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This is an Accepted Manuscript of an article published by Taylor & Francis in Planning Theory and Practice, 16 (1), 45-62. The final definitive version is available online: https://dx.doi.org/10.1080/14649357.2014.1000950

Britta Restemeyer, Johan Woltjer, Margo van den Brink (2015) A strategy-based framework for assessing the flood resilience of cities; Planning Theory and Practice, 16(1), pp. 45-62.

# A strategy-based framework for assessing the flood resilience of cities – a Hamburg case study

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Abstract

Climate change and continuous urbanization contribute to an increased urban vulnerability towards flooding. Only relying on traditional flood control measures is recognized as inadequate, since the damage can be catastrophic if flood controls fail. The idea of a flood resilient city – one which can withstand or adapt to a flood event without being harmed in its functionality – seems promising. But what does resilience actually mean when it is applied to urban environments exposed to flood risk, and how can resilience be achieved? This paper presents a heuristic framework for assessing the flood resilience of cities, for scientists and policy-makers alike. It enriches the current literature on flood resilience by clarifying the meaning of its three key characteristics – robustness, adaptability and transformability – and identifying important components to implement resilience strategies. The resilience discussion moves a step forward: from predominantly defining resilience to generating insight into 'doing' resilience in practice. The framework is illustrated with two case studies from Hamburg, showing that resilience, and particularly the underlying notions of adaptability and transformability, require first and foremost further capacity-building among public as well as private stakeholders. The case studies suggest that flood resilience is currently not enough motivation to move from traditional to more resilient flood protection schemes in practice; it rather needs to be integrated into a bigger urban agenda.

**Keywords**: Resilient cities; flood risk management; urban planning; resilience strategies

## 1. INTRODUCTION

Globally, the number of damaging flood events has increased throughout the last century (White, 2010). The results of climate change such as rising sea levels, prolonged periods of precipitation and more intense rainfall will likely add to future flood risk. Cities accommodating a multitude of people, businesses and ecosystems – are particularly at risk. Continuous urban growth and a lack of conscientious planning increases urban susceptibility towards flooding (Zevenbergen, Veerbeek, Gersonius, & Van Herk, 2008).

There is a general consensus that using only traditional flood control measures is an inadequate response to dealing with growing risks (Hooijer, Klijn, Pedroli, & Van Os, 2004; Vis et al., 2003). As a result, more holistic kinds of risk management approaches are being introduced, focusing on the consequences of flood hazard. These newer approaches also include a shift from purely sectoral to integrated thinking, or, in other words, from pure water management to a more encompassing approach of integrating urban planning as a means to keep vulnerable land uses out of flood-prone areas (Godschalk, 2003; Woltjer & Al, 2007).

In this context, the concept of resilience is considered a promising framework to include risk and uncertainty within planning (Davoudi, 2012; Scott, 2013; White, 2010). While resilience once had a clear physical meaning (“resistance of a material to shocks”), today the concept is multi-interpretable and refers to an interdisciplinary field of research. It has been applied to ecology (Holling, 1973, 1996) as well as to the social sciences. Central to both applications is the idea that ecosystems or groups can withstand or adapt to stress without being harmed in their functionality. Translating this idea to cities and flooding resilience necessitates consideration of the following: that a city takes necessary precautions

to prevent flooding, but also adapts land-use to suffer less in case of a flood disaster. Addressing the required shift in flood risk management, resilience can thus be considered a promising approach to deal with the unpredictability of climate change and future flood risk in cities. However, due to the ambiguity of the concept 'resilience', research has largely focused on exploring the meaning of the concept, a few recent examples include: 'Resilience and regions: building understanding of the metaphor' (Pendall, Foster, & Cowell, 2009), 'Resilience: a bridging concept or a dead end?' (Davoudi, 2012), and 'Resilience and disaster risk reduction: an etymological journey' (Alexander, 2013). By focusing on strategies, we aim to move the 'resilience discussion' a step forward: from 'defining' resilience to 'doing' resilience – from concept to action.

The central aim of this paper is to convert the concept of resilience into an operational framework that can be used by both, scientists as well as policy and decision-makers, to evaluate the flood resilience of cities. For this purpose, we first discuss the main implications of a resilience approach within the context of cities and flooding, conceptualising resilience as robustness, adaptability and transformability (Galderisi, Ferrara, Ceudech, 2010; Davoudi, 2012; Scott, 2013). Subsequently, we develop and present a strategy-based framework for assessing the resilience of cities endangered by flood risk. Following Hutter (2006), we define strategy as a multidimensional phenomenon composed of content, process and context parameters and develop resilience indicators for each dimension. Next, with the help of this strategy-based framework, we assess flood resilience patterns for the city of Hamburg in the north of Germany. Hamburg is a typical European delta city dominated by a traditional flood control approach and now shifting towards a more risk-based approach. We focus in particular on two specific urban development schemes: "Leap across the river Elbe" and "HafenCity". While the first scheme predominately features a traditional flood-control approach, the latter displays many more resilience-oriented characteristics. We conclude with

reflections on the framework used, and we suggest a series of lessons from the case necessary to implementing a resilience strategy.

## 2. A MORE HOLISTIC PERSPECTIVE ON FLOOD RESILIENCE STRATEGIES

### *Resistance vs. resilience strategies – a simplified dichotomy?*

Flood risk management literature commonly differentiates between resistance and resilience strategies (de Bruijn, 2005; Douven et al., 2012; Hooijer et al., 2004; Vis et al., 2003). The goal of a resistance strategy is to reduce the probability of a flood hazard whereas resilience aims at minimising the consequences of flooding. Hence, a resistance strategy is about keeping water away from land, e.g. by building embankments and raising them continuously. Conversely, a resilience approach takes the possibility of flooding into account. Therefore, land-use is adapted in order to minimize the damage potential, for example by elevating housing structures. Resilience strategies "rely on risk management instead of on hazard control" (Vis et al., 2003, p. 33).

Though this dichotomy appeals through its simplicity, it contradicts the original understanding of resilience. Other scholars from the resilience field (Holling, 1973; Godschalk, 2003; Davoudi, 2012) suggest that resistance and resilience are not clear opposites. Indeed, one attribute of resilience is "persistence" (Holling, 1973), "the power to resist attack or other outside force" (Godschalk, 2003, p. 139), and "robustness" (Davoudi, 2012). Being synonyms of resistance, these terms indicate that resistance can be seen as one important aspect of resilience.

### *Resilience as robustness, adaptability and transformability*

Nonetheless, in order to be flood resilient, a city needs more than robustness. Various authors suggest that two other important attributes of resilience are 'adaptability' and

'transformability' (Davoudi, 2012; Folke et al., 2010; Galderisi, Ferrara, & Ceudech, 2010; Scott, 2013). While adaptability is about making adjustments within the system to make it less vulnerable, transformability is about a transition to a new system "when ecological, economic, or social structures make the existing system untenable" (Walker, Holling, Carpenter, & Kinzig, 2004). Applied to cities threatened by flooding, these three terms can be interpreted as follows.

*Robustness* means that a city has to be strong to withstand a flood event, for example by building and maintaining dikes, sluices and storm surge barriers. However, recent flood events in England, Germany and elsewhere have shown that only being strong is not enough. There will always be flood events that overtop the first line of protection. Therefore, adaptability is crucial. *Adaptability* implies that the hinterland is adjusted to flooding so that a flood event may come without leaving substantial damage. For this purpose, an adjustment of the physical environment as well as the social sphere is required. Preparing the physical environment may include elevating houses with poles or defending the hinterland in such a way that areas with vital infrastructure have less chance of being flooded. Allowing controlled flooding, however, also adds a social dimension to flood risk management: people within the city have to know what to do to save their lives as well as their belongings. Changing the physical environment postulates a change in people's mind-sets. Flood risk management becomes a societal task that asks for cross-disciplinary collaborations (water management, spatial planning and disaster management) as well as the willingness of citizens to actively participate in flood risk management. If collaboration and participation are achieved, we can speak of a transformation. At the moment, *transformability* can hence be interpreted as the capacity of a city to make the often demanded shift from "fighting the water" to "living with the water". This can also be described as a "predict-and-control" to an "integrated-adaptive" regime (Pahl-Wostl, 2006), triggered by climate change as well as recent flood disasters such

as Hurricane Katrina in New Orleans in 2005. However, the future will doubtless bring new insights that will make another transformation necessary. Transformability hence implies a capacity to change based on new insights, searching for the most appropriate way to deal with flood risk.

***Implications of a resilience approach for strategy-making***

Acknowledging robustness, adaptability and transformability as prerequisites of a flood resilient city has various implications for making better strategies. First, acknowledging that a resilient city also needs a certain robustness implies that measures attributed to a resistance strategy (technical measures such as dikes, dams, and sluices) may also make a city more resilient because they help a city to withstand a flood event. Thus, technical measures may or must be an inherent part of a resilience strategy. Second, as described above, a resilience approach implies a broadening of responsibilities among public as well as private stakeholders. Third, transformability particularly asks for a different understanding of responsibilities and also requires the capacity for knowledge, creativity and envisioning in order to create innovative solutions, while power, resources and public support are required for actual implementation.

Establishing flood resilient cities hence becomes a highly complex and challenging task. It needs more than a list of possible measures – it also requires framing mind-sets to make different disciplines collaborate, and citizens to recognize their role in flood risk management. Consequently, a broad view on strategy-making is needed. It would be a view beyond identifying potential measures alone. It acknowledges that building resilience is a long-term process depending on contextual factors. Such a broader perspective on strategy-making has been suggested by Hutter (2006), who pointed out that a strategy is a

multidimensional phenomenon composed of content (what to do), process (how to do it) and context parameters (adjusted to internal and external conditions).

## 3. A STRATEGY-BASED FRAMEWORK FOR ASSESSING THE FLOOD RESILIENCE OF CITIES

The goal of this paper is to improve our understanding of flood resilience for two purposes. First, for the ability to evaluate the flood resilience of cities, and second for the recognition of potential strategies to build flood resilience. We therefore take the concepts of 'resilience' and 'strategy' as starting points to develop an operational framework for assessing urban flood resilience.

Based on the practical implications of resilience developed in section 2, we conceptualise the three dimensions of strategy specifically for flood resilience. Accordingly, in the content dimension, we focus on measures and policy instruments applied to reduce flood risk. In the context dimension, we look at key strategic issues as external conditions on the one hand, to identify motives for the strategy chosen. On the other hand, we analyse the institutional structure and legislation as internal conditions, to see how responsibilities between public and private stakeholders are divided and shared from a legal and organizational point of view. The process dimension incorporates the idea of building human capacities among public as well as private stakeholders. By interpreting current literature about flood risk management, resilience, adaptive governance and capacity-building (see references in section 2 and 3), we identify measures and institutions as well as human capacities which are favourable for robustness, adaptability and transformability. Thereby, a heuristic model evolves that can be used to assess the resilience of cities endangered by flood risk (figure 1). In the remainder of this section, we explain the framework in more detail.

[Figure 1 around here]

***Content***

Flood risk is often defined as the probability of a flood hazard times the consequences of that hazard (e.g. Jonkman et al., 2003). Measures and policy instruments to lower flood risk hence typically relate to either the first or the latter part of the equation. In this perspective, robustness refers to the first part, as reducing the probability of a flood event makes the city stronger to withstand a flood event. Adaptability refers to the latter part, as lowering the consequences of a flood event means that the hinterland is prepared for flooding. According to Meijerink & Dicke (2008), the probability of a flood event can be decreased by technical as well as spatial measures, whereby technical measures refer to dikes, dams and sluices and spatial measures can be understood as making more room for the river through, for example, river widening. On the other hand, the consequences of a flood event can be decreased by discouraging vulnerable land uses or flood-proofing existing buildings in flood-prone areas. Moreover, disaster management measures such as early warning and evacuation schemes can lower the impact of a flood event. Flood insurances and recovery funds help affected citizens to recover more quickly financially from flooding.

Transformability particularly asks for fostering societal change, as in our definition, changing people's behaviour and mind-sets is a necessary precondition for the physical transformation of a city. The general understanding is that, only when different disciplines, such as water management, spatial planning and disaster management collaborate intensively, vulnerability of the hinterland can be reduced (Woltjer & Al, 2007). Moreover, flood risk management can no longer be seen as a purely public task, as property rights require private developers and land-lords to flood-proof their houses themselves. Besides, well-informed citizens are likely to be less affected by a flood event, as they know how to rescue themselves and organize material belongings in their houses so that they are less damaged by flooding (Knieling, Schaerffer, & Tressl, 2009). Therefore, all kinds of measures aimed at raising

awareness and empowerment of local residents, such as brochures, public campaigns, but also early education in school, may contribute to transformability. Similarly, amongst public stakeholders; consensus-building and partnership practices as well as decision support tools help planners to assess flood risk in specific areas and may bring different disciplines together in order to design new, integrated solutions.

***Context***

Contextual factors may explain why certain contents or process patterns in strategy-making are chosen (Hutter, 2006). Population development, economic performance, and also culture are generally given as important factors when it comes to strategy choosing. A robustness strategy, for example, is likely to be favoured when water is seen more as a threat. Institutionally, this requires a strong water sector and collaboration of water managers and spatial planners on specific projects, such as making more space for water projects.

Land-use and socio-economic changes can be strategic factors for needing a more adaptive approach. Adaptability demands a stronger integration of both sectors; planning and water management, to flood-proof the hinterland. This could also be expressed in terms of the law, for example, when flood risk has to be considered in the planning process. What is laid down in law can also reveal if flood risk management is only seen as a public task, or if it emphasises a responsibility for private stakeholders. The existence of advanced disaster management arrangements show whether a city is prepared for the possibility of a flood event.

The capacity to transform additionally asks for envisioning long-term futures and embedding a broader societal learning process on how to deal with water. Woltjer and Al (2007) refer to this as a ‘new water culture’, in which water is understood as an asset for shaping places and identities, building social relations and informal networks. On a broader societal level, this can result in institutions such as “Learning and Action Alliances” as

described by van Herk, Zevenbergen, Ashley, & Rijke, 2011). On a more strategic level, interdisciplinary think tanks could help to create long-term visions and foster innovative solutions on the one hand, but could also help to recognize changing circumstances and adjust strategies accordingly.

***Process***

As argued before, the resilience concept generally implies a broader understanding of who is involved and what kind of capacities the stakeholders need to possess. Literature on the adaptive capacity of society (e.g. Gupta et al., 2010) suggests that a flood resilient city requires the capacity from organizations as well as from individual citizens to cope with, adapt to, recover from and renew themselves after a hazard. In the framework, we therefore operationalize the process dimension in terms of capacity-building. In capacity-building literature, three criteria – namely intellectual, social and political capital – are typically used for assessment (Healey, 1998; Healey, Khakee, Motte, & Needham, 1999; Khakee, 2002). All three criteria – when adjusted – also play a role in establishing flood resilient cities.

Intellectual capital refers to 'knowledge resources' (Khakee, 2002). While robustness demands a high amount of expert knowledge in technical engineering and planning, adaptability requires expert knowledge about vulnerability reduction and adaptation options. Moreover, local knowledge can be very valuable, for example, in identifying appropriate and socially accepted areas for water retention. Transformability, in turn, requires creativity to generate new and innovative solutions, openness towards new ideas to actually test them as well as the capacity to learn from these experiments.

Social capital is originally understood as 'relational resources' (Healey, 1997; Khakee, 2002); it is about trust relationships between all involved stakeholders. For robustness, good relations among water managers and spatial planners are sufficient. Adaptability additionally

asks for good relations with disaster managers, but also a high civil awareness and willingness to participate in flood risk management. As other authors emphasize (Kuhlicke & Steinführer, 2013; Pahl-Wostl, 2006; Pelling, 2011), social capacity-building asks for a local and participatory approach aimed at empowerment, instead of purely information. Transformability requires mutual trust between public as well as private stakeholders, evidenced in participating and accepting new interdisciplinary networks.

Political capital is defined as the 'capacity for mobilisation' (Healey, 1997; Khakee, 2002), encompassing support by policy and decision-makers for a certain strategy as well as financial resources. Robustness, for example, requires high public funds to construct and maintain primary defences. Adaptability, on the contrary, needs political and financial support for a risk-based approach and a population that is willing to invest into own precautionary measures. Transformability, again, presumes financial support for establishing informal and interdisciplinary networks. Moreover, so-called change agents and leadership can help to make different actors collaborate and create long-term visions (see Gupta et al. 2010).

To conclude, even though resilience demands all three aspects; robustness, adaptability and transformability, these aspects might seem contradictory. For example, is it possible to have a strong water management sector and foster informal networks at the same time? In general, we regard it as one of the strengths of the resilience concept, that it combines these seeming paradoxes. Obviously, depending on the situation, some aspects might be more important than others and hence explain different resilience priorities. The framework can help to identify these priorities, and at the same time show which other measures, institutions and capacities can be used to build resilience for the long-term future.

## 4. METHODOLOGY

The developed framework has been applied to assess the flood resilience of Hamburg. We chose Hamburg as a case study for three reasons. Firstly, Hamburg is experienced in tidal as well as pluvial flooding, and both types of flood risk are likely to increase because of climate change (Daschkeit & Renken, 2009; KlimaCampus, 2010; Storch & Woth, 2008). Secondly, Hamburg's situation is similar to that of other big European cities such as London and Rotterdam, which have to handle continuous urban growth on the one hand and increasing flood risks on the other, with a traditionally strong water management sector. Thirdly, Hamburg has participated in various research projects emphasizing flood risk management and urban planning (e.g. FLOWS, RIMAX, MARE, SAWA, KLIMZUG-NORD), which make it assumingly a frontrunner in the debate. All three reasons make Hamburg a great case to create generic knowledge about flood resilient cities in Europe.

Within Hamburg, we specifically look at two current urban development projects, the "Leap across the river Elbe" and the "HafenCity". Both are located in flood prone areas (see fig. 2). The "Leap across the river Elbe" project implies urban growth on the Elbe Island Wilhelmsburg – the former marshlands and the deepest part in Hamburg, which was flooded completely during the storm surge in 1962 causing more than 300 fatalities (Free and Hanseatic City Hamburg [FHH], 2005). The HafenCity is an urban regeneration project on the former port and industrial areas in the middle of the city, located outside of the main dike line. These two areas are interesting, as they show two different kinds of flood risk management strategies, one more based on robustness and the other one more based on adaptability.

[Figure 2 around here]

The case studies are based on different sources to validate the findings. First, we carried out an in-depth analysis of various policy documents to identify current measures and policy instruments, including information about current urban development projects (FHH, n.d., 2003, 2005b), Hamburg's flood protection concept (FHH, 2007), disaster management concept (FHH, 2005a) and brochures used for risk communication (FHH, 2004, 2008). In order to understand Hamburg's institutional structure, we looked at different national and Hamburg-specific legislation (for instance, Hamburg's water law), publications about disaster management in Hamburg (Gönnert & Triebner, 2004; Lange & Garrelts, 2008), as well as websites from pertinent agencies. We also scanned all land-use plans from the Elbe Island Wilhelmsburg (65 legally binding, 5 in a draft state) and the HafenCity (7 legally binding, 6 in a draft state) and looked at the extent to which planners made use of flood risk regulations in these plans. Last but not least, interviews with key stakeholders shed light on the process of the two urban development projects, revealing which capacities played a role and why certain solutions were favoured above others. In total, we interviewed 8 stakeholders, comprising planners, water managers, disaster managers, researchers as well as citizens. On a ministerial level, the governmental stakeholders come from the *BSU* (Ministry of Urban Development and Environment), *LSBG* (the operating water management authority) as well as *BIS* (Ministry of the Interior and Sports). On a district level, we spoke to representatives from the *Bezirksamt Mitte*, as they are responsible for both urban development projects from a planning as well as a disaster management perspective. We also spoke to a researcher involved in various research projects that try to embed more resilience-oriented flood protection in Hamburg, and a citizen of the HafenCity, who is at the same time the "*Flutschutzbeauftragter"* of his building, which means that he is responsible for operating the flood gates in case of a storm surge.

## 5. CASE STUDY: HAMBURG – A FLOOD RESILIENT CITY?

The “Leap across the river Elbe” and the HafenCity are the two biggest urban development projects in Hamburg at the moment. The main idea of the “Leap across the river Elbe” project is to grow in the middle of the city and connect Hamburg’s city parts north and south of the Elbe. This implies new residential and commercial areas on the Elbe Islands (FHH, 2003, 2005b). The prognoses varies between 15,000 and 50,000 new citizens that will be allocated to the marshlands. Currently, there are 50,000 people living on the Elbe Island, so the implementation of the project could even imply a doubling of today’s population. The HafenCity can be seen as the first stepping stone of the project, as it brings the inner city closer to the river Elbe. On 157 hectares of former port and industrial areas, more than 6,000 homes and 45,000 new jobs are supposed to be created. Thereby the inner city can be expanded by 40%. The goal is to create an attractive waterfront and a lively neighbourhood with retail, residential areas and office space.

### *“Leap across the Elbe” – Urban redevelopment on the Elbe island Wilhelmsburg*

*Content – measures and policy instruments applied to lower flood risk*

Like the rest of Hamburg, the Elbe Island Wilhelmsburg is protected by a main dike line which is continuously heightened and strengthened. The newest program for dike renewal, the so-called “*Bauprogramm Hochwasserschutz*”, dates back to 2007 and prescribes on average an elevation of 1m (FHH, 2007). The program ends in 2016. However, more elevations can be expected, as the design level for floods has been increased by another 80cm in 2012 due to the projected sea level rise. Although the dikes get higher and higher, Hamburg also attempts to be prepared for the case that a storm surge overtops the main dike line. For this purpose, detailed warning and evacuation schemes exist. The need for such schemes became obvious

after a disastrous storm surge in 1962 when one sixth of the whole city was flooded, 20.000 people had to be evacuated and 300 people died (FHH, 2005a).

The population is informed about these schemes by so-called "*Sturmflutmerkblätter*" (storm surge information sheets). These are distributed yearly among all concerned households. The storm surge information sheets vary per district, and apart from German, they are disseminated in five foreign languages (Polish, Turkish, Serbo-Croatian, English, and Russian) to make sure that everyone can understand the provided information. They include advice for individuals and a list of important telephone numbers to contact in case of a storm surge. The second page of the information sheet is always a map of the district indicating the safe areas, areas that will be warned and areas that will possibly be evacuated. It also includes emergency shelters and bus stops that serve as meeting points in case of evacuation.

In recent years, two ideas were developed trying to create synergies between flood risk management and urban planning on the Elbe island: a 'compartment system' and a 'dike park'. Whereas the idea for a compartment system was developed by researchers from the Technical University of Hamburg within the research project RIMAX in 2007, the idea for a dike park was created by a consultancy firm in 2011 within the context of an International Architecture Exhibition taking place in Hamburg.

Although both ideas open up opportunities for "living with water", the compartment system would have implied a much more radical social and physical transformation than the dike park. It is based on the idea that different compartments are created by building dike rings instead of one dike line. The possibility of flooding would vary from compartment to compartment, so that there is a smoother transition between water and land. This also means that in some compartments more adaptation measures are needed than in others. The compartment system would be designed in such a way that most vulnerable areas have the

lowest chance of being flooded (Helmholtz-Zentrum Potsdam, 2009; IBA Hamburg GmbH, 2009; Pasche, 2007). The dike park, in turn, works with the existing dike line. The goal is to make the dike more accessible for the public by seeing dike investments not only as a chance to maintain and heighten the dike, but also to create more open spaces at the waterfront, thereby improving improving the quality of life in the city (IBA Hamburg GmbH, 2011).

When the compartment system was introduced, it was rejected by policy- and decision-makers. According to the head of the department water management at the BSU, the compartment system will also not be part of Hamburg's future plans. A researcher involved in the project explains:

> "Back then, the idea was considered to be inadequate. […] Many people did not understand that the goal was to lower flood risk and offer chances for urban planning at the same time. […] that they would still be protected – but according to the concept of resilience, not resistance. Most people still associate flood protection with huge walls. However, smooth transitions between water and city are better since they also improve the risk awareness among the population".

Interestingly, the dike park project has partly been realized. When a piece of the dike line, the "*Klütjenfelder Hauptdeich*", had to be renewed as a matter of course, stairs were included in the dike to make the waterfront more accessible. However, the dike park does not imply a real transformation: the flood risk management strategy of the Elbe Island Wilhelmsburg is still mainly built on the idea of robustness. The hinterland is not physically prepared for flooding, but disaster management arrangements are in place to lower the damage in case of a storm surge.

*Context – institutional structure and legislation*

The choice of these measures and the rejection of others can partly be explained by the institutional structure. After the storm surge of 1962, flood risk management as well as

disaster management have become high priority policy fields. In particular the disaster management organization is unique within the German context, as an interviewee from the Ministry of the Interior explains. The Ministry of the Interior is the central disaster management institution. In case of emergency, it can instruct all other authorities and is even authorised to make decisions without the Senate. Thus, urgent decisions like a ban on driving on specific roads can be made immediately and with little bureaucracy (FHH, 2005a; Gönnert & Triebner, 2004).

Using spatial planning to lower the potential damage is not yet common practice. This shows for example in the fact that the "Leap across the Elbe" policy documents (FHH, 2003, 2005b) published by the planning authority do not include any statement about flood risk management. Moreover, our analysis of all land-use plans from the Elbe island (65 legally binding plans, 5 in a draft version[i]) reveals that only four plans prescribe measures with respect to flood risk. Land-use plan *"Wilhelmsburg 71"* from 1994 forbids basements, *"Wilhelmsburg 2"* from 1964 only allows construction if the whole parcel is elevated up to a minimum of 2.5m above mean sea level, while "*Wilhelmsburg 18"* and "*Wilhelmsburg 72"*, both from 1994, prescribe a fixed staircase to a permanently accessible level on 6m above mean sea level, if the building includes residential use. As legal changes in 2005 require flood risk to be considered as one concern that has to be balanced with other concerns in the act of plan-making (§1 VI no. 11 BauGB[ii]), one would expect more regulations in recent land-use plans. While they do include more measures to deal with precipitation, for example greening roofs, there are no explicit building restrictions because of storm surges. Although projects like the dike park work on improving the relations between water managers and planners, the collaboration between both disciplines is overall still limited.

*Process – intellectual, social and political capital*

The currently available intellectual, social and political capital offer another explanation as to why a transformation from "fighting the water" to "living with the water" seems to be so difficult. On the one hand, Hamburg possesses capacities that support the current strategy. For example, Hamburg has high trust in the expert knowledge of water engineers. On a symposium dealing with water challenges and climate change the former privy council of the BSU praises Hamburg's "high competencies in water engineering and flood control" (IBA Hamburg GmbH, 2009). Preventing another disaster like the storm surge of 1962 has a high priority among policy and decision-makers. Therefore, they are also willing to spend much public money on flood protection. The latest dike renewal programme costs more than 600 million €, although this is partly covered by the Federal Government of Germany. In a ranking comparing different budget groups within the Ministry of Urban Development and Environment for the years 2013 and 2014, water management and flood protection score the 2nd position after housing. A fifth of the overall budget is spent on water management and flood protection. It is significantly better resourced than urban planning, environmental or climate protection (FHH, 2012).

Experiences with the dike park, however, raise the question on how money is spent and to what extent the integration of urban planning and flood protection legitimizes extra costs. The integration of stairs into the *Klütjenfelder Hauptdeich* as a means to make it a multifunctional dike will result in extra costs for construction as well as maintenance. Compared to a normal dike, costs increase because of constructing the staircase, maintaining the staircase, increased usage of the dike (which leads to, for example, more refuse that has to be collected) and adjusting the staircase in case the dike needs to be heightened in future. A representative of the LSBG therefore states: "If urban planning and flood protection do something together, the city has to recognize that this causes extra costs. You don't get it for

free. However, that often does not work out." In the particular case of the *Klütjenfelder Hauptdeich*, the initial extra costs were paid by the International Architecture Exhibition. As this is only a temporary budget, it remains doubtful if other projects like this will also receive funding. Some water managers perceive that the multi-functionality of a dike requires a lot of additional work and money to make the dike safe. A water manager from the LSBG remarks: "I know a lot of water managers that say 'We want a dike as dike, without extensive usage, because this is the best way to protect the city and its people'." This may also explain why the compartment system was rejected. In general, a researcher from TUHH states:

> "There is still a rather low openness towards new ideas [...]. The reasons are manifold, mainly reflecting the "entrapment effect" i.e. the reluctance to change the current 'known' practices and accept something 'new' and as such 'unknown'. There is much concern about how those changes would fit into the existing legal frameworks and the internal rules and responsibilities established within and between institutions."

Moving towards a holistic resilience approach, based more on the ideas of adaptability and transformability, is not only difficult for public stakeholders, but also the broader population. Although national as well as Hamburg legislation acknowledges that flood risk management is not only a state's task, but also requires individuals to take necessary precautions within their means (§52 no. 2 HWaG), only few people are willing to do so. Two different studies about the risk awareness in Hamburg's society (Heinrichs & Grunenberg, 2009; Knieling et al., 2009; the latter specifically about risk awareness on the Elbe island) come to the conclusion that most people are actually aware of the flood risk, but that the awareness does not translate into taking own precautionary measures. A practitioner from the BSU doubts a high risk perception among the population. He explains: "The topic water has only little meaning for the people. […] People don't feel concerned. […] Especially new citizens have no risk perception at all".

For the same interviewee, the low awareness for flood risk is also a reason why it is so difficult to achieve public participation:

> "During a research project, we made an advertisement in the local newspaper 'Hamburger Abendblatt' that we are looking for people interested in participating in flood protection. The newspaper is read by more than 700000 people, 13 people answered, in the end 7 participated, all of them having already experienced a flood event".

All in all, although ideas for changing the flood protection scheme of the Elbe Island exist, public as well as private stakeholders are reluctant to move from a robustness strategy towards a more adaptable approach. A transformation in future is not impossible, but barely in sight at the moment. This is mainly due to a lack of social and political capital. The question therefore arises what makes the HafenCity different and why was a more adaptable approach realized here?

### *The HafenCity – Urban regeneration in the heart of the city*

*Content – measures and policy instruments applied to reduce flood risk*

Originally, the areas of the HafenCity lay not only outside the dike line, but they were also rather low: the height varied between 4.4 – 7.2 m above mean sea level rise, which means that most parts would get regularly flooded. When the idea of the HafenCity was born, two possible solutions to deal with flood risk were discussed: the 'polder solution' and the 'dwelling mound solution'. Whereas the first solution would imply a protection line of 4.75 km and at least 5 flood barriers, the second solution required an elevation to a minimum height of 7.5 m above mean sea level rise. This level is considered flood-proof as it resembles the height of the flood wall protecting the inner city. Hamburg opted for the urban dwelling mounds, because it was considered cheaper and it meant that they could start developing much earlier and step-by-step. With the first solution, developing could have only started

when all flood walls and barriers had been finalized (Bürgerschaft der Freien und Hansestadt Hamburg, Drucksache 15/7460, 1997).

[Figure 3 around here]

Figure 3 shows the flood protection concept for the HafenCity. The dwelling mound solution means that bridges and streets are elevated up to a minimum of 7.5 m, whereas buildings incorporate the dwelling mound in the form of a basement (see figures 4 and 5). Some of the basements are designed as parking areas, others are used as shops. In case of a storm surge, all openings such as windows are protected by temporarily installable flood gates (FHH, n.d.).

The disaster management arrangement is similar to that of the Elbe Island Wilhelmsburg. The HafenCity also has storm surge information sheets to inform the residents about storm surge related risks. Two streets are built higher to serve as evacuation roads in case of a high storm surge.

[Figure 4 around here]

[Figure 5 around here]

*Context*

The broader historic and economic context further motivates the choice for a quick development and hence the dwelling mound solution. The reunion of Germany in 1989 moved Hamburg from a marginal location to the middle of Germany and a bigger Europe. Already in the 1990s, the development of the HafenCity was considered an important project to position Hamburg as an economically viable harbour city in the core of Europe (Bürgerschaft der Freien und Hansestadt Hamburg, Drucksache 15/7460, 1997).

Before the dwelling mound solution could be realized, legal changes were necessary. Hamburg's harbour law had to be changed so that the Senate could convert areas of the HafenCity from harbour usage into a mixed urban neighbourhood. Hamburg's land use plan had to be changed accordingly. Moreover, a completely new act, the so-called *"Flutschutzverordnung"*, had to be passed by the Senate to allow living in the HafenCity. The HafenCity is now an exemption, as § 63 Abs. 1 HWaG usually prohibits living in areas outside of the main dike line.

Apart from legal changes, the HafenCity also establishes a new institution to operate the flood gates within the buildings, the so-called *"Flutschutzgemeinschaften"*. All property owners within a building complex are automatically part of it. Every *"Flutschutzgemeinschaft"* has a *"Flutschutzbeauftragter"* who is the main contact person and who is responsible for putting the flood gates in place when a storm surge is expected.

To conclude, the HafenCity brought about various institutional changes and innovations as well as capacity-building.

*Process*

First of all, the urban dwelling mound solution shows high intellectual capital. The flood protection concept of the HafenCity is often praised for being very innovative. Indeed, Hamburg's water managers translated a concept that they had already used in the harbour area for years in the context of a mixed urban quarter. In the harbour area, it is common practice that property owners form *"Poldergemeinschaften"* that cover the costs for constructing, operating and maintaining flood protection schemes.

In the case of the HafenCity, private stakeholders cover the costs for constructing, operating and maintaining the basements as well as the flood gates, whereas public money is spent on elevating the whole area and building evacuation roads. As this is not a common

agreement for residential areas, the question is why private developers accepted these conditions. One private developer explains his motives for living and working in the HafenCity:

> "It's the location. Working at the waterfront increases the productivity of your employees by at least 25%, you can feel that. Where can you find a nicer location than here, where you have a direct view on the river Elbe, a view on the cruise liners? Just this morning a cruise liner has again arrived. It is just a preferred location."

Hence, apparently living at the waterfront makes up for extra costs. Of course, it also requires the financial capacity among private stakeholders. As Menzl (2010) points out, the HafenCity is one of the highest-priced areas in Hamburg, for renters and buyers alike. It can therefore be assumed that people living in the HafenCity have the financial capacity to cover these costs. Interestingly, our interviewee doubts that the flood protection scheme leads to a higher civil awareness among residents:

> "To be honest, people here are rarely aware of flood risk. Of course it is visible, for example the storm surge last year December, but the HafenCity is safe. What I always say: If we are flooded here, the rest is already… ."

Hence, the willingness to invest in flood protection seems less driven by flood risk awareness or the idea of being 'resilient' than the location.

Similarly, public stakeholders did not opt for the flood protection concept because it was more flood resilient, but because it was politically necessary in order to develop as quickly as possible. The idea to develop a mixed quarter – first uttered by the Chief Planning Officer – was taken over by the mayor during the 1990s and even became a main issue of the mayor's election campaign in 1997, as an interviewee from the BSU explains. The political priority of the project is also expressed in the fact that the HafenCity got its own development agency, the HafenCity GmbH. Because of the strong political will, legal changes, as described

in the previous section, became possible. Some documents (e.g. FHH, n.d. and the master plan of the HafenCity) promoted the idea that the HafenCity might be included in the main dike line by installing flood barrages and flood walls at a later stage. This shows that the flood protection scheme was not about resilience per se, but instead a means towards a purely economic and political end: positing Hamburg as a harbour metropolis within Europe as quickly as possible.

## 6. CONCLUSIONS

This paper set out to develop a framework for assessing the flood resilience of cities, for scientists and policy and decision-makers alike. The presented framework is a heuristic one made for qualitative assessment. It enriches the current literature on flood resilience in two ways. First, the framework overcomes the resistance-resilience dichotomy often used in flood risk management (de Bruijn, 2005; Douven et al., 2012; Hooijer et al., 2004; Vis et al., 2003). The paper argues that technical measures usually attributed to a “resistance strategy” are not contradictory to a resilience strategy, because robustness and the ability to withstand a flood event are inherent characteristics of resilience itself (Holling, 1973; Davoudi 2012; Scott 2013; Galderisi et al. 2010). Second, it clarifies resilience and the meaning of its three key characteristics – robustness, adaptability and transformability – for the specific context of flooding in cities. By identifying important components for implementing resilience strategies, the paper goes beyond predominantly conceptualising resilience (e.g. Pendall et al. 2009; Davoudi 2012; Alexander 2013). These components comprise content, context and process factors for decreasing flood probability, reducing consequences of flooding and fostering societal change (see figure 1). The focus on strategies gives the resilience concept a new notion compared to the original ecological meaning – it is no longer descriptive, but a normative concept that can actively be achieved through intervention.

While the framework is derived from a literature review in this field, the two case studies from Hamburg add important practical insights into both the current barriers to implementing a resilience strategy and the chances to achieve such a strategy. The first case – the Elbe Island Wilhelmsburg – shows that building up social and political capital remains one of the main challenges to move to a holistic resilience approach. This includes a better integration of urban planning and water management as well as the willingness of private developers and citizens to contribute to flood risk management. Raising awareness among both, public as well as private stakeholders, is hence key to make a shift to more resilient approaches likely in future. For this purpose, the framework suggests measures for capacity-building; such as consensus-building-practices and decision support tools among public stakeholders, as well as public campaigns and early education in school among private stakeholders. The HafenCity teaches us another important lesson in this respect: spatial transformation processes offer the chance to embed flood resilience into a bigger urban agenda. While flood resilience alone is not enough motivation to change the flood risk management strategy, it has the potential to link into a broader political and economic agenda and thereby create win-win situations. Moreover, political capital is extremely important in the shift towards a resilience strategy. Leadership and key agents, as in this case - the mayor, made lots of legal changes possible. Moreover, the location convinced private developers to invest in the area, even though they had to carry the costs for flood protection.

Overall, we conclude with three suggestions for urban policy and research:

- The Wilhelmsburg case shows that urban policy makers are relatively unaware of the potential of a holistic approach for improving safety. In particular, that a resilience approach does not only create added value (e.g. water view instead of a fenced dike), but also may increase the safety of an area. Shifting to resilience approaches hence requires a new framing of mind-sets among both public as well as private stakeholders. How this can effectively be done will require further research.

- A holistic resilience approach requires a redistribution of responsibilities between public and private stakeholders. The HafenCity is a high-end urban development, where private developers as well as inhabitants have generally sufficient (financial) capacity to cover extra costs and efforts for flood protection. The case teaches us that public authorities can create incentives (i.e. living at the waterfront) for increasing the willingness among private stakeholders to take a more active role in flood risk management. Resilience, however, does not merely imply the advancement of 'rich' individuals or organisations (i.e. those holding higher levels of capacities and resources like knowledge, relations and support). Therefore, it is important that policy-makers consider social justice and equity aspects. Further research is needed to clarify how and to what extent public authorities can set the boundary conditions for a socially just 'public-private divide' in flood risk management.

- Often, more holistic resilience approaches are associated with higher costs. The example of the HafenCity shows, however, that resilience is not per se more costly. The financial aspect again strengthens the need to create synergies with other fields: flood resilience should not be a separate policy, but integrated into a broader urban agenda.

Please write a short biography of yourself and acknowledge any grant/funding information here.

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i All land-use plans are publicly accessible on http://www.hamburg.de/bebauungsplaene-online/.
ii BauGB, short for Baugesetzbuch, is the German federal building code.