaft der Freien und Hansestadt Hamburg, 2012). This means the measures will be adapted to the calculated design water level of 7.3m above NN (DC_HH). The measures are planned to be finished in 2040, which means that disaster control will be adapted to the new status quo in 2040, not earlier (DC_HH; Bürgerschaft der Freien und Hansestadt Hamburg, 2012).

As there are uncertainties faced regarding the consequences of climate change the focus for adaptation is on the year 2050 and not longer (Bürgerschaft der Freien und Hansestadt Hamburg, 2012). Additionally, the design water level is checked every 15-20 years and adapted when necessary (CP1_HH).

Moreover, interviewees argue that the system seems to be confirmed (CP1_HH; DC_HH), because no damaging event happened for more than 50 years. Additionally, German flood protection is seen ahead compared to other European countries (CP1_HH).

All of this proofs that there is no sense of urgency in adapting the system to the challenges faced in climate change. Rather, the existing measures are seen as advanced while climate change is expected to be a slow and constant process. Generally, authorities seem to be rather convinced about the exiting measures which proofs that there is no sense of urgency (-2).

Accept uncertainty

Models for expected sea level rise in Hamburg differ between 0 and 1.9m. At the administrative level expectations are around 50-80cm (CP2_HH; CA_HH). Calculations and adaptations of the defense line were done with these averaged numbers (CP2_HH), because climate changes are assumed to be neither sudden nor dramatic (CP1_HH). This is why the important indicators, like sea level rise, are only checked every 15-20 years. In case there are changes visible, the design water level will then be adapted (CP1_HH). But small changes do not make an adaptation of the defense measure necessary (CP3_HH).

As seen above there are uncertainties expected in policy making, but no focus is on complexity or non-linearity. The responsibilities are focusing on known unknown rather than on unknown unknowns. Consequently, uncertainties are reduced by the calculations done. Only in the interview regarding the climate adaptation strategy, the so called tipping points were mentioned (CA_HH). It is assumed that this climate adaptation strategy may face the whole complexity of climate change and can contribute to more awareness of unknown unknowns in the water safety sector. But this needs to be proven in future. Generally, the water safety institutions do not see climate change as a wicked problem. The criterion for considering uncertainty is therefore low (-1).

The previous sections explained the scores for each criterion of the modified Adaptive Capacity Wheel. All of these findings regarding the adaptive capacity of water safety institutions in Hamburg are visualized in the modified Adaptive Capacity Wheel for Hamburg (Figure 17).

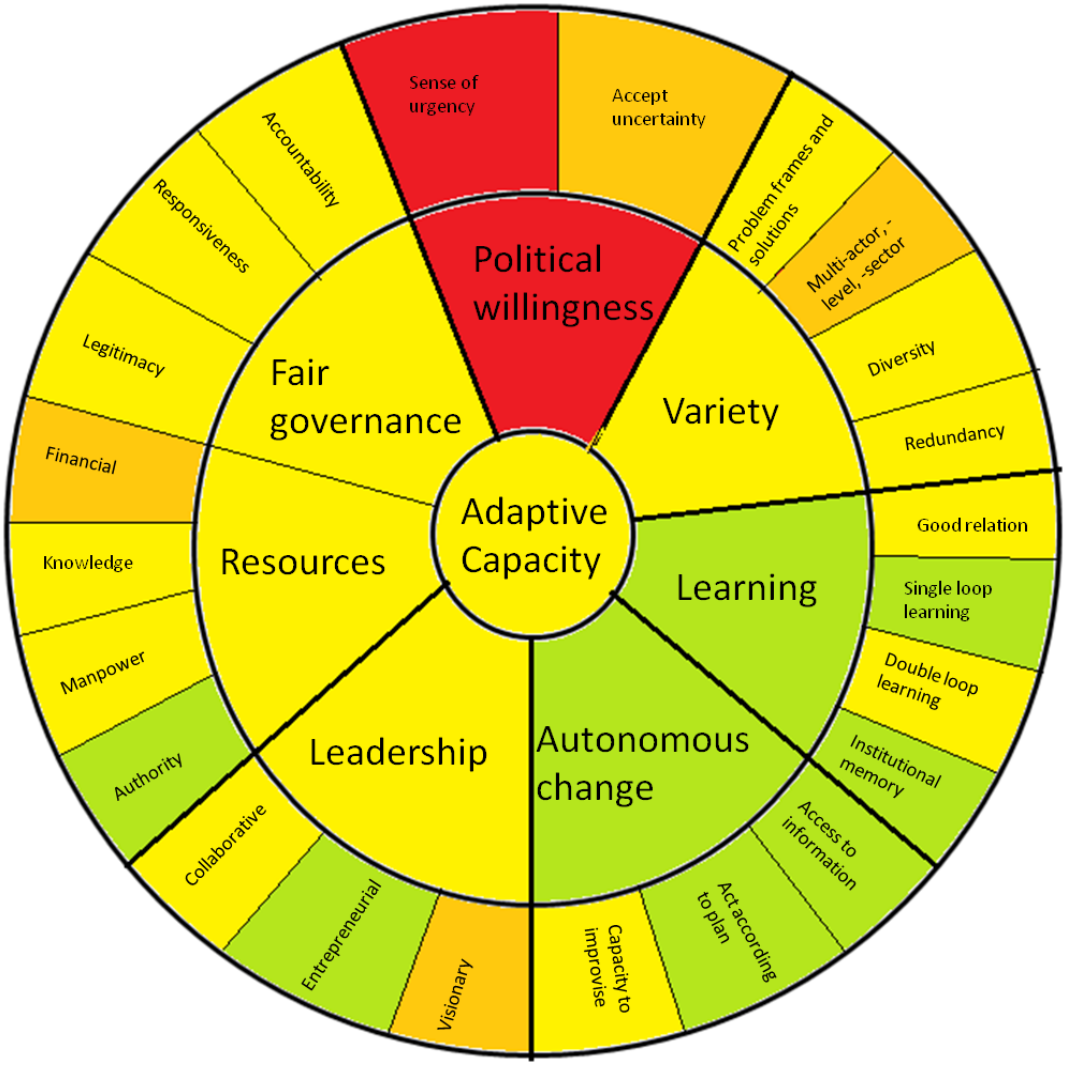

Figure 17: The resulting modified Adaptive Capacity Wheel for Hamburg (Source: Author)

This chapter dealt with the findings from the case of Hamburg. The results from the interviews and documents were given for each criterion separately. Based on the findings a reasoned score was given to each of the assessment criteria. All scores are visualized in the resulting modified Adaptive Capacity Wheel for Hamburg (Figure 17). Based on the results presented in this and the previous chapter, strengths and areas of concern, as well as recommendations for improvement for both cases will be formulated in the next chapter before a conclusion is drawn.

Chapter 6 Discussion and conclusion

The shift from the resistance approach towards flood resilience is seen as important for adequate adaptation to climate change and the increasing risk of floods. As the resistance approach dominated German flood protection for years the safety discourse became institutionalized. Thus, the historically grown formal and informal institutions strive for safety, while flood resilience asks for flexibility (Lange and Garrelts, 2007). A transformation from the safety towards the risk discourse is therefore challenging. While Hartmann and Albrecht (2014) state this shift is already happening in Germany and current planning practice is characterized by a coexistence of both approaches, Lange and Garrelts (2007) argue that German responsibilities reduce the risk discourse to make it compatible with the historically grown safety discourse (Lange and Garrelts, 2007). This is why this paper tries to answer the question: "Do the historically grown water safety institutions in the northern City-States of Bremen and Hamburg allow these cities to adequately deal with the increasing flood risk faced in times of climate change?"

For answering this question this final chapter formulates strengths and areas of concern of the adaptive capacity in Bremen and Hamburg separately. Next, a comparison of both cases is done, which allows for the formulation of similarities and differences as well as to come up with recommendation for improving future planning practice. Lastly, a final conclusion is given.

6.1 Strengths and areas of concern

Bremen

The overall adaptive capacity in Bremen is (-0.086) which shows that the criteria have a slightly negative effect on the overall adaptive capacity.

Grothmann et al. (2013) state a good score in the psychological dimension is a precondition for a high score in adaptive capacity. But in Bremen the political willingness is limited because of an unawareness of unknown unknowns and an overall disregard of the complexity and non-linearity of the issue. Next to this underestimation of the problem the responsible actors trust in current policy measures which results in a missing sense of urgency. This hinders the overall political willingness to change towards a flood resilient future.

All the available money is spent for probability reduction measures. This explains the bad scores of the criteria financial resources, problem frames and solutions, and diversity. Moreover, the focus on probability reduction is the reason why the society has nearly no access to information, cannot act according to plans, because no plans are published, nor has the capacity to improvise. Thus, the dimension room for autonomous change has a slightly negative effect on the adaptive capacity in Bremen.

The disregard of the limitations of the resistance approach also results in the fact that visionary leadership is not supported and double loop learning is not considered in Bremen. As Bremen is also characterized by a missing institutional memory it is assumed that due to the fact that Bremen was untouched by damaging flood events in the past no institutional memory has been built and double loop learning was not really considered, because the existing system seems to work well.

Besides these slightly negative effects, the supporting criteria scored relatively well. Especially, fair governance is given in Bremen, which shows that the shift towards a flood resilient city is not out of reach for future flood management. As Bremen is characterized by strong leaders that provide accountability the implementation of plans seems easy. If Bremen would want to become flood resilient in future, a change in the political willingness can initiate a transition. Especially, because the focus on continuous improvement in form of single loop learning can further perpetuate this transition.

A summary of the strengths and areas of concern is given in Table 8.

Table 8: Strengths and areas of concern in Bremen (Source: Author)

Bremen	
Strengths	**Areas of concern**
Single loop learning	Sense of urgency
Entrepreneurial leadership	Problem frames and solutions
Authority	Diversity
Accountability	Access to information
	Act according to plan
	Capacity to improvise
	Double-loop learning
	Institutional memory

Hamburg

The overall adaptive capacity of Hamburg is (+0.636) which shows that the criteria have a slightly positive effect on the overall adaptive capacity. Next to a continuous improvement of the methods used, Hamburg developed an institutional memory as well as started to question its methods and underlying assumptions of the former flood protection system after the damaging flood in 1962. This is why today's system is characterized by a good access to information and the availability of plans that allow acting adequately in case of a flooding.

Additionally, the supporting criteria scored on average also well, which shows that the provision and implementation of plans is no barrier for the transition towards a flood resilient city. Rather, entrepreneurial leadership as well as the preexistence of authority allows realizing the planned actions.

Besides, these good qualities Hamburg's shift towards a flood resilient future seems to be mainly hindered by the political unwillingness. Next to the unawareness of unknown unknowns Hamburg is characterized by no sense of urgency to adapt the system towards a risk based approach. Even, if Hamburg is already on its way towards a flood resilient future, the continuation of this process seems to be out of reach. Hamburg has a great potential to shift towards a flood resilient future but actors are not aware of this potential. The system seems to be stuck in a transition area which continuation seems to be restricted by little room for change agents and a missing political willingness. If these attitudes of political actors do not change the total transition towards living with water will never be reached.

A summary of the strengths and areas of concern is given in Table 9.

Table 9: Strengths and areas of concern in Hamburg (Source: Author)

Hamburg	
Strengths	**Areas of concern**
Single loop learning	Sense of urgency
Institutional Memory	Accept uncertainty
Access to information	Visionary leadership
Act according to plan	
Entrepreneurial leadership	
Authority	

Regarding the strengths and areas of concern in the water safety institutions in Bremen and Hamburg the following conclusion can be drawn:

Due to various limitations in the flood management systems in both cities it can be concluded that the historically grown water safety institutions in Bremen and Hamburg are currently not able to adequately deal with the increasing risk of floods faced in climate change.

This conclusion underpins the importance of institutional redesign in both cases, which is needed to transform to a flood resilient city in future. This is why the following section is summarizing the findings of this research in form of similarities and

differences. Especially, the identification of differences is important as these differences explain the varying overall adaptive capacities. Moreover, the comparison is used for formulating recommendations for future planning practice.

6.2 Comparing the adaptive capacity in Bremen and Hamburg

Regarding the two wheels in Figure 18 that were developed during this research various similarities and significant differences can be seen, which is explained next.

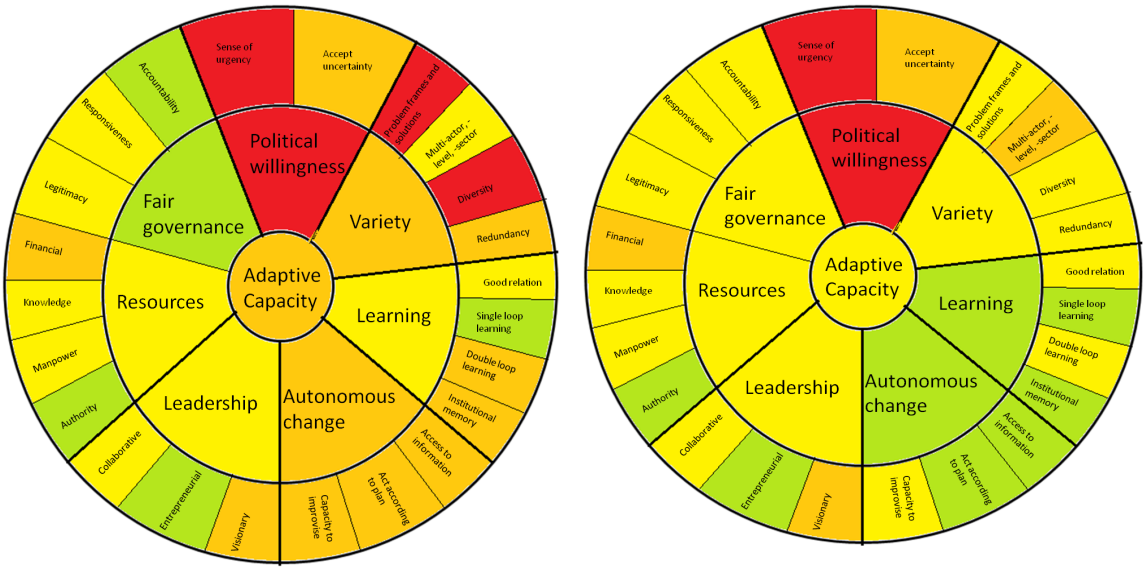

Figure 18: Comparison of the modified Adaptive Capacity Wheels of Bremen (left) and Hamburg (right) (Source: Author)

6.2.1 Similarities

Both cities are characterized by good scores in the supporting dimensions. Especially the scores in available resources as well as leadership are exactly the same. This shows that the institutional context in both cities differs only slightly. Moreover, both cities achieved good scores in the fair governance dimension, which is not surprising in a democratic state, because democracy leads to transparency and legitimacy in planning.

As both cities are characterized by high scores in entrepreneurial leadership as well as authority room for visionary and collaborative leadership is limited. In both cases strong leaders provide stability which hinders creativity and innovative ideas and limits collaboration. Moreover, this availability of strong leaders also seems to limit the

discussion of doubts which is why both cities are only characterized by a slightly positive effect in the criterion good relations.

Knowledge in both cases focuses on technical engineering and to some degree on impact reduction. These knowledge forms also seem to be available in future, because education of junior staff is supported by various new study programs that were implemented in Bremen and Hamburg. This continuous access to up to date knowledge is why single-loop learning already scored high and is also expected to continue in future due to the in general well educated junior staff. But junior staff and therefore manpower also seems to be limited in future due to the demographical change in Germany. While the incorporation of knowledge about adaptation options is already missing in both cases, a reduction of manpower in future may hinder adequate adaptation in future.

Furthermore Hamburg and Bremen seem to be unaware of the complexity and non-linearity of climate change and its consequences. Here, a missing focus on unknown unknowns can be realized in both cases. This also explains why all the involved actors in both cities assume that there is no urgency to adequately adapt the climate change now by changing the current system. Both cities seem to think they can handle climate change without huge changes until 2050. This is also why both cities invest most of their financial resources in "holding the line" rather than in more resilient measures.

6.2.2 Differences

Comparing the resulting modified Adaptive Capacity Wheels of Bremen and Hamburg main differences can be seen regarding the variety dimension. Hamburg scores better regarding its variety of problem frames and solutions as well as in diversity of measures, because next to probability reduction Hamburg also focuses on risk communication which can contribute to a lower potential damage when facing a flood. Additionally, Hamburg's measures are redundant. A huge variety of warning systems exists while Bremen suppresses old-fashioned warning measures and replaced them with more "electricity dependent" measures that have a limited scope. Contrasting, Bremen scores better in the regarding the criterion multi-actor, -level, -sector, because the dike associations in Bremen are an active part of flood protection while in Hamburg flood protection is completely done by the administrative level.

Hamburg scores better in double loop learning and institutional memory. This seems to be explained regarding the flood history of both cities. After the damaging flood of 1962 Hamburg evaluated the event and realized the weaknesses of the old system and improved a lot. This also seems to explain why not only the variety but also the room for autonomous change in Hamburg is higher than in Bremen. Due to the realized weaknesses a disaster control team was established. The main tasks of disaster control are the public information as well as the provision of plans. The public in Hamburg is

therefore not only informed about the risk itself, they are also educated about adequate behavior in case of a flooding which increases the local capacity to improvise during a flood. All of this public involvement is completely missing in Bremen. Here, disaster control mainly relies on the expertise of aid organizations and the disaster management staff, which means that in case the line of defense will fail in future, the public is completely unaware of the risk, does not know what to do and cannot improvise. It is assumed that due to the missing of a damaging flood in the history of Bremen, the resistance approach is not seen as insufficient. Therefore, no institutional memory has been built and no double-loop learning occurred. Consequently, the focus is still rather narrowed to probability reduction which explains the absence of public information, the missing provision of plans and the resulting inability to improvise in Bremen.

Besides these areas of concern in Bremen regarding the overall public involvement in flood risk management, Bremen's responsible actors seem to be more aware of their accountability in the system. A flood resilient approach seems just not being wanted. Contrasting, Hamburg's authorities seem to shift their accountability for still focusing on probability reduction measures to others. It is argued that space for other measures is limited in Hamburg which is why the neighboring countries or the Federal Government need to decide about the implementation of huge constructions like retention areas or a flood barrier outside of Hamburg. This proves that the concept of flood resilience is barely understood among policy makers, because the shift towards flood resilience does not need the construction of huge measures.

6.3 Recommendations

Political willingness is key for adequate climate change adaptation, but here, recommendations can hardly be given. Actors need to understand the whole complexity of climate change as well as the limitations of the current system. If this is the case, the political willingness can initiate further flood resilient measures. This willingness is also needed regarding the financial resources. In case political willingness will change the willingness to invest money differently, namely into a diversified set of measures and ideas will become possible. As mentioned earlier it is not one huge step needed to achieve flood resilience, rather, it is a series of actions that build on one another. Willingness needs to change first, and other measures will follow step by step. Here, it needs to be kept in mind that flood resilience cannot only increase the cities safety from floods; it can also add value to flood prone regions by making water accessible and incorporating water into the everyday life (Restemeyer et al., 2015). For realizing this idea of living with water the following recommendations for both cities can be given:

1. Invest the available money in a broader set of measures. Currently, lots of money is spent on holding the line. But money also needs to be invested in raising risk awareness. Even if Hamburg is doing risk communications, its

remains questionable to what extent people are really aware of the risk and internalize the threat of being flooded. Money should therefore be spend on education and public campaigns in school as well as other settings, not only once, but regularly. Bremen should also incorporate this idea but first needs to invest money in scripts, flayers etc. to inform about the risk in general as well as the development of evacuation plans and routes which should be accessible to the public. Here, they should have a look on Hamburg and their comprehensive warning system, evacuation plans and in general different attitude towards risk communication.

2. Both cities should give more room for reformist leaders and visionary leadership. The idea of flood resilience is to experiment with various ideas and do not have a predefined path for future. Even if the involved actors stated that planning for future is flexible and open, the narrowed system of holding the line does not allow for experimentation and flexibility. Visionary leadership should first of all be more appreciated, which will initiate more research and the possibility finding valuable insights increases. Currently, the responsible actors seem to be not open towards innovations. Here, innovation does not mean that the whole system needs to be reinvented, but improvement and adaptation to new variables and insights are always possible. Actors should trust in researcher's expertise as well as other forms of visionary leadership. In case valuable insights can be identified collaborative leadership and the incorporation of various forms of knowledge should be encouraged.
3. For increasing the variety of problem frames and solutions it is crucial to develop new routines and to unlearn old routines. This has much in common with the sense of urgency to adapt adequately to climate change. In case the limitations of the current system are seen, old routines should be unlearned and visionary leadership may lead to the development of new routines for future planning. Unlearning and a sense of urgency can result in a variety of problem frames and solutions which will have positive effects on the diversity of measures.
4. Furthermore, an integration of various sectors is needed. Currently, both cities are characterized by a strong water management sector. Besides, both cities have a disaster control management, but cooperation seems to be limited. Additionally, spatial planning as another important sector for future flood risk management is completely separated from the flood protection plans. This needs to change in future, because the idea of living with water needs space, housing adjustments or construction bans.

   Furthermore, within the sectors separation takes place. For example storm surges, fluvial floods and the idea of a rainproof city are also only slightly

integrated. But all of these types of floods generally have to deal with the same problem – a possible flooding. Parking places where water can be stored are therefore not only the solution for heavy rainfall, but can also be used in case of a flooding from fluvial floods. Or flood gates, as stated in the Kursbuch from KLIMZUG-NORD (KLIMZUG-NORD Verbund, 2014) that close automatically when a specific water level is reached can not only help to make a city rainproof, but also can make the city more flood resilient. Cooperation between the various sectors should not longer only take action when areas of concern overlap. Rather, the development of comprehensive plans needs to be done in cooperation across and within sectors.

5. Lastly, it can be said that more cooperation between Hamburg and Bremen would be wise in future. Currently, both are cooperating with their direct neighboring States, but only little with each other. But Hamburg and Bremen have many similarities, so that cooperation between these City-States makes much more sense than with the huge territorial states that surround them. During data collection it seemed that it is more competition than collaboration between Hamburg and Bremen. Maybe this negative focus can be tuned into an opportunity of cooperation and competition, the so called "coopetition". Competition can on the one hand stimulate actions and motivate actors to become better than the other which increase the local urgency. While cooperation on the other hand also means to create synergies and learn from each other. This learning is especially valuable as resilience means to experiment with various ideas. In case cooperation would take place the room for experiments and valuable new insights would increase, even if space for experimentation is little in both cities.

Next to the overall willingness that both cities need to adequately adapt to climate change general recommendations were given. But due to the fact that both cities have different "levels of adaptive capacity" more in-depth and tailored recommendations can be given:

Bremen

Bremen needs to focus on risk communication and awareness rising in near future. Currently, the public is completely separated from the planning process. This shift from pure probability reduction and expert knowledge towards a broader set of methods would increase the local adaptive capacity rapidly. The score for variety, its problem frames and solutions, as well as the diversity of measures would increase due to a broader set of solutions to tackle the problem. Additionally, this would imply that the public's access to information is increased, which together with the provision of plans can increase the overall room for autonomous change as well as the capacity to improvise.

Second, the focus should shift to the development of new routines and the unlearning of old routines and the creation of an institutional memory. Unlearning of routines and allowing for new methods would increase double loop learning, while monitoring and especially evaluation of monitored issues can help to create an institutional memory. But unlearning routines can only become possible when not only urgency is felt, but also when other alternatives exist. Unlearning routines now seems to be impossible, because this would mean to have no methods or routines left. Bremen therefore needs to start with increasing the local variety by incorporating risk communication and awareness rising to get the system running.

Hamburg

Hamburg needs to concentrate on a broadening of responsibilities. Currently, the lead for flood protection is given to the BSU, which is rather contradicting to a flood risk management approach. But this top-down approach explains why the system seems to be stuck in the transition. Regarding the adaptive capacity of Hamburg (+0.636) one assumes that the final shift towards flood resilience is close, but this thesis and also the paper from Restemeyer et al. (2015) prove that the construction of the HafenCity was only done due to economic and political reasons. Among policymakers the HafenCity is an excuse from the preexisting flood protection system which focuses mainly on holding the existing line of defense. Even if risk communications is an inherent part of the flood protection strategy from 1962, a progress in shifting towards flood resilience cannot be seen over the last 50 years. The strong water management sector seems to hinder the continuation of the transition process. This is also given in Gupta et al. (2015) who state that top-down approaches result in path dependence. For initiating a transition it is therefore crucial to broaden the responsibilities in Hamburg. Even if the dike associations contributed to the damaging event in 1962, they and also others can broaden the variety of problem frames and solutions and allow keeping the transition going, because water managers would no longer have the power to mainly focus on the heightening of the main defense line. Additionally, the acceptance and incorporation of visionary leadership is key to keep the transition going, because research can bring valuable new insights by embracing experimentation.

6.4 Conclusion

This paper has analyzed whether water safety institutions in Bremen and Hamburg encourage society to adequately adapt to the increasing risk of floods in future. As the shift towards a flood resilient city needs further capacity building, the Adaptive Capacity Wheel was used in a modified form. The modified wheel was not only advanced by a psychological dimension, it also links the definitions of the various criteria to the normative aim of flood resilience. The modified Adaptive Capacity Wheel

therefore allows showing strengths and areas of concern in local capacity building which is crucial for the transition towards flood resilience. The areas of concern therefore indicate where the shift towards a flood resilient future is hindered and therefore needs institutional redesign.

For the assessment of the wheel a document analysis and interviews were made which means that both formal and informal institutions were assessed in both cases. The results show that the missing political willingness is the main barrier regarding the shift towards flood resilience. Local institutions seem to be not aware of unknown unknowns and the limitations of the resistance approach, which is why changes in the current system are currently not initiated, neither in Bremen nor in Hamburg. This leads to the conclusion that the historically grown water safety institutions in Bremen and Hamburg are currently not able to adequately deal with the increasing risk of floods.

In the beginning of this thesis it was assumed that institutions are socially constructed and that the cities will be characterized by different institutional contexts due to varying flood histories. This assumption was proven in this research. Regarding the flood protection in Bremen, which was untouched by damaging flood events in the past, a strong focus on probability reduction can be seen which indicates that the flood protection system is still based in the resistance paradigm and the idea of holding the line. Contrasting, Hamburg suffered huge losses during the flood disaster of 1962, which had far-reaching consequences. Since 1962, and still today, Hamburg is doing active risk communication, by informing the public but also providing plans for actions in case of a flooding. This seems to shift the system towards flood resilience. But even if Hamburg has a broader set of measures available in dealing with floods, the strong water management sector hinders the final transition. Hamburg therefore still focuses on the main defense line and its continuous adaptation to climate change. This is also the fact for Bremen, where heightening the defense line is also the solution for the near future.

Based on these findings recommendations were made that emphasize the need to change local political willingness. This willingness is key for adequate adaptation to climate change (Grothmann et al., 2013). Here, the non-linearity and complexity of climate change need to be appreciated. This will result in the fact that climate change is no longer seen as a problem that can easily be modeled. Rather, the acceptance of the limitations of the models and methods used in facing the unknown unknowns will raise the political willingness to shift towards a risk based approach. Additionally, the limitations of the resistance paradigm need to be considered. The dependence on one single line of defense measures creates more vulnerability to climate change than the broadening of measures. When these limitations are acknowledged the sense of urgency amongst policy makers will increase. Here, it also needs to be considered that a risk based approach does not replace the old system, rather, it is advanced version. This means that there is on the one hand no risk of implementing resilience measures, and on

the other hand flood resilience cannot only make an area safer to floods, it can also add value by making the water an inherent part of the city (Restemeyer et al., 2015). This added value may even increase the political willingness to consider a flood resilience approach (Restemeyer et al., 2015) in future.

Moreover, as flood resilience is not just about adding measures but a change of minds, the implementation of flood resilient measures does not need to cost lots of money. For example adjusted houses can be achieved by fitting flood gates at windows and doors. When this is done voluntary by private households, investing in flood resilience does not need huge public funds, but risk awareness. This investment into risk communication, awareness raising, as well as the collaboration between actors, levels and sector and the provision of comprehensive plans and building permissions is rather cheep.

But still the shift towards flood resilient does not mean that damage is prevented completely, but the overall damage is limited and especially the live of humans can be saved. Germany in general needs to set priorities, like the Dutch do, by focusing on the prevention of human damage first. This makes flood resilience the path for future, because even if the resilience approach cannot prevent any damage at all, it can make living in flood prone areas safer and even more attractive.

Chapter 7 Reflection and future outlook

After the conclusions have been drawn this chapter reflects on the concepts used in this thesis as well as its contribution to planning theory and practice. Second, the methods for data collection and evaluation are reflected, before recommendations for further research are presented.

7.1 Theoretical reflection

In this thesis a modified Adaptive Capacity Wheel was developed first and later used to assess the adaptive capacity of water safety institutions in Bremen and Hamburg. Regarding the findings of this thesis it was concluded that the cities of Bremen and Hamburg need to build up further capacities to make the shift towards flood resilience possible. Moreover, areas of concern for both cities were identified and recommendations formulated. These findings give valuable insights where and how to improve. Local organizations should therefore take the recommendations at heard and initiate institutional redesign where needed to become able to adequately deal with the increasing risk of floods in future.

The combination of the two concepts of flood resilience and adaptive capacity was pending in planning theory, but regarding the development of the modified Adaptive Capacity Wheel this thesis successfully combined both concepts. Thus, this thesis gives valuable insights about the interconnectedness of these concepts and also delivers valuable in-depth information about the water safety institutions in Bremen and Hamburg.

Next to this contribution to planning theory this thesis also contributes to planning practice. As the modified wheel represents a standardized qualitative assessment tool, it can be used for the assessment of water safety institutions of various flood prone areas across the globe. By identifying areas of concern, institutional redesign can be initiated which can launch the shift towards a flood resilient future.

7.2 Methodological reflection

While Gupta et al. (2010) recommend involving various researchers into the scoring of the criteria, and this thesis is done by one single author, the scoring is at risk of being subjective. For objective results the scoring was done as transparent as possible, by using the research protocol from Gupta et al. (2010) in combination with the 7 step content analysis from Kuckartz (2012). Moreover, the development of an interview guide (Appendix I) and a coding list (Table 6), as well as the transcription of the interviews made (Appendix II) and the use of the computer program Atlas.ti result in an objective output of this thesis.

It can be argued that face-to-face interviews would have been better to gather information about informal knowledge, because non-verbal communication can give valuable hints for various criteria. But due to the problems in finding adequate partners in the beginning, the telephone interviews represent a compromise that was accepted. Here, it needs to be appreciated that most of the interviews were still really "familiar" and lot of information about formal and informal institutions could be gathered, even without having face-to-face discussions. But still, for future research it is recommended to do face-to-face interviews, because it would increases the output of the research.

In this research eleven interviews, where each took one hour on average, were sufficient for gathering the data needed. In combination with various policy documents that have been studied an adequate assessment of the modified Adaptive Capacity Wheels was possible. Regarding further research the amount of interviews depends on the interviewee's willingness to talk about in-depth information. In case actors are unwilling to talk about in-depth information it is recommended to do more interviews or studying more policy documents for gathering a sufficient amount of data.

Generally, the assessment of the adaptive capacity of water safety institutions in Bremen and Hamburg worked well and the modified Adaptive Capacity Wheel proofs to be adequate qualitative assessment tool, where the new psychological dimension proved to be an important dimension influencing the adaptive capacity.

7.3 Recommendations for further research

As neither Bremen nor Hamburg is characterized by a high adaptive capacity future research is recommended. The discussion about climate change adaptation and the development of climate adaptation strategies seems to be in its beginning in both cities which is why the limitations of the resistance paradigm are still underestimated. As the current measures are seen as adequate to prevent a flooding for the next 25 years, adjustments on current institutions are not probable before 2040, which is why further research may not show any institutional changes. This is why it is suggested to not start further research before 2040.

But in this time the modified Adaptive Capacity Wheel can be used to assess different cases across the globe. As the assessment of the modified wheel worked well in this thesis, the assessment of other contexts can deliver more valuable insights about adaptive institutions and flood management methods across the globe. Strengths and areas of concern can consequently be compared and learning from experiences made can be spread across the globe. As flood prone cities are often characterized by similar characteristics and similar problems faced in times of climate change strengths and areas of concern can be compared and improvement can be based on inspiration found elsewhere in the world.

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Appendix I

Interview-guideline

Masterarbeit zur Klimaanpassung in Bremen und Hamburg

Interview-Fragen

Der Zweck dieses Interviews ist:

1. Zu verstehen, was in Hamburg/Bremen zum Thema Klimaanpassung im Hochwasser/Küstenschutz Bereich geplant ist
2. Erkundung der Forschungsfrage: Ist der Küsten/Hochwasserschutz in Hamburg/Bremen in der Lage, eine unbekannte Zukunft zu bewältigen?

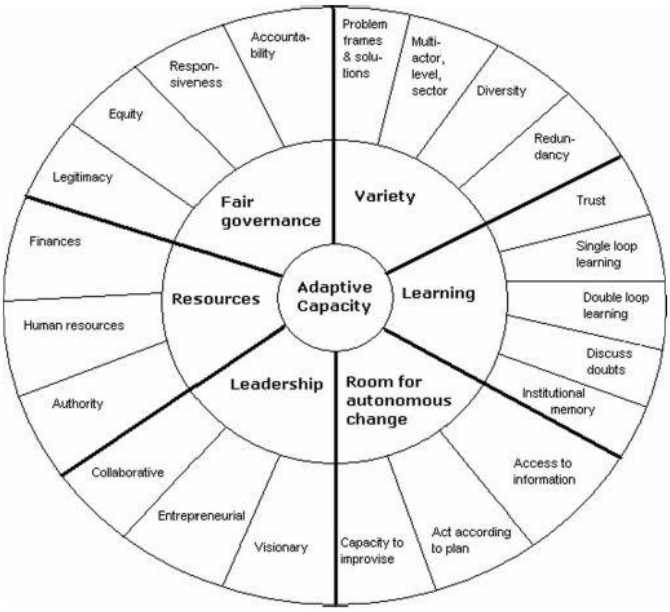
Einführung

• Mit wem spreche ich?
  -Qualifikation/ Arbeitsbereich/ in der Klimaanpassung beteiligt als../ Verantwortung etc.
• Was ist in Bezug auf die Klimaanpassung in Bremen/Hamburg geplant?
  - Gibt es einen Plan /eine Vision /bestimmte Projekte?

Geschichte & Erstellung des Plans/der Vision

• Beschreibung der Gestaltung/Entwicklung der Klimaanpassungsstrategie
  - Wer war beteiligt
  - Wer entscheidet was/wo
• Kooperation?
  - Provinz/ Gemeinde/ nationale Regierungen

Adaptive Capacity Wheel (bezieht sich auf den resultierenden "Klimaanpassungs-Plan")



(Quelle: Gupta et al (2010): The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of soeicety. In: Environmental Science & Policy (13). Seiten 459-471.)

Vielfalt (Variety)

• Wie hoch ist der Grad der Vielfalt des „Plans" in Bezug auf die Probleme mit denen der Hochwasser/Küstenschutz im Klimawandel konfrontiert ist?

-Wie viele Probleme werden gesehen bzw. in Angriff genommen?

• Inwieweit sind in dem „Plan" verschiedene Lösungsstrategien für die gesehenen Probleme gefunden worden?

• Welche Organisationen sind an den Lösungen beteiligt und wie sind die Aufgaben zwischen diesen Organisationen aufgeteilt?

• Ist in dem „Plan" auch Redundanz im Sinne von „überlappenden" Maßnahmen berücksichtigt worden?

Lernen (Learning)

• Inwieweit ist die Struktur des Lernens im Rahmen des Projektes gefördert?

-Gibt es zum Beispiel den Austausch von Wissen zwischen den verschiedenen Sektoren und Disziplinen?

• Wie ist die Zusammenarbeit zwischen den verschiedenen Parteien?

-Werden auch Zweifel diskutiert?

• Gibt es ein „institutionelles Gedächtnis", das zum Beispiel in anderen ähnlichen Projekten verwendet werden könnte?

• Haben Verbesserung und/oder Neuinterpretation von Routinen und Methoden stattgefunden?

Raum für autonome Änderung (Room for autonomous change)

• In welchem Umfang hat der „Plan“ Raum sich an verändernde (externe) Bedingungen anzupassen (Klimawandel)?

• Wurden Strategien entwickelt, die beschreiben, wie man im Krisenfall (Hochwassergefahr) handeln soll?

• Wurde das Projekt in der Vergangenheit an veränderte Rahmenbedingungen angepasst?

• Wie kann man den Zugang zu Informationen charakterisieren (z.B. Meeresspiegelanstieg oder Sturmflutrisiko)?

• Wie sieht es mit der Fähigkeit zu improvisieren aus? (Selbstorganisation der Gesellschaft, wenn Pläne „versagen“)

Führungsverhalten (Leadership)

• Wer /welche Organisation übernimmt die Führung und in welcher Weise?

o Verbinden von kurz- und langfristigen Entwicklungen der Zukunft

o Realisieren von Plänen

o Bilden von Bündnissen, Netzwerken

Ressourcen (Ressourcen)

• Inwieweit stehen Ressourcen zur Verfügung?

-Finanzen, Human (Wissen/Arbeitskraft) und Autorität?

• Fehlt eine bestimmte Ressource?

Fair-Governance

• Kann die Art und Weise, in der das Projekt realisiert wird als legitim, transparent und reaktionsfähig charakterisiert werden?

-Warum /nicht? Dilemmas?

• Reflexion über das Verfahren

-Was lief gut? Was war erfolgreich? Was kann gelernt werden?

Zukunft

• Wie stehen die Chancen des Plans? Gibt es mögliche Hindernisse, oder Engpässe?

Schneeball-Prinzip

• An wen sollte ich mich Ihrer Meinung nach werden, um einen guten Überblick über die aktuellen Entwicklungen zu bekommen?

Appendix II

Extra book (134 pages), available on request.

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Brake, August 2015

Fenja Kügler