Case Study

The Belgian coast

WP 2.5

Willekens Marian
Maes Frank
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Introduction - Belgian Coast

The Belgian Coast lies in the heart of the European core area, on the southern tip of the North Sea. The coastline is 67km long and 10 to 15 km broad. In the East the nature reserve Zwin forms the border with The Netherlands. In the West, the Belgian beach continues to the French Opal Coast in the east of Dunkirk. Behind the coastline, further inland, the polders are situated. The polders are a low laying area, situated below sea level, mainly used for agriculture. These polders and the coastline form the Belgian coast.

The study area can be seen in figure 1.

Figure 1: The spatial demarcation of "the coast", with indications of sea depth and altitude (Belpaeme et al. 2004)
Figure 2: Central location in the European core area (Belpaeme et al. 2004)

Figure 3: Zwin, showing the Belgian coast from the Dutch border. Spring 2010 (Willekens Marian and Van Roy Ward)
The relationship between the Maritime Institute (MI) and the Agency for Maritime and Coastal Services (MDK) is established since 2001 in the form of consultancy and legal support for policy initiatives. The idea behind this Couplet is that “together we know more than alone”. MDK is part of the Flemish Region, Flemish Ministry of Mobility and Public Works. MDK and its coastal Division is competent for Integrated Coastal Zone Management (ICZM), coastal defence, basic infrastructure in marina’s and hydrographical services. The MI is the maritime research division of the department International Public law at the Ghent University providing advice and different types of research for ICZM, Marine Spatial Planning (MSP), legal aspects of adaptation strategies for coastal zones, coastal zone legislation, International and European Environmental and Biodiversity Law etc.. A good collaboration between MDK and MI
means that theory and practice can be linked, leading to mutual support around some dedicated topics (mainly law and policy regarding the sea).

Case study aims

- To introduce the Belgian coast, highlight important features and provide relevant historical context.
- To study the history of coastal erosion and flooding at the Belgian coast and assess future events and issues with a focus on these hazards.
- To identify the climate change phenomena which are likely to affect the Belgian coast and assess their significance in light of their predicted magnitude through the presentation of pertinent data from recent research and policy literature.
- To present the likely impacts of the above effects on different sectors as identified by participants in the IMCORE Issues Identification Workshop.

Case study objectives

- Knowledge of relevant contextual information on the Belgian coast.
- An understanding of the uncertainty relating to the prediction of the effects of climate change, and the predictions being used to inform policy at the Belgian coast.
- Knowledge of the likely environmental and economic impacts of the predicted effects of climate change in the Belgian coast.
- Access to further information sources which will allow the reader to investigate climate change issues in their own area.

Learning outcomes

- A basic knowledge and understanding of climate change issues and their effects on coastal areas.
- Knowledge of the links between climate change, coastal erosion and coastal flooding, and their effects on the Belgian coast.
- The ability to interpret and analyse figures to help gain a better understanding of coastal climate change.
Key Themes

The main focus of this study is the examination of the effects of climate change on the Belgian Coast. The effects of climate change on flooding and erosion are highlighted, since an increase in flooding and erosion will increase the vulnerability of coastal areas. The main ways in which these phenomena are likely to be affected are through predicted increases in storminess and wave velocity, as well as increases in sea level.

The Case study also examines other climate change issues, such as the effects of climate change on ecological systems.

The Study will investigate how different coastal sectors are affected by these changes.
1. Belgian coastline historical context

1.1 Introduction

The appearance of the Belgian coastline today is not the same as 200 years ago. The coastline itself, where sea and land meet, is always in motion, due to erosion and sedimentation processes. The Belgian coastline is subjected to human interference since the second half of the 19\textsuperscript{th} century to protect the coastal infrastructure and the hinterland polders form regular flooding by the sea. This section will examine the evolution and processes the Belgian coastline has been subjected to what she is today.

The Belgian coastline is a densely populated area and hence a very intensively used zone with important economic and tourist activities. Directly on the shoreline more than 50\% of the area is occupied by industry or housing, while the low-laying polders further inland are mainly used for agricultural purposes. The same can be said of the Belgian Part of the North Sea, which is intensively used for different kinds of activities both ecological as industrial (e.g. NATURA-2000 sites, cables and pipelines, wind parks, shipping industry, fisheries, dredging and extraction activities). (Meas et al. 2005a and Van der Biest et al. 2008)

1.2 historical context

Before the Roman period, the Belgian coastline was subjected to several transgressions during which sea level rises and resulted into flooding. This can be seen in figure 5 on the next page.
From the Roman period on the coastal plain dried up, the channels were filled until the surface was back on the same level as the sea level, and the major part of the area evolved into salt marshes. As the coastline started receding and large areas of land located in the sea eroded, large parts of the salt marshes were no longer flooded by the sea, not even at spring tide. Consequently, the area gradually freshened and the salt marsh vegetation was gradually replaced by freshwater vegetation. The elevated parts evolved into salt pastures. (Belpaeme et al. 2004) Figure 6 on the next pages shows how the coastline looked like in the Roman period.

Ever since the area has been embanked systematically and man has increasingly bent nature to his will. Reclamations, embankments, alignments, dredging operations and coastal defence structures have given the coastal plain its current appearance and shape. (Belpaeme et al. 2004) Most hard coastal defence measures, such as dykes, are executed at the end of the 19th century. At that time planners designed completely new townships in different dune areas, which later become seaside resorts. To protect this new heritage against the sea, dykes were built and associated promenades. Related to this is the ever increasing coastal activities (e.g. increasing tourism, ports...
development) and population growth.

Figure 6: Schematic representation of the coastal plain in the Roman period (Belpaeme et al. 2004)

Figure 7: Ostend 1900 (Skipper)

One of the worst storms on the Belgian coast was the storm of 1953, which killed 8 people. This storm showed that some dykes could not provide adequate protection. Therefore the coastal protection policy, in the last decades of the 20th century, shifted from the use of hard coastal defence structures to soft coastal defence structures such as beach nourishment and dune reinforcement. The coastal defence policy falls under
the competences of the Flemish government, to be exact the Agency for Maritime and Coastal Services – Coastal division (MDK).

Figure 8: Storm Ostend 1953

Today the Belgian coastline consists of large sandy beaches, dunes and polders. Almost the entire Belgian coastline is equipped with hard coastal defence. 38km of the coast consists of dykes, other hard structures along the Belgian coast exists of dune foot reinforcements, breakwaters, groynes, seawalls and pears. Soft defence measures exist of dunes, sand nourishment, marram grass, brushwood and managed retreat. (Belpaeme et al. 2004)

An overview of the coastal defence techniques can be seen in figure 9 on the next page.
Figure 9: Overview of coastal defence techniques along the Belgian coastline (Belpaeme et al. 2004)

An example of hard coastal defence measures can be seen in figure 10.

Figure 10: Fixed coastal defence – Wenduine (Belpaeme et al. 2004)

An example of beach nourishment can be seen in figure 11 on the next page.
An example of dune foot strengthening can be seen in figure 12.

An example of dune marram grass plantation and brush wood can be seen in respectively figure 13 and figure 14.

An example of managed retreat can be seen in figure 15 on the next page.
The Belgian coast is subjected to a tidal regime with a half day schedule. The Belgian coast has two high tides and two low tides every day, with an average tidal range of 4 metres. The tide wave moves along the coast from west to east. The tidal difference decreases in the same direction by ± 0.5 m. Spring tides occur twice a month (after every new and each full moon) when the tidal variation has reached its maximum (± 5 m); neap tides occur twice a month when the tidal difference has reached its minimum (± 3 m).

In spite of the numerous measures taken to protect the coastline, large parts of it continue to be exposed to structural erosion. Elsewhere, beach accretion occurs. The fact that there are both erosive and sedimentary zones over such a small distance is the result of a combination of factors, such as the artificial fixation of a coastline that is dynamic by nature, the high-energy coastal environment and the loose sedimentary structure. The growth and erosion of the sandy coast are caused by sand being transported under the influence of wind, waves and tides. About 20 % of the coastline is sedimentary, 40 % is erosive and the remaining part is relatively stable. However, natural processes or human interference can reinforce, weaken or even completely reverse this situation very quickly. Moreover, the coastal system is always subject to temporary variations caused by hydro-meteorological circumstances, and it inevitably undergoes change over a longer period of time. (Belpaeme et al. 2004)

Figure 16 and 17 on the next page show the effects of erosion and sedimentation.
Figure 16: An erosive coastal zone (Belpaeme et al. 2004)

Figure 17: A sedimentary coastal zone - Zeebrugge (Belpaeme et al. 2004)
1.3 Conclusion

The Belgian coast plays an important role in our country's cultural, social, and economic well-being. The coastal zone is characterised by an increasing population and economic activity both on the coastline (tourism, transport, port activity, local industrial estates mainly intended for small and medium enterprises) as at sea (e.g. heavy ship traffic, intensive fishery, a number of offshore activities such as oil and gas extraction, sand and gravel extraction, dredging activities, and windmills).

In order to protect the Belgian coastline, hard and soft coastal defence measures been taken and are still taken. Nevertheless climate change and associated sea level rise will put extra pressure on the existing coastal defence structures and calls for a sustainable approach. To build an effective adaptation policy it is important to assess the estimated sea level rise due to climate change and the effects associated with this. The next section will examine some of the predicted effects of climate change in the study area, and their possible impacts on the beach.

1.4 Glossary

• dunes

Dunes are ridges or moulds of loose, wind blown sand (fine to medium) forming on the backshore and forming the coastal features at certain locations. Dunes are more or less vegetated. Dunes are active coastal form elements acting as a flexible sand reservoir\(^1\)

• dyke

A dyke is a natural or artificial slope or wall to regulate water levels. It is usually earthen and often parallel to the course of a river or the coast. The main purpose of

\(^1\) http://www.coastalwiki.org/coastalwiki/Dune
a dyke is to prevent flooding of the adjoining countryside; however, they also confine the flow of the river, resulting in higher and faster water flow. Dykes can be mainly found along the sea, where dunes are not strong enough, along rivers for protection against high-floods, along lakes or along polders. Furthermore, dykes have been built for the purpose of empoldering, or as a boundary for an inundation area.²

Breakwaters are structures constructed on coasts as part of coastal defence or to protect an anchorage from the effects of weather and longshore drift.

Offshore breakwaters, also called bulkheads, reduce the intensity of wave action in inshore waters and thereby reduce coastal erosion. They are constructed some distance away from the coast or built with one end linked to the coast. The breakwaters may be small structures, placed one to three hundred feet offshore in relatively shallow water, designed to protect a gently sloping beach. Breakwaters may be either fixed or floating: the choice depends on normal water depth and tidal range. Breakwater construction is usually parallel or perpendicular to the coast to maintain

• groynes

A groyne is an active structure extending from the shore into the sea, most often perpendicularly or slightly obliquely to the shoreline. Catching and trapping of a part of sediment moving in a surf zone (mainly in a longshore direction), as well as reduction of the sediment amount transported seawards, are the principle functions of the groyne. The groynes’ effectiveness increases significantly if they are employed together with other (soft) shore protection measures, like artificial beach nourishment or shore nourishment.\(^4\)

• beach nourishment

Beach nourishment — also referred to as beach replenishment — describes a process by which sediment (usually sand) lost through longshore drift or erosion is replaced from sources outside of the eroding beach. It involves transporting and depositing sand from elsewhere to the depleted area. Beach nourishment is typically part of a larger coastal defence scheme. Nourishment is typically a repetitive process, since nourished beaches tend to erode faster than natural beaches unless nourishment is complemented by measures to reduce

\(^3\) http://en.wikipedia.org/wiki/Breakwater_%28structure%29
\(^4\) http://www.coastalwiki.org/coastalwiki/Groyne
erosion rates. A marine transgression is a geologic event during which sea level rises relative to the land and the shoreline moves toward higher ground, resulting in flooding. Transgressions can be caused either by the land sinking or the ocean basins filling with water (or decreasing in capacity). Transgressions and regressions may be caused by tectonic events such as orogenies, severe climate change such as ice ages or isostatic adjustments following removal of ice or sediment load.

1.5 information sources

• Agency for Maritime and Coastal Services – Coastal division
  http://www.afdelingkust.be/home.asp

• Coastal Atlas

• Belgian Expert Couplet Node information
  http://www.imcore.eu/

• Impacts of coastal defence structures


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1.6 References


1.7 Further Reading


1.8 End-of-section questions on historical context

Content questions:

1. What coastal defence structure does the Belgian coast have in place that protects it from coastal erosion?

2. Is the Belgian beach susceptible to coastal erosion and flooding? Give evidence supplied in the text with your answer.

3. Describe how the form of the Belgian coastline evolved over time.

4. Who is the responsible authority at the Belgian coast to protect the coast from flooding?

5. From what defence structure consists the Belgian coast primarily?

Applying case study material and knowledge:

6. Describe the features of your coast, using both historical and recent information.

7. From using similar historical information about your local beach identify the potential climate issues that may affect your beach.
2. Predicted changes in climate for the study area

2.1 Introduction

There is no doubt: climate is changing. The effects of a changing climate are already perceptible and predictable. Despite uncertainties about the timing and magnitude of the changes associated with global warming, the problem of global climate change has become one of the most important environmental issues facing the world today. Scientific research has revealed that even when the emission of greenhouse gases decreases the impacts of climate change will be inevitable (Solomon et al. 2007).

Therefore it is necessary to assess which climate change effects the Belgian coast will undergo. This section will draw on a range of information sources on climate impacts in the Belgian coast, and their severity.

Almost 85% of the Belgian coast lies under 5m elevation, which makes the Belgian coast one of the most vulnerable coastlines in Europe, and makes the question: how to deal with climate change, even more pressing. It is now known that climate change will make coastal zones even more hazardous. The most consistent effects will be due to sea level rise.

2.1 Changes in climate

A Study carried out within the CLIMAR-project by the Management Unit of the North Sea Mathematical Models (MUMM) to assess the impacts of climate change for the Belgian part of the North Sea shows that it is likely to experience a greater incidence of storm damage and flooding in vulnerable coastal areas.

Though the exact impacts of climate change are difficult to predict, the study has made use of scenarios to make assumptions on the future. The study draws five scenarios for 2040 and 2100: two moderate (M, M+) scenarios, two warm scenarios (W, W+) and a worst case scenario (Worst).

In the M and W scenarios, there is no significant change in air circulation patterns, and the precipitation increases both in summer and in winter with about 3% per °C of air temperature increase. In the M+ and W+ scenarios, there are significant changes in air circulation patterns and the precipitation increases more in winter (about 7% per °C of
air temperature increase) and decreases in summer (about 10% per °C of air temperature). The study shows that the significant changes in air circulation patterns have no influence on the increase of sea level. The expectations are that in 2040 the sea level will rise up to 30 cm in the moderate scenario, in the warm scenario up to 40 cm and in the worst case scenario up to 50 cm. The expectations for 2100 are a sea level rise of 60 cm in the moderate scenario, 90 cm in the warm scenario and 2 m in the worst case scenario (CLIMAR 2008a).

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>M+</th>
<th>W</th>
<th>W+</th>
<th>Worst</th>
</tr>
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<tr>
<td>Air temperature</td>
<td>+ 1 °C</td>
<td>+ 1 °C</td>
<td>+ 2 °C</td>
<td>+ 2 °C</td>
<td>+ 2 °C</td>
</tr>
<tr>
<td>Change air circulation</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Winter precipitation</td>
<td>+ 4 %</td>
<td>+ 7 %</td>
<td>+ 8 %</td>
<td>+ 14 %</td>
<td>+ 14 %</td>
</tr>
<tr>
<td>Wind velocity</td>
<td>0 %</td>
<td>+ 2 %</td>
<td>- 1 %</td>
<td>+ 4 %</td>
<td>+ 4 %</td>
</tr>
<tr>
<td>Summer precipitation</td>
<td>+ 3 %</td>
<td>- 10 %</td>
<td>+ 6 %</td>
<td>- 20 %</td>
<td>- 20 %</td>
</tr>
<tr>
<td>Sea water temperature</td>
<td>+ 1.2 °C</td>
<td>+ 1.2 °C</td>
<td>+ 1.7 °C</td>
<td>+ 1.7 °C</td>
<td>+ 1.7 °C</td>
</tr>
<tr>
<td>Mean sea level</td>
<td>+ 30 cm</td>
<td>+ 30 cm</td>
<td>+ 40 cm</td>
<td>+ 40 cm</td>
<td>+ 100 cm</td>
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Figure 18. five scenarios presented for 2040 within the CLIMAR project (CLIMAR 2008a).

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>M+</th>
<th>W</th>
<th>W+</th>
<th>Worst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>+ 2 °C</td>
<td>+ 2 °C</td>
<td>+ 4 °C</td>
<td>+ 4 °C</td>
<td>+ 4 °C</td>
</tr>
<tr>
<td>Change air circulation</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Winter precipitation</td>
<td>+ 8 %</td>
<td>+ 14 %</td>
<td>+ 16 %</td>
<td>+ 28 %</td>
<td>+ 28 %</td>
</tr>
<tr>
<td>Wind velocity</td>
<td>0 %</td>
<td>+ 4 %</td>
<td>- 2 %</td>
<td>+ 8 %</td>
<td>+ 8 %</td>
</tr>
<tr>
<td>Summer precipitation</td>
<td>+ 6 %</td>
<td>- 20 %</td>
<td>+ 12 %</td>
<td>- 40 %</td>
<td>- 40 %</td>
</tr>
<tr>
<td>Sea water temperature</td>
<td>+ 2.5 °C</td>
<td>+ 2.5 °C</td>
<td>+ 3.5 °C</td>
<td>+ 3.5 °C</td>
<td>+ 3.5 °C</td>
</tr>
<tr>
<td>Mean sea level</td>
<td>+ 60 cm</td>
<td>+ 60 cm</td>
<td>+ 93 cm</td>
<td>+ 93 cm</td>
<td>+ 200 cm</td>
</tr>
</tbody>
</table>

Figure 19. five scenarios presented for 2100 within the CLIMAR project (CLIMAR 2008a).

Sea level rise is an important indicator of climate change in coastal regions. At the Belgian coast it will increases the likelihood of flooding and coastal erosion.
In the light of the CLIMAR-project the Flanders Hydraulic Research has made some flood models to assess the effects of flooding at the Belgian coast. The flood models are calculated for an extreme storm with a flood level of +8 m TAW in Ostend. This storm is the most extreme but still a realistic super storm. By comparison, the known worst storm of the past 100 years, namely the storm of February 1, 1953, reached a flood level at Ostend of +6.66 m TAW. This is 1.34 m lower than the +8 m TAW super storm. Statistically, this Super storm has a return period of 17.000 years. (Van der Biest et al.2009)

Figure 20 indicates the water depth in case of flooding during an extreme storm in the current situation. Figure 21 indicates the water depth in case of flooding during an extreme storm in the M + climate scenario. Figure 22 indicates the damage cost (in euro) in case of flooding during an extreme storm in the M + climate scenario. Figure 23 indicates the water depth in case of flooding during an extreme storm in the Worst Case climate scenario. Figure 24 indicates the damage cost in case of flooding during an extreme storm in the Worst Case climate scenario.

Figure 20. Water depth (in meter) in case of flooding during an extreme storm in the current situation (Van der Biest et al. 2009)
Figure 21. Water depth (in meter) in case of flooding during an extreme storm in the M + climate scenario (Van der Biest et al. 2009)

Figure 22. Damage cost (in euro) in case of flooding during an extreme storm in the M + climate scenario (Van der Biest et al. 2009)
Figure 23. Water depth (in meter) in case of flooding during an extreme storm in the Worst Case climate scenario (Van der Biest et al. 2009)

Figure 24. Damage cost (in euro) in case of flooding during an extreme storm in the Worst Case climate scenario (Van der Biest et al. 2009)
These models, together with the photo’s of the first winter storm in Ostend 2009, indicate that the Belgian coast is highly vulnerable to flooding.

Related to coastal erosion Van der Biest (2009) stated that one of the main ecological effects of climate change is the increasing erosion of beaches and dunes. Erosion will increase due to a rise in sea level and increased storm frequency and intensity, which will also increases the risk of flooding.

Furthermore the CLIMAR-project conducted studies to determine the ecological effects of climate change. This research is important because of the major ecological and economical importance of marine ecosystems. These studies show that coastal marine and estuarine ecosystems will be affected by changes in tidal height and tidal range caused by sea level rise. The consequences include changes in water depth, available light, current velocities, temperature, salinity distributions and a shift in the freshwater-saltwater distribution. This can lead to physiological burdens for some animal and plant species that could then require a habitat change. How regime shifts are triggered and what effects they have in the food web of an ecosystem are not yet thoroughly understood, even though climate change is predicted to have direct and indirect effects on marine plants and animals and consequently on marine food webs. For example, a northward shift in Atlantic cod is reported, while densities in monkfish remained constant. The population in haddock decreased in density in the southern part of the North Sea but increased in the northern part. Evidences of correlations of distribution of seabirds with sea temperature are also reported for the Atlantic puffin, the black legged kittiwake and the northern fulmar. (CLIMAR 2008b) (Van den Eynde et al. 2009)
Over the last decades, changes of phytoplankton species in the northeast Atlantic have created anomalous phytoplankton blooms with harmful consequences on humans and on the surrounding ecosystem. Toxic material released from these blooms are causing mass mortalities of marine organisms, as well as affecting human health through contaminated shellfish and fish populations. Global climate change expressed as an increase of the summer temperature maximum by 4°C in 2100, in combination with water column stratification, led to a doubling of growth rates of potentially harmful algal blooms. However, the wide ranges of uncertainties in the projected increases in temperature and precipitation associated with climate change, and the impossibility to take into account the effects of temperature and stratification changes on ecological processes that are important in phytoplankton species prevents a quantitative assessment of the risk of harmful blooms. (CLIMAR 2008b) (Van den Eynde et al. 2009)

Finally the increase in surface ocean CO₂ has consequences for the chemical equilibrium of the ocean which is becoming more acidic. It has also impacts on marine organisms using carbonate to produce shells consisting of calcium carbonate CaCO₃. (CLIMAR 2008b) (Van den Eynde et al. 2009).

2.3 Conclusion

The effects of climate change on the Belgian coast and marine systems are manifold. Sea level rise is an important indicator of climate change in the Belgian coastal zone. It will increase the likelihood of storm surges, floods, coastal erosion, landwater salt intrusion, endangers coastal ecosystems, etc.

The Belgian coast is partially protected from flooding. Already today there are some weak spots were flooding may occur, predicted climate change will only intensify this problem.
2.4 Glossary

- **CLIMAR**
  The CLIMAR-project is a project about the evaluation of climate change impacts and adaptation responses for marine activities especially for the Belgian part of the North Sea and is launched in December 2006.

- **TAW**
  Tweede Algemene Waterpassing

  TAW is the reference point for which an altitude is expressed in Belgium. TAW +0 m equals the average sea level at low tide in Ostend.\(^7\)

2.5 information sources

- Intergovernmental Panel on Climate Change (2007), Fourth Assessment Report
  [http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm](http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm)

- **CLIMAR**

2.6 References


\(^7\) [http://nl.wikipedia.org/wiki/TAW](http://nl.wikipedia.org/wiki/TAW)


2.7 Further Reading

• IPCC Reports & supporting documents
  
  http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

• Cisar, J-C., (2009) Climate change impacts in Europe Final report of the PESETA research project, European commission Joint Research Centre Institute for Prospective Technological Studies and Institute for Environment and Sustainability, Luxembourg: Office for Official Publications of the European Communities.
  
  http://www.jrc.ec.europa.eu

2.8 End-of-section questions on predicted effects of climate change on the Belgian coast

Content questions:

1. Belgian mean sea level will rise by 2040
   a) 0-30cm
   b) 30-100cm
   c) 100-150cm

2. Is the Belgian coast adequately protected against flooding?

3. Will the risk of flooding increase due to climate change?

4. Give an example of an ecological effect on climate change.

5. At the Belgian coast, winter precipitation is likely to increase by:
   a) 0-4%
   b) 4-14%
   c) 14-24%

Applying case study material and knowledge:

6. Through using the further reading section list all the possible effects future climate change predictions may have your study side? Which effects are relevant to your area?

7. Which of the phenomena associated with climate change will be most severe in your area?
3. Impacts of climate change in the case study area

3.1 Introduction

The effects of climate change will not only have an impact on sea level rise, changes in hydrodynamic climate (increase in storminess), changes in wave patterns (increase wave height) and changes in circulation patterns as know as the primary effects. These impacts will affect natural and human systems, such as ecological effects, economical effects and social effects, also called secondary impacts.

This section will present the secondary impacts of climate change associated with different coastal sectors at the Belgian coast, using the results of the IMCORE Issues Identification Workshop conducted in Ostend on the 29th of April 2009.

3.2 Sectors to be impacted

Already today there are some impacts that are perceptible. For example in the fisheries sector, fisherman observed an increased presence of cormorants, seals, porpoises, dolphins, sea birds and warm water species (e.g. anchovies, Japanese oyster and sea horses) in the Southern part the North Sea. Furthermore, the Japanese oyster is on a large scale present in the ports, on the quays and on palisades. Still there is not enough scientific evidence to conclude that the increasing presence of these species is related to climate change. The European conservation policy and ballast water exchanges from ships are also a possible explanation for these findings. An increase in storm events is also observed and the intensity of the storms is more severe. Furthermore, according to the Flemish government a rise in sea level has been recorded at the Belgian coast.

Tourism (coastal marinas/ water recreation)

Ecological impacts

The presence of more marine mammals along the coast will most likely result in more tourists excursions at sea.
Economic impacts

The main impact of climate change for this sector will be the increase of frequency and intensity of storms, followed by sea level rise and changes in coastal erosion and sedimentation processes. These impacts can lead to more damage to yachts and marinas, less available shipping days and more dredging activities. Consequently the exploitation and damage costs can increase due to higher maintenance and reparation costs of the marinas.

Social impacts

Extreme weather conditions and sea level rise will negatively influence the safety on board the yachts and in the marinas (on quays and jetties). The presence of marine mammals, however, could lead to more tourists and tourism activities.

Ports and maritime transport

Ecological impacts

Changing coastal erosion and sedimentation processes could have an increased impact on shipping lanes (displacement of sand, sedimentation, etc.) that will on its turn require more dredging.

Economic impacts

The main climate change impact on harbours will be the rising sea level. Since increases from 1 to 1.5 meters can cause problems related to safety and protection of harbours, higher safety factors will be required to anticipate sea level rise. The main constraint to anticipate sea level rise will be the outline of costs.

The second most important impact will be the increased frequency and intensity of storms and wave height. This situation will be more damaging to ships and harbour infrastructure, might result in less available shipping days and difficulties in executing certain harbour activities the year round.

Another economic impact indicated by the sector is the fact that temperature rise will increase the need for cooling. Consequently technical measures will have to be taken
to adapt ships to this primary impact.

**Social impacts**

Climate change impacts (extreme weather events, sea level rise, etc.) will negatively influence the working conditions on board ships and increase the risk on accidents.

**Fisheries**

**Ecological impacts**

The main impact of climate change on the marine environment will be the shift of species. Due to a rise in seawater temperature, a northward shift of marine species is already taking place in the North Sea and will occur more in the future. The northward shift will have an impact on the presence of cod, haddock and halibut in the North Sea, as these species inhabit in colder waters and there will be a higher incidence of warm water species in our region (including anchovies, sardines, seahorses and mullet). However, not all of these species are of interest for commercial fishing, such as seahorses. Besides the northern shift of marine species, it is likely that the rise in sea level, changes in wetland areas and in erosion and sedimentation processes can affect the existing nursery areas for shrimps, sole and plaice.

Another ecological impact would be the increase of harmful algal blooms due to rising seawater temperatures. At present newspapers report of contaminated mussels, but this coverage is often not correct. Harmful algal blooms are indeed a problem, but the amount of harmful algal blooms is primarily dependent on the tidal force. Therefore, the sector should reckon with the harmful algal blooms during the harvest of mussels which they do by taking daily samples of the water quality.

Finally, although the presence of marine mammals is of interest for tourism, it is not for fisheries. The increase of marine mammals is detrimental to fisheries as these animals also eat fish, and thus create food-web competition. Food-web competition occurs when there is potential overlap of the trophic flows supporting a given group (e.g. marine mammals) with the trophic flows supporting another group (e.g. fisheries).
**Economic impacts**

Due to an increase in storms and inclement weather, there will be more annual storm days and thus less shipping days. This is especially important for inshore fishing; they can only fish at sea up to 4-5 Beaufort. These climate change impacts will also adversely affect the safety on board vessels and in harbours. According to some, storms also have a positive impact on the catching of fish. After a storm the seabed is turbulent, therefore more food is available and more fish can be caught. But this theory only applies to bottom fish. Another reason for the increasing presence of fish could be that there was no fishing for a period of time in that area due to risk of storm.

**Social impacts**

Extreme weather events and sea level rise will negatively influence the safety on board the fishing vessels and in harbours. Climate change together with other stress factors on the sector (e.g. fuel and fish price) could lead to a further reduction of the Belgian fishery fleet.

**Dredging**

**Ecological impacts**

Massive algal blooms can lead to problems with the engines if these algal blooms are sucked through the cooling water and result in blockage of the engines. As such problems are already taking place today (e.g. India), the sector is searching for possible solutions to avoid these problems.

**Economic impacts**

The dredging sector has stated that temperature rises have an impact on the rate of corrosion of ships and the operation of the engine cooling and acidification influences the wear of ships. However, according to the dredging industry, the impact on ships and their machinery will be rather minimal and thus controllable as the sector is already equipped to anticipate these impacts (e.g. material selection, installation of protection layers).

Another economic impact will be the reduction of cargo that can be transported since
the rising of sea temperature will lead to lower water density which ensures that ships submerge in the sea and consequently are less able to carry cargo. Even today there are differences in water density across the world although the sector can do little against this impact.

As already stated by the fisheries and shipping sector, the dredging sector would also have less shipping days, due to more intense and frequent storms and waves.

Climate change could also create opportunities for the sector since sea level rise and the increase of storms and wave height would ensure more need for constructing and maintaining coastal defence in which the dredging industry can play a very important role. Thus, the sector sees sea level rise as the main impact of climate change but in a positive sense since it would create new opportunities. In what rate climate change would be an opportunity depends on the coastal defence policies that will be implemented by governments around the world.

Figure 27. Dredging activities at the Belgian coast (http://www.afdelingkust.be/home.asp)

Social impacts

Demand for more dredging activities, due to sea level rise and changes in sedimentation processes, will lead to a growth of the sector with more jobs as result.

Sea defence

MDK is the competent authority to guarantee the safety of the population and cultural heritage against storms and floods. In order to achieve this objective, MDK mainly focuses on sea level rise, since this climate change impact will have the greatest impact on the safety of the entire coastal zone.
To protect the coast and the hinterland against flooding, MDK is preparing a coastal safety plan (Masterplan 2050). This Masterplan employs a ‘hold-the-line’ policy and outlines actions in the short term (2010-2015) and a long-term approach (2050). The ‘hold-the-line’ policy implies that the Flemish government works with a fictitious line. The line must be maintained and no flooding may exceed that specific safety line. Actions in the short term imply that every five years the entire coastline is subjected to a so-called safety check. The safety line must be resistant against a storm with a statistical return period of 1/1000 year (=super storm); if this is not the case, the coastline needs further protection. The long-term approach takes not only super storms into account but also sea level rise, coastal erosion and sedimentation processes.

Figure 28 and 29 are examples of possible new coastal defence infrastructure to protect the Belgian coast from flooding.

Figure 28. Wall on the seafront, a few meters of the slope (http://www.afdelingkust.be/home.asp)
3.3 Conclusion

There is a wide range of effects related to climate change at the Belgian coast. Some climate change effects are already visible, others are predicted to happen within the next 100 years. Climate change effects will not necessarily be seen as negative for coastal sectors, for example sea level rise is seen as a negative effect by most of the sectors (e.g. tourism, coastal defence and shipping) although for the dredging industry sea level rise can create opportunities, since this will increase the demand of dredging activities. The increase of sea mammals is also expected to enhance tourist excursion. On the other hand marine mammals will have negative effects on fisheries. Finally some sectors will be more affected by climate change effects than others. For instance fisheries will be affected by 90% of the climate change effects (changes in fish population, harmful algal bloom, changes in temperature etc.), while the shipping industry will be less affected by climate change effects.

3.4 information sources

Services- Coastal division.

http://www.imcore.eu/

• Masterplan coastal defence 2050


3.5 References


2.6 Further Reading

• Report IMCORE Issues Identification Workshop

http://www.imcore.eu/

• Masterplan coastal defence 2050


http://www.jrc.ec.europa.eu

3.7 End-of-section questions on impacts of climate change on the Belgian coast

Content questions:

1. What kind of secondary effects categories exist?

2. What is the main impact climate change will have on fisheries?
3. Does climate change only have negative effects?

4. Are coastal sectors already thinking about climate change adaptation?

5. Is climate change already perceptible?

Applying case study material and knowledge:

6. List all the possible secondary effects future climate change predictions may have your study side? Which effects are relevant to your area?

7. Which sectors will be most affected by climate change in your area?
4. Summary and Conclusions

The Belgian coast plays an important role in our country’s cultural, social, and economic well-being. The coastal zone is characterised by an increasing population and economic activity both on the coastline (tourism, transport, local industrial estates mainly intended for small and medium enterprises) as at sea (e.g. heavy ship traffic, intensive fishery, a number of offshore activities such as oil and gas extraction, sand and gravel extraction, dredging activities, and windmills).

In order to protect the Belgian coastline, hard and soft coastal defence measures been taken and are still taken. Already today there are some weak spots were flooding may occur, predicted climate change and associated sea level rise will put extra pressure on the existing coastal defence structures. Section 2 of this study demonstrated that the effects of climate change on the Belgian coast and marine systems are manifold. First of all it is clear that sea level rise will occur. Sea level rise is an important indicator of climate change in the Belgian coastal zone. It will increase the likelihood of storm surges, floods, coastal erosion, landwater salt intrusion, endangers coastal ecosystems, etc. Furthermore climate change will also have some ecological effects. Climate change will cause changes in water depth, available light, current velocities, temperature, salinity distributions and a shift in the freshwater-saltwater distribution. Although the effects on the species are not yet thoroughly understood a northward shift of species will occur. For example, a northward shift in Atlantic cod is reported.

In section 3 there has been discussed how those effects will affect different important coastal sectors. Climate change will not necessarily adversely effect coastal sectors, for example sea level rise is seen as a negative effect by most of the sectors (e.g. tourism, coastal defence, shipping) although for the dredging industry sea level rise can create opportunities, since this will increase the demand of dredging activities. The increase of sea mammals is also expected to enhance tourist excursion. On the other hand marine mammals will have negative effects on fisheries. Finally some sectors will be more affected by climate change effects than others. For instance fisheries will be affected by 90% of the climate change effects (changes in fish population, harmful algal bloom, changes in temperature etc.), while the shipping industry will be less affected by climate change.
5. Contact details

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6. Feedback – See page 43 for contact details to send your feedback

Please answer these questions as completely as you can to help us improve the case study.

General Feedback on the case study

1. Why did you choose this case study?

2. How would you rate the case study and its questions overall?

Please **circle** a number from 1 = did not enjoy it 3= enjoyed it 5= really enjoyed it

1  2  3  4  5

3. Overall how useful did you find the case study?

Please **circle** a number from 1 to 5; 1 not useful 3= useful and 5 very useful

1  2  3  4  5
4. Please rate the following part? 1=poor 3= average 5= excellent

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6. What suggestions do you have for improving the case study?
Feedback on the value of the information provided

7. What was your prior understanding of climate change and its potential impacts before the case study?

Please circle a number from 1 to 5; 1 relatively little, 3 average, and 5 a lot

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8. Was the information useful?

Yes  No

Which information in particular?

9. Do you think what you have learned could be applicable to your job?

Yes  No

Why? Why not?
10. Would you consider using any of the information included in the case study in your professional activities?

   Yes            No

If so what?

11. Do you think what you have learned is applicable to your community?

   Yes            No

Why? Why not?

12. Have the Illustrations help to improve your understanding of the impacts of climate change?

   Yes            No

Why? Why not?
Raising Awareness about Climate Change, the Provision of Education and Training, and case study for professionals and the local community?

13. What other didactic materials would be beneficial to coastal practitioners?

14. What role do you think organisations like IMCORE should play in climate change in the local community?

15. How do you think local organisations could become more involved in projects like the IMCORE project?

16. In what ways do you feel it is best to engage the local community?
7. Answers to end-of-section questions

7.1 Belgian Coastline historical context:

Content questions:

1. **What defences does the Belgian coast have in place that protects it from coastal erosion?**

   **Answer:**
   
   The coastal defences the Belgian coast have in place to protect it from coastal erosion, include: hard coastal defences (e.g. dykes, groynes, dune foot reinforcements, breakwaters, seawalls) and soft coastal defences (e.g., sand nourishment, dunes and dune foot nourishment, marram grass, brushwood and managed retreat).

2. **Is the Belgian beach susceptible to coastal erosion and flooding? Give evidence supplied in the text with your answer.**

   **Answer:**
   
   The Belgian coast is susceptible to coastal erosion and flooding. Almost 40% of the Belgian coast is erosive. Previous flooding history indicates that the Belgian coast is susceptible to flooding. In 1953 the Belgian coast was impacted by the most severe flood, with a total of 8 deaths.

3. **Describe how the form of the Belgian coastline evolved over time.**

   **Answer:**
   
   Before the Roman period, the Belgian coastline was subjected to several transgressions during which sea level rises and resulted into flooding. From the Roman period on the coastal plain dried up, the channels were filled until the surface was back on the same level as the sea level, and the major part of the area evolved into salt marshes. As the coastline started receding and large areas of land located in the sea eroded, large parts of the salt marshes were no
longer flooded by the sea, not even at spring tide. Consequently, the area gradually freshened and the salt marsh vegetation was gradually replaced by freshwater vegetation. The elevated parts evolved into salt pastures. Ever since the area has been embanked systematically and man has increasingly bent nature to his will. Reclamations, embankments, alignments, dredging operations and coastal defence structures have given the coastal plain its current appearance and shape.

4. **Who is the responsible authority at the Belgian coast to protect the coast from flooding?**

   **Answer:**

   Agency for Maritime and Coastal Services – Coastal division

5. **From what defence structure consists the Belgian coast primarily?**

   **Answer:**

   The Belgian coastline primarily consists of dykes (38km), since the Belgian coastline is only 67 km long.

   Applying case study material and knowledge:

6. **Describe the features of your coast, using both historical and recent information.**

   **Answer Guidance:**

   - Identify historical and recent information for your beach, e.g. features and attractions.
   - Identify historical and recent studies for your area e.g. Council and organisations past studies.
   - Use the above information gained to describe the features of your coast.
7. From using similar historical information about your local beach identify the potential climate issues that may affect your beach.

Answer Guidance:

• Identify historical information for your beach, e.g. features and attractions.

• Identify historical studies for your area e.g. Council and organisations past studies.

• Use the above information gained to assess the possible climate issues.

7.2 Predicted effects of climate change on the Belgian coast

Content questions:

1. Belgian mean sea level will rise by 2040

   a) 0-30cm

   b) 30-100cm

   c) 100-150cm

   Answer:

   b) 30-100cm

2. Is the Belgian coast adequately protected against extreme storms?

   Answer:

   Figure 20 shows that in the current situation an extreme storm (return period 17,000 years) has caused breaches in the existing coastal defence at Ostend and between Wendevine and Blankenberge. Consequently the Belgian coast is not adequately protected against extreme storms.
3. Will the risk of flooding increase due to climate change?

Answer:

It is predicted to have a rise in sea level and increased storm frequency, this will lead to increasing erosion and consequently to a higher risk of flooding.

4. Give an example of an ecological effect on climate change.

Answer:

Climate change will cause changes in water depth, available light, current velocities, temperature, salinity distributions and a shift in the freshwater-saltwater distribution. Although the effects on the species is not yet thoroughly understood an northward shift of species will occur. For example, a northward shift in Atlantic cod is reported.

5. At the Belgian coast, winter precipitation is likely to increase by:

   a) 0-4%
   
   b) 4-14%
   
   c)14-24%

Answer:

b) 4-14%
Applying case study material and knowledge:

6. Through using the further reading section list all the possible effects future climate change predictions may have your study side? Which effects are relevant to your area?

Answer Guidance:

• Use the IPCC report, PESETA report and the EEA report.

• Include information not supplied within the case study, focusing the whole of the region.

7. Which of the phenomena associated with climate change will be most severe in your area?

• Identify historical information for your beach, e.g. features and attractions.

• Engage stakeholders to discuss the climate change impacts.

7.3 Impacts of climate change on the Belgian coast

Content questions:

1. What kind of secondary effects categories exist?

   Answer:

   Three kinds of effect categories, namely ecological, economic and social effects.

2. What is the main impact climate change will have on fisheries?

   Answer:

   The main impact of climate change on the marine environment will be the shift of species. The northward shift will have an impact on the presence of cod,
haddock and halibut in the North Sea, as these species inhabit in colder waters and there will be a higher incidence of warm water species in our region (including anchovies, sardines, seahorses and mullet).

3. Does climate change only has negative effects?

Answer:

No, for example the rise in sea level and the associated need for more sand nourishment will have positive effects on the dredging industry, since this will increase the demand of dredging activities. The increase of sea mammals is also expected to enhance tourist excursion.

4. Are coastal sectors already thinking on climate change adaptation?

Answer:

The agency for Maritime and Coastal Services -Coastal Division is preparing a coastal safety plan (Masterplan 2050). This Masterplan employs a ‘hold-the-line’ policy and outlines actions in the short term (2010-2015) and a long-term approach (2050). The long-term approach takes not only super storms into account but also sea level rise, coastal erosion and sedimentation processes.

5. Is climate change already perceptible?

Answer:

Yes, already today there are some impacts who are perceptible. For example in the fisheries sector, fisherman observed an increased presence of cormorants, seals, porpoises, dolphins, sea birds and warm water species (e.g. anchovies, Japanese oyster and sea horses) in the Southern part the North Sea. An increase in storm events is also observed and the intensity of the storms is more severe. Furthermore, according to the Flemish government a rise in sea level has been recorded at the Belgian coast.
Applying case study material and knowledge:

6. List all the possible secondary effects future climate change predictions may have your study side? Which effects are relevant to your area?

   • Use local knowledge and data.
   
   • Use the PESETA report.
   
   • Select those effects which are relevant for your area.

7. Which sectors will be most affected by climate change in your area?

   • Engage stakeholders to discuss the climate change effects on their sector, use guidelines produced in the IMCORE project.