Masterarbeit

ASSESSING COASTAL CITIES VULNERABILITY AND RESILIENCE IN THE FACE OF CLIMATE CHANGE

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ABSTRACT

In recent years we have become increasingly aware of the occurrence of climate change and the huge risks that climate change poses to cities. In particular a lot of cities are threatened by rising sea level, due to the fact many are situated next to the coast and their location heightens their exposure to the impacts of climate hazards. It is clear that, in order to reduce the risk and impact of these threats and to increase the safety and wellbeing of their residents, cities and their communities must be more resilient and prepared to address the threat.

Climate change, urbanisation, and related hazards are major challenges for scientists and planners and need to be dealt with. There is no doubt that planning systems are major factors in handling climate change related challenges. To prevent these problems and fatal impacts on cities it is indispensable to involve spatial planning in the adaptation process.

In order to cope with these increasing problems approaches were developed such as “vulnerability”, “adaptive capacity” and “resilience”. These concepts are important to support cities and other vulnerable regions to deal with climate change related impacts. Hence the thesis focuses on the terminology and methodologies of these concepts and develops a resilience assessment guideline. In addition the resilience of Rotterdam is assessed because the city is already adapting and planning in the context of climate change and is a valuable example to support the resilience assessment guideline.

In summary the thesis supports the understanding of climate change related topics and in particular contributes on the relevance of the “resilience” approach. Especially the developed framework represents a guideline for future planning to support safer city development and to face climate change related impacts and vulnerability. The evaluation of Rotterdam shows that vulnerable cities are able to adapt and be resilient but in addition it identifies the importance of the social factor in resilience planning. A city can’t be resilient without awareness and preparedness of the population.

ZUSAMMENFASSUNG

Klimawandel und die daraus folgenden Konsequenzen für Städte und Bevölkerung sind aufgrund der Ereignisse in den letzten Jahrzehnten nicht mehr zu leugnen. Vor allem Küstenstädte sind durch ihre Lage und die klimatisch bedingte Steigerung des Meeresspiegels extrem gefährdet. Daher ist es unumgänglich Lösungen zu finden, um Risiko und Gefährdung soweit es möglich ist zu reduzieren und dadurch die Sicherheit und das Wohlbefinden der Bevölkerung zu steigern. Das bedeutet Städte und Gemeinden müssen resistenter werden und vorbereitet sein, um der Gefahr zu begegnen.

Vor allem für Wissenschaft, Planung und Regierung stellen Klimawandel, Urbanisierung neue Herausforderungen dar welche mit Hilfe von Planungssystemen einen wichtigen Beitrag leisten können um den negativen Auswirkungen entgegenzuwirken. Dies macht es unumgänglich die Raumplanung in diese Anpassungsprozesse zu integrieren.

Um diese Probleme und Herausforderungen zu lösen und Städte und gefährdete Regionen zu unterstützen wurden wissenschaftliche Ansätze wie etwa „vulnerability“, „adaptive capacity“ und „resilience“ entwickelt. Diese Konzepte stellen die Grundlage der Arbeit dar und werden anhand von Definitionen und Modellen genauer erläutert. Aufbauend auf den theoretischen Teil wurde ein Leitfaden zur Bewertung von resilienten Städten entwickelt.

Kurz gefasst, die Diplomarbeit umfasst die Bedeutung und das Verständnis von Klimawandel und leistet einen Beitrag zum Thema „resilience“. Vor allem die entwickelte Grundstruktur für Bewertung von Resilienz bildet einen wichtigen Beitrag für zukünftige Planungen und unterstützt eine sichere Entwicklung von Städten. Die Analyse der Stadt Rotterdam verdeutlicht dies und zeigt dass verwundbare Städte in der Lage sind sich anzupassen und sogar resilient zu werden. Andererseits wird auch sichtbar dass Städte nur resilient werden können wenn alle Faktoren mit einbezogen werden, vor allem dem sozialen Aspekt muss mehr Beachtung geschenkt werden.

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CONTENTS

INTRODUCTION

Relevance of the topic

In recent years we have become increasingly aware of the occurrence of climate change and the huge risks that climate change poses to cities.

There is also a wide controversial discussion if human behaviour causes these changes or shifts in the global climate. Nevertheless, in the last 20 years global scientists and the general public noticed worldwide alterations in physical and biological systems, such as the increase of Earth's average surface and ocean temperature and most scientists are convinced that these changes are connected and the earth climate is affected by emissions of greenhouse gases (Houghton et al. 2001: 944pp; IPCC 2001a; IPCC 2011).

Overall the IPCC monitored, from the First Assessment Report published in 1990 to the last one published in 2011, that climate change is happening. Notably shifts in temperature and climate variability, greater numbers of extreme events, the destruction of ecosystems and biodiversity and changes in sea level are visible (2011). Furthermore, in recent reports, the IPCC focuses on "*How severe will the changes be?" and "How can societies both mitigate change and build adaptive capacity*" (IPCC 2007).

The most significant problem caused by climate change, as mentioned before, is the sea level rise (Barth and Titus 1984: 325pp, Broadus et al. 1986: 165pp). In the past the IPCC evaluated that "*the global average sea level has risen since 1961 at an average rate of 1.8 mm/yr and since 1993 at 3.1 mm/yr* "(IPCC 2011).

Along with climate change urbanisation is another worldwide challenge. Over the 20th and continuing over the 21st century, human population tend to move from rural to urban areas and the phenomenon of urbanisation will continue. Furthermore scientists at the World Conference on Natural Disaster Reduction in Yokohama noted that "*large-scale urban concentrations are particularly fragile because of their complexity and the accumulation of population and infrastructures"* (El Sabh 1994, in: Cross 2001: 63). In addition more than ¾ of the hundred largest cities are exposed to a minimum of one natural hazard and most are situated in low and middle income nations especially in Asia and Latin America (Sherbinin et al. 2007: 10pp)

In particular a lot of cities are threatened by rising sea level, due to the fact they are situated next to the coast and their location heightens their exposure to the impacts of climate hazards. It is obvious that, in order to reduce the risk and impact of these threats and to increase the safety and wellbeing of their residents, cities and communities must be more resilient and prepared to address the threat.

All before explained challenges and problems influence the future of spatial planning too, due to the fact that spatial planning is responsible for a sustainable and secure development, to improve quality of life. In addition it needs to understand and include all potential changes and problems of the 21st century.

Climate change, urbanisation, and related hazards are major challenges for scientists and planners need to be dealt with.

There is no doubt that planning systems are major factors in handling climate change related challenges and to prevent these problems and fatal impacts on cities it is indispensable to involve spatial planning in the adaptation process. In more detail concepts such as resilience need to be analysed and integrated in planning (Davoudi 2009: 6pp)

However, until today only a few cities incorporated adaptation issues in their local development strategies (Heinrichs et al. 2009: 2; Satterthwaite et al. 2009: 30). While adaptation must be high on the urban agenda, it might not be clear how this should best be done. Cities are confronted with the task to utilise the potential and advantages in their concentration of population and economic capacity. The challenge is that properly managed urban areas can reduce the risks of extreme weather events for the population, but a poor management can as well increase such risks (Ricardo 2008:18, Dodman 2009:2).

In order to cope with these increasing problems approaches were developed such as “vulnerability”, “adaptive capacity” and “resilience”. These concepts are important to support cities and other vulnerable regions to deal with climate change related impacts. But due to the variations of these concepts, based on fact that scholars with diverse knowledge domains and backgrounds are researching, no overall vulnerability and resilience concept exists that can be used to assess the resilience of coastal cities in the face of climate change.

Hence this thesis focuses on the terminology and methodologies of these concepts and develops a resilience assessment guideline. In addition the resilience of Rotterdam is assessed because the city is already adapting and planning in the context of climate change and it is a valuable example to support the resilience assessment guideline.

Aim of the study, research question and methodology

The objective of this thesis is to contribute to the current debate on climate change related vulnerability, resilience and adaptation because climate change, urbanisation, and related hazards are major challenges for planners. Hence it is important to understand all approaches to deal with vulnerability in the face of climate change and concepts of adapting and being resilient.

In summary the ambition of thesis is to develop a resilience assessment framework or guideline to support future planning in the face of climate change.

Thus, the research questions are:

1. Are there approaches and concepts dealing with vulnerability and resilience of coastal cities in the face of climate change?
2. How can coastal cities resilience, in context of climate change, be assessed?
3. What are the main factors of resilience assessment?

In order to answer these questions and to attain the aim of the paper the thesis is based on information obtained from literature review and the content of the case study Rotterdam is supported by data available in journals, articles and documents of municipality and government.

The thesis is divided into seven main chapters and particularly the chapters three and four are answering the first research question. Whereas the fourth, fifth and sixth chapter answer the other two questions.

Following, all chapters and contents are explained in detail.

The first chapter “Theoretical Background” covers a theoretical overview of relevant topics and challenges in the context of vulnerability, resilience, climate change and coastal cities. It should emphasize the importance of the research question of this thesis.

At the beginning an explanation of climate change and relevant impacts, such as changes in temperature, extreme weather events and sea level rise is given. Then the relevance of cities and urbanisation, with an accentuation on population and economic concentration, are outlined. Furthermore a focus is on coastal cities because they are highly exposed and at the end climate change and coastal cities are explained in context of hazard and vulnerability. After all the importance and challenges of spatial planning in the face of climate change are mentioned.

The second chapter “Context and Terminology” gives the reader an overview on the context of vulnerability and resilience. At the beginning the term adaptation is discussed associated with spatial planning in the face of climate change related impacts. Furthermore the chapter gives a summary of the term “vulnerability” as an overall concept and short information about vulnerability in context of climate change. In addition and to explain most important different approaches a review about often used definitions in relationship with vulnerability is stated. At the end of this chapter the term and approach of “resilience” is explained and discussed in the same manner as vulnerability.

In the scientific environment of vulnerability and resilience research, many different definitions, concepts, and terms exist hence this chapter should be used as an introduction and explanation of the topic of the thesis and not to give an all-embracing overview.

The third chapter “Conceptualizing Vulnerability” describes the concept of vulnerability and the first part gives an overview and classification of theoretical streams of vulnerability by grouping the most important studies and approaches. Furthermore aspects of assessment and measurement techniques of vulnerability are explained relevant to realize the wide range of techniques and approaches. Finally a selection of vulnerability assessment frameworks - concepts, from a social science to a hazard and disaster point of view, are represented and explained.

The whole chapter of vulnerability is important to support the approach of resilience because understanding the concept of vulnerability is the baseline for understanding the concept of resilience.

The fourth chapter “Conceptualizing Resilience” explains the concept of resilience and the first part gives an overview and classification of theoretical streams of resilience by grouping the most important studies and approaches. Furthermore aspects of assessment and measurement techniques of resilience are explained relevant to realize the wide range of techniques and approaches. Finally some resilience assessment frameworks are represented and explained and in the end the author gives a summary of main resilience characteristics. In addition resilience in context of spatial planning is discussed.

The fifth chapter “Guideline for Coastal City Resilience Assessment” is based on the chapters before and the different theoretical and methodological approaches of resilience. It explains the developed “guideline for resilience assessment”, its key elements and benchmarks and the importance of resilience assessment in urban planning is discussed..

The last chapter “Case Study – Rotterdam” supports the resilience assessment guideline by analysing the resilience of the city of Rotterdam.

The author decided to choose a city that is already adapting and planning for resilience to illustrate how the resilience framework can be applied. Due to the fact that Rotterdam is already adapting and planning for resilience, the city is chosen to illustrate the factors and benchmarks of the resilience framework.

At the beginning of the last chapter an overview of relevant facts and figures of the case study city, Rotterdam is given. In addition essential information about the country, the Netherlands, in the context of climate change adaptation and resilience planning, and at the end, according to the resilience framework and benchmarks, a possibility of a resilience assessment of Rotterdam is illustrated and explained.

1 THEORETICAL BACKGROUND

The first chapter covers a theoretical overview of relevant topics and challenges in the context of vulnerability, resilience, climate change and coastal cities. It should emphasize the importance of the research question of this thesis.

At the beginning an explanation of climate change and relevant impacts, such as changes in temperature, extreme weather events and sea level rise is given. Then the relevance of cities and urbanisation, with an accentuation on population and economic concentration, are outlined. Furthermore a focus is on coastal cities because they are highly exposed. At the end climate change and coastal cities are explained in context of hazard and vulnerability. After all the importance and challenges of spatial planning in the face of climate change are mentioned.

1.1 CLIMATE CHANGE

In recent years the term “climate change” was and is extremely fashionable, and of growing interest worldwide and this will continue, due to the particular relevance.

Translating climate change literally stands for a neutral definition and simply means a slight shift in climate that naturally changes (Birkmann et al. 2012: 1). In addition the term climate is understood as the average weather condition over a period of years, based on sunlight, distance from oceans, and altitude. Furthermore it is also natural and possible that climate can vary with the season and around the world (Dessler & Parson 2006: 1-9; NCAR 2011).

Whereas the Oxford Dictionary explains climate change as “*a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.*” This definition is based on findings in the 20th century and explains that due to burning fossil fuels the concentration of greenhouse gas is increasing significantly, while simultaneously an increase in global temperatures can be observed (Houghton et al. 2001: 944pp).

In addition there is a wide controversial discussion if human behaviour causes these changes or shifts in the global climate. Nevertheless, in the last 20 years global scientists and the general public noticed worldwide alterations in physical and biological systems, such as the increase of Earth’s average surface and ocean temperature and most scientists are convinced that these changes are connected and that the earth climate is affected by emissions of greenhouse gases (Houghton et al. 2001: 944pp; Dessler & Parson 2006: 1-9; IPCC 2001a; IPCC 2011).

To reach a consensus on the topic of climate change in 1988 the United Nations Environment Programme and the World Meteorological Organization established the Intergovernmental Panel on Climate Change (IPCC). The IPCC is composed of thousands of the world’s leading scientists from across 194 nations and it assesses reports, published every five years, on the current state of knowledge, on climate change and related impacts (IPCC 2011).

As an overall definition the IPCC states that "*Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use"* (IPCC 2011).

Notwithstanding the explanation of the UNFCCC (United Framework Convention on Climate Change) is slightly different and distinguishes between climate change caused by human behaviour and climate variability due to natural causes: *"Climate change is a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods"* (UNFCC 1992: Art. 1.2).

The UNFCCC was established in 1992 when countries joined the international treaty to limit average global temperature increase, the subsequent climate change and to cope with its impacts. The convention is composed of 195 parties and known for its protocols on emission reduction targets, such as the Kyoto-Protocol, and its conferences and summits around the world, such as Durban, Cancun and Copenhagen. The main intention of the UNFCCC is to "*to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner*" (UNFCC 1992: Art.2.1).

Overall the IPCC monitored, from the First Assessment Report published in 1990 to the last one published in 2011, that climate change is happening. Notably shifts in temperature and climate variability, greater numbers of extreme events, the destruction of ecosystems and biodiversity and changes in sea level are visible (2011).

Furthermore, in recent reports, the IPCC focuses on "*How severe will the changes be?*" and "*How can societies both mitigate change and build adaptive capacity"* (IPCC 2007). As a consequence scientists developed global climate models that describe the functioning of the earth system and are able to develop scenarios how the system would react in the future to greenhouse gases, deforestation and other changes caused by humans. Due to the complexity of these models they are based on assumptions but they are developing and are getting more precise during years of research (NCAR 2011). For example based on these models it is estimated that the frequency of heat waves, extreme weather events and sea level will increase globally (IPCC 2011). Furthermore future climate change estimations predict deviations across geo-graphical regions, several sectors and impacts on agriculture, fisheries, desertification, biodiversity, water resources, heat and cold related mortality, coastal zones and floods (IPCC 2007b). Although some impacts are positive, for example water-scarce regions may benefit from increased water availability, most of climate change related effects endanger people worldwide (IPCC 2001).

The following subsections specify the observed evidence and projected scenarios, most important for this research, by the IPCC.

Temperature

Results of IPCC assessment reports indicate an increase in the global average temperature. It is irreversible that over the last 100 years the global mean annual temperature increased by approximate 6℃. The cause of such warming can be traced back to an increase of atmospheric emissions of greenhouse gases. At the beginning the IPCC described it as "*likely*" that GHGs are responsible for temperature rises over the last 50 years but in more recent reports as "*very likely*" (IPCC 2001; 2007a). Best case scenarios, by the IPCC, estimate by 2100 "*a [temperature] rise of 1.8 to 4℃ with a likely range of 1.1 — 6.4℃ in relation to 1990"* (IPCC 2007a). As an example, the expected temperature rise of Bay of Bengal, that is part of the Indian Ocean region, is estimated by a low of 1.8° Celsius to a possible high of 4.0℃elsius by 2050 (IPCC 2007a).

Extreme weather events

Climate change is being more and more discussed in terms of extreme weather events, especially the increase of frequency, intensity and patterns of weather events, like periods of storm surges, wind intensities, waves and tropical cyclones (Houghton et al 2001: 944pp, Klein 2002: 10, Church et al 2010: 9-22). As mentioned before the IPCC indicates that climate change is happening and the evidence on the major causes of the change in climate increased in the last years. In addition, as reported by IPCC AR4, it is "*very likely*" that "*hot extremes, heat waves and heavy precipitation events* "will become more frequent in the future. For example the intensity of tropical cyclones is predicted to be between 10 to 20 % (IPCC 2001, IPCC 2007a). Summing up the following table shows the observed and projected changes in extreme weather and climate events summarized by the IPCC in their latest assessment report.

Table 1: Observed and projected change in extreme weather & climate events by AR4 of IPCC

OBSERVED AND PROJECTED CHANGE IN EXTREME WEATHER & CLIMATE EVENTS BY AR4 OF IPCC		
Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century	Likelihood of future trends (projections for 21st century)
Warmer and fewer cold days and nights over most land areas	Very likely	Virtually certain
Warmer and more frequent hot days and nights over most land areas	Very likely	Virtually certain
Warm spells/heat waves. Frequency increase over most land areas	Likely	Very likely
Heavy precipitation events (or proportion of total rainfall from heavy rainfalls) increase over most areas	Likely	Very likely
Areas affected by droughts increases	Likely in many regions since 1970s	Likely
Intense tropical cyclone activity increase	Likely in many regions since 1970s	Likely
Increases incidence of extreme high sea levels (excluding Tsunami)	Likely	Likely

Source: (IPCC 2007)

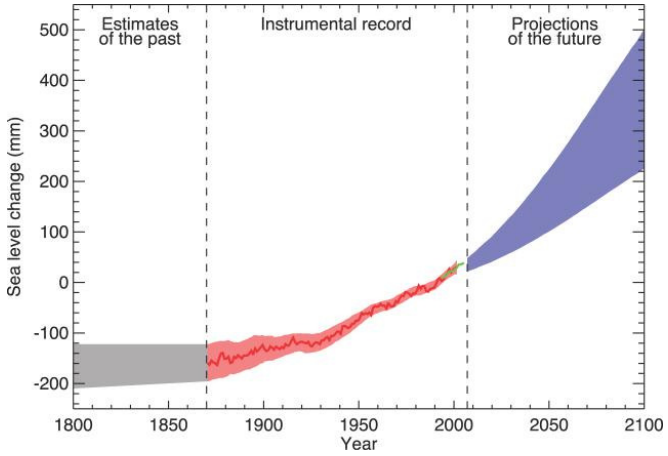
Sea level rise

The most significant problem, especially for cities, caused by climate change, as mentioned before, is the sea level rise (Barth and Titus 1984: 325pp, Broadus et al. 1986: 165pp). In past the IPCC evaluated that "the *global average sea level has risen since 1961 at an average rate of 1.8 mm/yr and since 1993 at 3.1 mm/yr "(*IPCC 2011). Furthermore in its 2nd assessment report, the IPCC estimated a global mean sea level rise from 1990 to 2100 to between 23 and 96 cm, in its most recent reports a rise to between 9 and 88 cm and in the 4th assessment report an estimated sea level rise at up to 0.6 meters or more by 2100 (IPCC 2001, 2007a).

In comparison researchers at the Hadley Centre for Climate Prediction and Research, projected a global average sea level rise between 0.10 m and 0.15 m by 2030, 0.18 m and 0.30 m by 2050 and 0.41 m and 0.88 m by 2100 (Hemming et al 2007, in: Oliver-Smith 2009: 18).

The following figure shows the past and present global mean sea level and the projections for the 21st century (IPCC 2007a).

Figure 1: Past, present and future global mean sea level



Source: (IPCC 2007a)

Different assessments of sea level rise are based on varying forecast methods and models, and by calibrating and estimating factors causing sea level rise (Nicholls 2002: 1455pp). For example these factors include ocean thermal expansion, the melting of glaciers and ice caps, changes in terrestrial water storage and they are also depending on projections about future greenhouse gas emissions. Most significant are studies on glaciological changes in Greenland and Antarctica that lead to higher estimations of sea level rise than a research of the IPCC in 2001 (Hemming et al. 2007). Furthermore regional differences in sea level rise have to be considered too (Bosello et al. 2012: 63-64).

Although there is a big discussion on quantifying this issue scientists agree on the evidence that global long term sea level is expected to continue rising faster than expected (Nicholls 2002: 1455pp; Church et al 2001: 9pp, Hemming et al 2007, in: Oliver-Smith 2009: 17pp; IPCC 2007a).

In context of sea level rise it is important to distinguish between two main terms: "*Eustatic sea level"* can be defined as a measure *"[...] between the sea surface at any given time and a fixed datum, normally the centre of the Earth. Eustatic sea-level changes occur because of changes in the volume of the ocean basins [...] or because of variations in the volume of the ocean water*" (Slatt 2006 :383).

In contras relative sea level is "*the distance or depth between the sea surface and a local moving datum, such as basement or as surface within a submarine sediment accumulation. Relative sea level may change as a result of tectonic subsidence or uplift of a basement datum, subsidence of a datum within the sediment accumulation due to compaction, or vertical eustatic movements of the sea surface".* (Slatt 2006 :383)

In other words when the term "*relative*" is used, it means a change relative to a fixed point in the sediment pile. The term "*eustatic*" refers to global changes in sea level relative to a fixed point, such as the centre of the earth, for example as a result of melting ice-caps. Most of impact researchers are concentrating on relative sea level rise and in contrast climate model estimation researchers focus on eustatic sea level change (IPCC 2001)

Particularly the Intergovernmental Panel on Climate Change estimates a rise in global-mean sea-level in the next century due to greenhouse gas emissions and they agree that this could have especially impacts on population in low-elevation coastal zones, port cities and river deltas (IPCC 2001; McGranahan 2007: 17-37).

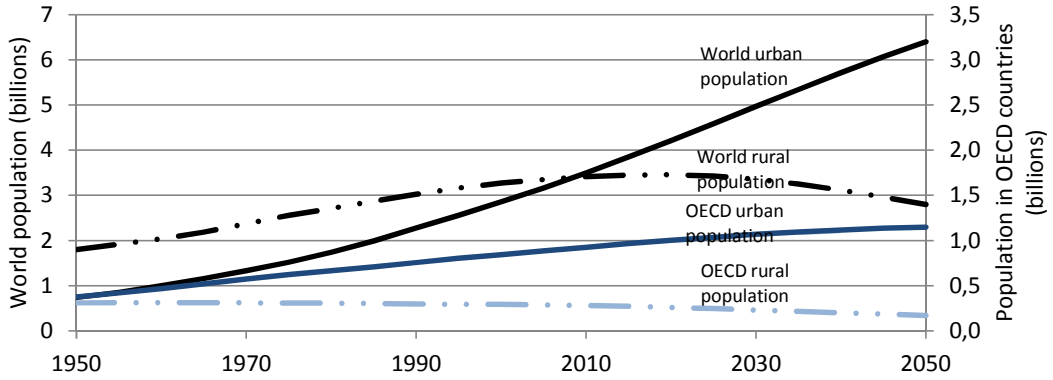
1.2 CITIES/URBANISATION

Along with climate change urbanisation is another worldwide challenge. Over the 20th and continuing over the 21st century, human population tend to move from rural to urban areas and the phenomenon of urbanisation will continue. There are a lot of factors influencing the future of cities, for example the growth of population and economic concentration. These challenges need to be kept in mind when analysing vulnerability or resilience of a city. Furthermore the location, such as cities at the coast, can increase risk and exposure of urban centres.

Growth of population

According to a United Nations research a side effect of urbanisation is a decline in rural population, after 2020. The following figure shows a projected population around 8 billion by 2025 and 9.3 billion by 2025. Further by 2050 70 per cent of the worldwide population will be urban. Another important fact is that urbanisation in the OECD countries is still ongoing but in the last years a second wave is appearing in the less developed regions. Now around 44 per cent of the population of the less developed regions live in urban areas and the growth rates are projected to double those of OECD countries between 2005 and 2030. Additionally the population in megacities (urban centres with more than 10 million people) will rise from 19 to 27 per cent in 2025 (OECD 2006: 36).

Figure 2: Urban and rural population in the world and the OECD



Source: OECD 2010:36; own figure

Economic Concentration

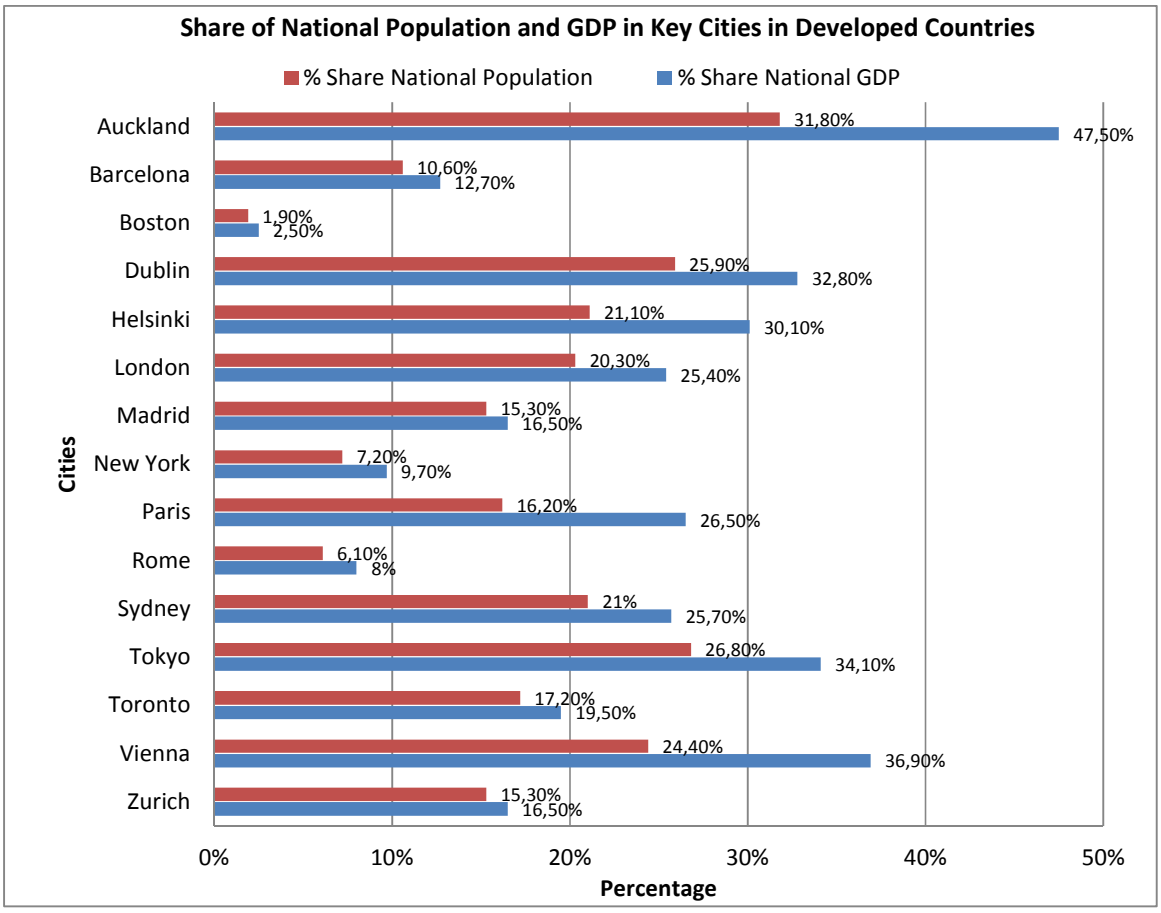
Urban areas are not only important because of their huge population, in addition urbanisation has brought huge opportunities to the cities. At the moment about half of the world's population live in cities due to the fact that urban areas have a high concentration of social, cultural, economic, technological and political activities. As a consequence cities centre a lot of opportunities for their population, for example knowledge, innovation, specialization, production and services. In addition urban centres can benefit from natural advantages as a result of their unique location such as coastal cities (OECD 2007: 5-10; Sherbinin et al. 2007: 39pp).

Closely linked with population density and urbanisation is the economic concentration. Especially, regarded in OECD countries, the higher the population the higher the per capita GDP or in more detail "*one single metropolitan area produces one-third (e.g. Oslo, Auckland, Prague, Tokyo, Stockholm, London, Paris) to one-half (e.g. Budapest, Seoul, Copenhagen, Dublin, Helsinki, Brussels) of the national GDP" (OECD 2010: 44).* At the moment more than 80 per cent of the GDP worldwide is being generated by cities, also for national economies cities play a major role. They generate a higher rate of economic growth than rural areas. In 2009 the most economically important cities were: Tokyo, New York, Los Angeles, London, Paris, Chicago, Osaka, Mexico, Washington DC and San Francisco. All these cities produced from San Francisco 374.5 billion USD to Tokyo 2.99 trillion USD (UN-Habitat 2011: 16 p)

Another important indicator is the concentration of international headquarters in cities. For example Tokyo inhabits 17 of the top 100 worldwide multinational corporations. By 1980 60 to 70 per cent of world share of the financial market were based in only 3 cities (New York, London, Tokyo). However in 10 years the most important financial cities will be New York, London, Shanghai, Beijing and Mumbai (OECD 2007: 5-10; Sherbinin et al. 2007: 39pp).

The following two figures illustrate the share of national population and GDP in key cities in developed and developing countries. For example London with 20.3 per cent of the national population produced 25.4 per cent of national GDP and Auckland, Vienna and Helsinki generate more than 50 per cent higher of GDP than their population share.

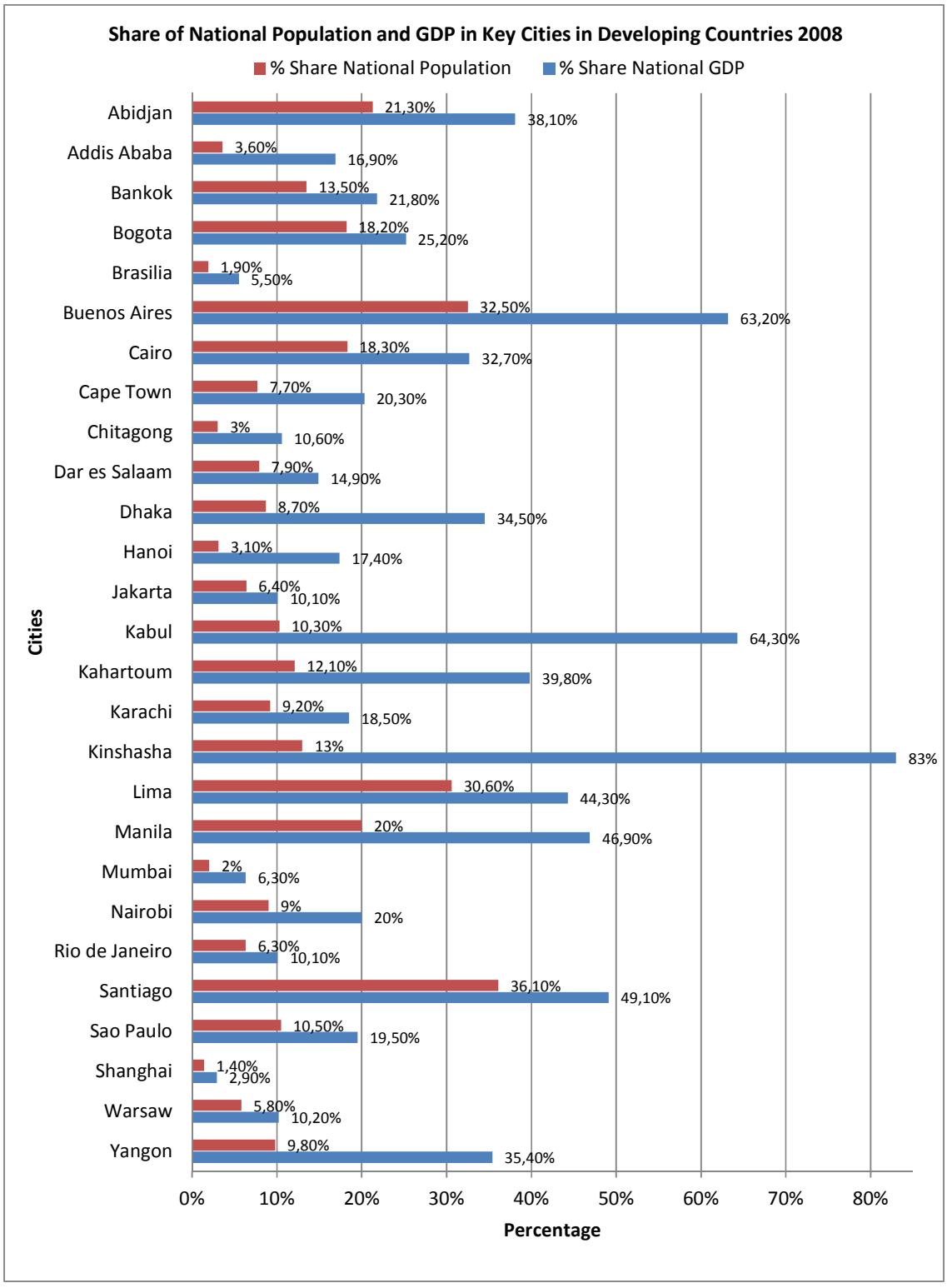
Figure 3: Share of national population and GDP in key cities in developed countries



Source: UN-Habitat 2011: 9, own figure

In comparison the importance of contribution to economy of cities in developing countries is much more visible. For example Hanoi, Kinshasa and Kabul produces more than 400 per cent higher GDP than its population share.

Figure 4: Share of national population and GDP in key cities in developing countries 2008



Source: UN-Habitat 2011: 9, own figure

By 2025 there will be a shift to the so-called developing countries and then cities with the highest GDP growth rate will be in countries such as China, United States, India, Brazil and Mexico.

Cities of particular importance: Coastal cities

Many cities are situated next to the coast, for example New York, Shanghai, Barcelona, Mumbai, Lagos, Copenhagen and Lisbon. The attraction of coastal areas for human beings has a long history especially by the reason of the significance of living next to the sea for resources and trading. This is also a factor why most human settlements are historically placed within 100 miles of coasts (Church, 2010: 16-19; Klein 2002: 1-23; Small & Nicholls, 2003: 591-592; Turner et al. 1996: 4-12).

Furthermore coastal zones provide a diversity of goods and services crucial to humans, especially of economic advantages and in addition coasts inhabit a variety of ecosystems, like coral reefs, mangroves, beaches and wetlands. Subsequently settlements in coastal areas are expanding since the beginning of the 20th century due to the fact that people focus more on the positive effects such as transportation. Hence urbanisation next to the sea is growing around the world due to globalisation, economic importance and environmental advantages of coastal areas. These facts can be supported by some figures: Already in 1990, 23 per cent of worldwide population lived nearest 100 km to the coast, in 2000 Nicholls and Small estimated coastal population at 37 per cent and for 2030 30 per cent. More precisely, between 2010 and 2015 20 out of 33 cities with a population more than 8 million people will be coastal (ibid.).

1.3 COASTAL CITIES, CLIMATE CHANGE AND HAZARD

However rapid urbanisation, increased population, essential economic assets and unique locations, such as coastal areas, are not only benefits for cities. Scientists at the World Conference on Natural Disaster Reduction in Yokohama noted that "l*arge-scale urban concentrations are particularly fragile because of their complexity and the accumulation of population and infrastructures*" (El Sabh 1994, in: Cross 2001: 63).

In addition more than ¾ of the hundred largest cities are exposed to a minimum of one natural hazard and most are situated in low and middle income nations, particularly in Asia and Latin America (Sherbinin et al. 2007: 10pp)

Although cities were familiar with natural hazards for quite some time, such as earthquakes, tsunamis, hurricanes and flooding, climate change puts cities at new kinds of risk (World Bank Group 2010; Romero 2010). Especially cities located near the coast in addition to climate change related events, such as sea level rise, floods and heat waves, are expected to increase their hazard potential. (Sherbin 2007: 10pp; Cross 2001: 63pp; Klein et al, 2003: 36 pp)

Recent IPCC working papers summarize most vulnerable settlements as "*those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring* "(IPCC 2007).

Estimated Climate change related impacts

As coastal systems are dynamic and complex they react in diverse ways to weather related events (Balica et al. 2012). Nicholls discovered the most important impacts on natural systems of coastal zones as: "*more frequent coastal inundation, ecosystem change, such as salt marsh and mangrove loss, increased erosion of beaches and soft cliffs, and salinisation of surface and ground waters*" (IPCC 2007). All these factors are able to remove the natural defences of coastal communities (Bosello et al. 2012: 63-67; Cronin 2010: 11; IPCC, 2007).

Furthermore impacts such as "*geomorphic changes (...) altered hydrology, habitat and species change, changes in water temperature and chemistry, changes in air temperature and chemistry, impacts on human economy and health, infrastructure, land use changes, variable risk, and ultimately inundation of land and communities*" are able to occur (Beever 2009, in UNO University 2009: 19).

In the 1990s studies had been carried out on the implications of **sea level rise** on local, national and regional scales of coastal countries. In the 2nd assessment report of the IPCC Bijlsma et al. (1996: 289pp) identified the vulnerability of coastal areas as a fact of different consequences of sea level rise (IPCC, 2001).

As already explained for different regions global absolute sea level is not as important as relative sea level because it is observed locally and considers regional variations and movements of the land. (Klein 2002: 10).

According to Hemming et al 2007 by 2030 the eastern United States, the Gulf of Mexico, the southern tip of South America, the Falkland Islands, and the Netherlands will be affected by the largest relative sea level rise, as well as the deltas of large rivers, such as the Mississippi, Rio Grande, Rhone, Nile, Brahmaputra, Euphrates/Tigris and the Niger. In correlation with the exposure of population and sea level rise South and Southeast Asia, especially Bangladesh, India, Pakistan, eastern China and southern Indonesia will be most vulnerable (Hemming et al. 2007, In: Oliver-Smith Anthony 2009: 19pp).

In addition all areas below 10 m elevation, also called **low-elevation coastal zones (LECZ),** are particularly at risk. The following table shows that small island states have the highest percentages of land area in the LECZ. Furthermore most of the population in LECZ can be found in Asian countries. Compared to the share of population most affected countries are smaller ones like Bahamas, Suriname and the Netherlands (McGrahan et al. 2007: 21pp; Church, 2008: 10pp).

Table 2: Ranking of countries with largest population counts and shares in the LECZ, 2000

Ranking of countries with largest population counts and shares in the Low Elevation Coastal Zone (LECZ), 2000								
	RANKED BY TOTAL POPULATION IN THE LECZ				RANKED BY SHARE OF POPULATION IN THE LECZ			
			POPULATION IN LECZ				POPULATION IN LECZ	
Top 10	Country	Overall rank*	Counts ('000)	%	Country	Overall rank**	Counts ('000)	%
1	China	1	143,880	11	Bahamas	174	267	88
2	India	2	63,188	6	Suriname	170	318	76
3	Bangladesh	8	62,524	46	Netherlands	59	11,717	74
4	Vietnam	13	43,051	55	Vietnam	13	43,051	55
5	Indonesia	4	41,610	20	Guyana	157	415	55
6	Japan	9	30,477	24	Bangladesh	8	62,524	46
7	Egypt	16	25,655	38	Djibouti	160	289	41
8	USA	3	22,859	8	Belize	179	91	40
9	Thailand	19	16,478	26	Egypt	16	25,695	38
10	Philippines	14	13,329	18	The Gambia	150	494	38
* Refers to overall rank in total population ** Countries with a total population of under 100,000, or smaller than 1,000 km2 were excluded from this list.								

Source: (McGranahan et al 2007:24; own figure)

Exposure of coastal cities

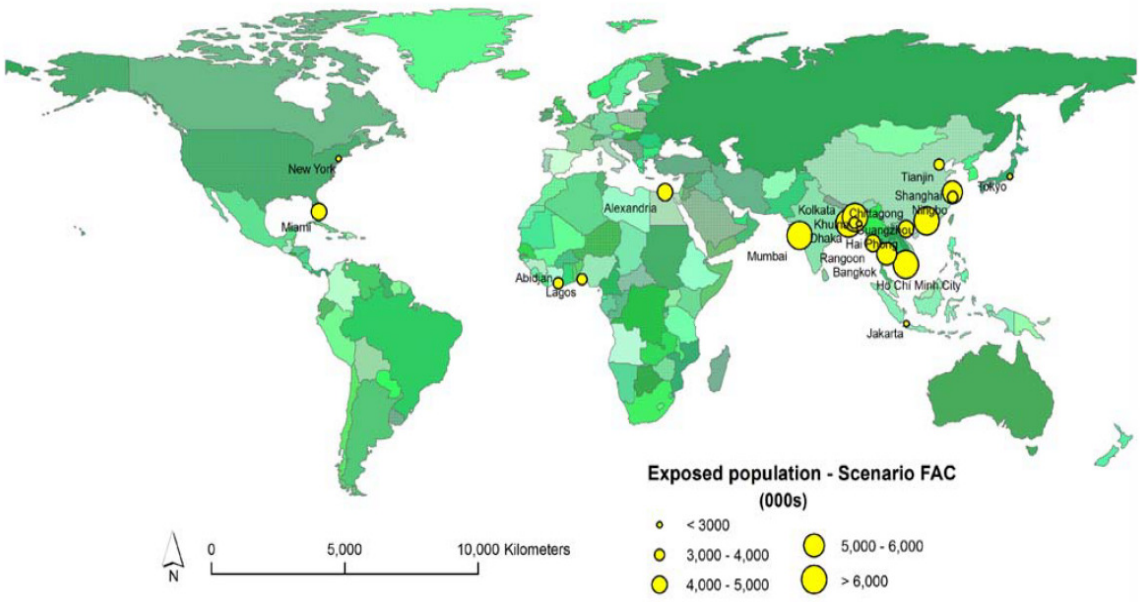
Particularly people's exposure to coastal flooding hazards mainly depends on variations of: *"flood levels, human exposure to flooding and the standard of flood management infrastructure"* (Nicholls 2004: 70). Therefore settlements and infrastructure such as ports, harbours, industry and built environment are at risk (World Bank Group 2010: 4 pp; Klein 2002: 2 pp; Small & Nicholls 2003: 585 pp).

According to Pelling (2011: 38) 5 factors influencing the vulnerability of coastal cities to flooding such as "*low elevation, topography, land use, sea/land breeze and population density*".

To compare exposures of coastal cities in different terms the OECD (Hallegatte et al 2008) conducted a study about population and assets exposure of port cities to coastal flooding.

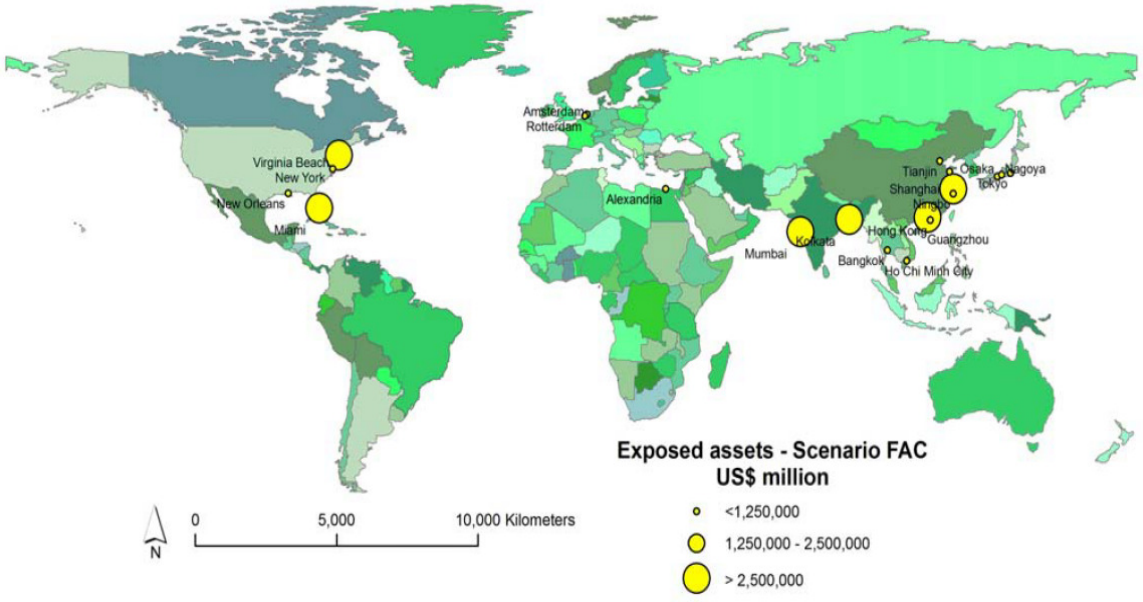
According to the study, and illustrated in the following figure, present cities most exposed to coastal flooding BY POPULATION are: Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Kolkata, Greater New York, Osaka-Kobe, Alexandria and New Orleans. Estimated figures by 2070, including environmental and socioeconomic factors, show a shift to Asia and the developing countries and the future exposed cities will be: Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon, Miami and Hai Phòng.

Figure 5: Top 20 cities for EXPOSED POPULATION under future climate change and socioeconomic change scenario



Source: OECD 2008: 7

Figure 6: Top 20 cities for EXPOSED ASSETS under future climate change and socioeconomic change scenario



Source: OECD 2008: 8

In contrast analysing in terms OF ASSETS, as illustrated in the second figure, most vulnerable cities are: Miami, Greater New York, New Orleans, Osaka-Kobe, Tokyo, Amsterdam, Rotterdam, Nagoya, Tampa-St Petersburg and Virginia Beach and these ten cities inhabit 60 % of the total exposure. At a closer look these cities, expect from St Petersburg, are all located in 3 countries: USA, Japan and the Netherlands.

In 2005 5 % of the global GDP, around US $ 3,000 billion, was generated in coastal cities and therefore exposed to climate change. In comparison the distribution of all assets in 2070 is considered to reach US $ 35,000 billion and will be situated in the following ten cities: Miami, Guangdong, Greater New York, Kolkata, Shanghai, Mumbai, Tianjin, Tokyo, Hong Kong, and Bangkok (Hallegatte et al 2008: 8-9).

Overall it is obvious that particularly cities in Asia, like in China, India and Thailand will become more exposed, in terms of population and assets, in the future and additionally a lot of smaller cities too (Hallegatte et al 2008).

1.4 SPATIAL PLANNING AND CLIMATE CHANGE

All before explained challenges and problems influence the future of spatial planning too. Due to the fact that spatial planning is responsible for a sustainable and secure development, to improve quality of life, it needs to understand and include all potential changes and problems of the 21st century. Climate change, urbanisation, and related hazards are major challenges for scientists and planners need to be dealt with. In the chapter before an overview of some climate change related impacts and in addition mentions exposure of coastal cities is already given (United Nations 2008: 17).

Even though spatial planning is different in most countries it *"is concerned with identifying long- or medium-term objectives and strategies for territories, dealing with land use and physical development as a distinct sector of government activity, and coordinating sectoral policies such as transport, agriculture and environment"* (Koresawa and Konvitz 2001, in: United Nations, 2008: 1).

There is no doubt that planning systems are major participants in handling climate change related challenges. However, the impact of spatial planning in tackling climate change depends on the definition of planning, the availability of tools, and resources, structure, level and types of interventions. Due to the various demographic and environmental impacts spatial planning need to be revised, changed, and renewed, as not all current planning approaches are able to deal with these emerging problems (Davoudi 2009: 6pp ;United Nations 2008: 1pp).

Already over the past decade policies in context with climate change have grown and in particular planning changed from promoting climate protection to more active planning policies. Especially in the areas of energy supply, energy demand and adaptation planners developed several approaches and policies (Davoudi 2009: 7pp).

However a major concern is that, according to an OECD report, most countries concentrate on greenhouse gas emissions and mitigation problems rather than on adaptation and resilience in the context of climate change to reduce impacts. Furthermore national authorities focus more on assessment of future climate changes scenarios and impacts and there is less focus on plans and actions (Davoudi 2009; United Nations 2008).

In context with potential risks and hazards planners need to have "*a sense of ownership of risk reduction*", and they also need to communicate "*between them and other professionals, and hence to encourage more work on risk reduction, that links the structural/physical with environmental, socio-economic, institutional and political aspects*." (Wamsler 2006: 161).

"It is [...] no longer a question of whether to mitigate climate change or to adapt to it. Both adaptation and mitigation are now essential in reducing the expected impacts of climate change on humans and their environment" (IPPC 2007: 748).

In summary to prevent climate change related problems and fatal impacts on cities it is indispensable to involve spatial planning in the adaptation process. In more detail concepts such as vulnerability and resilience need to be analysed and integrated in planning research and reality.

2 CONTEXT AND TERMINOLOGY

This chapter gives the reader an overview of the context of vulnerability and resilience. At the beginning the term adaptation is discussed associated with spatial planning in the face of climate change related impacts. Furthermore the chapter gives a summary of the term "vulnerability" as an overall concept and short information about vulnerability in context of climate change. In addition and to explain most important different approaches a review about often used definitions in relationship with vulnerability is stated. In the second part the term and approach of "resilience" is explained and discussed in the same manner as vulnerability.

In the scientific environment many different definitions, concepts, and terms exist of vulnerability and resilience, hence this chapter should be seen as an introduction and explanation of the topic of the thesis and not as an all-embracing overview.

2.1 SPATIAL PLANNING AND ADAPTATION

As explained before climate change adaptation has emerged as a major issue in the 21st century due to the potential impacts of changing climate and especially the associated rising sea levels in coastal regions. The huge physical and socio-economic impacts of sea level rise on the coastal zones require serious research effort and policy development towards integrated and sustainable adaptation strategies (Klein, 2002: 9pp). This mentioned term "adaptation" is frequently used in spatial planning and especially in context of climate change.

Adaptive capacity in short and simple terms means "*the ability to adapt*" (Engle, 2011: 648). In more detail as defined by the IPCC (2001) it is "*the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*.''

Furthermore according to Klein (2002: 9pp) adaptation, explained as actions responding to the impacts of climate change, can be understood as "*a multistage and iterative process [...]"* and countries are already adjusting their management approaches over the past decades *"to reflect new insights, programs, and policies"* to *"adapt"* to climate change related impacts.

Hence "*spatial planning is considered to be one of the main instruments available to govern adaptation to climate change and climate change impacts in spatial contexts*" and is important to develop, design and implement adaptation measures to reduce the vulnerability of cities and especially coastal ones to impacts of climate change (Rannow et al. 2010: 160).

Due to the fact that most impacts are unpredictable and expected to worsen over time, resilience of physical and social structures requires active planning and especially various forms of adaptation and resilience strategies. Spatial Planning provides support for regional and local authorities endeavouring to *"adapt to climate change by proposing and coordinating measures that impact on a variety of interests and responsibilities (ibid: 160)."*

Adaptation can be taken by an individual for his or her own benefit or by actions by governmental and public bodies to protect their citizens (Adger 2005: 269 pp). Often city governments and primary local planners are responsible for developing actions, regulations and services to ensure the well-being of their population. This includes *"land use planning and zoning, water provision, sanitation, and drainage, housing, construction, renovation, and regulation, economic development, public health and emergency management, transportation provision, and environmental protection"* (World Bank 2011: 22). Planning strategies in context with these services can influence the vulnerability or resilience of a whole city and they "*can take a major step towards development and climate change resilience simply by instituting and enforcing stronger management principles*". (World Bank 2011: 22).

According to Carter and Sherriff there are a lot of reasons why spatial planning has an important potential to adapt to climate change:

- *"the cross-boundary nature of spatial planning*
- *Long-term nature of spatial plans*
- *Influence over building design*
- *Influence over urban form*
- *A forum for engagement" (Carter & Sherriff 2011:7).*

Examples of city-scale climate change adaptation strategies began to emerge in the last years and are often included in wider climate change and sustainability strategies. Some climate change strategies are integrating adaptation in their mitigation strategies, for example in Madrid and Manchester. On the other hand there are also adaptation strategies that focus only on responding to impacts in context of climate change, for example the London Climate Change Adaptation Strategy, and the Strategies of Copenhagen and Rotterdam. In addition you can find specific policies and strategies often embedded within spatial planning frameworks at different levels. For example Freiburg's (Germany) planning policies are reducing the risk of surface water flooding by reducing the amount of hard surfaces in the city (Carter 2011, In: Carter & Sherriff 2011).

In summary *"[...] recognition of the complexity, uncertainty and irreversibility demonstrated by climate science is changing the nature and framing of spatial planning, with an increasing expectation for it to play a part in mitigation and adaptation efforts*" (Davoudi et al 2010; in: Carter & Sherriff 2010: 37).

The intensity of possible climate change related impacts is influenced by the often mentioned "adaptation" or also called "adaptive capacity" on one hand and by "exposure" and "sensitivity" on the other. Hence future spatial planning should consider this possible "vulnerability" and enhance the potential "adaptation" and "resilience". As already discussed before most of the climate change related spatial planning strategies focus on adaptation measures. But countries need to be aware of and integrate the approaches of vulnerability and especially the possibility of resilience to avoid future disasters.

The next section explains and distinguishes relevant terms in context of climate change and spatial planning such as “vulnerability”, “exposure”, “sensitivity”, “adaptive capacity” and “resilience”.

2.2 VULNERABILITY

An important term in context of climate change related impacts is “vulnerability”. According to the Oxford Dictionary the term vulnerability can be traced back to the early 17th century to the Latin word *vulnerabilis* or *vulnerare* “to wound” and *vulnus* “wound”. Hence more generally, stated by social scientists, vulnerability means “*the capacity to be wounded*” (Kates 1985 in: IPCC 2001).

Vulnerability is a frequently used, explained and determined concept in diverse areas of research and there is no all-embracing definition. Timmermann stated in the early 1980s that “*vulnerability is a term of such a broad use as to be almost useless for careful description at the present, expect as a rhetorical indicator of areas of greatest concern” (Timmermann, 1981, In: Füssel 2007: 155)*

Especially research focusing on geography, risk, natural hazards and disaster literature the term vulnerability is a frequently used but it is also going to be more important in global change and environmental studies (Cutter, 1996: 529).

The variations in vulnerability concepts are based on the fact that scholars with diverse knowledge domains and backgrounds are involved. For example natural scientists and engineers see the term in a completely different context than social scientists (Füssel, 2007: 155pp). A listing of different definitions and meanings of various sciences of the term vulnerability would be more confusing than helpful only one statement of Kasperson (2001: 3) should support understanding:

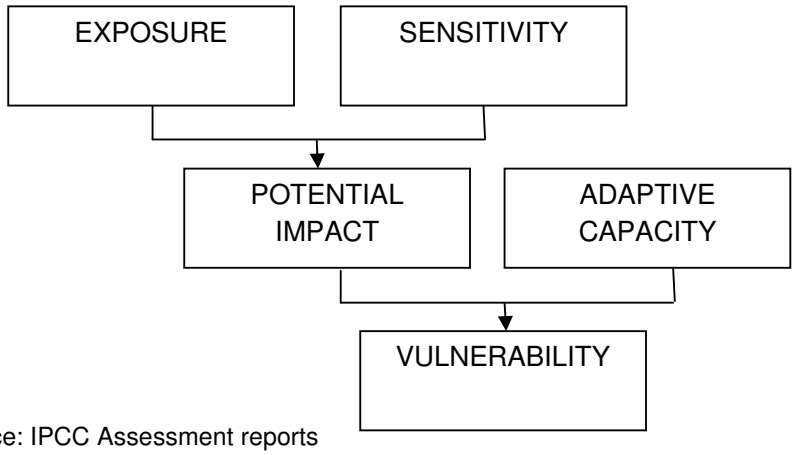
“*Vulnerability is the capacity to be wounded from a perturbation or stress, whether environmental or socioeconomic, upon peoples, systems or other receptors”.*

Furthermore vulnerability is connected and associated with concepts such as *“resilience, marginality, susceptibility, adaptability, fragility and risk”* and “*exposure, sensitivity and coping capacity*” (Füssel & Klein 2006: 302pp). All these concepts are discussed later in more detail.

Exposure, Sensitivity and Adaptive Capacity in context of Vulnerability

As mentioned before researchers agree on a relationship between vulnerability, exposure, sensitivity and adaptive capacity. The following illustration, based on a framework of IPCC assessments reports, shows the context.

Figure 7: Vulnerability, exposure, sensitivity and adaptive capacity framework



Source: IPCC Assessment reports

According to the IPCC **EXPOSURE** relates to "*the nature and degree to that a system is exposed to significant climatic variations*" (IPCC, 2001). Pelling states exposure as *"a product of physical location and the character of the surrounding built and natural environment*" (2003: 48)

In context with exposure **SENSITIVITY** can be describes as how a system is affected after being exposed to internal and external disturbances (Engle 2011: 649, Gallopin, 2005: 294) and according to the IPCC (2001) sensitivity is "*the degree to that a system will respond to a change in climate condition"* and this could be either positively or negatively or direct (e.g. a change crop due to variability of temperature) or indirect (e.g. a damages cause by coastal flooding due to sea level rise)(Gallopin 2005: 294pp,).

Furthermore exposure in combination with sensitivity results in **POTENTIAL IMPACT.**

ADAPTIVE CAPACITY in short and simple terms means "*the ability to adapt*" (Engle, 2011: 650). In more detail as defined by the IPCC (2001) it is "*the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*.'' The relationship of adaptive capacity and potential vulnerability depends on timeframe, hazards and the ability to adapt to those hazards (Brooks et al 2005: 152).

The original word ADAPTATION means to "*deal with consequences and to mitigate potential damages as well as to exploit opportunities that come up*" (Gallopin, 2005: 250).

Some examples for adaptive capacity are "*economic resources, technology, information and skills, infrastructure, institutions, and equity*" according to Smith et al (In: IPCC 2001). Furthermore adaptive capacity can affect vulnerability by adjusting sensitivity and exposure (Adger et al, 2006: 273).

According to Yohe et al. there is a relationship between vulnerability, exposure and adaptive capacity and he observed that:

- *"the higher the exposure, the higher the vulnerability.*
- *the higher the adaptive capacity, the lower the vulnerability" (2006: 37).*

In mathematical terms vulnerability can be measured as the ratio of exposure and adaptive capacity or stated in a formula:

Vulnerability = exposure / adaptive capacity (Yohe et al 2006: 37).

Risk, Hazard and Disaster in context of Vulnerability

In hazard and disaster research scientists describe the relationship of vulnerability, hazard, risk and disaster.

In this context **HAZARD** is "*a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage*" (United Nations). Hazards, particularly natural hazards, can occur anywhere worldwide. They are associated with extreme natural events such as earthquakes, floods, volcanoes and extreme weather variations. Furthermore they could turn into a disaster when they get in touch with vulnerable systems or conditions.

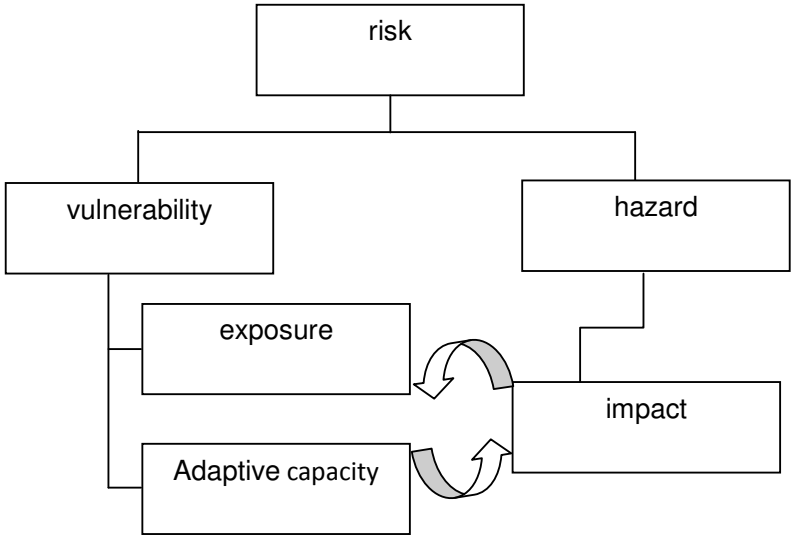
In more detail a **NATURAL DISASTER** is a result of hazard and vulnerability and can be defined as "*the interaction between a natural hazard, generated in most cases from a sudden and unexpected natural event, and vulnerable conditions that cause severe losses to man and his environment (built and natural)"* (El Masri & Tipple, 1994: 2).

Due to the fact that natural disasters are increasing, researchers defined vulnerability in context of hazards and disasters and developed the term "risk".

Hence **RISK** is explained as "*expected losses [...] due to a particular hazard for a given area and reference period" and "expected losses [...] [are] resulting from interactions between natural or human induced hazards and vulnerable condition*" (Füssel, 2007: 303). In this context risk is understood as a function of hazard and vulnerability (Risk = Hazard + Vulnerability).

Richter illustrated the relationship of risk, hazard and vulnerability in context of exposure and adaptive capacity as demonstrated in the following framework. The illustration shows the relationship and impacts of all factors in context of vulnerability. As explained before risk consists of hazard and vulnerability, furthermore vulnerability is composed of exposure and adaptive capacity. In addition there are physical or social impacts as a result of hazards and in turn they can positively or negatively influence exposure and adaptive capacity (Richter, 2010: 9).

Figure 8: Vulnerability, risk, hazard and disaster framework



Source: Richter (2010: 9), own elaboration

The context of Poverty and Vulnerability

There is a direct connection between poverty and vulnerability and although it is obvious that the poor are most affected by disasters, **POVERTY** should not be used as a synonymous of vulnerability, it can be rather seen as "*a rough indicator of the ability to cope*" (Dow, 1992, Yodami, 2001, Rayner & Malone, 1998; In: IPCC 2001.). Furthermore "*not all vulnerable groups are poor and poverty does not necessarily cause higher vulnerability*" (Moser, 1998: 20).

A statement according to Pelling (2003: 35) explains the relationship of poverty and vulnerability as *"[...] loss of [...] assets through environmental factors (...) will cause the income earning capability of the household to fall and lower the range of entitlements to that household members can make claim, making the household and its members more vulnerable to any subsequent everyday or catastrophic stresses or shocks*".

Vulnerability and Climate Change

Like the problem to find an overall definition of the term vulnerability there is no generally accepted view on vulnerability in context of climate change. This can be explained by the complexity of climate change science and that not only one discipline concentrates on that topic, rather more scientists in fields such as geography, ecology, sustainability science and natural hazard are doing research on this extensive subject.

Some researcher focussing on vulnerability in climate change related context are Adger (1999), Moss et al (2001), Leichenko and O'Brian (2002), Brooks (2003), and O'Brian et al (2004).

According to the IPCC a common definition of vulnerability in context of climate change is as follows: "T*he degree to that a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to that a system is exposed, its sensitivity, and its adaptive capacity*" (IPCC, 2007).

This definition, as most, concentrates on negative terms of vulnerability, or the conditions of a system, region, group or individual of being susceptible to an external factor or stress (Adger 2006: 268pp). In contrast Füssel & Klein (2006: 308p) describe two-sides of vulnerability: on one side "*exposure*", such as shocks, stress and risks, as an external dimension and "*sensitivity*" and "*adaptive capacity*" as an internal side to cope with external impacts.

2.3 RESILIENCE

Such as vulnerability resilience has a rich history (Folke, 2006). According to the Oxford Dictionary resilience refers to two different definitions. The first one defines resilience as "*the act of rebounding or springing back - elasticity*" and the second as "*the capacity to recover quickly from difficulties – toughness*". The source of the word resilience can be traced back to the Latin word "*resilio*" or better known as "*jump back*" (Klein, 2002: 16).

Since the 1970s the approach of resilience was and is being used in context of ecological systems when Holling (In: Gallopin 2006: 293) first defined it as "*the ability of [these] systems to absorb changes of state variables, driving variables, and parameters, and still persist*". Followed in 1984 by Pimms, who defined resilience "*as the speed or time a systems needs to return to equilibrium*" (In: Gallopin 2006: 293):

Although there was no consensus on the definition of resilience in the ecological science, social science adapted the approach and used it in context with social and ecological systems. As on overall description of social science resilience describes the behaviour of communities, institutions or economies in response to stress (Adger, 2010: 1036, Leichenko, 2011: 165).

Or according to Gunderson & Holling resilience is "*the capacity of a system to undergo disturbance and maintain its functions and controls" (In: Gallopin 2006: 293).*

Studies in more recent years applied resilience to ecological urban resilience, economic recovery, human social systems and disaster recovery (Jabareen 2012).

As already mentioned in the previous chapter a listing of different definitions and meanings of various sciences of the term resilience would be more confusing than helpful and so one statement of the UNISDR should support understanding.

"Resilience means the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2010, In: Jabareen 2012).

Furthermore in context of urban communities the main characteristics of resilience are:

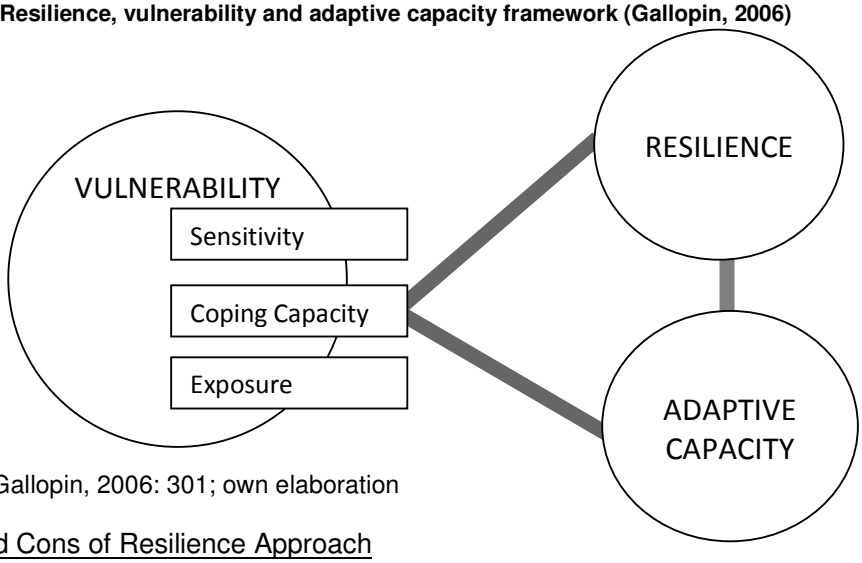
- "*capacity to absorb stress or destructive forces through resistance or adaptation*
- *capacity to mange or maintain certain basic functions and structures during disastrous events*
- *capacity to recover from bounce back after an event"* (Shaw et al, 2009: 387).

Resilience, Vulnerability and Adaptive Capacity

Some researchers see resilience as the flip side of vulnerability (Folke et al, 2002, In: Gallopin 2006: 299). However, it is obvious that a resilient system should be less vulnerable than a non resilient one, nevertheless the explanation that "*a system is vulnerable because it is not resilient; it is not resilient because it is vulnerable"* can be dangerous. Resilience could not be seen as the opposite of vulnerability because it is defined *"in terms of state shifts between domains of attraction" and* vulnerability can be referred to structural changes in the system too. *(Klein, 2003: 40, Gallopin, 2006: 299).*

According to Gallopin (2006) resilience is related to concepts such as adaptive capacity, coping capacity, coping, or capacity to response. The following illustration summarizes the view of Gallopin on context and relationship of resilience to vulnerability and adaptive capacity (Gallopin, 2006: 299pp)

Figure 9: Resilience, vulnerability and adaptive capacity framework (Gallopin, 2006)



Source: Gallopin, 2006: 301; own elaboration

Pros and Cons of Resilience Approach

Notwithstanding Resilience is an often mentioned approach and some scientists are concerned about possible negative aspects (Cannon & Müller-Mahn, 2010, Reghezzea-Zitt et al, 2012, Malone, 2009). Especially Berhout et al (2003) see a danger in the resilience approach because they worry that human action is going to be accused for problems of social-ecological coupled systems. This point of view results for example from the following statement (Adger, 2000, In: Cannon & Müller-Mahn, 2010: 14): *"Resilience examines the degree to which human action makes it possible for a social-ecological system to survive, revive or tip"*.

Furthermore Reghezzea-Zitt et al (2012) argue that Resilience could lead to the understanding that resilient is referred to as "*good*" and non-resilient as "*bad*" and this separation could stigmatizes those who do not participate in resilience's process, without any understanding of the reason for their passivity. To be based on the before mentioned theory Cannon & Müller-Mahn (2010: 15) criticise the shift from vulnerability to resilience "*as a shift of interests and objectives that leaves the poor and vulnerable behind*". Their opinion is that most of vulnerable people who have to adapt their livelihoods, especially in context of climate change, may not be resilient under existing conditions.

However there are studies define positive aspects of resilience. For example Malone's (2009) opinion is that the concept of vulnerability carries a negative connotation and concepts of resilience and/or adaptive capacity contain aspects that could help societies to change. Rayner and Melone (2001: 117) see resilience as an "*excellent umbrella concept, [...] incorporating environmental, social, economic, political, demographic, cultural, gender and psychological factors, in describing the capacity to recover and survive, to change and grow".* In particular these characteristics are important for research on climate change and related risk or hazard.

3 CONCEPTUALIZING VULNERABILITY

Conceptualizing Vulnerability is as hard as defining the term vulnerability due to the fact that definitions and concepts are broad and diverse. The first part of the chapter gives an overview and classification of theoretical streams of vulnerability by grouping the most important studies and approaches. Furthermore aspects of assessment and measurement techniques of vulnerability are explained, relevant to realize the wide range of techniques and approaches. Finally a selection of vulnerability assessment frameworks and concepts, from a social science to a hazard and disaster point of view, are represented and explained.

This chapter of vulnerability is important to support the relevance of the resilience approach because understanding the concept of vulnerability is the baseline for understanding the concept of resilience.

3.1 THEORETICAL STREAMS

Due to the fact that the central concept of vulnerability is used in a wide research context such as ecology, public health, poverty and development, secure livelihoods and famine, sustainability science, land change, and climate impacts and adaption, there is no explicit definition. The consequence is that a wide variety of frameworks have arisen to address the vulnerability of human and ecological systems to perturbation, shocks, and stressors, and hence components and linkages in vulnerability frameworks vary.

Therefore no single “correct” or “best” conceptualization of vulnerability exists that would fit in context of vulnerability due to climate change or more precise to sea level rise due to climate change.

The following three are only some of all existing definitions of vulnerability and should represent examples of the broad range of that topic.

“*Vulnerability is the capacity to be wounded from a perturbation or stress, whether environmental or socioeconomic, upon peoples, systems or other receptors*” (Kasperson, 2001: 3).

“Vulnerability is the degree to that different classes of society are differentially at risk” (Susman et al, 1984, In: Cutter 1996: 531)

“*Vulnerability is the threat or interaction between risk and preparedness. It is the degree to that hazardous materials threaten a particular population (risk) and the capacity of the community to reduce the risk or adverse consequences of hazardous materials releases”* (Pijawka and Radwan, 1985, In: Cutter 1996: 531).

In order to clarify the confusion on vulnerability approaches the chapter gives a theoretical overview about concepts classified by grouping the most important approaches and in addition gives some information on assessment and framework techniques.

The risk/hazard exposure approaches

The risk – hazard – exposure approach is an early approach assuming that nature causes hazards and addressing a single or a limited number of hazardous events to measure vulnerability. According to Cutter (1996: 533) the risk/hazard approaches examine the source of "*biophysical or technological hazards*" and put the emphasis on distribution of hazardous conditions, human settlement in this zone (e.g. coastal areas, seismic zones), and the degree of loss (life or property) related to a hazardous event (e.g. flood, earthquake). (Cutter, 1996; Turner et al 2003; IPCC, 2007; Füssel, 2007).

For example UNDRO (1982) defines vulnerability as "the degree of loss to a given elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude" (In: Cutter 1996: 531).

In contrast Fellmann (2012) calls it "*outcome vulnerability*" and defines it as "*the end point interpretation"*. He considers vulnerability as *"the (potential) net impacts of climate change on a specific exposure unit after adaptations are taken into account"*. Outcome vulnerability is mainly based on natural science and future climate change model scenarios and puts its focus on biophysical changes. (Cutter, 1996; Turner et al 2003; IPCC, 2007; Füssel, 2007).

The social human ecology approaches

This approach focuses on the analysis of people, arguing that human behaviour and perceptions are important, asking who is vulnerable, and why. The focus is on coping activities like societal resistance to hazards and the hazardous event is taken as given. Social construction of vulnerability and the ability of a society to cope and respond to disasters are main aspects. The social approach recognizes vulnerability as a social construct emphasizes the importance of social, economic, cultural, and political action at local, regional, national, and global levels (Cutter, 1996: 532; Füssel, 2007: 156pp).

In contrast Fellmann (2012) calls it "*contextual vulnerability*" and defines it as the "*starting point interpretation*". This approach is "*a concept that considers vulnerability as a present inability of a system to cope with changing climate conditions*" (Fellmann, 2012).

Integrated approaches

The last group explains vulnerability as a combination of the two before mentioned constructs: as a biophysical risk and as well as a social response. Hence one of the key features is the combination of 'internal' factors of a vulnerable system with its exposure to 'external' hazards. According to Cutter (1996) and Turner et al (2003) it is a place-based conceptualization and it's called "*vulnerability of place*". The focus is on a specific area or geographic space, or a social space, where places and people are most vulnerable. (Füssel, 2007, Cutter, 1996)

Integrated vulnerability approaches emerged in more recent natural hazards research, development literature, famine research and climate change impacts literature (Cutter 1996: 532)

Integrated definitions of vulnerability are widely used in the context of global environmental change and climate change with reference to regions, communities, or other social units. Integrated vulnerability assessments traditionally focus on physical stressors, such as natural hazards or climate change. Some recent efforts, such as the '*double exposure'* project assesses the combined effects of biophysical and socioeconomic stressors (O'Brien et al., 2004: 303),

Additional information on measurement and assessment of vulnerability

In addition to the before explained approaches more information or dimensions are important on assessing and measuring vulnerability.

Techniques used in vulnerability studies vary too. There are analytical approaches, historical narratives, contextual analyses, and statistical analyses including GIS and mapping techniques. In addition case studies are also frequently used in vulnerability research, especially when detailed knowledge is needed (IPCC, 2007).

However, a lot of approaches attempt to develop indicator and index systems that include a high number of factors often considered as being additive. (Cutter, 1996: 532) Indicator based approaches are frequently used to express vulnerability of a system by a set of independent elements (i.e. the indicators). Indicators are helpful in comparing different systems or places around the world. The main problem is that most indicator studies don't concentrate on smaller scales vulnerability, for example individuals or households. In addition index-based research is important too because vulnerability is expressed by one-dimensional factors. These indexes consist of a plurality of variables and are not really immediately transparent because they include a lot of assumptions and aggregations. (Malone, 2009: 7pp)

"Social impact can be measured by threat of lifelines or infrastructure to support basic needs, special needs population, poverty/wealth indicators, gender and race". (Cutter 1996: 534). Most social indicators are single variables but some researchers include multidimensional factors such as institutional development, social or political relations or power and food aid (ibid.).

Furthermore geographic scale is a difficult measurement because it ranges from local to global scale studies. All researchers need to focus on the question which research level – global, regional/country or local - is best for the individual study. For a detailed assessment local level is more relevant and furthermore some researchers use case-studies as an approach (Malone, 2009: 7pp; Cutter, 1996: 533).

Time dimension is another factor influencing vulnerability research. According to Fellmann (2012) it is important to understand the relationship between current and future determinants of vulnerability, especially in context of climate change and variability and for a "*complete picture both time horizons need to be combined with biophysical and socio-economic vulnerability determinants"*. Time dimension is complicated to assess vulnerability due to the fact that a lot of different additional factors would be necessary for a future vulnerability framework.

3.2 SPATIAL PLANNING AND VULNERABILITY

Due to the fact that spatial planning is an interdisciplinary matter the term vulnerability is used in various forms. Furthermore planners apply a lot of different vulnerability approaches and hence most of before mentioned explanations and theoretical streams are influencing vulnerability in the context of spatial planning and climate change related impact research.

3.3 METHODOLOGIES AND FRAMEWORKS FOR INTEGRATED ASSESSMENTS

Vulnerability of climate change needs to be assessed by an integrated approach, as climate change is a complex scientific research area.

Some climate change researchers object that common vulnerability methodologies are missing exact definitions and frameworks for assessments (Adger 1999: 250pp, Dolan and Walker 2003: 1316pp). The interdisciplinary makes it difficult to compare across various studies and results. However, the intent of methodologies is to provide guidelines, rather than an accurate framework (Nicholls 1995).

Below some examples of generated vulnerability frameworks are shown to provide an insight in the research topic and to understand the complexity and or similarity of integrated approaches.

Some studies are measuring vulnerability of coastal areas, others are applied to climate change, and some are related to hazard research in general. Most of the frameworks are trying to explain and illustrate the components and connections of a vulnerable system; including resilience, adaptation and coping capacity.

Classification scheme for vulnerability factors (Füssel, 2007)

From Füssels point of view most researchers need to make a distinction between sphere (or scale) and knowledge domain. **Sphere** can either be internal, referring to factors of the vulnerable community or system itself, or external, referring to something outside the vulnerable system. Furthermore the part **knowledge domain** can be split in socioeconomic and biophysical vulnerability factors. **Socioeconomic factors** are related to "*economic resources, the distribution of power, social institution, cultural practices, and other characteristics of social groups*". **Biophysical** ones are related to *"system properties investigated by the physical sciences*". The following table gives an overview of explained factors by giving examples for each factor and could be seen as a vulnerability profile for a particular system (Füssel, 2007: 155pp).

Table 3: Examples of vulnerability factors classified according to dimensions (Füssel, 2007)

	DOMAIN	
SPHERE	**Socioeconomic**	**biophysical**
Internal	Household income, Social networks, Access to information	Topography, Environmental conditions, land cover
External	National policies, International aid, Economic globalization	Severe storms, Earthquakes, Sea-level change

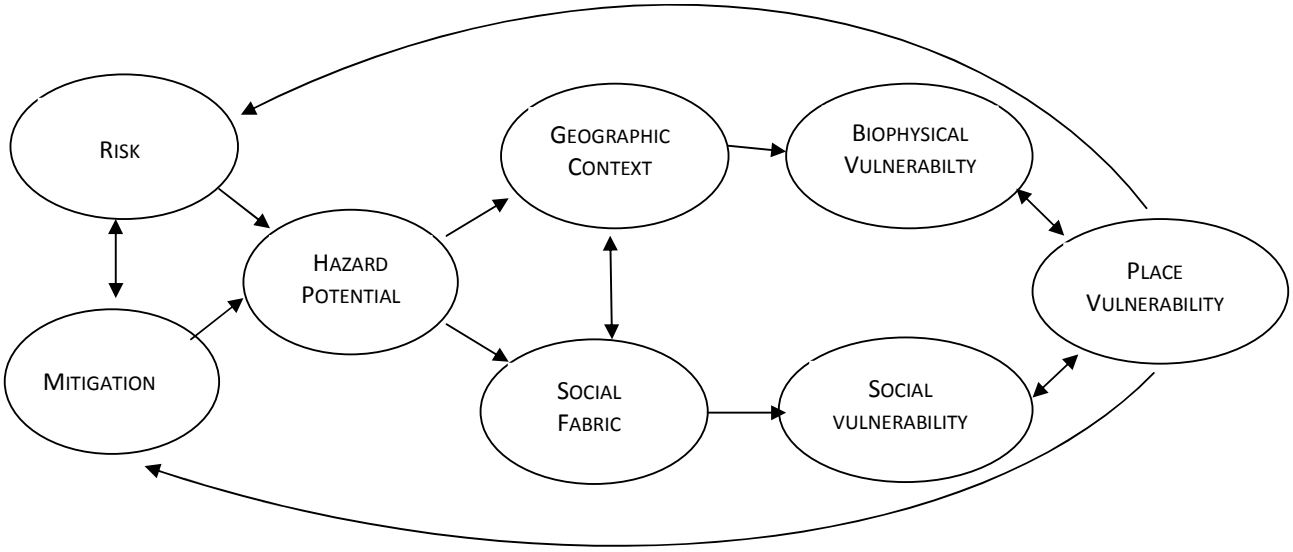
Source: Füssel, 2007: 158

The hazard of place model of vulnerability (Cutter, 1996)

Cutter developed a "*hazard of place model*" to define vulnerability in context of environmental hazards, to connect nature, society, and technology and to explain vulnerability of places. Locality is the focus of this concept and place forms the most important unit of analysis. All indicators consist of nested or contextual arrangements and can change over time.

The following graphic shows context and connections of the hazard of place model and each factor will be discussed thereafter.

Figure 10: The hazard of place model (Cutter, 1996)



Source: Cutter, 1996: 536

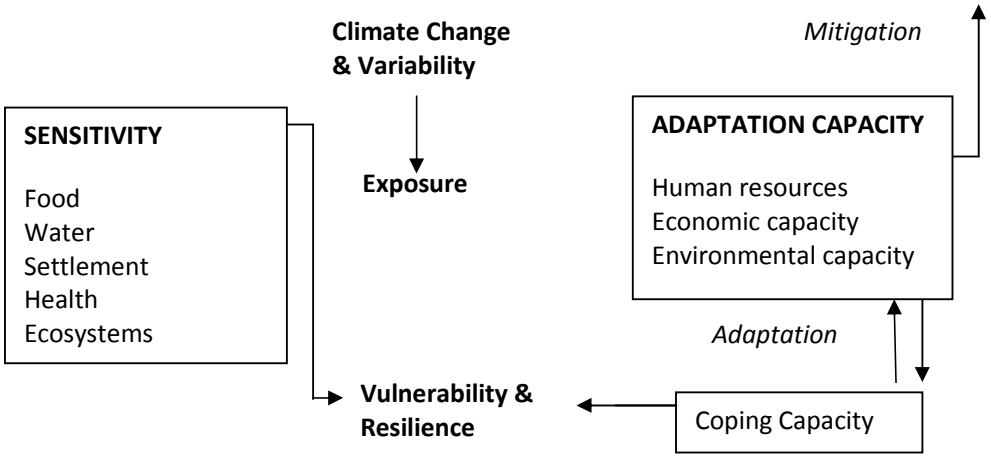
Risk is "*the likelihood of occurrence of the hazard*", it includes the factors "*potential source of risk (industrial, flooding, transportation)*" and "*contextual nature of risk itself*" (high or low consequence) and the second domain "*frequency of occurrence (100-year flood, 5 % risk)".* In combination with **mitigation** ("*efforts to reduce risk such as planning, prior experience*)" risk builds the overall "**Hazard potential"**. The hazard potential in turn is defined by the **social fabric** of the society ("*socioeconomic indicators, cognition of risk, individual/societal ability to respond*") and through its geographic context ("*site and situation, proximity*"). Social fabric defines overall **social vulnerability** and in turn **geographic context** defines overall **biophysical vulnerability.** Intersection and interaction of these two factors create the **vulnerability of place** and in turn the place vulnerability is the feedback for risk and mitigation (Cutter, 1996: 529 pp).

Vulnerability-Resilience Indicators Model (VRIM) by Brenkert and Malone (2005)

The VRIM is a hierarchical model, aggregating proxy values into sectors in a three-level process. Furthermore these proxy values are aggregated into sensitivity and adaptive capacity values and in the end into a vulnerability-resilience index.

Furthermore indicators are grouped in sectors and these sectors are classified as sensitivity (food security, water resources, settlement/infrastructure, human health, and ecosystems) or as capacity for coping and adaptation (environmental capacity, economic capacity, and human and civic resources). In the end (negative) sensitivities and (positive) coping/adaptation capacities are aggregated into one vulnerability index.

Figure 11: Vulnerability-Resilience Indicators Model (VRIM) (Brenket & Malone, 2005)



Source: Brenket & Malone, 2005: 63

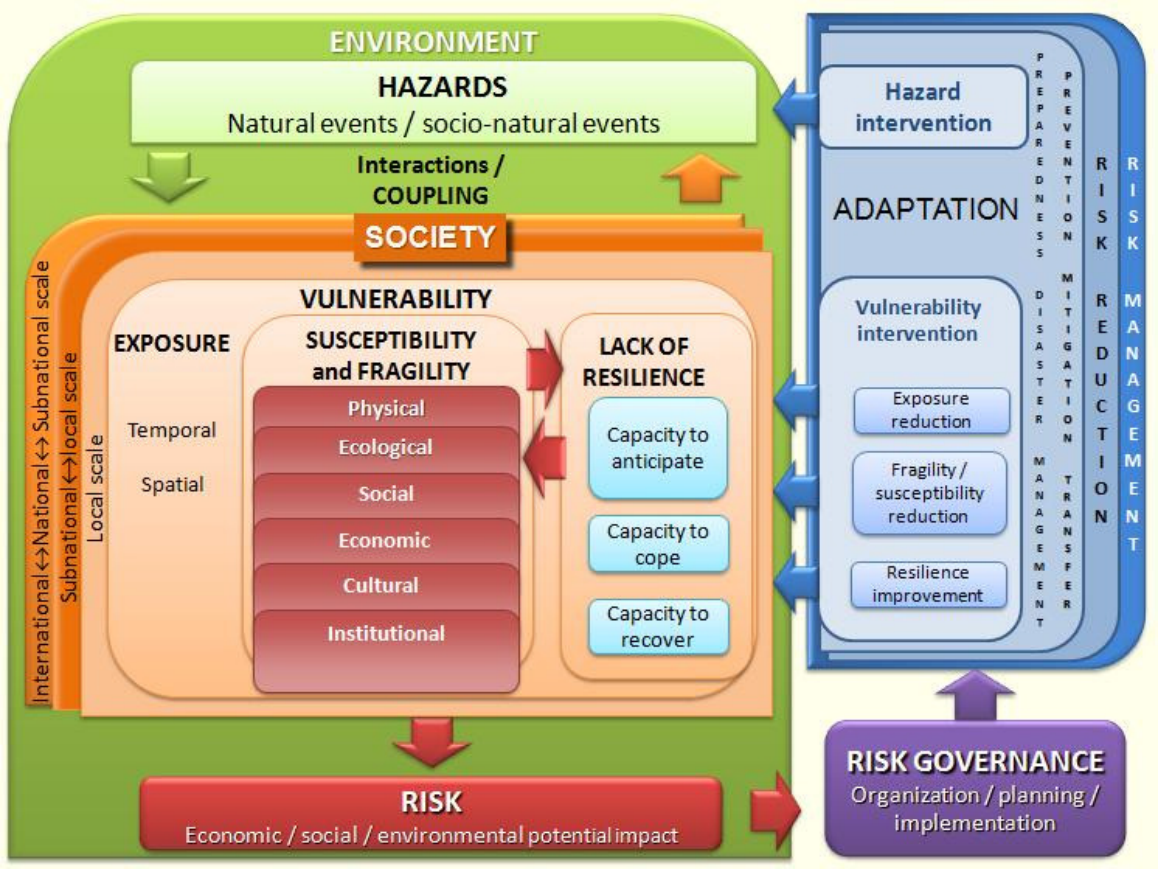
The VRIM's set of quantitative indicators allows comparisons of regional, country, state or provinces, or smaller localities in terms of their vulnerability and resilience to a current and changing climate (Brenkert & Malone 2005: 57pp).

MOVE - framework

The European Union launched the so called MOVE project – "*Methods for the improvement of Vulnerability Assessment in Europe"* – to find a consistent approach on vulnerability assessment to natural hazards and climate change in a European setting. For the project, researchers reviewed and compared different approaches and built a multidisciplinary framework.

The framework defines major characteristics and pillars of vulnerability. The dimensions are physical, social, economic, environmental, cultural, institutional and governance. The following figure shows the components of the framework and mostly relevant for this thesis the dimensions of vulnerability.

Figure 12: MOVE Generic - Framework



Source: European Union, MOVE Consortium, 2011: 59

The different dimensions of vulnerability are explained below and thereafter the possibility of assessment is discussed.

Physical vulnerability is the degree of exposure to a hazard. The social factor characterises the conditions of different social groups in relation to "*the demographic, ethnic, cultural or physical composition of the groups (e.g. elderly people or disadvantaged minorities) and to the levels of marginality and social segregation or other weaknesses and restrictions in the access to social, economic or health-related assets".* The economic dimension analysis the potential monetary loss and the difference in the affected groups. Environmental vulnerability involves the fragility of ecosystems and the importance of those systems for the population. The cultural factor is related to natural and urban landscapes and their values and significance for communities. The institutional aspect is explained by the involvement of important stakeholders, the effectiveness to co-ordinate and the process of decision-making. "*Mitigation, preparedness, response, recovery and adaptation activities are affected by institutional weaknesses and shortcomings*."

For vulnerability assessment of flood MOVE project researcher defines the following indicators as relevant. These indicators are relevant for the assessment of sea level rise too.

Table 4: MOVE Generic – Framework Vulnerability Indicators

	COMPOSITE INDICATORS	SINGLE INDICATORS
PHYSICAL DIMENSION	Transport Infrastructure	Highways
		Primary Roads
		Secondary Roads
		Railway
	Critical Infrastructure	Sewage plant
		Waste Deposit
		Gas stations
	Buildings	1-2 households
		>3 households per building
		Tourism relevant buildings
		Offices
		Commercial buildings
		Industry
	Critical buildings	Transport and communication infrastructure
		Hospital
		Kindergarten
		Nursing homes
		Primary schools/kindergarten
SOCIAL DIMENSION	Age	Population under 20 years
		Population 20-64 years
		Population over 64 years
	Employment	Employment in agriculture sector
		Employment in mining sector
		Employment in Production and construction sector
		Employment in Service sector
ECONOMIC DIMENSION	Transport network	Highways
		Primary Roads
		Secondary Roads
		Railway
	Employment by sectors	Employment in agriculture sector
		Employment in mining sector
		Employment in Production and construction sector
		Employment in Service sector
	Ecosystem Services	Food production
		Raw materials
	Land use	Crop
		Pasture
		Woodland

Source: European Union, MOVE Consortium, 2011: 29 pp

3.4 IDENTIFYING SOCIAL VULNERABILITY

"*Without people, there is no disaster!"* (O'Keefe et al, 1976, In: Adger 1999: 251) This statement illustrates the importance of including the human dimension and social context in vulnerability research.

Social vulnerability examines characteristics of the population important for a community, city or other system to prepare for, respond to, and recover from disasters and hazards. In interaction with natural processes and the built environment social vulnerability distributes impacts and risk of hazards and consequentially creates the social burdens of hazards (Cutter et al, 2003).

According to Adger (1999) social vulnerability is "*the exposure of groups or individuals to stress as a result of social and environmental change, where stress refers to unexpected changes and disruption to livelihoods"*. The term describes how susceptible people are to a hazard. In most social vulnerability studies the hazard itself isn't of big interest. (In: Nathalie et al, 2011)

Furthermore social vulnerability can be defined as a state of well-being and the possibility of socially differentiated population experience when affected by the same hazard or exposure, for example, level of flooding. (Adger, 1999, In: Nathalie et al, 2011)

Researchers of social vulnerability agree on the main factors influencing social vulnerability. These include: lack of access to resources (including information, knowledge, and technology); limited access to political power and representation; social capital, including social networks and connections; beliefs and customs; building stock and age; frail and physically limited individuals; and type and density of infrastructure and lifelines. However, researchers disagree in defining exact variables to represent social vulnerability (Adger, 1999, Cutter, 2001).

Furthermore for assessing social vulnerability it is essential to see the difference between individual and collective vulnerability. Adger defines individual vulnerability as *"access to resources and the diversity of income sources, as well as by social status of individuals or households within a community"*. In contrast collective vulnerability, of a nation, region or community is "*determined by institutional and market structures, such as the prevalence of informal and formal social security and insurance, and by infrastructure and income*." (Adger, 1999: 254)

The following table shows the difference of these two classifications and defines some indicators for each.

Table 5: Collective and individual vulnerability to climate change: determinants and indicators

TYPE OF VULNERABILITY	CAUSES IN RELATION TO CLIMATE CHANGE	INDICATORS OF VULNERABILITY
INDIVIDUAL VULNERABILITY	Relative and absolute poverty; entitlement failure; resource dependency	Poverty indices; proportion of income dependent on risky resources; dependency and stability
COLLECTIVE VULNERABILITY	Absolute levels of infrastructure development; institutional and political factors – insurance and formal and informal social security	GDP per capita; relative inequality; qualitative indicators of institutional arrangements

Source: Adger, 1999: 252

3.5 SUMMARY OF THE MAIN CHARACTERISTICS OF SOCIAL VULNERABILITY

The following part summarizes most important factors indicated as influencing social vulnerability according to before explained researchers and the following table shows a concise table of attributes of vulnerability assessment of different researchers by Conner 2003:

The **socio-economic status** of people affects their ability to absorb losses from hazards and disaster. It is a fact that people living in poverty are more vulnerable to hazard impacts than wealthy ones. The reason is that poor people aren't able to spend as much money on prevention measures, emergency supplies, and recovery. Notwithstanding the monetary value of material and economic losses of wealthy people may be greater, but the losses by poor ones are most often "*more fatal in relative terms*" (Cutter et al 2003: 231).

In addition there is a connection of poverty and housing standards. Most poor people are living in substandard houses and areas due to less availability of money and this directly endanger them when hazards or disasters will occur. For example researchers argue that the impacts of Hurricane Katrina were more related to the socioeconomic inequalities within the affected population rather than the hurricane's intensity (Cutter et al 2003: 231).

Furthermore Jabereen (2012) links informality to social vulnerability. He argues that informal spaces are more likely to be vulnerable and so he defines scale and human condition of informal places as an indicator for vulnerability.

Including value, quality, and density of residential construction into vulnerability assessment is followed by Cutter et al (2000).

Income and employment is also related to vulnerability because money gives people the possibility to improve their living conditions and to deal with disasters. In addition income and employment enables people to avoid living in hazard prone areas.

Several researchers are including education level or literacy rates in vulnerability assessment. They argue that educated people have more access to information and in addition education gives them the opportunity to reduce their risk (Cutter et al 2003).

Racial and ethnic minorities are also ranking among social vulnerability indicators. According to Peacock et al 2000 minorities are more likely to live in poverty. He argues that based on minorities and poverty these communities are often geographically and economically isolated from jobs, services and institutions. Furthermore due to the fact that minorities are often immigrates they can't to speak the native language and again this creates languages barriers and could increase vulnerability to disasters. According to Cutter et al *"race contributes to social vulnerability through the lack of access to resources, cultural differences, and the social, economic, and political marginalization that is often associated with racial disparities*" (Cutter 2003: 233)

Gender is another aspect of social vulnerability. The argumentation is that women are more vulnerable than men because they are more likely to live in poverty. The reason why particularly single mothers often suffer from poverty is because they hold more low-status jobs. (Enarson and Morrow 1998).

Furthermore young, elderly and people with mental or physical disabilities are often seen as more vulnerable due to the fact that most are unable to respond to disasters without outside support (2005, Smith et al 2009). Cutter et al 2003 discovered that percentage of children in a community and high birth rate as positively related to vulnerability and population over 65 too (Cutter, 2003: 232).

The degree of development of the built environment is also a factor influencing social vulnerability and Cutter et al (2003) defines it by measuring "*the density of manufacturing and commercial establishments, housing units, and new housing permits*". It is an indicator because communities will most likely expect higher structural losses from hazard events in a denser environment.

From an economic point of view single-sector economic dependence affects social vulnerability too, because communities or cities depending on one or little economic sectors are more vulnerable (Cutter et al 2003).

Some researchers argue that population growth negatively affects social vulnerability due to the fact that quality of settlements will lack and social services networks may not have time to adjust to increased population (Mitchell & Scott, 2000, In: Cutter et al. 2003).

Table 6: Summary of Attributes of vulnerability derived from existing scholarship

CATEGORY	ATTRIBUTE	RELATION TO VULNERABILITY	SOURCE(S)
GEOGRAPHIC	Location	Isolation and remoteness can present challenges of transportation and communication, in emergency situation	Armstrong and Read 2002, Dolan and Walker in press
	Geophysical sensitivity	Can increase rates of erosion and accretion	Shaw et al. 2001
	Exposure	Can increase proneness to flooding, erosion, and storminess	Burton et al. 1978, Barnett 2001, Sidle et al. 2004
SOCIAL	Experience	Experience can strengthen preparedness	Dolan and Walker in press
	Population size & stability	Small population may create economic disadvantages; high population density may increase difficulty in evacuation	Townsend et al. 1988, Cutter et al. 2000, Tapsell et al. 2002, Wu et al. 2002
	Education	A determinant of income that can increase the ability to adjust to economic changes; fosters greater awareness of hazards	Tobin 1999, Holman and Nicol 2004
	Health	Limited access to health care facilities; potential impacts to health care centers; current state of health	Wisner 1998, Shaw et al. 2001, Leichenko and O'Brien 2002, Tapsell et al. 2002
	Social relations	Large families may be difficult to track in emergency situations; strong social ties may strengthen community support; the ability of people to work together	Watts and Bohle 1993, Bohle et al. 1994, Clark et al. 1998
	Access to services	Greater distance to emergency services may increase vulnerability	Clark et al. 1998, Wisner 1998
	Culture	Strength of the local culture; human interactions with the environment	Yamada et al. 1995, Magistro and Roncoli 2001
ECONOMIC	Employment & income	Greater income allows spending on prevention planning; poverty is directly related to vulnerability	Clark et al. 1998, Wisner 1998, King 2001, Tapsell et al. 2002, Kundzwiez 2002, Yohe and Tol 2002
	Livelihood dependency	Dependence on natural resources can increase vulnerability; supply and demand and the international level	Barnett 2003, Dolan and Walker in press
	Economic development	Economic base for employment increases income levels; growing economic sector can strengthen adaptation options	Lorenzoni et al. 2000a, Barnett 2003, Sidle et al. 2004
POLITICAL	Institutions & infrastructure	The level of decision and communication; infrastructure available for decision makers	Yamada et al. 1995, Adger 2003a, Barnett 2003, Smit and Pilifosova 2003,
	Planning	Strong emergency planning can increase adaptive capacity to potential impacts	Tapsell et al. 2002, Sidle et al. 2004

Source: Conner, 2003: 21

4 CONCEPTUALIZING RESILIENCE

The first part of the chapter gives an overview and classification of theoretical streams of resilience by grouping the most important studies and approaches. Furthermore aspects of assessment and measurement techniques of resilience are explained which are relevant to realize the wide range of techniques and approaches. Finally some resilience assessment frameworks are represented and explained and in the end the author gives a summary of main resilience characteristics.

4.1 THEORETICAL STREAMS

The term resilience and the related research area is rapidly gaining ground and is going to replace the sustainability hype in politics and planning. Resilience is particularly important to provide understanding how communities act in context of environmental and social changes (Wilson, 2012; Adger, 2006).

As vulnerability researchers with different backgrounds understand resilience in different ways and this furthermore affects their opinion on characteristics, components, indicators and framework of resilient systems (Bahadur et al, 2010).

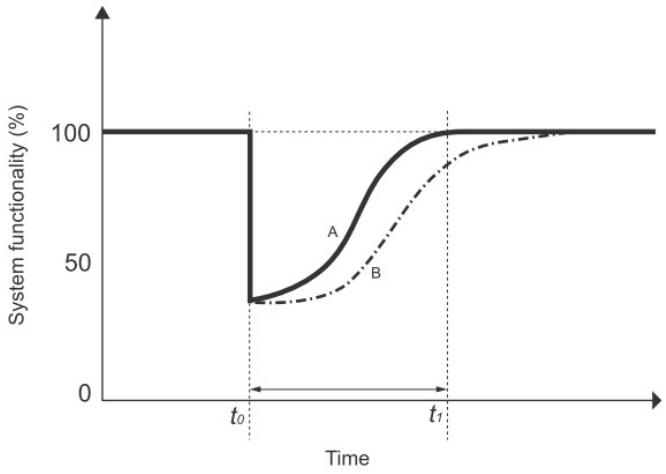
A definition of Walker and Salt (2006): Resilience is "*the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedback*" (In: Bahadur et al 2010: 12)

Resilience is as diverse as vulnerability research and to understand differences in concepts of resilience the following part classifies on one hand engineering, ecological, socio-ecological and social resilience and explains on the other hand the difference between outcome and process oriented resilience.

Engineering resilience

This approach focuses on resilience in context of engineering and is concerned with disturbances threatening the functional stability of engineering systems. Negative impacts on engineering systems often lead to failures and a quick recovery to normal levels of functionality is important. In such events robustness, redundancy, resourcefulness, and rapidity are indicators for resilience. (Wang and Blackmore 2009, In: Liao 2012). The following figure represents the concept of engineering resilience and measures resilience by "*the time it takes (t10-t0 for Case A) for the system to recover to 100% of its previous functionality. The longer it takes, the less resilient the system is."* (Case B) Wang and Blackmore, 2009, In: Liao, 2012: 48).

Figure 13: Engineering Resilience



Source: Liao 2012: Wang & Blackman, 2009; in: Liao, 2012: 48

Pimm (1993) defines engineering resilience as ‘‘*how fast a variable that has been displaced from equilibrium returns to it. Resilience could be estimated by a return time, the amount of time taken for the displacement to decay to some specified fraction of its initial value" (In: Folke 2006: 256)*

The concepts of ecological resilience

As mentioned in the chapter of “terminology” the term resilience has its roots in the 1960s/1970s in ecological science in context of ecological stability theory (Folke, 2006: 256).

In context of ecology Holling (1973) was the first introducing the concept of resilience when he published his research “*Resilience and Stability of Ecological Systems*”, describing observed ecosystems dynamics. He defined resilience as ‘*the system to absorb the disturbances between efficiency and persistence, constancy and change, predictability and unpredictability, in order to keep equilibrium continuously" (Holling,1973: 15)*. Holling studied ecological systems and he assumed that resilience is the ability of an ecological system to persist when a disturbance appears. He sees ecological natural systems as dynamic, and argues that variability reproduces stable equilibrium by continuous changing. In addition Holling explains that fluctuation is necessary in systems because they improve the ability to exist during a disturbing event. His opinion is that heterogeneity supports the resilience of systems. This concept was and is used in ecosystem management approaches.

Generally most of ecological definitions and concepts focus on the amount of disturbance a system can absorb without changing in its state and they emphasis stability, resistance and the return to equilibrium (Mayunga, 2007: 11).

The concepts of social resilience

As a result of criticisms scientists focused on resilience of human systems and communities, referred to as social resilience. It differs from ecological resilience by adding capacity of humans to anticipate and plan for the future (Moberg and Galaz, 2005, In: Folke 2006).

Adger (2000) defines it "*as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change*". In addition Folke (2006: 258) highlights that social resilience concentrates on human systems, the importance of learning by change and that "*uncertainty and surprise is part of the game*".

Maguire and Hagan (2007) explain social resilience as *a capacity of social entity e.g. group or community to bounce back.* They stated that sustainable and resilient communities can be achieved if all activities of disaster management phases (mitigation, preparedness, response, and recovery) are taken into account (In: Maguire and Cartwright, 2008: 4).

The concepts of social-ecological resilience

In late 1970s and 1990s research started to focus on hybrid systems, such as social-ecological systems due to the fact that development of human society relies massively on ecosystem services and goods. As a consequence scientists established the term "*social-ecological" system* (SES) to emphasize the integrated concept of humanity and nature (Folke, 2006).

A definition of resilience was defined by Walker and Salt (2006) as "*the capacity of a system to absorb disturbance and reorganize while undergoing change to still retain essentially the same function, structure, identity, and feedbacks" (In: Folke 2006: 254)*

Folke understands disturbances in social-ecological *systems as an opportunity for innovations and development and defines resilience as "[...] the ability to persist through continuous development in face of change, and innovate and transform into more desirable configurations*". He assumes that surprises in systems are necessary and that resilience results from learning to live with uncertainty. Folkes resilient system depends on different groups, different functions of each group and furthermore responding differently to the same disturbance (2006: 253pp)

However, the social-ecological approach has been criticized on relying on deterministic and positivist natural science-based behaviour which is not always true for human system resilience. Davidson (2010: 213) stated: ''*while the structural complexity of both ecological and social systems can be conceived of in similar terms, the feedback processes associated with each are incomparable: social systems are unique in that the tendencies toward complexity, and the responses of individual organisms to those levels of complexity, are defined not solely by structural variables, but by agency''*.

Resilience as stability

The main stream resilience is dominated by a "*single equilibrium view*" or in other words sees resilience as return-time after a disturbance. The stability view of resilience defines resilience as the ability to return to a pre-existing state. It is about resisting disturbance and change, to conserve what is present, focusing on a stable equilibrium (Holling, 1996, In: Folke 2006: 256). The argument is that safety can only be reached when systems maintain a safe stable state and that factors are maintaining, recovering and looking for equilibrium (Maguire & Cartwright, 2008: 4).

Single equilibrium view dominates main stream ecology and can be referred to before explained engineering resilience (Holling, 1996, In: Folke 2006: 256).

Resilience as Process / Transformation

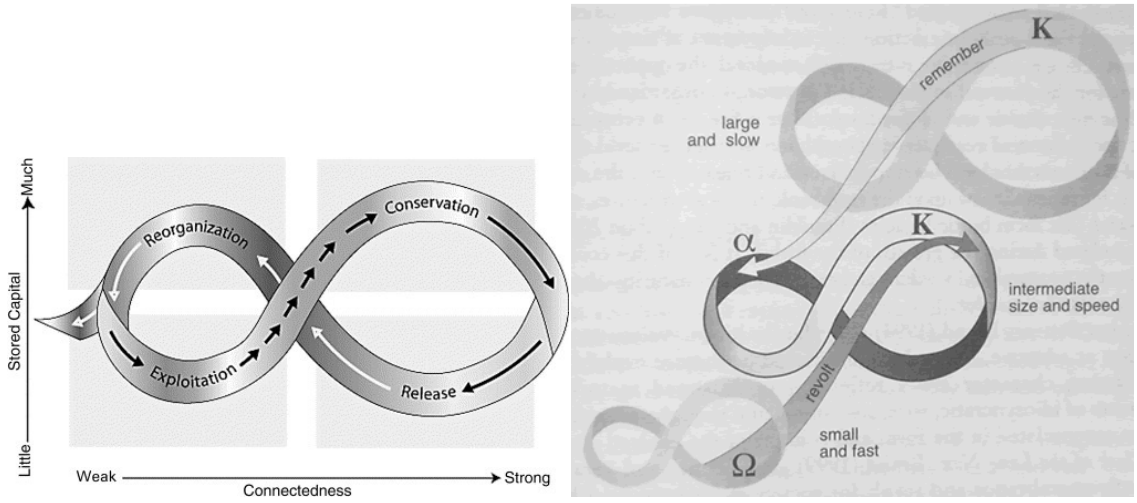
Further development of resilience considers new dimensions of resilience. The before mentioned approaches view resilience as stability and recovery and imply that a community can only be resilient or not, but further studies explores the dynamic of nature of change or transition of resilience (Folke, 2006: 255).

More recent studies explored that communities respond to a change in an adaptively way rather than returning to the previous state what could lead to a new, different and more sustainable state for the community. Due to the fact that human systems are complex systems with nonlinearity, uncertainty and self-organization and multi equilibrium states (ibid.).

A key issue of process-oriented resilience is that human systems can never return to their state before a disturbance especially due to social learning processes. Resilience is a process linked to dynamic changes over time and sees disturbances as an opportunity for change and development. Folke states that *"in a resilient social-ecological system, disturbance has the potential to create opportunity for doing new things, for innovation and for development*." More resilient communities are able to use the disturbance for developing instead of simply surviving. So as a result transformation approaches deal with concepts of regeneration, re-organisation and renewal (Folke, 2006: 256).

Development or transformation of dynamic systems is explained by the concept of adaptive renewal cycle by Holling (1986). In the following model the evolution process of systems is expressed as a dynamic cycle of growth (exploitation phase), conservation (steady state phase), collapse (release phase) and the reorganization phase. The potential of resilience depends on these phases. Therefore resilience is lower in conservation and collapse phases and higher in renewal and growth phases. In addition the model shows the requirement of disturbance for development, and furthermore learning and self-organization is more important for a resilient strategy than conservation or bouncing back (Holling and Gunderson, 2002, In: Chelleri, 2012: 258pp).

Figure 14: Renewal adaptive cycle model (Holling & Gunderson, 2002)



Source: Holling & Gunderson, 2002; in: Chelleri, 2012: 293, 258

The recovery view relates to a community's ability to "*bounce back*" from impact or change to return to its initial state. This leads to the assumption that a resilient community is able to return relatively quickly, whereas a less resilient one may need more time or will not be able to recover at all.

Furthermore the "*model of panarchy*" by Gunderson and Holling (2002) emphasizes the cross scale interplay of resilient systems and illustrates structures and processes in dynamic, complex systems. The relationship between scales is significant in the context of building resilience. Each step in that cascade of events moves the disturbance to a larger and slower level (ibid.)

4.2 SPATIAL PLANNING AND RESILIENCE

Such as vulnerability resilience is defined in various forms by planners due to the fact that spatial planning is an interdisciplinary matter. Furthermore a lot of different resilience approaches are applied and hence most of the before mentioned explanations and theoretical streams are influencing resilience in the context of spatial planning and climate change related impact research. Therefore the resilience methodologies and frameworks discussed in the following part need to be considered in spatial planning resilience assessment.

In contrast to vulnerability resilience is discussed more often in the context of spatial planning, in particular "urban resilience".

The key question in understanding cities as systems is whether a city has its capacity to react to diverse impacts of, in ways that pave the way to bounce back or grow and rebuilt itself in a stronger way than the city was before, or not.

According to Vale and Campanelle (2005) the city is "*humankind's most durable artefact*" or in other words "*cities were sacked, burned, bombed, flooded, starved, irradiated – they have, in almost every case, risen again like the myth of the phoenix* (In: Chelleri 2012: 209)

Cities are a good example for complex systems and hence a good example for resilience analysis. They are coupled human-ecological systems and composed of smaller ones (e.g. utilities, buildings, weather, businesses, open spaces, transportation networks, financial markets, people, politicians, planners, and so on). According to Bai (2003) cities are "*living systems – dynamic, connected, and open – constantly evolving in many and varied ways to internal interactions and influence of external impacts" (In: Chelleri 2012:212).*

In addition cities follow the non-equilibrium view of resilience and like all complex systems resilience is defined as "*the ability to withstand, recover from, and reorganize in response to crises" (Pickett et al 2004: 373)*.

In the context of cities Alberti et al (2003) defines urban resilience as "*the degree to that cities are able to tolerate alteration before reorganising around a new set of structures and processes"*. The explanation of urban resilience is based on the approach on measuring how well a city can balance human functions and ecosystem. An interesting outcome of resilience research is that societies are flexible, capable to adjust to uncertain events and is even able to benefit from negative impacts (In: Resilience Alliance, 2007: 8).

Some resilience research disciplines are focusing on urban resilience. One of the first concepts is from Paul Baran (1964), the concept of network resilience, characterised by the systems structure. His opinion is that centralized networks, with one source, are more vulnerable, decentralized networks, with a network of sources, are less vulnerable, and distributed networks are the most resilient ones (In: Chelleri 2012: 297)-

As stated by Batty et al (2004) the whole complexity of cities isn't explored, only parts of the multilayered systems is being understood so far. Hence urban resilience is complex too and this causes a diverse perception on the topic and a various range of frameworks and indicators (In: Resilience Alliance, 2007: 9).

4.3 METHODOLOGIES AND FRAMEWORKS FOR INTEGRATED ASSESSMENTS

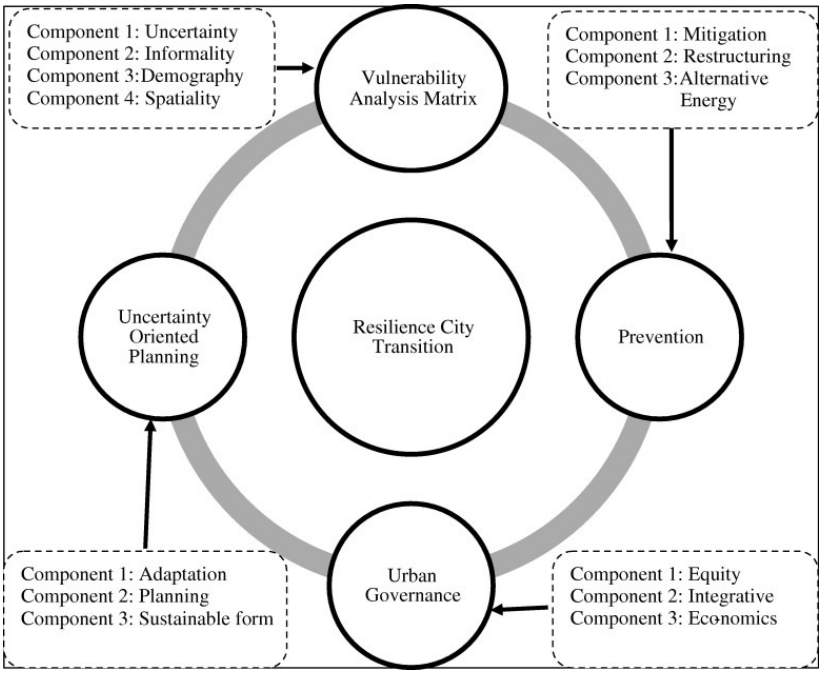
Assessing resilience is as complex as vulnerability assessment because of the various interactions of people, community, societies and the environment. Present a lot of conceptual frameworks exist to measure and define characteristics of resilience and following some are discussed and illustrated.

Resilient City Planning Framework (RCPF) (Jabareen 2012)

Jabareen (2012) suggests the so called "Resilient City Planning Framework" (RCPF). The framework should help urban communities to move towards a more resilient state in the future. According to Jabareen *"city and community resilience [is] a phenomenon that is complex, non-deterministic, dynamic in structure, and uncertain in nature[...], it is affected by a multiplicity of economic, social, spatial, and physical factors [...], and its planning involves a wide range of stakeholders including civil society, local and national governments, the private sector, and various professional communities."*

The following figure shows the conceptual framework of Jabareen and its four main interrelated concepts and components.

Figure 15: Resilient City Planning Framework (Jabereen, 2012)



Source: Jabareen, 2012: 4

The first component of the framework is the "Vulnerability Analysis Matrix" and it identifies types, demography, intensity, scope, and spatial distribution of environmental risk, natural disasters, and future uncertainties in cities and in addition to address how hazards, risks, and uncertainties affect various urban communities and urban groups. The Demography of vulnerability component focus on demographic and socio-economic aspects and informality assesses the scale and social, economic, and environmental conditions of informal urban spaces. Furthermore scenarios of uncertainties, especially with focus on the spatial distribution of vulnerability, are important because they can have an impact on the resilience of cities.

The second part is called "Urban Governance" and focuses on "*the governance culture, processes, area, and roles of the resilient city and it shows the importance of inclusive decision making processes, open dialog, accountability, and collaboration*". Jabereens argument is that cities are more resilient where the governance is able to quickly reorganize basic services and social, institutional, and economic activity after a disaster. In addition he sees negative impacts of weak governance, with lack of capacity and competence to engage in planning and decision making, on resilient cities. This integrative approach is necessary to improve local capacity by increasing knowledge, providing resources, establishing new institutions, enhancing good governance, and granting more local autonomy and integrates all different stakeholders in the process. Furthermore Jabereen integrates equity as a factor of resilience in his framework. The monetary factor shows the social issues as poverty, inequality, environmental justice, and public participation in context of equity of a community.

The next characteristic is the economic aspects of a community and the third component is called "prevention. It explains prevention of future, environmental hazards, and climate change impacts and consists of mitigation, restructuring, and methods on applying alternative energy. The restructuring factor shows the possibility of a community to restructure itself in order to diverse challenges.

The last component is called "uncertainty-oriented planning" and is seen as a way to rethink and revise current planning methods and approaches. It is necessary to bear in mind that planning shapes all dimensions of the built environment and its major impact on the resilience of a city. It incorporates adaptation planning approaches and sustainable forms (Jabareen, 2012)

The following table shows some key questions relevant for assessing city resilience according to Jabareen (2012):

Table 7: Resilient City Framework; important questions

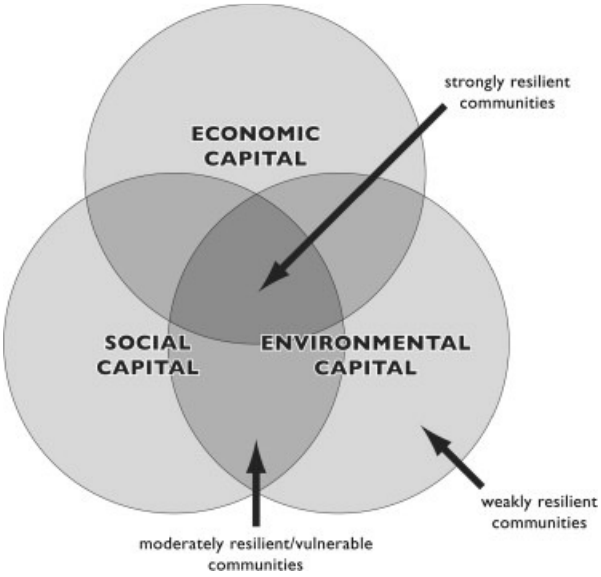
CONCEPTS	COMPONENTS	KEY QUESTIONS (MEASUREMENTS)
Concept 1: Urban vulnerability matrix analysis	C1: Uncertainty	C1: What are the hazard and environmental uncertainties?
	C2: Informality	C2: What is the scope, geography, socio-economic, demographic, and physical characters of existing informal settlements in or closed to the city?
	C3: Demography	C3: What is the nature of vulnerable demography in the city by age, gender, health, and other social group?
	C4: Spatiality	C4: What is the spatial distribution of environmental hazards or risks?
Concept 2: Uncertainty orientated planning	C1: Adaptation	C1: What adaptation measures are taken to reduce risks and cope with future uncertainties?
	C2: Planning	C2: How do planning methods cope with uncertainties?
	C3: Sustainable form	C3: what are characteristics of the existing and planned urban form typologies?
Concept 3: Urban governance	C1: Equity	C1: Who participates in decision-making and planning regarding environmental and uncertainty issues?
	C2: Integrative	C2: Is the urban governance approach integrating institutional, legal, social, economic, and environmental aspects?
	C3: Eco-economics	C3: What is the nature of the existing and planned ecological economy?
Concept 4: Prevention	C1: Mitigation	C1: What mitigation measures are taken to reduce risks and to prepare the city for future environmental hazards?
	C2: Restructuring	C2: What are the proposed or planned spatial, physical, and economic restructuring policies that aim to face the environmental hazards and uncertainties?
	C3: Alternative energy	C3: How does the city address the energy sector and whether it proposes strategies to reduce energy consumption and to use new alternative and cleaner energy sources?

Source: Jabareen, 2012: 8

Community resilience, vulnerability, and capital (Wilson, 2012)

Wilson explains that community resilience and vulnerability are best conceptualized in context of social, economic, and environmental capital existing in a community and how these capitals are interacting. The following figure shows a conceptual model of the linked factors.

Figure 16: Community resilience, vulnerability, and capital (Wilson, 2012)



Source: Wilson, 2012: 24

The strongest resilience can be achieved at the intersection between strong economic, social and environmental capital, when all 3 capitals are equally well developed.

Wilson describes communities where only two capitals are well developed as "*moderately resilient/vulnerable" and communities with only one developed capital with "weak resilience/high vulnerability*". He explains this by the following example: Communities, who focus almost entirely on developing economic capital, without taking social or environmental capital in account, will be vulnerable because some people may benefit disproportionately in financial terms. In addition resilient communities can also have some vulnerability characteristics and reverse. Wilson particularly emphasizes the importance of the interdependence between the three capitals and he also explains that strongest resilience can probably never be achieved in a community and should only be seen as an "ideal state" (ibid.).

Capital based resilience approach (Mayunga 2007)

Especially in hazard and disaster field researcher are using the social capital approach to define resilience because resilience and sustainability depend on the ability of a community *"to appreciate, access, and utilize the major forms of capital*" (Beeton, 2006 in Mayunga 2007:). Mayunga uses the capital approach to assess community disaster resilience. He defines the capital as: social, economic, physical, human, and natural. The definitions of the capitals are as follows.

Social capital includes aspects of social structure, trust, norms, and social networks all important to facilitate collective action. Community ties and networks are important because they allow people to rely on social resources of a community and furthermore these communities are more able to address collective concerns.

Mayunga recommends to asses social capital by the number "*of non-profit organizations, voluntary associations, religious organizations, voter participation and registration, newspaper readership, and sport and recreational clubs operating in the community [...] and in addition through activities such as involvement in public affairs, public meeting, informal sociability and trust" (ibid.).*

Economic capital is explained by financial resources of people to sustain their livelihoods and can be measured by "*savings, income, investments, and credit".* Economic capital shows the ability of an individual and or community to react to disaster impacts and the time they need to recover. It can be measured by household income, property value, employment, and investment. Mayungas opinion is that "*the more stable and growing, economy will generally enhance resilience" (ibid.)*

Physical capital refers to the built environment and contains "*residential housing, public buildings, business/industry, dams and levees, and shelters [...] and "lifelines such as electricity, water, telephone, roads, bridge, and critical infrastructure such as hospitals, schools, fire and police stations, and nursing homes*". All physical infrastructures are important for a proper functioning of a community and especially after a disaster and during evacuation. According to Mayunga it can be measured by "*the number, quality, and location of housing units, business/industry, shelters, lifelines, and critical infrastructures*" (ibid.).

Human capital is seen as the ability "*innate and derived or accumulated, embodied in the working-age population that allow it to work productively with other forms of capital to sustain the economic production*" (Smith et al., 2001). It refers to education, knowledge, skills, training and experience and in addition disaster experience. "*Human capital can thus be measured through education attainment (e.g., years of schooling), health, population density, population growth, demographic characteristics (e.g., racial and ethnicity), access to transportation services, household characteristics, housing quality, and dependence ratio*"(ibid.)

Natural capital refers to natural resources of a community such as water, minerals, oil, and land. In context of disaster resilience natural resources are necessary for protecting coastal areas from weather related hazards. "*Natural capital can thus be measured through water quality, air quality, soil quality, wetland, forests, and national and local parks*" (ibid.)

Climate Disaster Resilience Index (Shaw et al. 2006)

Shaw et al developed the so called CDRI or Climate Disaster Resilience Index focusing on coastal urban cities in Asia. The Index consists of 5 dimensions: physical, social, economic, institutional, and natural and for each dimension a set of variables is considered. Shaw et al assesses the resilience of each dimension and an overall resilience for each city. In the following table all dimensions and their variables are listed (Shaw et al. 2006).

Table 8: Climate Disaster Resilience Index

DIMENSIONS	VARIABLE CONSIDERED
1. Physical	Electricity, Water supply, Sanitation, Solid waste disposal, Internal road network, Housing and land use, Community assets, Warning system and evacuation
2. Social	Health status, Education and awareness, Social capital
3. Economic	Income, Employment, Households' assets, Access to financial service, Savings and insurance, Budget and subsidy
4. Institutional	Internal institutions and development plan, Effectiveness of internal institutions, External institutions and networks, Institutional collaboration and coordination
5. Natural	Hazard intensity, Hazard frequency

Source: Shaw et al., 2009: 6

Components of disaster resilience (Cutter 2010)

Cutter developed a set of indicators for measuring characteristics of communities fostering resilience and applied it to the South-Eastern United States.

The components contains of 5 resilience categories: social, economic, institutional, infrastructure, and community and are each measured by a set of indicators (Cutter, 2010).

Social Resilience refers to the social capacity within a community and links demographic attributes to social capacity. Cutter suggests that communities with a higher education level, fewer elderly, less disabled, and non-native speaking residents are more resilient.

Economic resilience measures the economic ability of a community and refers to housing capital, equitable incomes, employment, business size, and physician access. This component provides the possibility to measure if the local economy is diversified or based on a single sector, making a community less resilient.

Institutional resilience refers to mitigation, planning, and prior disaster experience. Organizational linkages, to enhance and protect the social systems, are an important factor for increasing resilience. Institutional resilience contains the percentage of the population covered by a hazard mitigation plan and people living at hazardous places.

Infrastructure resilience refers to community response and capacity to recover and to assess the number of private properties particularly vulnerable and this could lead to economic losses. In addition critical infrastructure is included in this component to show if a community provides evacuation ability.

Community capital refers to the relationship between individuals and between communities. Furthermore engagement of individuals in a community by forming organizations, religious, and self-help groups is an indicator of community or social capital.

Components of resilience (Twigg, 2007)

Twigg developed guidance for disaster resilient communities. The guidelines are developed for governments and civil society organisations working on disaster risk reduction (DRR) initiatives at community level, in partnership with vulnerable communities. In the following table Twigg summarizes resilience components in 5 thematic areas and gives an overview of the main factors (Twigg, 2007).

Table 9: Components of resilience (Twigg, 2007)

Thematic area	Components of resilience
1 Governance	• Policy, planning, priorities and political commitment. • Legal and regulatory systems • Integration with development policies and planning • Integration with emergency response and recovery • Institutional mechanisms, capacities and structures; allocation of • responsibilities • Partnerships • Accountability and community participation
2 Risk assessment	• Hazards/risk data and assessment • Vulnerability and impact data and assessment • Scientific and technical capacities and innovation
3 Knowledge and education	• Public awareness, knowledge and skills • Information management and sharing • Education and training • Cultures, attitudes, motivation • Learning and research
4 Risk management and vulnerability reduction	• Environmental and natural resource management • Health and well being • Sustainable livelihoods • Social protection • Financial instruments • Physical protection; structural and technical measures • Planning régimes
5 Disaster preparedness and response	• Organisational capacities and coordination • Early warning systems • Preparedness and contingency planning • Emergency resources and infrastructure • Emergency response and recovery • Participation, voluntarism, accountability

Source: Twigg, 2007: 9

Ten main characteristics of resilient systems (Bahadur et al, 2010)

Bahadur et al analysed 16 concepts of resilience in the context of climate change and disasters and developed 10 main characteristics and indicators of resilient systems.

- *"A high level of diversity*
- *"Effective governance and institutions*
- *Acceptance of uncertainty and change*
- *Community involvement and inclusion of local knowledge*
- *Preparedness, planning and readiness*
- *High degree of equity*
- *Social values and structures*
- *Non-equilibrium system dynamics*
- *Learning*
- *Adaption of a cross-scalar perspective"* (Bahadur et al 2010: 14 pp)

Characteristics for a safe and resilient community (ARUP, 2011)

For the international federation of the Red Cross and their community based disaster risk reduction programmes, ARUP defined characteristics for a safe and resilient community in a study on resilient and safe communities. According to a literature review and by classifying different assets ARUP develops main factors of a resilient community. According to ARUP *"a safe and resilient community:*

- *...is knowledgeable and healthy. It has the ability to assess, manage and monitor its risks. It can learn new skills and build on past experiences.*
- *...is organised. It has the capacity to identify problems, establish priorities and act.*
- *...is connected. It has relationships with external actors who provide a wider supportive environment, and supply goods and services when needed.*
- *...has infrastructure and services. It has strong housing, transport, power, water and sanitation systems. It has the ability to maintain, repair and renovate them.*
- *...has economic opportunities. It has a diverse range of employment opportunities, income and financial services. It is flexible, resourceful and has the capacity to accept uncertainty and respond (proactively) to change.*
- *...can manage their natural assets. It recognises their value and has the ability to protect, enhance and maintain them" (ARUP 2011: 58).*

4.4 SUMMARY OF THE MAIN CHARACTERISTICS OF RESILIENCE

The following part gives an overview of the main characteristics of resilient communities. According to the before mentioned frameworks, indicators and additional literature research the most important factors of resilience are:

PHYSICAL / INFRASTRUCTURE RESILIENCE

A RESILIENT COMMUNITY HAS INFRASTRUCTURE AND SERVICES. IT HAS STRONG HOUSING, TRANSPORT, POWER, WATER AND SANITATION SYSTEMS. IT HAS THE ABILITY TO MAINTAIN, REPAIR AND RENOVATE THEM.

Physical capital refers to the built environment and contains "*residential housing, public buildings, business/industry, dams and levees, and shelters [...] and "lifelines such as electricity, water, telephone, roads, bridge, and critical infrastructure such as hospitals, schools, fire and police stations, and nursing homes"*. All physical infrastructures are important for a proper functioning of a community and especially after a disaster and during evacuation. Physical assets are important to meet basic needs. In addition infrastructure resilience refers to community response and capacity to recover and to assess the number of private properties particularly vulnerable and lead to economic losses. In addition critical infrastructure is included in this component to show if a community provides evacuation ability. (Mayunga 2007, Twigg 2009, Cutter 2010)

ECONOMIC RESILIENCE – EQUITY

A RESILIENT COMMUNITY HAS EQUITY AND ECONOMIC OPPORTUNITIES. IT HAS A DIVERSE RANGE OF EMPLOYMENT OPPORTUNITIES, INCOME AND FINANCIAL SERVICES. IT IS FLEXIBLE, RESOURCEFUL AND HAS THE CAPACITY TO ACCEPT UNCERTAINTY AND RESPOND (PROACTIVELY) TO CHANGE.

A high degree of equity or capital is stressed by many approaches and most are certain that a high degree of equity in a system leads to an increase of resilience. Adger (2000) argues that stable livelihoods are important for social resilience. Furthermore Twigg (2007) sees an equal distribution of wealth and assets and a strong and equitable economy as an essential characteristic for building a resilient community. Jabereen integrated equity as a factor of resilience in his framework. It indicated social issues as poverty, inequality, environmental justice, and public participation in context of equity of a community. Furthermore economic assets are the ability of a community to be adaptive and flexible in terms of economic availability. Economic capital is explained by financial resources of people to sustain their livelihoods and it can be measured by "*savings, income, investments, and credit*". *(Mayunga 2007)*

Economic resilience measures the economic ability of a community and refers to housing capital, equitable incomes, employment, business size, and physician access.

This component provides a possibility to measure if the local economy is diversified or based on a singles sector that makes a community less resilient. (Mayunga, 2007, Twigg 2009, Cutter 2010, Jabereen 2012, Adger 2000)

NATURAL CAPITAL / ENVIRONMENTAL ASSETS

A RESILIENT COMMUNITY CAN MANAGE THEIR NATURAL ASSETS. IT RECOGNISES THEIR VALUE AND HAS THE ABILITY TO PROTECT, ENHANCE AND MAINTAIN THEM.

According to Mayunga (2007) natural capital refers to the natural resources of a community such as water, minerals, oil, and land. In context of disaster resilience natural resources are necessary for protecting coastal areas from weather related hazards. "*Natural capital can thus be measured through water quality, air quality, soil quality, wetland, forests, and national and local parks*". Furthermore Bahadur (2010) & Twigg (2009) see the importance of trees and forest to mitigate against wind, rain, tsunamis, landslides, erosion and fires.

HUMAN CAPITAL

A RESILIENT COMMUNITY IS KNOWLEDGEABLE AND HEALTHY. IT CAN LEARN NEW SKILLS AND BUILD ON PAST EXPERIENCES.

Human capital (Mayunga 2007: 42pp) is seen as the ability "*innate and derived or accumulated, embodied in the working-age population that allow it to work productively with other forms of capital to sustain the economic production"* (Smith et al., 2001). It refers to education, knowledge, skills, training and experience and in addition disaster experience. "*Human capital can thus be measured through education attainment (e.g., years of schooling), health, population density, population growth, demographic characteristics (e.g., racial and ethnicity), access to transportation services, household characteristics, housing quality, and dependence ratio*." (Mayunga 2007: 45) Furthermore human assets refer to the idea that human health and knowledge are central to the creation of a safe and resilient community. Important are skills, language competency, health, education and also local and traditional knowledge. (Pasteur, 2011, Mayunga 2007, Twigg, 2009, Bahadur 2010, Cutter 2010)

Social Resilience refers to the social capacity within a community and links demographic attributes to social capacity. Cutter suggests that communities with a higher education level, fewer elderly, less disabled, and non-native speaking residents are more resilient.

SOCIAL VALUES, COMMUNITY ENGAGEMENT, NETWORKS AND LOCAL KNOWLEDGE

A RESILIENT COMMUNITY HAS SOCIAL VALUES, ENGAGEMENT, NETWORKS AND LOCAL KNOWLEDGE. COMMUNITY TIES AND NETWORKS ARE SEEN AS NECESSARY BECAUSE THEY ALLOW PEOPLE TO RELY ON THE SOCIAL RESOURCES IN A COMMUNITY AND FURTHERMORE THESE COMMUNITIES ARE MORE ABLE TO ADDRESS COLLECTIVE CONCERNS.

Community engagement, ownership, participation and local knowledge are mentioned in most approaches. Furthermore engagement of individuals in a community by forming organizations, and self-help groups are indicator of community or social capital.

Social capital includes aspects of social structure, trust, norms, and social networks that are all important to facilitate collective action. Community ties and networks are seen as necessary because they allow people to rely on the social resources in a community and furthermore these communities are more able to address collective concerns. Mayunga (2007: 42) recommends to asses social capital by the number "*of non-profit organizations, voluntary associations, religious organizations, voter participation and registration, newspaper readership, and sport and recreational clubs operating in the community [...] and in addition through activities such as involvement in public affairs, public meeting, informal sociability and trust". (Cutter, 2010, Manyena 2006, Twigg, 2009, Bahadur 2010)*

INSTITUTIONS & GOVERNANCE

A RESILIENT COMMUNITY HAS EFFECTIVE INSTITUTIONS AND INSTITUTIONAL STRUCTURES AND AN EFFECTIVE GOVERNMENT TO QUICKLY REORGANIZE BASIC SERVICES AFTER A DISASTER. IT IS ORGANISED AND HAS THE CAPACITY TO IDENTIFY PROBLEMS, ESTABLISH PRIORITIES AND ACT.

A lot of approaches stress the need to have effective institutions or institutional structures within a system. Scientists focus on the importance of effective governance, polycentric and multi-layered institutions and institutions that can facilitate learning and development. In addition the governance must be representative and district or national government should support livelihoods (Resilience Alliance, 2007; Mayunga 2007, Bahadur 2010, Cutter 2010, Twigg 2009).

Tanner et al discovered "*good governance*" components that should help deliver climate resilience especially in developing countries. These components are: *decentralisation and autonomy, transparency and accountability, responsiveness and flexibility, participation and inclusion, and experience and support.* All before mentioned characterisations are necessary for planning and implementing integrated climate change resilience programmes (Tanner, 2010: 5pp)

Jabareens (2012) argues that cities are more resilient when governance is able to quickly reorganize basic services and social, institutional, and economic activity after a disaster. In contrast he sees negative impact of weak governance, with lack of capacity and competence to engage in planning and decision making, on resilient cities.

UNCERTAINTY / CHANGE & PREPARED, AWARE

A RESILIENT COMMUNITY IS AWARE OF HAZARDS, RISKS AND UNCERTAINTIES AND PREPARED FOR EMERGENCY CASES.

Furthermore acceptance of uncertainty and change is important for resilient systems. Especially Folke (2006) focuses on these characteristic. The main idea is that resilience of a community is influenced by its memory of past disturbances (Bahadur, 2010).

A component mentioned by Jabereen is called "*uncertainty-oriented planning*" and is seen as a way to rethink and revise current planning methods and approaches (Jabereen 2012: 3pp) It is necessary to bear in mind that planning shapes all dimensions of the built environment and that this has major impact on the resilience of a city. It should incorporate adaptation planning approaches and sustainable forms.

Preparedness, planning and readiness for disturbances also influence resilient systems. Especially the survival and recovery approach incorporates the acceptance that change will occur and preparing to live with it is necessary. Leadership and community members need to be are aware of hazards and risk information need to be utilized when making decisions. A community need to be capable of receiving notifications and alerts of coastal hazards, warning at-risk populations, and individuals acting on the alert. Mechanisms and networks need to be established and maintained to respond quickly to coastal disasters and address emergency needs at the community level. Plans need to be in place prior to hazard events to accelerate disaster recovery, engage communities in the recovery process, and minimize negative environmental, social, and economic impacts. (Foster 2006).

Learning and building on past experience and integrating it with current knowledge are also important for resilient systems (Folke 2006, Arup 2010, Bahadur 2010, Twigg 2009).

HIGH DIVERSITY

A RESILIENT COMMUNITY IS HIGHLY DIVERSE.

High diversity contributes greatly to the resilience of systems in the range of functional groups and especially ecological diversity is extended by a large number of theorists. (Berkes 2007: 289).The Social Infrastructure approach emphasises the importance of communities relying on diverse natural resources as it insulates them from the 'b*oom and bust nature of markets', environmental variability and extreme weather events, that may adversely impact some resources* (Adger 2000).

In addition the Survival and Recovery approach sees a diversity of planning, response and recovery activities as an essential component of resilience to climate change because 'a diversity of options has greater potential to match the particular scenario of impacts that occur' (Folke, 2006; Holling 1973, Resilience Alliance, 2007).

5 GUIDELINE FOR COASTAL CITY RESILIENCE ASSESSMENT

The following chapter explains a guideline for a coastal city resilience assessment with key elements and benchmarks. First the importance of resilience assessment in urban planning is discussed and after the framework and each category is defined in detail.

5.1 THE NEED FOR RESILIENCE ASSESSMENT IN URBAN PLANNING

In the previous chapters climate change, related impacts, in particular the exposure of coastal cities is explained. In addition the main part of the thesis discusses theoretical approaches, assessment frameworks and methodologies of the terms vulnerability and resilience.

As an implication of the literature review on resilience and vulnerability it is obvious that these science concepts are highly diverse, with a lot of different frameworks, assessment methods and indicators. Hence no model exists that includes all necessary factors for a resilience assessment of coastal cities. Furthermore in spatial planning theory no consistent approach can be found to assess resilience in the face of climate change. Therefore the author decided to develop a resilience framework, based on the different concepts of resilience and vulnerability, illustrated in the following part of the chapter.

Although there are many different ways to deal with climate change related impacts in spatial planning, especially mitigation and adaptation measures and strategies, the resilience approach plays a minor role in the planning discipline. However due to the interdisciplinary of spatial planning and the ability to influence society on all levels, resilience needs to be integrated in the field of planning. Furthermore spatial planning is one of the best environments to integrate all necessary factors for an urban resilience assessment and to built “resilient cities”.

The following framework is an example of a resilience assessment for a city in the context of climate change related impacts. It includes important factors of a resilient city and most of these factors can be changed and modified by spatial planning actions and policies.

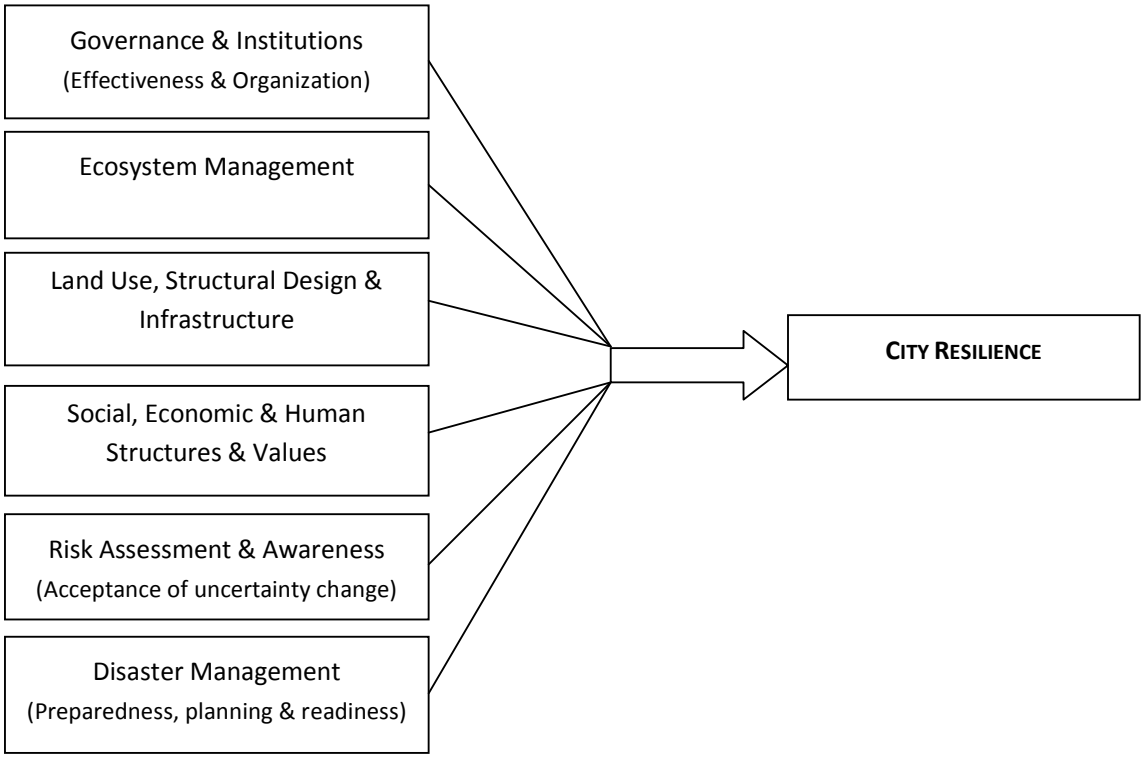
5.2 RESILIENCE FRAMEWORK

The framework of the “City Resilience” suggests 6 key sets of resilience. The six key factors are based on the “main characteristics of a resilient city”, listed and explained in the chapter before, and presents the fundamental parts of a resilient city: Governance & Institutions, Ecosystem Management, Land Use, Structural Design & Infrastructure, Social, Economic & Human Structures and Values, Risk Assessment and Awareness, and Disaster Management. Following, each of these components are briefly described and explained by benchmarks. Furthermore all benchmarks are illustrated by a couple of questions and statements to clarify the meaning and to assist the assessment.

Due to the fact that the resilience approach focuses on the positive side of climate change related impacts the author decided to focus mainly on resilience.

The following diagram illustrates the parts of “City Resilience” including all 6 key factors and the lines show the connection of the overall resilience and each element.

Figure 17: Resilience Framework



Source: own elaboration

An assessment of Coastal City Resilience (CCR) provides essential information needed to adapt plans and programs and to enhance resilience. For this thesis the assessment process uses desired conditions and benchmarks to evaluate the capacity of a city to reduce risk, accelerate disaster recovery, and adapt to change from climate change impacts.

The CCR assessment described in this guide is intended as a rapid assessment, to be conducted as a collaborative and participatory undertaking by coastal communities, national and local government agencies, nongovernmental organizations, private sector groups, and other key stakeholders to identify strengths, weaknesses, and opportunities to enhance resilience at local and national levels.

5.3 RESILIENCE CATEGORIES AND BENCHMARKS

The author decided to establish a benchmark guide for the resilience assessment of coastal cities. These benchmarks represent a generic list of desired conditions against the resilience status of a coastal city is evaluated.

The benchmarks provide the foundation of the Coastal City Resilience assessment and help to identify the strengths, weaknesses, and gaps in city resilience. Some benchmarks may need to be adapted to better reflect the local context in that they are used.

The list and elements needed to be evaluated and customized for each assessment based on the evaluation process, data availability and participations. Hence for every of the 6 components baseline ideas and concepts are mentioned and explained by questions that could be relevant for the resilience assessment for each component. These concepts and questions should be a guide to evaluate and assess the resilience of a city or community.

The elements and benchmarks are based on the literature review of this thesis and in addition parts of the benchmarks originate on a study called “How resilient is your coastal community” by the United States Agency for International Development (2007).

Governance & Institutions

A resilient community has effective institutions and institutional structures and an effective government to quickly reorganize basic services after a disaster. It is organised and has the capacity to identify problems, establish priorities and act. In addition leadership, a legal framework, and institutions provide positive conditions for resilience. Governance provides the enabling conditions for coastal communities to absorb or resist perturbations, bounce back from disturbances, and adapt to change.

A necessary trait of governance of building resilience is to grant an integrating framework for institutions at all levels and various scales, to address the management needs within a coastal community. A second essential characteristic of governance is participatory and to encourage engagement of multiple stakeholders, both public and private, within a democratic process for planning. Such participation strengthens community resilience and engenders ownership of processes and outcomes.

The final essential characteristic of governance is the need to be strong and efficient, and provide effective coordination of the various coastal environment and disaster management tools to build resilience. Furthermore governance needs to constantly promote education and to apply appropriate forms of law enforcement. Finally, the governance needs to ensure that legal, political and financial frameworks are aligned to support broad outcomes.

CITY DEVELOPMENT POLICIES, PLANS, AND PROGRAMS ARE IMPLEMENTED AND MONITORED IN A PARTICIPATORY AND TRANSPARENT MANNER

- Are there community goals for livelihoods, natural resources, and hazard resilience?
- Is there a shared vision for resilience in the city?
- Are specific actions to enhance resilience incorporated in plans and programs?
- Do local decisions on development, infrastructure investment, social programs, and other activities consider potential risks from natural hazards?

BASIC SERVICES (I.E. WATER, TRANSPORTATION, SECURITY, ETC) ARE ACCESSIBLE TO ALL SECTORS OF SOCIETY

- Are needed basic services provided efficiently and reliably?
- Are all sectors of society reached by these basic services?

PARTICIPATORY PLANNING AND COLLABORATION MECHANISMS AMONG DIFFERENT SECTORS AND VARIOUS LEVELS OF GOVERNMENT ARE ESTABLISHED AND USED TO MANAGE FOR RESILIENCE

- Are there interagency (national and local) and multi sectoral coordination bodies that meet to review policies, plans, and programs?
- Have resilience strategies and activities been developed that require several agencies to work together?
- Are programs in place that link sectors and institutions?

TECHNICAL AND FINANCIAL SUPPORT MECHANISMS ARE TRANSPARENT, ACCOUNTABLE, AND AVAILABLE TO SUPPORT PLANNED COMMUNITY ACTIONS

- Are there regular budget allocations and grants to support activities that reduce risks to future damage from natural hazards?
- Do community leaders have resources and tools available to build resilience for day-to-day activities?
- What resources, tools, and technical assistance are available to build community resilience?

Ecosystem Management

Natural resources provide many valuable and sustainable services to communities. These include, among others, a reliable source of food, economic development through the use of renewable resources like mangroves, transportation, protection from coastal hazards (storms, floods, tsunami, erosion, pollution, etc.), biodiversity conservation (a factor in ecological resilience and a source of benefits from nature-based tourism and new potential medicines), and a pleasant lifestyle. .

Coastal resource management (CRM) is a process to develop and implement a coastal management scheme or plan. CRM refers to a formal or informal set of rules, practices, technologies, economies, and interactions between humans and the natural resources (animals, plants, rocks, water, etc.) located both landward and seaward of the coast, that define how resources are utilized and protected.

SENSITIVE COASTAL HABITATS, ECOSYSTEMS, AND NATURAL FEATURES ARE PROTECTED AND MAINTAINED TO REDUCE RISK FROM COASTAL HAZARDS

- Have sensitive coastal habitats been identified and mapped?
- Have regulations been established for resource extraction based on conservation priorities and risks from hazards?

POLICIES AND PLANS ARE IMPLEMENTED AND MONITORED TO EFFECTIVELY MANAGE NATURAL COASTAL RESOURCES

- Have local and national governments endorsed policies for Coastal Resource Management?
- Is there a Coastal zoning plan to minimize conflicts among resource users and to ensure that important resource areas are protected from overuse?

COMMUNITIES ARE ACTIVELY ENGAGED IN PLANNING AND IMPLEMENTING COASTAL RESOURCE MANAGEMENT ACTIVITIES

- Have community groups been involved in aspects of planning for Coastal Resource Management?
- Do implementation plans call for the participation of community stakeholders in the process?

Land Use, Structural Design & Infrastructure

The desired outcome of this element of resilience is effective land use and structural design to complement environmental, economic, and community goals and reduce risks from hazards.

A common characteristic of resilient communities is that they accept the occurrence of disaster events and they take steps to plan for them. Land use management and structural designs are good examples of planning activities communities can use to minimize potential impacts of tsunami and other coastal hazards.

By steering particular land uses away from vulnerable areas and encouraging their development in less hazard-prone locations, a community can reduce the risk to individuals and livelihoods. However, when particular types of development occur in vulnerable areas, structural design can be an effective way to absorb the shock of coastal hazards. For example, by elevating coastal buildings and using appropriate construction techniques and building materials, a community can greatly reduce the potential impacts from tsunami and other causes of coastal flooding.

LAND USE POLICIES AND BUILDING STANDARDS THAT INCORPORATE MEASURES TO REDUCE RISKS FROM HAZARDS AND PROTECT SENSITIVE HABITATS ARE ESTABLISHED, MONITORED, AND ENFORCED

- Are building safety and hazard risk reduction standards and codes supported by law and enforced?
- Are there policies that limit investment in vulnerable land areas?
- Have critical facilities been located outside of the hazard area or built to be resistant to the known hazard impacts?
- Are hazard resistant building practices taught at the secondary and technical schools?

CRITICAL INFRASTRUCTURE ARE LOCATED OUTSIDE HIGH RISK AREAS AND CONSTRUCTED TO ADDRESS RISKS FROM PRIORITY HAZARDS

- Has an assessment of critical infrastructure been conducted to determine vulnerability to various hazards?
- Are coastal engineering structures designed to reduce vulnerability to coastal hazards and minimize impacts to sensitive coastal habitats?
- Does an information campaign operate to inform the public?

DEVELOPERS AND COMMUNITIES INCORPORATE RISK REDUCTION INTO THE LOCATION AND DESIGN OF STRUCTURES

- Are builders and architects in the area knowledgeable of and able to apply the building codes and good practices?
- Have building standards to site, design, and build infrastructure in hazard areas been adopted?

EDUCATION, OUTREACH, AND TRAINING PROGRAMS ARE ESTABLISHED TO IMPROVE COMPLIANCE WITH LAND USE POLICES AND BUILDING STANDARDS

- Is there a certification program on hazard mitigation for architects and builders?
- Do local colleges or trade schools incorporate courses on land use policies, building standards, and hazard mitigation?

Social, Economic & Human Structures & Values

The desired outcome of this element of resilience is that communities are engaged in diverse and environmentally sustainable livelihoods resistant to hazards.

Changes in the economy and people's quality of life are often the main criterion upon a community's resilience is judged after a disaster. The strength of the economy and the diversity of livelihoods greatly influence the community's ability to prepare for disasters, quicken the recovery process, and adapt to changes that make them less vulnerable in the future. Despite changes in coastal ecology, health, laws, governance frameworks, or hazard response programs, it is the improvement or decline in a person's livelihood that directly affects resilience.

Society and economy are an essential element of resilience because of the direct relationship between economic activity (markets and commerce) and social life (culture, family, recreation). Changes in the local and regional economy such as new industries, specific jobs, or manufacturing technology could lead to positive and negative impacts on individuals and communities through life expectancies, employment, wealth, and quality-of-life issues. Similarly, the culture of the community, family structure, and gender roles influence economic activities. Social, cultural, and economic conditions provide the enabling environment for self reliance in a community.

DEVELOPMENT POLICIES AND PLANS BUILD SOCIAL CAPITAL AND SKILLS FOR ECONOMIC DIVERSITY AND SELF RELIANCE

- Do community development plans exist?
- What types of social safety nets exist to help vulnerable sectors of society?

LOCAL ECONOMIES ARE CHARACTERIZED BY DIVERSE AND ENVIRONMENTALLY SUSTAINABLE LIVELIHOODS

- Is the local economy dominated by one sector (e.g. tourism)?
- Are local economies and livelihoods linked to internal and external markets?
- Are resource-extracting livelihoods based on a managed and sustainable natural resource base?

SOCIAL AND CULTURAL NETWORKS PROMOTE SELF-RELIANT COMMUNITIES AND HAVE THE CAPACITY TO PROVIDE SUPPORT TO DISASTER-STRICKEN AREAS

- Is a significant portion of the community economically and/or socially marginalized?
- Are there social networks that address the needs of the weaker segments of the public such as elderly, sick and poor?
- Are mechanisms used to increase community participation in community development planning?

TECHNICAL AND FINANCIAL RESOURCES ARE AVAILABLE TO PROMOTE STABLE AND ROBUST ECONOMIES, REDUCE VULNERABILITY TO HAZARDS, AND AID IN DISASTER RECOVERY

- Are there technical resources, such as local universities, government programs, or donor projects that provide assistance to communities in developing environment-friendly livelihood diversification?
- Are businesses owners and employees aware and informed of coastal hazards (including long-term effects to businesses from erosion and sea level rise)?

Risk Assessment & Knowledge

The desired outcome of this element of resilience is that leadership and community members are aware of hazards and risk information is utilized when making decisions.

Risk knowledge explains the awareness of a community about its potential hazards and its susceptibility to experiencing the negative impacts of those hazards. It requires an understanding of all of the past hazards that threaten the community, including the potential geographic extent of impact and the potential frequency of impact. Risk knowledge is the cornerstone for building a resilient community. A community cannot map out its path toward resilience if it does not first know what is at risk.

COASTAL HAZARD RISK ASSESSMENTS ARE COMPLETED AT A SCALE APPROPRIATE TO THE COMMUNITY AND ROUTINELY UPDATED

- Did the assessment consider historical events, existing hazards, and potential future coastal hazards?
- Are results of the assessment shared with local and national stakeholders?

COASTAL HAZARD RISK ASSESSMENTS ARE COMPREHENSIVE AND INCORPORATE RISKS TO ALL ELEMENTS OF RESILIENCE (E.G. LIVELIHOODS, COASTAL RESOURCES, LAND USE, ETC.)

- Has an assessment of social and cultural vulnerability been conducted that identified areas where individual resources for disaster preparation and recovery tend to be minimal (i.e. areas with high concentrations of poverty, elderly, illiteracy, gender issues, etc.)?
- Has the community identified areas where cultural differences may bring about special needs to build resilience, such as areas with high concentrations of persons who speak a foreign language?

COMMUNITY PARTICIPATES IN THE HAZARD RISK ASSESSMENT PROCESS

- Was the community involved when hazards risks were assessed?
- Is risk information shared and used among institutions to better inform policy and action?

INFORMATION FROM RISK ASSESSMENT IS ACCESSIBLE AND UTILIZED BY THE COMMUNITY AND GOVERNMENT

- Do community development goals and the plans to achieve them take into account hazard risk?
- Are hazard risks considered by institutions when making planning and development decisions?

THE CITY INVESTS IN SCIENCE, RESEARCH AND INNOVATION IN THE CONTEXT OF VULNERABILITY AND RISK AND HAS TECHNICAL CAPACITIES

- Are city members and organisations trained in hazards, risk and vulnerability assessment techniques and supported to carry out assessments?
- Does the city invest in science and innovation?

Disaster Management (Preparedness, planning and readiness)

The desired outcome of this element of resilience is a community that is capable of receiving notifications and alerts of coastal hazards, warning at-risk populations, and acting on an alert. Furthermore mechanisms and networks are established and maintained to respond quickly to coastal disasters and address emergency needs at the community level. In addition disaster recovery is important and plans need to be in place prior to hazard events to accelerate disaster recovery, engage communities in the recovery process, and minimize negative environmental, social, and economic impacts.

The establishment of an emergency response system, including all of the institutions that are maintained to respond quickly to disasters, is essential for addressing emergency needs at the community level. Effective emergency response enables a resilient coastal community to better absorb the shock associated with disaster events. Emergency response plans and mechanisms also provide the basis for the community to bounce back quickly from the impacts of disasters. In the event of a disaster, effective emergency response procedures can reduce the loss of life and help to lessen the time and investment needed for a community to recover.

Disaster recovery is the process of restoring and improving basic services, natural resources, and livelihoods in a community affected by a hazard event. Resilient coastal communities accept that hazard events will happen in their community and develop plans and procedures before they happen to guide the recovery process.

COMMUNITY WARNING AND EVACUATION SYSTEMS, POLICIES, PLANS, AND PROCEDURES ARE IN PLACE AND CAPABLE OF ALERTING VULNERABLE POPULATIONS IN A TIMELY MANNER

- Does the community have an evacuation plan in place that is comprehensive and addresses individuals with special needs?
- Are warning system and evacuation procedures tested regularly and evaluated after exercises or hazard events to improve effectiveness?

COMMUNITY WARNING AND EVACUATION INFRASTRUCTURE IS IN PLACE AND MAINTAINED

- Are warning system components in place and maintained?
- Are hazard zones, evacuation routes, shelters, and safe areas clearly marked throughout the community with signs and/or maps?

COMMUNITY IS PREPARED TO RESPOND TO HAZARD WARNINGS WITH APPROPRIATE ACTIONS

- Have outreach programs been established to ensure that community members are aware of hazard risks, warning procedures, and evacuation plans?
- Are there trained community volunteers and/or organizations that provide awareness information?

PREDEFINED ROLES AND RESPONSIBILITIES ARE ESTABLISHED FOR IMMEDIATE ACTION AT ALL LEVELS

- Have disaster-specific emergency response plans been developed?
- Do emergency response plans clearly define leadership roles and coordination mechanisms (e.g. incident command system)?
- Have response teams (e.g., damage assessment teams, search and rescue, etc.) or other relevant committees been formed and trained for action?

BASIC EMERGENCY AND RELIEF SERVICES ARE AVAILABLE

- Have facilities vital to emergency response activities been identified?
- Have measures been taken to ensure that emergency healthcare and life support systems for the community will be functional during a disaster?

PREPAREDNESS ACTIVITIES (DRILLS AND SIMULATIONS) ARE ONGOING TO TRAIN AND EDUCATE RESPONDERS

- Does the community conduct regular training programs for institutions responsible for emergency response activities?
- Do public awareness and education programs exist to inform all sectors of the community of the emergency response plans?

DISASTER RECOVERY PLAN IS PRE-ESTABLISHED THAT ADDRESSES ECONOMIC, ENVIRONMENTAL, AND SOCIAL CONCERNS OF THE COMMUNITY

- Does the community have pre-established disaster recovery plans?
- Are multiple hazard scenarios used to consider the range of potential impacts?

DISASTER RECOVERY PROCESS IS MONITORED, EVALUATED, AND IMPROVED AT PERIODIC INTERVALS

- Are there processes established to monitor and report on the progress of recovery efforts?
- Are post-disaster review and analysis of the recovery process conducted to revise protocols for the future?

TECHNICAL AND FINANCIAL RESOURCES ARE AVAILABLE TO SUPPORT THE RECOVERY PROCESS

- Are there recovery programs or incentives that offer funds for recovery?
- Is assistance available to manage the recovery resources to a useful end?

Summary of the 6 key sets of resilience and the benchmarks (1)

GOVERNANCE & INSTITUTIONS
• City development policies, plans, and programs are implemented and monitored in a participatory and transparent manner. • Basic services (i.e. water, transportation, security, etc) are accessible to all sectors of society. • Participatory planning and collaboration mechanisms among different sectors and various levels of government are established and used to manage for resilience. • Technical and financial support mechanisms are transparent, accountable, and available to support planned community actions.
ECOSYSTEM MANAGEMENT
• Sensitive coastal habitats, ecosystems, and natural features are protected and maintained to reduce risk from coastal hazards. • Communities are actively engaged in planning and implementing coastal resource management activities. • Policies and plans are implemented and monitored to effectively manage natural coastal resources.
LAND USE, STRUCTURAL DESIGN & INFRASTRUCTURE
• Land use policies and building standards that incorporate measures to reduce risks from hazards and protect sensitive habitats are established, monitored, and enforced. • Critical infrastructure are located outside high risk areas and constructed to address risks from priority hazards. • Developers and communities incorporate risk reduction into the location and design of structures. • Education, outreach, and training programs are established to improve compliance with land use polices and building standards.
SOCIAL, ECONOMIC & HUMAN STRUCTURES & VALUES
• Development policies and plans build social capital and skills for economic diversity and self reliance. • Local economies are characterized by diverse and environmentally sustainable livelihoods. • Social and cultural networks promote self-reliant communities and have the capacity to provide support to disaster-stricken areas. • Technical and financial resources are available to promote stable and robust economies, reduce vulnerability to hazards, and aid in disaster recovery.

Summary of the 6 key sets of resilience and the benchmarks (2)

RISK ASSESSMENT & KNOWLEDGE
• Coastal hazard risk assessments are completed at a scale appropriate to the community and routinely updated • Coastal hazard risk assessments are comprehensive and incorporate risks to all elements of resilience (e.g. livelihoods, coastal resources, land use, etc.). • Community participates in the hazard risk assessment process. • The city invests in science, research and innovation in the context of vulnerability and risk and has technical capacities • Information from risk assessment is accessible and utilized by the community and government.
DISASTER MANAGEMENT (PREPAREDNESS, PLANNING AND READINESS)
• Community warning and evacuation systems, policies, plans, and procedures are in place and capable of alerting vulnerable populations in a timely manner. • Community warning and evacuation infrastructure is in place and maintained • Community is prepared to respond to hazard warnings with appropriate actions. • Predefined roles and responsibilities are established for immediate action at all levels. • Basic emergency and relief services are available. • Preparedness activities (drills and simulations) are ongoing to train and educate responders. • Disaster recovery plan is pre-established that addresses economic, environmental, and social concerns of the community. • Technical and financial resources are available to support the recovery process. • Disaster recovery process is monitored, evaluated, and improved at periodic intervals.

6 CASE STUDY - ROTTERDAM

The author decided to choose a city that is already adapting and planning for resilience to illustrate how the resilience framework can be applied. Due to the fact that Rotterdam is already adapting and planning for resilience, the city is chosen to illustrate and explain the factors and benchmarks of the resilience framework.

The Netherlands and the city of Rotterdam are trying to be and act resilient and are "adapting" to climate change. As a result you can find a lot of different policies, programmes covering this topic but there is not an overall resilience concept in the face of climate change. Hence an assessment of the resilience of Rotterdam need to incorporate different aspects and therefore the "resilience assessment guideline" is useful.

At the beginning the following chapter gives an overview of relevant facts and figures of the Rotterdam. In addition essential information about the country in the context of climate change, adaptation and resilience planning is explained. At the end, as a summary, the resilience of Rotterdam is assessed, according to the resilience framework and benchmarks.

6.1 CITY PROFILE

Location & Connection

Figure 18: The Netherlands map

Source: www.in-netherlands.co.uk

The city of Rotterdam is the second largest city of the Netherlands with around 700.000 inhabitants; the urban region counts about 1.3 million citizens and is situated in the Province of Zuid-Holland. Rotterdam is part of the so-called “Randstad area”, the economic centre of the Netherlands that consists of the four biggest Dutch cities. Rotterdam is considered the marine access to Western Europe and is situated on the banks of the “New Meuse” River (“Nieuwe Maas”), one of the channels in the delta formed by the rivers Rhine and Meuse (City of Rotterdam 2009b; Dircke, 2010).

The region of Rotterdam includes Rotterdam, Vlaardingen, Schiedam, Spijkenisse and Capelle a.d. Ijssel (Connecting Delta Cities). The city is divided into a northern and a southern part by the river Nieuwe Maas and has 14 neighbourhoods. It is connected by the Beneluxtunnel, the Maastunnel, the Erasmus Bridge that is a subway tunnel, the Willems railway tunnel, the Willems Bridge, the Queen’s Bridge and the Van Brienenord Bridge (City of Rotterdam 2009b)

Figure 19: City of Rotterdam map

Source: city of Rotterdam (2012)

The location is conveniently because the city is well connected to the Randstad and the hinterland by road, rail, and inland waterway. In addition there are highways and an efficient rail network to other major cities like Amsterdam, Utrecht and The Hague. International destinations can be reached from the seaport, the river Maas and the airport. Rotterdam is strategically good located in close proximity to the North Sea and it is a large city with a well-equipped port infrastructure, multi-modal accessibility and considerable volumes of goods and passengers (City of Rotterdam 2009b)

Furthermore Rotterdam built the first Dutch metro in 1968 and it consists of three main lines, the system has 78, 3 km of rail tracks and about 62 stations. The system operates with 5 lines, 3 on the Caland-line, 1 on the Erasmusline and 1 on the Hofpleinline and a section of the Erasmusline. In addition the Rotterdam tramway network offers 13 tram lines with a total length of 93, 4 km. In addition 33 city busses are operating with a total length of 432, 7 km. On the water there is a so-called water bus that goes from Rotterdam to Dordrecht and back (ibid.)

The city is home to the Erasmus University of Rotterdam and several other universities of applied sciences. Rotterdam developed rapidly in the last decade and is one of the major economic areas of the Netherlands (ibid.).

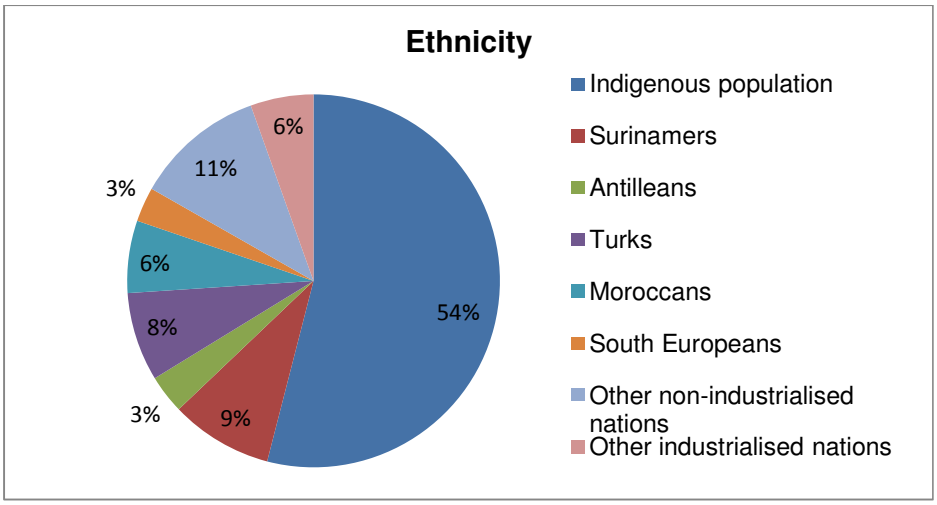
According to the State of European Cities report Rotterdam is seen as a city with "*specialised poles*" and plays "*an important international role in at least some aspects of the urban economy" and as a "gateway*" (ibid.: 18).

Demographics

Rotterdam population was 616,456 in 2012 and the density 2,994 per km^2. The population forecast for Rotterdam is expected to grow to 619.475 in 2025 and no major shift in the gender structure is expected. At the moment the division is more or less 50:50 (City of Rotterdam, 2012: 1).

The ethnicity, visualised in the following graphic, is diverse in Rotterdam. 54% are called "*Indigenous population*", people born in the Netherlands or whose parents were born there and 6 % are from other industrialised countries. The other bigger parts of population are Surinamers, Antilleans, Turks, Moroccans and South Europeans (ibid.)

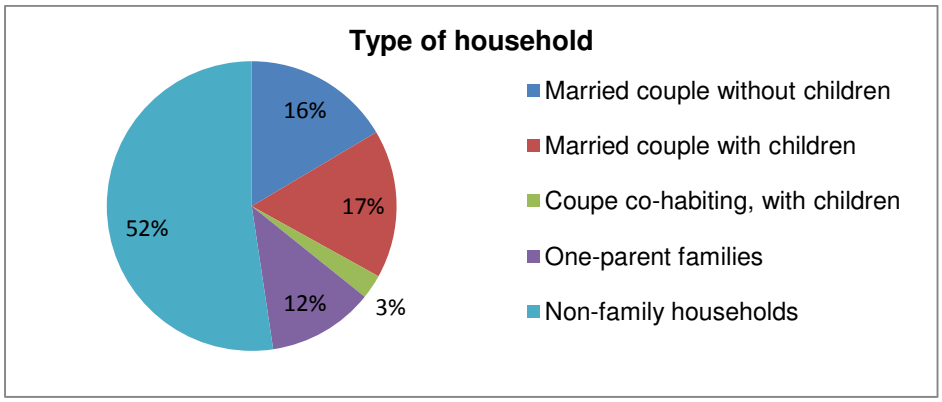
Figure 20: Ethnicity Rotterdam



Source: Centre for research and statistics The Netherlands, 2006:10 (own elaboration)

According to splitting up types of household 52 % are living in non-family households, 33 % are living with children and there is share of 12 % with only one parent (Centre for research and statistics, 2006: 8).

Figure 21: Type of household Rotterdam



Source: Centre for research and statistics The Netherlands, 2006: 8 (own elaboration)

The state of health can be expressed by the OECD indicator for the period 2004-2007 and amounts to 13, 4% for the region of Rotterdam. It is lower than in Amsterdam and The Hague (17, 5% and 13, 7%) but it is higher than the Dutch average (12, 6%). For example Rotterdam has the second highest portion of disabilities (10, 1%) after Amsterdam (11, 2%) and there are 4, 7 % (28.824) people who are receiving a disability benefit (City of Rotterdam 2009b: 21).

There are several factors worthwhile noting in comparison to other Dutch cities. The percentage of highly educated persons is lower than the Dutch average (4, 7 % in 2007). Furthermore the average household income is below the national average (Euro 30.100 in 2005). In addition non-native households have 3.500 Euro per year less to spend than native households and there are relatively more non-western households living below the poverty line. The education level of the migrant labour force is lower than that of the native population (ibid: 21)

The population of Rotterdam is imbalanced with a substantial underclass, a smaller middle class and a limited upper class. In some districts more than 40 % of the workforce is unemployed and more than 15 % of the population is living on social assistance benefit. Furthermore in other districts 60% of the local population has limited education level and also 60% of children in Rotterdam are growing up in a so called “problem district” (ibid. 21)

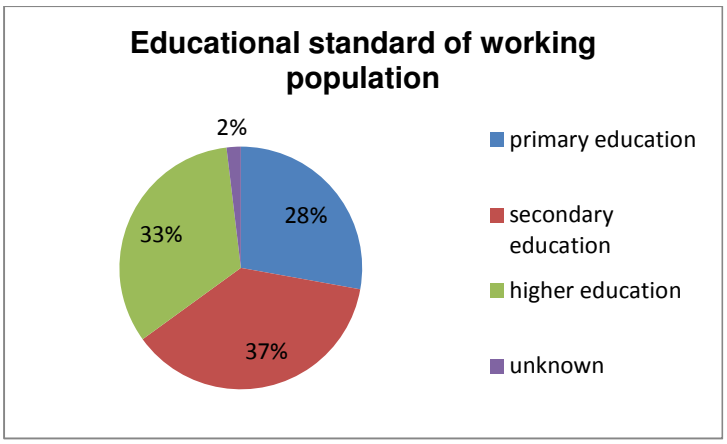
A total of 20% of the residents is younger than 18 and this percentage is rising. In addition there are nearly 170 different cultures living in Rotterdam. Hence there are a lot of risk factors like poverty, unemployment, growing up in deprived area and single parents. For example 20 % of children grow up in families living on or around social minimum, 30% grows up in a single parent family and 58 % of children have parents born outside the Netherlands. The city is trying to handle these problems in initiating projects and programmes by municipal services, youth care, knowledge institutions and judicial systems. One example was the memorandum called “Youth work in Rotterdam” in 2005. (City of Rotterdam 2009b, Centre for research and statistics, 2006)

Education

In 2008 the Dutch were concerned about the relatively low participation of non-Western minorities in higher education in the Netherlands as in other European countries. In addition the report shows that there is a relatively weak commitment to lifelong learning and professional upgrading in the award programmes that have important labour market validity. In 2008 the OECD reported that in the Netherlands 86, 1% of 15-19 year olds are enrolled in education, which is above the OECD average of 80.5% but on par with Western Europe. Participation of the 20-29 year age group in the Netherlands (25.5%) is just above the OEDC average (24.7%). After 30 years age participation rates fall well below the OECD average, however. Just 2.9% of 30-39 year olds are enrolled in education as defined by OECD compared to 5.6% in the OEDC as a whole. (City of Rotterdam 2009b: 29pp)

In contrast Rotterdam is a student city and reaches the 3rd position in the Netherlands based on the numbers of students. The educational standard of the working population accounts to 33 % with higher education, 37 % with secondary education and 28 % with only primary education. In addition there is also a part of 2 % of the population where their educational standard isn't known. The following graphic shows the share of educational standard of the working population of the city of Rotterdam. (City of Rotterdam 2009b, Centre for research and statistics, 2006)

Figure 22: Educational standard of working population Rotterdam



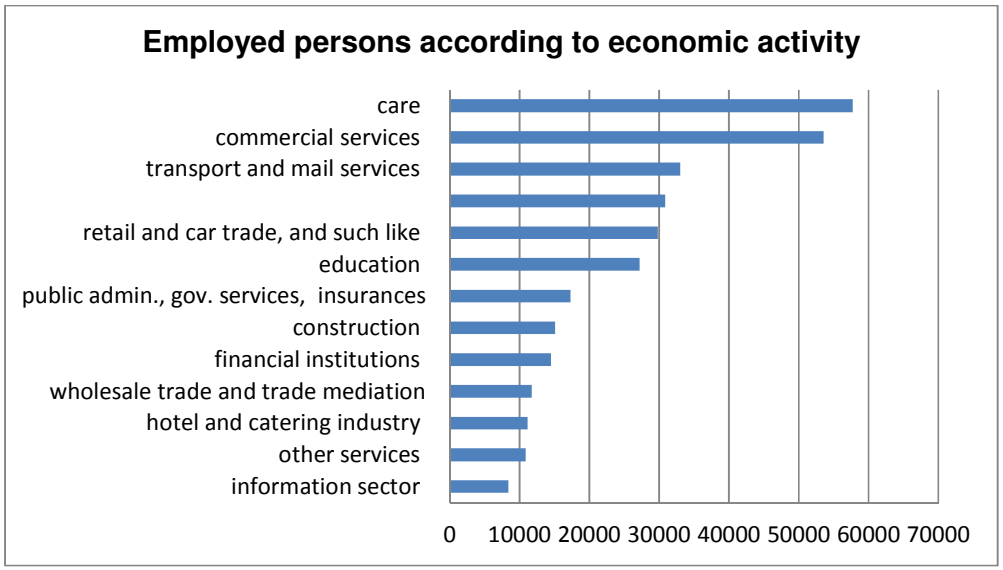
Source: City of Rotterdam 2009b: 29 (own elaboration)

Economic structure

As mentioned before the most important economic driver of Rotterdam is the port and the location in the Randstad strengthens the international importance of Rotterdam. GDP per capita of the city of Rotterdam was 40,082 EUR in 2012. By employment, the main sectors of the city's economy are business services, trade, and industry and the sectoral structure is characterised by a large share of transport and communication. The 3 main clusters of Rotterdam are the port-industrial complex, medical and care, and the creative sector. Especially the economic impact of the port is diverse. (City of Rotterdam 2009b, Centre for research and statistics, 2006)

The following graphic shows the employed persons according to economic activity. It is obvious that the main sectors are care and commercial services.

Figure 23: Employed persons according to economic activity, Rotterdam



Source: City of Rotterdam 2012: 1

In the city the following 5 sectors have been classified as the main important parts of the city and its positioning.

- *"Trade (Unilever, Hagemeyer)*
- *Water (Van Oord, Boskalis, Arcadis)*
- *Oil/Gas (E.ON, BP, Exxon, Tamoil)*
- *Port related business services (ING, Loyens & Loeff)*
- *Technical and Knowledge intensive business services (Deloitte, Ernst & Young, KPMG, PWC, Royal Haskonig, IBM)" (City of Rotterdam 2009b: 25)*

Rotterdam is the biggest seaport in Europe and the third largest in the world, with an annual throughput of more than 430 million tonnes of goods in 2010. The port is the key economic driver of Rotterdam's economy. In addition the transport sector has the highest numbers of employers of the port. The port of Rotterdam is investing continually to expand and improve its service. Since the industrial complex development of the port international services and companies have been pulled towards the city (ibid.)

The economics of the port are characterised by:

- "*resource dependency*
- *high added value for employees*
- *relatively low patenting in the port industries because of the chemical industry;*
- *innovation based port industries that are related to off-shore and dredging.*"(ibid. 25)

The unemployment rate is above the Dutch national average, with around 33,000 unemployed people of a working population of 291,000. There are also 33,240 people who receiving social assistance benefits (ibid.)

Rotterdam's labour market is characterised by:

- *"A labour force with large numbers of people with low levels of education*
- *A lower level of education within the immigrant labour force than found among the native working population*
- *A lower proportion of highly educated persons than found in other major Dutch cities*
- *An unemployment rate above the national average*" (Guidom 2010: 3)

For Rotterdam an important policy set by the national government was "Pieken in de Delta" and it was made by the Ministry of Economic Affairs. The period was from 2006-2010 and the priority sectors were port and industrial complex, suppliers of greenhouse farming, international law, peace and order and life & health sciences. However there are more programmes relevant for the region. For example: Kansen voor West, Clusterregeling Provincie Zuid Holland, Kennisalliantie: Ondersteuning bij Innovaties and Dutch Clean Tech Delta (*City of Rotterdam 2009b: 53)*

The municipality of Rotterdam has different programmes directed at innovation and cooperation with the knowledge of institutions and business communities. For example: the Rotterdam Climate Initiative, including the Rotterdam Climate Campus, the RDM Campus and the Rotterdam Climate and Innovation Fund (RCIF). (Guidom, 2010, *City of Rotterdam 2009b*, City of Rotterdam, 2012)

Figures and facts

The following table shows some important figures on the city of Rotterdam.

Table 10: Facts and figures City of Rotterdam

Surface area (2012)	319.35 km^2
Of that land (2012)	205.90 km^2
Of that water (2012)	113.45 km^2
Population (2012)	616,456
Population density per km2 (2012)	2,994
Internal migration balance	-2,558
Housing stock	297,312
Housing density per km2	1,385
Percentage of homeownership	34%
Family doctors (2005)	400
Pharmacists (2005)	80
Recipients of disability benefit	28,824
Average disposable income per household (EUR)	29,400
Working population	291,000
Of that unemployed	33,000
Social assistance benefits	33,240
GDP per capita (EUR)	40,082

Source: City of Rotterdam 2012, 2009b, own table

Social structure

The city of Rotterdam assesses the social structure of the city and in detail of every neighbourhood of the city by implementing the so-called “social-index”. The index is split into 4 separate indicators:

- *“Capacities (health, income, language)*
- *Quality of surrounding (physical)*
- *Participation (education, social contacts, social-cultural involvement)*
- *Social cohesion (neighbourhood level)” (Gemeente Rotterdam, 2012: 4)*

To assess these indicators and the overall social-index the scores are divided into 5 categories:

Very weak < 3,9

Problematic 3,9-4,9

Vulnerable 5-5,9

Sufficient 6-7

Strong >7

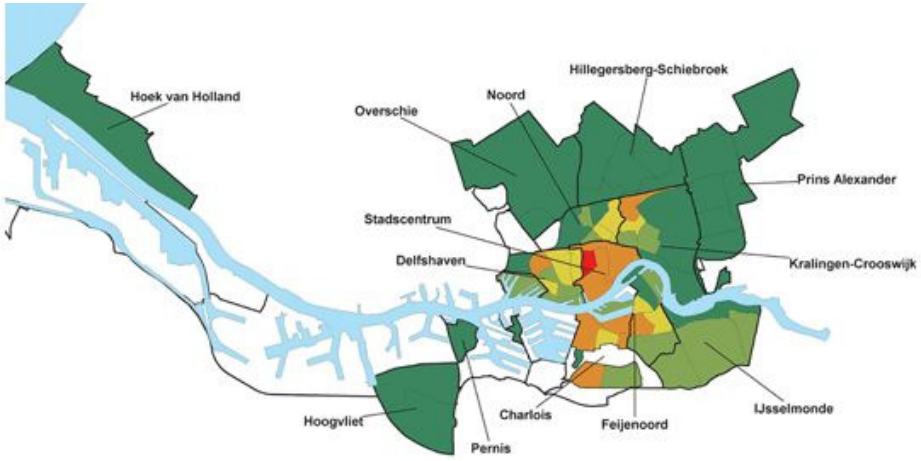
The following table shows the social index and each separate category of each neighbourhood and the whole city, followed by a map of the city to give an overview of the location of each community. (ibid. : 4pp)

Table 11: Social Index Rotterdam communities, 2012

Neighbourhoods	Social-index	Capacities	Quality of surrounding	Participation	Social cohesion
Charlois	4,7	4,2	5,2	5,1	4,3
Delfshaven	4,9	4,3	5,2	5,5	4,7
Feijenoord	4,9	4,0	5,2	5,3	4,9
Hillegersberg-Schiebroek	6,8	6,8	7,0	6,7	6,7
Hoek van Holland	7,5	7,6	7,7	7,2	7,6
Hoogvliet	6,1	5,5	6,7	5,8	6,2
IJsselmonde	5,6	4,9	6,0	5,8	5,7
Kralingen-Crooswijk	5,6	5,3	6,0	6,1	4,9
Noord	5,7	5,3	5,9	6,2	5,2
Overschie	6,0	5,6	5,9	6,2	6,1
Pernis	7,2	7,4	7,4	6,5	7,6
Prins Alexander	6,6	6,5	7,0	6,4	6,4
Rotterdam Centrum	5,8	5,8	6,1	6,4	4,9
Rozenburg	6,9	6,9	7,1	6,6	6,8
ROTTERDAM	**5,5**	**5,0**	**5,9**	**5,9**	**5,2**

Source: *Gemeente Rotterdam, 2012: 6*

Figure 24: Neighbourhoods of Rotterdam



Source: City of Rotterdam

The social index of the whole city in 2012 was 5, 5 in contrast to 6, 3 in 2009 and 5, 9 in 2008. The table shows that the social structure of the neighbourhoods is completely different. The overall strongest part is Hoek van Holland that is situated next to the waterfront and to the port. In addition there are several other neighbourhoods having a relatively strong social index. However 3 communities (Charlois, Delfshaven, Feijenoord) are classified as "*problematic*" (ibid. 6pp).

Due to problematic and vulnerable communities in context of socio-economic factors the city of Rotterdam has a general social index of 5, 5 that is considered as "*vulnerable*". Furthermore factors "*social cohesion*" and "*capacities*" are more vulnerable assessed than "*quality of surrounding*" and "*participation*" (ibid. 6).

There are several past and future planned projects such as the "Pact op Zuid" (Rotterdam South Pact) to compensate the disadvantages in the social, economic and physical fields in the district of Rotterdam South within 10 years (ibid.)

6.2 GOVERNANCE, INSTITUTIONS AND PLANNING

The Netherlands is a unitary state with 3 tiers of government: central, provincial and municipal with direct elections for all three tiers (*City of Rotterdam 2009b*: 41pp)

The central government is in charge of macro-economic and social-distributional policies and collects taxes (taxes on income, profits and capital gains, taxes on properties, taxes on goods and services, etc.) and allocated large amounts of tax revenues to lower-level governments (ibid.).

The Provinces are in charge of the coordination of public policies, for example planning, transport, culture, and social affairs and the provinces have legal control over the municipalities and over water boards. Furthermore they correspond with territorial level of decentralisation of some ministries such as those for administering public works, water management and agriculture (ibid.).

Municipalities are responsible for policy sectors such as roads, public transport, housing, local planning, environment, social affairs, economic development, education, health care, et cetera. With the central government the municipalities share a lot of responsibilities but they are relatively independent. The central government make general frameworks, rules and norms and the local authorities need to follow and monitor the implementation of most of the policies (ibid.).

The cities are divided into boroughs, which have their own local level administrative bodies responsible for the cities administration. In 1970 the Netherlands developed this system to enlarge involvement of citizens in local policy. These local level bodies are responsible for wellbeing, maintenance, execution of land use planning projects, issuing passports and permits, and safety and employment policy matters (ibid.).

The OECD distinguished that cooperation and networking is insufficient between stakeholders. The discovered a large gap between research and business and civil society organisations. In addition organisations are insufficient embedded with partners and insufficient expertise of knowledge protection and exploitation processes. (*City of Rotterdam 2009b*: 41pp)

Land use and Planning

There are 3 levels of government in the Netherlands: national government, province and municipality and they all have their own responsibilities. Strategic instruments like policy reports are made by the national government. The current report for land use is called the "Fourth Policy Report on Physical Planning, is made by the Ministry of Housing, Physical Planning and Environment and deals with issues in context of development of infrastructure in the Netherlands (N.A. 2000: 16pp, *City of Rotterdam 2009b*:27pp).

Transport is discussed in the Second Structure Plan Traffic and Transport and is made by the Ministry of Transport, Public Works and Water Management. The main parts of investments of infrastructure are made by the national government (ibid.).

The second level of government is the province, responsible for control of land use plans, developed by the municipalities and therefore Regional Plans are used. Rotterdam is situated in the province South Holland. Important departments are: Department of Physical Planning South Holland responsible for major planning issues (ibid.).

In Rotterdam there is a regional authority in between the authorities of the province and the municipality and some main tasks of the region of Rotterdam are mobility and infrastructure policies and extensions of land use plans (ibid.).

The third or local level of government is the municipality and they are direct planners of the land use in the land use plans. Major departments are: Department of Urban Planning and Housing, Department of Public Works, Rotterdam Municipality Port Management, Developing Department Rotterdam and Rotterdam Electric Tram. The province must supervise the municipality and is able to cancel the validity of a land use plan (ibid.)

Major cities such as Rotterdam have one more level of government, the districts. Rotterdam is divided in districts and these districts are responsible for policy issues like social safety and land use plans (ibid.)

The integration between all the departments is high and they work together in several projects. (N.A. 2000: 16pp, *City of Rotterdam 2009b*: 27pp)

Instruments for land use planning and infrastructure

On national level the Physical Planning Act defines the role of each government on all levels. Furthermore there is the Fourth Policy Report on Physical Planning, the current physical planning policy on national level, the Transport Structure Plan and the long range Report on Infrastructure and Transport on national level (N.A. 2000: 16pp)

On provincial and regional level there are regional plans, regional structure plans and the regional policy report on traffic and transport (N.A. 2000: 16pp)

On local level the spatial plan of Rotterdam, the land use plan, local policy report of traffic and transport, detailed strategic reports for thematic issues and the parking policy report of Rotterdam (N.A. 2000: 16pp).

One example for the future development of the city of Rotterdam is the so-called "Rotterdam Urban Vision – Spatial Development Strategy 2030". Rotterdam will continue to enhance its status and an international city on the river. They called the mission of the city council as "*work at a strong economy and an attractive residential city".* According to the mission two keystones were sat:

- *"Strong economy: more employment opportunities and attractive residential city: balanced composition of the population.*
- *International city on the river: the development of the areas along the river focuses on three elements: the excellent port, the gradual transformation of port areas into urban areas, an attractive and -fully fledged city centres."* (Gemeente Rotterdam (n.a.b: 26).

Administration and politics

The political situation in the Netherlands is very stable and has a smoothly operational political system. There is much consultation on how to integrate different point of views between official and also non-official organisations. The communication system called "*Poldermodel*" functions very well but it costs a lot of time (N.A. 2000: 16pp, *City of Rotterdam 2009b*: 27pp).

Land use planning in the Netherlands is strictly monitored by three levels of the government: national, provincial and local. The civil department has about 3000 people involved in planning and although the number of civil servants is high the organisation is quite good (ibid.).

The financial situation in the Netherlands is good and in addition the national government is trying to search for new possibilities to cover the spending, such as Private, Public

Partnerships. The departments and instruments for land use planning and infrastructure in Rotterdam are well organised but due to some budget restraints in the last few years not all necessary needs of the local authorities could be met. Especially the communication level of Dutch organisations is high and their experience with institutional and legislative transformations has been given to countries in Eastern Europe. (ibid.).

The Netherlands is a decentralised unitary state. The unitary character is clear in that most of the tax returns go to, and most policy is made at, central government level. The decentralised character is evident from the consensus oriented policy process between government and other actors and since the formal centralized power of state is often not used. On climate change, the FNEPP (2001) states that there should be greater integration between environmental and spatial policy, between the policies developed by different administrative levels and that responsibility should be moved to lower levels of government. The central government develops strategic plans, climate goals, policies and mechanisms and has instruments for implementation. The provinces have limited powers on strategic planning and focus on specific issues like spatial planning. They may be responsible for redistributing subsidies from the central to lower governments. The municipalities may make strategic plans at local scale and may develop policies on spatial issues, construction and housing, transport, environment and municipal management. Most municipalities do not have their own budgets for climate change related issues (Gupta et al 2008: 10pp).

6.3 CLIMATE & CLIMATE CHANGE

Rotterdam's climate is influenced by the North Sea leading to moderate temperatures the whole year. Summers are moderately hot with some wet periods especially at the coast due to the warm seawater temperatures. Rainfall is almost equally distributed over the year with an average rainfall of around 790 mm. Winters are relatively wet with persistent rainfall periods that could lead to floods in the rivers Rhine and Meuse (Dircke 2010: 20).

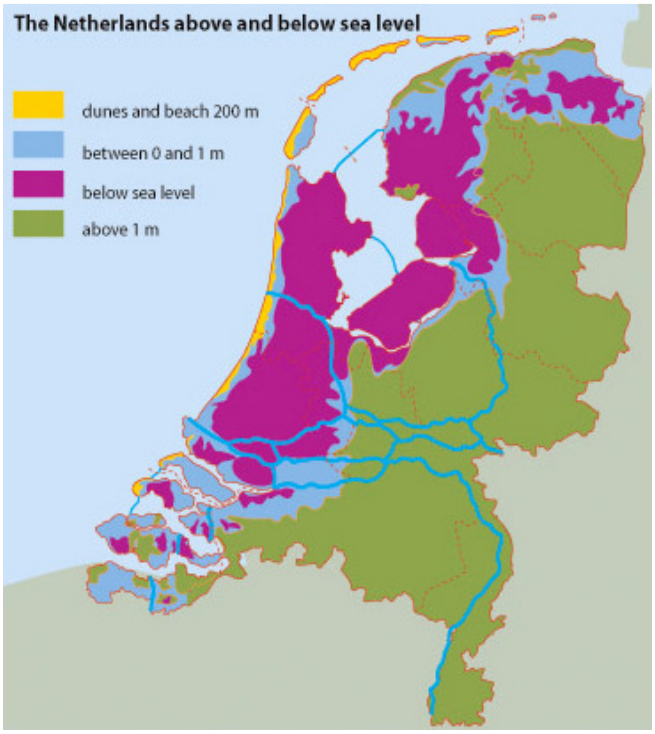
Flooding & sea level

The Netherlands are situated in a delta area in that the transboundary rivers Rhine, Meuse, Scheldt and Ems flow into the North Sea. This location threatens the country by flooding from these rivers, as well as from the North Sea and furthermore from large freshwater lakes. Overall about two-thirds of the Netherlands is prone to floods from these water systems. In addition around 50 % of the Netherlands lies below sea level, the lowest point of the country is at -7 m (Zuidplaspolder) and the highest point is at 322 m (Vaalserberg). Furthermore about 60 % of the country, 70 % of the GNP and especially large cities like Amsterdam and Rotterdam are threatened by floods (De Waal, n.d.; Van Alphen, n.a.)

In the Netherlands approximately 9 million people live below sea level and some areas lie at 7 meters below mean sea level, makes them to the lowest areas in Europe. Two thirds of the Dutch GDP is generated in these low-lying areas, and most of urban development is concentrated here too. (Dircke 2010: 20pp)

The following map shows the part of the Netherlands above and below the sea level.

Figure 25: The Netherlands above and below sea level



Source: De Waal, n.d.: 14

Past flooding events

There are a lot of historic flooding events in the last centuries in the Netherlands and in particular affecting the city of Rotterdam. In 1855, 1916, 1926 river flooding and storm surges occurred with fatalities and damage. But the major storm surge was in 1953 with impacts of 50,000 buildings destroyed, 300,000 people left homeless, about 1800 deaths and an economic damage of 70 billion US $. (Dircke 2010: 33pp)

"*The 1953 flood disaster was a low probability, high consequence event for its time. From Saturday January 31, 1953 to Sunday February 1, 1953 a storm tide raged across the European Shelf with a track much closer to The NL than any preceding storm track on record. The storm surge peak coincided with spring-tide high water and resulted in 150 dyke breaches in the sea defence, followed by breaches in the inner dyke system. The storms were strong and sustained that lead to extremely higher surge. Since the surge peak coincided with the time of spring tide high water, the total water level reached heights that in many locations exceeded those recorded ever before. In response to this event, people fled to their roofs and rescue operations began as quickly as possible. People found themselves in a race against the clock and "increasingly more people succumbed to the cold, or disappeared with their collapsing houses into the depth. Dikes had around 100 flow gaps, more than 800 km of dikes damaged and 200 000 hectares of land were under water*" (Haan & Haagsma, 1984, In: Dircke 2010: 34).

The second largest flood was in 1993, one in 60 to 100 years. It affected the Netherlands, Germany, France and Belgium. In the Netherlands 170 km^2 were flooded, over 8,000 people affected and the economic damage was over 100 million Euros (Engle & Trainor, 2010: 9).

Climate Change & sea level rise

Consequences of climate change for the Netherlands are immense. Sea level rise measures show an increase in main sea level rise of 17-22 cm over the last 100 years especially in Rotterdam and in addition there is land subsidence for 3-4 mm per year because of the post glacial geological process. (Dircke 2010: 33pp)

The Royal Netherlands Metrological Institute published climate scenarios for the Netherlands and they forecast sea level rise at the Dutch coast between 15-35 cm by 2050 and 35-85 cm by 2100. These scenarios are the guideline and have been accepted as a basis for government policies in 2008. (European Commission, n.a., NEEA, 2009)

In addition more prolonged periods of drought and more heavy rain showers in summer and winter are expected. Particularly precipitation is expected to increase by 7-28 % in winter and extreme precipitation can lead to flooding and water logging. Furthermore increasing wind velocity and storm by 33-66 % is forecasted too. (ibid.)

Moreover scenarios forecast that the average discharge of the river Rhine will increase in winter up to 12 % and the river Meuse by 5 %. (ibid.)

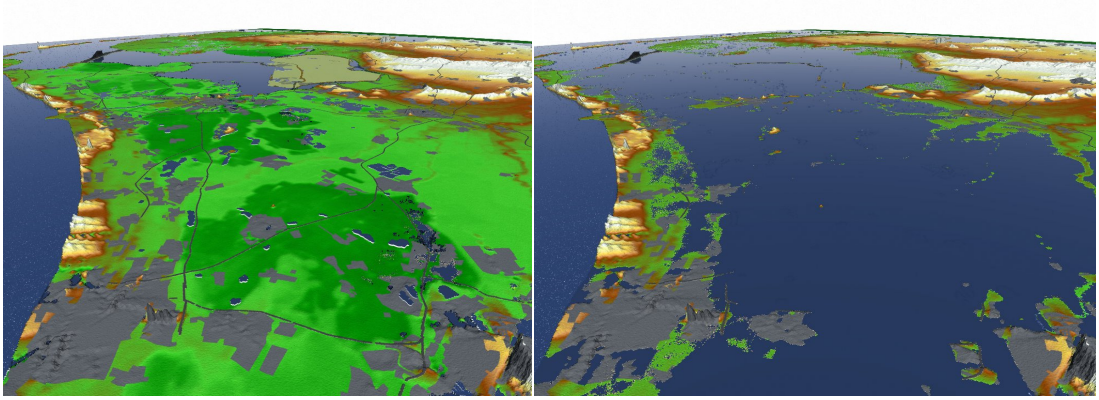
In 2005 the Dutch Prime Minister Jan-Peter Balkenende announced that *"the climate is changing and we should make our country climate proof. The national government together with science, policy and other stakeholders".* Regardless the Dutch are sure that *they "will stay*". (Dircke, 2010: 34)

"*With present-day spatial arrangement of land use, and the current sewage system in Rotterdam, it is unlikely that surplus storm water can be adequately coped with, without causing high economic damage*" (Dircke, 2010: 15)

Due to urbanization, population growth and land use change in the Randstad area flood risks have increased over the last 50 years by a factor 7. Therefore flood risk will increase, because settlements in vulnerable locations grow, even without climate change. (ibid.)

The following pictures show what could happen if the country does nothing against flooding and sea level rise.

Figure 26: Netherlands now and potential future



Source: De Waal, n.d.: 16

The Netherlands documented many possible consequences of climate change. For example in the Environmental Balance the Climate Policy report by the Parliament (Rooijers et al 2004) and the Climate reports of the Royal Netherlands Meteorological Institute. All studies agree that climate change will take place, despite all mitigation efforts and just mitigation is not enough to adapt (De Bruin, 2011).

In 2005 the Ministry of Housing, Spatial Planning and the Environment announced a project called "*Routeplanner*" to develop a national strategy for the Netherlands. To prepare this strategy the national research programme on climate change and spatial planning commissioned a study on adaptation options (De Bruin, 2011).

6.4 CLIMATE CHANGE & ADAPTATION

Programme on sustainability and Climate Change

The city aims to become an "*economically healthy city that attracts businesses encourages entrepreneurs and provides high quality employment. A green city where it is a pleasure to live and spend one's leisure time. A healthy city with clean air and a minimum of noise pollution. A city that promotes educational performance and where everyone can develop his or her own talent to its full potential. A city with a high-quality of life*" (City of Rotterdam, 2009a: 11)

Rotterdam plans to ecologically responsible solutions, reducing CO2 emissions, energy savings, use of clean energy and raw materials, the reduction and recycling or refuse, noise control and improving air quality. In addition more green spaces, especially parks, are planned to improve the biodiversity in the city. Furthermore it includes the aim to make the city and the port more climate-proof by protecting against floods (ibid.).

The programmes try to involve the whole community by including organisations, associations, institutions and schools.

The targets are

- *"to reduce CO2 emissions by 50% by 2025 compared to 1990".*
- *to reduce annual primary energy consumption by 20% by 2020.*
- *to reduce lorry and car mileage, encouraging the use of the cleanest forms of mobility and reducing the pollution caused by non-sustainable mobility.*
- *to increase the area covered by parks, gardens and water in the ten districts that had the least vegetation in 2010. We would also like to see more trees in the city. Our target is to plant 2,000 extra trees annually in 2011 and 2012. By 2014 there should be 160,000 m2 additional green roofs and green facades in the city.*
- *by 2025, sustainability will be an integral part of the education system and a guiding principle for education and research. By 2015, agreements relating to sustainability will have been made with the colleges and university, and these agreements will have been put into operation*
- *to make Rotterdam 100% climate-proof by 2025. By 2014, the Rotterdam Adaptation Strategy will have been drawn up and a start will have been made towards implementing it*".(City of Rotterdam, 2009a: 23pp)

Rotterdam Adaptation Strategy (RAS)

Rotterdam developed the RAS strategy to realize a climate-proof city. The focus topics are: water safety, urban water management, urban climate, accessibility and adaptive buildings. The adaption options are: minimizing the probability of a calamity, minimizing the consequences and improving the recovery. In addition focus is led on combining forecasting and back casting technique, awareness and communicating actions. (Dircke et al 2010)

Climate Programme Rotterdam (RCI)

The RCI was set up as an initiative of the city of Rotterdam, the Port of Rotterdam, DCMR Environmental Protection Agency Rijnmond, and Deltalinqs in 2006.

Their aims are:

- *"to 50% reduction of CO 2 emissions by 2025 as compared to 1990*
- *100% climate proof by 2025*
- *Strengthening the Rotterdam economy*
- *and to become the first climate neutral port city in the world (RCI, 2009: 6).*

The RCI is a part of the international Clinton Climate Initiative (CCI) where new technologies and finding practical solutions are main factors.

The RCI is based on pillars surrounding sustainable city, sustainable mobility, energy port and Rotterdam Climate Proof. Knowledge institutions such as Delft University of Technology, Rotterdam University, and the Dutch Research Institute for Transitions are participating.

For example "*Greening the Rotterdam University*" was a project to improve the sustainable management of buildings, energy consumption, waste disposal, transport and distribution channels and facilities. Furthermore there is the so-called KISSZ the Knowledge in Synergy for a Sustainable South Holland network that connects institutions and people in the Rotterdam region in the context of sustainability issues (ibid.)

In addition the Rotterdam Climate Initiative participates in the C40 Climate Leadership Group, a worldwide alliance of large cities all over the world collaborating on the issues of climate change (ibid.)

The structure of the organisation consists of a small scale project office responsible for streamlining the activities of the initiative. A management team, including representatives of the 4 partners, take decisions and reports to an independent Board, of that the Mayor of Rotterdam is the chairman. (*RCI, 2009*)

Rotterdam Climate Proof Programme (RCP)

Rotterdam Climate Proof participates in the Rotterdam Climate Initiative. The Initiative developed a programme to make the city climate change resilient by 2025. Key elements are permanent protection and accessibility, and to gain importance in research, innovative knowledge and to become "*the most important innovative water knowledge city in the world*" (RCP, 2009) the main guiding principles are:

- *"Rotterdam will develop into and present itself on a national and international level as a leading centre for water knowledge and climate change expertise.*
- *Investments will enhance the attractiveness of the city and port for residents, companies, and knowledge institutes.*
- *Innovations and knowledge are developed, implemented, and marketed as an export product" (RCP, 2009: 6pp).*

The first priority, with regard to making Rotterdam climate proof, is sustainable protection against flooding of the city and port, both on the landside and outside the levees. Apart from physical safety, the perception of safety of citizens and companies should be addressed as well. For the sake of economic development it is of vital importance for investors to perceive our city and world port to be permanently safe, accessible and attractive (ibid.)

The RCP programme pools this knowledge and innovation power to reinforce the climate for establishing businesses and port activities. In this manner, the Rotterdam region is developing into a global testing ground for delta technology, an international knowledge centre for water and climate issues, and a location of choice for companies in the field of climate-specific international services (specialized consultancy and engineering firms, internationally active research agencies and knowledge institutes) and industry (climate-related high-tech industry) (ibid.)

The three pillars of the programme are:

- "*Knowledge: Rotterdam knowledge city for climate and water*
    - *Climate proof barometer and climate guide*
    - *Rotterdam climate campus*
    - *Climate atlas*
- *Actions: Rotterdam as a testing ground*
    - *RCP Route Planner*
    - *Realization of Icon Project: Floating Pavillion*
- *Marketing communication: Rotterdam as an example for delta cities across the world*
    - *Branding: connecting Delta cities*" (RCP, 2009: 9pp)

For each category a schedule and list of important projects and deadlines was established. Next to the 3 pillars are 5 important topics:

- "*Flood management*
- *Accessibility*
- *Adaptive building*
- *Urban water system*
- *City climate" (RCP, 2009: 10pp)*

In addition to make Rotterdam Climate Proof there are 3 main challenges in the RCP plan related to water and climate change are: flood protection, architecture and spatial planning, and rainwater storage and updating the sewage system.

Innovations such as green roofs, water plazas, and alternative forms of water storage are essential for the further development of the city. In addition new suburban centres outside the levee system are planned.

Detailed planned adaptation measures are the following, according to Dircke (2009: 33pp):

Sand nourishment projects are a temporary solution to coastal erosion and protection against storm surges. It is a relatively cheap measure but has only temporary effects and has to be repeated on a regular (annual) basis. At the moment about 25 million m3 of sand is mined from offshore bares and is introduced onto Dutch beaches every year (ibid.)

Engineering measures: The low lying part of the Netherlands is divided into 53 levee rings and each levee ring is a separate administrative unit under the Water Embankment Act of 1995. For example the levee ring in northern Rotterdam is able to fight a flood with occurs every 10,000 years. The safety norm for this levee is 1/10,000 and reflects the number of inhabitants and economic assets within the ring (ibid.).

Furthermore storm surge barriers and large shipping locks and sluices are built along the Dutch coast too. Constructions were designed to function for at least 1000 years, by taking a sea level rise of 30 cm per century into account (ibid.).

Figure 27: Maeslant barrier

Source: De Waal, n.d.: 17

Wetland restoration: In the more rural areas around Rotterdam agricultural land is used for temporary storage of water during floods. Therefore farmers and nature conservation institutions are involved by identifying the most suitable areas. Cost for converting agricultural land into water storage areas may be up to 250,000 EUROS /ha (ibid.).

Peak water storage in urban areas: In the city 300,000 m3 of water storage facilities must be developed to accommodate the additional volume of rainwater that is expected due to climate change. For example open water areas are used by retrofitting ponds in city parks or adjusting canals to store more water (ibid.).

Figure 28: Architecture and water storage

Source: Dircke et al. 2012: 41

An example are the so-called “water plazas” in Rotterdam that can store water in times of peak events but are normally used as playgrounds in normal conditions (ibid.).

Figure 29: Water plazas in Rotterdam

Source: Dircke et al. 2012: 40

Another example is green roofs to decrease the total amount of runoff. They are slowing the rate of runoff from roofs and can retain between 10-20 mm of rainwater (ibid.).

Water development: Rotterdam's plan is to develop 1600 ha of waterfront locations in the old harbour areas in the city centre. The properties are built on elevated land and adaptive architecture is being used. For example architects are thinking of allowing water to move through the neighbourhood during flooding events without causing fatalities or damage (ibid.).

Building codes & insurance: In the Netherlands there is no flood insurance available and households depend on ad hoc compensation of damage by the government (ibid.).

6.5 WATER MANAGEMENT – LIVING ON AND WITH WATER

The following table gives an overview of the parties involved in the water management of the city of Rotterdam.

Table 12: Relevant stakeholders in the Rotterdam urban water governance system

Actor	Abbr	Responsibility in Rotterdam	Activities
Ministry of Transport, Public Works and Water Management	V&W	- Flood protection and water management of main river system - Supervision on implementation of European Water Framework Directive (EWFD)	Drawing up national water policy and legislation
Ministry of the Environment and Spatial Planning	VROM	- National housing policy and spatial planning. Environmental affairs - Regulation on drinking water supply	- Policy and legislation on housing, spatial planning (including water retention) and environment. - Determination of drinking water quality standards
Waterboards ▪ Delfland ▪ Hollandse Delta ▪ Schieland and Krimpenerwaard	WS HHD WSHD HHSK	- Water quantity management of main canal system and polder system - Water quality management including wastewater treatment - Flood protection	- Drawing up policy plans - Executing water assessments - Operation and maintenance of flood defence infrastructure and wwtp's
Municipality of Rotterdam	GR	- Land use planning	- Drawing up legally binding Land Use Plans
Municipality of Rotterdam, department of public works	GWR	- Sewer system - Public space maintenance - Urban infrastructure - Groundwater management (limited)	-Drawing up municipal sewer plan - Drawing up Waterplan Rotterdam - Operation and maintenance of sewer system and other infrastructure and public space - Collecting and transporting excess groundwater from allotment boundary
Municipality of Rotterdam, department of planning, housing and urban design	DS+V	- Spatial planning - Housing - Urban functions - Urban landscape design	- Designing and planning urban renewal projects and new urban areas - Drawing up spatial plans
Municipality of Rotterdam, department of economical development and project development	OBR	- Project development - Economical development - Real estate management and development	- Developing new urban areas and urban renewal projects

Source: Graaf, 2009: 137

Urban Water plan

The urban water plan is the most important water policy plan, although it is not legally obliged. The urban water plan is made by the municipality and the water board. It describes the joint ambitions for urban water management and it provides a strategy how this can be achieved. In 2002, the municipalities and water boards in the Netherlands agreed to make urban water plans for all municipalities (Van der Meide and Van der Werf, 2002). In Rotterdam, the main policy objectives were (Gemeente Rotterdam (n.a.a) :

- *"To create 600.000 m3 of addition water retention capacity to prevent pluvial flooding*
- *To apply risk based measures in order to secure flood safety of the riverbed area and polder area*
- *To accelerate sewer system renewal from 14 kilometres per year (2000) to 40 kilometres per year (2010)*
- *To introduce flexible surface water levels for improved water storage capacity during dry spells.*
- *To develop water quality and measures to comply with European Water Framework Directive" (Gemeente Rotterdam, n.a.a: 10pp).*

The envisioning project Rotterdam Water City 2035 (in Dutch: Rotterdam Waterstad 2035) turned out to be an important step towards a transformative water management approach. During this project an integral future vision on urban design was combined with a climate adaptation strategy. The policy niche was initiated by the 2nd International Architecture Biennale Rotterdam (IABR) The actual design encompasses three images: River City for the city centre, Water Network City for the south and Channel City for the north (*Gemeente Rotterdam, n.a.a)*

"*The water challenge is the urban map of opportunities. The result is not only that the water challenge will be solved but also new qualities are included in the city*." At the final symposium, The Rotterdam Water City 2035 design was awarded the first prize, the Biennale Infrastructure and Construction Award. Following the prizewinning vision, the Kuyper-motion was submitted in the municipal council. It proposed to develop a feasible program based on the design and time strategy of Rotterdam Water City 2035 (ibid.).

The 2nd water plan (WP2) was developed in 2006 and 2007 and is the further specification of Rotterdam Water City 2035 in official policy. Technical innovations, the integrated approach and the long-term climate adaption strategy were included in WP2. The document is a co-production of the water boards, urban planners and municipal water experts. WP2 was also integrated with the official Urban Development Vision Rotterdam 2030 (ibid.).

In summary in Rotterdam, significant cultural and institutional changes were made. The perception of stakeholders has changed. Urban planning and urban water management are integrated. Despite the success of Rotterdam Watercity 2035, integration of urban planning and water management in infrastructure is still mainly limited to a number of demonstration projects. This is understandable because changes in infrastructure take decades to develop.

Therefore, it is too soon to speak of a transition. The developments that were described in this chapter are crucial steps. However, more steps are required to complete the transition. The most important one is connecting strategy and policy making with practice. (De Graaf 2009)

Waterplan II – Waterstad 2030

The municipality of Rotterdam, the Schieland and Krimpnenerwaard Water Control Board, the Hollandse Delta Water Authority and the Delfland Water Control Board developed a new Waterplan for Rotterdam. The plan outlines how the city wants to deal with its water in the future and how to make the city waterproof. The vision is till the end of 2030 and includes decision on so-called “crucial importance” and plans for new developments. The decisions of crucial importance are: protection against flooding, clean water, an attractive city, enhancing sewerage system. New developments are planned for the “river city”, the area outside the dykes and the waterfront, Rotterdam-Noord and Rotterdam-Zuid (*Gemeente Rotterdam, n.a.a)*

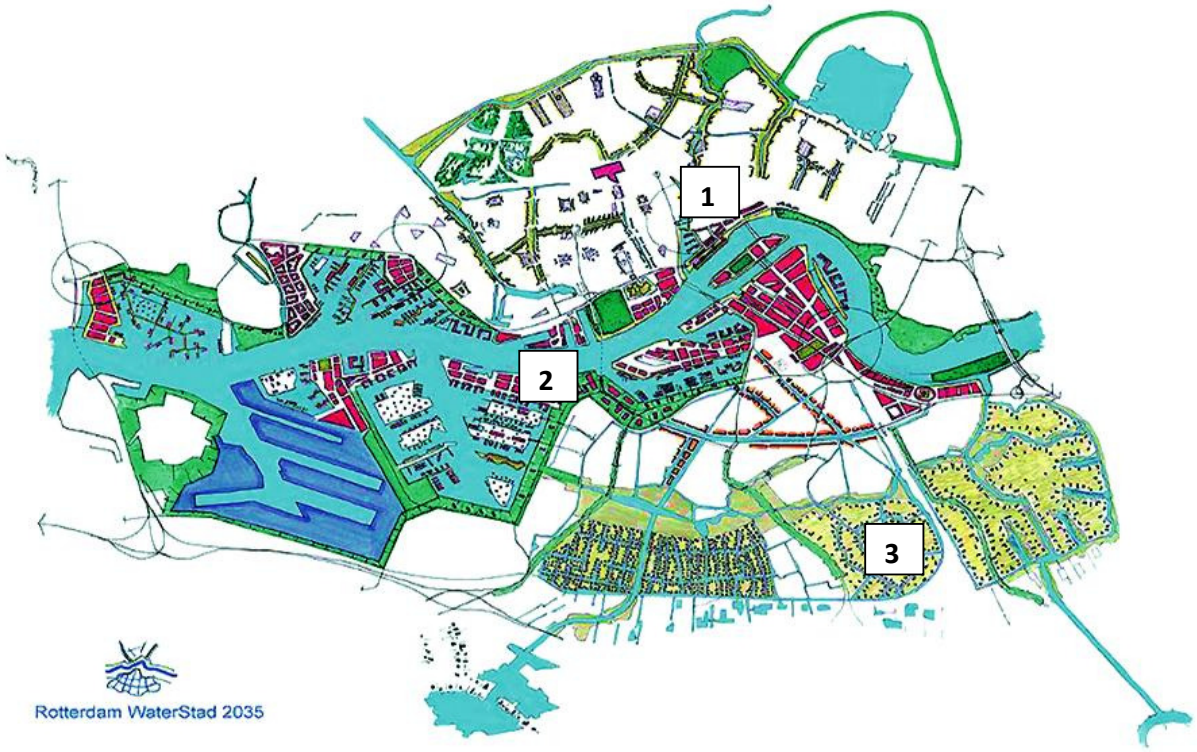
The main priorities are:

- *“Improving the water system*
- *Enhancing the urban quality*
- *Introducing innovative and alternative solutions” (ibid. 12).*

The main point of the water plan is that the city thinks about “*how water can make a contribution to the ambitions of the city”* and tries to integrate the water into the city planning. They are planning to tackle water-related requirements (*Gemeente Rotterdam, n.a.a)*

The following map shows the water plan, the 3 main development areas and the projects on these areas.

Figure 30: Rotterdam Waterstad 2035



Source: *Gemeente Rotterdam, n.a.a.*: 23

Rotterdam Waterstad 2035 (Quelle: Rotterdam Waterstad 2035)

Rotterdam Waterstad 2035 is a real water city, with unprecedented possibilities fornew water-based residential environments, transport over water, and a healthy water system. Rotterdam Waterstad 2035 consists of Rivierstad (centre), Vaartenstad (Rotterdam Zuid) and Singelstad (Noord). Rotterdam Waterstad 2035, the joint entry from the City of Rotterdam, the Hollandse Delta Water Board, and the Schieland and Krimpenerwaard District Water Board for the 2nd International Architecture Biennale Rotterdam, gives a perspective on the action that Rotterdam should take. The plan is inspiring, optimistic, high-profile, evocative and points the way to an attractive city in attractive surroundings. Thanks to its progressive and innovative ideas, the plan received the Architecture Biennale Real Estate Award.

1. **Singelstad 2035**

The strategy in Rotterdam Noord is to strengthen what is good and to intervene wherever necessary. Typical of the Singelstad townscape are the new canals, that connect the existing canals and serve to extend them. The Rivers Rotte and Schie, that had disappeared from view, are set to reappear. New residential environments will be created here. There will be some delightful squares in Singelstad where excess water from heavy rainfall will be stored. Green roofs will also become common here.

2. **Rivierstad 2035**

In 2035 the river will be the jewel in Rotterdam's crown. Rotterdam really is a river city. Possible rises in sea levels are a serious consideration for Rivierstad. Wherever necessary, dykes will have to be raised in order to protect the city, although there are also areas outside the dykes, such as Waalhaven and Merwedehaven, that need to be redeveloped and where all kinds of new living environments can be created, including on the water. In addition, water-based transport will serve to 're-attach' these harbour areas to the city.

3. **Vaartenstad 2035**

The water in Rotterdam Zuid is virtually all at the same level, that makes it possible to connect all the bodies of water together, forming one cohesive network. A new and attractive waterway network is developed in Vaartenstad, as are many options for living by the water.

6.6 THE NETHERLANDS (CLIMATE CHANGE ADAPTATION TOPICS)

As in most countries the governance of cities are mostly managed and influenced by their national authority. Hence the following part gives an overview of important Dutch national topics.

Dutch Coastal Defence and Climate Change Adaptation

Several national coastal defence and climate change adaptation initiatives are ongoing in the Netherlands both at policy and operational level. At policy level initiatives are centred upon two main themes: spatial planning and the increased flood-risk in the Netherlands. Different national studies and commission advices have served as a starting point for the first National Water Plan published in December 2008 and the national Adaptation Agenda scheduled for publication in spring 2009. At operational level four plans/programmes are to be mentioned in the context of climate change adaptation: the Delta Plan, the National Flood Defence Construction Programme, the Sand Nourishment Programme and the forthcoming Delta Law and Delta Programme (European Commission, n.a.).

The EU's far-reaching Water Framework Directive is a significant driver for new water policy in the Netherlands. The Directive was implemented by the Netherlands at the beginning of 2005 and it will increasingly become a very important tool for ensuring that Member States meet their respective environmental objectives, in particular, ensuring that all bodies of (surface) water reach a certain standard of ecological potential by 2015. The measures that each Member State must take in order to reach the target of 2015 will be made public in 2009. The Act will help to achieve these objectives in the Netherlands along with other water policy imperatives including the EU Flood Risk Directive and other proposals being considered including policies on water scarcity and droughts. (ibid.)

Policy initiatives in relation to climate change and spatial planning are mostly performed at the national level by or on behalf of the Ministry of Housing, Spatial Planning and the Environment (VROM). The most important ongoing research initiatives related to spatial planning are ‘Climate for Space’, ‘Living with Water’ and ‘Habiforum’ (ibid.).

The aim of the National Adaptation Strategy is to make spatial planning in the Netherlands more climate-proof. To this end, general action points have been defined, that will be further elaborated in a *National Adaptation Agenda*. The actions of the Dutch government focus on:

- *“Raising awareness and willingness to act, together with business and research organisations;*
- *Verifying to that extent spatial plans and regional development plans are climate-proof*
- *Stimulating innovation and knowledge development, together with business and research*
- *Striving for a more future oriented government strategy and better cooperation between different departments” (ibid.: 6)*

Besides the initiatives with regard to spatial planning and climate change, Dutch policy makers devote much attention to the risk of flooding. National studies and commission advices on the vulnerability and adaptation to increased flood-risk have served as a basis for the First National Water Plan (European Commission, n.a).

Centuries the Dutch were fighting the water and now they are trying to turn into a more sustainable vision of 'living with water'. Several national policy plans in the Netherlands already brought this vision in practice in large scale engineering projects and in public campaigns. Firstly, the *Commission on Water Management 21st Century* Secondly, the new water vision is implemented in the national programme *Room for the River* (in Dutch: Ruimte voor de Rivier), that provides rivers with more space to flow (ibid.).

In 2007, the new State Secretary for Public Works and Water Management, Mrs. Tineke Huizinga, developed the policy document 'Watervision 2007, "reclaiming the Netherlands from the future. The required policy is described to keep the Netherlands climate-proof in the future in the field of national water policy. This was the basis for the established Delta Commission that examines how the Netherlands can handle the consequences of climate change up to 2100-2200 (ibid.).

The Water Act (2009) contains provisions for the management and use of water systems and it integrates 8 sectorial water acts of the Netherlands. Furthermore it highlights water management based on the "water system approach" and addresses all relationships within water systems. The objectives of the Act are the prevention and mitigation of flooding and water shortages as well as the protection and improvement of the chemical and ecological quality of water systems and it should help to assist in the achievement of a number of EU water objectives in these areas. The focus of the Act is achieving an integrated system of water management by the authorities.(N.A., 2012)

Following the different national studies and commission advices, the Dutch State Secretary for Public Works and Water Management has published the first National Water Plan in December 2008. The National Water Plan outlines the future water policy in the Netherlands and concerns the entire Dutch water system including amongst others surface water, groundwater, primary and secondary weirs and shores. The plan describes the measures to be taken to ensure the future safety of the Dutch population as well as how to make most of the different opportunities water offers (European Commission, n.a.)

The first operational action to protect the Netherlands from flooding dates back to 1937 with the establishment of the Delta Plan and to 1953 with the Delta Commission to advice on the accelerated execution of the Delta Plan. At present, the National Flood Defence Construction programme and the Weak Links project as well as the yearly Sand Nourishment Programme are the main operational ones (ibid.).

According to research in 1937 safety in many parts of the Netherlands wasn't guaranteed at times of storms and high sea levels. As it was very difficult to build new dikes or strengthen the original ones, another alternative was to close all the river mouths. This was the origin of the Delta Plan. In 1950 the first river mouths were closed. The plan was to build the remaining dams in the following decades but the flood of 1953 prevented this from happening. Twenty days after the flood of 1953, the first Delta Commission was established. The task of the Delta Commission was to provide advice about the execution of the Deltaplan and later on in 1959 the Delta Law was passed to organise the constructions of the dams. The building of the 'Deltaworks' was an enormous project that was finalised by 1997 (European Commission, n.a).

The National Flood Defence Construction Programme exists since 2001 and is managed by the Ministry of Transport, Public Works and Water Management and its aim is to make the Netherlands flood resistant. The Ministry of Transport, Public Works and Water Management is responsible for safeguarding the coastline since 1990. In order to preserve this coastline the beaches need to be replenished every year. The Sand Nourishment Programme is the framework for the execution of the yearly beach nourishments. (ibid).

The local government in the Netherlands is based on the Municipal Act (1851; in Dutch: Gemeentewet) that prescribes some environmental tasks, such as an annual Environmental Policy Plan, but it does not deal with climate related issues. The Disaster Act (1985; in Dutch: Wet op rampen en zware ongevallen) prescribes the municipal tasks involved with disasters and heavy accidents, and it only deals with the possibility of 'regular' extreme events such as flooding or extreme weather events heavy accidents, and it only deals with the possibility of 'regular' extreme events such as flooding or extreme weather events. The most important policy documents at the national level, mentioning climate change are the Spatial Strategy (*'Nota Ruimte'*), the National Water Management Agreement (*Nota Nationaal Bestuursakkoord Water*) and the Memorandum on Water Policy of the 21st Century (*Nota Waterbeleid van de 21e eeuw*). However, these policy documents and resulting activities are not an integrated part of coordinated climate policy with regard to spatial planning and adaptation in the Netherlands (Gupta et al. 2008, Van den Berg, 2010).

At the national level an effort is now being made to arrive at an integrated policy in the Adaptation, Space and Climate programme (Adaptatie, Ruimte en Klimaat: ARK). The ARK programme is a cooperation of the four departments that are most involved with long term spatial planning in the Netherlands: the Ministry of Housing, Spatial Planning and the Environment; the Ministry of Transport, Public Works and Water Management; the Ministry of Agriculture, Nature and Food Quality and the Ministry of Economic Affairs (ibid.)

At the level of nongovernmental organisations on environmental protection, adaptation is gradually being included. For example three NGO activities on climate change adaptation (we do not intend to give a representative picture) are mentioned. 'Climate Buffers', seven environmental protection organisations have started this project as a precursor of the national Delta Programme. '

Climate Buffers' are wildlife areas that react to climate change in a natural way by acting as a sponge: they can catch, store and discharge water. Some buffers are already functioning, others are being developed.

In addition the so-called "HERE campaign" urges to pay more attention to adaptation and to exchange experience and knowledge with scientific institutes, business and the government in order to make the Dutch population more aware of the fact that climate change is happening now and not in the future. Furthermore in its manifesto on climate change, Friends of the Earth Netherlands (in Dutch: Milieudefensie) stresses the need to adapt to climate change. Nature should be given more space as natural processes can help us in getting a '*climate proof'* country (Milieudefensie 2007). (Van den Berg, 2010)

FINANCE OF COASTAL DEFENCE

In the Netherlands on the national level are the Ministry of Transport, Public Works and Water Management and its executive agency, the Directorate General for Public Works and Water Management responsible for financing of coastal defence. In addition at regional level the water boards, the provincial and municipal authorities and the Provincial Consultative Bodies for the Coast are involved. The total amount spent to flood-risk protection is estimated at € 550 million per year. Over the period 1998-2015, measures to *protect the Dutch coasts* against flooding and erosion and adapt to increased storminess amount to a total of € 3.4 billion. A*verage yearly coastal maintenance* expenditure amounts to € 63 million. This expenditure includes the maintenance of the primary weirs, the storm surge barriers and the closure dike ('Afsluitdijk'). The *yearly capital coastal expenditure* totalled € 172.5 million in 2008. This amount includes the beach nourishments carried out under the Sand Nourishment Programme and the expenditure to strengthen the primary weirs as well as the weak links under the National Flood Defence Construction Programme. (European Commission, n.at)

EVALUATION OF THE DUTCH WATER MANAGEMENT

The Netherlands has an international reputation regarding water management (Meyer 2009). Water management plans are common in Dutch municipalities. About 60% of Dutch municipalities claim to anticipate increased flooding risks due to climate change. Based on case studies and research, the impression is that most municipalities are not very active in developing concrete adaptation plans, and if they do, their attention concentrates on sewerage systems (for that they bear responsibility). In the case of Rotterdam, innovative adaptation measures such as multi-purpose dykes, water plazas and floating buildings are considered to be useful for profiling the city for its water management expertise as well as maintaining its attractiveness as a location for companies; long-term investments of companies may be relocated to less flood vulnerable areas if they consider cities as inadequately prepared for increased flood risks (Runhaar et al. 2011).

In Rotterdam, the plans for dealing with increased flooding are embedded in the already existing water management plan and the so-called Rotterdam Climate Proof programme initiated in order to profile Rotterdam internationally as a city with expertise in water management. However, the municipalities also face a few barriers, including uncertainties about the projections of increased flood risks, institutional fragmentation within the municipal organisation (in Rotterdam), the inflexibility of existing urban areas, the high costs involved, in combination with budget constraints and shortage of staff. (Runhaar et al 2011)

Dutch Flood risk management

The National Risk Assessment is part of the National Security Strategy, an instrument that allows the government to identify and measure different kinds of disaster and crisis scenarios against common parameters. The Minister of the Interior and Royal Relations is responsible for implementing the National Security Strategy as well as the National Risk Assessment. As an important first step in raising awareness of and initiating preparedness for catastrophic flooding, the Ministry of the Interior and Royal Relations and the Ministry of Transport, Public Works and Water Management (now the Ministry of Infrastructure and Environment) launched the Taskforce Management Flooding (TMO). For over two years, this taskforce directed their efforts at establishing greater disaster preparedness in the light of flooding and they ended their term with a large scale flood exercise in 2008. (Kolen et al 2009)

Furthermore the government of the NL requested an independent committee of state (the Delta committee) to give its advice on flood protection and flood risk management in the Netherlands for the next century, while keeping the country an attractive place to live, work and invest. Now the Dutch delta is safe, but preserving this safety requires, according to the committee, "*immediate action"*. (Engel & Trainor, 2010)

Flood risk management generally consists of a combination of measures, such as prevention with levees, land use planning, building codes, insurance and emergency management. In The Netherlands, a so-called multiple layer safety approach, comprising three layers is used. (Van Alphen, n.a.)

In The Netherlands the capabilities of these services are tuned to an event that occurs roughly once in ten years. In the case of floods, these services will also be used to mitigate the impact of a flood. To enable an adequate response to a disaster/ crisis situation The Netherlands utilizes a process-oriented approach to emergency management. (Engel & Trainor, 2010).

DUTCH FLOOD PROTECTION

The Dutch's approach to flood protection consists of:

- *"Coastal zone management: maintaining the coastline and compensating coastal erosion*
- *Rivers management: space for the major rivers, to increase the discharge capacity*
- *Maintaining and improving flood protection works*
- *Providing information (warning), issuing guidelines and research programme's" (Gemeente Rotterdam n.a. b:10)*

On national level the government is responsible for legislation, safety standards, guidelines and hydraulic loads, financing major improvement works and the management and maintenance of sandy coast, rivers, lakes, as well as most of the large structures (dams, barriers.)

Furthermore the Water boards are responsible for Daily management and maintenance of levees, dunes, some structures (funding by local tax) and safety assessment and improvement works. Regional supervision and spatial planning issues related to flooding are key responsibilities of the provinces. Every 5 years a safety assessment is carried out by the water boards analysing if the flood defences meet the standards. Based on the assessment improvement works are identified. For example the estimated cost of improvement between 2006 and 2015 are 3 billion Euros. (Gemeente Rotterdam, n.a.)

Disaster risk reduction (DRR) instruments include flood-awareness planning, flood zoning, evacuation planning and controlled flooding. A risk approach invites spatial differentiation between stakeholders on the basis of cost-benefit analysis. DRR instruments are still not well integrated in Dutch flood policy, while risk differentiation is resisted in Dutch society (Kolen et al, 2009: 5pp)

Horizontally, in addition to the Ministry of Infrastructure and the Environment (that includes Water Management), other ministries are involved in behaviours reducing flood impacts and help in evacuation, including the Ministry of the Interior and Kingdom Relations, the Ministry of Economic Affairs, Agriculture and Innovation and the Provinces. Vertically, lower-level authorities, private and civil-society actors need to be made flood-aware. DRR in integrated flood management is, according to the Hyogo Framework for Action, also assumed to be community-based and participatory to increase community involvement and resilience (ibid.).

Over the past decade Dutch safety agencies have started to integrate their operations better and to increase the speed of decision-making through the creation of so-called safety and security regions ('veiligheidsregio'). Police, fire services, ambulance and public health emergency ('GHOR') services are now organised into 25 such regions, coordinated by the Ministry of Internal Affairs and Kingdom Relations. The water boards are also represented in the safety region's executive boards. (Kolen et al 2009)

THE DUTCH EMERGENCY MANAGEMENT STRUCTURE

Compared to other countries, e.g., the United States, mass evacuation is less common in the Netherlands or Germany. In absence of real events, emergency planners in the Netherlands must use (small-scale) exercises and research instruments to develop, test and evaluate emergency plans (ibid.).

In The Netherlands flood response plans exist describing the role of organizations on the national level, for dike rings, for safety regions, for water boards and regional services of Directorate-General for Public Works and Water management. On a regional level the following public organizations can be involved in managing the response to floods: 26 water boards, 10 regional services of the Directorate-General for Public Works and Water management (RWS) and 25 safety regions with emergency services and more than 400 municipalities. Even though a horizontal evacuation plan has been drawn up by various local government agencies, everyone that has worked on this document knows that horizontal evacuation is an undesirable strategy for this region.

Kolen explains the importance of emergency plans by the following fact. The area is characterized by traffic congestion on a daily basis. "*If we imagine the traffic situation in case of a large scale flood, everyone would agree that the only real 'solution' is vertical evacuation or moving people to a location within the threatened area that is higher than the perceived threat*". (Kolen et al 2009: 5pp)

Emergency planning for flooding and evacuation is conducted by national and regional authorities. The role of national organizations in decision making is described in the National Crisis Plan for Extreme Water Levels and Flooding and an emergency plan for evacuation On the local level, 23 of the 25 safety regions (that combine police, fire and medical services and several municipalities) and all water boards have made preparations for flooding within the last two years. As part of a national operational emergency plan for evacuation, a national concept for traffic management has been developed by the National Traffic Centre that is part of the Ministry of Public Works, Transportation and Water Management. (Kolen et al 2009)

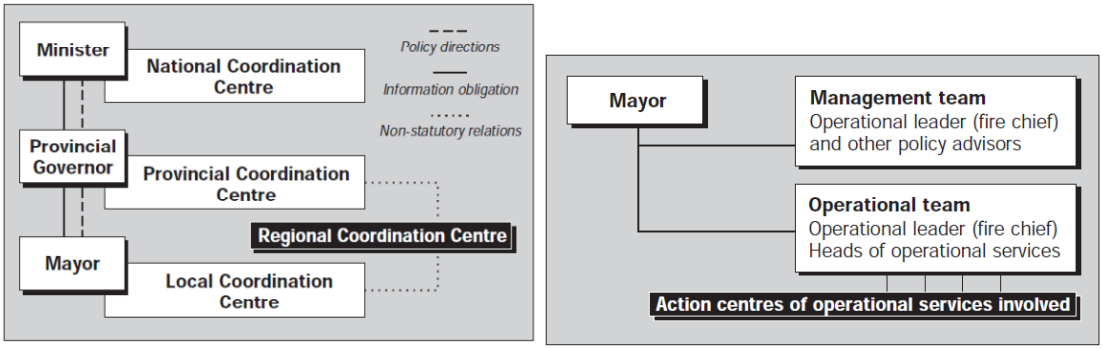
The Netherlands have three coordination and preparedness levels within the local/regional structure:

- *"Field*
- *Municipal*
- *Provincial/Regional"* (Kolen et al, 2009: 5pp)

All these various levels use distinctive preparedness plans varying in their content, based on the area and incident they cover. They contain information about the response mechanism such as coordination structures and the responders various tasks. During an emergency the mayor of the municipality is, by disaster law, the most senior command and control mechanism.

On an operational/field level the mayor can delegate his responsibilities to the operational leader who might be supported by a multi-disciplinary operational team in directing and coordinating the responding services such as police, ambulance and fire/rescue at a field level. (Beerens 2007: 94pp) The following figure illustrates the organisation of emergency management.

Figure 31: The organisation of emergency management



Source: Bezuyen et al., 1998: 43

In addition local emergency management coordination centres and operational centres are established and furthermore so called action-centres become active. Therefore teams of specific divisions perform tasks in fields such as public relations, civil services, public works, and environmental services. The approach is decentralised because local authorities are the key actors.

The Directorate-General of Public Works and Water Management is responsible for communications about the water-level of the Dutch rivers and communication about water-levels is done through the Regional Coordination Centres. (Bezuyen et al 1998: 43pp)

EARLY WARNING SYSTEM:

Early warning is dependent on predictions made by forecasting models and experts. These models use the actual circumstances and predictions of the weather. The forecasts result in an expected water level, with a margin of uncertainty. When these (forecasted) water levels exceed predefined warning or safety levels, alarms will be triggered and crisis organizations will be put into place (Kolen et al, 2009: 5pp)

Two approaches to initiating these crisis organizations in the case of flooding (using early warning) can be distinguished:

1. *Bottom up approach*: in case of extreme water levels but no severe risk for flooding. When water levels are rising, the water boards will be warned by flood forecasting centres for rivers, lakes and the sea, and can take measures to prevent flooding. Water boards inform Safety Regions in case of a serious risk of flooding that may lead to measures such as evacuation. If necessary, local and regional organisations inform national organisations (ibid.).

2. *Top down approach*, as recently developed by the National Commission of Flooding: in case of extreme water levels that cause a realistic immediate flood risk. Due to the situation, a longer warning period is preferred; this requires more sophisticated forecasting models that generate warnings farther in advance of the actual flood, potentially leading to greater uncertainty [10]. After detection of possible extreme water levels, the national crisis organisations and the water boards will be warned of the impending danger. National crisis centres will begin crisis management and coordination between regions. (Kolen et al, 2009: 6pp)

EVACUATION

Research shows that the capacity of the Dutch road infrastructure is limited in case of an evacuation (worst case scenario). Based on a realistic 48-hour prediction, a complete and timely evacuation of the Dutch coastal area is unrealistic, simply because of the limited available road capacity. The problem is most pressing in the North and South Holland provinces. Even with an optimal use of exits (a steady flow and not taking into account the possibility of accidents and conflicting behaviour), more than 72 hours are required for a maximum preventive evacuation. Although a prior warning system is available, it is uncertain how much time really exists for evacuation.

Preparation, available infrastructure and risk perception can improve the success of evacuation. This can be seen as a fourth phase, but during a crisis it will be a boundary condition. (Kolen et al, 2009: 5pp)

EVALUATION OF THE DUTCH EMERGENCY AND DISASTER MANAGEMENT

It should be acknowledged that there are many positive features in the Dutch system of emergency, crisis, and disaster management. First and foremost, it is important to highlight the flood mitigation systems. Even if one considers the difficulties discussed here, no other country has taken mitigation more seriously than the Netherlands. Next, it should be recognized that the Dutch emergency management system is quite serious about local and regional development. The Dutch invented the so-called polder model. The approach is a reference to the model of decision making characteristic to the Netherlands that can be characterized by: consultation, consensus and compromise. Third, it is apparent that the Netherlands government has done a great deal of work to put in place a workable system for emergency response. (Engel & Trainor, 2010: 10pp)

While it is true that the Dutch safety standards are high and that this approach has allowed the Dutch to prevent many incidents, it has also resulted in a reduction of risk perception that increased the potential for a catastrophic event by allowing people to develop unsafe areas. (COT, 1999), (Muller, Rosenthal, Helsloot, & Dijkman, 2009). Disaster management is meant to safeguard and protect people, but the general public is absent in most key planning and developmental activities. These types of situations often generate a great deal of uncertainty in the public and it will be of great importance that public officials engage in open and honest communication with the public. (Engel & Trainor, 2010: 10pp)

In The Netherlands, disaster management researchers and professionals feel that organizational learning is limited and that few evaluations are substantively shaping standards, policy, and practice: "*It seems like all evaluations result in the same recommendations and crisis organizations don't seem to visibly improve*". With respect to flood preparedness, learning from evaluations is particularly difficult since there have been very few large-scale flood events. Therefore, in The Netherlands, most learning for flood crises has been derived from preparative activities such as the Waterproef exercise and FloodEx activities that provided important but rare opportunities to examine flood preparedness and response capabilities. For example, the primary objective of FloodEx, a command post and field exercise conducted to test the coordination of international assistance from the EU was clear—"*to improve and train in practice, existing procedures for alerting, mobilising and dispatching international emergency services*." (NUWCReN, 2009: 63)

Public Awareness

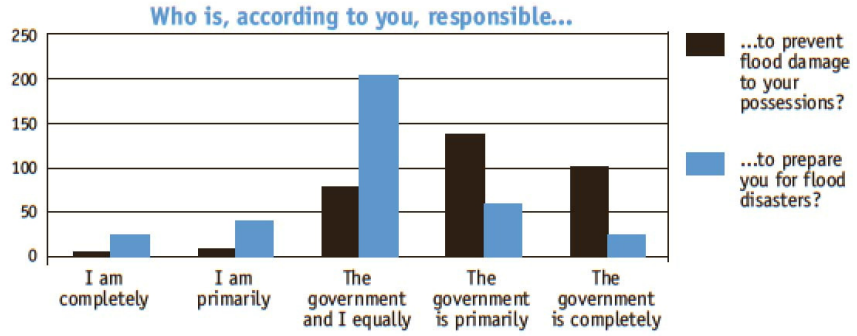
Public Awareness in context with climate change related hazards or and flooding is relatively low in the Netherlands. The attitudes of the Dutch citizens can be illustrated as "*not really worried*". They see crime and recession more important than the risk of flooding.

Hence people don't collect information for preparedness and rely on the government. Only people who experienced flood in the past are more prepared (Terpstra, 2009: 6pp).

As predicted, respondents of studies generally held low perceptions of flood risk, they hardly perceived flood risk as a personal risk, the vast majority (85%) indicated almost never or only sometimes thinking of flood risk and the occurrence of flooding in the next 10 years was regarded as hardly likely (Terpstra, 2009: 6pp).

Survey results, for example illustrated in the following figure indicate that flood risk perception is low, that 73% of the respondents regard the government as primarily responsible for protection against flood damage, but that about 50% viewed disaster preparedness as an equal responsibility between themselves and the government. (Terpstra, 2009: 6pp)

Figure 32: Distributions of number of respondents with respect to flood risk responsibility attribution



Source: Terpstra, 2009: 64

The government developed a campaign on preparedness called "*think ahead*" in 2003 and on "*emergency kit at home*" (Terpstra, 2009: 6pp).

At the level of individual households, the Ministry of the Interior and Kingdom Relations has developed the Denk Vooruit ("Think Ahead") communication campaign, that aims to increase the disaster preparedness of citizens for a number of risks (e.g., terrorism and pandemic flu), including floods. It will be a great challenge to promote flood preparedness among Dutch citizens. The campaign emphasises the need to store water along both the main national and regional water management systems during times of excessive rainfall or high levels of river discharge. It also promotes the actions that individuals can do themselves to help reduce the threat of flooding. The campaign has used the Netherlands favourite weather presenter as their spokesman. Independent reviewers have assessed the campaign as being an effective awareness raising approach (ibid.).

The aims of "*The Netherlands Live with Water*" campaign were:

- "*To increase the awareness of the water problem, stimulating a sense of urgency without frightening the people;*
- *To communicate that a new approach and policy for water management is needed and also the reasons why;*
- *To increase knowledge of what this new policy ('giving more room to water') means and what the consequences will be;*
- *To get acceptance of the idea that far-reaching measures are needed now to keep Holland safe in the future, even if these measures have unpleasant personal consequences* " (Kazmierczak and Carter, 2010: 4)

The lead authority responsible for the development and implementation of the initiative was the Ministry of Transport, Public Works and Water Management. Other organisations involved include Association of the Provinces of the Netherlands, Association of Dutch Water Boards, Association of Netherlands Municipalities, Ministry of Public Health, Spatial Planning and Environment, and Ministry of Agriculture, Nature and Food Quality. (Kazmierczak and Carter, 2010)

Citizens largely accept co-responsibility, know the two campaigns and accept the need to prepare themselves. At the end of 2003 82 percent of the citizens recognized the importance of measures to protect against and prepare for flooding. But in the end for example only 0, 3% acquired an emergency kit and in reality they don't prepare. (Lee, 2007, Terpstra, 2009)

7 ROTTERDAM - RESILIENCE ASSESSMENT

First the author would like to point out that the following assessment can't be seen as an overall evaluation of the resilience of the city of Rotterdam. The assessment should only be an example to support the understanding of the resilience characteristics and baselines developed and explained in the previous chapters. In addition to the facts and figures in the chapter about Rotterdam there is possibly more information that could be included in the resilience analysis.

According to the resilience framework in chapter six the following key sectors: Governance and Institutions, Ecosystem Management, Land Use, Structural Design and Infrastructure, Social, Economic and Human Structures and Values, Risk Assessment and Knowledge, Disaster Management and benchmarks are evaluated separately for the city of Rotterdam.

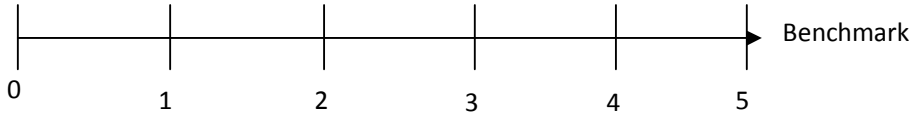
The evaluation of the resilience of each sector and benchmark is based on the information, facts and figures of Rotterdam explained in the previous chapter. For the assessment each key sector and each benchmark is assessed on its own first and then an overall resilience assessment of each key sector is given. The overall rating of the resilience of Rotterdam includes all 6 characteristics and explains and illustrates the resilience of the city.

Furthermore radar charts illustrate the resilience and short information explains the assessment of the factors. Each table shows the rating of all the key benchmarks and an overall resilience rating. In addition the Resilience rating for each category is illustrated too.

A rating system is established for the benchmark evaluation because it is a useful tool to compare current conditions for each benchmark. The rating system is decided to be simple and easy to communicate to all diverse stakeholders. Hence a numerical rating is being used with scores for 0 to 5 can be assigned to each benchmark based on an analysis of the assessment results. In the end the scores for each element are averaged to give an overall indication of resilience for a given area and to make comparisons among areas and to aid in defining priorities for action.

Figure 33: Resilience Benchmark Rating

Source: own elaboration



5 Excellent (81 to 100 % fulfilled)
4 Very good (61 to 80 % fulfilled)
3 Good (41 to 60 % fulfilled)
2 Fair (21 to 40 % fulfilled)
1 Poor (1 to 20 % fulfilled)
0 Condition absent

Example of rating tool

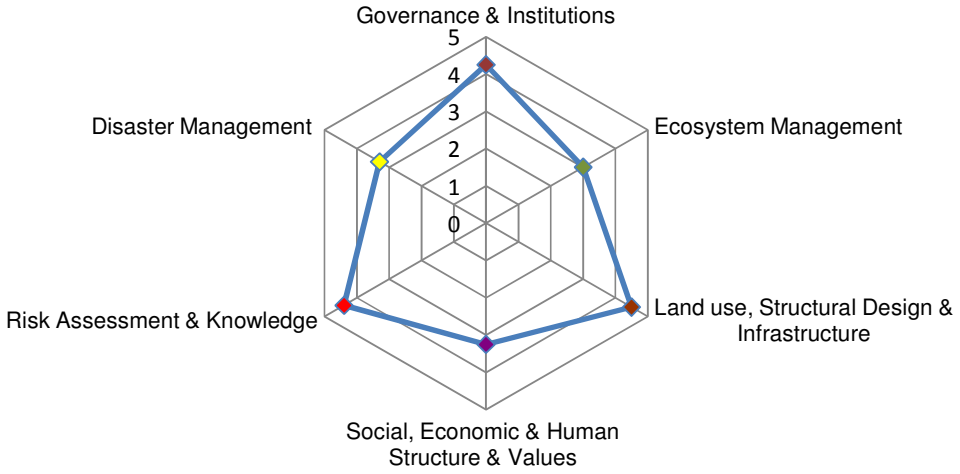
Resilience of Rotterdam

The following illustration displays the overall resilience of the city of Rotterdam in the face of climate change. The radar chart overlays the resilience of all 6 sectors and it emphasizes that Rotterdam is already adapting and planning for a future resilient city.

Figure 34: Resilience of Rotterdam
(own elaboration)

	RATING
Governance and Institutions	4,25
Ecosystem Management	3
Land use, structural design and Infrastructure	3
Social, economic and human structures and values	3,25
Risk assessment and knowledge	3,8
Disaster Management	3,6
Overall Resilience of Rotterdam	3,5

Resilience of Rotterdam



The overall resilience is relatively high and there are only some factors need to be improved. Rotterdam is especially resilient because of its planning strategies, infrastructure and architectural improvements and its risk assessment and knowledge. The only problem of governance and institutions is the complexity of the responsible departments and institutions involved in climate change adaptation strategies in Rotterdam. Furthermore the social and human factor isn't as good as possible because the social index in the city varies; this leads to different social groups and in the end to a higher vulnerability of specific areas and people. Disaster Management need to be developed too and the main problem is the missing integration of the people into disaster management. Just as Disaster Management, Ecosystem Management needs to raise participation of the population to be more effective.

The previous chart and the brief statement summarize the 6 categories and in detail each sector is explained, assessed and illustrated afterwards.

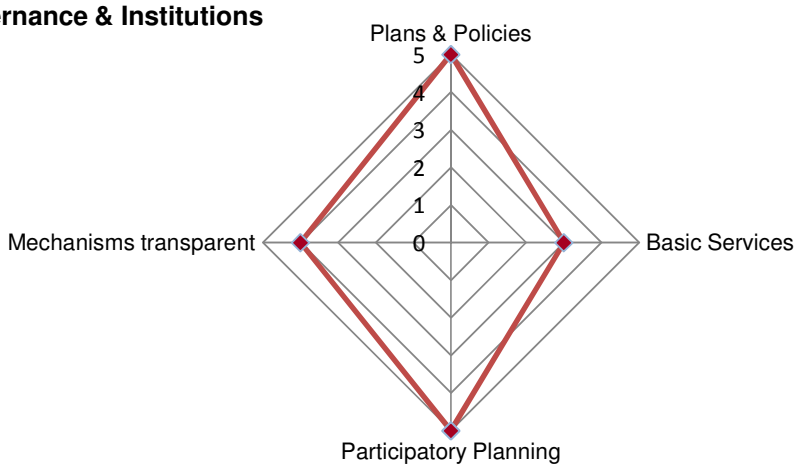
Governance & Institutions

Rotterdam has effective institutions, structures and an effective government. Furthermore process and frameworks are given to organise, adapt, absorb and resist disturbances and disasters. Participatory planning and collaboration among sectors and levels of government are established and used in context with climate change planning. Especially the communication level of Dutch organisations is high. Technical and financial support mechanisms are transparent and accountable as it is possible in such a complex system. The financial situation in the Netherlands is good and in addition the national government is trying to search for new possibilities to cover the spending, such as Private, Public Partnerships.

However some Dutch municipalities aren't very active in adaption planning the city of Rotterdam is a positive exception. A problem is the availability of basic services that aren't accessible to all part of society. The social index of Rotterdam shows the differences in the social structure and the linked differences in the various neighbourhoods of the city.

Figure 35: Rotterdam Resilience - Governance & Institutions
(own elaboration)

	RATING
Plans, policies and programs are implemented and monitored in a participatory and transparent manner.	5
Basic services are accessible to all sectors of society.	3
Participatory planning and collaboration mechanisms among different sectors and various levels of government are established and used to manage for resilience.	5
Technical and financial support mechanisms are transparent, accountable, and available to support planned community actions.	4
Governance & Institutions	4,25



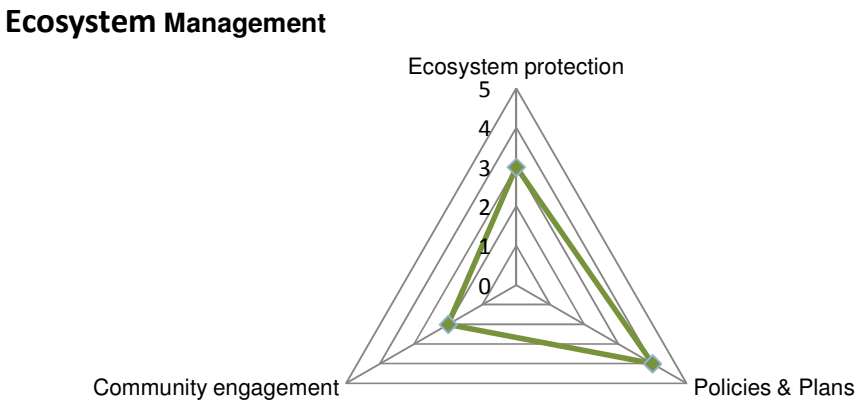
Ecosystem Management

In the past flood protection techniques and the port industry affected the city negatively. Pollutants affecting the Dutch coastal zone mainly come from point and diffuse land-based sources. Transport to the sea is largely by rivers where the chemical compounds adhere to clay and silt particles. In the past there were damaging effects on the environment. But in the last years Rotterdam focuses more on sustainability and environmental friendly techniques and development.

Since 1990 annual sand nourishment, using this principle has become standard practice in the Netherlands. It is an economically viable way of protecting the mainly sandy coastline. It increases coastal resilience and provides a flexible response to the uncertainties of future sea level change. More recently there has been a focus on integrated spatial planning of the maritime and terrestrial parts of the wider coastal zone. Community engagement in wider sense isn't big in the city of Rotterdam. Programs and policies in Rotterdam and the whole Netherlands are trying to involve people in campaigns but they aren't reaching peoples of all social structures across the city. The following table shows the rating of the four key areas in context of governance and institutions and an overall resilience rating. Afterwards the Resilience Rating is illustrated

Figure 36: Rotterdam Resilience – Ecosystem Management
(own elaboration)

	RATING
Sensitive coastal habitats, ecosystems, and natural features are protected and maintained to reduce risk from coastal hazards.	3
Policies and plans are implemented and monitored to effectively manage natural coastal resources.	4
Communities are actively engaged in planning and implementing coastal resource management activities.	2
Ecosystem Management	3



Land Use, Structural Design & Infrastructure

Land use planning in the Netherlands is strictly monitored by three levels of the government: national, provincial and local. The departments and instruments for land use planning and infrastructure in Rotterdam are well organised but due to some budget restraints in the last few years not all necessary needs of the local authorities could be met.

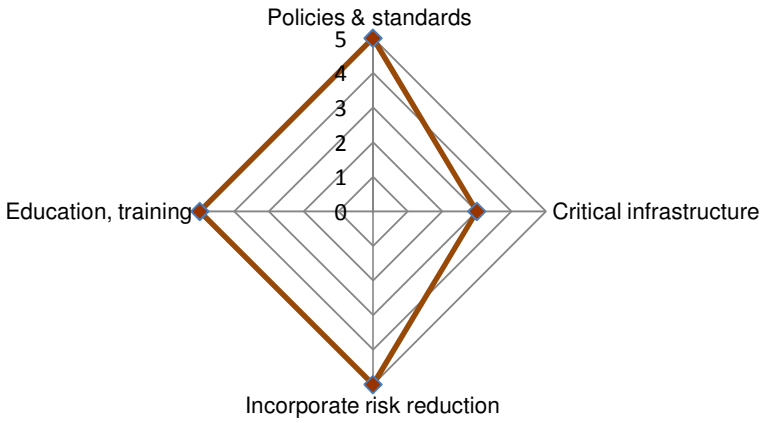
Critical infrastructure is located next to the rivers and to the sea too. Due to the fact that there isn't enough space to build elsewhere Rotterdam decided to be a "city on the water" and not move away. However innovations such as green roofs, water plazas, and alternative forms of water storage are supporting a water resilient development of the infrastructure and the city.

In most of the policies, programs and plans risk reduction and adaptation to climate change are integrated in future developments. Furthermore new standards are developed to improve all adaptation measures. Especially there is high research, science and education concentration in context of climate change, flooding and risk management and preparedness in the city of Rotterdam.

Figure 37: Rotterdam Resilience – Land use, Structural Design, Infrastructure
(own elaboration)

	RATING
Land use policies and building standards that incorporate measures to reduce risks from hazards and protect sensitive habitats are established, monitored, and enforced	5
Critical infrastructure are located outside high risk areas and constructed to address risks from priority hazards.	3
Developers and communities incorporate risk reduction into the location and design of structures.	5
Education, outreach, and training programs are established to improve compliance with land use polices and building standards.	5
Land use, Structural Design & Infrastructure	3

Land Use, Structural Design, Infrastructure



Social, Economic & Human Structures & Values

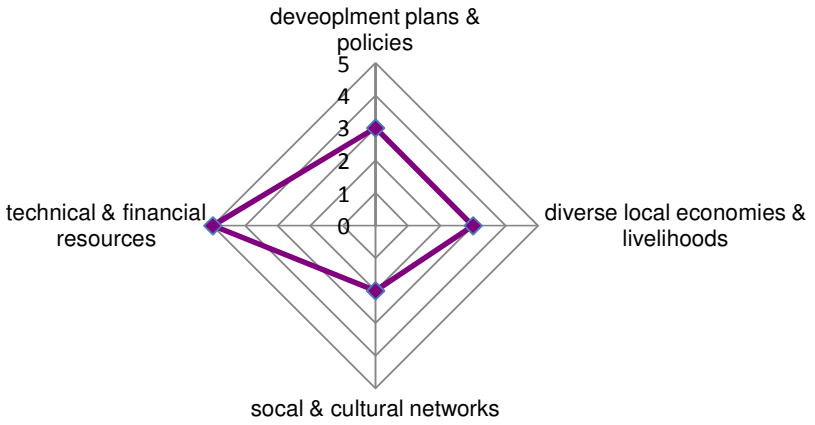
The population of Rotterdam is imbalanced with a substantial underclass, a smaller middle class and a limited upper class. In some districts 60% of the local population have limited education levels. 60% of children in Rotterdam grow up in a so called “problem district”. The ethnicity in the city is diverse, with 54 % so-called “Indigenous population” and 6 % are from other industrialised countries and the other bigger groups of ethnicity are Surinamers, Antilleans, Turks, Moroccans and South Europeans. According to the social-index the city of Rotterdam is in average “vulnerable” due to the fact that some parts are more vulnerable than others. Furthermore the factors “social cohesion” and “capacities” are more vulnerable assessed than “quality of surrounding” and “participation”. Rotterdam tries to compensate the disadvantages by establishing urban renovation projects within 10 years.

As mentioned before the most important economic driver of Rotterdam is the port and the GDP per capita is around 40,082 EUR. By employment, the main sectors of the city’s economy are business services, trade, and industry and the sectoral structure is characterised by a large share of transport and communication and the 3 main clusters are the port-industrial complex, medical and care, and the creative sector.

Figure 38: Social, Economic & Human Structure & Values
(own elaboration)

	RATING
Development policies and plans build social capital and skills for economic diversity and self reliance.	3
Local economies are characterized by diverse and environmentally sustainable livelihoods.	3
Social and cultural networks promote self-reliant communities and have the capacity to provide support to disaster-stricken areas.	2
Technical and financial resources are available to promote stable and robust economies, reduce vulnerability to hazards, and aid in disaster recovery.	5
Social, Economic & Human Structure & Values	3,25

Social, Economic & Human Strucutre & Values



Risk Assessment & Knowledge

The risk management in the Netherlands is part of the National Security Strategy and it organizes disaster and crisis scenarios and management. An important part is the awareness and preparedness for flooding and therefore the Taskforce Management Flooding was launched. In addition there is the Delta Committee that gives advice on flood protection and flood risk. Furthermore the Dutch uses a multi layer safety approach that integrates risk, spatial planning and disaster mitigation. The Netherlands also uses disaster risk reduction instruments that include flood awareness, flood zoning, evacuation planning and controlled flooding.

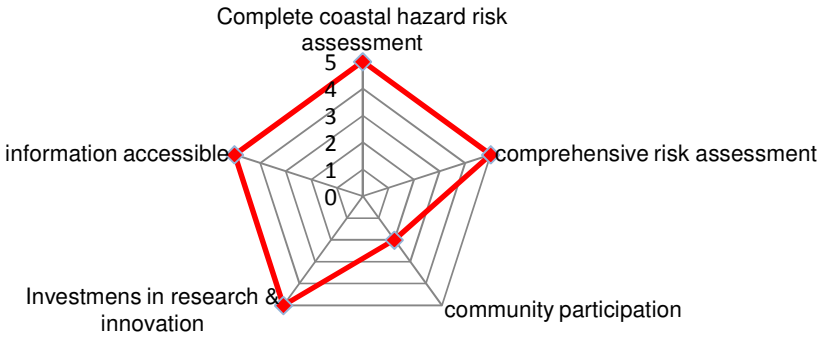
The city also invests in science, research and innovation in diverse ways national and also international. There are a lot of university programmes focussing on climate change, vulnerability and resilience and the Netherlands also cooperate internationally, share their knowledge and adopt possible actions and strategies from other countries at risk.

The only negative aspect of risk assessment and knowledge in Rotterdam is the participation of the community. The city tries to involve the population by some awareness and preparedness methods but evaluations show that they aren't effective enough.

Figure 39: Rotterdam Resilience – Risk Assessment & Knowledge
(own elaboration)

	RATING
Coastal hazard risk assessments are completed at a scale appropriate to the community and routinely updated	4
Coastal hazard risk assessments are comprehensive and incorporate risks to all elements of resilience (e.g. livelihoods, coastal resources, land use, etc.).	4
Community participates in the hazard risk assessment process.	2
The city invests in science, research and innovation in the context of vulnerability and risk and has technical capacities	5
Information from risk assessment is accessible and utilized by the community and government.	4
Risk Assessment & Knowledge	3,8

Risk assessment & Knowledge



Disaster Management (Preparedness, planning and readiness)

There are a lot of different organizations and institutions responsible for disaster management in the Netherlands and in Rotterdam. Disaster risk reduction instruments include flood-awareness planning, flood zoning, evacuation planning and controlled flooding.

The Dutch emergency system consists of flood response plans that describe the role of organizations on the national level, for dike rings, for safety regions, for water boards and regional services. Emergency planning for flooding and evacuation is conducted by national and regional authorities. The country has 3 coordination and preparedness levels: field, municipal and provincial/regional. In addition local emergency management coordination centres and operational centres are established and furthermore so called action-centres become active. Therefore teams of specific divisions perform tasks in fields such as public relations, civil services, public works, and environmental services. The approach is decentralised because local authorities are the key actors.

Early warning is dependent on predictions made by forecasting models and experts. These models use the actual circumstances and predictions of the weather. The forecasts result in an expected water level, with a margin of uncertainty. When these (forecasted) water levels exceed predefined warning or safety levels, alarms will be triggered and crisis organizations will be put into place.

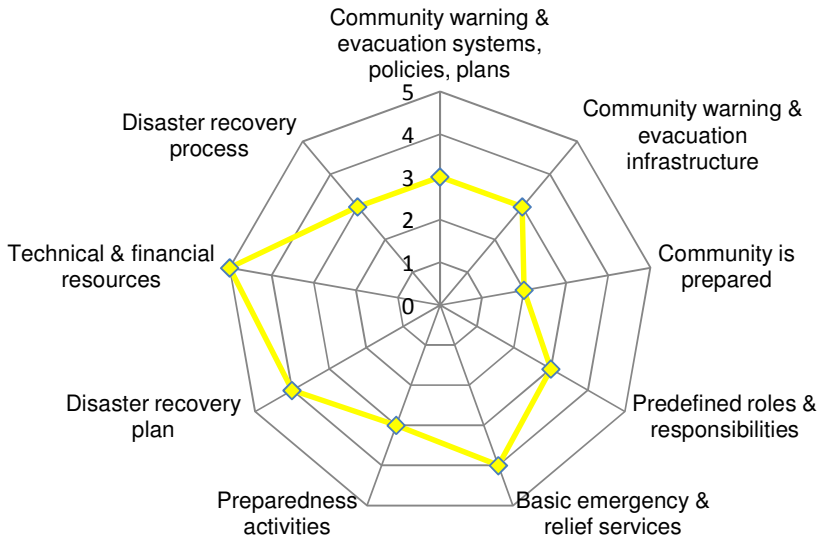
Compared to other countries mass evacuation is less common in the Netherlands. Studies show that the capacity of the Dutch road infrastructure is limited in case of an evacuation (worst case scenario). Based on a realistic 48-hour prediction, a complete and timely evacuation of the Dutch coastal area is unrealistic, simply because of the limited available road capacity.

It should be acknowledged that there are many positive features in the Dutch system of emergency, crisis, and disaster management. While it is true that the Dutch safety standards are high and that this approach has allowed the Dutch to prevent many incidents, it also resulted in a reduction of risk perception increasing the potential for a catastrophic event by allowing people to develop unsafe areas. With respect to flood preparedness, learning from evaluations is particularly difficult since there have been very few large-scale flood events. Therefore, in The Netherlands, most learning for flood crises has been derived from preparative activities such as the Waterproef exercise and FloodEx activities that provided important but rare opportunities to examine flood preparedness and response capabilities.

Figure 40: Rotterdam Resilience – Disaster Management (preparedness, planning and readiness) (own elaboration)

	RATING
Community warning and evacuation systems, policies, plans, and procedures are in place and capable of alerting vulnerable populations in a timely manner.	3
Community warning and evacuation infrastructure is in place and maintained	4
Community is prepared to respond to hazard warnings with appropriate actions.	2
Predefined roles and responsibilities are established for immediate action at all levels.	3
Basic emergency and relief services are available.	4
Preparedness activities (drills and simulations) are ongoing to train and educate responders.	3
Disaster recovery plan is pre-established that addresses economic, environmental, and social concerns of the community.	4
Technical and financial resources are available to support the recovery process.	5
Disaster recovery process is monitored, evaluated, and improved at periodic intervals.	4
Disaster Management (Preparedness, planning and readiness)	3,6

Disaster Management



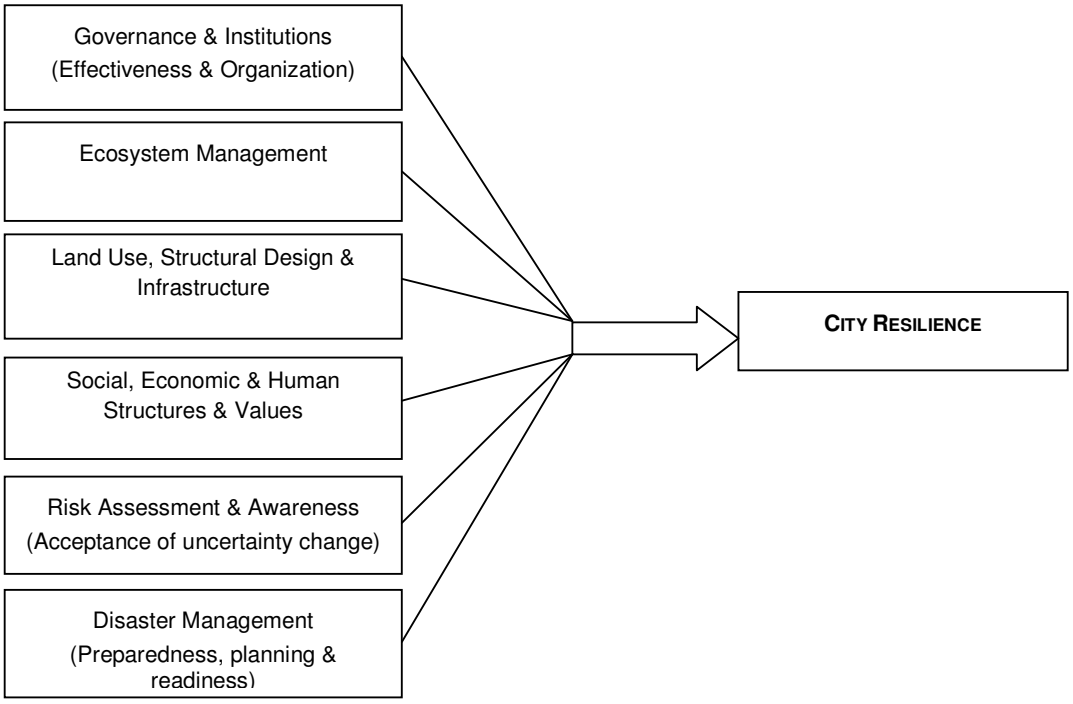
CONCLUSION

The aim of the thesis was to contribute to the current debate on climate change related vulnerability, resilience and adaptation because climate change, urbanisation, and related hazards are major challenges for urban planners. In addition the ambition of the paper was to develop a resilience assessment framework or guideline for coastal cities.

In order to accomplish the intention of the thesis it is classified into three main parts. The first part gives a theoretical background, the second one explains the developed resilience assessment framework and the last part applies this resilience framework to a specific case study.

The theoretical chapters describe the challenges of climate change, urbanisation, and hazards for future cities and what makes cities most vulnerable. In addition vulnerability and resilience are defined and important concepts and approaches are illustrated. The theoretical part of the thesis outlines the missing of overall concepts on resilience and vulnerability to assess coastal cities vulnerability and resilience in the context of climate change. However most approaches consist of main ideas and the author was able to identify important components of resilience and vulnerability concepts.

As a result of the theoretical part the second part explains the developed resilience assessment framework and the following figure illustrates the main components of a so-called “resilient city”:



Furthermore, in order to demonstrate the possibility of the implementation of this theoretically developed framework, the last chapter analysis the resilience of Rotterdam, as an example. Rotterdam was chosen as a case study because the city is already adapting and planning in the context of climate change and it is a valuable example to support the topic of resilience.

In summary the thesis supports the understanding of climate change related topics and in particular contributes on the relevance of the “resilience” approach. Especially the developed framework represents a guideline for future planning to support safer city development and to face climate change related impacts and vulnerability. The evaluation of the resilience of Rotterdam shows on one hand that vulnerable cities are able to adapt and be resilient, and on the other hand it identifies the importance of the social factor in resilience planning. The city is overall resilient but in particular awareness and preparedness of the population, a really important factor, need to be increased.

For the future the author would like to indicate the importance of concepts of adaptation and resilience to counter climate change impacts. In particular actions and measures need to be taken to make future cities and population less vulnerable. Overall all people need to be aware of climate change and the possibility to make communities more resilient due to the fact that for resilient planning all aspects, such as physical, social, economic, ecological, and institutional, are necessary. Without this knowledge and awareness the implementation of resilience will be more complicated.

ABBREVIATIONS

AR	Assessment Report
CCI	Clinton Climate Initiative
CCR	Coastal City Resilience
CDRI	Climate Disaster Resilience Index
CRM	Coastal resource management
DRR	Disaster risk reduction
GDP	Gross Domestic Product
GNP	Gross National Product
IABR	International Architecture Biennale Rotterdam
IPCC	International Panel on Climate Change
LECZ	Low Elevation Coastal Zone
MOVE	Methods for the improvement of Vulnerability Assessment in Europe
NCAR	National Centre for Atmospheric Research
OECD	Organisation for Economic Co-operation and Development
RAS	Rotterdam Adaptation Strategy
RCI	Climate Programme Rotterdam
RCP	Rotterdam Climate Proof Programme
RCPF	Resilient City Planning Framework
TMO	Taskforce Management Flooding
UN	United Nations
UNCHS	United Nations Centre for Human Settlements
UNDP	United Nations Development Programme
UNDRO	United Nations Disaster Relief Organization
UNFCCC	United Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
VROM	Ministry of Housing, Spatial Planning and the Environment
WP	Water Plan

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