CLIMATE PROOF AREAS
TIME TO ADAPT

Comparison of climate change effects across North Sea countries

CPA Work Package 1 report

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Investing in the future by working for a sustainable and competitive region

Authors CPA Work Package 1 report

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1. INTRODUCTION

1.1 Background

The North Sea region is threatened by the effects of climate change and particularly by rising sea levels since this region mainly consists of coastal areas. The frequency and impact of natural disasters such as storm surges and floods will increase in the future whilst increased levels of rainfall and higher water levels in rivers are also expected. This directly threatens areas of central significance to the North Sea regions such as precious natural areas and densely populated urban areas along the North Sea coast.

1.2 Aim of the project

The aim of the Climate Proof Areas project (CPA) is to accelerate the climate change adaptation process in the North Sea Region by means of the joint development and testing of innovative adaptation measures in pilot locations for a variety of areas representative of the North Sea Region as a whole, and to use the results to give recommendations for regional, national and North Sea region-wide adaptation strategies in order to create a toolkit for adaptation in the North Sea region, thus preparing and the whole of the North Sea region for anticipated changes in the climate.

1.3 Outline of this report and the link with the country reports

Climate change adaptation is in different phases of the policy cycle within the various partner countries: Belgium is in the process of analysing the potential impact and will then develop an adaptation policy; Sweden, the Netherlands and Germany are in the process of developing adaptation policies and testing potential adaptation measures, (Germany also announced an 'action plan' for April 2011 to be presented by an inter-ministerial working group at the national level), while the UK (and NL in part for flood risk issues related to climate change) is in the process of policy implementation.

The scope of the individual country reports includes primary and secondary impacts, an overview of the different adaptation measures and the current adaptation policy. In this report a straightforward comparison of primary impacts is provided. Because the kind of data available differ from country to country, data are processed in different models, or the climate change data differ because of local conditions, a straightforward comparison is not always possible. In such cases an appropriate study or striking example is discussed for each country.

1.4 Interreg 4B - North Sea Region Programme

The Interreg programmes aim at stimulating transnational cooperation in the EU whereas the North Sea Region Programme focuses on encouraging and supporting transnational cooperation in the North Sea Region. The aim of the Programme is to make the North Sea Region a better place to live work and invest in. This means that the North Sea Region Programme has a role in enhancing the overall quality of life for residents of the North Sea Region by ensuring that there is access to more and better jobs, by sustaining and enhancing the acknowledged environmental qualities of the region, by improving accessibility to places and ensuring that communities are viable, vibrant and attractive places to live and work.

The seven North Sea Region Programme countries are Sweden, Denmark, Germany, the Netherlands, the Flemish Region of Belgium, the UK and Norway. These areas share many of the same problems and challenges. By working together and sharing knowledge and experiences it is hoped that a sustainable and balanced future will be secured for the whole region.

The Programme is financed through the European Regional Development Fund (ERDF). 50% of the investments made for Climate Proof Areas is covered by this fund.

2. COMPARISON OF CLIMATE CHANGE INDUCED PRIMARY EFFECTS

2.1 Temperature: average and extremes

For all countries investigated in the CPA project temperature is expected to rise in the future (Table 1). Whilst the warming rates differ between the projections for the countries, in most countries the warming in winter is expected to occur more strongly than that in summer. Extreme events, hot days and heat waves are expected to become more frequent in the future.

2.2 Precipitation: average and extremes (per season if available)

Due in part to its high natural variability, summarising expected future impacts on precipitation is mo difficult than doing so for temperature. There is often a wide range of results from different climate modelling simulations. Nevertheless, some robust conclusions can be drawn from the different climate projections used by the region. Different time periods have been used in the different countries involved in CPA, but the changes are expected to evolve gradually over the coming decades to become most pronounced by the end of the century.

For the whole North Sea region in general, winter precipitation is expected to increase during the coming century, with a possible range to 50% and more, depending on the climate projections used and the location within the region. The pattern of change tends to increase the further north one looks, with the largest increases occurring in northern Sweden.

Projections for summer precipitation tend toward decreases in much of the region. However, there is a transition zone between increase and decrease that generally falls in mid-Sweden. Northern Sweden is expected to have some increase in summer precipitation as well, although not as large as the increases expected for winter. Some of the projections used for Flanders also indicate some increase in summer precipitation there.

Precipitation extremes in the form of heavy rainfall are expected to increase throughout the region, occurring both in summer and winter. Increases in the most intensive precipitation are expected even in areas where the seasonal precipitation is expected to decrease.

Specific detailed results are being used in each participating country in CPA. Updated results that have yet to be reported on will be used in some cases. However, the latest results still tend to follow the general trends as described here. As an example, Figure 1 and Figure 2 show both precipitation and temperature change over Europe from a composite of regionally downscaled results using 6 different global climate models (Kjellström et al., 2010). These projections originate in part from the recently completed ENSEMBLES Project (van der Linden and Mitchell, 2009).

	Annual		Summer	Winter	Notes
	Average temperature increase	Extremes	Average	Average	
Flanders	4 c	4 c in worst case scenario			to 2100, using CLI-MAR W scenario
Germany	1.5-3.5 c	Doubling of days over 25c and tripling of days over 30c			to 2100. Strongest increase in winter time
The Nether-lands	Historic data, plus data on the increase in numbers of warms days		0.9 - 2.8 c	0.9-2.3 c	Temperature ranges according to four scenarios, for cli-matic period 2036-2065 (KNMI report: Climate Change and Climate ef-fect Sketchbook, adopted by Climate team Provincie Zeeland)
The UK	1-5 c		1-6 c	1-4 c	UKCP02 figures, consistent with Country report
Sweden	3-5 c		2-4c	5-6 c	by 2080. Average winter temp for Southern Sweden only

Table 1: Average and extreme temperatures

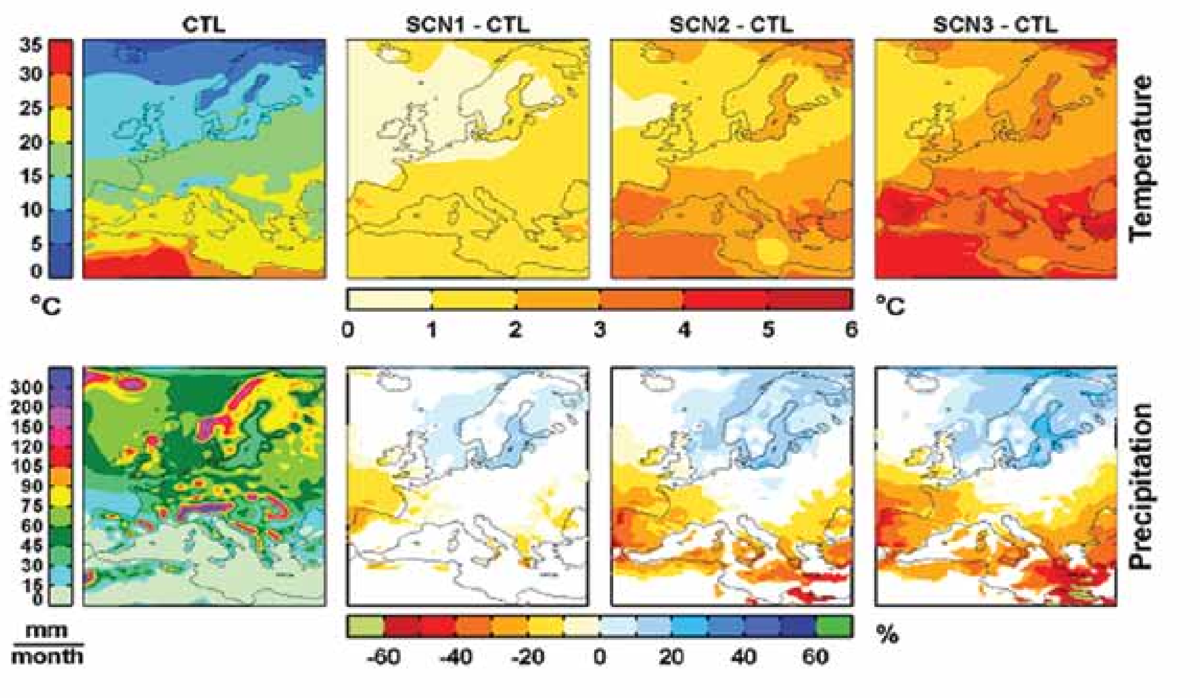


Figure 1: Change in temperature (top) and precipitation (bottom) for summer (Jun-Jul-Aug) from an ensemble of 6 regionally downscaled global climate model projections using the SRES - A1b emissions scenario. Shown are ensemble mean values for 1961-1990 (CTL, left) and the respective ensemble mean changes for 2011-2040 (SCN1), 2041-2070 (SCN2) and 2071-2100 (SCN3) compared to 1961-1990 (three rightmost columns). Only differences significant at the 5% significance level are shown. (adapted from Kjellström et al, 2010)

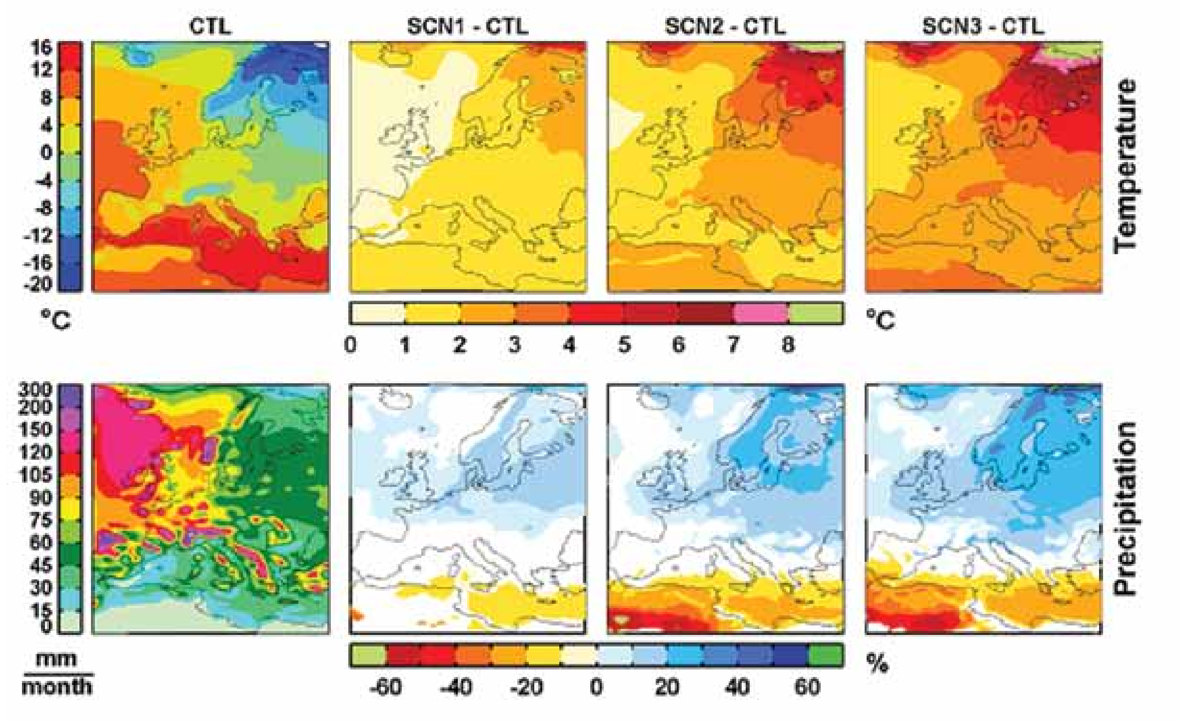


Figure 2: Change in temperature (top) and precipitation (bottom) for winter (Dec-Jan-Feb) from an ensemble of 6 region ally downscaled global climate model projections using the SRES-A1b emissions scenario. Shown are ensemble mean values for 1961-1990 (CTL, left) and the respective ensemble mean changes for 2011-2040 (SCN1), 2041-2070 (SCN2) and 2071-2100 (SCN3) compared to 1961-1990 (three rightmost columns). Only differences significant at the 5% significance level are shown. (adapted from Kjellström et al, 2010)

2.3 Sea level rise

Together with the drainage of melting land ice into the sea, the thermal expansion of seawater is the main cause of the sea level rise already observed. The temperature affects the density of the water and consequently also the currents and sea level. In addition temperature also affects the solubility of CO2 in seawater and is thereby connected to the composition of the atmosphere. The temperature of the seawater is rising in all sub-regions of the North Sea. The increase in the temperature of the seawater is between 0.023 °C/year (in the northern North Sea) and 0.053 °C/year in the central and southern North Sea.

As regards wave height, the historical data series show a natural variation with a period of around seven years. There is also a seasonal cycle: there are higher waves on average in the winter and lower waves in the summer months. A clear climate trend could not yet be shown in the historical series of measurements of wave heights and wind speeds. The wave heights vary from location to location in the North Sea region.

Furthermore sea level rise might induce salt-water intrusion, due to intensified drainage and/or sea level rise, which can affect the quality and the quantity of fresh water reserves, ecosystems and food production.

2.3.1. Flanders

The sea level in Ostend has risen on average by 1.69 mm/year since 1927. This rise conforms closely to the global average, which the Intergovernmental Panel on Climate Change (IPCC)derived for the 20th century (1.7 mm/ year). Measurement series which started later on the Flemish coast, show even higher values. This indicates an acceleration of the rise in sea level. This is confirmed by regression analysis of the Ostend series of measurements: for instance a staged linear profile results in a kink in 1992. The increase was 1.41 mm/year on average between 1927 and 1992, but already 4.41 mm/year between 1992 and 2006. Extrapolation of the historical trend shows a further rise in the sea level for the Flemish coast, depending on the relations applied, of 20 cm to 200 cm for the period from 1990 to 2100 (Figure 3).

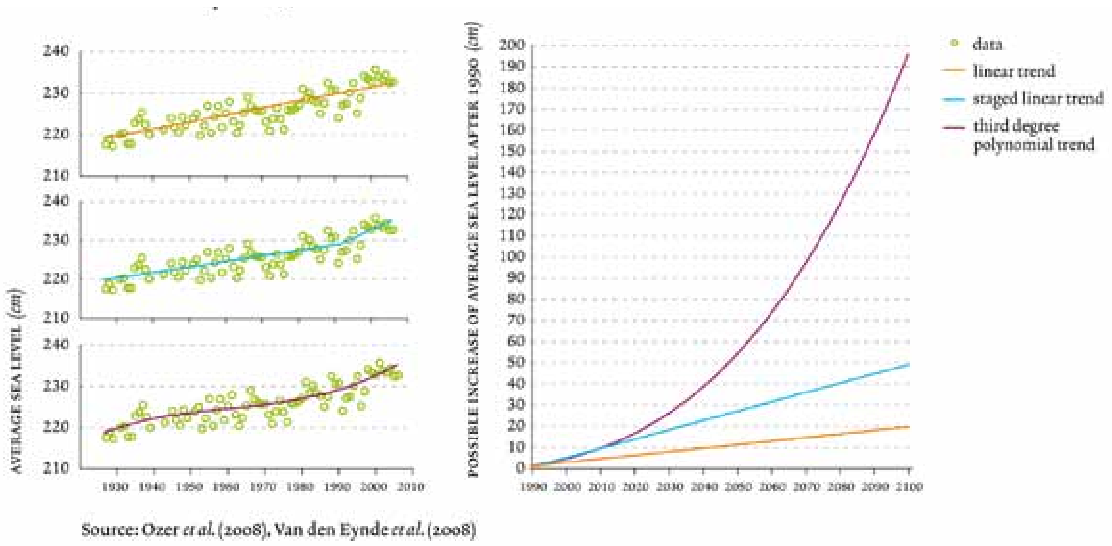


Figure 3: Trend analysis of the sea level measurement (Ostend, 1927-2006) and extrapolation to a possible sea level rise in the period 1990-2100

2.3.2. Germany

For the East Frisian Wadden Sea (Lower Saxony), a sea level rise of 2.43 mm per year sea level rise has been observed in the time period between 1906 and 2006 by the Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN, 2007). Projections of future sea level rise in Lower Saxony are based on the global projections of the Intergovernmental Panel on Climate Change (IPCC 2007) and are compared to linear extrapolation of the changes observed in the past (NLWKN, 2007). This results in an expected sea level rise of 18 to 59 cm by 2100 (NLWKN, 2007).

2.3.3. The Netherlands

The predicted absolute sea level rise (meaning without taking the subsidence into account) for 2050 varies between 15 and 35 cm. Around 2100 the sea level rise will be 35 to 85 cm. See Figure 4. The relative sea level rise will be higher due to land subsidence.

2.3.4. The UK

Sea level rise varies around the UK coastline. The average sea level around the UK coastline is currently 10cm higher than it was in 1900 (Hulme et al.,2002) and the 1990s and 2000s have experienced a higher rate of sea level rise than other decades. The UK also experiences glacial rebound from the last Ice Age. Because of this, the southeast is sinking at about 1mm per year and the northwest and west of Scotland is rising at about 1.6 mm/yr (Alcamo et al.,2007). Sediment consolidation is also being experienced in the south-east, causing coastal subsidence. Taking all of this into account during the 20th Century the sea level has risen at a rate of about 1mm per year more in the south-east.
Compared to the period between 1961 and 1990, a potential mean sea level rise of 20-80 cm in the southwest of England and 0 – 60 cm in Scotland is likely by the 2080s

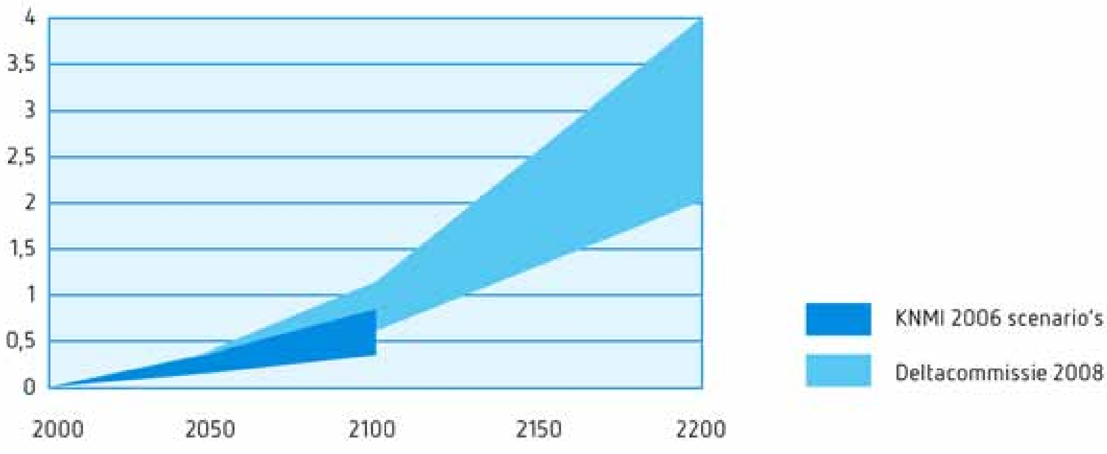
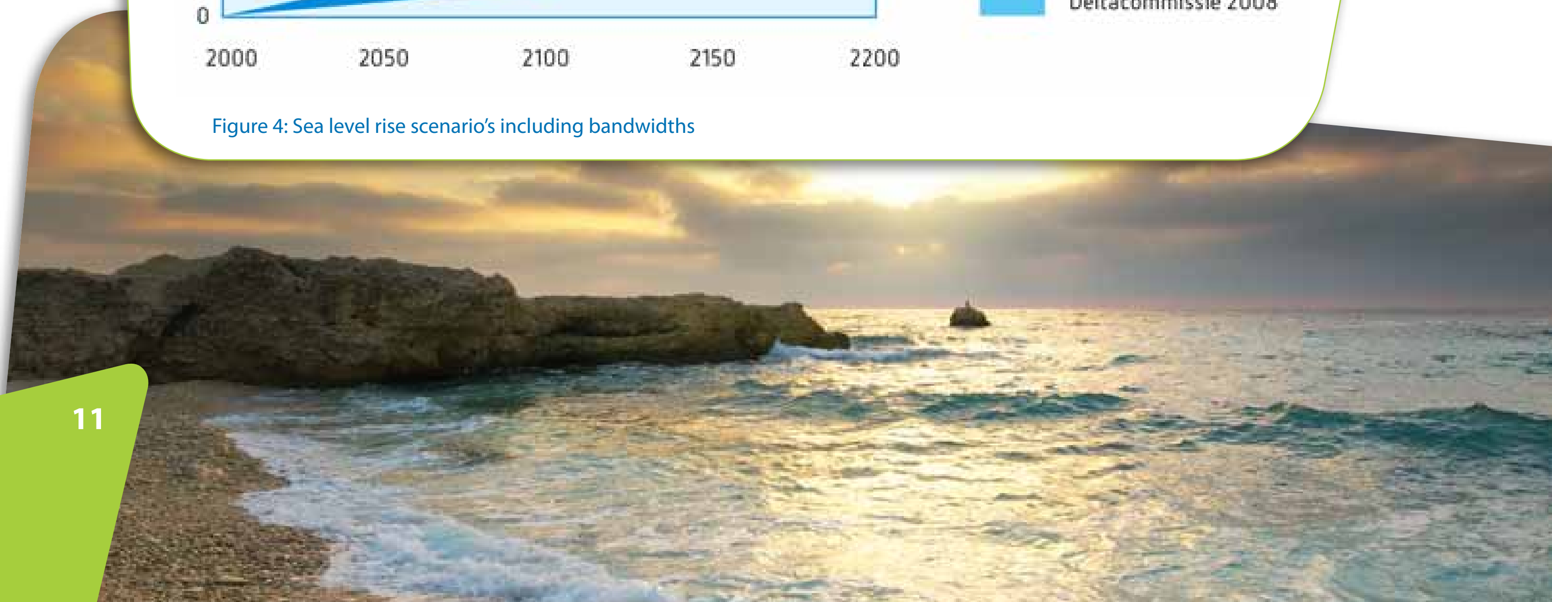


Figure 4: Sea level rise scenario's including bandwidths



2.3.5. Sweden

In the Baltic Sea and the North Sea, the rise is expected to be 10- 20 cm greater than the global average (IPCC, 2007b, SOU 2007:60). In the Baltic Sea this increase is countered by rises in land levels, but is boosted by the fact that westerly winds are expected to increase in frequency. In simulations by Sveriges Meteorogiska och Hydrologiska Institut (SMHI) of how sea levels in the Baltic will change by the end of the century in various scenarios for global sea levels, the level along Sweden's coastline increases by anything from a few centimetres to 80 cm in the southern Baltic, while along the coast of northern Norrland, the rises in land and sea levels cancel each other out. Extremes of high water are expected to increase by more than the average water level. (SOU 2007:60). Low-pressure movements and winds are also of great significance to sea levels and the risk of flooding and erosion along the coasts. With increased dominance of westerly winds, the maximum high-water levels in the Baltic Sea will rise substantially. For example the maximum high-water level in Karlskrona today is one metre above the present-day mean water level. It is estimated that it will be two metres above today's level by the end of the century.

2.3.6. Comparison table of scenarios on mean sea level rise

(cm)	Base year/period	2040	2050	2080	2100
Flanders	2005				
Min.		+ 30			+ 60
Average.		+ 40			+ 93
Max.		+ 100			+ 200
Germany					
					+ 18-59
United Kingdom	1961-1990				
Min.				+ 0-20	
Average.			+41		
Max.				+ 60-80	
Sweden					
Min.					+ 20
Average.					+ 60
Max.					
The Netherlands					
Min.			+ 15		+ 35
Average.					
Max.			+ 35		+85

Table 2: Comparison table of scenario's on mean sea level rise

2.4 Flooding

2.4.1. Flanders

Rainfall run-off from river catchments

The simulation of the wet, moderate and dry climate scenarios to 2100 makes it possible to study the impact on high and low rainfall run-off discharges to rivers in Flanders. The wet scenario results in the most extreme impact for high flows and floods, the dry scenario in the most extreme impact for low flows and droughts. The conclusions for all rivers are similar:

High flows in winter: the sharp increase in evaporation (both during the winter and the summer) compensates for the increase in winter precipitation to a great extent. As a result, the increase in the number and extent of floods (particularly along rivers in the winter) is relatively limited. Peak flows in the rivers will increase by a maximum of 35 % in the most unfavourable scenario. This increase could result locally in more frequent and more extensive flooding.

High flows in summer: extreme summer showers could result in flooding of sewers and smaller watercourses. The majority of climate models predict an increase in the number (the frequency) and extent of heavy summer thunderstorms, so that an increase in the number of such floods is also to be expected. For the largest events, which currently occur once a decade, the average daily precipitation in the most unfavourable scenario increases by approximately 30 %.

The impact of climate change is not only highly seasonal but also extremely variable regionally. Climate models show a north-south variation in the precipitation and temperature change (Baguis et al., 2009). In northern France, climate change will further strengthen the development towards desiccation, with a decrease in both summer and winter runoff volumes and consequently also a decrease in the number of floods. The probability of water shortage also increases in Flanders. The trend towards more floods is, however, still unclear. The increase in the number of floods is clearer to the North of Belgium, e.g. in The Netherlands.

Adaptation of sewer systems and urban retention basins

In Flanders, sewers are often not only used to remove waste water. Together with ditches and streams they are often also responsible for the removal of rainwater (precipitation). The peak drainage into the sewage systems, ditches and streams increases due to heavy precipitation. A precipitation intensity that in the current climate only occurs once every one and a half months, might occur monthly by 2100 under the wet climate scenario. A period of heavy precipitation that now only occurs once every two years would occur annually according to the same wet climate scenario. The heaviest short precipitation episodes (1 hour or less) that previously only occurred once a century might occur once a decade (Willems, 2009). In the coming decades climate change might result in a gradual increase in the number of sewer floods and overflows, with a negative impact on the quality of the surface waters.

Flooding translated into economic risk

The impact of climate change on high and low river flows are further converted into a possible economic risk as a result of flooding. This risk of flooding is described as the average expected damage per surface and time unit, expressed in euro per m^2 and per year. In this way damage at a specific location is primarily defined by land use and the local socio-economic context (housing prices in a specific municipality, yield from arable land, price of agricultural produce, vehicle prices, etc.). Densely built-up areas will suffer greater damage than pasture in the same flood; natural areas would not suffer any financial damage from the same flood.

Figure 5 shows the ratio of the risk under a climate scenario with the current risk per zone from the Flemish Hydrographical Atlas (vha-zone). Green indicates a drop in the risk of flooding; red indicates an increase in the risk.
In the dry climate scenario the risk decreases strongly for all basins in Flanders. The total risk for the modelled part of Flanders has consequently also fallen sharply (56 % lower than the risk in the current situation). The drop is particularly pronounced primarily in the Demer (-84 %) and Yser basins (-72 %). This is a direct result of the fact that the peak drainage into the watercourses in the dry climate scenario and consequently also the flooding areas are much smaller than in the current situation. Naturally this drop is not homogeneous in all parts of a river basin.
In the moderate climate scenario there is still a drop at the Flemish level (-8 %) when compared to the current situation, albeit of a different order of magnitude than in the dry scenario. However the risk increases both in the Upper Scheldt basin and within individual vha-zones in other basins.
There is an increase in the risk for all basins in the wet climate scenario. At the Flemish level the increase in risk is 33 %. The Leie, Upper Scheldt and Demer basins particularly experience a very sharp increase in the risk by a factor of 2 to 3. For the Lower Scheldt and tributaries the increase is minimal: the risk would only increase strongly along the Nete and the Dijle.

It has to be mentioned that the exercise has been carried out primarily for navigable watercourses and that the increase of hardened surfaces is not included in the spatial scenarios.

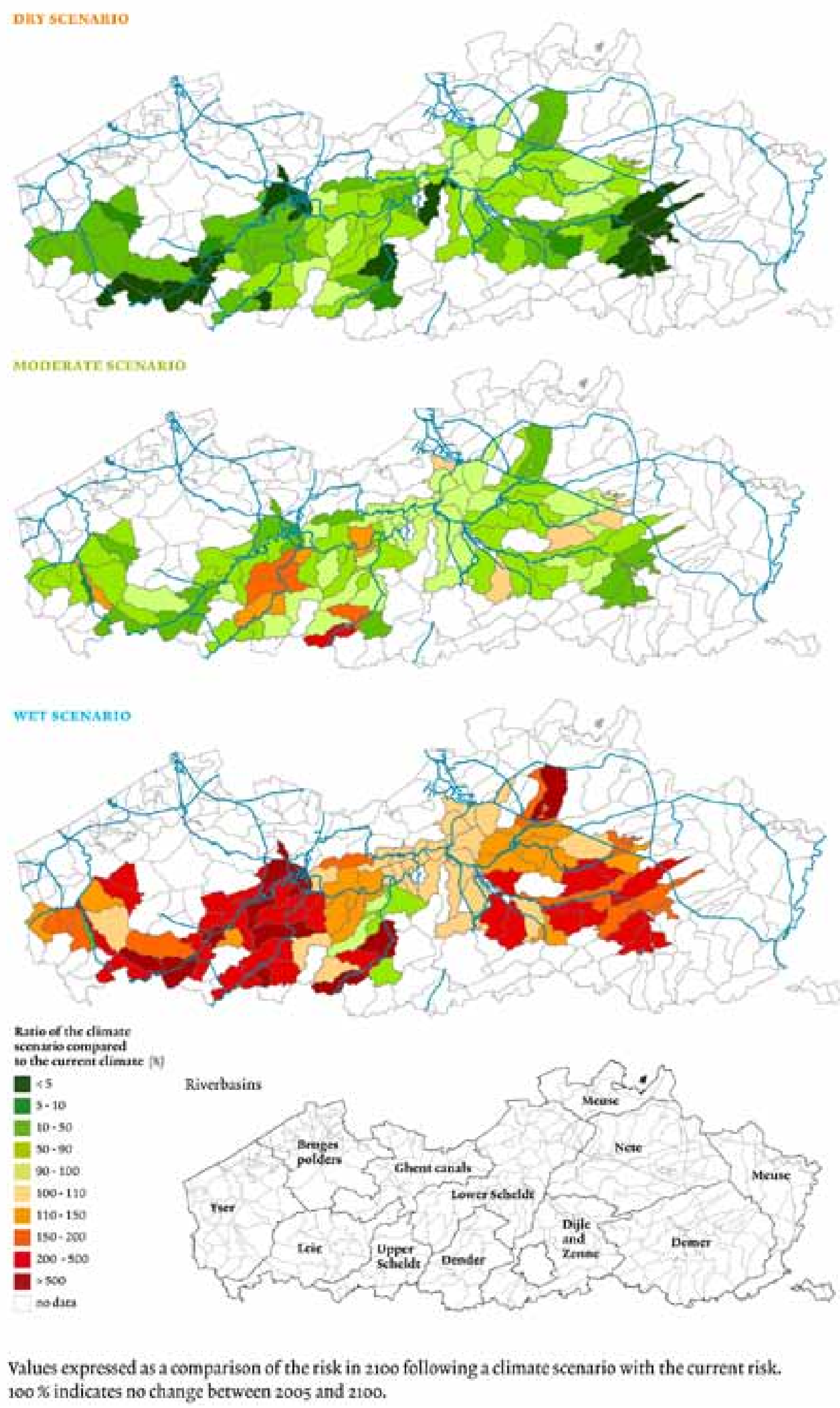


Figure 5: Evolution of the risk of flooding with the current land use as a result of the three climate change scenarios by 2100 (Mira Team, 2009)

2.4.2. Germany

Inland flooding:
Exemplary remarkable floods in German North Sea tributaries were floods of the Rhine (1993, 1995), the Odra (1997), and the Elbe Rivers (2002). Observations only partly show slight increases in flood intensity and flood probability. However, most of the identified trends are statistically not significant using all historically available gauge data (Bormann et al., 2008). In contrast, Petrow and Merz (2009) identified regionally significant trends in the second half of the 20th century in German river basins. Projections by the German Federal Government (Bundesregierung, 2008) assume an increasing flood risk in winter due to lighter snow fall as well as snow cover and strengthened direct runoff generation mechanisms.
In northern Germany there is currently no concrete strategy available to adapt flood protection to climate change conditions. In comparison, in southern Germany (Bavaria and Baden-Württemberg) so called 'climate change adaptation factors' have been introduced to adapt design floods to climate change conditions; thus, to take into account the non-stationary behaviour of hydrological time series, design floods are multiplied by factors depending on the flood probability, e.g., 15% for a hundred year flood, 8% for a 200 year flood, and 3% for a 500 year flood (Katzenberger, 2008; LfU BW, 2005).

Coastal flooding:
In Lower Saxony, sea dikes are assumed to be safe, assuming that there is no risk 'behind' the dike with respect to a potential dike breach. As mentioned above, projections of future sea level rise in Lower Saxony are based on the global projections of the IPCC (2007), compared to a linear extrapolation of the changes observed in the past (NLWKN, 2007). This results in an expected sea level rise of 18 to 59 cm by 2100 (NLWKN, 2007). The current strategy therefore is to increase the height of dikes by the expected climate change induced sea level rise to further ensure safety.

2.4.3. The Netherlands

Flooding in the Netherlands is approached by means of the description of flood risk. This risk of flooding is projected as the probability of the occurrence of a flood event and the quantified damage that this event causes.

The acceptable risk level is assigned to different dike rings using an economical optimum. The risk formula translates a minimum level of safety, prescribed by law. This level of safety is described by the conditions that the dike-ring has to be able to withstand. This is called the level of exceedence. In Figure 6, the different dike rings and their level of safety (level of exceedence) are shown.

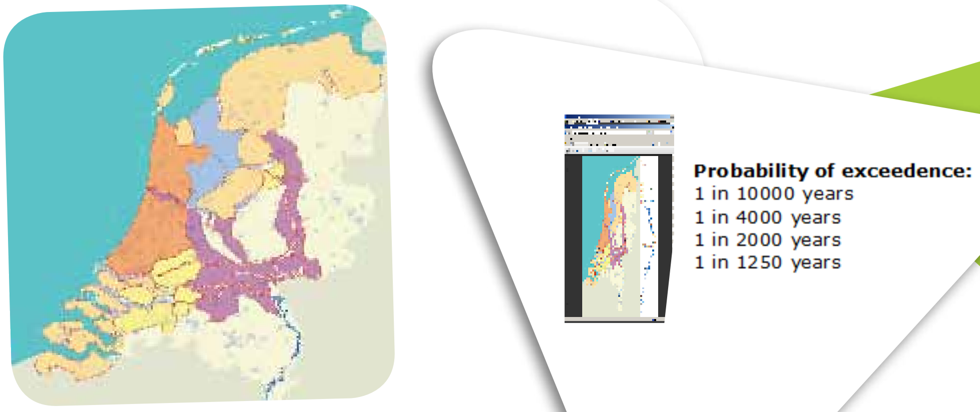


Figure 6: Dutch dike rings and their level of safety

In the Netherlands, the dike-rings and the dikes that make up the dike-ring are subject to testing. Every five years the dikes are tested, whether they still meet the levels of safety as prescribed by law.

Climate-proofness of the risk approach
When the dikes are subject to the five yearly testing, they are required to be able to meet hydraulic conditions. These conditions are prescribed for a period of 50-100 years.

The Delta program 2011

The Delta Program is a national program. Government, provinces and municipalities collaborate in this project with input from civil society. The goal is to protect the Netherlands against flooding and to ensure sufficient fresh water for future generations. The Delta Commissioner encourages the establishment and implementation of the Delta Program. He makes an annual Delta program proposal to the Ministers of I&M (Infrastructure and Environment)and EL&I (Economics, Agriculture and Innovation). This proposal includes measures and actions to reduce flooding and water shortages. The Delta program has nine sub-programs: Security; Freshwater; New construction and Restructuring; the IJsselmeer area; the Rijnmond-Drecht-cities; the South-western Delta; the Rivers; the Coast and the Wadden area.

2.4.4. The UK

There are approximately 5.2 million properties in England under threat from flooding and climate change is expected to increase this threat in the future. Floods in recent years have forced the issue up the political agenda and the amount of funding from central government to deal with the problem has increased. The previous administration committed £2.15 billion between 2008/9 and 2010/11 in flood risk management. This resource is split between different agencies including local authorities, the Department of the Environment, Food and Rural Affairs (Defra) and the Environment Agency.

Investigations of floods in the middle of the first decade of this century highlighted deficiencies in managing flood risk. Multiple agencies are involved in managing the risk of flooding from surface water, foul water, rivers and seawater. This has resulted in the Flood and Water Management Act 2010, which became law on 8th April 2010. This had a number of impacts:

- **The Environment Agency were given an overview of all flood and coastal erosion risk management schemes;**
- **County councils and unitary authorities have been given the lead role in managing local flood risk;**
- **The uptake of sustainable urban drainage schemes has been made more likely by removing the auto matic right to connect to sewer systems.**

2.4.5. Sweden

High river flows and flooding occur in Sweden on a regular basis. However, as the country is more sparsely populated than many other European countries, the impacts are often relatively less severe. Apart from climate, another factor that has an impact on the severity of flooding is the expansion of settlements and infrastructure into risk zones near watercourses, lakes and coasts. Such development makes it more difficult to ascertain whether flooding is on the increase due to a changing climate or due to society making it self more vulnerable to such risks. (SOU 2007:60)

Several notable floods have occurred in Sweden since the year 2000. These include several regions that were hit in autumn 2000/winter 2001 by prolonged periods of rain. This was probably the most severe case of flooding for Lake Vänern and surrounding areas in the last 100 years. Other examples include a prolonged summer rain in northern parts of the country in 2000, the southwest coast in 2002, and south eastern Sweden in 2003 and 2004. Autumn rains caused flooding in south western Sweden in 2006 and in extensive areas of southern Sweden in 2007. (SOU 2007:60)

Climate change projections have been translated into hydrological projections with the help of hydrological models. Studies to date indicate that mean runoff will increase across most of the country under future climate conditions. This is particularly true for western and northern parts of the country. Looking at extreme events, analysis of 100-year floods shows increases in magnitude for south western and north western parts of the country. This also indicates that floods with a 100-year magnitude in the present climate will become more frequent in these areas in the future climate. The changes in precipitation, water flows and water levels are also expected to increase the risks of erosion and landslide as well as changed behaviour and increased mobility of soil contaminants. (SOU 2007:60, Andersson-Sköld et al., 2008)

Figure 7: Flooding in Arvika

Flooding in Arvika 2000

In autumn 2000 there was flooding, the most severe in modern times in the Arvika municipality. The central part of the town was under water from early November 2000 until the end of January 2001. Temporary walls were built and the water was pumped out of the central parts. Traffic in the central parts of Arvika had to be redirected, the central bus station had to be relocated, railway traffic (personal transport, SJ) had to be shut down, lake traffic was hindered and industrial production in the region was affected. The National Road Administration board worked intensively to raise the levels of flooded roads in the areas as water levels increased. The costs for damages, redirections, delays and other inconveniences for society caused by this event are estimated to be around 200 Mkr (M€ 20) according to the municipal street and road manager Anders Norrby. (Norrby, 2010)

The costs are very high compared to the total budget for a medium-sized Swedish municipality such as Arvika. This is despite there having been no severe long-term damages and no deaths. In future such events are expected to become more common not only in Arvika but also in many other parts of Sweden where there is today no experience of and often not even awareness of the potential for such events (e.g. SOU 2007:60, Annex 15).

As a consequence of the flood event in 2000-2001, the Arvika municipality is now working purposefully to analyse what happened and to identify and put into action measures to reduce damage should a similar event occur in the future. Advanced investigations of potential risks and potential measures have been carried out in the recent past and are continuing today. For example the Arvika municipality is making use of international experience and knowledge by participating in European networks and projects such as Flows and CPA (Norrby, 2010).

3. COMPARISON OF RECOGNISED SECONDARY EFFECTS

When secondary climate impacts are being analysed they must inevitably be examined in the context of ongoing developments: the climate aspect is invariably only a single component of a broader sectoral, physical or socio-economic development. This can be described very well by linking the factors to the economic aspects of climate change. The economic aspects of adaptation strategies, including the interconnection between impacts and adaptation, for instance cost-benefit analyses, are not considered in this problem analysis.

Economic impacts of climate change
Climate impacts from the perspective of economy can be analyzed in different ways:

- General economic impacts, e.g. health issues, employment, higher or lower productivity of workers, regional attractiveness, accessibility, etc.
- Impacts on various economic sectors:
  - Agriculture
  - Forestry
  - Fisheries
  - Energy
  - Tourism/ recreation
  - Housing / building sector
  - Water management
  - Transport
  - Landscape and Nature

The following table gives a brief outline of the recognised secondary impacts on the different pilot countries in the light, including an estimate of the time frame of the impacts and the associated autonomous trends for each area.

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Agriculture				
Agriculture	Quantified assessments: Crop loss max 30% for all scenarios Production loss (chicken, cattle, pigs, sheep) max 10% due to heat stress Increased chance of exotic diseases (for example Blue-tongue disease) Assessments not quantified: Potential increase of salinity in polder areas Possibilities for growing new crops (salt loving species) Increased flooding threat to agricultural areas Future impacts on greenhouse cultivation (e.g. decrease of heating costs due to higher winter temperatures) Lower yields due to drought periods	N/a	Flanders area	- Market liberalisation - European Commission funding schemes - Green and blue services delivered by agriculture
Germany	An increasing risk to agricultural production due to increasing probability and intensity of extreme weather conditions (droughts, floods, heat waves, cold waves) can be expected. Climate change also induces a change in recommended species composition in agricultural systems (Bundesregierung, 2008).	n/a	Regionally specific climate change of course has regional impacts.	n/a
Netherlands	1.Decreased fresh water supply due to drought and increase in salt intrusion. 2 Climate for crop growth improves due to increase of CO_2 in the atmosphere and temperature	Problems increase dramatically after 2040. Currently problems are incidental.	Areas with low capacity for water storage Areas prone to salt intrusion	Opportunities for aquaculture, diversity of products and expansion of growth season

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
United Kingdom	Climate change is likely to lead to an increased growing season which would positively benefit yields. However, increased soil moisture deficits in summer will have the opposite effect. Storms may lead to more regular floods than are currently experienced. Increased degradation of peat soils decreases the availability of Grade 1 agricultural soils for farming and makes ecological restoration more problematic. This in turn leads to greater competition between land use and archaeology. New crops may need to be grown and may introduce novel impacts on local ecology. Livestock production will also be affected by higher temperatures and scarce water, resulting in stress to animals. Potential spread of vector-borne diseases into the UK.	2040-2100	South east England in particular Fens and other areas with highly organic soils	
Sweden	The distribution of species will generally be shifted northwards. Vegetation and cultivation periods will be prolonged. Primary estimates indicate that for current crop types the harvests will increase by around 20 % in the valley of Lake Mälaren and by more than 50 % further north (Västerbotten). Yields of autumn-sown crops will increase, and new crops may be introduced. Conditions for livestock farming will be improved by a prolonged grazing season and increased harvests of forage crops (SOU 2007:60). Problems that are expected to arise include an increased use of pesticides, an increase in animal induced infectious diseases and overloaded drainage systems.	- 2100	Examples for Lake Mälaren and Västerbotten Trend: growth shifting north	Opportunities for aquaculture, diversity of products and expansion of growth season

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Forestry				
Flanders	n/a	n/a	n/a	n/a
Germany	An increasing risk for forestry production due to increasing probability and intensity of extreme weather conditions (storms in particular) can be expected. Climate change also induces a change in recommended species composition in forestry systems (Bundesregierung, 2008).	n/a	n/a	n/a
Netherlands	n.a	n.a	n.a	n.a
United Kingdom	Increased risk of forest fires in the south east. New tree species tolerant of higher temperatures will replace existing species.	n/a	n/a	n/a
Sweden	The distribution of species will generally be shifted northwards. New tree species and different types may lead to higher production. In the south less spruce growth towards the end of the century. The proportion of deciduous trees might increase in forestry. Increase in growth, reduced ground frost and wetter conditions will lead to a greater risk of wind-felling. Forests may become more prone to fire, fungal and insect attack. New demands on both drainage and irrigation. (SOU 2007:60)	- 2100	Trend: species shifting north	Opportunities for increased growth. Primary calculations show that the rate of growth of pine, spruce and birch will gradually increase so that by the end of the century it is 20 - 40 per cent higher than today. But also increased risks and costs related to storm felling and diseases. (SOU 2007:60).
Fisheries				

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Flanders	Increased vulnerability of fish stock due to change of sea water temperature Variation in strength and frequency of storms may influence the state of the fishing fleet			- European funding schemes - Cost of fuel overall determining price factor - New fishing techniques (less environmental impact) instead of traditional "boomkor" - CLIMAR: "Evaluation of climate change impacts and adaptation responses for marine activities" – including a complete study of impact on fisheries - It is an evaluation framework for adaptation scenario's /measures as a response to climate induced impacts, and this for the North Sea environment - www.arcadisbelgium.be/climar/
Germany	n/a	n/a	n/a	n/a
Netherlands	Shellfish (mussels and oysters) threatened by eutrophication and algae in warmer climate. Possibility of fish farming on land.	Not well known, but occurring incidentally at present	Eastern Scheldt, Grevelingen	Opening Grevelingen to tidal variation increases breeding grounds Increasing tidal variation in Oosterschelde will benefit biodiversity. Nature regulations prompt shell fish industry to develop nurseries on land.
United Kingdom	Coastal squeeze and sea level rise may affect the productivity and viability of inshore fisheries. Regular flooding could affect stocks in fresh water fisheries. Marine fisheries affected by changes in surface temperatures.	n/a	n/a	n/a

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Sweden	Great changes are expected. New species will gradually colonise Swedish waters and may seriously disrupt ecosystems. Arctic char will decrease in the watercourses of Norrland, while salmon will be threatened in the watercourses of southern Sweden. Cod may be completely eliminated, and replaced by freshwater species, in the Baltic. Flatfish will decrease in the Baltic Sea. Warm water species such as perch, pike and pike-perch will increase and become established much further north. (SOU 2007:60)	2010 - 2100	Regional variations	Climate change justifies further efforts against overfishing in the Baltic. Total net loss in Sweden may be 0-1.5 M€ over the period 2010-2100. Catches of crayfish and pike-perch in the large lakes may increase by a value equivalent to 1.5–2 M€ million per year. Fisheries on the west coast will probably be favoured by climate change.
Energy				

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Flanders	Direct influence: - Diminution of gas and electricity consumption due to increasing winter temperature - Rise of electricity consumption for cooling due to increase in average summer temperature - Strong fluctuations in energy demand as a consequence of extreme weather conditions Influence on operational management: - Potential shortage of cooling water for electricity plants - Potential negative influence on productive capacity of wind farms due to increased chances of storms - Positive effect on the use of solar energy due to increased hours of sunshine - Unquantified influence on transport and distribution of energy Possible indirect effects: - Change of consumer perception on energy demand due to more rational energy consumption			- European-based need for renewable energy (wind energy at sea, on land, solar energy, biomass, ...) - Political uncertainty about keeping nuclear energy

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Germany	The energy demand for heating is expected to decrease with regional warming conditions while an increase in the demand for cooling systems is likely. Moreover, a decrease in the efficiency of power plants during summer is likely, as well (Bundesregierung, 2008)	n/a	n/a	e.g., the establishment of offshore wind parks.
Netherlands	Increase of domestic and tourist demand in summer for cooling systems and decrease in winter. More frequent and heavier rain in winter requires more energy for pumping. Wind farms may be less efficient due to larger fluctuations in wind force/storms. Possibility for increase of solar energy systems.	Gradual development	Energy is produced outside Schouwen-Duiveland, but wind farms are being developed along the coast.	Political base for wind farms is decreasing
United Kingdom	Major energy generation facilities exist along the coast and will require protection from sea-level rise. Increased demand for renewable energy will lead to more wind farms in the countryside. Use of wood fuel may increase short-rotation coppice in the countryside. Soil moisture impacts on soil stability could affect transmission lines, as could higher wind speeds. Increased potential for renewable energy, especially from solar power.	Depends on policy responses. increases in wind farm and wood fuel in the short-term	Low lying areas in south east, especially the Fens, have a profitable wind supply. All three UK projects will be affected by wind farm applications (including off-shore)	

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Sweden	An increase in water-driven energy production can be expected. A country-wide analysis of the Swedish hydrological power system's ability to cope with high water flows is ongoing, including investigation of impacts from climate change.	2010-2100	Water power	Primary estimate of potential increase in water power is 19000-26000 M€.
Tourism/ recreation				
Flanders	- Higher temperatures will possibly attract more people for tourism. - Increased water scarcity, energy demand, incidence of storms in combination with sea level rise and a potential decrease in the water quality may mitigate the increasing potential for tourism	n/a	- Coast	- CLIMAR: "Evaluation of climate change impacts and adaptation responses for marine activities" – including a complete study of impact on coastal tourism – It is an evaluation framework for adaptation scenario's /measures as a response to climate induced impacts, and this for the North Sea environment - www.arcadisbelgium.be/climar/
Germany	A longer tourist seasons in coastal areas of the North Sea region is expected due to higher temperatures in summer. In mountainous regions, the winter season will also be affected due to snow scarcity (BMU, 2009).	n/a	e.g., coastal and mountainous areas (see left)	n/a

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Netherlands	1.More warm days with unstable weather patterns (frequent and intense showers) 2. Issues with water quality 3 Frequent higher (i.e. Mediterranean) temperatures in summer can become unbearable.	Gradually over time (+6 degrees warmer around 2100)	Beaches and hinterland. Harbours and marinas.	- Population growth until 2030, ageing until 2040 after which rejuvenation will take place. - Change towards tourism based economy. Development of eco-tourism sector - integration of work environment, recreation activities and living space
United Kingdom	Increased potential for people from the UK holidaying in UK and taking day trips in the UK due to better weather. Increased incidence of storms may mitigate this in summer. Fewer people flying to foreign holidays with greater awareness of carbon emissions	Gradually over time, especially dependent on social trends and policy/legislation	The three UK projects are found in the South east, where a large growth in population is projected.	
Sweden	The opportunities open to the rapidly expanding tourist industry in Sweden may be further improved in a changed climate with warmer summers and higher bathing water temperatures. However, water resources and quality will remain a key issue. Winter tourism and outdoor leisure will be affected by winters with increasingly depleted levels of snow, particularly in the southern mountains, and adaptation measures will be required (SOU 2007:60)	n/a	n/a	Opportunities for tourism with warmer summers and higher bathing water temperatures.
Housing/ building				

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Flanders	No quantified assessments yet for housing policy and spatial/urban planning	n/a	n/a	CCASPAR research project (2009-2012) – Climate change and changes in spatial structures, i.e. natural structure, landscape structure and structures of human activities (residential, economical, recreation, infrastructures) - Overall pressure on spatial environment: - Fragmentation of space through increasing urbanization, rise of urban sprawl; - Decrease of open space (i.e. land for nature, urban green, parks, …) - Increase of traffic load (trend in relation with scattered urban pattern) - Increase population density - System which promotes homeownership (tax advantage)
Germany	It can be expected that there will be new requirements for the building industry (civil engineering) to cope with changing climate conditions (temperature, humidity, heavy rainfalls, wind speed during storm events, etc.) and soil conditions (increasing variability of soil moisture causing potential instabilities) (Bundesregierung, 2008).	n/a	n/a	n/a

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Netherlands	- flood safety: dikes will be raised and made wider, encroaching on existing residential areas. - heat stress: in towns the high temperatures will become unpleasant - Rising groundwater levels in winter, lower levels in summer. Possible adverse effect on wooden foundations.	2020-2075 and onward	Coastal residential areas. Towns are located along the coast.	Measures to provide a safer coast are already planned, but designs can be adjusted. Remembrance of 1953 flood still governs attitude towards flood risk. Population growth scenarios predict decrease until 2015
United Kingdom	Greater flooding risk means fewer suitable areas for housing development. Existing properties in floodplains and along coastal areas will be at greater risk from flooding. The south-east of England already has the lowest rainfall and freshwater resources will be under more pressure, affecting how housing is constructed. Providing freshwater for domestic uses will add to pressures on the natural environment.	n/a	n/a	n/a
Sweden	There may be great financial impact on existing buildings and constructions due to flooding, landslides and erosion. All municipalities are required by law to carry out hazard, risk and vulnerability analyses where climate change is often included. The need for heating will decrease sharply as a consequence of the rise in temperature, while the need for cooling will increase The National Board of Housing, Building and Planning is at present updating a guide for physical planning.	2010-2100		Expected costs due to risks related to flooding, landslides and erosion on buildings and constructions was calculated to 5 -24 M€ over the period 2010-2100 (SOU2007:60). The awareness of climate change, and the related uncertainties, is increasing in the spatial planning. The uncertainties are still regarded as difficult to handle (SOU 2007:60).

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Water management (fresh and waste water)				
Flanders	Decrease in average summer precipitation Threat of sewage flooding due to increased chance of severe thunderstorms in summer Increase of average winter precipitation	n/a	Low lying areas, brooks, rivers and hardened surfaces	- The EU Water Framework Directive - integrated river basin management for Europe (22 December 2000) - The Flanders decree on integrated water management (18 July 2003)
Germany	Adaptation will make significant investments in infrastructure necessary. For example, for water supply and waste water disposal increasing capacity will be required due to the expected increase in water consumption in summer as well as increasing intensity of heavy rainfall events (Bundesregierung, 2008).	n/a	n/a	n/a
Netherlands	Urban flooding: capacity of sewage systems will become too low. Drier summers and wetter winters will place higher demand on water management capacity. See further Agriculture	Gradual	Urban areas. Most are pre-WW2	Dutch Water Framework Directive in place. Sewage systems are due for upgrade.

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
United Kingdom	Decline in water quality with reduced dilution. Storms stirring up river sediment will reduce water quality further and reduce visibility. Threat of waste water services being overwhelmed in storms. Restrictions on water use may mean wetlands will be drier than they should be.	2040-2100	Particular pressure in the south-east where water stress is at its worst and where population growth is anticipated.	
Sweden	The quality of the raw water in water sources will be adversely affected, with increased humus levels, increased algal bloom and increased contamination with microorganisms and chemicals. Present-day treatment techniques will be inadequate, and new technology will have to be introduced, increasing the costs of drinking water treatment. Sweden has good access to water of good quality. Although there will be considerable consequences for the supply of drinking water, Sweden will be affected to a far lesser degree than many other countries.	2010-2100		Primary estimates of need of increase in water management costs in Sweden are 6-12,5 M€ over the period 2010-2100 (SOU 2007:60)
Transport				

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Flanders	- Potential pressure on road-, rail- and airport infrastructure as a consequence of peaks in temperature, precipitation and increased chance for storminess (e.g. melting asphalt, bursting rails, broken overhead wires due to higher wind velocities or falling trees) - Precarious traffic situations as a result of bad weather conditions	n/a	Roads, railroads and airports	
Germany	Mobility is an important factor for further economic development. But the transport sector is very energy intensive in general. Therefore, as energy consumption has to be reduced in the coming decades, (e.g., global reduction by 50% by 2050), alternative concepts are required for the transport sector. The following exemplary climate adaptation concepts on saving energy for mobility purposes are currently being discussed in Germany: Increasing the efficiency of energy use in the transport sector, Reduction of transport routes, Promotion of carrying goods by rail, Promoting of using renewable energies for the transport sector, Promoting of public transport, car sharing concepts and bicycle use.	n/a	n/a	n/a

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Netherlands	Roads are vulnerable to floods. Capacity roads to recreation areas will become insufficient. Islands are dependent on access roads. Increased tourism demands upgrade of access roads. Demand on parking space.	Gradual, but congestion already occurs frequently in summer	Access roads to island and beach areas	Spatial planning scenarios for tourism development. Maintenance schedule for roads. Plans to double the main roads.
United Kingdom	Flood risk and subsidence (especially in the Fens) are the most important potential impacts on transport infrastructure including major road and rail links to London and between other major towns and cities. Specifications for transport infrastructure will have to change to be resilient to increased temperatures.			
Sweden	The consequences of climate change on the road and railway networks may become considerable. Increasing precipitation and increased flows lead to flooding, the washing away of roads and rail embankments, damaged bridges and an increased risk of land collapse, landslide and erosion. (SOU 2007:60).	2010 - 2100		Preliminary expected increase in costs is 1.000-2.000 M€ over the period 2010-2100 due to flooding, landslides and erosion.
Landscape and nature				

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
Flanders	Quantified assessments for nature: - There is a possibility that 18 summer bird species and 16 butterfly species will become more vulnerable due to increased temperature Non quantified assessments: - Resident species move northward - More heat-loving exotic species may settle in the future			- CCASPAR research project (2009-2012) – Climate change and changes in spatial structures, i.e. natural structure, landscape structure and structures of human activities (residential, economical, recreation, infrastructures) - European habitat and bird directive leading to a higher degree of protection in natural areas
Germany	Changes are expected with respect to seasonality and phenology, dispersal and reproduction of species and composition of biocoenoses. The extinction of 30% of the species (flora and fauna) in Germany in the next decades seems to be possible. Due to the absence of alternative niches, negative impacts are expected for coastal and mountain species in particular (Bundesregierung, 2008).	n/a	Coastal and mountain areas are at risk (often, alternative niches are not available)	n/a
Netherlands	1 Drought 2 exotic species 3 species move northward 4 salt water intrusion 5 change of vegetation patterns 6 ticks 7 degradation of shoals	Gradual change. Drought and tick activity already noticeable. Shoals area have decreased since installing storm surge barrier	All waters surrounding Schouwen-Duiveland. Tureluur and dune areas.	Natura 2000, European habitat and bird directives

Theme / sector	Development climate change	Time factor	Geographic area	Autonomous development trends/ scenarios
United Kingdom	Changes in phenology will alter species distributions New species will colonise – generally the south east could experience a net increase in species Alien species may have greater detrimental effects on native flora and fauna Temperature and rainfall changes will alter species' climate space and viability of certain habitats such as lowland fens Difficulties managing existing habitats sustainably in their current state with varying temperature/ precipitation etc Loss of valuable freshwater wetlands on the low-lying coast caused by rising sea levels and increased storminess	2040-2100	Effects across the whole of the UK. Initial and most severe impacts in the south-east where the three UK projects are located.	
Sweden	Nature, which represents an important cultural basis for a large proportion of the population, will change. The mountain tree line will rise and an invasion of scrub on large parts of the bare mountains is expected. Rare species may completely disappear. Increased algal bloom in freshwater is expected. In the Baltic sea the reduced salinity together with temperature rise and increased input of nutrients will probably lead to large-scale consequences and an increased burden on an already polluted sea. There is great uncertainty on how the aggregate changes will affect biology. (SOU 2007:60)	2010-2100		There is great uncertainty on how changes will affect biology. (SOU 2007:60)

4. CONCLUSIONS

4.1 Country conclusions

4.1.1. Flanders

In Flanders, thanks to the scientific projects of the last 5 years (e.g. CCI-HYDR), quantitative information on future climate change effects, mostly using scenarios and statistical analysis of data on climate parameters, has been made available. For instance, abundant rainfall during storms is more frequent nowadays than in the past. Droughts have not yet become more intense during the 20th century according to current data. A rise in sea level, and probably in the frequency of storms, could aggravate coastal flooding, coastal erosion and general coastal activity. This is further investigated in the Flanders Global Coastal Safety Plan (to 2050) and the scientific CLIMAR project (to 2100). Regarding extreme inland events, the frequency of recorded floods in Belgium has already increased during the last decades. Major inundations took place in 1995, 1998, 2002, 2003 and 2005. Land use planning is obviously partly responsible for those floods, but variations in winter precipitation and increased frequency of heavy rainfalls will nevertheless amplify flood risk.

There is not a lot of quantitative information available on secondary impacts of climate change in Belgium. Damage by flooding is the exception where detailed damage studies are available. An initial study on the effects on agriculture, considering part of the CC effects with available models, revealed limited effects for this sector. Coastal tourism, with a net positive effect due to climate change, is studied in the CLIMAR project. Descriptive studies for nature revealed less biodiversity and geographical shift of species in the future.

Integrated water management planning in the Flemish region has evolved considerably. The aspect of climate change has, however, not generally been taken into account in the first planning cycle (up to 2009), but considered bottom-up (e.g. % changes in precipitation or discharges in models). Generally, there is much more interest in flooding than in other issues (drought, salinization) whilst it may be that drought is a more important issue than increase in flooding events.

Several actions have been taken in the framework of integrated coastal zone management but there is no vision yet on spatial planning or adaptation strategies. The ongoing BLAST project (also Interreg)

aims at partly filling this gap.
In the nature conservation area there is - compared to the great attention given to the impact of climate change on biodiversity –still a long way to go with the adaptation strategy (e.g. protection via Birds and Habitat Directive versus cc effects, choice for connection of natural areas or larger entities of nature …).

Currently there is no proof of any ongoing policy actions in the spatial planning field. On a scientific level, there is the CCASPAR project. This project aims at a scientific evaluation and assessment of existing planning instruments and governance mechanisms for the implementation of spatial planning strategies related to climate change.

In general, Flanders is currently implementing a bottom-up sectoral policy (adaptation of ongoing policy and measures in the water management and nature conservation field). However, in 2012, a regional top-down strategy for adaptation in Flanders will be made available. Currently, the administration of environment, nature and energy has made the first steps in creating this plan.

At the local level, a lack of interest is detected. There are, however, some interesting innovative approaches in case-studies.

4.1.2. Germany

In the past century, statistically significant increasing trends have been observed for temperature and sea level while for many other variables such as precipitation the underlying variability is very large. For this reason detectable trends are not statistically significant. With respect to model based climate projections, there is similarly a clear indication of a rise in temperature. Precipitation is expected to change as well although models tend to disagree even in the direction change for summer precipitation in northern Germany (IPCC, 2007). Sea level rise is expected to continue further in future, thus increasing the risk for coastal areas in particular.
Most water-related problems are concerned with floods and droughts. Extreme weather events are expected to occur more frequently in future while a quantification based on the available model projections is uncertain. However, climate change will aggravate current water management problems and have strong impact on other sectors as described above. The knowledge gained about such climate change impacts is still in a preliminary stage and in many cases does not allow for an exact quantification. Further research is urgently needed.
An adaptation to future climate change is doubtless necessary. The German government has approved a national adaptation strategy which up to now has to be understood as an organisational framework. It contains a national adaptation policy (top-down approach) but no regional recommendations for action. Pilot projects such as 'Climate Proof Areas' work on the development of regional solutions which might be useful in other regions as well (bottom-up approach). In the current state of the process adaptation planning focuses more on technical solutions based on current systems. In the future it can be expected that an adaptation in terms of alternative land use strategies needs to be integrated into adaptation concepts. Currently the uncertainties in the future projections prevent an adequate integration of climate change effects into the planning process. For this reason further research on improved projections and impact assessments is required to accelerate the adaptation process.

4.1.3. The Netherlands

The direct effects of climate change have been well documented, on a national as well as on a regional scale. Secondary effects are often not yet perceived as factors to consider in developments in the near future on a regional scale or are still under investigation, such as the effects of drought on the availability of fresh water and the extent of heat stress in cities.
This can be attributed to uncertainty and the timescale of the expected changes, which are small within the policy horizon. This means that for a sense of urgency at least the development of a possible change must be known and the extent of the change will be larger than that which can be handled in the present situation. Typical for the Netherlands is the general awareness of flood risk. The devastating flood of 1953 is still remembered and high river stands in the last decades have contributed to the national prioritization of flood risk prevention. The maintenance of a determined level of safety is an ongoing process and thus the projected relative sea level rise and river high stands were incorporated in the nationwide plans to upgrade dikes, embankments and other constructions. The effects of an expected drier climate can also be well understood, because drought has been a subject of concern and study in the present climate conditions. As a result the expected impact of climate change on the local area of Schouwen-Duiveland has been identified including an assessment of the timescales, uncertainties and resulting urgencies.

The main conclusions for Schouwen-Duiveland are:

- Climate change does not give cause for any major need for urgency before 2030.
- On a very large timescale it may be that agriculture and the seadefences face challenges.
- Opportunities to incorporate measures which are proof against cli mate change in the area lie in the application of climate-proof design in new developments or planned refurbishments. Examples are the upgrading of the Bruinisse harbour front (floods in present situation), and multifunctional design of dikes.

Drinking water supply

Problems exist regarding the limited fresh water supply. This is due to low groundwater tables and the expectation of a further lowering. This has the effect –amongst others – on the fresh water supply for the recreational functions on the west side of the island. At this moment, the water supply is partly provided by a pipe connection. In the long term (given identified climate impacts) this solution will have to be extended to the rest of Schouwen-Duiveland. The time scale on which this phenomenon may arise ranges from 50 to 100 years.

Agriculture: salinization and drought

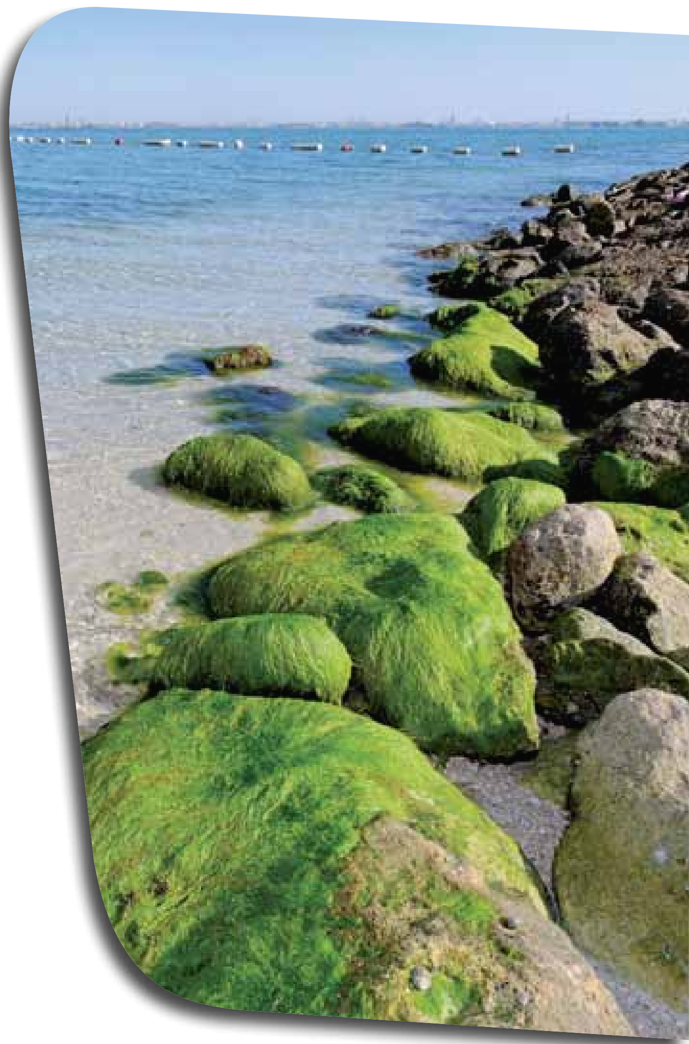
For years now, salinization and drought have had effects on agriculture. The industry has, up to now, adapted to these changes. Structural increase of salinization and drought can increase the scale and urgency of these effects. The timescale on which the effects are expected is 30 to 75 years. The underlying primary climate effect – drier summers – is subject to a great deal of uncertainty.

Water defences and flood safety

Not all the sea dikes on Schouwen-Duiveland meet safety requirements. The scale of the safety issues is not of a serious nature. Within the time span of 5 to 15 years adjustments to the dikes can be made to meet current and future safety requirements. On a longer time scale – 40 to 100 years – larger modifications of the water defences will be needed to meet changing conditions in the sea level and water levels in the Oosterschelde and Grevelingen. Scenarios exist concerning decommissioning of the Oosterschelde barrier. In the long term (2075 – 2100) this would require further robust structural changes in the way the water defences function.

Ecology

The effects of climate change on the ecology are already tangible. The water in the Eastern Scheldt barrier is subject to declining ecological life due to the lack of tidal dynamics. The ecological areas behind the dikes (land) are affected by changes in precipitation regime and temperature rise. This has impact, not so much on the area of ecological life, but on the species of ecological life. These effects will increase with persisting climate change. Ecological goals (formulated in national and European policy guidelines) will come under threat. A vision is required of what new ecological life is suitable in the expected climate change and the circumstances it creates for the area of Schouwen-Duiveland.



Tourism and recreation

In shorter and longer timescales climate change effects on these sectors are limited. The possibilities for the rejuvenation of the industry to a more durable (climate proof) form does open new opportunities.

4.1.4. The UK

Climate change is happening. Without a reduction in global greenhouse gas emissions, climate change effects are likely to increase to dangerous levels. All sectors will be affected in some way. The economy, the natural environment and society are not immune to climate change.
The flooding of recent years has had a major impact on many people's lives and on the economy. Such events are more likely without adaptation and mitigation measures.
Biodiversity is threatened now more than ever with many species facing uncertain futures.
Even if the emission of global greenhouse gases was halted, the effects of previous emissions are still likely to be felt well into the future. Adaptation is therefore essential to reduce the inevitable effects of climate change.
The UK is working towards mitigation and adaptation through its many policies. Integrated, holistic and sustainable approaches are seen as key to meeting the UK Government's vision of a healthy and resilient country in terms of the economy, the natural environment and society, while reducing the effects of the UK's activities on the climate.

4.1.5. Sweden

Potential vulnerabilities in different sectors are fairly well described on a national sector basis. In many sectors and many areas in Sweden a need for adaptation has been identified. Adaptation to a changed climate should permeate virtually the whole of society. Practical efforts will largely be implemented at a local level, by individuals, companies and municipalities. The vulnerability analyses have to a large extent already been downscaled to regional level but need to be downscaled even further. Based on local and regional vulnerability analyses, the need for adaptation should be assessed and adaptation strategies developed.

There is a bottom-up structure regarding responsibility for climate change impacts and preventive activities. The main climate change adaptation-related activities are, however, found at the municipal level and among different sectors at national level. Further discussion is needed regarding responsibilities on the scale from land owners up to the national level, as well as sector responsibilities including the insurance sector. At present there is no national agency and ministry responsible overall for adaptation co-ordination and policy development.

4.2 Overall conclusions

The aim of this analysis (Work Package 1) is to provide a status, to analyse the current situation. We will therefore highlight this analysis, without providing our view on future development yet. The recommendations of the CPA partners for overcoming the issues mentioned below are formulated in the other work package reports.

4.2.1. Primary effects of climate change

The projected change in climate will significantly impact the hydrological cycle. The issue of sea level rises is well documented. Due to a warmer climate evaporation will increase, the magnitude and frequency of extreme weather events will increase, and so hydrological extremes such as floods and droughts are also likely to be more frequent and severe. A changing precipitation regime will impact run-off, sediment transport, water quality and the groundwater level.

The range of problems, as summarized above, encountered (or assumed to occur) within the different North Sea Regions show numerous similarities. In this project we focused on effects related to changes in the precipitation pattern, sea level rise, river and coastal flooding and salinization. For these effects we present an overview of the generally accepted scenarios in the different countries. The similarity in scale considered in these scenarios is enhanced by the international exchange between the scientific communities in the regions under consideration. When we consider current trends in the near past, general trends are obvious but in general it is too soon to consider them statistically significant. Some trends (e.g. rising average temperature in Germany) can already be considered as statistically sound.

The awareness and hence the knowledge of the different effects is quite varied. Again, this difference in awareness seems to be the case in most countries. It is for instance quite obvious that the water managers pay much attention to the flooding problems (coastal or river flooding) and hence develop their adaptation strategy starting from solutions for this flooding issue. They already consider climate change effects in their problem description and flood management solutions. This is in strong contrast to the limited scientific knowledge, availability of pilot projects and general awareness of issues such as drought and salinization. The drought problem – due to rising temperatures and the probable increase of longer (summer) periods without any precipitation is gaining recognition in the different countries. Drought manifests itself in different forms, depending on the local socio-economic and physical situation. There is for instance a low water supply on the island of Schouwen-Duiveland (the Netherlands) due to lowering ground water tables and salinization. In Flanders, the densely populated coastal area will suffer in the future from drinking water shortages, certainly if the current and future increasing pressure of coastal tourism is considered. A well-known issue throughout the UK is the increasing vulnerability of ecologically valuable areas, due to decreasing water availability and increasing public demand and irrigation by agriculture.

Another striking observation is **the need for more detailed, integral and regional information about the effects of climate change.** On the one hand, it remains unclear whether the available climatologic models currently allow further downsizing and integrated assessments. On the other hand, with the available information and using the scenarios as a means for scaling the uncertainty, there should be no more delay with more detailed and integrated assessments on a more local (catchment) scale.

Finally, **more work is needed on the determination of "tipping points".** For what "value" (of temperature, rainfall intensity, number of droughts, …) does the situation become intolerable, unstoppable, … Hence, in addition to "thinking in linear time processes" with scenarios, the determination of these "tipping points" would allow us to determine in a more efficient way the future targets and establishing the timing of adaptation measures.

4.2.2. Secondary effects on and opportunities for socio-economic activities

The sensitivity of each sector will be determined by the influence of (water-related) climate change effects on the functioning of the system. **In this summary report, we have provided an overview of the most important sectors and their likely vulnerability for climate change.**

Quantitative assessments on overall climate change effects for a specific sector remain scarce and the available results reveal a need for more detailed work. The complexity of the issue and the interaction of different primary effects on these overall sectoral effects are certainly the major reasons.

Furthermore, these sectoral assessments should **incorporate socio-economic scenarios** in parallel with the climate change scenarios. Demographic change, land use change, economical and technological developments – regardless of climate change or partly influenced by mitigation policy – will also affect (increase or decrease) the vulnerability of NSR ecosystems, infrastructure and human settlements. It is therefore important to take into account the other stress factors mentioned above when calculating net effects. It is obviously very naïve to consider that the real world will stand still for 100 years when considering 2100 climate change effects. It is therefore important to put the "storylines" into practice and start developing long-term socio-economic scenarios. Some pleasing examples do exist, e.g. the extrapolation of the WLO-scenario's in the Netherlands or the coastal tourism example in Flanders.

4.2.3. Adaptation policy , measures and opportunities

When considering the "national" adaptation policies in the different countries, some countries have already formulated their vision in a national adaptation strategy or plan; others haven't or are in the process of doing so.
When considering the countries that do not have a **"top-down approach"** yet, it seems that **"bottom-up initiatives"** haven't waited for the general plan. In most cases, water management measures and policy form this bottom-up approach.
When evaluating the countries which have such a national strategy, the existence of this vision has not led yet to the implementation at a local policy level. **This general lack of political interest at the local level (e.g. municipalities) is in strong contrast to the belief in and urgent need for local solutions and a planning approach based on local socio-economic and climate change effect conditions.**

Adaptation policy is not a "new policy" or thematic issue: **our adaptation policy will consist of a clever shift in the existing "sectoral" policy and an integration of these sectoral policies towards a common goal: adapting for the future.** When evaluating the different sectoral policies in their awareness, state of preparedness for adapting, it is clear that **water management leads the way.** Their experience in dealing with uncertainty, long term predictions and exceptional events (e.g. preparing for a 100 year flood) on the one hand and the fact that climate change will act primarily by changing the hydrological cycle in all its components, are probably the two main reasons for their leading role in adaptation policy. Also **nature conservation policy**, given the important effect of climate change on biodiversity, is certainly considering and deepening their view on adaptation policy.
A striking observation in most countries is, however, the defensive, hesitating role of spatial planning in the adaptation strategy.

While the appropriate instruments for developing the spatial dimension of adaptation strategy and implementing the clear "need for space" (or efficient sharing of space) seem to be present, no pro-active developments, given the proverbial exception on the rule, could be identified.

With the CPA case studies, (e.g. the integrated spatial planning approach at the Schouwen-Duiveland case) we hope to contribute to the solution of this issue.

From the organisational point of view, it is often unclear who is responsible for develop-

ing and implementing adaptation strategy at the different policy levels. While this project is not pleading for "new structures for adaptation policy", our suggestion is to point out – in a flexible way and pointed towards the local situation – clear responsibilities when walking the adaptation path. In addition, **the importance of stakeholder identification and integration in any adaptation project** cannot be underestimated. The complexity of the projects (and the climate change problem) and the need to invest now in solutions to long term effects and problems will not make this task easier.

It is clear **that policy still relies principally on technical solutions.** The leading role of water management described above is certainly a factor in this conclusion. However, there is an urgent need for non-structural and alternative measures. **The need for an abrupt change towards alternative land use strategies** is probably the most important example of these non-structural measures. We should also develop an integrated approach within the built-up environment (e.g. more blue and green in our cities). The type of measures to be implemented in the open land is better known.

Finally – to end on a positive note - it is important, when developing an adaptation policy, to **consider possible opportunities** that will arise due to changing climate conditions. The most frequently cited sectors that can look forward to these positive effects are the **(coastal) tourism sector** and the **agricultural sector**. While the "general feeling" is overall positive for the tourism sector due to the overriding importance of better climatic conditions (rising temperatures in the North Sea region), the net effect on agricultural activities will have to be evaluated case by case. Negative effects will arise due to salinization, water scarcity etc., whilst a positive effect on production will result from an overall CO_2 rise or it may be that new crops will be possible thanks to increasing temperatures.

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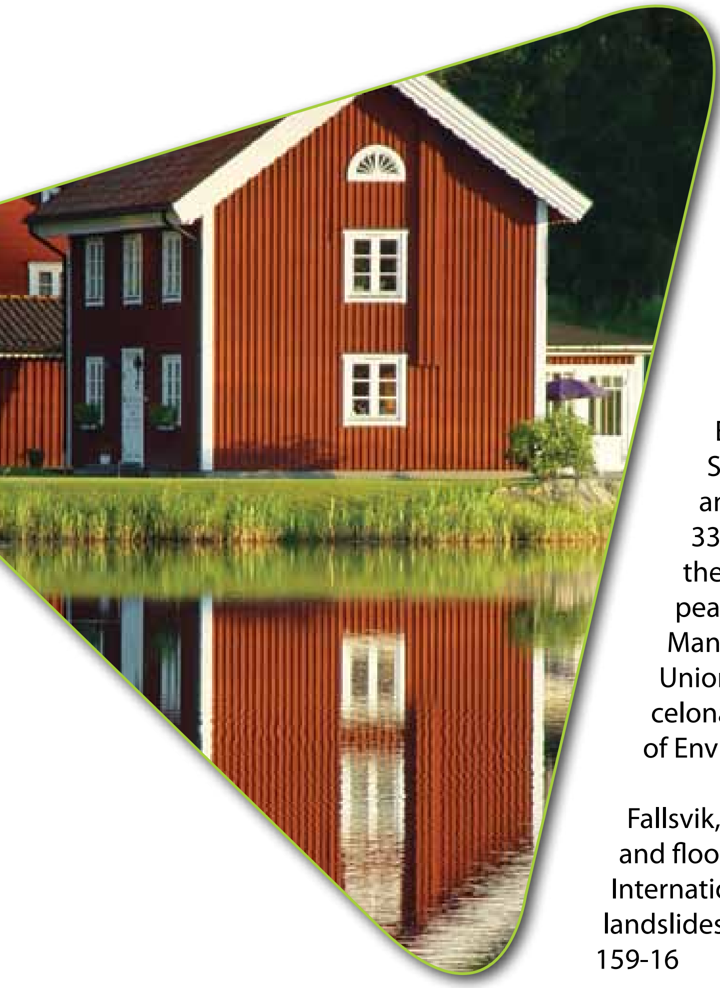

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