Socio-economic Impacts—Coastal Management and Governance

19

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Abstract

Climate change will have important impacts on the North Sea coastal zones. Major threats include sea-level rise and the associated increase in flood risk, coastal erosion and wetland loss, and hazards arising from more frequent storm surges. The North Sea countries—Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden and the UK—have developed strategies to deal with these threats. This chapter provides a short introduction to the present adaptation strategies and highlights differences and similarities between them. All the North Sea countries face dilemmas in the implementation of their adaptation strategies. Uncertainty about the extent and timing of climate-driven impacts is a major underlying cause. In view of this, adaptation plans focus on no-regret measures. The most considered measures in the North Sea countries are spatial planning in the coastal zone (set-back lines), wetland restoration, coastal nourishment and reinforcement of existing protection structures. The difficulty of identifying the climate-driven component of observed change in the coastal zone is a critical obstacle to obtaining a widely shared understanding of the urgency of adaptation. A better coordinated and more consistent approach to marine monitoring is crucial for informing policy and the general public and for developing the adaptive capacity of institutions and wider society. A dedicated coastal observation network is not yet in place in the North Sea region.

19.1 Introduction

Climate change will have important impacts in the coastal zones of the eight countries around the North Sea: Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden and the UK. Major threats include sea-level rise and the associated increase in flood risk, coastal erosion and wetland loss, and hazards arising from more frequent storm surges. The North Sea countries have developed strategies to deal with these threats. For each country a short introduction is given to their present adaptation strategy; differences and similarities are highlighted. All the North Sea countries face dilemmas in the implementation of their adaptation strategies. Uncertainty about the extent and timing of climate-driven impacts is a major underlying cause. Several approaches are available to deal with these dilemmas. The key findings are summarised in a final section.

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19.2 Coastal Management in the North Sea Countries

This section briefly reviews coastal management practice in the North Sea countries in relation to climate change. Some working definitions of key terms used within this chapter are given in Box 1.

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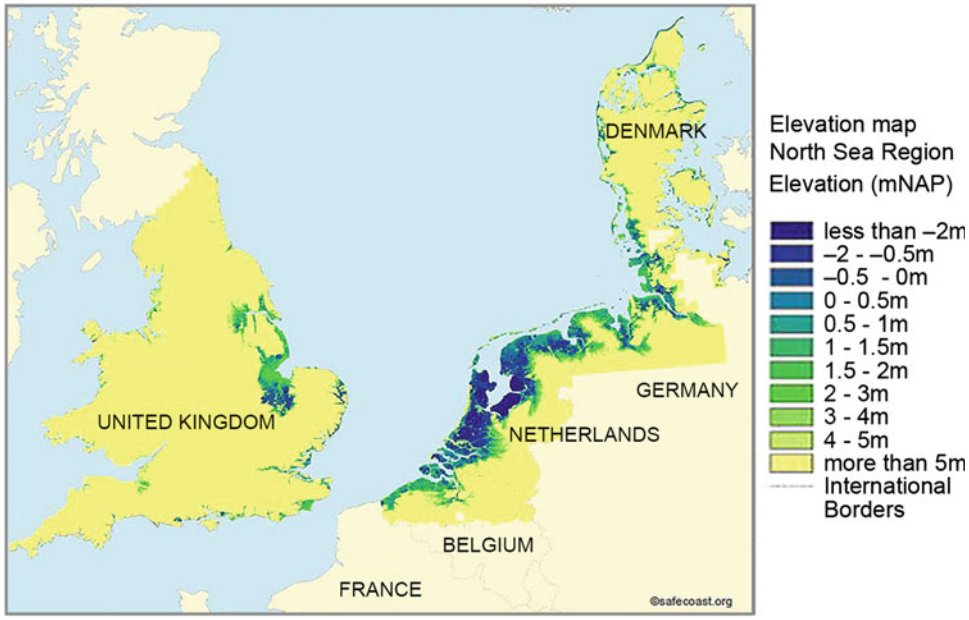

Fig. 19.1 North Sea regions potentially vulnerable to inundation by the sea (Roode et al. 2008)

19.2.1 The Coastal Zone

The shoreline is the most obviously delineated feature of the coastal zone. The North Sea countries have no commonly adopted definition of what else should be considered as the 'coastal zone'. Shoreline management mainly deals with coastal protection; this is the topic of Chap. 18. The present chapter deals mainly with coastal zone governance issues. Whether the societies in North Sea countries effectively adapt to the impacts of climate change in the coastal zone depends on a broad range of factors including continuing drivers for coastal development, and political debate about which measures should be adopted. The framework of 'governance' provides the broadest perspective to consider these issues.

In their climate adaptation strategies, all North Sea countries give particular consideration to marine-related risks. The present chapter therefore equates the coastal zone with the zone of marine-related risks. Figure 19.1 shows North Sea regions subject to marine flooding risk and Fig. 19.2 the North Sea regions with a special protection status under the EU Habitats Directive.

Each North Sea country has its own legal and institutional arrangements for coastal governance. The legal frameworks relating to the coastal zone are complex and diverse, and further complicated by the federal structure or devolution within countries (Gibson 2003). France has specific legislation for the coastal zone (Loi Littoral 1986). The UK has passed the Marine and Coastal Access Act (2009)[1] which has jurisdiction seaward from mean high water. In other countries, the coastal zone is governed through more general legal and institutional frameworks, such as 'Environment', 'Water Management', 'Climate Change Adaptation', 'Territorial Planning', 'Natural Hazards', and 'Fishery', among others. The coordination of national policies rests with the central governments. None of the North Sea countries has an authority dedicated specifically to coastal governance. The implementation of national policies in coastal zone management plans is commonly delegated to regional and/or local authorities.

19.2.2 Coastal Management Issues

The coastal zone is considered a region in its own right because of its dependence on land-ocean interaction. The coastal zone is not only shaped by human interventions, but also by the feedback of natural processes to these interventions. This imposes limitations on the uses of the coastal zone; non-respect of these limitations entails the risk of loss of life and investments. Inappropriate development entails the loss of precious ecosystem values.

Recognition of the particular nature of the coastal zone led to the development of the concept of ICZM (Integrated Coastal Zone Management) in the 1990s. The term 'integrated' points to the need for coordination of the policies of different sectors and different levels of government. The challenges of making disjointed, hierarchical and sector bureaucracies effective, are common to many forms of management and regulation. However, for the coastal zone additional requirements result from the highly dynamic natural land-ocean interaction. Large parts of the European coastal zones received a special protection status through the

[1] www.legislation.gov.uk/ukpga/2009/23/contents.

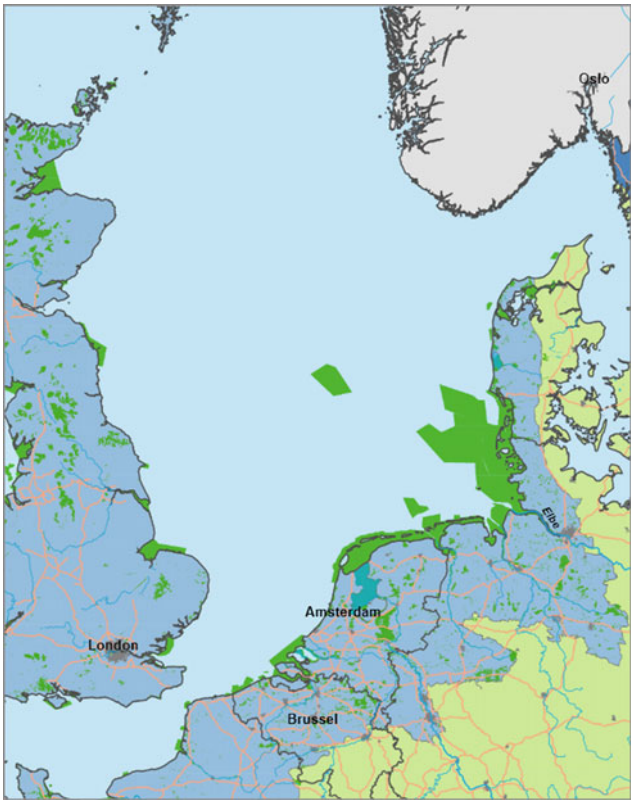

Fig. 19.2 North Sea coastal and marine regions with a special protection status under the EU Habitats Directive (marked in *green*)

EU Habitats Directive and the Natura 2000 network of the European Union. The countries around the Mediterranean Sea agreed on a protocol for ICZM that entered into force in 2011 (Barcelona Protocol 2008). In 2013, the European Commission proposed a directive binding all member states to put into practice the principles of ICZM and to develop spatial marine plans. The directive was adopted in 2014 (EC 2014), but ICZM was excluded following amendments by member states.

According to the evaluation report on IZCM prepared for the European Commission in 2006 (Ruprecht Consult 2006), major coastal issues for the North Sea region include resource management, species and habitat protection, establishment and management of reserves and protected areas, protection of the coast against natural and human induced disasters, and long-term consequences of climate change.

19.2.3 Drivers of Coastal Change

The ELOISE programme (European Land-Ocean Interaction Studies, Vermaat et al. 2005) has collected ample evidence to show that climate change will have serious impacts in the European coastal zones. The effects of climate change will add to the effects of other drivers of change. Other major drivers are related to human population growth and economic expansion. Industrialisation, shipping traffic intensity, fisheries, coastal aquaculture and port development as well as offshore mining for gas and oil have all increased greatly in recent decades, and will probably continue to do so (Stojanovic and Farmer 2013). Together with increased tourism this has led to urbanisation of highly dynamic natural zones. It is expected that climate change will exacerbate most of the adverse impacts of existing drivers of change.

The scale and type of impact that drivers can bring about varies considerably. There are various methods for classifying drivers, for example, PESTLE analysis (Political, Economic, Social, Technological, Legal and Environmental drivers, Ballinger and Rhisiart 2011). Drivers of change in coastal systems are typically external to the coastal zone. Effective coastal zone management therefore requires consideration of policies in many other fields. This implies that coastal adaptation is only a partial response to change.

19.2.4 The Challenge of Adaptation to Climate Change

Development of the coastal zone was accompanied in the past by reclamation and armouring with hard coastal defences, narrowing the active coastal zone (Nicholls and Klein 2005; Vermaat and Gilbert 2006). This process was identified as ‘coastal squeeze’. Coastal squeeze is strongly enhanced by sea-level rise and compromises the natural capability of coastal adaptation to climate change. In order to address these problems, new engineering techniques have been developed, following the principle of ‘working with nature’ (EEA 2006). This practice uses the dynamic response of marine processes, by designing interventions such that the feedback of marine processes is positive (contributes to achieving the objective of the intervention) rather than negative (opposes the intervention). Foreshore nourishment and wetland restoration are typical examples. Further examples of new coastal engineering practices are given in Chap. 18.

Owing to the strong interference of human interventions with natural processes, reversing adverse trends, such as erosion or ecosystem alteration, is not always feasible and is in any case expensive. A long-term perspective is therefore key to coastal governance. Anticipating the effects of climate change is one of the major challenges. Adaptation to climate change may already require a revision of present management strategies in some coastal regions. According to the EEA report *The Changing Faces of Europe’s Coastal Areas* (EEA 2006), coastal zones will be subject to many pressures during the 21st century. “These pressures will interact with climate change and exacerbate or ameliorate vulnerability to climate

change. Coastal development cannot ignore climate change and development plans should be evaluated with respect to their sustainability under changed climate conditions".

According to Richards and Nicholls (2009), adaptation measures should not be postponed in densely populated and industrial coastal zones. Their calculations indicate that a 'wait and see' strategy generates higher costs in the long run than the costs of protection.

Awareness of the challenges posed by climate change is reflected in coastal policy plans of the North Sea countries. Major features of the coastal policy plans of the North Sea countries are summarised in the following section.

19.3 Adaptation Strategies in the North Sea Countries

19.3.1 Belgium

Most of the effects of climate change at the Belgian coast relate to sea-level rise, resulting in higher storm flood levels, coastal erosion, and deterioration or loss of natural ecosystems, including wetlands. Other impacts associated with higher sea levels are rising groundwater levels and an increase in soil and groundwater salinity in coastal and estuarine areas. Freshwater lenses developed within the dunes are also vulnerable to sea-level rise, leading to threats to drinking water supplies through saltwater intrusion. Climate change will also affect fisheries and coastal tourism (Lebbe et al. 2008; Van den Eynde et al. 2011). One of the most significant social secondary effects is the number of people at risk due to flooding. Economic impacts result not only from direct damage, but also from indirect damage associated with the temporary suspension of production and loss of jobs (Van der Biest et al. 2008, 2009).

The Belgian coastal adaptation strategy for coping with climate change aims at combining flood risk control with the development of ecosystem services (NCC 2010). For controlling flood risks along the Scheldt Estuary, the Sigma-plan has been developed. This provides for the creation of controlled flood zones along the estuary, combining safety against flooding with objectives related to recreation, nature and agriculture.

An ambitious proposal for coastal adaptation has been launched by a group of private investors. The central idea is to combine the need of climate change adaptation with the development of new opportunities for the economy of the Belgian coastal zone. This plan was endorsed by the Flemish government that developed the three-track master plan Vlaamse Baaien (Vlaamse Overheid 2012). This master plan aims at (1) a safe and sustainable coastline with opportunities for economic development, (2) a resilient coastal ecosystem with opportunities for the development of ecosystem services and (3) the establishment of a supportive research platform. The time horizon of Vlaamse Baaien is 2100; the master plan therefore fully incorporates the projected impacts of climate change for this period.

19.3.2 Denmark

The Danish climate adaptation strategy has been elaborated by the Danish Energy Agency (DEA 2008); the strategy for coastal adaptation is mainly concerned with erosion control and protection from flooding. The DEA estimates that opportunities for continuous climate change adaptation in Denmark are generally good.

The DEA reports several climate-related threats. Higher sea levels and stronger storms with higher storm surges are expected. This means an increased risk of flooding and more erosion along many stretches of the coast. Since the strongest storms will come from the west, the increased risk of flooding and erosion will vary widely from the west coast of Jutland, to the Wadden Sea tidal areas and to the interior shores of Danish waters. Moreover, new waterfront construction, port-related operations and sanding up of harbour entrances pose special problems. Cities located at coastal inlets and within fjords may face a very complex set of problems, since they can be under pressure from higher sea levels, increased precipitation and runoff, and changes in groundwater levels.

Increased precipitation, altered precipitation patterns and higher sea levels—with consequent higher water levels in fjords and rivers—will exacerbate problems associated with drainage of low-lying areas, particularly in coastal areas, where about 43 % of Denmark's population occurs. The majority of Denmark's approximately 250,000 summer houses and 73 % of camp sites are within 3 km of the coastal zone. Moreover, increased volumes of water may result in landslides which can affect various types of infrastructure (DEA 2008).

The Danish government considers planning legislation an important means of reducing the negative socio-economic consequences of climate change. Regulations for the coastal zone already restrict new construction areas on open coasts. The Protection of Nature Act 1992 establishes a 300-m protection zone outside urban areas, where most new developments are prohibited, and the Planning Act 1992 defines a coastal planning zone that extends 3 km inland (Gibson 2003). The responsible national authorities continuously evaluate whether there is a need for a follow-up with further restrictions on new building in risk areas. Socio-economic analyses are included as a part of the decision process.

The Danish adaptation strategy allows site owners to raise the beach at their own cost by regular beach nourishment to

combat coastal erosion. The same applies to channel dredging, where the amount dredged can be increased as required. Also in the case of reinforcing dikes/dunes or adapting harbour installations and ferry berths, which are relatively simple constructions, it will be possible for owners to adapt to ongoing climate change. Generally speaking, it is a land owner's own choice whether and how to protect themselves from flooding and erosion. Therefore, there are no general laws or regulations stipulating protection, or to what degree owners must or can protect themselves.

An important source of information is municipal planning, which reflects and adapts to the risks and opportunities brought by climate change. Each coastal town must develop an adaptation plan taking into account climate change impacts in the coastal zone. Municipalities are supported in this task by a National Task Force on climate change adaptation. The coastal adaptation plans focus on shoreline management.

However, the general approach of Denmark's climate policy is a stronger focus on mitigation than on adaptation, with no systematic consideration of sea-level rise in present planning policies (Fenger et al. 2008).

19.3.3 France

France has no national coastal management strategy. Coastal management is the responsibility of municipalities. The Loi Littoral imposes restrictions on urban development plans in coastal areas. These restrictions concern mitigation of coastal hazards, assurance of public access to the coast and protection of the environment. In 2013, the Conseil National de la Mer et des Littoraux was installed for the exchange of views and experience among concerned authorities and civil organisations; the Conseil will contribute to the development of a national coastal management strategy. Specific strategies for coastal adaptation in view of climate change are still in a study phase (Idier et al. 2013).

The French macrotidal coasts along the North Sea and the Channel are mostly fairly stable (Anthony 2013; Battiau-Queney et al. 2003). However, at the Pas de Calais a high rate of sea-level rise has been observed over recent decades (Héquette 2010). Some sites (Wissant, in particular) are subject to severe erosion, requiring the construction of seawalls to protect settlements. Climate change will exacerbate erosion and increase the instability of soft cliffs along the French Channel coast (Lissak 2012).

19.3.4 Germany

According to the National Adaptation Strategy on climate change (GFG 2008), coastal regions will be increasingly at risk from sea-level rise and changes in the storm climate. However, there is great uncertainty about the extent of future changes in sea level and the storm climate. One aspect of special importance is the potential danger to wetlands and low-lying areas and to regions with high damage potential, such as the port of Hamburg. There is also concern about saltmarsh ecosystems (Bauer et al. 2010), safety of the estuaries, erosion on coastlines and beaches, safety of shipping traffic and about the future development of the port industry (Reboreda et al. 2007).

The German North Sea coast is part of the Wadden Sea region. The Trilateral Wadden Sea secretariat has developed a climate adaptation strategy for the Wadden Sea, which has been endorsed by the three Wadden Sea countries—Germany, Denmark and the Netherlands (TWS 2014). This strategy comprises seven basic elements: Natural dynamics, Interconnectivity, Integration, Flexibility, Long-term approach, Site specific approach and Participation.

German coastal states are following a strategy mainly based on hard coastal protection measures against flooding, see Chap. 18. This coastline defence policy entails the risk of coastal squeeze on the seaward side, endangering important coastal ecosystems such as tidal flats (Wadden Sea), saltmarshes and dunes when the sea level rises (Sterr 2008).

The German adaptation strategy also attributes importance to 'soft' auxiliary measures such as research, knowledge dissemination, awareness raising and capacity building. Significant organisational and steering measures are also considered necessary. Above all, the National Adaptation Strategy (GFG 2008) places considerable emphasis on the importance of spatial planning, as a means of making a thorough assessment of all relevant adaptation needs within individual regions. Spatial planning provides a formal means through which all concerned parties are able to present their interests and cooperate in the development of a coherent spatial structure and an integrated programme of measures (Swart et al. 2009).

The national adaptation strategy is implemented at state (Länder) level.

19.3.5 Netherlands

As a low-lying country, the Netherlands is particularly vulnerable to sea-level rise and river floods. The damage costs of climate change impacts without adaptation are likely to be substantially higher than for all other North Sea countries combined (Richards and Nicholls 2009). Major impacts expected are increased flood risk in the historic towns of the downstream section of the Rhine-Meuse delta and shortage of fresh water to prevent salinisation of the polders, when river discharges are low. In wet periods, the present capacity of discharge sluices and pumping stations will be insufficient

to control inland water levels, in particular in the lake IJssel. There are also concerns related to the loss of ecosystem values in the Wadden Sea and in the heavily modified south-western Delta basins. National study programmes have been launched for assessing other potential climate change impacts and for investigating possible adaptation measures (Oude Essink et al. 2010; Klijn et al. 2012).

The Dutch government has designated a Delta Commissioner, who coordinates a national programme for adapting the Dutch water infrastructure to climate change, in order to secure safety against high water and availability of sufficient fresh water. The Dutch adaptation policy follows a risk-based approach, as in the UK. New adaptation measures are implemented when, as a consequence of climate change and other developments, a tipping point is reached, that is, a point where previous adaptation measures are no longer sufficient to keep damage risks below a certain predefined threshold (Kwadijk et al. 2010).

The Water Test is an important legal instrument that requires regional and local authorities to ensure that water issues, including climate adaptation, are taken into account in spatial and land use planning, such that negative effects on the water system are prevented or compensated for elsewhere.

Sediment management (using sand nourishments) and *Making Space for Water* (realignment of dikes) are the major adaptation strategies for the coastal zone (Aarninkhof et al. 2010) and the lowland fluvial system (Menke and Nijland 2008), respectively.

19.3.6 Norway

Although most of the Norwegian coast is not very sensitive to sea-level rise, there is concern for the low-lying areas in the southwest, which are characterised by soft, erosive coasts. Along the western and northern coastlines, the extensive and well-developed infrastructure of roads, bridges, and ferries linking cities, towns, and villages is likely to be adversely affected by sea-level rise, particularly if this is concurrent with an increased risk and height of storm surges. The potential economic costs of rebuilding and relocating infrastructure and other capital assets in these regions may be considerable (Aunan and Romstad 2008).

The Norwegian Water Resources and Energy Directorate has developed a climate change adaptation strategy that includes monitoring, research and measures to prevent increased damage by floods and landslides in a future climate (NME 2009). Under the Planning and Building Act, municipalities are responsible for ensuring that natural hazards are assessed and taken into account in spatial planning and processing of building applications. Adaptation to climate change, including the implications of sea-level rise and the resulting higher tides, is an integral part of municipal responsibilities. To enable municipalities to ensure resilient and sustainable communities, the central government therefore draws up guidelines for the incorporation of climate change adaptation into the planning activities of municipalities and counties.

The premise of the Norwegian climate adaptation policy is that individuals, private companies, public bodies and local and central government authorities all have a responsibility to take steps to safeguard their own property. If appropriate steps are taken, public and private property are protected from financial risk associated with extreme weather events by adequate national insurance schemes.

19.3.7 Sweden

Rising sea levels are expected to aggravate coastal erosion problems in southern Sweden and increase flood risk along the western and southern coasts. As in the other Scandinavian countries, coastal protection policy in Sweden is mainly focused on spatial planning (EC 2009; OSPAR Commission 2009). The Nature Conservation Act of 1974 states that the first 100–300 m of the coast needs to be free of exploitation. Spatial plans of the different municipalities need to comply with this Act. In addition, new development projects must incorporate a certain safety margin to protect against future erosion or higher water levels. To reduce the vulnerability of Sweden's coasts and to adapt society to long-term climate change and extreme weather events, the Swedish Commission on Climate and Vulnerability made the following recommendations in 2007:

- Spatial planning should be considered the most important tool to protect against marine hazards;
- The risks of coastal erosion in built-up areas should be investigated, bathymetric information should be compiled and evaluated, and extreme weather warning systems should be expanded;
- Compensation and subsidy systems for preventive measures for coastal erosion in built-up areas should be developed;
- Areas of the coastal zones without private or public interests should not be protected but given back to the sea (managed retreat).

19.3.8 UK

Major perceived threats are related to coastal protection. Higher sea level and more intense and frequent storms due to climate change will increase damage to coastal defences.

Approximately one third of existing coastal defences could be destroyed if the level of expenditure on coastal defence does not keep pace with coastal erosion in the coming decades (DEFRA 2010, 2012). Extensive coastal erosion around parts of the UK, in particular along estuaries and the east coast, reduces intertidal area (OST 2004). Loss of intertidal areas (coastal squeeze) occurs mainly where hard defences are present. This in turn causes loss of land, property and coastal habitat, particularly saltmarshes and mud flats, which are also bird feeding grounds.

In the UK, policies for adaptation to sea-level rise are more advanced than in most European coastal countries (De la Vega-Leinert and Nicholls 2008). The UK coastal climate change adaptation policy is based on the appraisal method for dealing with the risks of climate change impacts, as outlined in the DEFRA Policy Statement (DEFRA 2009). This appraisal method is based on a comparison of different options (including the managed adaptive approach, the precautionary approach and the no-regret approach) with respect to costs, benefits and residual risk.

The *no-regret* approach is generally preferred where possible. The *managed adaptive* approach aligns with principles in *Making Space for Water*, which promotes a holistic and long-term approach for flood and coastal management, and reinforces existing climate change policy on 'no-regret' actions and longer term adaptation. This approach promotes flexibility in the appraisal options to respond to future change, during the whole life of a measure, as well as the uncertainties (DEFRA 2009). The *precautionary* approach may be adopted where it is not possible to adapt with multiple interventions on a periodic and flexible basis. Figure 19.3 illustrates the different approaches.

'Managed retreat' as an element of coastal management policy has thus far been applied mainly for ecological reasons and where the retreated area has relatively low value.

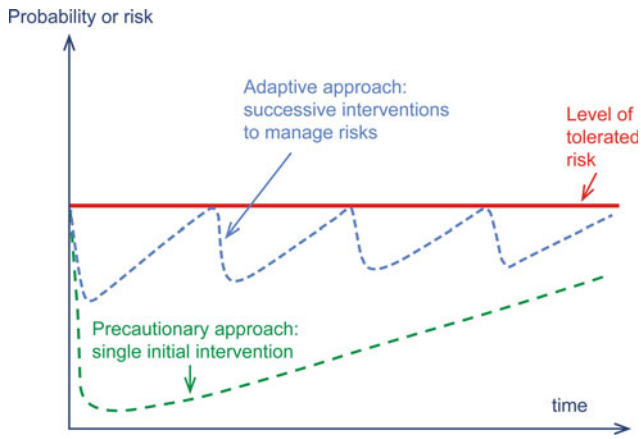

Fig. 19.3 Schematic representation of different adaptation approaches for the UK coastal zones (based on DEFRA 2009)

The Planning Policy Statement (DCLG 2010) obliges local authorities to develop climate adaptation policies and to report on progress. The Marine (Scotland) Act[2] stipulates that forthcoming national and regional marine plans should set objectives relating to the mitigation of, and adaptation to, climate change. An independent UK body, the Adaptation Subcommittee, assesses the preparedness to meet the risks and opportunities of climate change.

In this context adaptation is required to include protecting and restoring marine habitats to increase their resilience to climate change. More than 25 % of English waters is designated as Marine Protected Areas and managed as a network of habitats to aid the movement of species affected by climate change and to decrease threats such as overfishing. The National Heritage Protection Plan sets out how England's landscapes, archaeological sites and historic buildings will be protected from the impacts of climate change. This includes actions such as the continuation of 'Rapid Coastal Zone Assessment Surveys' that record and assess the risk to heritage assets on the coast (DEFRA 2013).

19.4 Governance Issues and Dilemmas for Adaptation

This section compares the various adaptation strategies adopted by the North Sea countries, as well as the dilemmas arising during their implementation and the means by which these dilemmas may be addressed.

19.4.1 Top-Down and Bottom-Up Strategies

The North Sea countries are following different approaches for adapting to change in the coastal zone. In Germany, the Netherlands and Belgium, implementation is steered by national or regional government, whereas in the UK, Sweden, Norway and Denmark, implementation is delegated to local authorities aided by civil organisations and private stakeholders.

Richards and Nicholls (2009) estimated the adaptation costs required for avoiding extra damage related to sea-level rise, and compared them to the costs actually spent on coastal defence measures. They estimated that in Germany, the Netherlands and Belgium more money is presently spent on coastal defence than the avoided damage costs. This can be imputed to a different governance culture, but also to a higher flood-risk awareness and higher standards for acceptable risk. Current adaptation plans in these countries involve large infrastructural projects, with planning

[2] http://www.scotland.gov.uk/Topics/marine/seamanagement/marineact.

procedures similar to other infrastructural projects. National and regional governments bear almost all the costs. In the UK, Sweden and Denmark, governmental steering of adaptation is more indirect, and operates through regulation and guidance. Local and private initiatives play an important role in the implementation plans. In the UK, many local institutions and associations are actively involved in coastal planning and adaptation through the Shoreline Management Planning process.

Several studies (EC 2011; IPCC 2012) have found that national systems play a crucial role in countries' capacity to meet the challenges brought by the observed and projected trends in exposure, vulnerability, and weather and climate extremes. Effective national systems comprise multiple actors from national and regional governments, the private sector, research bodies, and civil society including community-based organisations. Organisations beyond the state are increasingly playing a role in planning and risk management.

Governance theorists highlight different 'modes' of governance, including hierarchies, networks, markets, adaptive management and transition. Coastal management in the North Sea region shares many characteristics with the 'network' mode of governance, focusing on participation, using non-regulatory approaches to achieve progress, and the involvement of multiple actors. However, the evaluation and 'lesson drawing' components have been assessed as somewhat weak (Stojanovic and Ballinger 2009). A key analytical question is which modes of governance have the best 'fit' for the challenges of climate adaptation? (Young et al. 2008).

19.4.2 Public Participation

The recent OURCOAST inventory of coastal management practices in Europe (EC 2011) shows that awareness of coastal and marine issues by the general public and the responsible authorities is strongly stimulated when the public is involved in the development of adaptation strategies. Adaptation strategies are more effective when they are informed by and customised to specific local circumstances and when there is a broadly shared understanding of long-term coastal change. Public participation leads to less conflict between coastal managers or coastal developers and other involved parties. Local populations document their experiences with the changing climate, particularly extreme weather events, in many different ways, and this self-generated knowledge can uncover existing capacity within the community and important current shortcomings. Local participation and community-based adaptation lead to better management of disaster risk and climate extremes. Improvements in the availability of human and financial capital and of disaster risk and climate information customised for local stakeholders can enhance community-based adaptation (IPCC 2012).

Adaptation strategies can widely differ, according to the values to be protected, when, to what extent, how and by whom. The choice between different adaptation strategies is basically a political choice. Valuing coastal assets is intrinsically subjective, even if attempts are made to express some values, such as ecosystem services, in monetary terms. These attempts do not result in generally agreed answers on how to mutually rank different types of damage: loss of human life, loss of economic assets (including ecosystem services), loss of biodiversity and loss of cultural values.

According to the EEA (2006), there is often a fundamental conflict between protecting socio-economic activity and sustaining the ecological functioning of coastal zones in Europe under conditions of rising sea level—a conflict that cannot be resolved by technical or scientific means. Integrated, long-term coastal management should not be exclusively orientated to physical planning and technical solutions, but to combinations of social and physical management mechanisms. The policy and governance strategies for coastal conflict and natural resource management should therefore be improved by developing adaptive, participatory and multi-scale governance (Stepanova and Bruckmeier 2013).

Prerequisites for public participation in coastal adaptation strategies include: political legitimacy through securing broad political support; a process-driven approach in an inclusive, voluntary and culturally sensitive manner; the empowering of historically disadvantaged individuals, groups and communities; building partnerships to provide the basis upon which stakeholders can learn about and appreciate the interest of others; deepening public deliberation through alternative forums and participatory methodologies; and promoting innovation, reflection and feedback in response to changing circumstances and stakeholder interests (Henocque 2013).

Social Impact Assessment (SIA) has been proposed as an instrument to reduce likely future expenditure by the early identification and resolution of potential issues that could otherwise lead to litigation, delays to approval, costs in the form of managing protest actions, and business lost through reputational harm (Vanclay 2012). However, there is little practical experience with SIA to date.

19.4.3 Uncertainty and Awareness

North Sea countries will have to face the implications of climate change and some impacts are already occurring. However, separating the impacts of climate change from change resulting from other natural or human causes is far from obvious. This is illustrated by a study of past

ecosystem shifts in the North Sea region. There is evidence, for instance, that these regime shifts are related to decadal-scale fluctuations in the North Atlantic Oscillation index (Kröncke et al. 2013). The full long-term impacts of climate change are still uncertain, especially the question as to when they will occur. For instance, present data do not yet show clear evidence for an increase in the average rate of sea-level rise in the North Sea region (NOAA 2015).

Uncertainty is a serious (perhaps the most serious) obstacle to raising public awareness and to getting climate adaptation high on the political agenda, compared to issues with a more immediate impact (EEA 2014). Uncertainty about the possible impacts of climate change is not the only reason for this. The fact that the greatest impacts are related to exceptional extreme events, plays also a role. According to an enquiry among policymakers, the occurrence of an extreme weather event is presently the most important trigger for progress in climate adaptation (EEA 2014).

While some countries—especially those with low-lying coasts—are traditionally alerted to sea-level rise and flooding, awareness is still low in other countries (Ruprecht Consult 2006). Due to the absence of recent coastal flood disasters in North Sea countries there is a risk of decreasing societal awareness and support for protection measures in specific, flood prone areas. This highlights the need and importance of risk communication and awareness raising to ensure the continuity and support for coastal risk management strategies (Safecoast 2008).

In the Netherlands, risks associated with climate change are made more tangible through tipping-point analysis. This involves testing the robustness of existing policies for addressing anticipated climate-driven changes in environmental conditions, such as temperature, precipitation, and sea level. 'Tipping points' are the thresholds in future environmental conditions at which existing policies fail to keep risk (potential damage) within acceptable limits. Awareness of these tipping points guides policymakers to prepare the necessary adaptation strategies, even if uncertainty remains regarding the timing of required adaptations (Kwadijk et al. 2010).

Greater awareness can also be pursued by internalising costs. Development projects in the coastal zone often increase climate change adaptation costs. According to the EUROSION study (Doody et al. 2004), the costs of reducing coastal risks are mainly supported by national or regional budgets in the North Sea countries and almost never by the developers or the owners of assets at risk. Only in Denmark and Sweden are adaptation costs (partly) supported by owners and the local community. Hence, risk assessment is hardly incorporated in decision-making processes at the local level and risk awareness of the public is poor. The impact, cost and risks associated with coastal development are better controlled through internalising adaptation costs in planning and investment decisions: thus an appropriate part of the risks and risk mitigation costs is transferred to the direct beneficiaries and investors. Risk monitoring and mapping is a prerequisite for incorporating risk into planning and investment policies. The distribution of risks and costs requires due consideration of the interests of all stakeholders in order to guarantee social justice (Safecoast 2008; OST 2004).

19.4.4 Risk-Based Adaptation

The largest climate change impacts in the coastal zone result from extreme events which have a low probability of occurrence within a given time interval. The concept of risk, defined as the product of probability of occurrence and resulting damage, provides an objective measure for the need to adapt to such impacts. By evaluating what damage is avoided at what costs, informed choices can be made among different adaptation strategies. Coastal adaptation strategies of the North Sea countries are increasingly based on risk management considerations. Uncertainty in the probability of occurrence and uncertainty in the extent of damage can be incorporated in risk estimation—for instance, by defining probability distributions for all variables and using a Monte Carlo method. The application of the risk concept in adaptation strategies is limited, however, by the difficulty of quantifying uncertainty in the probability of occurrence and by the more fundamental difficulty of predicting possible damage caused by rare extreme events.

A further complication arises when a choice has to be made among different possible adaptation measures: which temporal and spatial scales must be considered when these measures are evaluated through ranking methods such as cost-benefit, cost-effectiveness or multi-criteria analyses? This choice strongly influences the results. This complication is enhanced by uncertainty about the future in general. How are present values affected by other future global or local change, in addition to climate change? The combination of these different sources of uncertainty is sometimes termed 'deep uncertainty'.

Scenarios provide a way to deal with limitations related to quantifying uncertainty (the probability that some damage will occur) and to quantifying possible damage (loss of certain values). Scenarios describe different futures that can be imagined. These scenarios should be internally consistent, but need not necessarily be expressed in terms of probability and money. Their main function is to open those who are involved in climate adaptation to the wide spectrum of situations and adaptation options that should be considered. Scenarios help in avoiding suboptimal sector approaches and a unilateral focus on certain adaptation options, which are major shortcomings of present coastal adaptation strategies

in the North Sea countries (EEA 2005). But scenarios do not of course, in themselves, answer the question as to which adaptation strategy of the options available should be preferred.

The EEA (2007) has provided methodological guidance for quantifying and costing climate change impacts at the global and regional scale. These methods include: treatment of scenarios (both climate and socio-economic projections); issues of valuation (market and non-market effects); indirect effects on the economy; approaches taken to spatial and temporal variation; uncertainty and irreversibility (especially in relation to large-scale irreversible events); and coverage (which climate parameters and which impact categories are included). However, there is limited application of exploratory scenarios at the local level and those applications involving local stakeholders are even rarer. This highlights the need for pilot projects to evaluate, demonstrate and disseminate the effectiveness of scenario approaches to the ICZM community, including predictive, exploratory, and normative scenarios (Ballinger and Rhisiart 2011). To date, few projects have attempted to downscale SRES scenarios to the regional and local level in the North Sea region (Andrews et al. 2005; Holman et al. 2005a, b; Nicholls et al. 2006).

19.4.5 Adaptation Pathways

There is broad agreement that adapting to the impacts of climate change is inevitable and that preparatory actions should already be initiated. But once it becomes clear that a fundamental revision of present coastal policies is needed, questions arise as to which actions are most appropriate to cope with the impacts of climate change at the long term. Revised policies need to deal not only with uncertainty related to the future impacts of climate change, but also with uncertainties related to future social and economic developments. A blueprint plan is inadequate, as the future can unfold differently from what is anticipated. Actions that are appropriate for the foreseeable future could turn out to be inadequate for the long term and could even hinder actions that may become necessary later.

One way of dealing with this problem of 'robust decision making' is the strategy of adaptive pathways (Hallegatte 2009). According to this strategy, adaptation pathways are developed that comprise different sets of successive adaptation actions. Each pathway leads to successful long-term adaptation within a particular scenario of climate change and socio-economic development. Analysis of the different pathways enables the selection of short-term actions that are suitable (no adverse lock-in effects) within different scenarios. The most promising actions are those with the best performance in terms of societal benefits and costs. The exercise of pathway definition and analysis is repeated when new follow-up actions become needed; the lessons of the first actions ('learning-by-doing') as well as the latest knowledge of climate change and socio-economic development serve as input. A sophisticated version of this approach ('strategy of dynamic adaptive policy pathways') was used to underpin the Dutch Delta programme for adaptation to climate change (Haasnoot et al. 2013). A similar method has been developed by Sayers et al. (2013) and applied to the Thames Estuary, UK (McGahey and Sayers 2008).

19.4.6 No-Regret Adaptation Strategy

The measures envisioned in the North Sea countries for adaptation to climate change are similar. Preference for certain measures depends on the nature and seriousness of the climate change threats and on social acceptance. In all North Sea countries there is consensus that adaptation to climate change is inevitable and that some action is already required. Climate change projections for the economic life cycle of coastal infrastructure are currently incorporated in the development of long-term investment plans. This is done, for instance, by adjusting design criteria for the renovation of coastal protection works (see Chap. 18). Spatial planning is recognised as a key instrument for the integration of adaptation measures in a broader coastal management policy and for taking into account developments at larger temporal and spatial scales. Spatial reservations are made for future reinforcement or realignment of coastal defences, and set-back lines for new buildings in the coastal zone are revised. In most North Sea countries, studies are undertaken on how far adaptation should go and whether investment can be postponed. At present, no major public investments are being made with the sole purpose of long-term climate change adaptation.

There is an increasing preference for flexible measures with as much as possible a no-regret character. Potential low-regret measures include early warning systems; risk communication between decision makers and local citizens; sustainable land management, including land use planning; ecosystem management and restoration; improvements to water supply, sanitation, irrigation and drainage systems; climate proofing of infrastructure; development and enforcement of building codes and better education and awareness (IPCC 2012). Such measures deliver additional benefits, such as opportunities for tourism, recreation, nature development and other ecosystem services.

Beach and shoreface nourishment and wetland restoration are examples of no-regret measures already practiced in North Sea countries. They are often part of a broader water

management strategy that includes land-use planning in the upstream catchment area. Such measures are implemented step-wise, allowing for adjustment when better knowledge of the impacts of climate change impacts becomes available. They also respond to the insight that natural dynamics generally offer greater long-term resilience (self-regulating capacity) against climate change impacts than hard man-made structures (Dronkers 2005).

An important notion in this context is that present levels of greenhouse gases already imply a commitment to sustained adaptation for several centuries to come (Nicholls et al. 2007; Wong et al. 2014). In some cases, this might lead to more radical strategies, such as the wholesale re-location of coastal settlements, or design of housing infrastructure which can cope with being regularly inundated.

19.4.7 Knowledge and Monitoring

Adaptation efforts benefit from iterative risk management strategies because of the complexity, uncertainties, and long time frame associated with climate change (IPCC 2012). An iterative risk management strategy consists of an iterative process of monitoring, research, evaluation, learning, and innovation. Addressing knowledge gaps through enhanced observation and research reduces uncertainty and helps in designing effective adaptation and risk management strategies.

Because uncertainty is a major obstacle to preparing for climate change adaptation, more reliable predictions of climate change and its impacts are needed (EEA 2014). Many studies address climate change prediction at the global scale. However, there are indications that global-scale projections of climate change may not be representative for the North Sea region, especially in relation to the characteristics of the North Atlantic Gulf Stream (Nicholls et al. 2007). Better understanding of the coupled ocean-atmosphere system for the North Atlantic is therefore a highly relevant and urgent research topic (Vellinga and Wood 2007; Rahmstorf et al. 2015).

Monitoring is also essential for a better understanding of climate change impacts in the North Sea coastal and marine zone. Many data are collected within the different North Sea countries, by public agencies, research institutes and private companies. However, the European Commission (EC 2010) notes that "There are restrictions on access to data, and on use and re-use. Fragmented standards, formats and nomenclature, lack of information on precision and accuracy, the pricing policy of some providers and insufficient temporal or spatial resolution are further barriers." It may be expected that the situation will improve by progress in the implementation of the EU Water Framework Directive, the EU Marine Strategy Framework Directive and the EMODnet marine data network (EC 2012).

A better coordinated and more consistent approach to marine monitoring is essential for a proper analysis of change in the coastal and marine system. This analysis should focus on establishing cause-impact relationships, which make it possible to distinguish climate change impacts from natural variability and other impacts. Monitoring data are often not directly fit for policy evaluation; translating data into indicators pertinent to policy making is a further subject of special attention (Breton 2006; Martí et al. 2007; EEA 2012). This kind of knowledge is crucial for informing policy and the general public and for developing the adaptive capacity of institutions and wider society.

19.5 Summary and Conclusions

1. Strategy

All North Sea countries have developed a climate adaptation strategy. In these strategies special consideration is given to the coastal zone.

2. Perceived Risks

The North Sea countries consider flooding by the sea and coastal erosion as major climate-related coastal risks.

3. Aggravation of Existing Trends

Several studies show that climate change will enhance erosion and habitat loss that occur already, as a result of existing pressures related to use and development of the coastal zone.

4. Governmental Steering

In all North Sea countries, actors at national and regional level have been designated for initiating and coordinating adaptation to climate change. In the Netherlands, the country with the highest number of potentially threatened people, a special governance mechanism, the Delta Commissioner, has been created.

5. Centralised Versus Decentralised Implementation

In Germany, the Netherlands and Belgium coastal adaptation is steered by national and regional programmes and plans. In the UK, Denmark, Sweden and Norway, regional and local governments are responsible for adaptation; coastal communities have the duty to develop adaptation plans and to report (in the UK) on the implementation progress.

6. Public Participation

In all North Sea countries, adaptation plans are subject to public consultation. The UK and the Scandinavian countries pursue active public involvement by accruing adaptation responsibilities to private stakeholders.

7. Risk-Based Adaptation

In all North Sea countries some form of risk assessment (comparison of adaptation costs with costs of avoided risks) is considered for the prioritisation of adaptation measures. However, at present there is no generally accepted methodology.

8. Uncertainty

Uncertainty about the extent and timing of climate-driven impacts is a major obstacle to political and public mobilisation on the issue of climate adaptation. Different methods to deal with uncertainty of climate impacts are being developed, involving scenario development, tipping point analysis and more robust decision-making techniques (such as adaptive pathways).

9. No-Regret Measures

In view of the uncertainties, adaptation plans focus on no-regret measures. The most considered measures in the North Sea countries are spatial planning in the coastal zone (set-back lines), wetland restoration, coastal nourishment and reinforcement of existing protection structures.

10. Monitoring and Research

The climate of the North Sea countries is strongly influenced by the North Atlantic Oscillation (NAO) and the Gulf Stream. Better understanding of ocean-atmosphere dynamics in the North-Atlantic region is important to reduce the uncertainty in climate predictions for the North Sea region. The difficulty of identifying the climate-related component in observed changes of physical and biological parameters in the coastal zone is a critical obstacle to obtaining a widely shared understanding of the urgency of adaptation. A dedicated coastal observation network is not yet in place in the North Sea region.

Box 1

Working definitions of key terms used within this chapter

Governance: The exercise of political, economic and administrative authority in the management of a country's affairs at all levels. Governance comprises the complex mechanisms, processes, and institutions through which citizens and groups articulate their interests, mediate their differences, and exercise their legal rights and obligations (UNDP 1997).

Integrated Coastal (Zone) Management: A continuous process of administration, the general aim of which is to put into practice sustainable development and conservation in coastal zones and to maintain their biodiversity. This involves the coordinated management and synchronised planning of multiple issues and areas of overlapping interest (EC 1999). In Europe this has been characterised by the implementation of the EU Recommendation on Integrated Coastal Zone Management (cf synonyms ICM, ICZM, CZM, ICAM.).

Shoreline Management Planning: Strategic approach to managing the risks of coastal flooding and erosion, especially as they relate to changes in coastal processes (DEFRA 2009).

Coastal Adaptation: Efforts and actions (in the coastal zone) targeted at vulnerable systems to deal with actual or expected problems with the objective of moderating harm (IPPC 2001).

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