Introduction

In northern Europe, climate change is expected to cause grave challenges for cities and regions. Settlements, and particularly along the waterfronts, will be confronted with heat waves, cold spells and rising sea levels. Thus, climate change has impacts on both people and the built environment (Gill et al. 2007: 116). Effects of climate change will be recognised increasingly in the coming decades (IPCC 2007). As a result the discussion about adaptation strategies, along with effective climate protection, has recently become a major topic in politics as well as in science (ARL 2007: 1). At first, the political discussion focused primarily on requirements for adequate mitigation strategies that help to prevent climate change for example by controlling CO_2 emissions. But in recent years, attention has also been drawn towards the topic of adaptation and corresponding measures to cope with climate change and its impacts (e.g. Adger et al. 2003; Bulkeley 2006; Bruin et al. 2009; Füssel and Klein 2006).

Looking at Germany, in anticipation of the effects of climate change, the coastal zones need to be prepared not only for a rise in sea level but also for a growing risk of storm surges (Woth et al. 2005: 3). Northern German waterfronts are densely populated areas and hence highly vulnerable. Looking to the past, it is obvious that adaptation to the natural dynamics of the sea level has a long tradition on the coastline of the North Sea. Dwelling mounds, such as those on North Frisian Holms, or water-orientated living, like houseboats in the Netherlands, show experiences in flood-adapted construction. It is anticipated that climate change will create a new dimension of threat, especially to the coastline.

Although multiple adaptation options are already available, more extensive efforts seem to be required to reduce the vulnerability to climate change (IPCC 2007: 14). This article deals with the question of how adaptation can handle a high level of uncertainty concerning future risks of climate change and how this can be included in the concept of resilience. The thesis states that adaptation to climate change needs a change of underlying paradigms. This article exemplifies the new paradigm "living with water" for the Metropolitan Region of Hamburg and in particular for the case of Hamburg's Elbe Island with about 50.000 inhabitants.

Urban Development and Climate Change in Hamburg

The Free and Hanseatic City of Hamburg is situated 120 km south-east of the North Sea. Affected by tides on a daily basis, the tidal area extends to a flood barrage in the city of Geesthacht, 30 km east of Hamburg. Hence, Hamburg is formally located on the North Sea coastline. As a result the city not only profits from the advantages of being a port city, but is also obliged to deal with the difficulties of its location. The most significant of these challenges is the threat of storm surges, a phenomenon which is likely to increase due to climate change (Woth et al. 2005: 3).

The risk of storm surges has a direct influence not only on dike construction, but also on life within the floodplains. Against this background urban and regional planning in Hamburg have followed a strict pattern throughout the centuries: living was situated in the "Geest" (dry area) and working in the "Marsch" (wet area). For example Hamburg's prominent "Federplan", designed in 1920 by Fritz Schumacher, head of the city's planning department, not only shows urban development along traffic axes – thus reminiscent of the lines of a feather-shape – but also identifies the Hamburg Elbe Island as being located in the "Marsch", underlining that this is no area for further settlement (see figure 1).

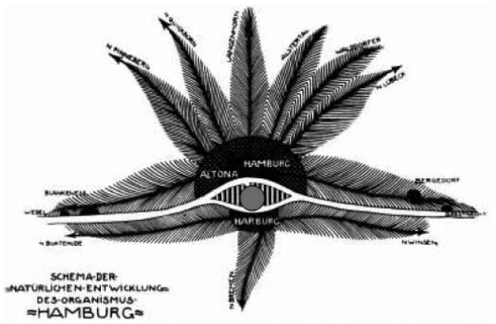

Abb. 1

The Senate of Hamburg departed from this pattern some years ago. Hamburg's recent vision of a growing city and the urban development concept "Leap across River Elbe" are results of this change. On Hamburg's Elbe Island new living and working areas have been planned in the quarter of Wilhelmsburg (FHH 2005: 7 and 71; FHH 2007: 30). This new orientation of urban development has not only been inspired by politics and administration, but also by interest groups such as the Chamber of Commerce (Handelskammer 2004: 7). It is estimated that between 15,000 and 50,000 new inhabitants could live on the Elbe Island in the near future (FHH 2007; FHH 2003; FHH 2002). This would mean the potential to double the current population and would also correspond with an expansion of the associated commercial and industrial areas. If new building projects were to be conducted at this scale, it would vastly increase the danger of damage by storm surges. However, none of the various predictions studied discusses how to deal with the potential risks posed to the Elbe Island's population by climate change.

In order to illustrate the extent of the threat, it is worth looking back at events that have already occurred. In 1962 Hamburg was hit by a heavy storm surge which took the lives of more than 300 people. At that time the Senate of Hamburg passed a resolution that envisioned a withdrawal of housing from the whole western part of the Elbe Island. The resolution stipulated that these areas should be abandoned and used solely for the expansion of the port (Schubert and Harms 1993: 49). It was enacted in 1965 and was officially binding until 1977, when it was withdrawn by the Senate because new plans had come up to develop the Elbe Island. Despite this, the port never expanded into this area. The resolution's effects were long-lasting, as people left the affected district and land and real estate owners no longer

Fig. 1: Plan for the development of Hamburg from 1920 according to Schumacher (modified by FHH 2007: 30; Kallmorgen 1968: 161)

invested in the supposedly worthless buildings. As a result, residential buildings decayed and there was a socio-economic shift from middle-class to low-income inhabitants. Although the existing buildings were renovated after 1977 due to governmental subsidies, the social marginalisation of the quarter still is a matter of concern for the city and is a dominant topic of current urban renewal efforts. An example of this is the International Construction Exhibition which is taking place in Wilhelmsburg from 2007 to 2013.
The development of the Elbe Island after the traumatic storm surge of 1962 shows that flooding can have immediate as well as long-lasting effects. The importance of the topic of storm surges within urban planning cannot be overemphasised. As a result it seems particularly surprising that there are hardly any building restrictions behind the dikes on Elbe Island, although living in front of the dikes is prohibited, and those who live behind are to a large extent reliant on the existing flood protection systems.
However, in the interest of the population the question arises, how the growing risks resulting from climate change could be dealt with and which planning guidelines could help minimise damage in case of a dike failure? In the following sections the handling of storm surges in urban development is discussed and the necessity of a paradigm shift from flood protection systems to a risk management in coastal zones is outlined.

Vulnerability, Resilience and Adaptation Capacity as Variables of Adaptation

Climate change adaptation is described as a *"[…]process, action or outcome in a system […] in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard risk or opportunity"* (Smit and Wandel 2006: 282). Vulnerability, resilience and adaptation capacity can be seen as basic variables of adaptation to climate change (Adger et al. 2003; IPCC 2007; Smit et al. 2000). In this context the concept of vulnerability is characterised by its distinct spatial and temporal scales, by scientific uncertainties regarding scenarios and models, and by the policy context (Füssel and Klein 2006: 301–2). Therefore the sensibility of cities and regions towards unpredictable changes depends on social, ecological, economic and political conditions.
Regarding increasing storm surge risks, the concept of resilience is related to vulnerability. The notion of "resilience" is discussed in different ways and a transfer of the concept in practice is difficult to consider. One definition describes resilience as "*degree to which a system rebounds, recoups or recovers from stimulus*" (Smit et al. 2000: 238). Other definitions characterise resilience as "*a return time to a steady-state following a perturbation*" (Gunderson 2003: 34). According to these, and with respect to climate change, resilience can be seen as the resistance of systems to change their capacity to adapt on their own. In dealing with cities, resilience has been used in the context of their sensitivity to disasters and their ability to deal with natural disasters and uncertainties. Resilient cities aim at built-in systems that help adapt to change (Newman et al. 2009: 6). Resilience includes three integrated systems to enable people and nature to face disturbance: first, "*the amount of change a system can undergo […] and still remain the same controls on function and structure*", secondly, "*the degree to which the system is capable of self-organization*", and finally, "*the degree to which the system expresses capacity for learning and adaptation*" (Resilience Alliance 2009). Therefore, the concept of resilience goes along with the adaptation capacity. Against this background the characteristics of flexibility and robustness are considered the most relevant to enhance resilience (Folke et al. 2002: 6 f.; Gunderson 2000: 434; Zevenbergen 2007: 6).

- Flexibility is explained in terms of ecological adaptivity and as living with environmental variability. Corresponding ways of life that cope with increased variability and unpredictability of environmental conditions, like changes in seasonal cycles or water levels, are able to increase the adaptive capacity (Berkes and Jolly 2001: 18). Furthermore, the buffering capacity in flood-prone areas is seen as criteria of flexibility. An example of this is the capacity for water storage (Fankhauser et al. 1999: 72). Thus, reserve areas become relevant to protect against extreme floods because they offer retention space for minimizing high water levels.
- Robustness means strengthening coastal protection to withstand severe storms and floods (Bruin 2009: 24, Fankhauser 1999: 72). The built environment is described as robust as it can be adjusted to withstand a wider range of future weather conditions (ibid.: 76). Hence, strong, less sensible building structures have become relevant criteria for the adaptation capacity.

Living with environmental dynamics as well as providing buffer capacities to withstand extreme events are relevant criteria for the development of resilient settlement structures. Urban systems are obliged to be pliable and compliant to achieve a sufficient adaptation capacity (Smit et al. 2000: 238).
Against the background of the described variables of adaptation the question arises of whether the current practices are still suitable.

Shifting Paradigms of Adaptation to Climate Change

Today's flood management in Hamburg relies mainly on technical engineering solutions. The water management administration has developed highly qualified flood protection systems with excellent safety standards. Nevertheless, although technical installations for flood control provide protection, they create an illusory sense of security for living behind the dikes so that the potential danger is suppressed or forgotten (Kron 2003: 88). While flood protection traditionally has been focused on technical solutions like dikes, flood barriers or walls which contain the natural river bed and concentrate on a single line of protection, the recent debate about consequences of climate change has taken into account the

limits of existing danger prevention (e.g. Aerts 2008: 41; Jolly 2008: 147). The faith in technical measures and their capability to contain nature is increasingly being questioned and there have been many discussions regarding the reduction of vulnerability in the event of flooding. Plate (2003: 40) describes this change as a new requirement for flood management: technical security in regard to flood protection is no longer able to cope with the exigencies of modern flood hazards. It constitutes fixed waterfronts and does not allow flexibility in floodplains. Therefore a change of paradigm from prevention to management of danger has been proposed (Greiving 2003: 129; Schmitt 2011: 43). Risk analysis and risk assessment describe new ways of planning in coastal zones.
These changes become apparent when taking a closer look at the international debate on the topic. For example, in the Netherlands where for a long time flood protection has also primarily been based on technical solutions such as raising levees and building flood barrages and walls, an increasing number of supplementary approaches have been considered (Bruin et al. 2009: 25). Besides technical solutions, new ways of handling uncertainties in water management – for example flood insurances, flood risk mapping systems, general risk management systems, and urban concepts like "room for the river", which includes measures to give the natural flooding area back to the river – have been applied (Aerts et al. 2008: 41; McGranahan et al. 2007: 20). Lately the discourse has gone further and has switched the attention to alternative ways of "living with water" (Immink 2004: 388). Studies and projects concentrating on flood adaptive building in urban development have been completed (e.g. Flesche and Burchard 2005: 29; Veerbeek 2008: 52; Zevenbergen 2007: 8 f.).

Within these strategies the areas behind the dikes and near the river have become a main focus of coastal protection. Restricted and adjusted behaviour in the coastal zones has now become relevant. The adjusted focus on dike zones rather than dike lines is also a new approach for urban planning because these areas are part of the already existing urban settlement structure. As a result, a close cooperation between water management and spatial planning is required, including more institutional flexibility and learning within the different stakeholders groups being involved in waterfront planning (Aerts et al. 2008: 41). Against this background, strategies tackling storm surge risk can be divided into four categories of prevention (BMBVS 2006: 4; Egli 2005: 64 ff.):

- Area prevention: either maintaining open spaces or conscious positioning of buildings and constructions.
- Constructional prevention: the adaptation of buildings regarding potential flood dangers.
- Risk prevention: specifically financial prevention in the form of private savings or insurance policies as well as emergency measures like mobile walls and sandbags.
- Behaviour prevention: individual preparation for possible flood events.

"Living with water" and "cascading flood compartments": New approaches of adaptation on Hamburg's Elbe Island

Hamburg's Elbe Island is an urban quarter with about 50,000 inhabitants. It is situated directly on the River Elbe which has developed a broad delta of various streams in this part of the city. Its limits are the Northern Elbe and the Southern Elbe. For the City of Hamburg this broad extension of the river Elbe is a main challenge because of the question it poses: how can these different parts of the city which are situated north and south of the river Elbe be linked? Because of this unique linkage for Hamburg's urban development, the Elbe Island has become the focus of an ambitious urban development processes (FHH 2005). The concept "Leap across the River Elbe" and the International Building Exhibition "IBA 2013" have been initiated to connect the northern and southern parts of Hamburg in a better way.

Abb. 2

An additional challenge is that the Elbe Island is exposed to severe storm flood risks – formally still being part of the North Sea that reaches far into the inland. Currently, the island is protected by a circular embankment. However, in respect to future climate change, these levees cannot be raised indefinitely. Against this background of limited flood protection by the embankment, in the research project "Urban Flood Management" new ways of "living with water" were explored, and the "system of cascading flood compartments" was developed as an unconventional strategy for the Elbe Island to protect flood resilient waterfronts (Knieling et al. 2009; Pasche et al. 2008). At present, this strategy has the status of a scientific concept and one that steps out of line of current flood protection strategies in Hamburg.

Fig. 2: Elbe Island of Hamburg-Wilhelmsburg (modified by FHH 2009, map of Hamburg 1:60 000)

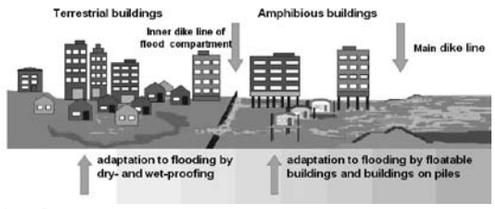

Abb. 3

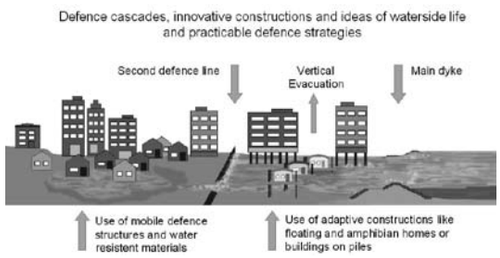

Abb. 4

The "system of cascading flood compartments" combines area prevention with constructional solutions. The idea is to (re)build a second dike-line of polders behind the primary dike, thereby creating a system of different compartments (see fig. 3 and 4). Polders are low lying areas enclosed by embankments or dikes. In the case of a dike overflowing, the system diverts the water to the hinterland. New internal dikes within the existing ring-dike would protect the most economically valuable areas on the Elbe Island (Aerts et al. 2008: 41). In addition, certain housing areas with a dense population would gain further protection against extreme floods. Residences within these compartments would get additional fortification against flood risks by constructional prevention. When expanding to the waterfronts, these areas could also be used for flood-secure types of housing like floating or amphibian homes. Four different types of adaptive building can be identified specifically for this area (e.g. Waterstedenbouw 2007; Flesche 2005: 24 ff.; Simons 2008: 13 ff.):

- Swimming or floating houses, which are dependent on permanent high water levels; they are options for canals or the river themselves.
- Dike houses, which are multi-functional: they build a dike line, and provide housing.
- Amphibian houses, which need temporary high water. They flow with the dynamic of changing water levels.
- Houses on stilts, which have a long tradition in flood protection and may safeguard their inhabitants in temporary flooded areas.

Living with a degree of environmental variability is a key criterion of adaptive capacity (Berkes and Jollys 2001: 18). This criterion is integrated into the way people live with varying levels of water within the compartments and possible future risks. The compartments presented offer multifunctional spaces, which under normal conditions can be used as open spaces, like public squares or sporting fields, and during flood events converted into floodwater retention areas (Veerbeek et al. 2008: 64). Depending on the water level, the compartments provide flexible elements for dealing with flood risks.

With regard to the system's ability to function in the face of a disturbance, e.g. extreme flood events, a "system of cascading flood compartments" is expected to be less vulnerable. Because the buildings within the flood compartments are to be adapted to high water levels, the damage will be less than without any restrictions for buildings and usages behind the dikes. However, some local authorities view the strategy critically because the population's trust concerning the main dike line could be undermined. Already existing buildings in the area that have not been adapted sufficiently could lose value compared to flood adapted dwellings. This demonstrates that it is relevant to tackle obstacles that can occur during the transition period of implementing such a new strategy. Aspects like citizens' risk perception, acceptance of new types of living, or willingness to accept the new orientation are relevant constraints on the implementation of a "system of cascading flood compartments" (Knieling et al. 2009).

The compartment strategy and the different approaches for "living with water" goes along with the above-mentioned change of paradigms in flood protection management. Instead of only relying on a single dike line, the whole area behind the dike is part of the adaptation strategy. Restrictions for building and usages as well as a new concept of "living with water" enhance the protection.

Conclusion

With the growing threat of storm surges, the impacts of climate change on waterfronts can be tackled in two different ways: first, it is possible to seal off areas from the sea by flood barrages and dikes; and second, adapted settlement structures behind these dikes can provide additional flexibility and contribute to strengthening the resilience of cities. Both approaches stand for different paradigms of flood protection; they compete with each other, but can as well be complementary. This contribution aimed at describing potentials as well as restrictions of the second approach.

In the case of the Hamburg Elbe Island, so far protection strategies have mainly been focused on a single dike line. The "system of cascading flood compartments" described above is expected to offer additional protection. It contains second dike lines, a compartment structure providing flexible water storage capacity, and adaptive types of building. Furthermore, floating and amphibian homes as well as technical adaptation measures concerning single houses, such as removable walls, complete water-related settlement sites and provide future flood-secure living.

The existing instruments of spatial planning provide various possibilities to integrate elements of the described adaptation strategies. An example is securing buffer areas for extreme weather events over long time periods or to rule specific quality standards concerning adaptive building. In any case, as far as planning instruments are concerned, the finality of planning as well as of the built environment

Fig. 3: Adaptation strategy "System of Cascading Flood Compartments" (Pasche et al. 2008: 308; Knieling et al. 2009)

Fig. 4: Principle of the adaptation strategy "System of Cascading Flood Compartments" (Pasche et al. 2008: 305)

implies the disadvantage of being relatively static and, therefore, not meeting the requirement of flexibility. Further research should deal with this contradiction and consider how urban planning as well as the building environment can integrate more elements of flexibility and dynamics, including the degree of responsiveness of settlement sites with regard to the expected changing requirements concerning future climate change.

On the one hand strategies like the "system of cascading flood compartments" may contribute to a more appropriate understanding of future adaptation challenges and enhance the resilience of urban waterfronts. On the other hand, concerning the necessary shift of paradigms in adaptation, it seems to be of essential importance to analyze properly the dominant planning cultures and self-conceptions of flood adaptation in administration and politics. If a planning paradigm shift from a safety-oriented to a risk-management culture takes place, the approach of "living with water" can play a key role in the redevelopment of resilient water-related residential areas. From this point of view, adaptation might not only be seen as a necessity but could also become a potential for urban development regarding water-related sites.

Another aspect of adaptation is the social and institutional implication, which has only been briefly touched upon in this article. The inhabitants', as well as the house owners', willingness to participate and their acceptance of new concepts and measures are essential elements of the development and implementation of adaptation strategies. With its specific history and social structure Hamburg's Elbe Island shows that water-related settlements have to be sensitive to the demands of economically deprived inhabitants. Otherwise they threaten to accelerate gentrification processes, pushing people out of their quarter. Further research about adaptation strategies and adaptive urban planning should include the analysis of social consequences as well as communication and learning processes.

From an institutional point of view adaptation is managed in a highly complex field of public and private actors, administrative resorts, and different levels of competencies. For implementing changes in paradigmatic understanding of adaption as well as in strategic thinking – "living with water" as a new risk perception – the institutional context is of high importance. Further research topics can be identified in the field of climate adaptation governance, including the analysis of actor interests and reasoning as well as the institutional perspective of coordinating flood adaptation.

In conclusion, it should be mentioned that the conceptual considerations described must also be aware of the societal framework of waterfront development. On one hand this final aspect underlines the complexity of the urban development processes; on the other it emphasises the fact that the question of resilience is not only a technical or engineering issue, but also a broad debate between both engineering and social sciences. In this field, there is still quite a substantial range of research opportunities yet to be explored.

Literature:

Adger, W. Neil, Saleemul Huq, Katrina Brown, Declan Conway, and Mike Hulme (2003): *Adaptation to climate change in the developing world.* Progress in Development Studies 3, no. 3: 179-95.

Aerts, Jeroen C. J. H., Wouter Botzen, Anne van der Veen, Joerg Krywkow, and Saskia Werners (2008): *Dealing with Uncertainty in Flood Management through Diversification.* Ecology and Society 13, no. 1: Article 41.

ARL - Academy for spatial research and planning (ed.) (2007): *European Strategies of Adaptation to Climate Change. The Spatial Planning and Spatial Development Policy Perspective.* Positions Papers 73. Hannover.

Berkes, Fikret, and Dyanna Jolly (2001): *Adapting to climate change: Social-ecological Resilience in a Canadian Western ArcticCommunity.* InConservationEcological5,no.2:Article18. http://www.ecologyandsociety.org/vol5/iss2/art18/print.pdf.

Bruin, Karianne de, Rob Dellink, Arjan Ruijs, Leonie Bolwidt et al. (2009): *Adaptation to climate change in The Netherlands: an inventory of climate adaptation options and ranking of alternatives.* Climatic Change 95, no. 1-2: 23-45.

Bulkeley, Harriet (2006): *A Changing Climate for Spatial Planning.* Planning Theory & Practice 7, no. 2: 203-14.

Egli, Thomas (2005): *Vorsorge gegenüber Naturrisiken: Darlegung des Handlungsspielraumes am Beispiel der Hochwasservorsorge.* In: *Risiken in Umwelt und Technik. Vorsorge durch Raumplanung,* ed. Helmut Karl, Jürgen Pohl, and Horst Zimmermann, 64-66. Forschungs- und Sitzungsberichte der Akademie für Raumforschung und Landesplanung 223. Hannover.

Fankhauser, Samuel, Joel B. Smith, and Richard S.J. Tol. (1999): *Weathering climate change: some simple rules to guide adaptation decisions.* In Ecological Economics, 30: 67-78. http://www.fnu.zmaw.de/fileadmin/fnu-files/publication/tol/ececadaptation.pdf.

FHH - Freie und Hansestadt Hamburg, Landesbetrieb Geoinformation und Vermessung. LGV G1-121 (2009): *Stadtkarte 1: 60 000.* Hamburg. www.geoinfo.hamburg.de. (Copyright FHH).

FHH - Freie und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt (2007): *Räumliches Leitbild – Entwurf.* Hamburg.

FHH - Freie und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt (2005): *Sprung über die Elbe.* Hamburg.

FHH – Freie und Hansestadt Hamburg, Staatliche Pressestelle (2003): *Fortschreibung des Leitbildes: Metropole Hamburg – Wachsende Stadt.* Hamburg.

FHH **–** Freie und Hansestadt Hamburg (2002): *Leitbild: Metropole Hamburg – Wachsende Stadt.* Hamburg.

Flesche, Felix, and Christoph Burchard (2005): *Water House.* Munich: Prestel.

Folke, Carl, Steve Carpenter, Thomas Elmqvist, Lance Gunderson, Crawford S. Holling, Brian Walker et al. (2002): *Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations.* Scientific Background Paper on Resilience for the process of the World Summit on Sustainable Development on behalf of the Environmental Advisory Council to the Swedish Government. http://www.intelligentcoast.es/downloads/1144440669_resilience_and_sustainable_development.pdf.

Füssel, Hans-Martin, and Richard J. T. Klein (2006): *Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking.* Climate Change 75, no. 3: 301-29.

Gill, Susannah, John Handley, Roland Ennos, and Stephan Pauleit (2007): *Adapting Cities for Climate Change: the Role of the Green Infrastructure.* Built Environment 33, no.1: 115-33.

Greiving, Stefan (2003): *Im Hochwasserschutz ist ein Umdenken von der Gefahrenabwehr zum Risikomanagement erforderlich.* In: *Flusslandschaften an Elbe und Rhein. Aspekte der Landschaftsanalyse, des Hochwasserschutzes und der Landschaftsgestaltung*, ed. Isolde Roch, 129-43. Berlin: WFV.

Gunderson, Lance H. (2000): *Ecological Resilience - In Theory and Application.* Annual Reviews of Ecology and Systematics 31: 425-39.

Gunderson, Lance H. (2003): *Adaptive dancing: interaction between social resilience and ecological crises.* In: *Navigating Social-ecological Systems. Building resilience for Complexity and Change*, ed. Fikret Berkes, Johan Colding, and Carl Folke, 33-52. Cambride: Cambridge University Press.

Handelskammer Hamburg (2004): *Leben und Arbeiten im Herzen Hamburgs - Die Entwicklungsperspektive der Elbinsel*. Hamburg.

Immink, Irene (2004): *Established and recent policy arrangements for river management in The Netherlands: an analysis of discourses.* In: *From Landscape Research to Landscape Planning. Aspects of Integration, Education and Application,* ed. Bärbel Tress, Gunther Tress, Gary Fry, and Paul Opdam, 387-404. Dordrecht: Springer.

IPCC - Intergovernmental Panel on Climate Change (2007): *Climate Change 2007 - The Physical Science Basis.* Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

Jolly, Adam (2008): *Managing Climate Risk: A practical guide for business.* London: Thorogood.

Kallmorgen, Werner (1968): *Schumacher und Hamburg - Eine fachliche Dokumentation.* Hamburg: Christians.

Knieling, Jörg, Mareike Schaerffer, and Stephan Tressl (2009): *Klimawandel und Raumplanung – Flächen- und Risikomanagement überschwemmungsgefährdeter Gebiete am Beispiel der Hamburger Elbinsel.* EUCC - The Coastal Union. Coastline Reports. Warnemünde. (to be released)

Kron, Wolfgang (2003): *Hochwasserrisiko und Überschwemmungsvorsorge in Flussauen.* In: *Raumorientiertes Risikomanagement in Technik und Umwelt. Katastrophenvorsorge durch Raumplanung*, ed. Helmut Karl, Jürgen Pohl, and Horst Zimmermann, 79-101. Forschungs- und Sitzungsberichte der Akademie für Raumforschung und Landesplanung 202. Hannover.

McGranahan, Gordon, Deborah Balk, and Bridget Anderson (2007): *The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones.* Environment and Urbanization 19, no. 1: 16-37.

Newman, Peter, Timothy Beatley, and Heather Boyer (2009): *Resilient cities. Responding to peak oil and climate change.* Washington, DC: Island Press.

Pasche, Erik, Gehad Ujeyl, Dagmar Goltermann, J. Meng, Edgar Nehlsen, and Markus Wilke (2008): *Cascading flood compartments with adaptive response.* In: *Flood Recovery, Innovation and Response*, ed. David Proverbs, Carlos Brebbia, and Edmund Penning-Roswell, 303-12. Southampton: WIT Press.

Plate, Erich (2003): *Neue Gedanken zum Hochwassermanagement.* In: *Das Elbe-Hochwasser. Eine neue Dimension der Naturkatastrophe?* ed. Erik Pasche Hamburger Wasserbau-Schriften 1. Hamburg. Arbeitsbereich Wasserbau, Technical University Hamburg-Harburg.

Resilience Alliance (2009): Key Concepts. Resilience. http://www.resalliance.org/576.php.

Schmitt, Theo G. (2011): *Risikomanagement statt Sicherheitsversprechen. Paradigmenwechsel auch im kommunalen Überflutungsschutz.* KA Korrespondenz Abasser, Abfall 58, no. 1: 40-49.

Schubert, Dirk, and Hans Harms (1993): *Wohnen am Hafen. Leben und Arbeiten an der Wasserkante. Stadtgeschichte - Gegenwart - Zukunft. Das Beispiel Hamburg.* Hamburg: VSA-Verlag.

Simons, Jacinte (2008): *Wie will waar waterwonen?* Waterwonen 1: 13-16.

Smit, Barry, and Johanna Wandel (2006): *Adaptation, adaptive capacity and vulnerability.* Global Environmental Change 16: 282-92.

Smit, Barry, Ian Burton, Richard J. T. Klein, and Johanna Wandel (2000): *An Anatomy of Adaptation to Climate Change and Variability.* Climatic Change 45: 223-51.

Veerbeek, William, Berry Gersonius, Chris Zevenbergen, Najib Pyan, M. M. M. Billah, and Rikko Fransen (2008): *Urban Flood Management Dordrecht.* Proceedings of Workpackage 3: Resilient Building and Planning. Rotterdam.

Waterstedenbouw (2007): *Bouwen met Water.* http://www.traverse.nl.sharepointsite.com/Traverse/Platforms/Leven%20met%20Water/Bouwen%20met%20Water/Waterstedenbouw.pdf .

Woth, Katja, Ralf Weisse, and Hans von Storch (2005): *Dynamical modelling of North Sea storm surge extremes under climate change conditions - an ensemble study.* Ocean Dynamics: 3-15.

Zevenbergen, Chris (2007): *Adapting to Change: Towards Flood Resilient Cities.* Inaugural Address of Chris Zevenbergen, Professor of Flood Resilience of Urban Systems at UNESCO-IHE Institute for Water Education in Delft. The Netherlands.

Legal Sources:

BauGB (Baugesetzbuch) (2006): Baugesetzbuch from 23.09.2004. BGBl. I: 2414. Changed by article 1 of the law from 21.12.2006. BGBl. I: 3316.

Jörg Knieling
Acquired a diploma and his PhD in urban- and regional planning and an MA in political sciences and sociology from the University of Hanover. From 1992 until 2001 he was managing director of a private planning and research agency (KoRiS); then he became member of the Office of the Senate of the Free and Hanseatic City of Hamburg. In 2003 he was appointed as Professor of Spatial Planning at Dresden Technical University and in 2004 moved to Technical University Hamburg-Harburg as Professor of Urban Planning and Regional Development. Since 2006 he has been member of the HafenCity University Hamburg (HCU). His main research fields are metropolitan development strategies, urban and regional governance, and spatial planning and climate change, exploring mitigation as well as adaptation strategies.

Mareike Schärffer
works for the Department of Urban Development and Environment of the Free and Hanseatic City of Hamburg. She achieved a diploma in environmental sciences from the University of Lüneburg. From 2006 until 2010 she worked as a researcher at the Technical University of Hamburg-Harburg and HafenCity University of Hamburg joining national and international projects on sustainable water management, flood risk management and climate change governance. Her main research fields are sustainable urban and regional development, planning processes in river catchment areas, climate change and governance. Her PhD thesis deals with citizen engagement in planning processes concerning flood protection.