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Final report

**“The economics of climate change adaptation in
EU coastal areas”**

For the attention of

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Directorate-General for Maritime Affairs and Fisheries

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INTRODUCTION

In this study, the economics of climate change adaptation in EU coastal areas are explained from an empirical perspective and are benchmarked with the latest insights stemming from the scientific literature.

The most recent IPCC report (2007)¹ underlines that climate-related changes over the 21st century will include an acceleration in Sea Level Rise, further rise in sea surface temperature, more extreme weather events and storm surges, altered precipitation and ocean acidification. These meteorological effects are projected to increase flood-risk along the coast but could also impact freshwater availability or result in an accelerated loss of coastal eco-systems. Climate experts emphasise the importance of adapting to the potential effects of climate change by developing and implementing coastal protection and adaptation strategies. Nevertheless, to date, little is known about the actual climate change adaptation practices and investments made by the different member states to protect and adapt their coastal areas against the effects of climate change.

This study ‘The economics of climate change adaptation in EU coastal areas’ learns that:

- In most EU countries detailed knowledge about climate change, potential scenarios and negative consequences is not yet widespread and therefore □ for the time being □ many (national) authorities tend to respond to climate change in a reactive manner;
- In particular the countries that have suffered from severe weather events in the past have taken the initiative to investigate the potential impacts of climate change for their country specifically, but research results on climate impacts remain in general rather indistinct and less suited for policy development;
- Although differences exist at national level, the actual coastal protection expenditure in Europe, amounting to *on average* € 0.88 billion per year over the period 1998-2015², is in line with the projected adaptation cost of 0.49-0.85 billion³ per year presented by Richards and Nicholls (2009) in the light of the PESETA study (see <http://peseta.jrc.ec.europa.eu/docs/Costalareas.html>);

¹ Intergovernmental Panel on Climate Change, Working Group II, 2007, *IPCC fourth assessment report on impacts, adaptation and vulnerability*.

² The expenditure evolves from € 375 million in 1998 to € 740.8 million in 2015; in 2008, the coastal protection expenditure in Europe amounted to € 1.05 billion.

³ Following a low (22.6 cm) and high (50.8 cm) SLR scenario (under the ECHAM4B2 socio-economic scenario).

- The gap between the actual expenditures and the theoretically estimated adaptation cost on a country level measures the mismatch between theory and practice, which appears to be largest for the Baltic Sea countries followed by the Mediterranean countries (with the exception of Spain);
- Close to 85% of the total coastal protection expenditure (1998-2015) to protect Europe's coasts against flooding and erosion is borne by 5 countries (the Netherlands, UK, Germany, Spain and Italy);
- In terms of policy recommendations, it is suggested that the organisation and responsibility of coastal protection and climate change adaptation are clearly defined in each member state, that the European Commission takes a leading and coordinating role in research into the effects of climate change and that efforts are made to stimulate the pro-active involvement of national authorities as well as to support cross-boundary cooperation.

This report is structured as follows. *Chapter I* describes the scientific literature perspective of climate change adaptation in Europe's coastal zones. *Chapter II* provides a detailed empirical assessment of (the economics of) coastal protection and climate change adaptation practices across Europe. The comparison of empirical facts and figures with scientific literature insights is presented in *Chapter III*. Last, recommendations are made and conclusions drawn.

This study has to be seen as 'part of the puzzle' of climate change adaptation in Europe, focusing primarily on the *actual* status of climate change adaptation across Europe's coastal zones and the related expenditure at European, national and sub-national level. Hence, *Chapter II*, 'The empirical perspective of climate change adaptation in Europe's coastal zones' details the insights from the core part of the study. The chapter focuses on the actual practices and the expenditure of the 22 coastal member states⁴ and the Outermost regions⁵. To gather this information, an extensive in-depth country-by-country data collection and analysis has been carried out at national as well as sub-national level, centring upon the following:

- Climate change *vulnerability* of European coastal areas;
- Level of *responsibility and key actors* involved in coastal protection and climate adaptation;
- Adaptation *plans and practices* in European coastal areas;
- Past (between 1998 and 2007), present (2008) and future (until 2015) coastal protection and climate change adaptation *expenditure* in European coastal areas.

Empirical information has been collected through desk and internet research, contacts by telephone as well as field research. All information gathered has been extensively reviewed and assessed, discussed with, cross-checked and validated by the majority of interviewees and written up in 22 individual

⁴ The 22 EU coastal member states are Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden and the UK.

⁵ The EU Outermost regions are the Azores, Madeira, the Canaries, Guadeloupe, Guyana, Martinique and the Reunion Island.

country fiches and one report for the Outermost regions, for which a link is provided in *Annex I*. The methodology applied is detailed in *Annex II* of this report.

In total, about 600 sources of information related to climate change adaptation in EU coastal areas and country specific studies and reports have been used to draft this study of which the full text reports can be obtained from the European Commission's website⁶. During fifteen 2-3 day field visits and numerous contacts by e-mail and telephone, close to 240 key persons have been interviewed to collect all relevant information. *Policy Research* acknowledges all those valuable contributions.

⁶ [Http://ec.europa.eu/maritimeaffairs/climate_change_en.html](http://ec.europa.eu/maritimeaffairs/climate_change_en.html).

I. SCIENTIFIC PERSPECTIVE OF CLIMATE CHANGE ADAPTATION IN EUROPE'S COASTAL ZONES

Assessment of the scientific literature reveals that the estimate of the annual adaptation cost to protect Europe's coastal zones against Sea Level Rise (SLR) ranges between \$ 0.2 billion and € 5.4 billion and this for a period of at least 30 years. The most recent and (per country) detailed assessment currently available (Richards and Nicholls, 2009 – PESETA study) narrows this annual adaptation cost range to € 0.49-0.85 billion⁷. Estimates are influenced by the projected level of (local) physical and socio-economic vulnerability, the type of risk reduction and adaptation strategy and measures chosen as well as the assessment methodology applied. The annual adaptation cost to overcome freshwater shortage might be even more significant but is not specifically related to coastal zones. Scientific literature rarely discusses the loss of coastal eco-systems or marine biodiversity from an economic point of view.

Chapter I presents the different climate change adaptation issues to be drawn from the scientific literature.

I.1. CLIMATE CHANGE RISKS AND IMPACTS

In the literature, climate change risks and impacts are discussed for many areas and sectors. *Coastal zones* often are considered as a case-in-point. The projected climate changes and climate change effects relevant for coastal zones include among others SLR, changes in temperature, the direction and the power of waves, wind, precipitation and ice-cover as well as an increase in extreme weather events. To date, however, studies and report dedicated to climate change adaptation in coastal zones focus primarily on SLR.

⁷ Following a low (22.6 cm) and high (50.8 cm) SLR scenario (under the ECHAM4B2 socio-economic scenario); these figures are derived from the study performed by Richards and Nicholls in the framework of the wider PESETA (2009) study; see: <http://peseta.jrc.ec.europa.eu/docs/Coastalareas.html>; all references to the PESETA study included further in the text refer to this footnote.

The main climate *change impacts relevant* for coastal zones, pointed out by EEA (2008) and others, are⁸ flooding and erosion, saline intrusion and freshwater shortage, and the loss of coastal eco-systems.

By the end of this century, sea level is likely to rise by 0.18-0.59 m (IPCC, 2007)

Scientific studies projecting meteorological changes and assessing their potential impact, often take the reports of the Intergovernmental Panel for Climate Change (IPCC) as a baseline. The first observations of the IPCC, dating back to 1990, estimated a global rise in sea level of 0.3 m to 1 m by 2100. Based on new scenarios and better modelling capacity leading to refined projections of CO₂ emission scenarios, the maximum estimated SLR by 2100 was reduced in 2001 to 0.88 m and in 2007 to 0.59 m⁹. Temperature estimates were only slightly adjusted over time: the average near surface temperature is expected to rise by 1.8-4°C.

According to the 2007 IPCC report there is also a higher confidence than before in projected patterns of other changes in climate such as wind, precipitation, extreme events and ice cover. Earlier studies (Nicholls and Klein, 2003 and Swiss Re, 2006) have concluded that although fluctuations in for example the characteristics of storm events can be observed during the 20th century, no evidence of long-term trends exists. As a result, SLR remains the most discussed climate-related effect for coastal zones. SLR can cause flooding, coastal erosion and the loss of flat and low-lying areas, it magnifies landward intrusion of salt water and endangers coastal eco-systems (EEA, 2008).

Nevertheless, discussions remain concerning the future SLR scenarios and especially the IPCC predictions. The IPCC estimates explicitly exclude the effects of the melting of ice-covers (Antarctic and Greenland). When also taking into account these effects, SLR could far exceed the IPCC estimates.

Main risks for coastal zones: flooding, erosion, loss of eco-systems and freshwater shortage

Regarding *SLR and flood-risk*, Nicholls and Klein (2003) stress that for coastal areas it is not the global mean sea level that matters, but the locally observed relative sea level, which takes into account regional sea level variations and vertical movements of the land. Part of Scandinavia for example is experiencing a land-uplift which may (partly) offset SLR whereas other areas such as deltas and coastal low-lands are characterised by sinking of the land aggravating a rise in sea level. EEA (2006) indicates that 12% of all EU coastal zones (10 km strip) are located below the 5 m

⁸ Next to other climate change risks such as heat waves, reduced crop yield in the agricultural sector and the emergence of new diseases, which are less specifically related to coastal zones.

⁹ At the recent international Copenhagen-conference on climate change ('Climate Change: Global Risks, Challenges & Decisions', 10-12 March 2009, Copenhagen), leading climate change scientists warned that the IPCC SLR scenarios are likely to yield an underestimation; on the basis of the most recent estimates (accounting also for the melting of the ice caps), scientists claim that the SLR scenarios by 2100 range between 0.5 m and 1 m or even more.

elevation and thereby highly vulnerable to coastal flooding. The North Sea and Atlantic coasts are most at risk in this respect.

The vulnerability of Europe's coastal areas to the problem of *erosion*¹⁰ □ another factor determining flood-risk □ has been examined extensively in the EuroSION project¹¹. The project concluded that 20% of the total EU coastline faces serious erosion problems and annually 15 km² of land is lost or seriously impacted by erosion (reference year 2004). The coastlines of the Mediterranean Sea (30% erosion loss), the North Sea (20%) and the Black Sea (13%) have the most critical erosion hot-spots.

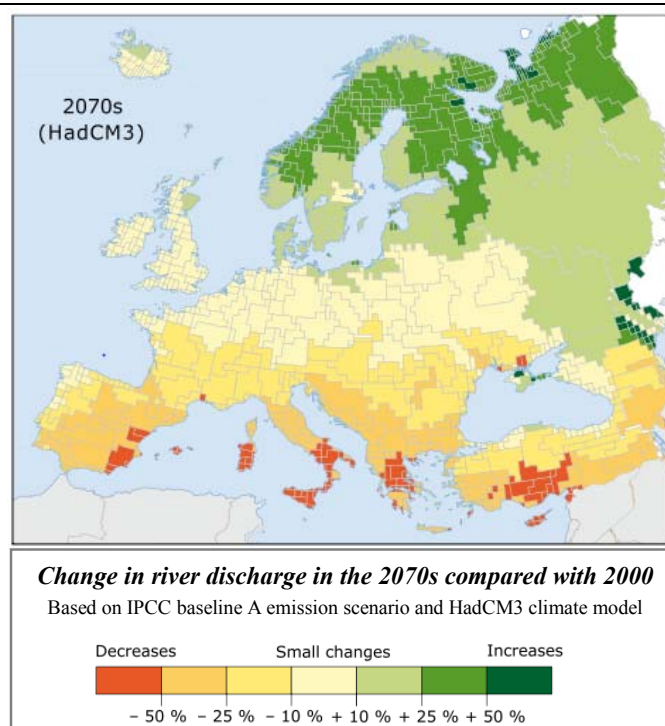
Reports of the EEA, JRC and MED EUWI¹² focus on Europe's vulnerability to droughts, *freshwater shortage and salination*. Though few European countries suffer critical water shortages, an imbalance of supply and demand has created hydrological 'hot spots', where local water abstraction far exceeds supply. As a result, saline intrusion is widespread along the Mediterranean coastlines of Italy and Spain where water demands of tourist resorts are a major cause of over-abstraction. In Malta, most groundwater can no longer be used for domestic consumption or irrigation because of saline intrusion, and the country has resorted to desalination. Cyprus on the other hand had to import water from Greece to satisfy demand in 2008. It is emphasised that longer projected drought periods in southern Europe will further reduce the recharge of groundwater. Rising sea levels and intensified storm surges also increase the risk of saltwater intrusion. The European regions in which water availability is likely to become a major problem based on the change in annual river discharge are visualised in *Figure I-1*.

¹⁰ As erosion is usually the result of both natural and human induced factors, the project examined factors such as coastline length, highest water levels, shoreline instability, coastal urbanisation and engineering, and economic assets within the impacted area to determine the overall vulnerability of Europe's coasts.

¹¹ European Commission (EuroSION study), 2004, *Living with coastal erosion in Europe: Sediment and space for sustainability*; www.euroSION.org.

¹² References include: EEA, 2005, *The European environment state and outlook*; JRC, 2005, *Climate change and European water dimension*; MED EUWI, 2008, *Integrating the climate change dimension into water resources management in the Mediterranean*.

Figure I-1: Projected changes in annual river discharge in Europe for 2070



As many rivers are an important source of water, water availability could become a major problem in regions where the annual river discharge (the volume of water transported by a river) is projected to decrease.

The annual river discharge and the resulting water availability is projected to increase in northern and north-western Europe and decrease in large parts of the Mediterranean region.

Another important factor influencing water scarcity is the increase in demand. In many parts of the Mediterranean region water scarcity is likely to increase due to a combination of increasing demand, temperature increase and precipitation decrease.

Source: Policy Research Corporation based on EEA, 2007

As regards *coastal eco-systems*, Nicholls (2004) estimates that under the different 2001 IPCC emission scenarios, 14-20% of the world's coastal wetlands could be lost by 2080 due to SLR. The European Science Foundation (2007) states that wetland losses due to SLR are expected to be in the order of 17% along the Atlantic coasts, 31-100% along the Mediterranean and 84-98% along the Baltic coasts. Nicholls and Klein (2003) conclude that the Baltic, Mediterranean and Black Sea coasts are most vulnerable to the impact of SLR on intertidal habitats and eco-systems due to their low tidal range and limited scope for on-shore migration. In the worst case, intertidal eco-systems could be largely eliminated in these areas by the 2080s. EEA (2008) and the ESF (2007) highlight the impact increased sea surface temperature may have on the diversity and number of *marine fishes*. The number and diversity of cold water species has declined in the North and Baltic Sea and warm water species from the south are moving northwards. This will have an impact on the distribution of fish in the region and may affect the management of fisheries.

The EU Outermost regions are particularly vulnerable to different types of extreme weather events (e.g. floods, drought and cyclones). Their specific characteristics such as the high concentration of population and economic activities along the coastline aggravate their overall vulnerability. Recent climate change discussions for the Outermost regions were focused in particular on the loss of *biodiversity*. Petit and Prudent (2008) highlight that the Outermost regions are concerned about the

consequences of biodiversity loss as this contributes to economic growth through tourism, and to human well being. Martinique for example has lost in specific sites over 30% of its coral reefs since 2005.

Climate change has also an impact on port infrastructure and maritime navigation

PIANC¹³, the World Association for Waterborne Transport Infrastructure, examines the drivers and impacts of climate change to maritime navigation. PIANC's findings demonstrate that maritime navigation is sensitive to storminess and wind/wave conditions as well as to sea level in ports and waterways (Ecosphere, 2009). The association stresses that the industry needs to be prepared to adapt sea waterways and sea ports, infrastructure and facilities, as well as the ships and navigational equipment to be able to continue to operate successfully in the future. Also the OECD examines the likely impact of climate change on port cities in its 2008 working paper '*Ranking port cities with high exposure and vulnerability to climate extremes*'. The paper analyses the exposure of 136 port cities around the world to coastal flooding by the 2070s.

European marine basins differ in their vulnerability to climate change

Each European coastal member state is exposed differently to climate change, but trends can be observed per marine basin.

Baltic Sea: Overall vulnerability low, most impact projected for marine species



- Low SLR expectations, projected land-uplift along major parts of the coastline and many uninhabited areas minimise the vulnerability to coastal flooding;
- Projected increase in sea surface temperature in the semi-enclosed Baltic marine basin threatens marine species as migration is difficult;
- Ice-cover reduction resulting in a different exposure of the coast to winter storms (erosion and sediment transport)¹⁴.

North Sea: Mainly vulnerable to coastal flooding



- Significant SLR expectations, storm surges, many low-lying areas (more than 85% in BE and NL) and high economic and population concentrations make flood-risk a major concern;
- Significant erosion problems (20% of the coastline).

¹³ www.pianc.org.

¹⁴ Ice-cover scenarios for the coming 100 years indicate a reduction of ice by 2/3rd; as a side effect, the possibilities for navigation in the Baltic area are expected to improve as seasonal ice is an important restricting factor.

Atlantic Ocean: Coastal flooding is the main climate threat



- Main climate risk is flooding due to SLR and changes in both the direction and the power of waves;
- Southern countries could become more exposed to freshwater shortage in the future due to prolonged and more intense periods of droughts.

Mediterranean Sea: Mainly at risk of freshwater shortage



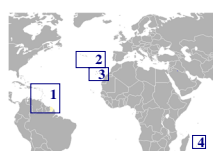
- Medium SLR and few parts of the coastline situated below 5 m elevation result in a modest risk of coastal flooding, with the exception of hot-spot Venice;
- Longest stretch of coastline affected by erosion (30%);
- Large areas affected by saltwater intrusion; dry periods projected to increase in length and frequency putting additional pressure on freshwater availability.

Black Sea: Erosion is at present the most significant problem



- Considerable presence of coastal erosion (13% of the coastline);
- Vulnerable to the impact of SLR on intertidal habitats and eco-systems due to low intertidal range and limited scope for on-shore migration;
- Dry periods are projected to increase in length and frequency putting pressure on freshwater availability.

Outermost regions¹⁵: Vulnerable to a variety of extreme weather events



- Highly sensitive to different extreme weather conditions (e.g. cyclones, drought and floods);
- The specific characteristics of the Outermost regions aggravate vulnerability to climate change and complicate adaptation, these include the high concentration of population and socio-economic activities along the coastline, remoteness from the mainland, insularity, small size, difficult topography and economic dependence on a few products and sectors (often tourist related);
- For some of the regions, also the loss of biodiversity is a major concern.

(1) Martinique, Guadeloupe and Guyana (FR); (2) Azores and Madeira (PT); (3) Canaries (ES); (4) Reunion Island (FR)

¹⁵ The Canaries, the Azores, Madeira and Guyana are situated in the Atlantic Ocean, Guadeloupe and Martinique in the Caribbean Sea and the Reunion Island in the Indian Ocean.

I.2. APPROACH AND MEASURES TO CLIMATE CHANGE ADAPTATION IN COASTAL ZONES

To date, climate change adaptation is widely recognised as a complementary response to climate change mitigation (OECD, 2008). As the benefits of climate change mitigation will only become visible in the long-run, *adaptation* to climate change – to reduce society's vulnerability to the short and medium-term impacts of climate change – is equally important. *Figure I-2* presents the main differences between mitigation and adaptation to climate change.

Figure I-2: A comparison of mitigation and adaptation

<i>Mitigation</i>		<i>Adaptation</i>
Reduce the potential impact of climate change (limit CO ₂ emissions)	<i>Aim</i>	Reduce societies' vulnerability to the impacts of climate change
Long-term (global) benefits (30-40 years)	<i>Timeframe</i>	Short to medium-term (local) benefits
(Supra-) national governments in the context of international negotiations	<i>Primary actors</i>	Responsible managers ((supra-) national governments, regional authorities, local water boards, land/property owners)
For all sectors in all countries	<i>Advantages</i>	For specific sectors and countries

Source: Policy Research Corporation

Adaptation to climate change is a major European policy concern

Adapting to climate change is a major European policy concern and forms part of the Second European Climate Change Programme (ECCP II). In 2008, a green paper was adopted that outlined options for adaptation. A White Paper on adapting to climate change has been adopted on the 1st of April 2009. This White Paper paves the way towards a comprehensive climate change adaptation strategy at EU level while encouraging Member States to adopt national adaptation strategies by 2012.

At present, a number of member states have prepared and adopted national adaptation strategies which are discussed in further detail in *Chapter II* of this report¹⁶.

A successful strategy to counteract climate change risks requires multilevel governance

The 2007 EC green paper on adapting to climate change in Europe indicates that multilevel governance, involving all actors from the individual citizens and public authorities to the EU level, is emerging for climate change adaptation. However, division of competence between states and their

¹⁶ Nevertheless, there is scope for advancing adaptation planning and implementation in areas such as public health, water resources and management of eco-systems.

regions varies significantly across the EU. The EC White Paper on adapting to climate change, adopted on the 1st of April 2009, further elaborates on the responsibility of European, national and sub-national actors to develop the most effective adaptation policies across the EU.

Tol et al. (2008) conclude that it is impossible to say which institutional arrangement is best for adaptation, as all depends on the context. Coastal zones are frequently managed by a number of regional, national and international authorities responsible for specific aspects (e.g. flooding, drinking water, land use). Tol et al. (2008) furthermore mention that more research is required to better inform about the most appropriate institutional arrangement for effective adaptation and decision-making.

Climate change adaptation measures for coastal zones are mainly discussed in relation to SLR, flooding and erosion

Most of the literature dealing with climate change adaptation in coastal zones is dedicated to potential measures to counteract SLR, flooding and erosion. Some studies and reports highlight the impact of flooding and erosion related adaptation measures on coastal eco-systems. In the literature, measures to overcome freshwater shortage are rarely discussed from a coastal zone perspective.

Therefore, the remainder of this report focuses primarily on the risk of flooding, erosion and SLR and to a lesser extent on the loss of coastal eco-systems and freshwater shortage.

Measures to reduce coastal vulnerability to SLR, flooding and erosion are mainly categorised as 'protect', 'accommodate' and 'retreat' options

For coastal zones there are many adaptation options to counteract flood-risk, erosion and SLR. One of the most common categorisations of adaptation measures was introduced by the IPCC in 1990 and has been applied by many authors (Klein et al. (2001)¹⁷, Nicholls and Klein (2003), Tol et al. (2008)¹⁸) since then:

- *Protect*: effort to continue use of vulnerable areas;
- *Accommodate*: effort to continue living in vulnerable areas by adjusting living and working habits;
- *Retreat*: effort to abandon vulnerable areas.

Figure I-3 illustrates the most common categorisation of adaptation measures with concrete examples further categorised into hard and soft measures.

¹⁷ Klein R.J.T., Nicholls R.J., Ragoonaden S., Capobianco M., Aston J. and Buckley E.N., 2001, *Technological options for adaptation to climate change in coastal zones*, Journal of coastal research, volume 17, number 3, p. 531-543.

¹⁸ Tol R.S.J., Klein R.J.T. and Nicholls R.J., 2008, *Towards successful adaptation to Sea Level Rise along Europe's coasts*, Journal of coastal research, volume 24, number 2, p. 432-442.

Figure I-3: Adaptation measures to SLR, flooding and erosion

	<i>Protect</i> = effort to continue use of vulnerable areas	<i>Accommodate</i> = effort to continue living in vulnerable areas by adjusting living and working habits	<i>Retreat</i> = effort to abandon vulnerable areas
<i>Hard</i>	Dikes, seawalls, groins, breakwaters, salt water intrusion barriers	Building on pilings, adapting drainage, emergency flood shelters	Relocating threatened buildings
<i>Soft</i>	Sand nourishments, dune building, wetland restoration or creation	New building codes, growing flood or salt tolerant crops, early warning and evacuation systems, risk-based hazard insurance	Land use restriction, set-back zones

Source: Policy Research Corporation

Traditionally, adaptation to coastal hazards has been concentrating on protecting land using hard structures (JRC, 2006), but in the last few decades there has been growing interest in soft protection such as beach nourishments and dune rehabilitation. In addition, accommodation and retreat are being increasingly applied by adapting spatial planning regulations including new building codes or land use restrictions as well as establishing set-back zones (Klein et al, 2001 and Nicholls, 2007).

Whereas the adaptation options described above concern planned adaptation, Nicholls and Klein (2003) stress the significant influence natural adaptation (e.g. vertical accretion of wetlands in reaction to SLR) may have on climate impacts. These autonomous processes are often ignored by coastal managers, but can be significant. A good example is Oost-Ameland, situated along the Dutch Wadden coast. While gas drills caused a subsidence of the island of more than 30 cm in the last two decades, natural sediment supply counteracted this effect with 20 cm in 20 years. Such natural soil accretion is mainly observed along coastline areas where plants grow¹⁹.

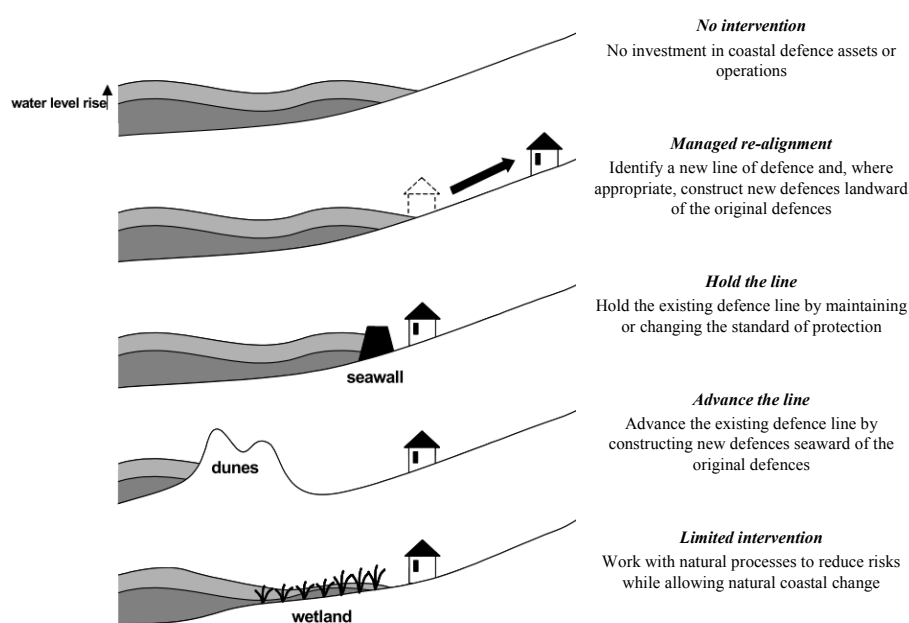
Nicholls (2007) states that in terms of timing ‘accommodate’ and ‘retreat’ are best implemented in a proactive manner, whereas ‘protection’ can be implemented in both a proactive or reactive way. The difference between anticipatory and reactive adaptation is further discussed by Klein et al. (2001), UNFCCC (2006) and Tol et al. (2008). Although the distinction is not always clear (Tol et al., 2008), anticipatory adaptation is mostly defined as measures which are implemented before the impacts of climate change are observed with the aim of reducing overall vulnerability²⁰. Whereas natural systems can only react, human systems should anticipate and plan ahead (IPCCC, 2006). Nicholls and Klein (2003) confirm that commitment to coastal adaptation needs to be built into long-term coastal management policy.

¹⁹ Research conducted by Alterra (research institute at Wageningen University funded by the Dutch Ministry of Agriculture, Nature and Food Quality).

²⁰ Klein et al. (2001) discuss five possible proactive adaptation options including for example increasing the robustness of infrastructure (e.g. sea walls) which can be classified as a ‘protect’ measure, increasing the flexibility of managed systems (e.g.. new agricultural practices) which can be classified as an ‘accommodate’ measure and enhancing the adaptability of coastal systems (e.g. allowing wetland to migrate inland) which can be classified as a ‘retreat’ measure.

Nicholls and Klein (2003) suggest that the shoreline management guidelines used in England and Wales and adapted for use in the EuroSION project provide good examples of anticipatory adaptation. These plans comprise a set of proactive strategies for shoreline management including the options managed re-alignment, hold the line, advance the line, limited intervention or no intervention. The different options are visualised in *Figure I-4*.

Figure I-4 : Proactive strategies for shoreline management



Source: Policy Research Corporation based on European Commission (EuroSION study), 2004, Living with coastal erosion in Europe: Sediment and space for sustainability, EuroSION project

Whereas hold the line and advance the line are primarily based on ‘protective’ measures to reduce the vulnerability to SLR, flooding and erosion, managed re-alignment is comparable with the option of ‘retreat’.

Adaptation measures to SLR have different consequences for coastal eco-systems

Some adaptation actions that are taken may increase vulnerability rather than reduce in and thereby result in mal-adaptation. Nicholls and Klein (2003) discuss for example the impacts different adaptation measures (to SLR, flooding and erosion) may have on coastal eco-systems. In order to sustain the ecology of the coastal zones, accommodation or retreat options are advisable over protective measures as they allow eco-systems such as wetlands to migrate landwards in response to SLR. Protective measures tend to cause a ‘coastal squeeze’, trapping eco-systems between the sea and coastal constructions. This can however be minimised by using soft protection techniques which aim to preserve the natural dynamics of the coast.

Next to SLR, flooding and erosion, water stress is a key climate change risk

In literature, adaptation measures in the water sector are mainly categorised as measures boosting supply (e.g. building more reservoirs, harvesting rainwater) or reducing demand (e.g. leakage reduction, raising awareness). JRC (2005) indicates that policies are needed which encourage soft demand management rather than hard infrastructure supply side approaches, as they offer greater scope for ensuring that limited resources are used in a sustainable way. In the latest European water scarcity and droughts communication²¹ the EC also stresses the importance of sustainable water demand management including water saving policies and optimisation of water efficiency throughout Europe.

I.3. ECONOMIC ASPECTS OF ADAPTATION - THEORETICAL APPROACH

This section focuses on the different economic aspects of adaptation. Estimates are provided on the cost of inaction and the cost of adaptation at global, European and member states level. Furthermore, the use of cost-benefit methodologies in scientific literature to decide on 'action' or 'inaction' is discussed. Last, the specific underlying differences, uncertainties and constraints of scientific cost estimates are summarised.

I.3.1. THE MONETISATION OF CLIMATE CHANGE ADAPTATION

EEA (2007) defines the **full cost of climate change** as a balance of costs and benefits, in particular:

$$\text{costs of mitigation} + \text{costs of adaptation} + \text{costs of inaction}^{22} - \text{benefits of mitigation} - \text{benefits of adaptation}$$

The definition points in the direction of a *cost-benefit analysis* (CBA) to help policy makers select the best option: 'action' or 'inaction' and the optimal type of action to be taken. In order to be comparable, costs and benefits will have to be quantified in monetary terms to determine the optimal strategy. Such monetisation of costs and benefits could also be helpful as an indication of the investments that would have to be met by (inter)national, regional or private actors to ensure sufficient protection (OECD, 2008).

²¹ European Commission, 2007, *Addressing the challenge of water scarcity and droughts in the European Union*.

²² Cost of inaction is taken as the total cost due to climate change in the absence of mitigation and adaptation policies and measures; the residual damage cost is defined as the cost of inaction minus the benefits from mitigation and adaptation.

In the literature on risk reduction and adaptation policies, the reference to CBA methodologies is occasionally presented in more detail, but rarely discussed at full length²³. At present, two tools, the Climate Framework for Uncertainty, Negotiation and Distribution (FUND)²⁴ and the Dynamic Interactive Vulnerability Assessment (DIVA)²⁵, are the most referred to for calculating the financial and economic impact of SLR with and without adaptation. Although these tools do not quantify all the benefits of adaptation in monetary terms (e.g. potential displacement of population), they provide a first basis for exploring the impact of different adaptation strategies.

The FUND model analyses the potential impacts of SLR for coastal flood-risk

The FUND model is mainly used in cost-benefit analyses of mitigation (greenhouse gas reduction) policies, but also provides a model dedicated to Sea Level Rise adaptation²⁶. Using distinct SLR scenarios of 0.5 m, 1 m and 2 m, the related area of wetland and dryland lost, and fixed evolutions in GDP and population over time, the tool verifies the potential impact of the respective rise in sea level. It also estimates the optimal amount of protection needed related to areas of *dryland lost*, *wetland lost*, the *cost of displaced people* and the *cost of protection*. These parameters interact with one another. If a piece of dryland is fully protected, no dryland will be lost but the cost of protection will be high and the adjacent wetland may be inundated. The model runs in time-steps of 5 year from 1995 to 2100 and distinguishes 16 major world regions. The tool is mainly developed for research purposes and no examples of its implementation in practice seem available to date.

The DIVA model allows exploration of SLR for all main direct impacts of climate change

The DIVA model also examines the impact of SLR, but analyses the effects of coastal adaptation strategies in much more detail than FUND. In addition to a wide range of SLR scenarios, the DIVA model allows the user to explore specific adaptation measures together with their costs. An underlying global database of 30 indicators mapped onto more than 12 000 coastal segments²⁷ and 20 indicators mapped onto 300 countries may provide the user with information on the physical as well as economic impacts resulting from *increased flood-risk and inundation*, *erosion*, *coastal wetland changes or losses* and *saltwater intrusion*. The impacts of SLR are thus studied for all major direct effects of climate change in coastal areas and are open for analysis at the global, national and coastal segment level.

²³ A characteristic of CBA is that all benefits are expressed in monetary terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their 'present value'; a CBA expresses the net gains in terms of welfare; from a theoretic perspective this makes the methodology elegant, yet in practice it is not always simple to use as much of the 'output' is determined by the (often difficult to measure) 'input' (cf. marginal utility and opportunity costs, the □ region or time-dependent □ value in their best alternative use); in practice, closely related techniques such as cost-effectiveness and economic impact analysis are often used to overcome some of these difficulties.

²⁴ FUND does not have an institutional home, the tool was originally developed by Prof Dr Tol R.S.J.

²⁵ DIVA is produced by the EU-funded DINAS-COAST Project (2001-2004).

²⁶ Tol R.S.J., 2007, *The double trade-off between adaptation and mitigation: an application of FUND*.

²⁷ Coastal segments are defined as a combination of natural, administrative and socio-economic characteristics.

Richards and Nicholls (2009) have used DIVA within the PESETA study to analyse the physical and economic impacts of SLR within the 22 EU coastal member states with and without adaptation.

Adaptation benefits are rarely monetised

Deke et al. (2001) highlight that because the damages from SLR are difficult to evaluate they are often quantified in terms of physical units, such as acres of land lost or number of species extinct, rather than in monetary values. Indeed, in most studies and reports reviewed, the benefits of adaptation or the cost of inaction have not been monetised. They are mainly expressed as the potential value of assets at risk in case of no adaptation. As a result, only a limited number of benefits are considered in scientific assessment models. Examples of such recent studies are Tol (2002) and Nicholls (2007) as well as Richards and Nicholls (2009) who use the FUND or DIVA model to calculate the 'optimal' coastal protection cost. These models consider the value of dryland and wetland at risk by multiplying the area concerned with an assumed value per km².

As monetisation of benefits is generally lacking, costs-benefit analyses in the field of risk reduction and adaptation policies is usually limited to an analysis of the cost of adaptation strategies.

1.3.2. THE COST OF INACTION

Most literature assessing the impacts of climate change and the cost of inaction focuses primarily on the impacts and costs related to a specific rise in sea level. The following paragraphs highlight the indicators examined most often to express the risks of inaction for coastal zones at global, European and member states level.

GDP, land loss and population at risk of flooding are the most common costs of inaction

Most studies and reports on the cost of inaction in relation to coastal flooding and SLR focus on the GDP, land area and population at risk. Other indicators often examined with respect to climate change are the number of properties at risk as well as the loss of wetland and coral reefs.

Scientific estimates of the potential cost of inaction for the coastal zones at European level include the following:

- The total *GDP* of the 22 European coastal member states in 2004 is estimated at about € 9.8 trillion out of which 35% or € 3.5 trillion is generated in the area within 50 km of the coast (Eurostat); EEA (2005) indicates that the value of the economic assets within 500 m of the coastline (reference year 2000) is estimated at € 500-1000 billion;
- European coastal zones (50 km coastal strip) host 1/3rd of the EU population (EEA, 2007); higher *population* densities are found in Southern Europe as well as the North Sea coasts, lower densities can be observed along the Baltic (Eurostat);

- Under a 1 m SLR, 139 000 km² of *land area*, 13.6 million *people* and € 305.2 billion *GDP* is at risk of coastal flooding in Europe (Anthoff et al, 2006);
- In port cities around the world, about 40 million *people* are exposed to a 1 in 100 year coastal flood event; the total value of *assets* exposed corresponds to around 5% of global GDP (for the reference year 2005) (OECD, 2008);
- In London 2.75 (5.5) million *people* would be threatened by a SLR of 1 m (5 m); it is also estimated that a SLR of 5 m would cause \$ 160-200 billion of *economic damages* (Naples and Aerts, 2007);
- Under a 34 cm SLR by 2080, Nicholls (2004) estimates that 5-20% of *wetlands* could be lost on a global level;
- It is estimated that 60% of *coral reefs* will be lost through fishing, pollution, diseases, invasive alien species and coral bleaching due to climate change (EC, 2008);
- Under the ECHAM4B2 socio-economic scenario, projecting SLR between 22.6 cm and 50.8 cm by 2100, it is estimated that by 2020 between 141 km² and 329 km² of *land* could be lost due to submergence or erosion and 44 000 to 405 000 *people* would be exposed to coastal flooding each year in Europe.

Richards and Nicholls (2009) monetise the cost of inaction at member states level

Richards and Nicholls (2009) estimate besides the physical impacts of SLR the cost of inaction in monetary terms. They calculate the cost of inaction (the so called ‘damage cost’) on the basis of the following indicators:

- *Sea flood cost*: Damages are calculated on the basis of the flooded area, the maximum flood depth and the probability of flooding; the value of land occupied by humans is assumed to be the agricultural land value;
- *Salinity intrusion cost*: It is assumed that the value of saline agricultural land is half as valuable as non-saline land;
- *Migration (due to land loss) cost*: Costs are related to the number of people that are forced to migrate, calculated by multiplying the coastal area permanently flooded with the population density of the area concerned; the value per migrant is assumed to be 3 times the per capita income of the country of origin.

The total cost of inaction, based on these three indicators is estimated under high, medium and low SLR scenarios and under different socio-economic scenarios. Under the ECHAM4B2 socio-economic scenario, for example, projecting SLR between 22.6 cm and 50.8 cm by 2100, Richards and Nicholls (2009) estimate the annual cost of inaction, aggregated at EU level between € 5.6 billion and € 6.7 billion by 2020.

The cost of inaction for port cities

The 2008 OECD working paper ‘*Ranking port cities with high exposure and vulnerability to climate extremes*’ estimates how climate change is likely to impact port cities’ exposure to coastal flooding by the 2070’s. The study focuses on 136 port cities around the world. Across all cities, about

40 million people (on average 1 person out of 10 of the port city population in the cities concerned) are exposed to a 1 in 100 year coastal flood event. The total value of assets exposed corresponds to around 5% of global GDP (for the reference year 2005). The most exposed European ports are Amsterdam and Rotterdam. Under the assumption of a 1 in a 100 year event and SLR of 0.5 m, in the period up to 2070, the assets at risk in the city of Amsterdam would rise from \$ 128 billion to \$ 843 billion and the city's population at risk would almost double from 0.8 to 1.4 million inhabitants.

I.3.3. THE COST OF ADAPTATION

In line with the cost of inaction, most literature assessing the cost of adaptation for coastal zones concentrates on the expenditure necessary to protect against SLR (OECD, 2008). Some studies also look at the potential loss of coastal eco-systems in the form of wetland lost, but impacts such as saltwater intrusion or effects of storm surges are rarely discussed. Global, European and national scientific estimates presented in the following paragraphs focus primarily on the cost of adaptation in relation to coastal protection against flooding and erosion due to SLR.

Table I-1 and *Table I-2* provide a comprehensive overview of studies and reports estimating the cost of adaptation to SLR and coastal flooding at global as well as European level.

Global estimates of the coastal adaptation cost range between \$ 5 billion and \$ 15 billion per year

From the literature presented one may conclude that the annual global adaptation cost to protect against coastal flooding due to SLR lies somewhere between \$ 5 billion (IPPC, 1990) and \$ 15 billion (Nicholls, 2007). The time period over which this adaptation cost needs to be carried is difficult to indicate. Based on the information available it could be concluded that this annual amount would need to be spent for 30 – 40 years.

Estimates of the coastal adaptation cost for Europe ranges from \$ 0.2 billion to € 5.4 billion per year

Also at European level, the available estimations differ widely. Bosello et al. (2006) have calculated a projected annual adaptation cost of \$ 0.2 billion whereas the estimates presented in EuroSION (2004), Response (2006) and JRC (2006) point in the direction of up to € 5.4 billion for at least 30 years.

Table I-1: Estimates of the coastal adaptation cost on a global level (related to SLR)

	<i>Reference</i>	<i>Assessment model used</i>	<i>SLR scenario</i>	<i>Total coastal protection cost includes:</i>	<i>Total cost (billion)</i>	<i>Cost/year (billion)</i>	<i>% GNP % GDP</i>
<i>Global</i>	IPCC, 1990	n.a.	100 cm SLR (100 years)	Costs of additional protection <i>protection level not specified</i>	\$ 500	\$ 5.0 ²⁸	0.037 % GNP
	Tol, 2002	FUND model	100 cm SLR (100 years)	Protective construction costs, dryland and wetland lost costs, migration costs <i>most optimal level of protection based on costs vs. benefits</i>		\$ 12.8	n.a.
	Nicholls, 2007	DIVA model	9.1 cm SLR (1990-2030)	Beach nourishment costs, sea dike costs, residual land lost costs residual sea flood costs <i>most optimal level of protection based on costs vs benefits (people actually flooded also taken into account but not monetised)</i>		\$ 14.6	n.a.

Source: Policy Research Corporation

Table I-2: Estimates of the coastal adaptation cost on a European level (related to SLR)

	<i>Reference</i>	<i>Assessment model used</i>	<i>SLR scenario</i>	<i>Total coastal protection cost includes:</i>	<i>Total cost (billion)</i>	<i>Cost/year (billion)</i>	<i>% GNP % GDP</i>
<i>Europe</i>	Deke et al., 2001	n.a.	100 cm SLR (1990-2100)	Costs of additional protection ²⁹ <i>total protection (limited to Western Europe)</i>	\$ 176	\$ 1.6	0.02 % GDP
	Eurosion, 2004 Response, 2006 JRC, 2006	Global Vulnerability Assessment (1993) ³⁰	# cm SLR (1990-2020)	Direct and indirect coastal protection costs <i>protection level not specified</i>	€ 161	€ 5.4	n.a.
			n.a.	Public expenditures in 2001 to coastline protection (new investments, maintenance and purchasing coastal land at risk)		€ 3.2	n.a.
	Bosello et al., 2006	n.a.	25 cm SLR (1997-2050)	Costs of additional protection ³¹ <i>total protection (except wetland)</i>	\$ 11.2	\$ 0.2 ³²	0.0025% GDP
	Richards and Nicholls, 2009	DIVA model	22.6 cm SLR (2020) 50.8 cm SLR (2020)	Optimal protection cost (Beach nourishments and heightening of dikes)		€ 0.49 € 0.85 ³³	n.a.

Source: Policy Research Corporation

²⁸ Calculated by Policy Research by dividing the total cost by the number of years covered.

²⁹ Deke et al. (2001) based the cost of protection on a comparison of the estimates made for the Netherlands by IPCC (1996) with the costs estimates made by Fankhauser (1994) and applying the same share to the estimations of Fankhauser (1994) for all Western European countries; the protection cost derived by Fankhauser (1994) was not used directly as this cost includes besides the costs for protection measures the costs related to land loss which occurs if protection measures are taken.

³⁰ The Global Vulnerability Assessment, carried out by Hoozemans et al. (1993), produced vulnerability assessments for 192 coastal segments representing the entire global coastline; analyses are based on national estimates of the impacts of 1 m SLR to the population at risk of flooding, the protection costs, and impacts on wetland loss and on rice production.

³¹ Bosello et al. (2006) used the Global Vulnerability Assessment of Hoozemans et al. (1993) as the main source of information.

³² Calculated by Policy Research by dividing the total cost by the number of years covered.

³³ These figures, provided by Richards and Nicholls (2009) do not consider Cyprus but they do take into account Croatia.

Minimum total adaptation cost amounts to \$ 11.2 billion for Europe and to \$ 500 billion globally

From a scientific point of view, the minimum total adaptation cost for the coastal zones is likely to amount to about \$ 500 billion at global level (IPCC, 1990) and to some \$ 11.2 billion at European level (Bosello et al., 2006). The underlying parameters of both estimates however differ. Whereas the estimate at global level is based on a 100 cm SLR by 2100, the estimate for Europe accounts for a 25 cm SLR by 2050. Both estimates seem to include primarily the direct cost of adaptation, presumably under a 100% protection scenario.

The maximum cost of adaptation mentioned in literature, both at global and at European level, is a factor 5 to 10 higher.

Richards and Nicholls (2009) estimate the cost of adaptation at member states level

In the light of the PESETA study³⁴, Richards and Nicholls (2009) have conducted an assessment of the physical and economic impacts of SLR on the coastal systems of the 22 coastal member states. Supported by the DIVA model this assessment seems to be the most accurate scientific estimate of the cost of adaptation for Europe's coasts currently available.

The *cost of adaptation* in the PESETA analysis is based on the cost of two adaptation options, namely increasing flood defence dikes and the application of beach nourishments. The PESETA authors indicate that while these two adaptation options are realistic they are not comprehensive and the PESETA study should not be seen as a tool to endorse these approaches. Furthermore, the DIVA model is more global than European in its design. To this end, the beach nourishment cost applied in DIVA has been updated³⁵ and economic results in 1995 US dollars have been converted to Euros (using the International Monetary Fund currency archive). The cost of the two adaptation options does not change over time under the assumption that the technologies are mature.

Within the DIVA model, and thus the PESETA analysis, it is furthermore assumed that adaptation takes place under minimum costs and maximum benefits. This is illustrated later on in this report.

An overview of the cost of adaptation at member states level following PESETA – Richards and Nicholls (2009) is presented in *Table I-3*.

³⁴ PESETA stands for **P**rojections of **E**conomic impacts of climate change in **S**ectors of **E**urope based on **b**oTtom-up **A**nalysis; the coastal economic part of the study was coordinated by Dr Richards and Prof Nicholls of the University of Southampton.

³⁵ \$ 5 per m³ for areas of plentiful sand, \$ 10 per m³ as a mid-range figure and a low supply area figure of \$ 15 per m³; the authors indicate that a more systematic assessment of the beach nourishment cost would benefit future coastal analyses.

Table I-3: Cost of adaptation at member states level (PESETA – Richards and Nicholls (2009))³⁶

<i>Richards and Nicholls (2009) – PESETA Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)</i>			
<i>Country</i>	<i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	
The Netherlands	54.3	88.1	<p>Richard and Nicholls (2009) only consider the application of beach nourishments and the increase in flood defence dike heights in their assessment. Accommodation or retreat measures have not been considered in the scientific estimations. Furthermore, the amounts do not account for residual damage costs.</p> <p>At national level, Richard and Nicholls (2009) estimate the highest annual cost of adaptation for the UK, followed by France, Germany, the Netherlands and Denmark.</p> <p>Under the ECHAM4B2 socio-economic scenario, projecting SLR between 22.6 cm and 50.8 cm by 2100, Richards and Nicholls (2009) estimate the annual cost of adaptation, aggregated at EU level under ‘optimal’ protection (costs versus benefits), between € 0.49 billion and € 0.85 billion by 2020.</p>
Germany	50	101	
UK	99.5	174.2	
Spain	20.7	40.7	
Italy	29.7	49.8	
Belgium	2	2.5	
Denmark	44.9	80.1	
Romania	5.9	7.4	
Greece	19.6	33.9	
France	58.2	109.9	
Portugal	10.6	21.8	
Sweden	12.5	23.1	
Poland	12.2	16.2	
Ireland	26.7	45.8	
Malta	0.2	0.3	
Slovenia	0.1	0.2	
Bulgaria	1.5	2.1	
Cyprus	<i>n.a.</i>	<i>n.a.</i>	
Lithuania	2.5	3.8	
Finland	8.6	13.3	
Estonia	21.2	28.9	
Latvia	7.4	10.8	
Outermost regions	<i>n.a.</i>	<i>n.a.</i>	
<i>Europe's total</i>	<i>488.3</i>	<i>853.9</i>	

Source: Richards and Nicholls (2009) – PESETA study

Other studies and reports looking at the cost of adaptation for the coastal zones of specific member states, but without mentioning the ‘annual’ cost of adaptation or the period of time are:

- ABI, 2006: Cost of adaptation for *UK* coastal area estimated at £ 6.1-8.6 billion (40 cm SLR);
- IPCC based on Nicholls and de la Vega-Leinart, 2000:
 - Cost of adaptation for coastal area of *Germany* estimated at \$ 30 billion (100 cm SLR);
 - Cost of adaptation for coastal area of *Poland* estimated at \$ 4.8 billion (100 cm SLR);
 - Cost of adaptation for coastal area of *the Netherlands* estimated at \$ 12.3 billion (100 cm SLR).

³⁶ The cost of inaction and the benefits of adaptation estimated by Richards and Nicholls (2009) in the framework of the PESETA study are discussed in *Chapter I.3.4.*

The adaptation cost in the water sector is presumably much higher than the cost to protect against flooding and erosion

The comprehensive review of studies and reports revealed that the focus in literature is mainly on the risk of inundation of dryland and/or inhabited coastal areas. Impacts such as saltwater intrusion or effects of storm surges are rarely discussed. The DIVA model – explained in *Chapter I.3.1* – allows estimating the economic impact of saltwater intrusion. Richards and Nicholls (2009), who applied this model in PESETA, estimate that without adaptation, the annual salinity intrusion cost for Europe by 2020 (under the ECHAM4B2 scenario) will amount to € 595-610 million. OECD (2008) highlights one study dealing with the cost of adaptation for the water sector. The study provides an estimate of the cost of additional water infrastructure needed by 2030 taking into account water demands and supplies in more than 200 countries. The total estimated amount is \$ 531 billion, including the adaptation responses to both economic and climate changes. The majority of this amount is estimated to be required in developing countries of Asia and Africa.

The Plan Blue³⁷ indicates that there is a huge scope for improving water demand management in the Mediterranean region. Over 25 years the potential savings could reach nearly € 270 billion, or € 11 billion per year. The cost of exploiting this potential (e.g. subsidies, awareness campaigns, trainings) needs to be subtracted but they are much lower than the resulting benefits. These figures show the potential of better water demand management in the Mediterranean.

I.3.4. COST-BENEFIT ANALYSIS

Cost-benefit analyses (CBA) constitute an important element of literature concerning the economics of climate change adaptation. A cost-benefit analysis can be used to evaluate if the benefits of (additional) coastal protection measures outweigh the costs from a socio-economic point of view.

The benefits of adaptation generally outweigh the costs

Most studies and reports dealing with the economics of climate change conclude that the benefits of adaptation generally outweigh the cost of adaptation strategies and measures. Within the PESETA study, Richards and Nicholls (2009) compared the cost of adaptation (based on the most optimal level of protection in terms of costs versus benefits) with the cost of inaction at EU level using the DIVA model. The different economic costs presented are:

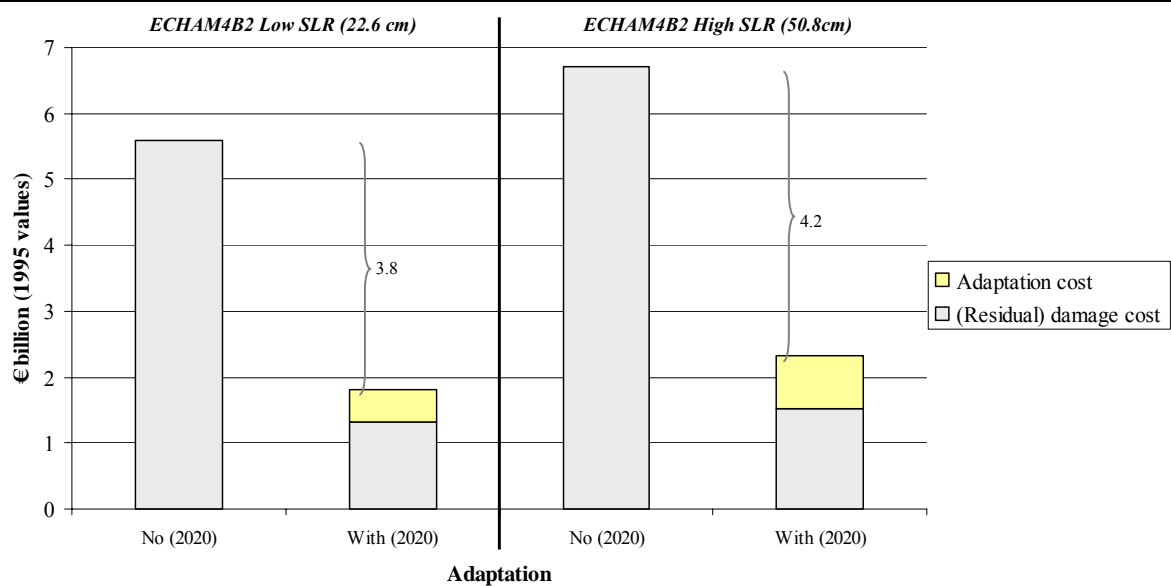
- Damage cost (or cost of inaction): Sea flood costs, salinity intrusion costs and migration costs;
- Adaptation cost: Sea dike costs and beach nourishment costs;
- Residual damage cost: Damage costs that still remain after adaptation.

³⁷ Plan Bleu, 2005, *Chapter 1: Water*, in: A sustainable future for the Mediterranean: the blue plan's environment and development outlook.

By 2020, the net-benefit of adaptation – defined as the damage cost without adaptation *minus* the cost of adaptation *minus* the residual damage cost with adaptation – ranges between € 3.8 billion (low SLR) and € 4.2 billion (high SLR). By 2080, this net-benefit is expected to further increase. Although the net-benefit of adaptation at EU level is positive for both the low and high SLR scenario by 2020, this is not the case for all member states individually.

The results of this cost-benefit analysis at EU and member states level are visualised in *Figure I-5* and further detailed in *Table I-4*.

Figure I-5: Cost of adaptation versus cost of inaction for Europe (under low and high SLR)



Source: Policy Research based on the PESETA study

Table I-4: Net-benefit of adaptation at member states level according to the PESETA study (Richards and Nicholls, 2009)

<i>Richards and Nicholls (2009) – PESETA ECHAM4B2 (1995-2020) Low SLR (22.6 cm)</i>				
<i>Country</i>	<i>Damage cost without adaptation in € million per year</i>	<i>Adaptation cost in € million per year</i>	<i>Residual damage cost in € million per year</i>	<i>Net-benefit of adaptation in € million per year</i>
The Netherlands	3332	54.3	518.4	2759.3
Germany	498.6	50	401.7	46.9
UK	594.7	99.5	46.9	448.3
Spain	36.3	20.7	9.6	6
Italy	93.6	29.7	6.8	57.1
Belgium	584.8	2	56.2	526.6
Denmark	15.6	44.9	0.4	-29.7
Romania	0.9	5.9	0.8	-5.8
Greece	4.4	19.6	1.7	-16.9
France	410.9	58.2	230.6	122.1
Portugal	8.7	10.6	6.3	-8.2
Sweden	3.1	12.5	0	-9.4
Poland	10.7	12.2	9.7	-11.2
Ireland	25.9	26.7	17.7	-18.5
Malta	0.4	0.2	0	0.2
Slovenia	0.1	0.1	0	0
Bulgaria	0.2	1.5	0.2	-1.5
Cyprus	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>
Lithuania	0.1	2.5	0.1	-2.5
Finland	1.8	8.6	0.3	-7.1
Estonia	0.2	21.2	0.2	-21.2
Latvia	2.2	7.4	2.1	-7.3
Outermost regions	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>
<i>Europe's total</i>	5625.2	488.3	1309.7	3827.2

When considering the net-benefit of adaptation at member states level, calculated by Richards and Nicholls (2009) under the low (22.6 cm) SLR scenario, the net effect may be positive or negative.

This observation confirms that deciding on coastal protection and climate change adaptation is not just a question of measuring the level of financial costs versus financial benefits at an aggregated level; also sociological aspects, the value of eco-systems services (to for example human health and well-being) as well as the 'allocative' versus the 'distributive' aspects of adaptation should be considered.

It is important to note that Richard and Nicholls (2009) only consider 2 adaptation options: namely beach nourishments and the increase in flood defence dike heights; accommodation or retreat measures have not been considered in these estimates.

Source: Policy Research based on the PESETA study

ABI (2006) made a similar cost-benefit analysis for Eastern England. Although not all benefits of adaptation have been expressed in monetary terms, they concluded that the benefits of improving coastal defences are seven times higher than the related cost.

Box I-1: Cost versus benefits of adaptation at national level – example of the UK

UK – Eastern England

For the UK, recent studies confirm that the benefits to cost ratio of improving coastal defences in Eastern England is around 7:1. ABI (2006) estimates that, under a 40 cm SLR scenario and without adaptation, the number of properties at risk of flooding in Eastern England would rise by 40% (from 270 000 to 404 000) and the financial cost of a major flood event could increase up to \$ 16 billion. Furthermore, the number of elderly people living nearby the coast is projected to rise, increasing the human and financial cost of flooding. Essential services are also at risk: 15% of fire and ambulance stations and 12% of hospitals and schools are located in flood-prone areas. ABI (2006) also estimates that spending around \$ 6-8.5 billion on improving coastal defences would have a substantial impact on damages, both now and in the future. Investment now in improvements to coastal defences could reduce the number of properties at risk from 270 000 to 170 000. A 40 cm SLR would increase this number again to 270 000 properties, roughly the same as today. The maximum cost of a major flood event would decrease to \$ 7 billion.

1.3.5. CONSTRAINTS AND UNCERTAINTY OF SCIENTIFIC ESTIMATES

Prudence is called for when mentioning the overall adaptation cost based on a comparison of existing studies and reports due to the *differences* and *uncertainties* in underlying assumptions considered and models used by the authors. *Table I-1* and *Table I-2* (see before) provide global and European scientific estimates of the cost of coastal adaptation. The specific underlying differences, uncertainties and constraints of these estimates, elaborated upon in the following paragraphs, are that:

- Different input parameters and assessment models lead to different cost estimates;
- Most cost studies focus on the direct cost of capital protective measures;
- Most cost studies do not consider the socio-economic influence on disaster losses;
- Most cost studies consider a narrow scope of climate change impact.

Constraint 1: Different input parameters and assessment models lead to different cost estimates

Scientific estimates are mostly based on models that seek to minimise the total cost of climate change. This is the cost or investment in additional protection needed and the residual damage or loss that will occur with a certain rise in sea level (OECD, 2008). Obviously, cost estimates depend on the input parameters used and the values attributed to them.

The most visible input parameters which differ across the studies and reports are the expected SLR, the reference year and the (optimal or required) level of protection chosen. While the reference (baseline) year is not always clearly mentioned, the SLR scenarios range from 9 cm in 40 years (Nicholls, 2007) to 100 cm in 100 years (IPPC, 1990 and Tol, 2002). Also the optimal level of protection differs from study to study. IPCC (1990), Deke et al. (2001)³⁸ and Bosello et al. (2006)³⁹ take into account 100% protection of the coastline, while Tol (2002), Nicholls (2007) and Richards and Nicholls (2009)⁴⁰ consider that certain areas of land (wetland and dryland) will be lost in order to minimise the total cost (adaptation and residual damage cost) to counter the consequences of climate change.

Furthermore, it can be concluded that the various studies and reports consider different socio-economic and physical indicators of the coastal areas □ although less reported upon □ to calculate the potential climate impacts and thereby the protection (cost) needed. In addition, assumptions about the cost of protection measures (the protection cost is typically extrapolated from local projects) and the economic value attributed to the areas or properties at risk (e.g. wetland, dryland) influence the final result (OECD, 2008).

³⁸ Deke O., Hooss K.G., Kasten C., Klepper G. and Springer K., 2001, *Economic impact of climate change: Simulations with a regionalised climate-economy model*.

³⁹ Bosello F., Roson R. and Nicholls R.S.J., 2006, *Economy-wide estimates of the implications of climate change: SLR*.

⁴⁰ Economic analysis of Richards and Nicholls (2009) was carried out in the framework of the PESETA study.

Constraint 2: Most cost studies focus on the direct cost of capital protective measures

Most scientific estimates are based on the additional capital cost of protective infrastructure needed to respond to SLR. IPCC (1990), Deke et al. (2001) and Bosello et al. (2006) indicate that they only consider the cost of additional protection measures and do not include the cost associated with coastal protection in place or existing flood defence needs. Richards and Nicholls (2009) account for the cost of beach nourishments and the heightening (but not the maintenance) of dikes. Tol (2002) and Nicholls (2007) do not mention this explicitly. All studies focus on protective adaptation, which is a stylised approach as many other (lower-cost) adaptation responses ('accommodate', 'retreat') exist and are being increasingly applied (Klein et al., 2001).

The indirect cost of climate change, such as research to the potential changes and effects, is rarely referred to. EuroSION (2004) and Response (2006) indicate that they consider direct as well as indirect coastal protection expenditure but refrain from detailing what this exactly entails. In addition, most studies provide estimates under the assumption that the cost of SLR does not affect other sectors of the economy. Darwin and Tol (2001) report that global welfare losses \square under a general equilibrium analysis \square could be up to 13% higher as they entail an opportunity cost for other welfare investments. Also Deke et al. (2001) and Bosello et al. (2006) analyse the wider economic effects of expenditure to climate adaptation⁴¹.

Constraint 3: Most cost studies do not consider the socio-economic influence on disaster losses

Economic losses from flooding disasters can be the result of both social and climate factors. Barredo (2009), who investigated the economic losses of floods in Europe over the period 1970-2006, claims that an observed trend in economic losses is mostly driven by societal factors, such as increases in population and wealth, rather than climate factors. Barredo (2009) stipulates that economic losses from floods have shown a positive upward trend over the years, which may suggest that climate change has an influence. However, most studies do not tend to take into account societal factors, such as changes in population or the wealth of a country. EEA (2007) confirms that future socio-economic scenarios can provide a significant change in vulnerability or exposure, even without climate change. The results of the analysis of Barredo (2009) are detailed in *Box I-2*.

⁴¹ The effects are not included in the absolute amounts presented in *Table I-1*.

Box I-2: Impact of socio-economic factors on economic losses of weather-related disasters

Barredo J.I., 2009, *Normalised flood losses in Europe*, JRC

The study, 'Barredo J.I., 2009, *Normalised flood losses in Europe*' led by the European Commission's Joint Research Centre (JRC), assessed the economic losses of floods in 31 European countries in 1970- 2006.

The study adjusted the data on economic flood losses over the years according to inflation, population and GDP per capita for that year and for the country in which the flood occurred. The 'Purchasing Power Parity' factor was used to account for differences in price levels between countries. The 27 largest floods in Europe were considered. When the influence of societal factors⁴² on floods was excluded, the data suggests there is no significant increase in economic losses between 1970 and 2006. This indicates that socio-economic factors were in fact the main contributors to the original upward trend in stead of climate change.

The study appears to show no link to climate change but does point out that there is no simple relation between flood-disaster losses and anthropogenic climate change. Furthermore, Barredo (2009) stresses that monitoring of losses from floods and other weather-driven disasters should become a priority over the coming years.

Constraint 4: Most cost studies consider a narrow scope of climate change impacts

A comprehensive review of studies and reports reveals that the focus in literature is mainly on the risk of inundation of dryland and/or inhabited coastal areas. Tol (2002) and Nicholls (2007) also look at the potential loss of coastal eco-systems in the form of wetland lost, but impacts such as saltwater intrusion or effects of storm surges are rarely discussed. Richards and Nicholls (2009) estimate, using the DIVA model, the economic impacts of four main climate risks for coastal zones: flooding, erosion, wetland lost and saltwater intrusion. OECD (2008) highlights another study dealing with the cost of adaptation for the water sector. The study provides an estimate of the cost of additional water infrastructure needed by 2030 taking into account water demands and supplies in more than 200 countries. The total estimated amount is \$ 531 billion, including the adaptation responses to both economic and climate changes. The majority of this amount is estimated to be required in developing countries of Asia and Africa.

EEA (2007) and OECD (2008) highlight additional methodological challenges and uncertainties in relation to cost estimates

Besides the constraints detailed above, EEA (2007) and OECD (2008) outline additional methodological challenges and uncertainties regarding estimates of the cost of adaptation and inaction. In particular worth mentioning are:

- The valuation of 'non-market' effects such as the impact on human health or eco-systems;
- Discounting the cost and benefits of adaptation occurring at different times in the future;
- The comparison of economic damages from climate change (the cost of inaction) across countries with very different levels of impacts and income levels;
- Separating the cost of adaptation to climate change effects from the costs triggered by socio-economic changes.

⁴² Between 1970 and 2006, European countries have experienced increases in the standard of living and wealth, and the population has grown. As a consequence, there may be greater exposure of people and assets in flood-prone areas.

Uncertainty in climate change predictions and costs may hamper decision-making

EEA (2007) highlights that despite increasing efforts being devoted to research on various aspects of the economics of climate change in Europe, there is limited confidence in the magnitude and ranges of estimates. Knowledge of the potential impacts of economic changes on natural and human systems is not yet detailed enough and there are important evidence gaps⁴³. Nicholls (2007) adds to this that while there is significant interest in elaborating coastal adaptation measures and understanding their cost, hard numbers on investments in coastal adaptation are difficult to identify as there is never a single 'Ministry for Coastal Adaptation' which publishes consolidated accounts of the adaptation cost in a country.

EEA (2007) furthermore stipulates that learning and irreversibility play a crucial role in how to deal with uncertainty. If a climate change effect would be irreversible, stakeholders may want to prevent it regardless of the level of uncertainty or the results of future research.

Many studies and reports indicate the need for *more research on the economics of climate change adaptation to reduce uncertainty*. When the level of uncertainty can be decreased, decision-making can become more effective and policies can be decided upon in a more accurate way. Despite that fact that a certain level of uncertainty will always remain, most climate change experts do stress the benefits of 'early (proactive) adaptation'. When considering risk aversion in economic analysis, the impact of climate change effects would increase.

⁴³ The potential impacts most often referred to in literature are the cost of additional protection measures needed, dryland and wetland at risk of flooding as well as GDP and population at risk of flooding.

II. EMPIRICAL PERSPECTIVE OF CLIMATE CHANGE ADAPTATION IN EUROPE'S COASTAL ZONES

Over the period 1998-2015, EU, national and sub-national authorities will have spent in total about € 15.8 billion or on average € 0.88 billion per year on coastal risk reduction and climate change adaptation⁴⁴. Especially along the North Sea coasts, exposed the most to coastal flood-risk and erosion, significant normal coastal protection expenditures continue to take place. Hot-spots such as Venice (Mediterranean Sea) also receive major attention during the period examined⁴⁵. In addition, in most countries strategic climate change adaptation plans are emerging.

This chapter provides more details on the (economics of) coastal protection and climate change adaptation practices in the different EU coastal member states and highlights:

- National differences in plans and programmes to counteract climate change risks;
- The specific measures undertaken to counteract climate change risks across Europe;
- The past, present and future coastal protection expenditure of the member states and the Outermost regions.

Information per coastal member state is further detailed in 22 country fiches and a dedicated Outermost regions fiche, for which a link is provided in *Annex I*.

⁴⁴ The amounts do not include expenditure related to freshwater shortage as this is not one-to-one related to climate change and coastal zones; the amounts of € 15.8 billion and € 0.88 billion mentioned here mainly refer to money spent on coastal flood-risk and erosion.

⁴⁵ The management plan for the future of the London Thames Barrier will be finalised by 2010.

II.1. A LONGSTANDING TRADITION FACING CHANGING CONDITIONS

For most EU member states, coastal protection is not a new topic, but it goes without saying that the level of attention and degree of action correlate with the risks involved. Areas that have been affected by severe weather events in the past and host a significant share of inhabitants or economic activity have been defending their coasts for decades. In countries that have been exposed only recently to persistent weather events or climate change related effects, plans and measures, directly or indirectly related to climate change, are starting to emerge.

Countries with historic flood-risk have the most profound coastal plans

All EU coastal member states have implemented coastal protection measures (mainly to protect against flooding and erosion) to some extent in the past. Countries with historic experience of flooding and extreme weather events along their coasts seem to embed such measures in dedicated coastal plans and programmes. Consequently, *North Sea* and some *Atlantic Ocean* countries currently have the most profound coastal protection or development plans.

Along the *North Sea*, the UK and Germany have implemented coastal protection plans for decades. In the UK, Shoreline Management Plans are developed for each *coastal segment* (see *Box II-1*), whereas in Germany, each *coastal state* has its own a coastal defence Master Plan. In addition, in 1984, the Thames Barrier was constructed to protect the UK and especially London from tidal flooding until 2030. In Belgium, an Integrated Master Plan is currently under construction and will be finalised by 2010. In the Netherlands, plans and programmes relate to coastal as well as inland flood-risk protection. At policy level, the first National Water Plan was published in December 2008 and will result in a Delta Programme in the course of 2009.

Box II-1: Coastal planning following the natural boundaries of the coast

The UK – Shoreline Management Plans

SMP for the coast zone of the River Wyre to Walney Island (England)



Source: Wyre Borough Council (www.wyrebc.gov.uk)

The implementation of coastal protection and sea defence measures in the UK starts with the development of Shoreline Management Plans (SMPs). These plans are not developed for a specific region or county but cover a dedicated part of the UK coastline based on the natural boundaries of the coast. Each Shoreline Management Plan provides, for the different coastal segments covered, guidelines on the main strategy option to be followed: *hold the line*, *advance the line*, *managed re-alignment* or *no active intervention*. In a second step and in line with the respective SMPs, Individual Schemes are developed, detailing the exact measures to be undertaken along each coastal (sub-)segment. In England and Wales, 36 (first generation) SMPs are currently available, for Scotland 3 plans have been prepared so far.

Along the *Atlantic Ocean*, countries do not possess dedicated coastal protection plans but in general tend to integrate protection measures in wider coastal development programmes. In Portugal, for example, Coastal Management Plans (POOCs⁴⁶) include protective actions against flooding, erosion and extreme weather events. Other key objectives include the conservation of environmental values of the coastline and regulating tourist use of beaches.

At present, most countries situated in the *Mediterranean, Baltic and Black Sea* marine basins as well as the *Outermost regions* do not have dedicated coastal strategies or operational plans in place yet, but reduce risks mainly through ad-hoc actions. Exception to this are *Poland, Italy (Venice), Spain* and since recently *Romania*.

Although *Poland* has not suffered from any extreme coastal weather event in the past, detailed long-term coastal protection strategies have been developed and implemented since 1985 by the national government. In 2000 a new Polish Long-Term Coastal protection Strategy was drafted which takes climate change explicitly into account. The areas in need of protection have been put forward and funding has been secured up to 2023. In *Italy*, especially *Venice* receives national coastal protection attention with the development of the General Plan of Intervention and the Mose project. At the regional level, Lazio and Emilia Romagna have an operational Coastal Protection Programme in place. In *Spain*, the protection of the coastal zones will mainly be dealt with through the National Strategy for Sustainable Coastal Management, currently under development. *Romania* developed in 2007 a Master Plan against erosion for its southern coastal segment which will be implemented in priority areas over the period 2007-2013. For the northern coastal segment, such plan is currently under development.

Climate change adds a new dimension to existing coastal protection activities

Projected changes in climate and related impacts such as coastal flooding and erosion, salinity intrusion and freshwater shortage, and the potential loss in coastal eco-systems add a new dimension to existing coastal protection activities. The North Sea countries and Venice are good examples of how climate change adds a new dimension to coastal protection activities. These examples are described below in *Box II-2*.

⁴⁶ POOC stands for 'Planos de Ordenamento da Orla Costeira'.

Box II-2: Climate change adds a new dimension to coastal protection

North Sea countries

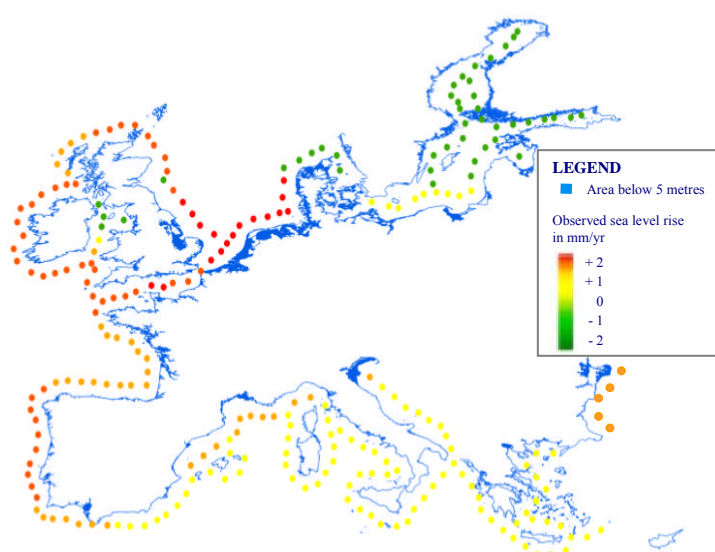
Ever since the 1953 flood-disaster the importance of reliable flood protection infrastructure has been acknowledged by the North Sea countries. A combination of a high spring tide and a severe windstorm resulted in local water levels of more than 5.6 m above sea level with devastating economic and human consequences in Belgium, Germany, the Netherlands and the UK. As a result, most North Sea countries have an explicit coastal protection policy in place and prepare for additional climate change effects in a proactive manner.

Venice

In 1966, a catastrophic weather event completely submerged Venice under a metre of water. Consequently, the Italian government accepted the protection of the area as a national commitment and passed a specific law for it in 1984. To date, a general plan of interventions supports the implementation of the defence actions needed and the innovative *Mose-project* is being constructed to separate the Venice lagoon from the sea during high tides. A potential increase in SLR is incorporated in its design.

To date, SLR is the most examined climate change for the coastal zones. Impacts are the most significant for low-lying areas and estuaries which is illustrated in *Figure II-1*.

Figure II-1: SLR impact for low-lying areas and estuaries



The countries most vulnerable to SLR in terms of low-lying areas are the Netherlands and Belgium where 85% of the coast is located under 5 m elevation, followed by Germany (50%), Romania (50%), Poland (30%) and Denmark (22%).

High concentrations of population and economic activities are often found in major delta cities; the cities most vulnerable in this regard are London (UK), Venice (IT), Gdansk (PL), Hamburg (DE) and Bremen (DE)⁴⁷.

Source: European Environment Agency (EEA), 2006, *The changing faces of Europe's coastal areas*; www.eea.europa.eu; Naples M. and Aerts J., 2007, *Extreme sea level rise and major coastal cities: effects and solutions*; the sea level rise for the Black Sea is based on <http://www.survas.mdx.ac.uk/pdfs/1volrom.pdf> where a sea level rise of 1.28 mm/year is estimated

In order to take the most appropriate action to adapt to climate change and facilitate the decision-making process, (national) authorities have – to a certain extent – taken the initiative to study the new climate conditions and impacts for the coastal zones.

⁴⁷ Also the ports of Antwerp, Amsterdam and Rotterdam are vulnerable but they are not mentioned explicitly in the studies reviewed.

Detailed research results on climate impacts accelerate climate adaptation in coastal zones

Since 1990, the Intergovernmental Panel on Climate Change (IPCC) publishes global climate change scenarios. These scenarios provide a global overview but are not specific enough to pinpoint the effects at a regional or local level. The impacts of climate change at national and sub-national level will depend on the specific meteorological, physical and socio-economic circumstances.

In particular, countries that have suffered from severe weather events in the past have taken the initiative to investigate the potential impacts of climate change specifically for their country. Hence, the countries along the *North Sea* are most advanced with regard to climate change research and the impacts of flood-risk, with the UK and the Netherlands being the forerunners. Dedicated national research institutes in the UK (UKCIP⁴⁸) and the Netherlands (KNMI⁴⁹) have developed climate change scenarios which are used as a basis for government policy. In Germany, different institutions perform extensive climate change research, but no unanimity exists at national level as to the specific scenarios that are taken into account.

Along the *Atlantic Ocean*, especially Ireland is advanced in climate change research. In Ireland, one of the principal themes of the Environmental Protection Agency's research programme STRIVE for the period 2007-2013 relates to climate change. The programme will support several research projects dealing with climate modelling and observations to reduce uncertainty. Furthermore, the Irish Climate Analysis and Research Unit (ICARUS), funded under the National Development Plan, developed local temperature and precipitation scenarios.

Along the *Baltic Sea*, most of the climate research activities are performed under EU-funded projects and focus on the entire marine basin. Examples of such projects are SEAREG⁵⁰ and ASTRA⁵¹. Finland and Poland have organised national funding. In Finland national climate change research programmes exist since 1990 and the 2005 National Adaptation Strategy to Climate Change is build on precipitation, temperature and SLR scenarios. In Poland, research with regard to climate change scenarios has been carried out in support of the most recent (2003) Long-Term Coastal Protection Strategy. Also Sweden has performed already profound research to the vulnerability of its coastal areas but on how climate change will affect different sectors from an economic point of view and which adaptation measures should be taken is still limited.

In the *Mediterranean and the Black Sea* marine basins most member states do not have additional national or sub-national scientific insights to build their strategies on. In countries such as Greece and Bulgaria, several institutes are performing research projects related to climate change but all within

⁴⁸ UK Climate Impacts Programme, www.ukcip.org.uk.

⁴⁹ Royal Dutch Meteorological Institute, www.knmi.nl.

⁵⁰ www.gtk.fi/projects/seareg.

⁵¹ www.astra-project.org; project time-frame 2005-2007; the ASTRA-project aimed to develop regional and local impact scenarios to support climate change adaption strategies along the Baltic Sea.

their own field of expertise and without much coordination between the different institutes. There are also countries that do not have research results on future climate change scenarios or specific vulnerability assessments available yet, due to the lack of appropriate infrastructure (e.g. Malta and Cyprus). Spain on the other hand, seems quite advanced. A dedicated vulnerability and impact assessment methodology for Spain, developed by Professor Losada under the authority of the climate change office in the Spanish Ministry of Environment, drives policy development in the field of coastal adaptation. The methodology is used to determine structure stability in the different Spanish harbours and beaches and to pinpoint the adaptation needs which will be incorporated in the forthcoming National Strategy for Sustainable Coastal Management.

For most *Outermost regions*, research to climate change vulnerability as well as specific climate change scenarios is at a preliminary stage. Currently, Outermost regions are increasingly being included in studies performed by national institutions of the corresponding mainland as is the case for the Canaries. The Spanish Meteorological Office AEMET carries out research to climate change scenarios for each of the Spanish regions including now also the Canaries for which climate change scenarios on temperature and precipitation have been published in 2007. The regional Government of the Canaries and the Canarian Institute of Marine Sciences will carry out in 2009 a study to determine the impacts of climate change on the coastal areas of the islands, following the same climate change vulnerability and assessment methodology developed by Professor Losada. Furthermore, the islands are accounted for in the forthcoming Spanish National Strategy for Sustainable Coastal Management.

The EU has been supporting research into climate change and climate change scenarios through its different framework programmes. In *Box II-3* the examples of ASTRA and NET-BIOME are provided⁵². Moreover, research to the impacts of climate change on oceans and on coastal areas has been put forward as one of the main topics requiring a cross-thematic approach in the new Strategy for Marine and Maritime research of the European Commission. During the period 2009-2010 such research will be supported under the 7th EU Framework Programme.

⁵² A comprehensive overview of recent EU-funded projects related to climate change adaptation (in coastal zones) can be found in *Annex III*; NET-BIOME: **NET**working tropical and sub-tropical **BI**odiversity research in **O**uter**M**ost regions and territories of Europe in support of sustainable development, www.netbiome.azores.gov.pt/Netbiome; project time-frame: 2007-2011; SAFECOAST: www.safecoast.org, project time-frame: 2005-2008.

Box II-3: European climate related projects

ASTRA

The ASTRA-project, which was completed in 2007, aimed to develop regional and local impact scenarios to support climate change adaptation strategies. The project also calculated estimates of the cost of adaptation to climate change compared to the cost of inaction. For the Island Saaremaa in Estonia for example a detailed coastal zone management plan was set-up in order to determine the best way of protecting the coastal zone. For the municipalities Pärnu and Tallinn in Estonia, recommendations have been presented on how to protect these areas against violence of the sea. The main recommendation for both areas was to stop constructing long-lasting expensive buildings in low-lying areas until the rate of SLR has been determined more reliably. The project was co-financed by the Baltic Sea Region's Interreg 3b Programme of the European Union.

NET-BIOME

In May 2007, the European Commission launched NET-BIOME. This project brings together 11 research organisations and regional authorities from the Outermost regions as well as most of the tropical and sub-tropical overseas entities of 5 EU member states (France, the Netherlands, Portugal, Spain and the UK). The aim is to enhance cooperation and coordination of biodiversity research in support of sustainable development taking into account global changes. The Regional Council of the Reunion Island has been attributed as project leader.

Uncertainty hampers proactive policy development for climate adaptation or coastal protection

In most countries detailed knowledge about climate change, potential scenarios and negative consequences is not yet widespread and therefore – for the time being – many (national) authorities tend to respond to climate change impacts along their coasts, mainly *flooding and erosion*, in a reactive manner. Especially the Baltic, Mediterranean and Black Sea governments still consider changes in climate too uncertain to proactively invest in and (implicitly) adopt a ‘wait and see’ approach. As a consequence, and in particular along the Baltic, financial support from the national level is often limited to the provision of flood insurance schemes or emergency funds and coastal protection remains in first instance the responsibility of the ‘person who profits’. As regards the risk of *freshwater shortage* or the potential *loss of coastal eco-systems*, it is difficult to say if related strategies are being undertaken in a proactive or rather reactive manner. This is mainly due to the fact that SLR or other climate change effects are often not the single or main cause of the problem⁵³.

Scientific evidence of the potential changes in climate and related impacts can accelerate (proactive) adaptation. Nevertheless, current scientific research results are not always supportive enough to develop climate adaptation strategies and coastal protection plans and decide on the optimal adaptation measures. Even in countries more advanced in climate change research, the uncertainties with respect to meteorological changes cause severe discrepancies between estimates given by different institutions and hamper accurate policy development. In the Netherlands, for example, the Royal Dutch Meteorological Institute (KNMI) is the main actor involved in research to climate change scenarios. The KNMI 2006 scenarios, which have been accepted as a basis for government policy, estimate SLR along the Dutch coast between 15-35 cm by 2050 and 35-85 cm by 2100. On the

⁵³ The problem of freshwater shortage is largely influenced by (touristic) demand and the over-abstraction of available water resources; coastal eco-systems are mainly threatened by pollution and urbanisation.

other hand, the Dutch Delta Commission established by the state secretary in 2007 to examine how the Netherlands can handle the future consequences of climate change, is more pessimistic. Their 2008 advice suggests taking into account a SLR of 0.65-1.3 m by 2100 and 2-4 m by 2200 in future coastal protection policies.

II.2. APPROACH AND MEASURES TO CLIMATE CHANGE ADAPTATION IN COASTAL ZONES

In most EU member states climate risks are not approached from a coastal zone perspective

The majority of EU coastal member states do not have a climate change adaptation plan or strategy dedicated to their coastal zones. Most countries start with a study of the projected meteorological changes and, with the exception of coastal flood-risk and erosion in some countries, these changes rarely have an impact solely on coastal areas. Hence, the protection against the effects of climate change (e.g. freshwater shortage, flood-risk) for coastal zones often becomes part of a wider climate change adaptation plan, covering many sectors and areas, but seldom receives specific adaptation plans. Flood-risk in *Malta* and the *Netherlands* and the problem of heat waves in *France* illustrate this observation. The problem of freshwater shortage along the Mediterranean and especially in Cyprus and Spain are highlighted further in the report.

In 2003, Western Europe, and especially *France*, experienced a heat wave which was exceptionally in terms of duration and intensity. Following this event a *National Heat Wave Plan* was set up by the Directorate General for Health in France. The plan includes preventive measures as well as actions to be undertaken in case a heat wave alert occurs. Subsequent research has indicated that this kind of extreme event fits with global warming. As a result, more extensive research is now being carried out to the climate vulnerability of other sectors in France such as agriculture, water resources and tourism. More concrete adaptation plans are expected in the course of 2009.

In the past few years *Malta* has suffered from intense flooding events. In September 2003, heavy storms and flash floods caused severe disruption of Malta's economic activities and damage of infrastructure throughout the island. Consequently, the government of Malta engaged in the development of a *National Storm Water Project*. The aim of the project is 'to manage water away from where it is a hazard to where they are short of it' as freshwater shortage is another important issue for Malta. At present, a *Storm Water Master Plan* is being formalised. The actual site works are projected to start by the end of 2010.

In the *Netherlands*, the entire country is affected by the (increased) risk of flooding. As a result, coastal zones do not receive a separate protection strategy, but become an integral part of dedicated national plans and programmes, both at strategic (e.g. National Water Plan) and operational level (e.g.

National Flood Defence Construction Programme, forthcoming Delta Programme). This integrated national approach to climate change in the Netherlands is presented *Box II-4*.

Box II-4: An integrated national approach to climate change

The Netherlands – National Water Plan, Delta Law and Delta Programme

Following different national studies and commission advices, the Dutch State Secretary for Public Works and Water Management has published the first National Water Plan in December 2008. The National Water Plan outlines the future water policy in the Netherlands and concerns the entire Dutch water system including amongst others surface water, groundwater, primary and secondary weirs and shores. The plan describes the measures to be taken to ensure the future safety of the Dutch population as well as how to make most of the different opportunities water offers. The plan is to a large extent based on the advice of the Delta Commission of September 2008 and is currently open for consultation. In the course of 2009, a Delta Law, a Delta Programme as well as the financial means that will be put forward will be presented.

Cross-boundary harmonisation of coastal protection plans and measures is limited

Overall, coastal member states rarely bring their coastal protection plans and measures into line with the actions undertaken by their neighbouring countries. Cross-boundary cooperation limits for the moment to research into climate change vulnerability or the exchange of knowledge on adaptation methods. Such activities are most of the time carried out under EU-funded research projects such as SAFECOAST and OURCOAST.

Box II-5: EU-funded projects in support of cross-boundary research into climate change

SAFECOAST

During the period 2005-2008 different partners from the five North Sea countries worked together on the project SAFECOAST. The final report of the project considers the question ‘*How to manage our North Sea coasts in 2050?*’ and focuses on how coastal vulnerability can be impacted by climate change and spatial developments. The report emphasises the need for enhancing knowledge on the aspects and impacts of climate change and for raising public awareness on the topic of climate change. The project was funded by national and regional governments of the five North Sea countries and was co-funded by the European Union’s Regional Development Fund in the framework of the Interreg 3b North Sea Programme for transnational projects.

OURCOAST

OURCOAST is a three-year project commissioned by the Directorate-General for the Environment of the European Commission. The project started in January 2009 and will be implemented by a consortium lead by ARCADIS (NL) and the Coastal & Marine Union (EUCC). The aim of the project is to support and ensure the exchange of experiences and best practices in coastal planning and management. The project will produce numerous tools, studies and develop activities of public interest for the implementation of Integrated Coastal Zone Management (ICZM) in Europe. One of the project themes focuses on climate change adaptation.

The same can be observed within member states. As most countries have not yet defined a detailed approach to climate change adaptation, harmonisation of risk reduction activities for their entire coastline is limited. Even in countries that have already a specific coastal protection policy in place, detailed national guidelines streamlining regional policies often seem absent. This may result in potential discrepancies across different regions.

In *Germany* for example, coastal protection is the responsibility of the individual coastal states. As a consequence, in Germany, each coastal state drafts its own Coastal Defence Master Plan and decides independently on the research results and climate change scenarios it takes into account. Though local protection measures can clearly affect areas more downstream and cause a negative impact on the coastal areas of the neighbouring state, cross-boundary coordination in general hardly takes place⁵⁴.

The organisation and approach to climate change adaptation differs between member states. Besides differences in the level of responsibility for coastal protection (national, regional, local, private) and research into climate change and climate change scenarios (very limited, limited, advanced, forerunner), the availability of climate change adaptation strategies (with a coastal focus) and operational coastal plans and programmes varies greatly. Furthermore, the type of measures taken at national and sub-national level to counteract the main climate impacts for coastal zones also widely differs. The key differences and characteristics are discussed in the next paragraphs.

Coastal protection and climate adaptation is mainly a national and regional affair

In most European member states, coastal protection and climate adaptation is mainly a national and regional affair. Clear exceptions are the countries along the *Baltic Sea* where in general local authorities and landowners bear the responsibility.

In *Denmark* for example, coastal protection measures need to be initiated, financed and implemented by local landowners or can be arranged for within municipalities. When private landowners feel the need to protect their coastal property, they have to submit their project proposal to the Danish Coastal Authority. Permission will be granted when there is concrete evidence that the landowner will be threatened by the sea within the next 20-25 years, the project does not harm any nearby Nature 2000 areas and complies with the coastal planning restrictions.

In *Latvia*, it is the responsibility of the municipalities to plan and implement coastal zone management and protection. The state financially supports coastal defence actions undertaken by the municipalities but does not coordinate any actions in the field. The state believes coastal protection is the sole responsibility of the local authorities.

Furthermore, adaptation to climate change is only dealt with by a small number of people who are not always easy to identify especially with respect to the coast. This is foremost in countries where coastal protection is mostly implemented in an ad-hoc fashion and climate change adaptation is still at its infancy. A typical example is Greece.

In *Greece* no coordinated actions are undertaken in the field of coastal protection. Measures are decided upon ad-hoc by different national authorities and implemented by local authorities. Recently,

⁵⁴ With the positive exception of the states Lower-Saxony and Bremen who drafted their latest master plan jointly.

the Ministry of Environment, Physical Planning and public Works has appointed a climate change 'official' who will, amongst other things, prepare an overview of the different authorities involved in coastal protection and the measures undertaken to protect the coastal zones of Greece.

Intrinsic climate change risks and threats drive the involvement of national decision makers

In general, it can be observed that regional and especially national authorities are more involved in (financing) coastal protection when risks or threats, in physical or socio-economic terms, are significant. As long as the risks for flooding, erosion, freshwater shortage or other climate change impacts are limited or have not been proven, the urgency felt and priority given by national and regional authorities to (additional) coastal protection and climate adaptation is rather low. In these cases, it is mostly local authorities and landowners which are assigned responsibility for coastal protection. Taking again the example of Denmark, where in general the 'person who profits' bears the responsibility, the national government offers systematic financial support to the west coast of Jutland in order to counter the high natural annual erosion rate.

Overview of coastal protection and climate change adaptation in Europe

Table II-1 provides a schematic overview of all aspects which have been discussed in the previous paragraphs.

Table II-1: Overview of climate change adaptation and coastal protection in Europe

<i>Member state</i>	<i>Responsibility level</i>	<i>Research</i>	<i>Strategic climate change adaptation plans (incl coast) or coastal adaptation plans</i>	<i>Operational coastal plans and programmes</i>	<i>Climate scenario?</i>
<i>Belgium</i>	Regional (Flanders)	Limited	Integrated Master Plan for Coastal Protection (2010)	Implementation Integrated Master Plan for Coastal Protection (2010)	Yes
<i>Bulgaria</i>	National	Very limited	<i>Not available</i>	<i>Not available</i>	No
<i>Cyprus</i>	National (partly financed local)	Very limited	<i>Not available</i>	Master Plans (erosion) per coastal segment	No
<i>Denmark</i>	Local and private	Limited	General Strategy for Climate Change Adaptation (2008)	<i>Not available</i> , but strict spatial planning regulation	Some municipalities
<i>Estonia</i>	Unclearly defined	Very limited	<i>Not available</i>	<i>Not available</i>	No
<i>Finland</i>	Local and private	Advanced	National Adaptation Strategy to Climate Change (2005)	<i>Not available</i> , much attention to co-ordinated land-use planning in relation to climate change	Most municipalities
<i>France</i>	Regional (partly financed national)	Advanced	National Adaptation Plan to Climate Change (2007)	<i>Not available</i> , CPERs ⁵⁵ may include measures	No
<i>Germany</i>	Regional (states) (partly financed national)	Advanced	Master Plan for Coastal Defence per coastal state and Climate Change Adaptation Strategy announced	Implementation of Master Plan for Coastal Defence per coastal state	Yes
<i>Greece</i>	Unclearly defined	Very limited	<i>Not available</i>	<i>Not available</i>	No
<i>Ireland</i>	National and local	Advanced	National Adaptation Strategy announced (2009); Local Coastal Management Strategies emerging	Coastal Protection Programme under National Development Programme 2007-2013	Yes
<i>Italy</i>	Regional	Limited	General Plan of Interventions (Venice); National Conference on Climate change organised in September 2007	Some regional plans e.g. General Plan of Interventions and Mose project (Venice), Coastal Protection Programme (Lazio) and Coastal Plan (Emilia Romagna)	No, except Venice
<i>Latvia</i>	Local (partly financed national)	Limited	<i>Not available</i>	<i>Not available</i>	No
<i>Lithuania</i>	Local (partly financed national)	Very limited	<i>Not available</i>	Lithuanian Coastal Zone Programme (limited activities)	No
<i>Malta</i>	National	Very limited	<i>Not available</i>	Storm Water Master Plan (2009) ⁵⁶	No
<i>the Netherlands</i> ⁵⁷	National	Forerunner	Delta Commission recommendations (2008), National Water Plan (2009), National Adaptation Agenda spatial planning (forthcoming - 2009)	National Flood Defence Construction Programme (incl. Weak Links); Sand Nourishment Programme; Delta Programme (forthcoming - 2009)	Yes
<i>Poland</i>	National	Advanced	Long-Term Coastal Protection Strategy 2004-2023	Long-Term Operational Programme 2004-2023	Yes
<i>Portugal</i>	National	Limited	Climate Adaptation Strategy foreseen for 2009, strategic plans water sector (not focused on climate change)	Coastal Management Plans (POOCs) ⁵⁸	No, except in 2 POOCs
<i>Romania</i>	National	Limited	Coastal Protection Plan southern coastal segment defines a strategy to combat erosion but does not account directly for climate change	Implementation of Coastal Protection Plan southern coastal segment (under development for northern segment); Master Plan Danube Delta	No
<i>Slovenia</i>	National	Very limited	<i>Not available</i> ⁵⁹	<i>Not available</i>	No
<i>Spain</i>	National	Forerunner	National Plan for Adaptation to Climate Change (2006); National Strategy for Sustainable Coastal Management (2010); Regional strategies e.g. Andalusian Strategy for Adaptation to Climate Change (2007) and Basque Plan for Climate Change	Directorate-General for the Sustainability of the Coast and the Sea allocates budget for coastal protection to the coastal regions; Drought management plans (not only coastal); implementation of National Strategy for Sustainable Coastal Management (2010)	Yes
<i>Sweden</i>	Local and private	Advanced	Some local plans, e.g. Ystad Policy for the Management and Protection of the Coast (Ystad) (2008), Water Plan (Göteborg) (2003)	Some local plans: e.g. Ystad action plan and maintenance plan linked to Ystad Policy (forthcoming - 2009) and implementation of Göteborg Water Plan	Some municipalities
<i>UK</i>	Regional (4 administrations)	Forerunner	No overarching plan, but UK guidelines; many strategies developed at administration level	Shoreline Management Plans (mainly in England and Wales)	Yes
<i>Outermost regions(OR)</i>	According to mainland (except Azores and Madeira (regional))	Very limited	Canaries: Adaptation Strategy (2010), the Canaries will be included in National Strategy for Sustainable Coastal Management Spain (2010)	Madeira and Azores: Coastal Management Plans (POOCs); French ORs: CPERs may include measures; Operational Programme Madeira-Azores-Canaries	Yes: Canaries No: other ORs

Source: Policy Research Corporation

⁵⁵ CPER stands for 'Contrat-Projet-Etat-Région' or Regional Development Plan.

⁵⁶ The Storm Water Master Plan is aimed to manage water away from where it is a hazard to where there is short of it; the plan therefore does not only concern the coastal zone of Malta but the entire country.

⁵⁷ POOC stands for 'Planos de Ordenamento da Orla Costeira'.

⁵⁸ The coastal zone is not a priority for Slovenia (coastline of 45 km); Slovenia does have a *strategy on the adaptation of Slovenian agriculture and forestry to climate change*.

⁵⁹ With the exception of the operational Sand Nourishment Programme all strategies, plans and programmes in the Netherlands concern the entire country and are not focused solely on the coastal areas.

Each European member state approaches climate change adaptation and coastal protection in a different manner, but particularities can be observed per marine basin.

Baltic Sea: Integrate coastal zones in overall climate change adaptation plans and implement coastal measures ad-hoc



- Almost all countries have or are currently developing a climate change adaptation strategy in which coastal zones are briefly discussed;
- To date, these plans often remain a high level strategy without a concrete implementation plan and dedicated financial resources;
- An exception is Poland which has implemented long-term coastal protection strategies since 1985 and within these has recently taken climate change into account; Finland developed a National Adaptation Strategy in 2005 including actions relevant for the coastal zones and devotes much attention to co-ordinated land use planning in relation to climate change.

North Sea and Atlantic Ocean: Start to develop overall climate change adaptation plans at strategic level and integrate climate change in dedicated coastal plans, both at strategic and operational level



- The Netherlands and the UK are very active in climate change adaptation both at strategic and operational level; whereas the Netherlands follows an integrated national approach to climate change adaptation, in the UK main strategic actions are undertaken by the four devolved administrations;
- At operational level, German states and UK administrations integrate climate scenarios into Master Plans and Shoreline Management Plans respectively; Belgium accounts for climate change in its forthcoming Master Plan for coastal protection as well as in current hot-spot activities (Ostend, Zwin);
- With the exception of the Sand Nourishment Programme, the current operational programmes of the Netherlands focus on flood-risk in the entire country and are not specifically developed for the coastal areas.



- Portugal has started to account for climate change in its POOCs and recognises climate change in its preliminary national Integrated Coastal Zone Management Strategy;
- Spain has developed a National Climate Change Adaptation Plan in 2006, is developing a National Strategy for Coastal Management including climate change by 2010 and has a number of regional strategies available;
- France and Ireland do not account for climate change in practice yet; Ireland did establish a Coastal Protection Programme under its National Development Programme 2007-2013 and will publish a national adaptation strategy in the course of 2009; France refers to its coastal zones in the strategic national adaptation plan to climate change of 2007 and measures may be included in CPERs.

Mediterranean Sea: With the exception of Spain, climate change adaptation or coastal adaptation plans are not available and coastal protection is implemented ad-hoc



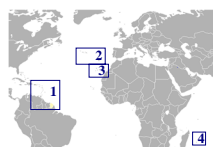
- With the exception of Spain, Mediterranean countries do not have climate change adaptation strategies or coastal adaptation plans available;
- Spain has developed a National Climate Change Adaptation Plan in 2006, is developing a National Strategy for Coastal Management including climate change by 2010 and has a number of regional strategies available;
- Climate change scenarios are not accounted for in operational actions, with the exception of hot-spot Venice; Spain includes climate change scenarios in its forthcoming National Strategy for Coastal Management.

Black Sea: Climate plans focus mainly on mitigation and coastal protection is implemented ad-hoc



- Romania is the most active in coastal protection in the Black Sea marine basin: a Master Plan for the southern coastal segment is available, and under development for the northern segment;
- In Bulgaria, coastal protection measures are mainly decided on and implemented in an ad-hoc fashion;
- National climate change strategies do exist but the focus is presently on mitigation rather than adaptation; SLR scenarios are not yet taken into account.

Outermost regions: Climate adaptation plans are not yet widespread and coastal actions are mainly taken in an ad-hoc fashion



- Outermost regions are not yet incorporated systematically in strategies or plans of the corresponding mainland; Spain sets the example and takes the Canaries into account in its forthcoming National Strategy for Coastal Management;
- Guyana established a proposal for an adaptation plan in 2001, but a final strategy is not available; the Canaries foresee the adoption of an adaptation strategy in 2010;
- Coastal protection measures are mainly decided on and implemented in an ad-hoc fashion; French ORs may include measures in CPERs; Madeira and Azores foresee measures under POOCs.

(1) Martinique, Guadeloupe and Guyana (FR); (2) Azores and Madeira (PT); (3) Canaries (ES); (4) Reunion Island (FR)

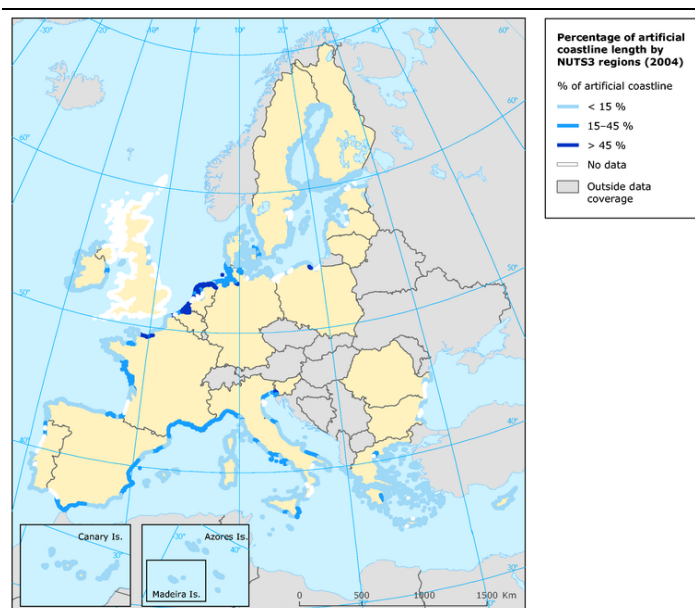
Specific measures to counteract climate change risks

The coastal measures implemented within the marine basins mainly respond to coastal flooding and erosion. The problems of freshwater shortage, especially apparent in the Mediterranean area, as well as the potential biodiversity loss in the Outermost regions are currently seen as issues in their own right.

To protect against flooding and erosion, most European coastal member states mainly opt for 'protective' coastal measures

To date, the main measures undertaken to safeguard Europe's coastal zones from flooding and erosion can be categorised as protective actions, especially along the *North Sea*, the *Mediterranean* and the *Black Sea* shoreline. The *Baltic States* clearly opt for soft accommodate and retreat options wherever possible whereas countries situated along the *Atlantic Ocean* seem to apply a mixture of protect and soft accommodate and retreat policies. Concrete examples are given in the following paragraphs. The percentage of artificial coastline length in Europe is visualised in *Figure II-2*.

Figure II-2: Percentage of artificial coastline length in Europe



A significant part of the European coastline is artificial. About 3.4% of the coastline is covered by harbours and other protective structures cover 1.8%. Therefore, more than 5% of the European coastline is protected and defended against erosion by 'hard' structures.

The main areas with an artificial coastline are located in the North Sea. This is explained by the fact that extensive areas of these countries have been retrieved from the sea and by the high importance and large dimension of ports.

Source: Policy Research Corporation based on European Environment Agency and the Deduce project

Nevertheless, 'accommodate' and 'retreat' are increasingly being examined by EU coastal member states

Almost all EU coastal member states have defined a specific coastal set-back zone ranging on average between 100 m and 300 m. At present it can be observed that, besides the Baltic countries, other member states more advanced in coastal defence and climate change adaptation, such as the UK and the Netherlands, are now also examining more explicit accommodate and retreat options⁶⁰. Hafencity Hamburg (Germany) and Rotterdam Climate Proof (the Netherlands), both presented in *Box II-6*, are two remarkable city development projects illustrating the incorporation of climate change in territorial development.

⁶⁰ The Netherlands is performing extensive research to make spatial planning in the Netherlands climate proof and aims to publish a related National Adaptation Agenda in 2009; the UK is experimenting with a roll-back initiative which allows caravan parks to 'roll back' as the land slips into the sea.

Box II-6: Integrating climate change in territorial development

Hafencity Hamburg (Germany)

Hafencity Hamburg is situated between the historic city district and the River Elbe, on the waterside of the main dike line⁶¹. As the site is being developed in front of the main dike line, flood protection will be provided by means of ground level elevation. Construction sites which are today situated 4.50 to 7.20 m above sea level will be elevated to at least 7.50 metres to comply with the general safety standards for Hamburg. Each elevated site will be connected to the main dike line by special flood-protected roadways, ensuring access for fire brigades and ambulance vehicles at all times. Building's foundations will serve as ground floor garages, which can be flooded in severe cases. The development of the entire area started in 2000 and will continue until 2020-2025. The project is managed by Hafencity Hamburg GmbH, a 100% subsidiary of the Free and Hanseatic City of Hamburg and is to be financed as a public-private partnership. The public investment will amount to approximately € 1.3 billion, private contributions are in the range of € 5 to 5.5 billion.

Rotterdam Climate Proof (the Netherlands)

The port of Rotterdam has recently published 'Rotterdam Climate Proof', the climate adaptation programme of the Rotterdam Climate Initiative, together with several water boards, the province of Zuid-Holland and the municipality of Rotterdam⁶². The aim of the programme is to make Rotterdam climate proof by 2025. The city of Rotterdam has set aside € 30 million for this programme. Plans are being developed to construct floating residential areas and parks, and the construction of canals in order to create a safe but attractive city. One of the plans is construct "water plazas". The plazas will have to catch excess rainwater during heavy rainstorms. This is a necessity as over the coming decades Rotterdam will require extra water storage capacity due to the changing climate. During dry periods the water plazas will serve as playgrounds so that the neighbourhood can benefit from the adaptation measures taken. To facilitate the development of the city an area of 1600 hectares has been designated in the port for climate experiments.

The measures currently undertaken per marine basin to protect against coastal flooding and erosion can be summarised as:

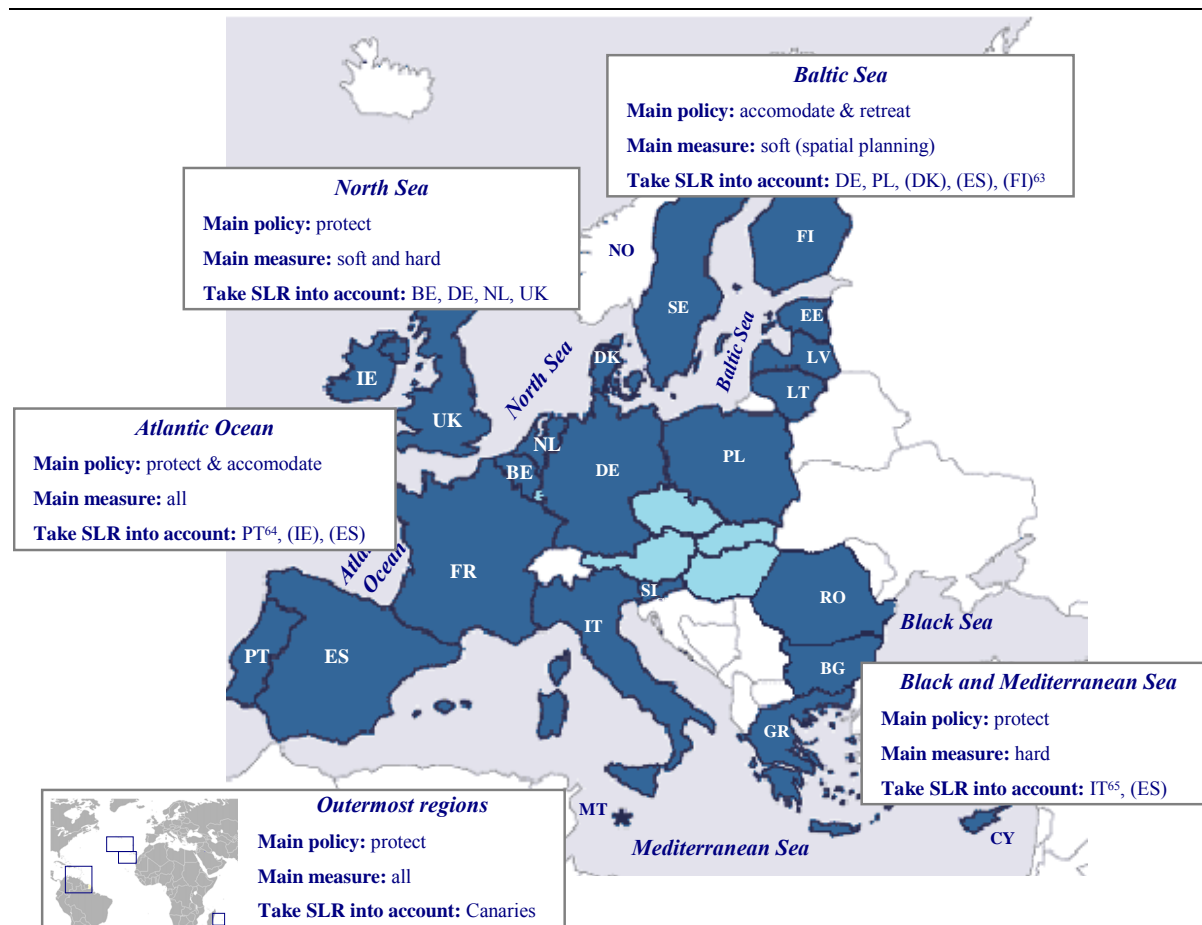
- *Baltic Sea*: Coastal risk reduction measures mainly relate to spatial planning;
- *North Sea*: Mostly a mixture of hard and soft protective measures;
- *Atlantic Ocean*: Some countries implement protective measures, other countries combine 'protect' and 'accommodate';
- *Mediterranean Sea*: Rely mostly on ad-hoc hard defences;
- *Black Sea*: Rely mostly on ad-hoc hard defences.

A visualisation of the main measures applied across the different marine basins and an overview of the countries which take SLR scenarios into account when implementing new risk reduction or climate adaptation measures are presented in *Figure II-3*.

⁶¹ The site will increase the size of Hamburg's city centre with 40% and offers amongst others 5 500 residences for approximately 12 000 people, office and business premises with a potential for more than 40 000 jobs, a concert hall and the International Maritime Museum of Hamburg.

⁶² The Rotterdam Climate Initiative aims to reduce CO₂ emissions by 50% in 2025 and to ensure that Rotterdam is 100% climate proof in the same year.

Figure II-3: Typology of measures undertaken per marine basin



Source: Policy Research Corporation

Along the Baltic marine basin, coastal risk reduction measures relate mainly to spatial planning

In the Baltic Sea most countries implement accommodation and retreat measures by means of spatial planning regulation. Most Baltic countries give the land back to the sea in case of flooding or erosion in uninhabited areas. Furthermore, they apply strict laws and regulations defining set-back zones and building restrictions for their coastal zone. Coastal ‘protective’ measures against flooding, erosion and extreme weather events are only undertaken when there is a concrete need for it. In these cases, public or private property owners need to obtain permission at the national level and beach nourishments or soft defences are preferred.

⁶³ In Denmark, Ireland and Sweden, climate change scenarios are generally not been considered in practice yet; however the counties Hedensted (DK) and Kristianstad (SE) are known to already take SLR into account; in Finland, each municipality is expected to take the Environment Centre’s recommendations on construction heights (including SLR) into account; in Spain SLR is primarily taken into account at strategic level.

⁶⁴ To date, two Coastal Development Plans account for SLR.

⁶⁵ In Italy, only in Venice a SLR is taken into account.

In Finland for example, national authorities consider carefully coordinated planning as an important tool to meet major land use challenges such as urbanisation as well as potential climate change risks in coastal zones. Concrete examples of soft accommodate actions in Finland are included in *Box II-7*.

Box II-7: Countering climate change effects with spatial planning regulation at local level

Finland and Espoo city

In Finland, each municipality is expected to have a preparedness plan which takes into account all kinds of risks and accidents communities may face, including flooding. Climate change is mainly taken into account through the Environment Centre's recommendations on construction heights which includes the risk of SLR.

The Finnish city of Espoo, situated in the Uusimaa region, is with 235 000 inhabitants the second largest city in Finland. The city appointed a dedicated 'flood group' to assess flood-risk in Espoo, draw up flood maps and propose measures to be adapted in preparation of floods. The results were bundled in a report at the end of 2005 and discuss the effects of major storm events, especially flooding, on city planning. The city has not yet incorporated the results in definitive building restrictions, but it is used by city planners in their daily work. In the Kurtilla area for example, climate change has been considered in the planning process of the area:

- Building is not recommended where the ground is under 2.5 m above sea level;
- Housing will be further away from the coastline;
- When building on low-land, 'islands' will be build on a 3 m elevation;
- Extra attention has been given to the location of buildings to prepare for heavy winds.

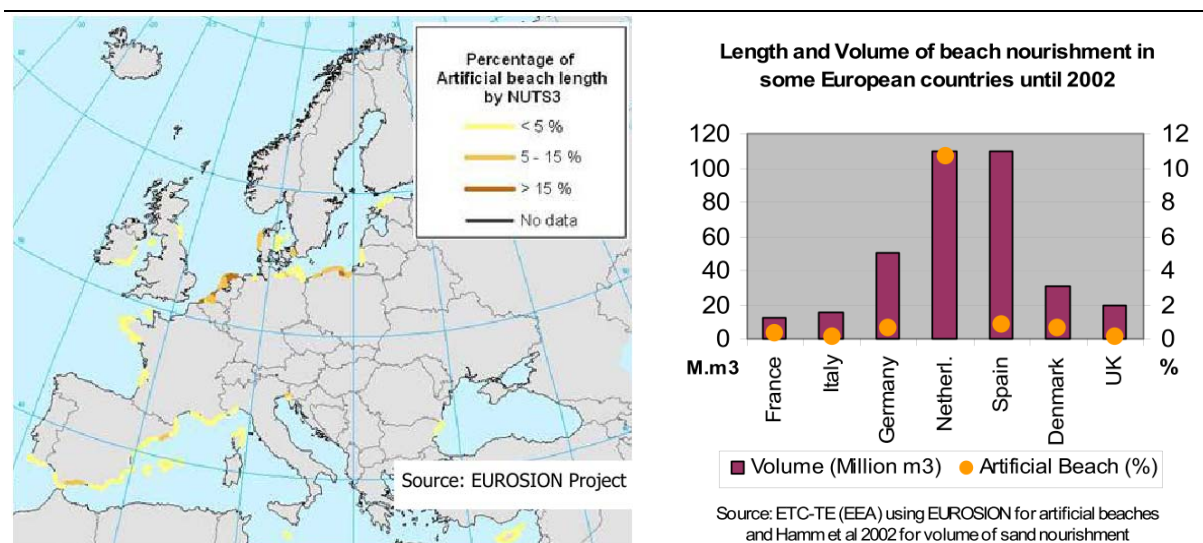
North Sea countries use a mixture of hard and soft protective measures

Along the North Sea, protective measures have been used for decades. Whereas all countries traditionally focused on hard defences such as dikes and breakwaters, '*soft where possible and hard where needed*' is currently the preferred policy. At present, beach nourishments constitute a major part of the coastal protection expenditure in the Netherlands as well as in Belgium, only in Germany the majority of coastal expenditure still goes to hard infrastructures⁶⁶. In the UK, Individual Schemes, developed according to the guidelines of the Shoreline Management Plans, detail the exact measures to be implemented which differ for each coastal segment.

More information on the use of beach nourishment in Europe is provided in *Figure II-4*.

⁶⁶ This is mainly due to the geological characteristics of the German coastline; Hamburg and Bremen are respectively situated along the river Elbe and Weser but exposed to the North Sea tides.

Figure II-4: The use of beach nourishment in Europe



Source: Deduce project based on EuroSION (2004) and Hamm et al. (2002)

Atlantic Ocean countries implement both protective and accommodation measures

For France, Portugal, Ireland and part of Spain it is difficult to indicate which measures are currently leading. Most countries seem to use a combination of soft and hard protective measures but also accommodate options can be identified. In France, for example, counties are encouraged to establish risk prevention plans. In addition, the French government created the public agency 'Conservatoire du Littoral' with the remit to acquire and restore threatened natural areas on the coast, banks of lakes and stretches of water throughout the country. Also in Portugal, there seems to be a hierarchy of spatial planning instruments for regulating the organisation and use of the national territory.

Mediterranean and Black Sea countries rely mostly on ad-hoc hard defences

In most Mediterranean and Black Sea countries, specialised technical standards and guidelines for the design of coastal defence structures seem lacking. As a result, the investments in protective measures along these marine basins, if any, are mainly provided for ad-hoc hard defences such as breakwaters and groins, often resulting in mal-adaptation causing further impacts (i.e. rate of erosion) on other parts of the coastline. Clear exceptions are the actions undertaken to protect the south coast of Romania and the Venice lagoon of Italy⁶⁷ for which the most optimal protection options were extensively studied beforehand.

The government of Romania has had a study prepared on the 'Protection and the rehabilitation of the Black Sea shore' (JICA, 2007). The study had the objective to formulate a coastal protection master plan for the southern coastal unit and to propose priority projects to halt coastal erosion and increase

⁶⁷ The actions currently undertaken to protect the hot-spot Venice are presented in Box II-9.

the value of the coastal zone with the creation of new beaches. The master plan and feasibility studies for the priority areas Mamaia Sud and Euforie Nord were completed in 2007. For these priority areas, the mast plan proposes the installation of new coastal protection infrastructures such as groins, breakwaters, jetties and artificial reefs as well as beach nourishments. Funding has been secured under Romania's Sectoral Operational Programme 'Environment' for the period 2007-2013. Over this period of time, a total amount of close to € 250 million is going to be invested, of which about 80% is supported by the EU.

The minority of coastal member states take a climate change scenario into account

At present, Belgium, the Netherlands, Germany, the UK, Spain, Poland as well as parts of Portugal and Italy take a climate change scenario into account when implementing new coastal protection measures. Mainly SLR is taken into account, as accurate information on the other effects of climate change (e.g. increase in the intensity and frequency of storms, change in wind direction) is less available. Exceptions are the UK where the government also accounts for predictions of other changes in climate such as offshore wind speeds and extreme wave heights. Such predictions are also being taken into account by Spain in their forthcoming National Strategy for Coastal Management. The development of vulnerability assessments which consider besides SLR, also wave climate, storm surges, winds and currents is welcomed by all key actors involved.

In Denmark, Ireland and Sweden, climate change scenarios are generally not been considered in practice yet; however the counties Hedensted (DK) and Kristianstad (SE) are known to already take SLR into account; In Finland, each municipality ought to take the Environment Centre's recommendations on construction heights (including SLR) into account.

Water scarcity is a significant issue in the Mediterranean marine basin

Water scarcity is a significant issue in the Mediterranean marine basin, especially in *Spain, Cyprus* and *Malta*. Climate change may aggravate the existing problem with longer periods of dry weather. Water scarcity is however not one-to-one related to coastal zones and SLR and climate change are not the sole causes of water stress. High water demand in these countries often leads to over-abstraction of ground- and surface water and results in local saltwater intrusion of coastal aquifers.

In *Spain*, actions to counteract water stress are aimed at increasing the public water supply in order to overcome peaks in demand. The government devotes much attention to the construction of new water infrastructure or the modernisation of the existing one. Metering programmes, for both surface and groundwater, are being used to control water abstraction. Water saving and efficiency technologies are being promoted and an increase of non-conventional water resources, such as waste water and desalination, can be observed. Desalination has been existing in Spain for decades. In 2005, Spain had already more than 700 desalination facilities. Over the period 2005-2009 over 20 desalination facilities are to be built in addition in order to meet growing water demand. Spain has furthermore

developed drought management plans which define drought phases, the measures to be applied progressively and the necessary monitoring and follow-up processes.

In *Cyprus*, water management efforts concentrate not only on the efficient use of the available conventional water resources but also on the use of non-conventional water resources and the promotion of a water conservation culture. Since the end of the '90s, *Cyprus* resorted to supplying non-conventional water resources by means of desalination techniques, wastewater reclamation as well as re-use and utilisation of low quality water. Currently, two desalination plants operate on the island with a total capacity of 33 million m³ per year. As also this resource is not sufficient to satisfy demand the government of *Cyprus* has applied a drastic Drought Mitigation and Response Plan with a series of emergency measures, including the transfer of potable water from Greece, a limitation of the public supply of water to agriculture and strict restrictions on the supply of drinking water to households, limiting the supply to only 36 hours a week. Furthermore, an effort is made to promote a water conservation culture amongst its population to satisfy demand. In the near future, *Cyprus* is planning significant investments in state of the art, renewable energy solutions (e.g. desalination plants using concentrated solar power, stored for 24 hours operations) in order to ensure water supply without increasing greenhouse gas emissions.

In *Malta*, three desalination plants have been installed around 1990 to increase freshwater availability. Today, these plants produce around 55% of the total drinking water supply. Furthermore, the Maltese government, with the support of the EU Structural and Cohesion Funds invested in water demand management actions as the reduction of leakages and the upgrading of water distribution networks. A main issue remains the current capacity of storage reservoirs. To tackle this problem, the government has engaged in the development of a National Storm Water Project with the objective to 'manage water away from where it is a hazard to where they are short of it'. At present, a Storm Water Master Plan is being formalised. The plan will outline the necessary actions to re-use, store, recycle and re-distribute 'storm' water in order to augment the water resources of the Maltese Islands. The actual construction works are expected to start by the end of 2010 for a period of three years.

Potential loss of marine eco-systems and biodiversity as major concern for the Baltic Sea countries and the Outermost regions

The potential loss of marine eco-systems and biodiversity due to climate change is a problem across the EU, which is in particular apparent along the Baltic Sea coast and for the Outermost regions. The *Baltic Sea* is a semi-enclosed sea with many river inflows and limited water refreshment from the ocean. At the same time, the sea suffers from many ecological problems⁶⁸ and the salinity level is low, decreasing from south to north. Rising temperature and increased precipitation may further reduce the salt level of the water and put additional pressure on the marine eco-systems.

⁶⁸ Examples of ecological problems in the Baltic Sea include among others low oxygen levels, algal blooms and dead sea-beds.

In 2007, the countries surrounding the Baltic Sea, agreed on the Baltic Sea Action Plan. This programme aims to restore the good ecological status of the Baltic marine environment by 2010. The strategy is seen as a crucial starting point for wider and more efficient actions to combat the continuing deterioration of the marine environment resulting in the first instance from human activities. The main objectives are to intensify measures that ensure water quality, to reduce emission from marine transport and to enhance the protection of marine and coastal landscapes and habitats. The Baltic Sea Action Plan was initiated by HELCOM, the governing body of the Helsinki Convention. With the action plan, HELCOM aims to improve the capacity of the Baltic marine environment to cope with the stress of climate change. On the 10th of June 2009, the European Commission adopted the *Communication on a EU Strategy for the Baltic Sea Region* (COM (2009) 248). This strategy acknowledges that climate change adaptation is a growing challenge in the area and proposes in its related action plan to ‘establish a regional adaptation strategy at the level of the Baltic Sea Region’. Such action could be seen as a good example of cross-boundary cooperation among riparian member states of a sea basin.

The *Outermost regions* are home to a great number of animal and plant species and have a rich biodiversity compared to continental Europe. To date, the coastal eco-systems are already under severe threat from the impacts of human activities (e.g. pollution, over-exploitation of resources, urbanisation)⁶⁹. Climate change is likely to exacerbate this threat. Coral reefs for example have a huge influence on the life of people in some of the Outermost regions. They function as natural breakwaters along the coasts and represent one of the most important natural resources for food, beach sand and building materials. These corals are being threatened by SLR, a rise in sea surface temperature and an increase in extreme weather events. *Martinique* for example, has lost in specific sites about 30% of its coral reefs in one year time (2005-2006). Furthermore, due to the increase in sea surface temperature many species of Martinique will likely have to migrate to the north where the sea surface temperature is more moderate⁷⁰.

The loss of biodiversity due to climate change receives also a lot of attention by the *International Union for Conservation of Nature* (IUCN). Recently, a study on the impact of climate change on biodiversity in all *EU overseas entities* has been published⁷¹. This study provides for each of the Outermost regions an overview has been given of the potential negative consequences of biodiversity loss to illustrate the urgent need to adapt. As a follow-up, a dedicated international conference⁷² was organised at the end of 2008. It was the first time that the EU member states together with their overseas entities met to debate on climate change and biodiversity in the EU overseas entities.

⁶⁹ Petit J. and Prudent G., 2008, *Climate change and biodiversity in the European union overseas entities*, IUCN, Brussels.

⁷⁰ Gillet M., 2008, *Changement Climatique, les conséquences pour l'outre-mer*, EC Conference on the future of a European strategy for the Outermost regions, Brussels, 14-15 May 2008.

⁷¹ Petit J. and Prudent G., 2008, *Climate change and biodiversity in the European Union overseas entities*, IUCN, Brussels.

⁷² Conference on ‘*The European Union and its overseas entities: strategies to counter climate change and biodiversity loss*’, 7-11 July 2008, hosted on the Reunion Island.

Risk reduction and climate change adaptation are broadly supported at the EU level

The EU supports risk reduction and climate change adaptation through different *directives* and *communications* (e.g. *Integrated Maritime Policy* and *Risk Prevention*) as well as the *Integrated Coastal Zone Management (ICZM) recommendation*. The *White Paper on adapting to climate change* constitutes the main reference document for future EU action. The EU provides moreover financial support to climate change adaptation by means of dedicated priority themes under the *Structural and Cohesion Funds*⁷³ and supports research into climate change under the different *EU Research Framework Programmes* (e.g. the recent initiated ClimateCost project which aims to advance knowledge on the full economic costs of climate change and to inform policy makers on long-term climate change policy targets)⁷⁴.

Over the past years, the European Commission has published several *European Directives* relevant to risk reduction and climate change adaptation:

- The *Birds Directive* (1979/409/EEC) provides a framework for the conservation and management of wild birds in Europe;
- The *Habitat Directive* (1992/43/EEC) aims to safeguard biodiversity through the conservation of natural habitats and of wild fauna and flora;
- The *Water Framework Directive* (2000/60/EC) specifies the EU requests for the protection of inland surface waters, transitional waters, coastal waters and groundwater;
- The *Flood Directive* (2007/60/EC) outlines the requirements related to the assessment and management of flood risks in order to reduce the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods.

Whereas all directives indirectly support climate change adaptation, the notion of climate change was first introduced in the *Flood Directive* (2007/60/EC). The directive requires member states to undertake a preliminary flood-risk assessment by the end of 2011, taking the impact of climate change into account. Furthermore, member states must prepare flood hazard maps and corresponding flood risk management plans by the end of 2015. Following the *Water Framework Directive*, the European Commission published a set of policy options to increase water efficiency and saving in a dedicated *communication on water scarcity and droughts*⁷⁵.

Many countries apply the *Habitats Directive* and *Birds Directive* to protect their coastal eco-systems. The *Birds Directive*, which was adopted in 1979, requires the establishment of Special Protection Areas for birds. The *Habitats Directives*, adopted in 1992 to complement the Bird Directive, requires

⁷³ These EU contributions by means of the Structural and Cohesion Funds are discussed in further detail in *Chapter II.5* of this report.

⁷⁴ A comprehensive overview of recent EU-funded projects related to climate change adaptation (in coastal zones) can be found in *Annex III*.

⁷⁵ COM(2007) 414 final: Addressing the challenge of water scarcity and droughts in the European Union.

Special Areas of Conservation to be designated for threatened habitats and species. Together, these areas, of which many are coastal areas, make up the *Natura 2000 network* of protected areas.

The European Commission has also published a recommendation concerning the implementation of *Integrated Coastal Zone Management* (ICZM) in Europe (2002/413/EC). The objective of ICZM is to establish sustainable development of economic and social activities in coastal areas while protecting the coastal environment. The EC recommendation outlines the different steps member states have to take to develop national strategies for ICZM. Reviews made by the EC during the period 2006-2007 indicate that the majority of member states have made significant progress with respect to ICZM. At present, the EC also urges the use of ICZM as an instrument for adaptation to climate change.

Furthermore, the future threat of climate change for the maritime environment has been put forward as one of the main future challenges for the European Union in the *Integrated Maritime Policy*⁷⁶ in October 2007. With regard to the effects of climate change the European Commission committed to:

- Develop a *Roadmap for Maritime Spatial Planning* (COM (2008) 791) which encourages a broad debate on how a common approach to maritime spatial planning can be achieved;
- Develop a comprehensive *European Strategy for Marine and Maritime Research* (COM (2008) 534) which enhances the knowledge of the oceans and ability to manage sea-related activities in a sustainable way;
- Launch joint calls under the 7th Research Framework Programme promoting an integrated approach and improve understanding of maritime affairs (impact of climate change is one aspect);
- Support research to predict, mitigate and adapt to the effects of climate change on maritime activities, the marine environment and the coastal zones and islands.

The first communication of the European Commission which referred indirectly to climate change was the *Communication on the wise use and conservation of wetlands* (COM (1995) 189). This communication recommended already in 1995 the use of coastal wetlands in order to cope with floods and a potential SLR. Within the recent *communication on the prevention of natural and man-made disasters* (COM (2009) 82), the European Commission acknowledged that climate change increases the frequency and magnitude of extreme meteorological events, such as heat waves, storms and heavy rains. In order to enhance disaster prevention through Europe, areas for action and specific measures to boost disaster prevention have been put forward in this communication (e.g. the creation of an inventory of information on disasters and the development of guidelines for hazard/risk mapping).

Finally, the *White Paper on adapting to climate change* constitutes the main reference document for future EU action. The White Paper, adopted on the 1st of April 2009, proposes a strategy for adaptation in 2 phases. *Phase 1* (2009-2012) will lay the ground work for the preparation of a

⁷⁶ COM (2007) 577 final: An integrated Maritime Policy for the European Union.

comprehensive adaptation strategy for the EU to be implemented during *phase 2* commencing in 2012. In particular *phase 1* will focus on:

- Strengthening the knowledge base: The current lack of information on the risks and impacts of climate change is a barrier to adaptation;
- Ensuring that adaptation is embedded into key EU policies: Key sectors with strong EU policy involvement must build resilience in their policies in the light of climate change risks;
- Employing a combination of policy instruments – ‘adaptation needs funding’: innovative funding means should also be explored including market based instruments;
- Enhancing support for wider international efforts to deal with adaptation, particularly with developing countries;
- Supporting co-operation at all levels – adaptation must involve cooperation at all levels: between the EU, national, regional and local authorities.

In addition, the White Paper encourages the further development of national and regional adaptation strategies with a view to consider mandatory adaptation strategies from 2012.

II.3. ECONOMIC ASPECTS OF ADAPTATION – EMPIRICAL APPROACH

To date, little insights exist as to the actual coastal protection and climate change adaptation expenditure across Europe. Many scientific studies and reports (e.g. EEA, 2007 and OECD, 2008) as well as the EC White Paper on adapting to climate change call for a more comprehensive assessment of the economic aspects of adaptation to reduce uncertainty and to increase the knowledge on the potential financial impact of climate change.

In response, this chapter provides the basis for a more thorough analysis of the economic impact of climate change adaptation in Europe. A systematic bottom-up data collection regarding the past, present and future coastal protection and climate change adaptation expenditure (1998-2015) of the 22 *EU coastal member states* as well as the *Outermost regions*, allows to draw conclusions on the *real* amounts spent to protect Europe's coastal zones against the different main climate change impacts. The detailed methodology followed to collect this information, to extrapolate any missing data as well as to allocate amounts spent by countries situated in more than one marine basin is explained in *Annex 2*.

To carry out the assessment of the actual coastal protection and climate change adaptation expenditure across Europe, presented in the following sub-chapters, information on the past, present and future expenditure (1998-2015) of the 22 EU member states and the seven Outermost regions was collected at national and sub-national level following a bottom-up, country wise approach.

This sub-chapter describes the approach followed to categorise the actual coastal protection and climate change adaptation expenditure across Europe. The underlying reasoning for these categorisations is explained in *Sub-Chapter II.4.5* on ‘data availability’, the detailed methodology for collecting the information can be found in *Annex 2*.

The actual coastal protection and climate change adaptation expenditure across Europe, are being discussed using the following approach⁷⁷:

- Coastal protection and climate change adaptation activities for coastal zones are highly intertwined: in countries which are not yet taking a climate change scenario explicitly into account, the coastal protection activities are still relevant to consider as – indirectly – they might also protect against more extreme weather related events; in countries which explicitly account for climate change, it is often difficult if not impossible to indicate which part of the investment is solely made in relation to climate change adaptation; in addition, some member states have defined climate change adaptation measures but have not devoted a separate plan or allocated a specific budget to them; consequently, adaptation measures are undertaken together with ordinary coastal protection activities; therefore, both climate-related and non-climate-related coastal protection expenditures have been considered for all countries when defining the actual coastal protection and climate change adaptation expenditure;
- The coastal protection and climate adaptation expenditure mentioned in the following paragraphs focuses on the amounts spent on ‘protective’ measures against *coastal flooding and erosion*; ‘accommodate’ and ‘retreat’ measures are not monetised but are described in a qualitative manner in the previous sub-chapters;
- Total coastal protection expenditure is split between ‘*normal*’ *coastal protection and climate adaptation expenditure* and the amounts spent on specific ‘*hot-spots*’ along Europe’s coastline⁷⁸;
- *Normal coastal protection* expenditure is defined as the total coastal protection expenditure excluding hot-spot expenditure; normal coastal protection expenditure includes primarily the amounts spent on maintenance, capital (new constructions) and extra-ordinary expenditure (repairing damages to coastal defences) to protect against flooding and erosion (excluding hot-spot expenditure); indirect expenditure directly related to the implementation of protective actions (e.g. drafting master plans, carrying out specific research, monitoring progress) is included as far as this information could be made available by national and sub-national stakeholders;
- *Hot-spot expenditure* includes the expenditure to protect exceptional cities or singular eco-systems which were confirmed by national and sub-national authorities as specific hot-spots in terms of coastal protection and climate change adaptation;
- Normal coastal protection expenditure are split between the amounts spent at ‘European’, ‘national’ and sub-national (regional versus local and private) level;
- Normal coastal protection expenditure is split between the average past expenditure (1999-2007), the present expenditure (2008) and the average future expenditure (2009-2015) and compared to 1998, which is defined as the baseline year; for the present and future expenditure, only the

⁷⁷ The underlying reasoning for these assumptions is detailed in *Sub-Chapter II.4.4* ‘Constraints of statistical data analysis’.

⁷⁸ All amounts mentioned in this report are derived from information provided by national and sub-national authorities and is based as far as possible on national and regional financial accounts; the level of detail of the financial data available in (sub)national financial accounts differs from country to country; hence, a common classification, as presented here, was identified by the researchers.

amounts currently being spent, already committed or very likely to be committed have been taken into account.

Expenditure dedicated to *freshwater shortage* is discussed in separate paragraphs as it is not one-to-one related to coastal zones.

II.3.1. THE COST OF INACTION

In most (vulnerable) member states, inaction is often not considered an option

In most member states policy makers do not investigate the option of ‘doing nothing’ when deciding on risk reduction or climate adaptation measures. Especially in coastal zones where the socio-economic consequences of an extreme weather event would be enormous; decision makers do not take the option of ‘inaction’ into account. The *Mose-project in Venice* and the *Thames Estuary Project 2100* can be considered as case in point, although it goes without saying that there are indeed large assets at stake.

Values at risk have generally increased, but are potentially less insured

To stress the importance of adapting to climate change, governments also use information on the economic and insured losses published on a regular basis by the insurance industry. As the values at risk and insured losses generally have increased over time, adapting to climate change may also have the indirect benefit of safeguarding the ability to insure extreme weather events.

Large re-insurance companies (e.g. Munich Re and Swiss Re) and insurance associations (e.g. Association of British Insurers) collect economic data on natural catastrophes or loss events. On an annual basis, these organisations publish information regarding total economic losses and total insured losses per type of weather event (storms, floods, droughts) and aggregate these at a global, European and national level.

Preliminary figures of Swiss Re⁷⁹ for 2008 indicate a sharp increase in economic and insured losses related to extreme weather events compared with previous years. With a total cost to society of \$ 225 billion (and \$ 50 billion covered by property insurance), 2008 was the second costliest year in terms of insured losses since 1970. Some 50% of the insured losses are related to the Caribbean hurricanes in August and September. In Europe, about \$ 1.5 billion was spent to cover damages related to winter storm Emma.

⁷⁹ Swiss Re, 2008, *Preliminary Swiss Re sigma* estimates that over 238 000 people were killed by catastrophes in 2008, insured losses soar to \$ 50 billion.

For the coastal zones specifically, data on economic and insured losses is not available as the insurance sector does not look at losses in this form⁸⁰. This is not surprising as the most costly extreme weather events in Europe seem to be situated more inland⁸¹.

As to the evolution of insurance premiums, Mills E. (2005)⁸² studied the ratio of global weather-related losses to property/casualty premiums and concluded that the insurance sector has increasing difficulties to absorb weather-related disasters. As a result, the insurance sector is likely to adopt a strategy of higher insurance premiums or withdraw coverage for certain vulnerable areas. Organisations such as the Comité Européen des Assurances (CEA) call for public-private partnerships in the field of risk awareness and the development of territorial strategies in order to increase the insurability of natural catastrophes.

The specific case of the UK is presented in *Box II-8*.

Box II-8: Adapting to climate change to safeguard insurability in the UK

UK – agreement between government and insurers

In July 2008, the Association of British Insurers (ABI) and the government renewed their agreement to ensure that flood insurance remains widely available, also in the long-term⁸³. The UK government offered to develop a long-term investment strategy defining flood prevention objectives and assessing policy options and funding needs. In return, UK insurers to make flood insurance for homes and small businesses available under household and commercial insurance where the flood-risk has a maximum return period of 1:75. In case flood-risk is more significant, coverage will be offered whenever there are plans available to reduce the risk to an acceptable level within a period of 5 years.

II.3.2. THE COST OF ADAPTATION: PAST, PRESENT AND FUTURE EXPENDITURE

Over the period 1998-2015, Europe's total coastal protection cost amounts to € 15.8 billion

The total coastal protection cost to safeguard Europe's coastal zones from flooding and erosion (including the Outermost regions) amounts to € 15.8 billion over the period 1998-2015. A breakdown per coastal member state as well as a summary per marine basin and for the Outermost regions, focusing both on the normal and hot-spot expenditure, is given in the following paragraphs.

The total coastal protection cost is further detailed with respect to 'normal' coastal protection and 'hot-spot' protection in the following paragraphs. The main conclusions to be drawn are:

- Normal coastal protection and climate adaptation expenditure steadily increases over time;

⁸⁰ Only the ABI of the UK indicates that they are in the position to (and sometimes do) investigate such data also at sub-national level according to postal code.

⁸¹ In Europe, the costliest weather events between 1980 and 2005 included inland floods in Germany, Austria and the Czech Republic (August 2002), heat waves all over Europe and especially in France (2003) and inland floods in Italy and Switzerland (2000); see also Munich Re, 2006, *NatCatService Geo risk research*.

⁸² Mills E., 2005, *Insurance in a climate of change*, Science vol. 309 no. 5737 p. 1040-1044.

⁸³ ABI, 2008, *Agreement on flood insurance is good news for customers*.

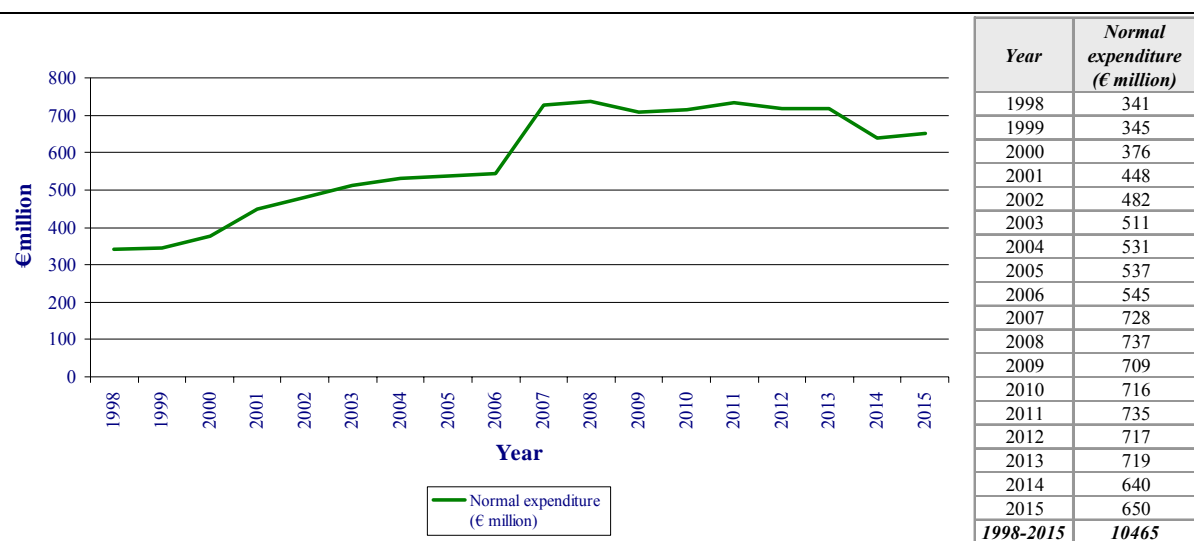
- Compared to 1998 coastal protection and climate adaptation expenditure has increased for most member states, but future expenditure will remain stable to today's situation;
- More than 60% of the normal coastal protection cost, totalling € 10.47 billion over all marine basins, is dedicated to the North Sea basin;
- The majority of the normal coastal protection expenditure are borne by national authorities;
- Normal coastal protection expenditure at sub-national level is determined by the amounts spent at regional level which is comparable to national spending;
- Hot-spot protection represents 1/3rd of the total coastal protection budget and totals € 5.3 billion over all marine basins;
- Hot-spot expenditure peaks in 2002 and 2009;
- Total average coastal protection expenditure (1998-2015) amounts to € 0.88 billion per year;
- Close to 85% of total coastal protection expenditure is borne by 5 countries;
- Expenditure to counteract freshwater shortage steadily increases between 1998 and 2015;
- EU contributes to climate change adaptation through Structural and Cohesion Funds.

Normal coastal protection and climate adaptation expenditure steadily increases over time

In general, annual normal coastal protection and climate adaptation expenditure increases over time, but differences can be observed in the different EU programming periods 2000-2006 and 2007-2013. Whereas the annual normal expenditure tends to steadily increase over the period 2000-2006, it remains rather stable over the period 2007-2013. Changes in the annual amounts spent on normal coastal protection and climate adaptation are being observed primarily with the *start* of new EU programming periods, respectively in 2007 and 2013. Average normal expenditure over the period 2007-2013 is about 48% higher compared to the period 2000-2006. This is not solely due to an increase in EU funding (Structural and Cohesion Funds). In particular, annual national investments determine the actual evolution of normal coastal protection expenditure. This will be elaborated on in the following paragraphs.

Over the period 1998-2015, the total normal expenditure amounts to € 10.47 billion. The evolution of amounts spent on normal coastal protection measures over these years is presented in *Figure II-5*.

Figure II-5: Evolution of annual normal coastal protection expenditure (1998-2015)



Source: Policy Research Corporation

Compared to 1998, coastal protection and climate adaptation expenditure has increased for most member states, but future expenditure will remain stable to today's situation

To better understand the evolution of normal coastal protection and climate adaptation expenditure over time, one needs to analyse the underlying country differences. Compared to the baseline year (1998), in which the climate discussion was still at a very preliminary stage, an increase in annual expenditure has been observed for most countries till today. Future annual normal coastal protection expenditure (2009-2015), however, remains for most countries stable or tends to slightly decrease in comparison with the present expenditure.

Most of the *North Sea* countries have been protecting their coasts since decades. Compared to 1998, especially the Netherlands and the UK have intensified coastal protection expenditure to cope with the effects of climate change and their expenditure is expected to further rise. For the Netherlands, the Delta Commission (2008) estimated that for the period 2010-2100 around € 1.0-1.5 billion per year will be needed to prevent the Netherlands from inland and coastal flooding and to ensure sufficient freshwater resources in the long run. This amount has not yet been committed by the Dutch government. The Delta Programme, currently being prepared, will define the financial means that will be put forward. In Belgium, coastal protection and climate adaptation expenditure will increase with the start of the Integrated Master Plan for coastal protection in 2010. In Germany, most increases in coastal protection expenditure date back to the period before 2007. Their current and future coastal protection and climate adaptation expenditure remains rather stable.

Along the *Baltic Sea coast*, no (additional) expenditure has been made to date or shall be made in the near future. This is primarily related to the coastal protection and climate change adaptation approach of the countries concerned. Most Baltic Sea countries consider climate change still too uncertain to

proactively invest in. Moreover, when measures are taken, priority is given to 'accommodate' actions such as regional development and building regulations which do not pop-up in the cost as these usually are not monetised.

In the *Atlantic Ocean*, the *Mediterranean* and the *Black Sea* marine basin, about half of the member states have recently slightly increased their coastal protection expenditure or foresee limited additional investments in the near future. Along the Mediterranean, especially Spain and Italy intensified its past (1999-2007) and present (2008) normal expenditure. Especially for Spain, future expenditure can be expected to further increase with the implementation of the Integrated Coastal Zone Management Strategy. Along the Black Sea, especially Romania devotes since recently more attention to the protection of its coastline against erosion which can be noticed also in the present expenditures.

Overall, the annual normal expenditure to protect Europe's coast against flooding and erosion has grown from € 341 million in 1998, to an annual amount of € 500 million over the period 1999-2007 and to some € 737 million in 2008. In the near future (2009-2015) Europe's annual normal expenditure will slightly decrease to € 698 million. The trend in past, present and future normal coastal protection expenditure across the different EU coastal member states is visualised in *Table II-2*.

Arrows are used to indicate the evolution of expenditure over time. The expenditure in each period is compared to the previous one (past to baseline, present to past and future to present). As an example the evolution of coastal protection expenditure in Cyprus is explained. When comparing the past expenditure on coastal protection in Cyprus against the baseline year, one can conclude that the amounts spent on coastal protection have increased over the period 1999-2007 (↑) in comparison to the baseline year (1998). At present (2008) Cyprus spends less (↓) on coastal protection compared to the 1999-2007 period. In the future (2009-2015), the expenditure on coastal protection is expected to be in line (=) with the present (2008) expenditure.

Table II-2: Past, present and future annual normal coastal protection and climate adaptation expenditure in Europe

Country	Annual normal expenditure (in € million)						
	Baseline year (1998)		Past (1999-2007 average)		Present (2008)		Future (2009-2015 average)
BE ⁸⁴	18.0	↑	18.3	↑	42.6	↓	18.2
BG	1.0	=	1.0	=	1.0	=	1.0
CY	0.8	↑	0.9	↓	0.8	=	0.8
DE	75.9	↑	91.0	↑	98.3	↓	93.5
DK	19.2	↓	16.8	↓	14.7	↑	18.6
EE	0.1	↑	0.2	↓	0.1	=	0.1
ES	28.2	↑	53.4	↑	62.7	↓	52.0
FI	0.0	↑	0.2	↑	1.0	↓	0.7
FR	1.0	↑	4.5	↑	27.3	↓	19.8
GR	16.0	=	16.0	=	16.0	=	16.0
IE	1.6	↑	6.8	↓	3.9	↑	4.0
IT	12.2	↑	24.5	↑	31.4	↓	28.2
LT	0.1	↑	0.2	↑	1.1	=	1.1
LV	0.1	=	0.1	=	0.1	↓	0.0
MT	0.0	↑	1.7	↓	0.5	↑	10.5
NL ⁸⁵	85.0	↑	152.7	↑	255.0	↓	243.9
PL	5.5	↑	5.9	↑	7.5	↓	7.4
PT	10.6	↓	6.5	↑	11.7	↓	7.2
RO	1.0	↑	5.0	↑	36.9	↓	26.4
SE	5.4	↑	6.8	↑	10.5	↓	7.2
SI	0.0	=	0.0	↑	0.2	=	0.2
UK	56.3	↑	75.5	↑	98.0	↑	125.5
OR ⁸⁶	3.3	↑	12.2	↑	15.7	↓	15.5
Total	341.3	↑	500.2	↑	736.9	↓	697.8

Source: Policy Research Corporation

More than 60% of the normal coastal protection cost, totalling € 10.47 billion over all marine basins, is dedicated to the North Sea basin

Not surprisingly, the *North Sea* marine basin accounts for the majority (61%) of ordinary coastal protection expenditure. These countries have the longest history in flood defence and invest mainly in hard and soft protective measures. Another 15% is spent in the *Mediterranean* area whereas the *Atlantic Ocean* coastline accounts for 12%. The remaining 10% is dedicated to the *Baltic* (7%) and the *Black Sea* (3%) shore. The normal coastal protection expenditure of the Outermost regions over the period 1998-2015 totals € 237 million⁸⁷, which is about 2% of Europe's total normal expenditure. *Figure II-6* illustrates the normal coastal protection expenditure per marine basin (in cumulative terms), totalling € 10.47 billion over all marine basins.

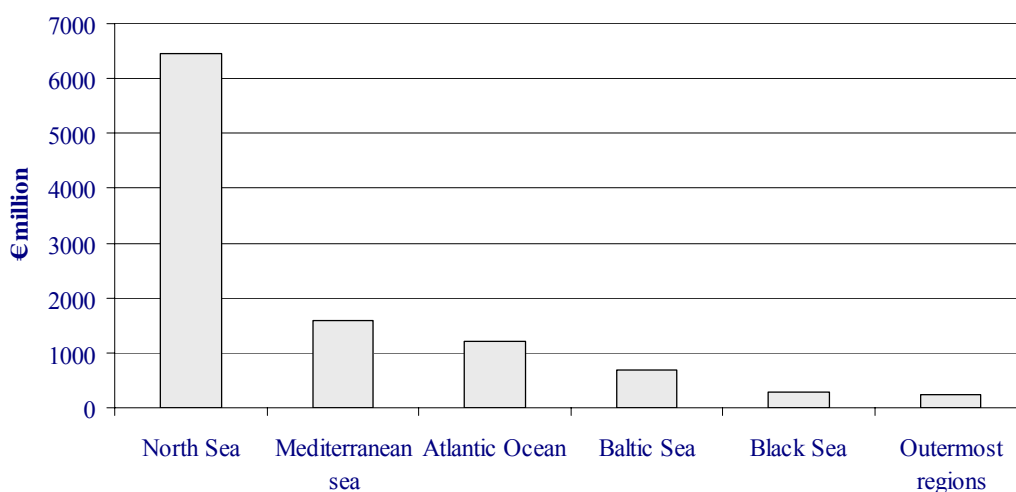
⁸⁴ The expenditure related to the forthcoming Master Plan (2010) is not yet available.

⁸⁵ For the Netherlands, the Delta Commission (2008) estimated that for the period 2010-2100 close to € 1.0-1.5 billion per year will be needed to prevent the Netherlands from inland and coastal flooding as well as to ensure sufficient freshwater resources in the future; this amount has not been taken into account as this amount has not been committed yet and it has not been defined which part will be dedicated to the coastal areas.

⁸⁶ OR stands for Outermost regions.

⁸⁷ The amount of € 237 million includes the normal coastal protection expenditure of the 7 Outermost regions over the period 1998-2015: in the Canaries (ES), this expenditure amounts to € 68 million, in Madeira (PT) to € 67 million as well as in the Azores (PT), around € 1 million in Guadeloupe and Guyana (FR), close to € 20 million in Martinique (FR) and € 14.5 million in the Reunion Island (FR).

Figure II-6: Cumulative normal coastal protection expenditure per marine basin (1998-2015)⁸⁸



Source: Policy Research Corporation

The majority of the normal coastal protection expenditure is borne by national authorities

Over the period 1998-2015, national authorities bear on average close to 63% of the ordinary coastal protection cost whereas some 32% is taken care of at the sub-national level⁸⁹. The remaining 5% is matched by EU funds⁹⁰.

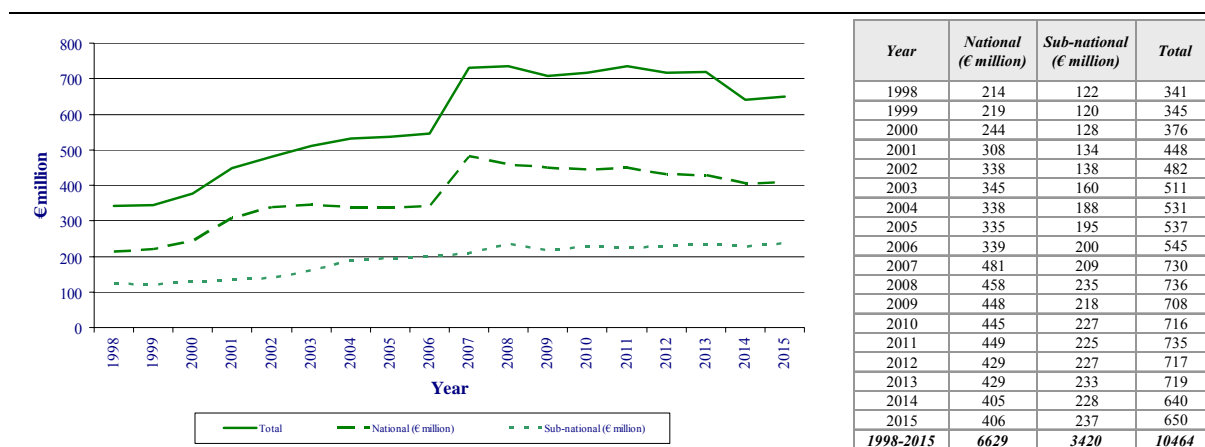
Since the late nineties, national expenditure has doubled. As of 2007, the expenditure is around € 400-500 million per year. Especially with (the start of) a new EU programming period, respectively covering the periods 2000-2006 and 2007-2013, significant increases in national coastal protection expenditure can be noted. Sub-national expenditure has slightly, but continuously, risen over the years. *Figure II-7* provides an overview of the national versus sub-national contributions to normal coastal protection over the period 1998-2015.

⁸⁸ The allocation of the expenditure of the 22 EU coastal member states to the different marine basins has been explained in the study methodology (Annex II).

⁸⁹ Sub-national expenditure represents mainly regional and local spending to coastal protection; amounts spent by private actors are in general unknown but expected to have a minor impact.

⁹⁰ The EU contribution to coastal protection which has been identified on the basis of concrete data provided by national and regional authorities totals about € 416 million over the period 1998-2015.

Figure II-7: Normal coastal protection expenditure at national and sub-national level⁹¹



Source: Policy Research Corporation

Normal coastal protection expenditure at sub-national level is determined by the amounts spent at regional level which is comparable to national spending

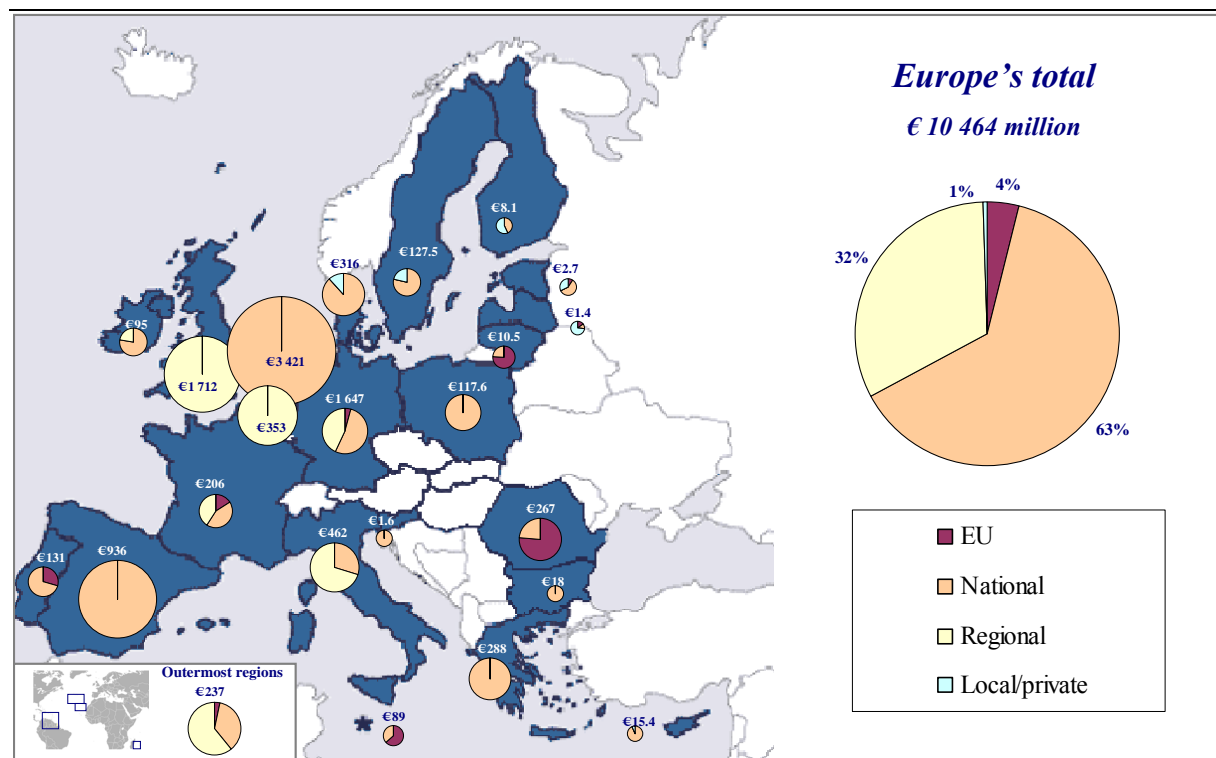
The normal coastal protection expenditure by sub-national authorities is most significant in the UK, Germany, Italy and Belgium. In these countries, the regions are primarily responsible for coastal protection and climate adaptation. Due to the structure of the country and the high autonomy given by the national authorities to the regions for what concerns the management and protection of the coastal zone, these regional expenditures could as well be labelled as ‘national’.

National and regional authorities bear on average around 95% of the normal coastal protection expenditure whereas 1% is taken care of by local and private actors. The EU funds the remaining 4%.

The difference between the European, national, regional and local and private contributions per member state are visualised in *Figure II-8*.

⁹¹ The EU contribution of € 416 million has been included in the total expenditure but has not been illustrated separately in the figure.

Figure II-8: Normal coastal protection expenditure at European, national and sub-national level (regional, local and private) across Europe in €million (1998-2015)



Source: Policy Research Corporation

Hot-spot protection represents 1/3rd of the total coastal protection budget and totals € 5.37 billion over all marine basins

Over the period 1998-2015, additional investments are made to protect the following coastal hot-spots from flooding and erosion:

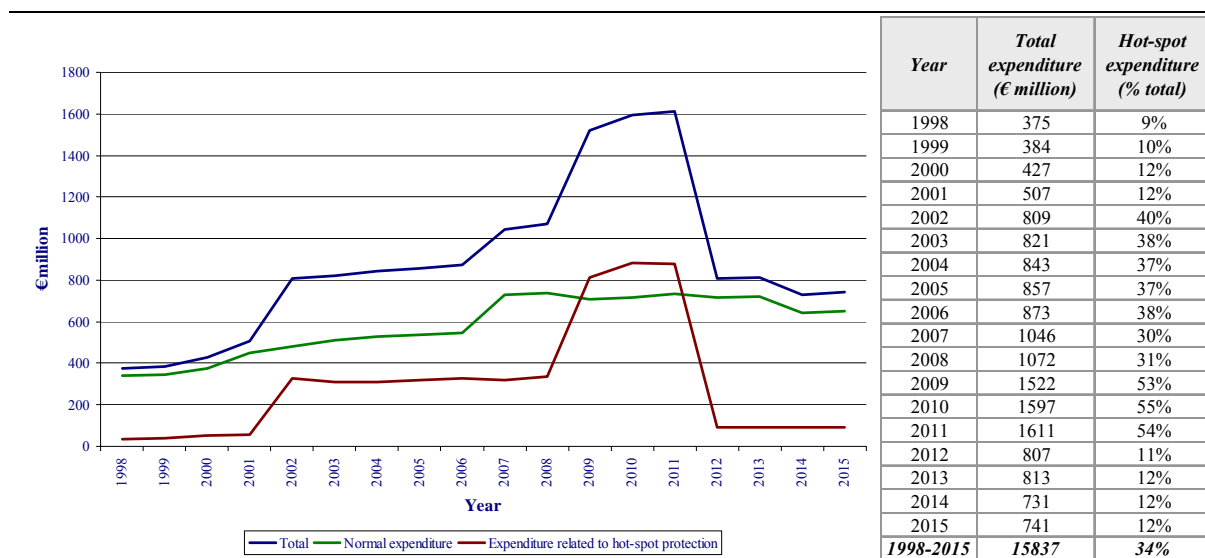
- Venice (Italy): € 4.2 billion (2002-2011);
- Hamburg (Germany): € 660 million (1998-2015);
- London (UK): € 380 million (2006-2015)⁹²;
- Zwin and Ostend (Belgium): € 66 million (2002-2012);
- Danube Delta (Romania): € 45 million (2006-2015);
- Slovenian saltpan: € 20 million (2007-2013).

Whereas normal expenditure only slightly increases over time, it becomes apparent that the amounts spent on hot-spots determine the trend of total coastal protection expenditure. Over the period 1998-

⁹² The preliminary Thames Estuary 2100 plan stipulates that about € 1.49 billion (€ 59.47 million per year) will be required to upgrade the Thames Barrier between 2010-2035; close to € 24 million has been spent on drafting the plan in 2006-2009.

2015, hot-spots will have received around 1/3rd of the total coastal protection expenditure committed to Europe's coasts. The 2009-2011 peak relates to the cumulative effect of the expenditure on the Mose (Venice) project and the Thames Barrier (London), whereas from 2012, the expenditure to the Thames Barrier is of essence. *Figure II-9* illustrates the evolution of these hot-spot protection costs over time and compares them with the annual amounts spent on normal coastal protection.

Figure II-9: Normal versus hot-spot coastal protection expenditure in coastal member states



Source: Policy Research Corporation

Hot-spot expenditure peaks in 2002 and 2009

Significant increases in the hot-spot protection cost can be noticed in 2002 and 2009, both primarily linked to the construction of the *Mose project*. The implementation of the *Thames Estuary 2100* project is scheduled to be launched in 2010.

The expenditure to hot-spot *Hamburg* amounts to an annual € 37 million over the period 1998-2015. The amount concerns primarily the cost to implement Hamburg's Building Programmes as well as the yearly maintenance cost of the pubic dike lines. In *Belgium*, the hot-spot expenditure is dedicated to protect the city of Ostend as well as the nature reserve 'Het Zwin' in anticipation of the Integrated Master Plan for Coastal Defence. In *Romania*, a master plan has been approved by the government in 2005 to support the sustainable development of the Danube Delta Biosphere Reserve. This plan foresees € 45 million to protect the villages surrounding the delta from flooding. In *Slovenia*, the government has foreseen to spend around € 20 million (2007-2013) to preserve the ecological value of the Sečlova saltpan, one of the most famous wetlands in Slovenia.

More detailed descriptions of the Mose project to protect hot-spot Venice and the Thames Estuary 2100 project is provided in *Box II-9*.

Box II-9: Hot-spots Venice (Italy) and London (UK)

Venice Mose project (Italy)

The *Mose project* in Venice has been set up to temporarily separate the sea from the lagoon during high tides. The design consists of a system of 78 mobile barriers that can be activated during exceptional high tides. The barriers will lie on the seabed most of the time, but will be filled with air to create a dam when Venice is threatened. The defence structure has been designed to cope with a 60 cm SLR. Work constructions started in 2002 and completion is scheduled for 2012 for a total amount of € 4.2 billion. During the first few years, annual expenditure amounted to € 276 million. As of 2009, the annual cost is projected to rise to € 756 million per year.

Thames Estuary 2100 (UK)

In 1984, the Thames Barrier was constructed to protect the UK and especially London from tidal flooding until 2030. The *Thames Estuary 2100* project aims to extend the life of the Thames Barrier with 50-70 years through appropriate adaptation. The final management plan, which will be delivered to the government in early 2010, will allow for adaptation to further increases in SLR and more intense storm surges. In the short and medium term (2010-2035, 2035-2075), flood management may continue to use existing assets (flood defences and barriers) with some renewal and replacement in areas until 2070. According to the preliminary plan, a total investment of € 1.49 billion is required for the period 2010-2035 and an additional € 4.46 billion between 2035 and 2075.

Total average coastal protection expenditure (1998-2015) amounts to € 0.88 billion per year

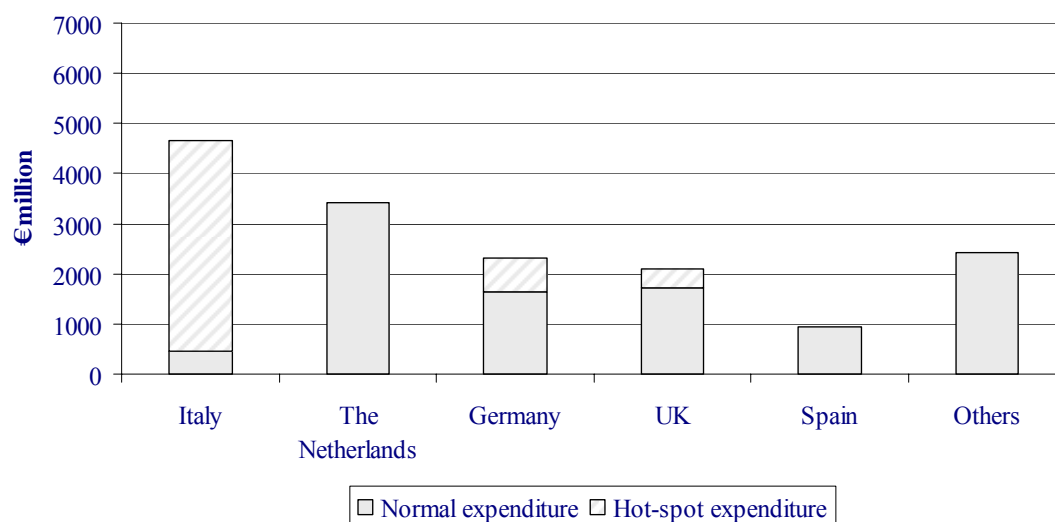
In 1998, the expenditure of the 22 EU coastal member states, their islands as well as the seven Outermost regions to protect Europe's coastal areas against flooding and erosion was close to € 0.4 billion. The total expenditure steadily increases in the years after, with € 1.07 billion in 2008 and € 1.5-1.6 billion in 2009-2011. As of 2012 the total expenditure will stabilise at an amount of € 0.7-0.8 billion. In total, EU member states will have spent some € 15.8 billion or € 0.88 billion on average per year over the period concerned. The evolution in total coastal protection expenditure (normal and hot-spots) is shown in *Figure II-9* before.

Close to 85% of total coastal protection expenditure is borne by 5 countries

When comparing the contribution of individual countries for the period 1998-2015, one can conclude that the majority of coastal protection activities in financial terms is situated within 5 countries, namely Italy, the Netherlands, Germany, the UK and Spain⁹³. In Italy, the hot-spot Venice accounts for the majority or 90% of Italy's coastal protection budget. In Germany and the UK, the expenditure to protect hot-spots Hamburg and London represents close to 30% and 20% respectively of the total national coastal protection investment. The amounts spent to normal coastal protection and climate adaptation as well as to hot-spots by the top 5 countries is visualised in *Figure II-10*.

⁹³ In *Figure II-10* this is presented for the total expenditure, including normal and hot-spot expenditures; the same countries are concerned for the normal expenditure, though in a different order: NL, UK, DE, ES, IT.

Figure II-10: Top 5 countries in terms of coastal protection and climate adaptation expenditure



Source: Policy Research Corporation

Expenditure to counteract freshwater shortage steadily increases between 1998 and 2015

Expenditure to protect the coastal zones against freshwater scarcity has been analysed primarily for the Mediterranean marine basin as the problem is at present the greatest in this area⁹⁴. In general, this expenditure is much higher compared to the amounts spent to counteract flooding and erosion. Nevertheless, one needs to bear in mind that this cost is not one-to-one related to coastal zones. Furthermore, none of the Mediterranean countries takes climate change explicitly into account when defining actions to overcome the problem of freshwater shortage. It is therefore difficult, if not impossible to indicate the extent to which expenditure on freshwater protection is related to climate change or to the increase in demand and the over-use of available resources.

In *Cyprus, Malta and Spain*, expenditure is mainly dedicated to improving existing infrastructure and reducing leakages. Dedicated emergency actions required additional expenditure in the past years in Cyprus as well as in Spain. The specific expenditures made to counteract freshwater shortage in each of these countries are further detailed in *Box II-10*.

⁹⁴ In most other areas, water scarcity is addressed from time-to-time, but does not yet constitute a major issue.

Box II-10: Specific expenditure to counteract freshwater shortage in Cyprus, Malta and Spain

Cyprus: Expenditure on freshwater supply and policy amounts to € 65.8 million in 2008

The total cost of purchasing desalinated water from private investors steadily increased over the past decade from about € 10 million in 1998 to about € 30 million in 2008. Furthermore, € 54 million has been earmarked for the import of water from Greece for the period 2008-2009. Finally, the total cost for the improvement of village water supply distribution networks and awareness raising campaigns amounted to € 8.7 million in 2008.

Malta: € 71 million set aside for National Storm Water project (2010-2013)

A National Storm Water project has been set up to manage water from where it is a hazard to where there is a shortage of it. A budget of € 71 million has been set aside for the period 2010-2013 of which about € 56 million is secured through EU funding. Actions will be undertaken to re-use, store, recycle and re-distribute 'storm' water in order to augment the water resources of the Maltese Islands. Actual site works are aimed to start by the end of 2010.

Spain: Expenditure on freshwater supply in the Mediterranean regions is close to € 3.8 billion (2005-2009)

In Spain, actions to counteract water stress are aimed at increasing the public water supply in order to overcome peaks in demand. Over the period 2005-2009, close to € 3.8 billion is being invested to upgrade the water supply. The regions that are in first instance eligible for support are situated along the Mediterranean Sea coast. Spain has furthermore developed Drought Management Plans which, since 2007, are binding for all river basins.

EU contributes to climate change adaptation through Structural and Cohesion Funds

At the community level, about € 10 billion or 3% of the 2007-2013 Structural Funds has been reserved for risk prevention and climate change adaptation activities, including:

- Mitigation and adaptation to climate change (0.1%);
- Promotion of biodiversity and nature protection (0.8%);
- Risk prevention (1.6%);
- Other measures to preserve the environment and prevent risks (0.5%).

Another € 8 billion or 2.3% of the 2007-2013 Structural Funds has been earmarked for the management and distribution of drinking water.

No further specifications are available as to the share that will be dedicated to the coastal zones under each of these priorities. The EU contribution to coastal protection (flooding and erosion) which has been identified on the basis of concrete data provided by national and regional authorities equals € 53 million for the period 1998-2006 and € 363 million between 2007 and 2015, corresponding to about 3% of the total (normal and hot-spots) expenditure made on Europe's coasts over the entire period.

The cost of adaptation: a summary per marine basin

The following paragraphs provide a summary per marine basin as well as for the Outermost regions on the past, present and future cost of adaptation.

Baltic Sea total coastal protection expenditure amounts to € 0.7 billion (4%)



- The cumulative normal coastal protection cost of Baltic countries amounts to about € 0.7 billion over the period 1998-2015, corresponding to 4% of Europe's total expenditure; no major expenditure is made to specific hot-spots;
- The cumulative *annual* normal coastal protection expenditure of all Baltic countries evolves from around € 30 million in 1998 to € 35 million over the period 1999-2007, to an actual expenditure of € 45 million which slightly decreases in the future;
- Germany (56%), Sweden (19%) and Poland (17%) account for the majority of the total expenditure made along the Baltic Sea coastline.

North Sea total coastal protection expenditure amounts to € 7.6 billion (47.5%)



- The cumulative normal coastal protection cost of the North Sea countries totals close to € 6.5 billion over the period 1998-2015, corresponding to 41% of Europe's total expenditure;
- Hot-spots Hamburg (DE), London (UK), and Zwin/Ostend (BE) receive respectively 4%, 2% and 0.5% of Europe's total 1998-2015 expenditure, corresponding to another € 1.1 billion in total;
- The cumulative *annual* normal coastal protection expenditure of the North Sea countries evolves from around € 215 million in 1998 to € 307 million over the period 1999-2007, to an actual expenditure of € 450 million and a future expenditure of € 433 million (2009-2015);
- The Netherlands (53%), Germany (20%) and the UK (17%), account for the majority of the total North Sea expenditure.

Atlantic Ocean total coastal protection expenditure amounts to € 1.2 billion (8%)



- The normal coastal protection cost is close to € 1.2 billion over the period 1998-2015, corresponding to 8% of Europe's total expenditure; no major expenditure is foreseen for specific hot-spots;
- The cumulative *annual* normal coastal protection expenditure of the Atlantic Ocean countries evolves from € 45 million in 1998 to some € 60 million over the period 1999-2007 and € 75 million at present as well as in the near future (2009-2015);
- UK (49%) and Spain (31%) account for the majority of total expenditure along the Atlantic Ocean coastline.

Mediterranean Sea total coastal protection expenditure amounts to € 5.8 billion (37%)



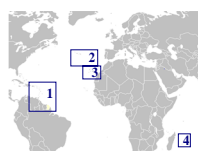
- Normal coastal protection accounts for about € 1.6 billion over the period 1998-2015, corresponding to 10% of Europe's total expenditure;
- Hot-spots in Venice (IT) and Slovenian salt pans receive respectively 27% and 0.1% of Europe's total 1998-2015 expenditure, corresponding to € 4.2 billion;
- The cumulative *annual* normal coastal protection expenditure of the Mediterranean Sea countries evolves from € 45 million in 1998 to € 78 million over the period 1999-2007 to an actual expenditure of € 109 million and a slight decrease in the near future;
- Italy (29%) and Spain (35%) account for the majority of total expenditure in the Mediterranean marine basin.

Black Sea total coastal protection expenditure amounts to € 0.3 billion (2%)



- The normal coastal protection cost totals almost € 0.3 billion over the period 1998-2015, corresponding to some 2% of Europe's total expenditure; hot-spot Danube Delta in Romania receives an additional € 45 million over the period 1998-2015;
- The cumulative *annual* normal coastal protection expenditure of the Black Sea countries evolves from € 2 million in 1998 to € 6 million over the period 1999-2007; a significant increase can be noticed when looking at the present expenditure of € 45 million which will remain almost stable in the near future (2009-2015);
- Romania (94%) accounts for the majority of total expenditure along the Black Sea shoreline.

Outermost regions total coastal protection expenditure amounts to € 0.2 billion (1.5%)



- The normal coastal protection cost over the period 1998-2015, amounts to € 0.2 billion, corresponding to some 1.5% of Europe's total expenditure;
- Over the period 1998-2015, close to € 68 million is spent by the Canaries (ES), € 134 million by the Azores and Madeira (PT) and € 35 million by the four French Outermost regions (primarily in Martinique and the Reunion Island);
- The cumulative *annual* normal coastal protection expenditure of the Outermost regions countries evolves from € 3 million in 1998 to € 12 million over the period 1999-2007; the actual expenditure reaches € 16 million which remains stable in the near future (2009-2015).

(1) Martinique, Guadeloupe and Guyana (FR); (2) Azores and Madeira (PT); (3) Canaries (ES); (4) Reunion Island (FR)

II.3.3. COST-BENEFIT ANALYSIS

Benefits of adaptation are in practice rarely expressed in monetary values

Decision-making for action or inaction in coastal protection, rarely involves a cost-benefit analysis. As a result, whenever the benefits of adaptation or the costs of inaction are listed, they usually are expressed in a qualitative rather than monetary manner, especially when assessing the population at risk of flooding. Hence, the mere indication of assets or population at risk where no action is taken serves to raise awareness of the importance of climate adaptation.

A concrete example is the national study '*Sweden facing climate change threats and opportunities*', which was published by the Swedish National Commission on Climate and Vulnerability in October 2007. Based on a global SLR of 88 cm, the study estimates the affected parts of the coastal zone from north to south at 100 m, 65 m and 30 m inland. Without additional protection measures, the total value of threatened buildings due to coastal erosion and flooding between 2010 and 2100 would approximate € 3-11 billion. Monetary values for population at risk have not been presented. The study only stipulates that in the period 1999-2005, Sweden's population increased by 169.000 citizens and that in parallel 97% of new residential buildings were built in the coastal zone.

Decision-making to date is largely based on an assessment of cost-effectiveness

In practice, the cost of inaction is rarely expressed in monetary terms. Hence, most cost-benefit assessments tend more towards cost-assessments: in other words, which actions are optimal from a technical and financial point of view to ensure the safety of the area at risk. If financial resources are limited, priority projects, based on the level of exposure of the areas concerned, are defined in a second step.

Along the *North Sea* for example, all countries, with the exception of the UK, have defined minimum safety levels⁹⁵ for the entire coastline. As soon as the determined safety level is no longer guaranteed, additional protection measures are undertaken. In the Netherlands, such safety levels are moreover defined by law. At present, only UK governments have replaced safety standards by a true risk-based approach. In the UK, cost-benefit analysis is used to decide on the policy options to be followed (ranging from hold the line to doing nothing) per coastal segment.

Nevertheless, it becomes apparent that countries highly exposed to the destructive force of the sea and thereby also to increasing coastal protection costs have examined the possibilities and receptiveness of cost-benefit analyses as a basis for decision-making. *The Netherlands* can be considered as an example. Since 2007 it is obligatory to perform a cost-benefit analysis in the first step (exploration of the different alternatives) and second step (examination of the different alternatives in more detail) of water related projects exceeding € 25 million⁹⁶. Every cost-benefit analysis needs to describe and assess the impact of different alternatives in terms of the safety of the population, economic consequences (e.g. reduced damages to infrastructures), the environment as well as implementation and maintenance costs. These impacts need to be expressed in monetary values as much as possible.

II.3.4. DATA AVAILABILITY

The following paragraphs discuss the data availability and explain the underlying reasoning for the main cost categorisations followed in the previous paragraphs. The methodology used to extrapolate any missing data as well as to allocate amounts spent by countries situated in more than one marine basin is explained in *Annex 2*.

For most countries, national authorities were able to provide an overview of the amounts spent over the period 1998-2015 to protect the coastal zones against *flooding and erosion* at national level. At the

⁹⁵ Safety levels are mainly based on design water levels for a certain return period or on the most unfavourable water level of the past; they are expressed in the form of storm return periods; cost-benefit analysis did serve to a certain extent as a basis for defining the safety levels (but not to determine which parts will or will not be protected); in the Netherlands safety levels for the different coastal provinces range from 1:4000 to 1:10000, in Belgium the required safety level is set at 1:1000 and in Germany values range between 1:100 (Schleswig-Holstein) and 1:400 (Hamburg).

⁹⁶ In the past it was already obligatory to perform such cost-benefit analysis for other type of projects; water related projects concern high water protection as well water quality or quantity.

sub-national level, the coastal protection and climate adaptation expenditure has been assessed for a number of key areas on the basis of their vulnerability or climate adaptation activities. The amounts spent to protect against freshwater shortage and saline intrusion has been discussed separately as these amounts are not one-to-one related to the coastal zones.

In most cases the financial data available in (sub)national financial accounts was classified differently in each country and in order to be able to make comparisons, the total coastal protection expenditure dedicated to the protection against flooding and erosion has been further broken down by the researchers along the following lines.

The normal coastal protection and climate change adaptation expenditure versus the expenditure dedicated to specific hot-spots along Europe's coastline

Normal coastal protection expenditure is interpreted as the total coastal protection expenditure excluding hot-spot expenditure. The normal coastal protection expenditure includes primarily the amounts spent on maintenance, capital (new constructions) and extra-ordinary expenditure (repairing damages to coastal defences) to protect against flooding and erosion (excluding hot-spot expenditure). The indirect expenditure directly related to the implementation of protective actions (e.g. drafting master plans, carrying out specific research, monitoring progress) is included as far as this information could be made available by national and sub-national stakeholders.

Hot-spot expenditure includes the expenditure to protect exceptional cities or singular eco-systems which were confirmed by national and sub-national authorities as specific hot-spots in terms of coastal protection and climate change adaptation.

Per country, much effort has been put to further categorise the normal coastal protection and climate change adaptation expenditure according to *type of measures* 'hard', 'soft' and 'mixed'. Many countries were however not able to provide this data as financial information on coastal protection is not recorded as such in their financial accounts. Although some countries could provide an indication or a proxy, not all stakeholders were able to do so, and hence such categorisation in financial terms is not included. Nevertheless, *Sub-chapter II.3* details this information per country and marine basin from a qualitative point of view.

The way *extra-ordinary expenditure* is dealt with differs from country to country. In Belgium for example a separate budget line exists for such expenditure. Also in Denmark a Storm Flood Fund, which compensates landowners, companies or farms that have suffered flood damage due to severe storm events. In extreme situations, the EU may offer support from the European Solidarity Fund. However, in most countries extra-ordinary expenditure due to severe storm events is covered under the general budget foreseen for the development of the coast. Extra-ordinary expenditure is therefore

incorporated in total normal coastal protection expenditure and climate change adaptation expenditure.

The normal coastal protection expenditure at ‘national’ level versus the expenditure at ‘sub-national’ (regional versus local and private) level and the European expenditure

Normal coastal protection expenditure is divided between the amounts spent at *European, national* and *sub-national* level. A further distinction is made between sub-national ‘*regional*’ and ‘*local*’ expenditure. In Belgium, Germany and the UK, the country is structured in such a way that regions have a high autonomy for what concerns the management and protection of the coastal zone. Their regional expenditures could therefore as well be labelled as ‘national’ if it is compared with other countries across Europe.

‘Local’ expenditure is mainly related to amounts spent to coastal protection by local actors such as counties and municipalities. This is primarily apparent in the Baltic Sea marine basin. From the large number of counties and municipalities present in these countries (e.g. Estonia is divided in 15 counties and 227 municipalities), the expenditures of the key municipalities have been taken into account. Municipalities were selected on the basis of their vulnerability or climate change adaptation activities. Private expenditure can be considered minimal in most countries (e.g. annual coastal spending on 110 km of the Danish west coast in 2004-2008 is expected to be below € 5 million, following Safecoast (2008)).

The average normal coastal protection expenditure in the baseline year (1998) versus the past (1999-2007), the present expenditure (2008) and the average future expenditure (2009-2015)

The evolution of coastal protection and climate change adaptation expenditure over time is based on data collection over the period 1998-2015. Four ‘periods’ are considered: (1) the baseline year 1998, the average past expenditure (1999-2007), the present (2008) expenditure and the average future expenditure (2009-2015). All amounts mentioned in this study are derived from information provided by national and sub-national authorities and is based as far as possible on national and regional financial accounts. For the present and future expenditure, only the amounts currently being spent, already committed or very likely to be committed – as indicated by the relevant authority – have been taken into account.

III. ECONOMIC ASPECTS OF ADAPTATION: COMPARISON OF SCIENTIFIC ESTIMATES WITH ACTUAL EXPENDITURE

Assessments within scientific literature on the annual adaptation cost to protect Europe's coastal zones against SLR range between \$ 0.2 billion and € 5.4 billion. Based on a per country analysis, the PESETA study narrows the range of the annual adaptation cost – for Europe's coastal zones to € 0.49-0.85 billion, under a respective low (22.6 cm) and high (50.8 cm) SLR scenario⁹⁷. These estimates take only two adaptation options into consideration: the application of beach nourishments and the heightening of dikes. The actual coastal protection expenditure in Europe, amounting to € 1.07 billion in 2008 (and to on average € 0.88 billion per year for the period 1998-2015), corresponds to the upper-bound of the scientific PESETA estimates but considers all types of protective actions. Nevertheless, beach nourishments and dikes constitute two important ones.

Comparing scientific estimates with actual expenditure leads to the following main economic insights:

- Actual adaptation expenditure mainly correlates with the size of vulnerable coastal areas and – to a lesser extent – with the GDP and population in the 50 km coastal zone;*
- Decision-making on action or inaction in practice boils down to a cost-effectiveness assessment;*
- Actual expenditure in Europe is currently in line with scientific⁹⁸ projections, but the underlying differences between actual expenditure and the calculation of scientific estimates need to be carefully considered;*
- Nevertheless, at marine basin level/national level actual average expenditure often differs from scientific estimates.*

Chapter III concludes with pinpointing the gaps between the real coastal protection and climate change adaptation expenditure and the scientific PESETA estimate per EU member state and summarising the economic impacts of climate change adaptation at marine basin level.

⁹⁷ Based on the ECHAM4B2 socio-economic scenario; the related SLR scenarios correspond most to the 2007 IPCC SLR scenarios of 18-59 cm.

⁹⁸ Richards and Nicholls (2009).

III.1. COMPARISON OF NORMAL ADAPTATION EXPENDITURE WITH VULNERABILITY

In the following paragraphs, the normal coastal protection and adaptation investments of the different coastal member states are benchmarked with the vulnerability of each country to *coastal flood-risk*. To date, limited uniform information is publicly available on the national and regional characteristics of Europe's coastal zones. To this end, the correlation between expenditure and vulnerability can only be examined for a small number of indicators.

More specifically, the *normal expenditure on coastal protection*⁹⁹ is compared with the following *vulnerability indicators*¹⁰⁰:

- Coastline length;
- Coastal floodplain;
- Population in 50 km coastal zone;
- GDP in 50 km coastal zone.

Coastline length is not a key determinant for normal coastal protection

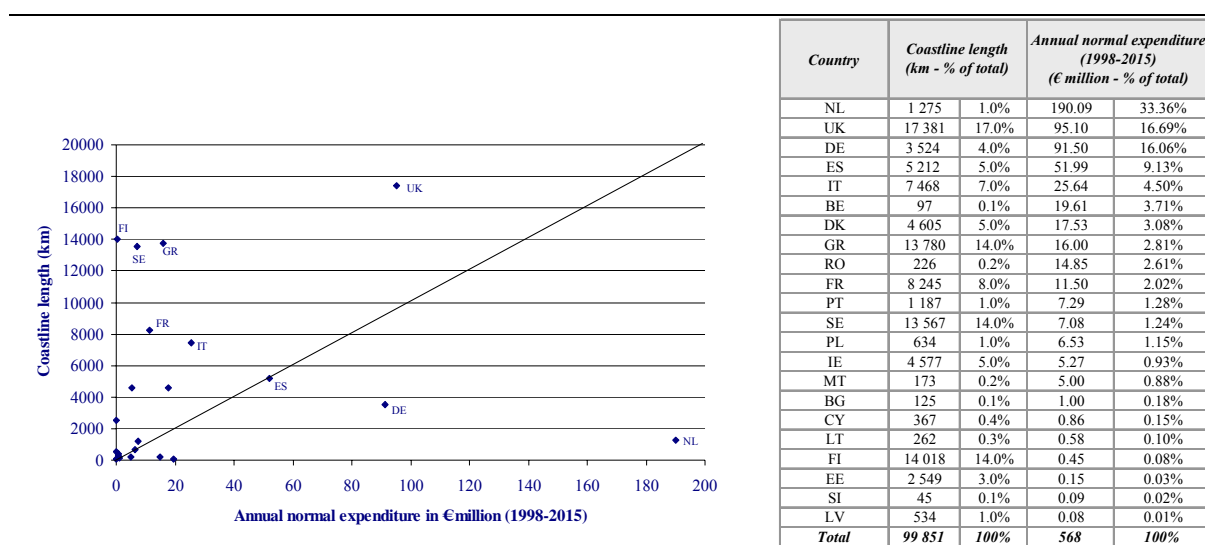
The total EU coastline measures close to 100 000 km (Eurosion study, 2004). The longest stretches of coastline can be found in the UK (17 381 km), Finland (14 018 km), Greece (13 780 km), Sweden (13 567 km) and France (8 245 km).

Overall, coastline length is not a key determinant for the normal coastal protection expenditure of EU countries. Besides for Spain, linear correlation between the annual normal expenditure and the coastline length is mainly observed for countries with a short coastline (e.g. Belgium, Bulgaria, Lithuania, Malta, Romania, and Slovenia). The Netherlands and Germany which defend their coast since decades as a high number of people and economic assets is located near the coast tend to spend a much higher amount per km coastline compared to all other countries. The correlation between the coastline lengths of the different member states and their average annual normal coastal protection expenditure (1998-2015) is visualised for all countries in *Figure III-1*.

⁹⁹ Coastal protection expenditure mentioned in this section focus on the 'normal' amounts spent to 'protect' coastal zones against flooding and erosion, thus excluding 'hot-spots' as well as 'accommodate' and 'retreat' measures.

¹⁰⁰ The indicator build-up area, could be better to compare the coastal protection and climate change adaptation cost but such data is not available for all countries in a uniform manner but should be based on GIS-data.

Figure III-1: Annual normal coastal protection expenditure versus coastline length¹⁰¹



Source: Policy Research Corporation

Almost 80% of normal coastal protection expenditure is spent along 35% of Europe's coastline

The investments made by Finland, Greece, Sweden and France account for less than 7% of the total normal coastal protection expenditure made in Europe whereas their shorelines represent almost half of Europe's entire coastline. The highest annual normal coastal protection expenditure can be found in the Netherlands, UK, Germany, Spain and Italy. Their coastlines account for only 35% of Europe's shoreline, but consume more than 80% of the total coastal protection expenditure across the EU. When hot-spot expenditure is also considered, the total value would increase up to 85%.

Normal coastal protection and adaptation expenditure correlates at first sight more with the size of coastal floodplains¹⁰² than with the population in the 50 km coastal zone

Overall, normal coastal protection and adaptation expenditure correlates with the size of coastal floodplains. Besides the countries with a short coastline, correlation is primarily observed in the Netherlands and – to a lesser extent – in the UK and Germany. These countries have also the largest coastal floodplains across Europe. France, Sweden and Finland invest less in coastal protection, but both countries devote specific attention to 'accommodation' measures¹⁰³ which have not been monetised.

¹⁰¹ There are many figures for the EU coastline length; within this report the figures from the EuroSION study are being used; in the EuroSION study the national coastline lengths have been calculated using a uniform cartography scale (1:100 000) and concern all continental and insular coasts with a few exceptions (e.g. islands with an area less than 1 km² or population less than 50 inhabitants and the overseas territories other than the 7 Outermost regions have been excluded); European Commission (EuroSION study), 2004, *Living with coastal erosion in Europe: Sediment and space for sustainability*, final report EuroSION project.

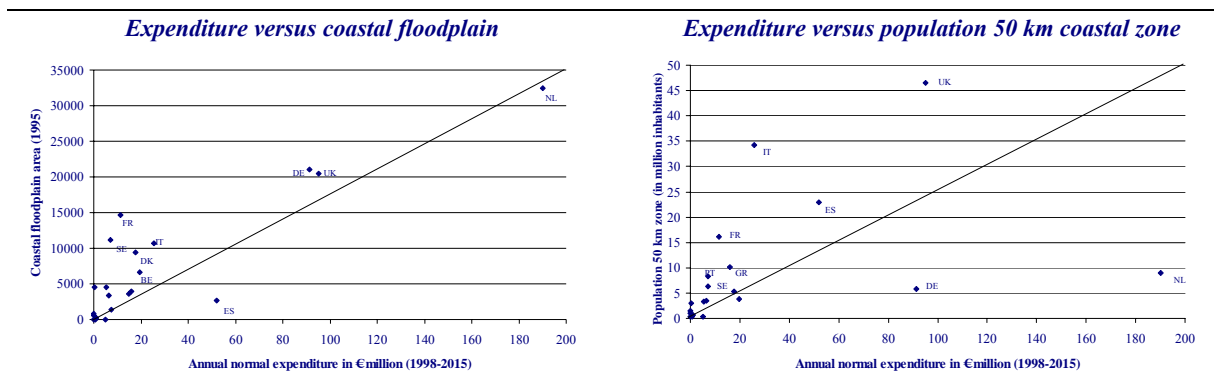
¹⁰² A strip of relatively flat and normally dry land adjacent to a body of water that is flooded during high-water; for further details please see PESETA, Richards and Nicholls (2009).

¹⁰³ In France, counties are encouraged to establish risk prevention plans; in Sweden, strict laws and regulations define setback zones and building restrictions for the coastal zones.

The annual normal coastal protection expenditure seems less correlated with the population in the 50 km coastal zone for many countries. However, when excluding the top 5 countries (NL, UK, DE, ES and IT) a more linear relation can be observed.

The annual normal coastal protection expenditure of the different member states are compared with the size of the coastal floodplain and with the population in the 50 km coastal zone in *Figure III-2*. In particular for the big spenders, the correlation to coastal floodplain (being related to the area below 5 m elevation) is apparent. Comparing expenditure with the population in the 50 km coastal strip, leads to the opposite conclusion. There might be a better correlation with the population in the 10 km or 500 m coastal zone but such data is not publicly available for each member state.

Figure III-2: Annual normal coastal protection expenditure versus coastal floodplain¹⁰⁴ and population in the 50 km coastal zone



Source: Policy Research Corporation

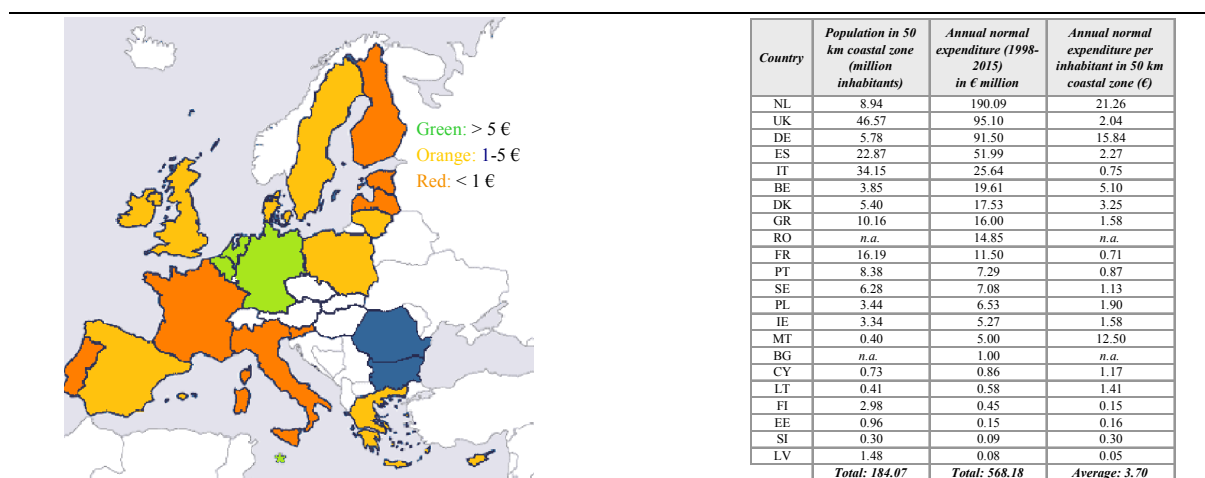
Member states spend close to € 3.7 per inhabitant in the 50 km coastal zone on coastal protection

On average, € 3.7 per inhabitant in the 50 km coastal zone is being spent to normal coastal protection and climate adaptation in Europe. In the *North Sea* countries, the Netherlands and Germany, governments spend between € 15-20 per person whereas expenditure in *Southern Europe*, more specifically, in Spain, Italy, Greece, France and Portugal is below the EU average. In the Baltic area, coastal protection investments are generally low, in line with the population at risk.

The annual normal coastal protection expenditure per inhabitant in the 50 km coastal zone is presented in *Figure III-3*.

¹⁰⁴ For the exact definition of coastal floodplain see Richards and Nicholls (2009).

Figure III-3: Annual normal expenditure per inhabitant in 50 km coastal zone



Source: Policy Research Corporation

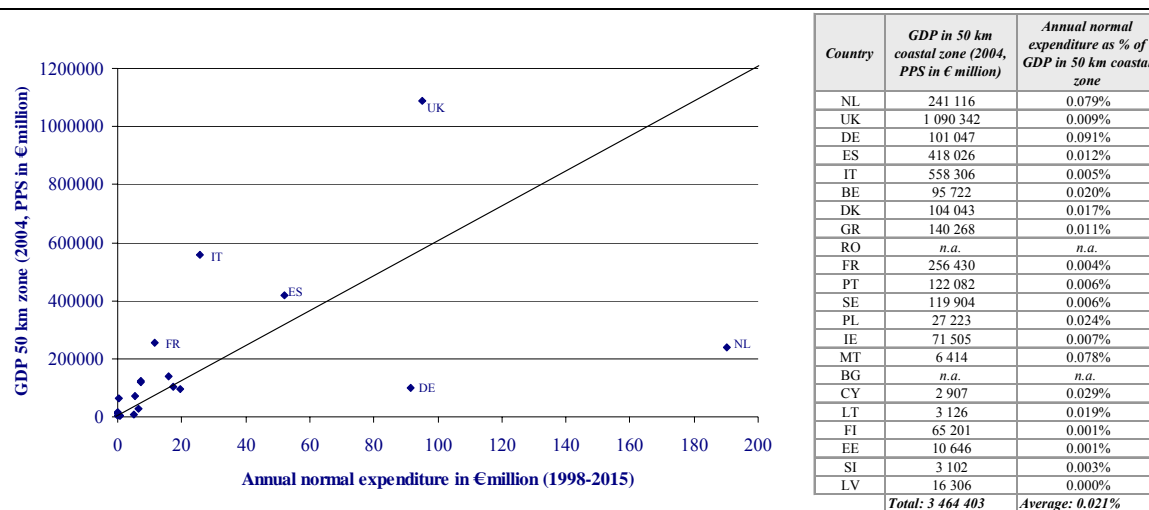
Coastal protection expenditure correlates with the GDP in coastal zone and expenditure amounts on average to 0.02% of GDP in 50 km coastal strip

Overall, the coastal protection and adaptation expenditure in coastal zones follows the same trend as the GDP in the 50 km coastal strip. The highest GDP's can be observed in the coastal zones of the UK, Italy, Spain, France and the Netherlands.

Over the period 1998-2015, the coastal protection expenditure in terms of GDP generated in the 50 km coastal strip amounts at most to 0.09%. In particular, Germany, the Netherlands and Malta dedicate a higher % of GDP to protect and adapt their shorelines to (increased) flood-risk and erosion. On average only 0.02% of coastal GDP is spent on normal coastal protection and adaptation. It might be that a better correlation would be obtained with the GDP in the 10 km or 500 m coastal zone but such data is not publicly available for each member state.

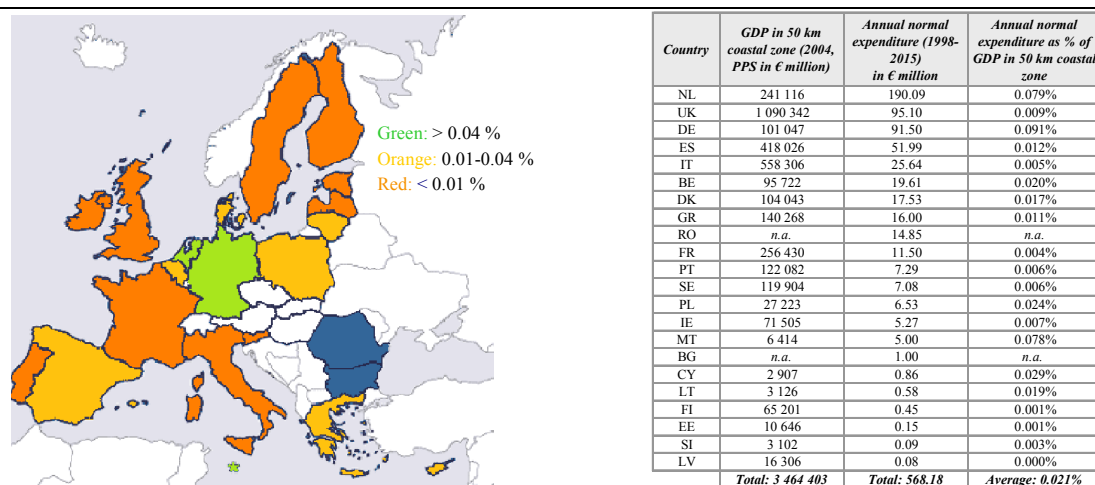
The GDP in the 50 km coastal strip is presented in relation to the average annual normal coastal protection expenditure of each coastal member state in *Figure III-4*. The annual normal coastal protection expenditure as % of GDP in the 50 km coastal zone is presented in *Figure III-5*.

Figure III-4: Annual normal coastal protection expenditure versus GDP in 50 km coastal zone¹⁰⁵



Source: Policy Research Corporation

Figure III-5: Annual normal coastal protection expenditure as % of GDP in 50 km coastal zone



Source: Policy Research Corporation

¹⁰⁵ GDP in the 50 km zone following Eurostat (2004).

III.2. DECISION-MAKING ON ACTION OR INACTION

Cost-benefit evaluations in practice boil down to cost-effectiveness assessments

In *theory*, decision-making on risk reduction or climate adaptation for Europe's coastal zones would best be based on a cost-benefit analysis (CBA) to evaluate if the benefits of (additional) measures outweigh the costs from a socio-economic point of view. Assessment models such as DIVA and FUND allow investigation of the consequences of a specific rise in sea level in the case that no adaptation actions are undertaken. Yet, it is recognised that it is difficult to measure all (costs and) benefits in monetary terms.

In *practice*, most decision makers do not investigate the option of 'doing nothing' when deciding on risk reduction or climate adaptation measures. Especially in coastal zones where the socio-economic consequences of an extreme weather event would be enormous decision makers do not take the option of 'inaction' into account. Hence, most cost-benefit assessments tend more towards a cost-assessment: measuring which actions are optimal from a technical and financial point of view to ensure the safety of the area at risk. In cases where sufficient financial resources are lacking, priority projects are defined in a second step, based on the level of exposure of the areas concerned.

Adaptation benefits (population, GDP and land secured) mostly expressed in a qualitative manner

The analysis of the benefits of adaptation is a means to raise awareness on the importance of adaptation to climate change. The benefits of adaptation or costs of inaction most often referred to both in theory and in practice are:

- Population at risk;
- Value of dryland or wetland loss;
- Value of threatened economic assets or GDP.

When EU coastal member states provide information related to the benefits of adaptation, mostly estimates are expressed in a qualitative rather than as a monetary value. Also in literature dedicated to coastal protection and climate change the benefits of adaptation are monetised only in few cases. The cost-benefit models DIVA and FUND monetise the value of land at risk by multiplying the area concerned with an assumed value per km². Population at risk is expressed in a qualitative manner.

III.3. ESTIMATION OF THE TOTAL PRESENT AND FUTURE COST OF ADAPTATION

The PESETA study is the most recent (exhaustive) report estimating the cost of adaptation that would be required to protect Europe's coastal zones against SLR and flooding on a country-by-country basis. Therefore, this study has been taken as benchmark to assess the gaps between the real expenditure and the theoretical estimated amount of coastal protection and climate adaptation. The gap analysis

focuses primarily on the risk of flooding and erosion. Comparison of the cost of adaptation needed to protect against the other climate related impacts relevant for coastal zones (freshwater shortage and saline intrusion, the loss of coastal eco-systems), cannot be made as such information is not available in scientific literature and actual expenditure is not one-to-one related to the coastal zones.

Gaps between the theoretical and actual coastal protection and climate change adaptation expenditure are assessed in line with the underlying differences presented in *Table III-1*.

Table III-1: Underlying differences between PESETA estimates and actual expenditure

	<i>Scientific cost of adaptation</i> <i>Based on PESETA study (Richards and Nicholls, 2009) & DIVA model</i>	<i>Empirical cost of adaptation</i> <i>Based on data from national and sub-national authorities</i>
Countries	22 EU coastal member states with the exception of Cyprus, and excluding the Outermost regions	22 EU coastal member states, including the Outermost regions
Coastal area	The coastal area is not defined as a fixed area in km ² , the DIVA model is build on 12 000 coastal 'segments' defined on the basis of natural, administrative and socio-economic characteristics	Coastal area as defined by each member state (many member states do not work with a specific definition)
SLR scenarios	A uniform low (22.6 cm) and high (50.8) SLR scenario is taken into account for each member state	Every member state takes a different SLR scenario into account, many countries do not yet account for SLR
Measures	Measures taken into account are limited to two types of protective actions: the application of beach nourishments and the increase in flood defence dike heights; accommodation or retreat measures have not been considered	Measures taken into account are limited to all types of protective actions (e.g. beach nourishments, dikes, breakwaters, groins, dune building); accommodation or retreat measures undertaken by different member states in practice have not been monetised but described in a qualitative manner
Costs	A theoretical cost of beach nourishments (based on uniform pricing of \$ 5 for areas of plentiful sand, mid-range figure of \$ 10 and a low supply area figure of \$ 15) and theoretical cost of heightening flood defence dikes	Normal coastal protection and climate change adaptation expenditure (maintenance, capital (new constructions) and extraordinary) and expenditure to protect specific coastal hot-spots against violence from the sea (related as well as not related to climate change) as provided by national and sub-national authorities
Method	The cost is calculated using a uniform model (DIVA) functioning as a cost-benefit model: minimum cost (adaptation and residual damage cost) for maximum benefits (protecting the human use of the coast)	The costs are derived from information provided by national and sub-national authorities and based on (sub)-national financial accounts as far as possible, in practice, cost-benefit assessments are rarely made ¹⁰⁶
Context	The DIVA model / PESETA study does not put the cost of adaptation in the context of the actual situation of the country (e.g. strategies and measures undertaken in practice, other problems which are more pertinent)	The empirical cost of adaptation is based on the actual coastal protection and climate change adaptation expenditure of each member state and complemented with qualitative information on the strategies, actions and measures currently undertaken in each respective country

Source: Policy Research Corporation

The 'actual' total coastal protection and climate adaptation expenditure (normal and hot-spot expenditure) on a country level is compared with the cost of adaptation analysed by Richards and Nicholls (2009) in the scope of the PESETA study in *Figure III-6*. Countries have been ranked according to the actual cost of adaptation. The colours used in the table represent the safety level when comparing the *real* expenditure with the *theoretically estimated* investment that is needed to protect the human use of the coast.

¹⁰⁶ Measures taken to protect the hot-spots in Belgium, Germany, Slovenia and Romania are mainly the heightening of dikes or beach nourishments, which are comparable to the measures accounted for by Richards and Nicholls (2009), which is not the case for the hot-spots Venice (Mose-project) and London (Thames Barrier).

Figure III-6: Comparative analysis of scientific estimates of the annual cost of adaptation with the actual expenditure

Country	Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)		Actual average cost of adaptation per annum in € million (1998-2015)
	Low SLR (22.6 cm)	High SLR (50.8 cm)	Annual normal and hot-spot related expenditure
The Netherlands	54.3	88.1	190.1
Germany	50.0	101.0	128.1
UK	99.5	174.2	116.3 (95)
Spain	20.7	40.7	51.5
Italy	29.7	49.8	258.9 (25.6)
Belgium	2.0	2.5	23.3
Denmark	44.9	80.1	17.3
Romania	5.9	7.4	17.4
Greece	19.6	33.9	16.0
France	58.2	109.9	11.4
Portugal	10.6	21.8	7.3
Sweden	12.5	23.1	7.1
Poland	12.2	16.2	6.5
Ireland	26.7	45.8	5.3
Malta	0.2	0.3	5.0
Slovenia	0.1	0.2	1.2
Bulgaria	1.5	2.1	1.0
Cyprus	n.a.	n.a.	0.9
Lithuania	2.5	3.8	0.6
Finland	8.6	13.3	0.4
Estonia	21.2	28.9	0.2
Latvia	7.4	10.8	0.1
Outermost regions	n.a.	n.a.	(13.2)
Europe's total	488.3	853.9	879.1 (611.3) ¹⁰⁷

Red: low SLR > actual < high SLR
Orange: low SLR < actual < high SLR
Green: low SLR < actual > high SLR

Source: Policy Research Corporation

Comparison of the ‘scientific estimates of Richards and Nicholls (2009) with the actual expenditure yields the following:

- The actual coastal protection and climate change adaptation expenditure in Europe, amounting to € 1.07 billion in 2008 (and on average € 0.88 billion per year for the period 1998-2015), corresponds with the upper-bound of the annual adaptation estimate of € 0.49-0.85 billion presented by Richards and Nicholls (2009);
- Actual expenditure to protect Europe’s coastal zones – excluding budgets dedicated to protect the hot-spots Venice and London as well as the Outermost regions as these have not been accounted for by Richards and Nicholls (2009) – amounts to € 0.61 billion; this brings the actual expenditure somewhat in between the high and low SLR scientific estimates;
- At marine basin and at a national level, the actual expenditure on coastal protection and climate adaptation is often different to the scientific PESETA estimates;
- At a national level, the actual expenditure on coastal protection and climate adaptation for the five countries with highest expenditure is in line with or well above the theoretic figures from Richards

¹⁰⁷ The total amount of € 611.3 million excludes the yearly expenditure made to the Thames Barrier (UK) and the Mose project (IT) as well as the expenditure in the Outermost regions.

and Nicholls (2009); for the other countries in general the actual expenditure is well below the theoretic figures from Richards and Nicholls (2009); differences are the largest for the Baltic Sea countries followed by the Mediterranean countries (with the exception of Spain).

Under low SLR, annual total expenditure is 80% higher than PESETA projected adaptation cost

Richards and Nicholls (2009) estimate the annual adaptation cost under a low SLR scenario (22.6 cm) to be around **€488 million** between 1995 and 2020 whereas Europe's annual expenditure comes to **€879 million** for the period 1998-2015. This implies that all together, Europe is spending under a modest rise in sea level more than the scientific estimated amount to protect its coastal zones against flood-risk. The real expenditure does however take into account, besides climate adaptation also the regular coastal protection expenditure of each coastal member state and includes the expenditure for the hot-spots Venice and London as well as the Outermost regions.

Under high SLR, annual total expenditure is close to the PESETA projected adaptation cost

Under a high SLR scenario (50.8 cm), EU member states are spending close to the scientific estimated adaptation cost of **€854 million**. When excluding the expenditure related to hot-spots Venice and London, EU member states are spending about 30% less than the scientific estimate under a high SLR scenario. This may be related to the fact that at present only a minority of EU countries take a SLR scenario into account when implementing coastal protection measures.

At a national level, actual expenditure often differs from scientific estimates

At country level, the scientific estimation of the annual adaptation cost analysed by Richards and Nicholls (2009) for the period 1995-2020, often differs from the actual annual expenditure that will have been made between 1998 and 2015 by the different member states. Especially for the Netherlands, Belgium and Romania, the *actual coastal protection cost is much higher than the scientific estimate*. For France, Ireland as well as the majority of the Baltic Sea countries, the *actual coastal protection cost is much lower than the scientific estimate*. More details on the potential underlying differences between the real expenditure and the theoretical estimated investment needed to protect the human use of the coast are presented *Box III-1* and *Box III-2*. The difference for the Baltic Sea countries is detailed in the summary per marine basin, presented in the following paragraphs.

Box III-1: National differences between ‘scientific’ estimates and ‘actual’ expenditure: the case of the Netherlands, Belgium and Romania

The Netherlands and Belgium

The actual annual coastal protection and climate change adaptation expenditure in the Netherlands over the period 1998-2015 amounts to € 190 million whereas the theoretical estimate under a high SLR scenario is only € 88 million. In Belgium the actual annual expenditure amounts to € 23 million whereas the theoretical estimate reaches only € 2.5 million. Much can be explained by the historic flood event both countries faced in 1953 as well as the high concentration of people and economic assets in the coastal zones. Both countries protect their coastal zones since decades and are adapting to climate change and especially to the increased risk of flooding at a much faster pace than most other countries. In addition, both countries consider a higher SLR scenario in their coastal protection plans (the Netherlands takes 85 cm SLR into account and Belgium accounts for 60 cm SLR, both by 2100) than the SLR accounted for under the theoretical estimate (50 cm SLR). Considering the recent advice of the Delta Commission in the Netherlands that the present safety levels should be further increased and significant additional investments will be needed to protect the entire country from flooding, the actual expenditure seems much closer to the real cost of adaptation for the Netherlands as well as for Belgium than the theoretical estimate.

Romania

The actual annual coastal protection and climate change adaptation expenditure in Romania over the period 1998-2015 is around € 17 million whereas the theoretical estimate of Richards and Nicholls (2009) is € 7.4 million. This gap can be explained by the fact that the Romanian government currently spends much attention to the protection against erosion, but not explicitly in relation to SLR. In 2007, the government of Romania has had a study prepared on the protection and rehabilitation of the Black Sea shore to counter the severe problem of erosion. The plan is foreseen to be implemented in the period 2007-2013. A total budget of close to € 250 million (€ 35 million/year) has been secured under Romania’s Sectoral Operational Programme ‘Environment’ for the period 2007-2013.

Box III-2: National differences between ‘scientific’ estimates and ‘actual’ expenditure: the case of France and Ireland

France

In France, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 amounts to € 11 million whereas the theoretical estimates under a high and low SLR scenario lie between € 58 million and € 110 million. In France, private actors are by law responsible for coastal protection measures. Nevertheless, CPER’s – State Regional Planning Contracts – are the only reference documents for coastal measures scheduled by the regions that could be identified in practice. As a result, the actual coastal protection expenditure could be slightly underestimated, but is not expected to reach the minimum theoretically estimated amount as France does not yet take any SLR scenarios into account in current coastal protection activities. In general, large parts of the French coast are not so vulnerable to SLR as compared to countries like the Netherlands.

Ireland

In Ireland, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 amounts to only € 5 million whereas the theoretical estimates under a high and low SLR scenario lie between € 27 million and € 46 million. Ireland does not yet account for SLR at operational level. On the other hand, the government has formulated preliminary ‘Guidelines on the Planning System and Flood Risk Management’. These guidelines provide a comprehensive statement of good planning practice which will become a key step towards a national climate change adaptation strategy, expected to be published in 2009. The aim is to guide development away from areas at risk from flooding. As a result, it might well be that Ireland will resort to the use of accommodate and retreat measures rather than taking protective actions. Such alternative measures are not accounted for in the PESETA study.

Nonetheless these national differences, certain particularities can be summarised per marine basin¹⁰⁸.

Baltic Sea: Actual expenditure is much lower than the scientific estimates of PESETA



- In the Baltic marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to only € 38 million whereas the cumulative theoretical estimates under a high and low SLR scenario lie between € 81 million and € 128 million;
- Baltic Sea countries focus primarily on accommodation and retreat measures by means of regional development and building regulations which have not been accounted for in the theoretical estimates of Richards and Nicholls (2009);
- In the Baltic marine basin, climate change scenarios are in general not yet considered in practice; most Baltic Sea countries consider climate change still to uncertain to proactively invest in and – implicitly – adopt a wait and see approach.

North Sea: Actual expenditure is similar or higher than the PESETA projected adaptation cost



- Along the North Sea coast, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to € 399 million (€ 420 million including expenses to the Thames barrier) which is slightly above the cumulative theoretical estimate € 369 million under a high SLR scenario, under a low SLR scenario the theoretical estimate is around € 208 million;
- North Sea countries use primarily hard and soft ‘protective’ measures (beach nourishments, heightening of dikes) which corresponds to the measures taken into account in the theoretical estimate of Richards and Nicholls (2009);
- The actual UK expenditure is close to the scientific investment under a low SLR scenario when also considering the additional hot-spot investment of the UK (London Thames Barrier); the Belgian, Dutch and German expenditures are much higher than the scientific estimated investment needed under a high SLR scenario but these countries defend their coasts since decades and are more advanced (and risk-averse) when it comes to the protection against increased flood-risk.

Atlantic Ocean: General tendency to spend less than the scientific estimates of PESETA



- In the Atlantic Ocean marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to € 67 million whereas the cumulative theoretical estimates under a high and low SLR scenario amount to € 82 million and € 148 million respectively;
- France and Ireland spend 5 to 10 times less than the scientific investment; the gap might relate to the fact that both countries do not take a SLR scenario into account in current coastal protection operations; Ireland moreover tends to the use of accommodate and retreat actions in the future, which have not been accounted for by Richards and Nicholls (2009); Portugal spends slightly less than the scientific amount under low SLR but, to date, a SLR scenario is taken into account in only 2-3 regional plans;
- Spain spends slightly more than the scientific estimate and is in general more advanced in climate adaptation than the other Atlantic Ocean countries.

¹⁰⁸ The PESETA estimates of Richards and Nicholls (2009) are allocated to the 5 different marine basins according to the % of actual coastal protection and climate adaptation expenditure in each of the basins; the allocation of actual coastal protection expenditure to the different marine basins is detailed in *Annex 2*.

Mediterranean and Black Sea: Expenditure is in range or slightly higher than PESETA estimates

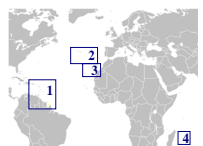


- Along the Mediterranean coastline, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to € 89 million whereas the cumulative theoretical estimates under a high and low SLR scenario amount to € 110 million and € 199 million respectively;
- Although most Mediterranean countries are not yet advanced in climate change adaptation, the actual expenditure reaches almost the theoretical estimate; it is however apparent that protective actions are used both the actual and theoretical estimated amounts;
- Spain spends slightly more than the scientific amount under high SLR and Greece and Italy (excluding the Mose project) slightly less under a low SLR scenario; this correlates with the progress made in climate adaptation; Malta invests more than the theoretical estimated investment needed but the Storm Water Management Plan determining the annual expenditure concerns the entire country.



- In the Black Sea marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to € 18.4 million whereas the cumulative theoretical estimates under a high and low SLR scenario amount to € 7.4 million and € 9.5 million respectively;
- In Bulgaria, actual expenditure corresponds to the scientific amount, both are very low; Romania is most active in coastal protection along the Black Sea coast and is especially focused on the problem of erosion, but not specifically in relation to SLR.

Outermost regions: Actual expenditure amounts to € 13.2 million per annum



- The actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 amounts to € 13.18 million;
- For the Outermost regions, no comparison with scientific estimates can be made as these have not been provided for in the PESETA study; as the Outermost regions cannot be compared with any other region in Europe, extrapolation of data would give a wrong impression; it is clear that also from a scientific point of view, more efforts are needed to support the Outermost regions with adapting to climate change.

(1) Martinique, Guadeloupe and Guyana (FR); (2) Azores and Madeira (PT); (3) Canaries (ES); (4) Reunion Island (FR)

IV. RECOMMENDATIONS

In terms of policy recommendations, it is suggested that:

- The European Commission takes a leading and coordinating role in research into the effects of climate change at local level for all EU member states as well as for the Outermost regions;
- In each member state, the organisation and responsibility of coastal protection and climate change adaptation is clearly defined and key actors are listed publicly per country;
- Efforts are made to stimulate the proactive involvement of national authorities in climate change adaptation and coastal protection;
- Efforts are made to support cross-boundary cooperation in the field of climate change adaptation, in particular at marine basin level;
- Policy makers should not aim to rank climate change adaptation plans and programmes as ‘one size does not fit all’; an (electronic) handbook with overall guidelines for the development of strategic and operational plans and programmes illustrating good practice examples across Europe could be developed instead;
- A central database is developed to present the climate change adaptation strategies, plans, programmes and measures applied as well as investments made in the different member states.

Recommendation 1: Take a leading and coordinating role in research into the effects of climate change at local level for all EU member states as well as for the Outermost regions

Sufficient knowledge on the effects of climate change and the projected climate change scenarios at local level is a pre-requisite for accurate adaptation policies. The IPCC regularly publishes global climate change scenarios but these estimates are not specific enough to pinpoint the effects at regional or local level. Many uncertainties on meteorological changes remain resulting in discrepancies between estimates of different institutions even in countries more advanced in climate research.

A coordinated research unit (e.g. under the IPCC) developing local level climate change scenarios, considering at the same time the specific physical and socio-economic circumstances of (coastal) areas could lay the foundation of a more uniform climate change approach across the different EU member states. In this respect, more research can also be carried out to the specific vulnerability indicators of coastal zones. To date, limited information is publicly available on the national and

regional coastal characteristics: e.g. GDP and population in the 10 km or 500 m coastal zone and the coastal areas situated below 5 metre elevation.

Recommendation 2: Ensure the organisation and responsibility for coastal protection and climate change adaptation is clearly defined in each member state and list key actors per country

With the exception of the Baltic countries, coastal protection and climate adaptation is in most European member states primarily a national and regional affair. Roles and responsibilities are however not always crystal-clear. Furthermore, adaptation to climate change is only dealt with by a small number of people who are not that easy to identify especially with respect to the coast. This is foremost in countries where coastal protection is mostly implemented in an ad-hoc fashion and climate change adaptation is still at its infancy. In order to streamline coastal protection and climate adaptation efforts in each country and be able to stimulate cross-boundary cooperation, it is important that the organisation and responsibility for coastal protection and climate change adaptation are clearly defined within each member state. An electronic handbook could be advisable to keep information updated. Furthermore, it is worthwhile to establish a public list of the key actors involved per member state. This recommendation could be implemented in conjunction with recommendation 6.

Recommendation 3: Stimulate the proactive involvement of national authorities in climate change adaptation and coastal protection

From the empirical analysis, it can be observed that national authorities are more involved in (financing) coastal protection and climate adaptation when risks or threats, in physical or socio-economic terms, are significant. As long as the risks for flooding, erosion or extreme weather events are limited or have not been proven, the urgency felt and priority given by national and regional authorities to (additional) coastal protection is rather low. In these cases, it is mostly local authorities and landowners which are assigned responsibility for coastal protection.

Nevertheless, the scientific and empirical analyses have revealed that (national) coordination is a prerequisite for the success of climate adaptation in coastal zones. Determining the optimal coastal policy and measures requires the involvement of different administrations to avoid conflicting initiatives in different areas (e.g. coastal protection, freshwater provision, spatial planning) as well as the harmonisation of actions across regions and counties.

The European Commission could establish an incentive scheme (e.g. voucher scheme) to the benefit of national authorities developing overarching climate adaptation or coastal protection plans. A financial contribution (e.g. buying in consulting services through an EU-funded project) where national authorities can apply for when preparing their national adaptation or coastal protection strategy could be a way to stimulate and support the development of such national adaptation or protection plans.

Recommendation 4: Make efforts to support cross-boundary cooperation in the field of climate change adaptation, at least at marine basin level

Local coastal protection measures can clearly affect areas more downstream and cause a negative impact on the conditions of neighbouring coastal areas. Nevertheless, to date, coastal member states rarely bring their coastal protection strategies, policies and measures in line with the actions undertaken by their neighbouring countries. The same can be observed between regions within a country.

Cross-boundary cooperation at EU level could be more focused on the development of joint adaptation strategies and policies to harmonise risk reduction climate adaptation activities along Europe's coastline. To this end, dedicated networking projects could be launched and roundtable meetings organised in order to implement such regional or national cooperation as a continuous effort.

Recommendation 5: Do not aim to rank coastal adaptation plans and programmes as 'one size does not fit all', a handbook with practical guidelines supporting the development of a profound strategy and a clear-cut operational plan illustrating good practice examples across Europe could be published instead

'One size' coastal adaptation plans or programmes do not 'fit all' countries. It would therefore give a wrong impression to rank (sub-) national plans on a qualitative scale as the 'optimal' approach is highly dependent of the national and sub-national meteorological, physical, socio-economic as well as regulatory circumstances. Many countries as well as the Outermost regions could benefit from a handbook which illustrates good practice examples across Europe and provides overall guidelines helping them in creating a comprehensive coastal adaptation strategy and operational plan or programme in account of their specific situation. Based on the scientific and empirical assessment made in this study, the following high-level criteria are suggested to be taken into consideration when developing (coastal) climate change adaptation strategies and plans:

- Develop strategies based on sufficient research insights;
- Coordinate with all (public and private) stakeholders involved;
- Aim to develop strategies and plans on the basis of the specific (meteorological, physical, socio-economic) circumstances instead of regional or national boundaries;
- Develop strategies or plans at the national level (or by national coastal groups) to ensure harmonisations across 'boundaries' (at least within the same country);
- Develop overarching (national) strategies for different climate change risks to apply the 'most optimal' strategy in every field;
- Carry out cost-effectiveness studies on coastal protection measures, examining also 'accommodate' and 'retreat' options.

Recommendation 6: Create a central database presenting the climate change adaptation strategies, plans, programmes and measures applied as well as investments made in the different member states

The empirical analysis learned that most member states are eager to learn from other countries. To date, the public information on national and regional climate change adaptation practices in the EU member states as well as the Outermost regions is scarce. To this end, a central database presenting the climate change adaptation, strategies, plans, programmes and measures applied across Europe could be beneficial. This database could furthermore be used to collect related financial information in a systematic manner and list the key persons involved per country.

V. CONCLUSIONS

The main conclusions to be drawn on *the economics of climate change adaptation in EU coastal areas* are presented in this chapter. First, overall conclusions are drawn that bring together the insights from theory and practice. Second, the key conclusions are summarised per marine basin with particular attention to the gaps between the cost of adaptation *in theory* and the expenditure to coastal protection and climate change adaptation *in practice*.

Overall conclusions

Climate change adaptation has come to the agenda in almost all member states, yet, is at different stages. Countries more advanced in coastal protection and climate adaptation are in general most affected and have experienced some severe weather events in the past. This phenomenon can be observed especially in the North Sea countries for what concerns flood-risk. The coastal protection and climate adaptation activities in Spain confirm this observation when it comes to counteracting the problem of intense drought and freshwater shortage.

From a theoretical point of view one would expect that policy makers base their decisions for additional coastal protection and climate adaptation in highly vulnerable – and thereby budget consuming – coastal areas on a cost-benefit analysis (CBA) to evaluate if the benefits of (additional) measures outweigh the costs from a socio-economic point of view. In practice, most decision makers do not investigate the option of ‘doing nothing’ when deciding on risk reduction or climate adaptation measures. Especially in coastal zones where the socio-economic consequences of an extreme weather event would be enormous decision makers do not take the option of ‘inaction’ into account. Hence, most cost-benefit assessments tend more towards a cost-assessment: measuring which actions are optimal from a technical and financial point of view to ensure the safety of the area at risk. Nevertheless, most experts highlight the benefits of early (proactive) adaptation to climate change to minimise the potential risks, damages and residual costs.

Assessments within scientific literature on the annual adaptation cost to protect Europe’s coastal zones against SLR range between \$ 0.2 billion and € 5.4 billion. The actual coastal protection expenditure in Europe, amounting to € 1.07 billion in 2008 (and to on average **€0.88 billion per year**

for the period 1998-2015) corresponds with the upper-bound of the annual adaptation estimate of € **0.49-0.85 billion**¹⁰⁹ presented by Richards and Nicholls (2009) in the light of the PESETA study.

The normal coastal protection expenditure represents 2/3rd of the total coastal protection investment in Europe. The *normal coastal protection* expenditure in Europe steadily increases over time driven by the evolution in a few member states. On average expenditure evolves from € 341 million in 1998 to an annual amount of € 500 million over the period 1999-2007 and to some € 737 million in 2008. In the near future (2009-2015) the annual normal expenditure tends to slightly decrease to € 698 million. Close to 60% is dedicated to the North Sea marine basin and the majority is borne by national and 'high' regional authorities. Coastal protection *expenditure dedicated to hot-spots* represents 1/3rd of the total coastal protection budget across the EU and peak in 2002 and 2009 which is primarily linked to the construction of the Mose-project in Venice.

The size and scope of coastal area risks and efforts to overcome these risks vary largely between member states, depending on the physical situation. From the empirical analysis, it can be observed that *current scientific research results with respect to the more local effects of climate change are too uncertain* for policy development. National and regional authorities, in particular in the less advanced (and newer) member states, remain reluctant to proactively invest in climate change adaptation and coastal protection as long as the effects of climate change are limited or have not been proven at the local level. Even in countries more advanced in climate change research, the uncertainties with respect to meteorological changes cause severe discrepancies between estimates given by different institutions and hamper accurate decision-making. Nevertheless, both the scientific and empirical analysis indicates that (national) coordination is a prerequisite for the success of climate adaptation in coastal zones.

Albeit the uncertainties linked to the potential effects of climate change, *long-term strategic questions are put on the political agenda, for example in relation to spatial development.* More and more countries tend to investigate how a more integrated approach to climate change adaptation in coastal zones can be followed to capture various climate change effects and streamline actions across different, but related, policy fields. Nonetheless, in the majority of European member states, additional efforts are needed to turn strategic thinking into comprehensive adaptation policies and operational actions.

Conclusions per marine basin

The colours used in each little table represent the safety level when comparing the *real* expenditure with *theoretically estimated* investment that is needed to protect the human use of the coast¹¹⁰. Figures


¹⁰⁹ Following a low (22.6 cm) and high (50.8 cm) SLR scenario under the ECHAM4B2 socio-economic scenario.

¹¹⁰ Red indicates that real expenditure is below the theoretic minimum; orange indicates that real expenditure is above the theoretic minimum and below the theoretic maximum; green indicates that real expenditure is well above the theoretic maximum.

Conclusions

have to be interpreted against the background of the underlying differences between the PESETA estimates and the actual coastal protection and climate change adaptation expenditure presented in *Chapter III.1* of this report. Countries which are indicated with a ‘*’ are located within more than one marine basin, therefore their expenditures have been split between the different basins.

a/ Baltic Sea

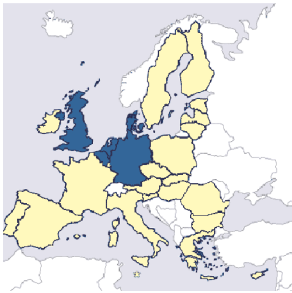
	<i>Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)</i>		<i>Actual average cost of adaptation per annum in € million (1998-2015)</i>
	<i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	<i>Annual normal and hot-spot related expenditure</i>
			
<i>Baltic Sea</i>			
Denmark*	5.1	9.1	1.8
Estonia	21.2	28.9	0.2
Finland	8.6	13.3	0.4
Germany*	11.5	23.2	21.0
Latvia	7.4	10.8	0.1
Lithuania	2.5	3.8	0.6
Poland	12.2	16.2	6.5
Sweden	12.5	23.1	7.1
Total	81.0	128.4	37.8

Source: Policy Research Corporation

- Along the Baltic coastline, the overall vulnerability to coastal flooding and erosion due to SLR is expected to be low, most climate change impacts are projected for marine species;
- The total coastal protection expenditure of the Baltic countries amounts to € 0.7 billion over the period 1998-2015; DE, SE and PL account for the majority of total expenditure;
- In the Baltic marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to only **€38 million** whereas the cumulative theoretical estimates under a high and low SLR scenario lie between **€81 million** and **€128 million**;
- With the exception of Germany, all Baltic Sea countries currently spend much less than the theoretical estimated cost of adaptation of Richards and Nicholls (2009);
- Almost all Baltic countries have or are currently developing a climate change adaptation strategy in which coastal zones are briefly discussed; to date, these plans often remain a – high level – strategy document without a concrete implementation plan and dedicated financial resources; an exception is Poland which has implemented long-term coastal protection strategies since 1985 and within these has recently taken climate change into account; Finland developed a National Adaptation Strategy in 2005 including actions relevant for the coastal zones and devotes much attention to co-ordinated land use planning in relation to climate change;
- In the Baltic marine basin, climate change scenarios are in general not yet considered in practice; most Baltic Sea countries consider climate change still too uncertain to proactively invest in and – implicitly – adopt a wait and see approach; in general ‘the persons who profit’ (private landowners and local authorities) bear the responsibility for coastal protection;

- Baltic Sea countries focus primarily on accommodation and retreat measures by means of regional development and building regulations which have not been accounted for in the theoretical estimates of Richards and Nicholls (2009).

b/ North Sea

	<i>Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)</i>		<i>Actual average cost of adaptation per annum in € million (1998-2015)</i>	
	<i>North Sea</i>	<i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	<i>Annual normal and hot-spot related expenditure</i>
	Belgium	2.0	2.5	23.3
	Denmark*	39.8	71.0	15.5
	France*	8.8	16.6	1.7
	Germany*	38.4	77.6	107.1
	the Netherlands	54.3	88.1	190.1
	UK*	64.4	112.8	61.6 (83) ¹¹¹
	Total	207.7	368.8	399.3 (420.7)

Source: Policy Research Corporation


- Significant SLR expectations, storm surges, many low-lying areas (more than 85% in BE and NL) and high economic and population concentrations make flood-risk a major concern for the North Sea countries;
- The North Sea countries will have spent in total € 7.6 billion to coastal protection over the period 1998-2015; the NL, DE and the UK account for the majority of total expenditure;
- Along the North Sea coast, the actual annual coastal protection and climate change adaptation expenditure for the countries concerned – excluding the expenditure to the Thames barrier – over the period 1998-2015 amounts to **€399 million (€420 million** including expenses to the Thames barrier) which is slightly above to the cumulative theoretical estimate of **€369 million** under a high SLR scenario, under a low SLR scenario the theoretical estimate is around **€208 million**;
- The actual UK expenditure is close to the scientific estimate under a low SLR scenario when also considering the additional hot-spot investment of the UK (London Thames Barrier); the Belgian, Dutch and German expenditures are much higher than the scientific estimated investment needed to protect the human use of the coast under a high SLR scenario but these countries defend their coasts since decades and are more advanced and risk-averse when it comes to the protection against increased flood-risk;
- The Netherlands and the UK are very active in climate change adaptation both at strategic and operational level; whereas the Netherlands follows an integrated national approach to climate change adaptation, in the UK main strategic actions are undertaken by the four devolved administrations; at operational level, German states and UK administrations integrate climate scenarios into Master Plans and Shoreline Management Plans respectively; Hamburg (DE) has accounted for climate change in their latest regional development project ‘Hafencity Hamburg’; Belgium accounts for climate change in its forthcoming Master Plan for coastal protection as well as in current hot-spot activities (Ostend, Zwin);

¹¹¹ The total amount of € 83 million includes the yearly expenditure made to the Thames Barrier (UK), but this has not been taken into account in the PESETA estimates.

Conclusions

- North Sea countries use primarily hard and soft ‘protective’ measures (beach nourishments, heightening of dikes) which corresponds to the measures taken into account in the theoretical estimate of Richards and Nicholls (2009).


c/ Atlantic Ocean

	Scientific cost of adaptation per annum in € million <i>ECHAM4B2 (1995-2020)</i>		Actual average cost of adaptation per annum in € million <i>(1998-2015)</i>
	Atlantic Ocean <i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	Annual normal and hot-spot related expenditure
France*	1.7	3.2	0.3
Ireland	26.7	45.8	5.3
Portugal	10.6	21.8	7.3
Spain*	8.3	16.3	20.8
UK*	35.1	61.4	33.4
Total	82.3	148.5	67.1

Source: Policy Research Corporation

- In the Atlantic marine basin, the main climate risk is flooding due to SLR and changes in both the direction and the power of waves; southern countries could become more exposed to freshwater shortage in the future due to prolonged and more intense periods of drought;
- The total coastal protection expenditure of the Atlantic Ocean countries amounts to € 1.2 billion over the period 1998-2015, UK and ES account for the majority of the total expenditure;
- In the Atlantic Ocean marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to **€67 million** whereas the cumulative theoretical estimates under a high and low SLR scenario amount to **€82 million** and **€148 million** respectively;
- France and Ireland spend less than the scientific estimation; the gap might relate to the fact that both countries do not take a SLR scenario into account in current coastal protection operations; Ireland moreover tends to use accommodate and retreat actions in the future, which have not been accounted for by Richards and Nicholls (2009); Portugal spends slightly less than the scientific estimation under low SLR but, to date, a SLR scenario is taken into account in only 2-3 regional plans;
- Spain spends slightly more than the scientific estimate and is in general more advanced in climate adaptation than the other Atlantic Ocean countries.

d/ Mediterranean Sea

		<i>Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)</i>		<i>Actual average cost of adaptation per annum in € million (1998-2015)</i>
	<i>Mediterranean Sea</i>	<i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	<i>Annual normal and hot-spot related expenditure</i>
	Cyprus	0.2	0.3	0.9
	France*	47.7	90.1	9.4
	Greece	19.6	33.9	16.0
	Italy	29.7	49.8	25.6 (258.9) ¹¹²
	Malta	0.2	0.3	5.0
	Slovenia	0.1	0.2	1.2
	Spain*	12.4	24.4	31.2
	<i>Total</i>	<i>109.9</i>	<i>199.0</i>	<i>89.3 (322.4)</i>

Source: Policy Research Corporation


- Medium SLR is projected for the Mediterranean marine basin where few parts of the coastline are situated below 5 metre elevation; the area is however highly exposed to erosion; freshwater shortage is the most significant issue in the Mediterranean; large areas are affected by salt water intrusion and dry periods projected to increase in length and frequency put additional pressure on freshwater availability;
- The Mediterranean countries will have spent over the period 1998-2015 close to € 5.8 billion to protect their coasts against flooding and erosion; much higher amounts are invested in freshwater but this expense is not one-to-one related to coastal zones;
- Along the Mediterranean coastline, actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned – excluding the Mose project in Venice – amounts to **€89 million** whereas the cumulative theoretical estimates under a high and low SLR scenario amount to **€110 million** and **€199 million** respectively;
- In Cyprus, the expenditure on freshwater supply and policy amounts to € 65.8 million in 2008; Malta has set aside € 71 million for the implementation of a National Storm Water project to ‘manage water away from where it is a hazard to where there is short of it; Spain is spending over the period 2005-2009 close to € 3.8 billion on freshwater supply – primarily in the Mediterranean regions – and has developed drought management plans which are binding for all river basins;
- With the exception of Spain, Mediterranean countries are not yet advanced in climate change adaptation, though the actual expenditure is close to the theoretical estimate; it is however apparent that protective actions are used both in actual and theoretical estimated amounts;
- Spain spends slightly more than the scientific estimated amount under high SLR and Greece and Italy (excluding the Mose project) slightly less under a low SLR scenario; this correlates with the progress made in climate adaptation; Spain has developed a National Climate Change Adaptation Plan in 2006, is developing a National Strategy for Coastal Management including climate change by 2010 and has a number of regional strategies available; Malta invests more than the theoretical estimated investment needed but the Storm Water Management Plan determining the annual expenditure concerns the entire country;

¹¹² The total amount of € 258.9 million includes the yearly expenditure made to the Mose project (IT), but this has not been taken into account in the PESETA estimates.

Conclusions

- Climate change scenarios are not accounted for in operational actions, with the exception of hot-spot Venice; Spain includes climate change scenarios in its forthcoming National Strategy for Coastal Management;
- Mediterranean countries rely mostly on ad-hoc hard defences such as breakwaters and groins often resulting in further impacts (erosion) on other parts of the coastline.

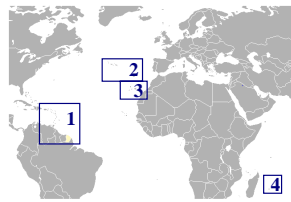
e/ Black Sea

	Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)		Actual average cost of adaptation per annum in € million (1998-2015)	
	Black Sea	Low SLR (22.6 cm)	High SLR (50.8 cm)	Annual normal and hot-spot related expenditure
	Bulgaria	1.5	2.1	1.0
	Romania	5.9	7.4	17.4
	Total	7.4	9.5	18.4

Source: Policy Research Corporation

- Erosion is at present the most significant climate related problem for the Black Sea marine basin; furthermore, the area is vulnerable to the impacts of SLR on intertidal habitats and eco-systems due to the low intertidal range and limited scope for on-shore migration;
- The total coastal protection expenditure of the Black Sea countries will have amounted to € 0.3 billion over the period 1998-2015;
- In the Black Sea marine basin, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 for the countries concerned amounts to **€18.4 million** whereas the cumulative theoretical estimates under a high and low SLR scenario amount to **€7.4 million** and **€9.5 million** respectively;
- In Bulgaria, actual expenditure corresponds to the scientific estimated amount, both are very low; Romania is most active in coastal protection along the Black Sea coast and is especially focused on the problem of erosion, but not specifically in relation to climate change (SLR) which may explain the higher actual than theoretical amount;
- Romania has had a study prepared on the protection and rehabilitation of the Black Sea shore to counter the severe problem of erosion; the plan is foreseen to be implemented in the period 2007-2013; the required budget of close to € 250 million (€ 35 million/year) has been secured under Romania's Sectoral Operational Programme 'Environment' for the period 2007-2013;
- Black Sea countries rely primarily on hard coastal defences; SLR scenarios are not taken into account.

f/ Outermost regions



<i>Outermost regions</i>	<i>Scientific cost of adaptation per annum in € million ECHAM4B2 (1995-2020)</i>		<i>Actual cost of adaptation per annum in € million (1998-2015)</i>
	<i>Low SLR (22.6 cm)</i>	<i>High SLR (50.8 cm)</i>	<i>Annual normal and hot-spot related expenditure</i>
Total	<i>n.a.</i>	<i>n.a.</i>	13.2

(1) Martinique, Guadeloupe and Guyana (FR); (2) Azores and Madeira (PT); (3) Canaries (ES); (4) Reunion Island (FR)

Source: Policy Research Corporation

- As small islands, the Outermost regions are particularly vulnerable to climate change; the threat from flooding and erosion is limited due to the geological characteristics of the coast but high economic and population concentrations make it an issue; also the potential loss of biodiversity is of major concern;
- Coastal protection expenditures against flooding and erosion will have amounted to around € 237 million over the period 1998-2015;
- For the Outermost regions, the actual annual coastal protection and climate change adaptation expenditure over the period 1998-2015 amounts to **€13.18 million**; theoretical estimates have not been provided for in the PESETA study and extrapolation of data from any other region in Europe would give a wrong impression; it is therefore clear that also from a scientific point of view, more efforts are needed to support the Outermost regions with adapting to climate change;
- Outermost regions are not incorporated systematically in climate change or coastal protection strategies and plans of the corresponding mainland; Spain sets however the example and takes the Canaries into account in its forthcoming National Strategy for Coastal Management;
- The EC, the member states and their overseas territories have initiated at the end of 2008 joint-discussions on the plans and measures needed to protect biodiversity loss in the Outermost regions;
- Guyana established a proposal for an adaptation plan in 2001, but a final strategy is not available; the Canaries foresee the adoption of an adaptation strategy in 2010; coastal protection measures are mainly decided on and implemented in an ad-hoc fashion; French ORs may include measures in CPERs; Madeira and Azores foresee measures under POOCs.

ANNEXES

Annex I: Website address country fiches

The individual fiches of the 22 EU coastal member states as well as the fiche dedicated to the Outermost regions can be downloaded at http://ec.europa.eu/maritimeaffairs/climate_change_en.html.

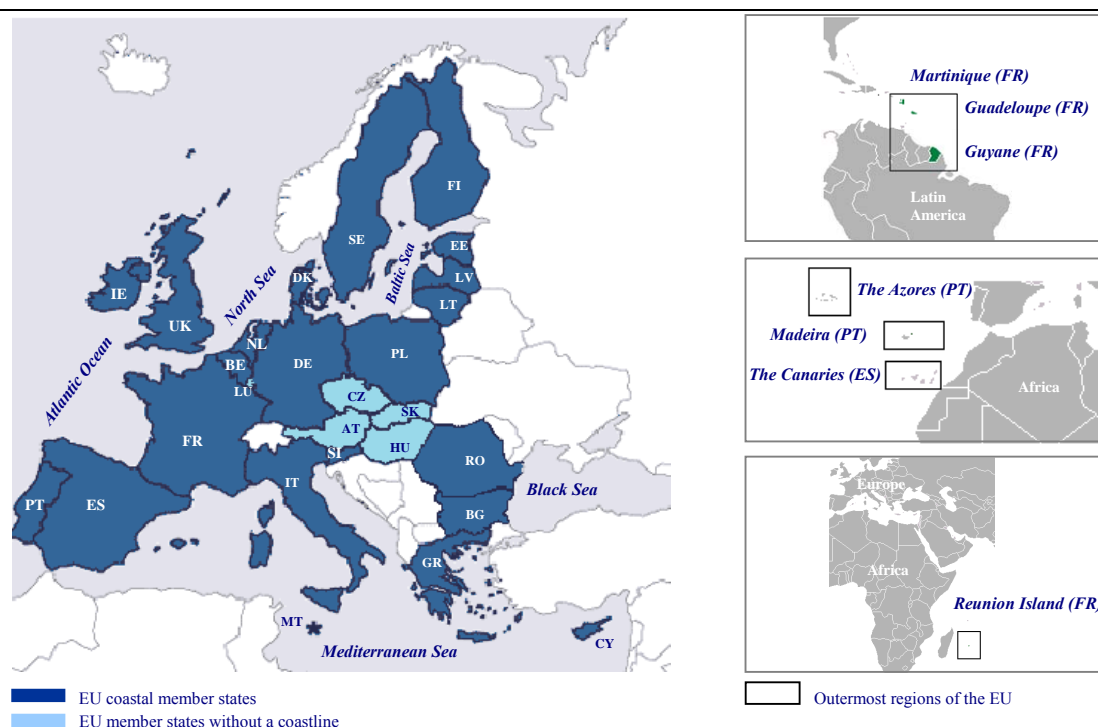
Annex II: Overview of the study methodology

Annex II describes the methodology used by *Policy Research* to carry out this study. First the study area is visualised. Next, the methodology used to collect and assess empirical data on climate change adaptation in Europe's coastal zones is described in detail. The empirical assessment of climate change adaptation in EU coastal areas, based on bottom-up (field) research, has been the core of this study. Finally, the approach followed to review related scientific literature is explained.

g/ Study area

This study focuses in first instance on the coastal zones of the EU member states. All resulting 22 coastal countries¹ have been assessed both at national and sub-national level. In addition, the EU Outermost regions² have received specific attention. *Figure A.II-1* visualises the study area of this report.

Figure A.II-1: Study area



Source: Policy Research Corporation

¹ The 22 EU coastal member states are Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden and the UK.

² The EU Outermost regions are the Azores, Madeira, the Canaries, Guadeloupe, Guyana, Martinique and the Reunion Island.

h/ Empirical data collection and analysis

The following paragraphs explain the methodology that has been used by *Policy Research*, in cooperation with its subcontractor MRAG, to collect and analyse empirical information on the (economics) of climate change adaptation in the 22 EU coastal member states as well as in the Outermost regions.

Which information has been collected?

In line with the study area, *Policy Research* and MRAG have collected systematically information on:

- Climate change *vulnerability* of European coastal areas;
- Level of *responsibility and key actors* (e.g. national and sub-national authorities, private stakeholders, research institutes) involved in coastal protection and climate adaptation in coastal areas;
- Adaptation *plans and practices* in European coastal areas at (*sub-*) *national level*;
- Past (between 1998 and 2007), present (2008) and future (until 2015) coastal protection and climate change adaptation *expenditure* in European coastal areas at (*sub-*) *national level*.

Information on the climate change *vulnerability* of a specific country and the level of *responsibility and key actors* involved has been gathered in first instance through desk and internet research. In a second step, insights were discussed with national and sub-national stakeholders to identify the most important climate impacts, the areas (e.g. regions, municipalities and counties) concerned the most, and to verify the specific role of the different stakeholders involved both at policy and operational level.

An overview of *adaptation plans and practices* has been established in cooperation with the responsible actors at national and sub-national level. The main plans and practices applied were identified and analysed for all EU coastal member states and the Outermost regions at national level. At sub-national level, plans and practices were assessed for key areas.

The past, present and future *coastal protection and climate change adaptation expenditure* has been collected for the 22 coastal member states and the seven Outermost regions at national and sub-national level. At the sub-national level, the coastal protection and climate adaptation expenditure has been assessed for key areas on the basis of their vulnerability or climate adaptation activities. The coastal protection expenditure referred to in this report is mostly related to coastal flooding and erosion. The investment in freshwater by the Mediterranean countries has been reported separately as it is not one-to-one related to coastal zones.

The coastal protection and climate adaptation cost of each country has been split between the ‘normal’ coastal expenditure (defined as the total coastal protection expenditure to protect against flooding and erosion, *excluding* hot-spots) and the expenditure dedicated to specific hot-spots. For some countries,

based on the available national and sub-national data, the total expenditure has been further detailed according to the type of measures undertaken (expenditure to hard, mixed and soft measures).

The coastal protection and climate adaptation cost of the different member states has also been aggregated at marine basin level. The coastlines of the five countries, DE, DK, FR, ES and the UK border however more than one marine basin.

Figure A.II-2: Attribution of the 22 member states to the different marine basins

<i>Marine basin</i>	<i>Countries</i>
<i>Baltic Sea</i>	DE (23%), DK (11%), EE, FI, LT, LV, PL, SE
<i>North Sea</i>	BE, DE (97%), DK (89%), FR (15%), NL, UK (65%)
<i>Atlantic Ocean</i>	ES (40%), FR (3%) , IE, PT, UK (35%)
<i>Mediterranean Sea</i>	CY, ES (60%), FR (82%), GR, IT, MT, SI
<i>Black Sea</i>	BG, RO

In order to avoid double-counting of the coastal protection cost of these countries, their expenditure has been attributed as follows:

- *Germany*: The expenditure on coastal protection has been attributed to a marine basin on a regional basis; the expenditure dedicated to the coastlines of Bremen, Hamburg and Niedersachsen has been attributed to the North Sea, the expenditure for the coastal zones of Mecklenburg-Vorpommern to the Baltic Sea; the expenditure for Schleswig-Holstein, bordering both seas has been attributed proportional to the km of coastline below 5 metre elevation (following Nicholls, 2008);
- *Denmark*: The expenditure on coastal protection has been attributed to a marine basin on a regional basis; the expenditure dedicated to the coastline of Jutland has been attributed to the North Sea, the expenditure for the coastal zone of Frederikshavn has been attributed to the Baltic Sea; the expenditure related to the Storm flood fund has been split equally between the North Sea and the Baltic Sea;
- *France*: The expenditure on coastal protection has been attributed to a marine basin on a regional basis; the expenditure dedicated to the coastlines of Haute Normandie and Nord-pas-de-Calais has been attributed to the North Sea, the expenditure dedicated to Aquitaine to the Atlantic Ocean and the expenditure for the coastal zones of Languedoc-Roussillon to the Mediterranean marine basin; the indirect cost has been split equally over the three seas;
- *Spain*: The expenditure was not available at regional level; national expenditure has been attributed to the different marine basins proportional to the km coastline bordering the specific sea (following Eurosion, 2004);
- *United Kingdom*: The expenditure on coastal protection has been attributed to a marine basin on a regional basis; the expenditure dedicated to the coastlines of Wales en Northern Ireland has been attributed to the Atlantic Ocean, the expenditure dedicated to the coastline of Scotland to the North Sea and the expenditure dedicated to the coastline of England has been split over the North Sea and the Atlantic Ocean (the indirect expenditure and the expenditure related to the Thames Barrier have been attributed to the North Sea; 30% of the capital expenditure has been attributed to the Atlantic Ocean and 70% to the North Sea).

All quantitative and qualitative details have been written up in dedicated fiches: 22 country fiches and one fiche for the Outermost regions³. Specificities of the different countries as well as data extrapolation methodologies applied are described extensively in these fiches. Each fiche follows the same structure:

- Vulnerability of the coastal zones;
- Responsibility and financing for coastal protection and climate adaptation;
- Research into vulnerability to climate change and climate change scenarios;
- Coastal defence, risk reduction and adaptation plans in relation to climate change;
- Adaptation expenditures and forecast of budgets;
- Persons contacted and sources of information used.

Which data gaps exist and how has missing data generally been extrapolated?

For the majority of countries national as well as sub-national authorities have been able to provide the (proximate) investment in coastal protection and climate adaptation for the entire period 1998-2015 based as much as possible on information derived from (sub-)national accounts. The expenditure that could not be attributed to a specific year, but only to a certain period in time has been equally divided by *Policy Research* over the period concerned. For six countries, Italy, Ireland, Lithuania, Portugal, Spain and the UK, *Policy Research* has extrapolated certain past or future expenditures to receive a complete financial picture. Overall, costs have been extrapolated (in function of the specific situation of each country) on the basis of:

- Average yearly coastal protection expenditure over a past or future time period;
- Trends in past or future yearly coastal protection expenditure;
- Application of a certain proportion (based on a past or future time period) to annual general coastal budget lines.

For Bulgaria and Greece, national and sub-national authorities could not provide sufficient details on the coastal protection and climate adaptation expenditure. For these two countries, *Policy Research* has calculated the investment made in coastal protection and climate adaptation based on an extrapolation of the expenditure of neighbouring countries which apply similar coastal policies and practices. These countries are respectively Romania and Cyprus.

For the collection of data at the *sub-national level*, it goes without saying that it has been impossible, within the scope of the study, to get in contact with all potential local actors concerned. However, key areas (regions, municipalities, counties) were selected on the basis of their vulnerability or climate adaptation activities to get a good insight into the actions undertaken and the budgets dedicated to coastal protection and climate change adaptation at sub-national level.

³ All fiches are enclosed in Annex II of this report.

How has information been collected and have contacts been established?

In line with the study area, *Policy Research* gathered empirical data through desk and internet research, contacts by telephone as well as field research. Field research has been carried out in 15 member states⁴. On average 6-8 key players were visited per field trip, complemented with additional meetings by telephone. Besides the interviews to collect country specific information, there have been discussions with relevant academics and European associations and institutions to be able to integrate specific inputs from the research site as well.

For the field research at *national level*, contacts have been established in first instance with the relevant national authorities. These contact persons allowed to get in touch with the leading universities, port authorities or private companies to interview in addition. National authorities as well as regional associations have also been important access points to identify the relevant key players at the sub-national level.

In addition, a survey has been conducted in cooperation with the Comité Européen des Assurances (CEA)⁵. The results of the questionnaire provide additional insights in the expected impact of climate change for the insurance sector specifically, the type of information collected by insurance companies and the sector's adaptation strategies. Responses have been received from national insurance associations and insurance companies of Denmark, France, the Netherlands, Slovenia and the UK.

How has information been validated?

All qualitative and quantitative information gathered has been extensively reviewed and assessed by *Policy Research*, discussed with and cross-checked by the interviewers⁶ and written up in dedicated fiches enclosed in *Annex I*. This country-by-country analysis has been summarised and compared in *Chapter II* and *Chapter III* of this report. Results have been validated by a dedicated EC Steering Group⁷ and a member states meeting.

i/ Review of scientific literature

Next to the empirical bottom-up research, *Policy Research* reviewed also existing literature related to climate change adaptation in Europe's coastal zones. Much effort has been put in carefully selecting

⁴ Field research at national and sub-national level has been carried out in Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain, Sweden and the UK.

⁵ The original questionnaire has been enclosed in *Annex IV*.

⁶ In particular, each country fiche has been sent to the respective contact persons for validation and approval of the content; this process has allowed to pinpoint all details and has received a very high response.

⁷ Participants in the Steering Groups were: Mr Martin Fernandez Diez-Picazo and in alphabetical order: Mr Andrus Meiner, Ms Anita Vella, Ms Ariane Labat, Ms Birgit Snoeren, Ms Florencia Van Houdt, Mr Gert Verreet, Ms Haitze J. Siemers, Ms Helen McCarthy, Mr Jacques Delsalle, Ms Karen Fabbri, Ms Lucyna Kaminska, Mr Michael Grams, Mr Theodore Saramandis, Mr Thomas De Lannoy, Mr Wolfram Schrimpf.

and assessing the most relevant sources of information and EU projects available for European coastal areas. The results of the literature review have been summarised in *Chapter I*.

j/ Sources of information and persons contacted

More than 160 general sources of information related to climate change adaptation in EU coastal areas and 415 country specific studies and reports have been used to draft this study of which the full text reports have been made available to the European Commission. During fifteen 2-3 day field visits and numerous contacts by e-mail and telephone, close to 240 key persons have been interviewed to collect all relevant information⁸.

⁸ An overview of all persons contacted in the light of this study as well as the sources of information used have been enclosed at the end of this report.

Annex III: Overview EU-funded projects related to climate change adaptation

<i>Title</i>	<i>Country(ies)</i>	<i>Summary</i>	<i>Reference</i>
ASTRA	Finland, Germany, Estonia, Latvia, Lithuania, and Poland	Various research institutes and regional planning offices around the Baltic Sea region address the risks arising from climate change in the Baltic Sea region, such as extreme temperatures, droughts, forest fires, storm surges, winter storms and floods	www.astra-project.org
BALTCICA	Finland, Estonia, Latvia, Lithuania, Denmark, Sweden, Norway, Germany	The overall aim of the BaltCICA project is to achieve a better capability to deal with the impacts of climate change in the Baltic Sea area; the project will assess climate change impacts on the living environment and territorial development and test and implement concrete adaptation measures in the participating countries; the project draws on the results of the ASTRA project	www.baltcica.org/index.html
BRANCH	the Netherlands, France, the UK	The branch project discusses the need for change in spatial planning and land use systems to give Europe's biodiversity the chance to adapt to climate changes	www.branchproject.org/
CLIMATECOST	France, the United Kingdom, Greece, Germany, Ireland, Spain, Belgium, Austria, Czech Republic, Denmark, India, China	ClimateCost aims to advance knowledge on the full economic costs of climate change and inform policy makers on long-term climate change policy targets, the costs of inaction (the economic effects of climate change), and the costs and benefits of adaptation	/
COMCOAST	Denmark, Germany, the Netherlands, Belgium and the UK	ComCoast presents innovative solutions for flood protection in coastal areas and innovative ways of dealing with the use of space and abundance of water	www.comcoast.org
COMRISK	Belgium, Denmark, Germany, the Netherlands and the UK	Coastal defence authorities around the North Sea region discuss on improved risk management for coastal flood prone areas	http://comrisk.hosted-by-kfki.baw.de
CONSCIENCE	the Netherlands, Spain, Ireland, UK, Romania, Poland and Croatia	The objective is to develop and test concepts, guidelines and tools for the sustainable management of erosion along the European coastline, based on best available scientific knowledge and on existing practical experience	www.conscience-eu.net/
DEDUCE	Latvia, Poland, Spain, France, Malta	The main objective is to evaluate the utility of indicators for optimal decision making on the coast, following the principles and criteria established by the EU Recommendation on ICZM	www.deduce.eu/index.html

<i>Title</i>	<i>Country(ies)</i>	<i>Summary</i>	<i>Reference</i>
DINAS-COAST	the Netherlands, Germany, UK,	DINAS-COAST is an integrated modelling project that combines state-of-the-art science and data from a range of different disciplines to help policymakers interpret and evaluate coastal vulnerability; DINAS-COAST has developed a dynamic, interactive and flexible assessment tool on a CD-ROM, called DIVA (Dynamic Interactive Vulnerability Assessment) with which a range of mitigation and adaptation scenarios can be analysed	www.dinas-coast.net/
ENCORA	the Netherlands, Belgium, France, Germany, Greece, Ireland, Italy, Poland, Spain, Portugal, Sweden, UK, Ukraine, Russia, Morocco	ENCORA has developed several services to facilitate sharing of knowledge and experience across Europe: (1) to increase the quality and efficiency of research programmes and to stimulate cooperation among research institutes, (2) to spread best coastal practices throughout Europe among coastal management organisations, (3) to harmonise coastal policies in Europe for sustainable development among policy organisations	www.encora.eu/
ESPACE	UK, Belgium, The Netherlands and Germany	The project aims to create awareness on the importance of adapting to climate change and recommends that it is incorporated within spatial planning mechanisms at local, regional, national and European levels; focusing on North West Europe, ESPACE will look at how water resources are managed and how the involved countries plan to deal with a changing climate	www.espace-project.org/
EUROSION	Partners from the Netherlands, Portugal and Spain, with an assessment for all EU Member States	The EuroSION project studies the current status and trends of European coasts with regard to erosion; the major outcome is an analysis of where erosion management is being adopted now and where it should be adopted in the future	www.euroSION.org
FLOODSITE	UK, the Netherlands, Germany, France, Czech republic, Hungary, Italy, Spain, Sweden, Poland, Greece, Belgium	FLOODsite covers the physical, environmental, ecological and socio-economic aspects of floods from rivers, estuaries and the sea, it considers flood risk as a combination of hazard sources, pathways and the consequences of flooding on the “receptors” – people, property and the environment	www.floodsite.net/

<i>Title</i>	<i>Country(ies)</i>	<i>Summary</i>	<i>Reference</i>
MESSINA	France, Sweden, the Netherlands, Italy, Spain, Poland and the UK	Messina studies the latest shoreline management techniques and provides concrete examples of economic analysis methodologies applied to related policies in and outside Europe	www.interreg-messina.org
OURCOAST	the Netherlands, Belgium, Germany	The aim of the project is to support and ensure the exchange of experiences and best practices in coastal planning and management; the project will produce numerous tools, studies and develop activities of public interest for the implementation of ICZM in Europe	http://ec.europa.eu/environment/icz/ourcoast.htm
PESETA	Partners from Spain, UK and the Netherlands with an assessment for all EU Member States	The PESETA project makes an assessment of the possible impact of climate change in Europe up to 2100; different sectors, such as coastal systems, energy, agriculture, human health and tourism are examined	http://peseta.jrc.es/
PRUDENCE	Denmark, Italy, France, Germany, UK, Switzerland, Sweden, Spain, Finland, the Netherlands, Norway, Israel, Czech Republic	Prudence provides a series of climate change scenarios for 2071-2100 and an assessment of the risks arising from regional weather and climate changes in different parts of Europe, by estimating future changes in extreme events (flooding and windstorms) and by providing a robust estimation of the likelihood and magnitude of such changes	http://prudence.dmi.dk/
RESPONSE	UK, Italy, France, Poland	Response discusses major risks from climate change in coastal zones of Europe, namely coastal erosion, landslide and flooding and advises authorities on coastal risk management and the development of risk maps	www.coastalwight.gov.uk/response.html
SAFECOAST	the Netherlands, Germany, Denmark, Belgium, UK	Safecoast considers the question 'How to manage our North Sea coasts in 2050?' and focuses on how coastal vulnerability can be impacted by climate change and spatial developments	www.safecoast.org/

<i>Title</i>	<i>Country(ies)</i>	<i>Summary</i>	<i>Reference</i>
SAFER	UK, Switzerland, Germany	The aim is to develop a best practice flooding approach based on a greater partnership between the public at risk from flooding and the authorities responsible for spatial planning; flood protection; and flood emergency response management	www.floods.eu.com/main.htm
SPICOSA	France, Spain, Italy, Belgium, Norway, Turkey, Portugal, Ireland, UK, Sweden, Greece, the Netherlands, Poland, Denmark, Germany, Estonia, Latvia, Bulgaria, Israel, Ukraine	SPICOSA strengthens research throughout the European region and produce products useful to support operational framework for delivering prognostic assessments of policy options for the sustainable management of coastal zones	www.spicosa.eu/
TRESHOLDS	Spain, Italy, Germany, Sweden, Denmark, Finland, France, Norway, Belgium, UK, Bulgaria, Estonia	TRESHOLDS develops an innovative target-setting procedure, encompassing both the environmental and the socio-economic dimensions required to formulate robust policies ensuring sustainable development.	www.thresholds-eu.org/

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