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Partnership for Risk Reduction

ENHANCE

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SEVENTH FRAMEWORK PROGRAMME

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Executive summary

Case study number 3 focuses on the region of the Wadden Sea along the Dutch, German and Danish North Sea Coast. Similar to other coastal zones in Europe as well as on a global scale, the Wadden Sea Region represents an intensively used area in terms of agriculture, infrastructure and energy production. Representing a transitional zone between the North Sea and the mainland, the Wadden Sea Region is especially threatened by hydrological hazards. Meteorological conditions (depression systems crossing the North Sea on specific tracks) as well as morphological conditions (shallow water areas in front of the mainland) constitute preconditions for the occurrence of storm surges, which cause high water levels along the coast. In addition to this hazard, the Wadden Sea Region is exposed to heavy rainfall events and heavy storm events. In terms of long-term developments, most of all the rise in sea level has threatened the coastline for centuries. With regard to climate change, threats will increase in the future. These hazards, especially storm surges, put coastal societies at risk as long as people do settle in this region.

The long historical experience in managing risks along the coast is a key characteristic of the investigation area of the Wadden Sea Region. For centuries, major threats such as the increase of the mean sea level and periodic storm surge events have repeatedly caused huge damages and losses of life, land and goods. In order to handle these risks, inhabitants of the Wadden Sea Region have developed different kinds of adaptation and protection measures. Construction measures to protect settlements and agricultural areas against storm surges and increased sea level have changed over time and have generated profound transformative processes in the Wadden Sea landscape. These continuous processes of handling risks can be considered as important elements of framing the perception and cognition of individuals as well as of society and represent an important element of spatial development and land use in the Wadden Sea Region. Currently applied risk management strategies to manage coastal protection issues are focused mostly on highly developed technical and construction measures. In all three countries, actors of the public sector – such as ministries, authorities, municipalities etc. - are exclusively responsible for coastal protection. These processes are characterized by stringent, hierarchical top-down decision-making processes. In all countries of the trilateral Wadden Sea Region, coastal protection has priority over other concerns along the coast. This high level of priority is reflected in the high construction and technical standards which were established with a huge amount of funds for construction programs as well as funds for scientific and technical enhancement.

The success of technical measures apparently creates a feeling of security among the affected population and responsible actors. However, focussing on this technical / construction risk management strategy has created a mental lock-in in which continuous, successful investment in construction measures hinders a perspective on non-technical or mixed adaptation measures and strategies.

Vulnerability will notably rise in the Wadden Sea area and will require new challenges in risk management, in particular with regard to the increasing uses of the Wadden Sea Region in the future, increased population density and accumulation of values in urban coastal areas as well as climate changes. The currently applied top-down decision-making processes

implemented by governmental actors will not be an adequate answer to these future challenges. Multifaceted future risks and challenges require collaborative processes including stakeholders from all affected sectors in order to manage these risks. Case study research will initiate a dialogue on the challenges of and the opportunities for strengthening risk management strategies within the Wadden Sea Region to increase resilience against storm surges, heavy rain and storm events as well as long-lasting sea level rise.

It is the aim of the case study to include all affected stakeholders in this communication process and make use of the extensive historical experiences in risk management in the Wadden Sea Region.

The investigation area is highly characterised by trilateral objectives and approaches which can also be used in the ENHANCE North Sea case study. In addition to common approaches, regional strategies provide opportunities to analyse different strategic ways of working with the same problem. Strengths and weaknesses in current risk management can be worked out through detailed analyses of historic experiences as well as current applied strategies for managing risks along the Wadden Sea coast.

The current coastal protection management, which is dominated by hierarchical top-down decision-making processes, involves mostly governmental actors. Today's high protection level is mainly based on construction protection measures. Future challenges resulting from climatic and socio-economic changes will go beyond the construction limits of coastal protection facilities. Dealing with these future challenges requires a shift in mental concepts about risks in order to meet increased future risks. An extended time horizon in coastal protection management is needed as well as the integration of more flexible options to adapt to future challenges regarding current uncertainties about climate change issues.

Governmental actors will not be able to handle these challenges alone anymore. Managing increased risks also requires integrating stakeholders from different sectors in reframed coastal zone management strategies. A shift from governmental-steering management strategies to cooperative management systems integrating stakeholders from different sectors is needed. This shift towards enhanced governance processes provides potential capacity for new multi-sector partnerships in risk management in the Wadden Sea Region, especially in profound storm surge management.

In this respect, the ENHANCE case study will introduce perspectives for new MSPs, especially with regard to long-term changes in coastal protection strategies. The case study seeks to bring stakeholders together in workshops, where dialogues should be initiated and fostered between different stakeholders. Communication and discussions are essential in order to initiate changes in mental constructions about reframing risk management in coastal protection, displacing construction-dominated strategies with more flexible and multi-facetted risk management strategies. Based on this, analyses about risk awareness, risk perceptions and different stakeholder points of view in risk management will provide a scientific basis to start a communication process between different stakeholders. Close collaboration with the responsible stakeholders/institutions about the working processes will ensure a process of developing joint visions which can lead to feasible adaptation approaches. This will meet the requirements for managing current and future risks as well as uncertainties along the North Sea coast by multi-sector partnerships.

Contents

1 Introduction and motivation

The region of the Wadden Sea along the Dutch, German and Danish North Sea Coast is an area of profound transformative processes, resulting from natural forces as much as human activities. Regarding natural forces, storm surge events pose major risks to the Wadden Sea Region. Periodic storm surge water levels are caused by specific meteorological conditions (depression systems within the extra tropical west-wind-zone crossing the North Sea on specific tracks) above the North Sea and affect the shallow water areas as well as the river deltas along the coast. Beside this hazard, the Wadden Sea Region is additionally exposed to heavy storm and heavy rainfall events which can lead to flooding events in the hinterland. In terms of long-term developments which put risks on the Wadden Sea coast, especially sea level rise has threatened the coastline for centuries and will most probably increase due to climate change. Increased water levels will escalate the difficulties of coastal protection as well as draining the low-lying marshes behind the dykes.

The hazards mentioned above have put coastal societies at risk as long as people have been settling in this region. The North Sea coast, especially the Wadden Sea Region, has been a preferred settlement area for centuries. This long-lasting cultural-historical development is characterised by a fight against the sea, especially against disastrous damages and losses caused by storm surges. This continuous fight can be considered an important element of framing the perception and cognition of individuals as well as the society in the area. In addition, historic development represents an important framing element in spatial creation and construction of land use in the Wadden Sea Region.

Since the last disastrous storm surge events 1953 and 1962, large changes in coastal protection strategies have been initiated. Key elements of these strategies are immense financial and technical input. Resultant construction improvements of coastal protection facilities have been major objectives in order to create a high level of safety against storm surges. Since the improvements after 1953 and 1962, the construction facilities have resisted all storm surges that have occurred so far. Trust in construction measures and coastal engineering is manifest in society and among the responsible actors.

Currently there is a high standard of coastal protection along the Wadden Sea coast in urban and rural areas. This high standard co-occurs with a deep trust in coastal engineering capabilities. Nevertheless, the existing considerable low level of vulnerability is still accompanied by residual risks. Construction elements can never be totally safe. In addition, prospected climate change with intensified storm activity and sea level rise can increase vulnerabilities and residual risks in the area. These future challenges will go beyond the capacity of the existing coastal engineering capabilities and beyond financial scopes. Construction-dominated coastal protection measures and strategies themselves will reach their limits, especially with the challenges caused by future climate change impacts. These future impacts need to include an extended time horizon in storm surge management. For the future, it will be necessary to integrate more flexible options to adapt to future challenges regarding current uncertainties. The upcoming challenges require a transformation of the current applied storm surge protection management with the objective of managing future risks and uncertainties in the region of the Wadden Sea. After centuries

of fighting against the sea there is a need to rethink and re-orientate coastal protection. This is not only a challenge for the coastal engineers but also for the people living along the coast.

After hundreds of years fighting the sea, followed by decades of secured storm surge management, people feel safe behind the dykes. The current state-of-the-art in coastal engineering protection measures is characterized by an ample trust among the population. For the majority, there is no alternative to fighting the sea: they are locked in to a deep trust in only coastal engineering. But the above-mentioned changes in coastal management strategies have to include changes on all levels. It will be a major challenge to communicate advantages about reframing coastal protection management to potential stakeholders and to society.

Over the years, the population along the Wadden Sea coast has shifted the responsibility for storm surge protection and coastal management to governmental institutions. Coastal protection as well as storm surge management is driven by top-down governmental decision-making processes. However, improvement in future coastal protection management must be accompanied by a widening of the perspective on coastal protection and an inclusion of stakeholders and society. Multi-sector partnerships (MSPs), which are the main focus of the ENHANCE project, offer a perspective to initiate cooperative processes including different stakeholders in order to activate reframing of risk management in the Wadden Sea region.

The aims of the ENHANCE case study are to analyse current stakeholder involvement and to develop potential perspectives for new, multi-sector cooperation between stakeholders from governmental (currently involved stakeholders) and non-governmental institutions. This cooperation will strengthen management strategies regarding (future) risks and uncertainties in the Wadden coastal area. Analysing the capabilities of the storm surge management currently in use in the Netherlands, Germany and Denmark will provide the basis to identify potential partnership MSPs in the Wadden Sea Region. Getting stakeholders together in workshops will enable the case study to create communication and potential cooperation between governmental and non-governmental institutions. Communication and discussion are needed in order to initiate changes in mental constructions, reframing risk management in coastal protection and leaving construction-dominated strategies in favour of more flexible and multi-facetted risk management strategies.

Close collaboration and feedback with the current responsible stakeholders/institutions will ensure a process of developing visions which can be advanced into feasible adaptation approaches to manage current and future risks and uncertainties in MSPs. With regard to these visions and potential multi-sector cooperation, acceptance amongst stakeholders and society for new management strategies and tools will be increased. Especially acceptance amongst society is a basis for future dealings with uncertainties and hazard events.

1.1 Risk culture and risk perception

The Wadden Sea Coast is characterized by the fight against the sea and the reclamation of land over centuries (for a short overview see 2.1.1). It is assumed that this historic cultural development has influenced the perception and cognition of risks in society. In addition, an

influence on framing of spatial creation and land use during the centuries is assumed. Long-lasting cultural-historical development with special focus on managing hydrological risks represents a specific characteristic of the case study area. This key characteristic as well as the geological circumstances distinguish the North Sea case study from other hazard case studies in the ENHANCE project. The case study will undertake a detailed analysis on cultural-historic development in order to respect and include the culture of risk in this area. The trilateral research area offers a basis to identify if there are different kinds of risk cultures (e.g. related to the three national states) in the area, handling the same risk in a different way.

Potential influence of risk awareness and perceptions of society at large and the stakeholders on current and future risk management strategies will be analysed considering the historic development. Results should be transferred to the formation of new cooperative partnerships which might handle future storm surge management.

The scope of research will include the analysis of risks and uncertainties, the analysis of respective management strategies and the detection of people's and stakeholders' risk awareness, perception and possible mental lock-ins as obstacles for future changes. The results will help to understand the culture of risk that exists in the societies in the North Sea States. Risk culture and risk perceptions are important driving factors in risk management which requires a discussion about risks as a mental construction. Despite the huge variety of definition of risks[1], for ENHANCE risk should be understood as a result of different mental constructions that result from the perception of each affected person as well as their interpretations and responses which depend on social, political, economic and cultural contexts and judgments (comp. Luhmann 1993; IRGC 2005). Single actors as well as societies are involved in the process of perceiving risks. Hence, evaluation of risks is a process taking place within societies (Renn et al. 2011).

Reframing risk management strategies at the Wadden Sea coast is directly linked to communication about and sharing of different risk perceptions between affected stakeholders and the population at large in the affected area. The currently existing mental lock-in, characterized by focusing primarily on construction- and engineering-dominated coastal protection measures, requires intensive discussion between all affected stakeholders and in society about how to handle uncertainties in the Wadden Sea Region under current and future climate conditions. Successful implementation depends on increased communication between stakeholders from different sectors as well as implementing new collaborative actions to increase risk management in the Wadden Sea Region. The case study is based on a regional analysis of risk perception and risk culture (including the topic of *heimat*) in Germany (comp. Ratter et al. 2009).

[1]In economics: the possibility that an event will occur, which will impact an organization's achievement of objectives; Sociology: risk is defined as an inherent characteristic of decisions in the light of hazardous events (Luhmann 2003, Renn 2008, Birkmann 2012); risk management: risk is defined as a function of the probability or threat of quantifiable damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action (comp. UN/ISDR 2004).

1.2 The Wadden Sea research area

The Wadden Sea is the largest and most important marine wetland in Europe (Enemark 2005). Its coherent tidal flat area is situated along the Dutch, German and Danish North Sea Coast, incorporating the coast from Den Helder (Netherlands) to Esbjerg (Denmark). The area is mainly characterized by intertidal sand and mudflats, which are periodically flooded during high water. Landwards these areas move on to floodplains (foreland), where flooding is less rare than in the tidal flats. The adjacent elements of salt marshes, representing the main landward landscape elements, are nearly completely cut off from tidal range by dykes (Reise 2005). The embankments of salt marshes mark a huge large-scale habitat transformation of the landside area of the Wadden Sea into a heavily human-altered and intensively used area behind the dykes (Lotze et al. 2005). Embanked marshes can be found under different designations: 'polders' in the Netherlands, 'Groden' and 'Köge' in Germany and 'koge' in Denmark (Wadden Academy 2013). Similar to the intensified use of low-lying, fertile areas behind the dyke, most of the barrier islands in the Wadden Sea Region are inhabited and have been used for centuries. The barrier island system separating the Wadden Sea from the open North Sea serves as a natural buffer in terms of protecting the mainland against storm surges. In general the Wadden Sea can be differentiated in two different regions, in which both are dominated by an important barrier island subsystem: the West and East Frisian islands, which extend from the island of Texel (the Netherlands) to the area between the Weser and Elbe estuary in Germany; and the North Frisian islands extending from the Elbe estuary to the Skallingen peninsula in Denmark (Oost et al. 2012). Since 2009, parts of the Dutch and German Wadden Sea Region have been designated a UNESCO World Heritage Site (CWSS 2010). The protected area includes 4,700m² of intertidal flats, which emerges to its full extent during low tide (Kabat et al. 2008).

For the case study area we include the seaward areas of the Wadden Sea, the bordering North Sea as well as the affected landside – where hydrological threats put risks on inhabitants and areas in human use. The ecosystem of the Wadden Sea represents, amongst other capacities, a buffer system for the storm surges. The North Sea represents key elements from which both the hazard of single storm surge events as well as long-term threats such as sea level rise originate. For the landward limitation of the research area, the case study will follow the definition of the Wadden Sea Forum, encompassing the administrative units of municipalities/counties/provinces in all three countries along the Wadden Sea (comp. Figure 1).

In general, the Wadden Sea Region can be characterized as a rural area. The most important small- and medium-sized towns are Esbjerg (DK), Emden, Wilhelmshaven, Bremerhaven (GE), Leeuwarden and Groningen (NL) (see Figure 1).The landward part of the Wadden Sea research area comprises approximately 22,000 km², where more than 3.5 million inhabitants live (2012). The highest population numbers can be found in Germany (52.5 % of the total population 2011), followed by the Dutch Wadden Sea Region with 42.2 % and the Danish Wadden Sea Region with approximately 5.5 % of the population of the Trilateral Wadden Sea Region.

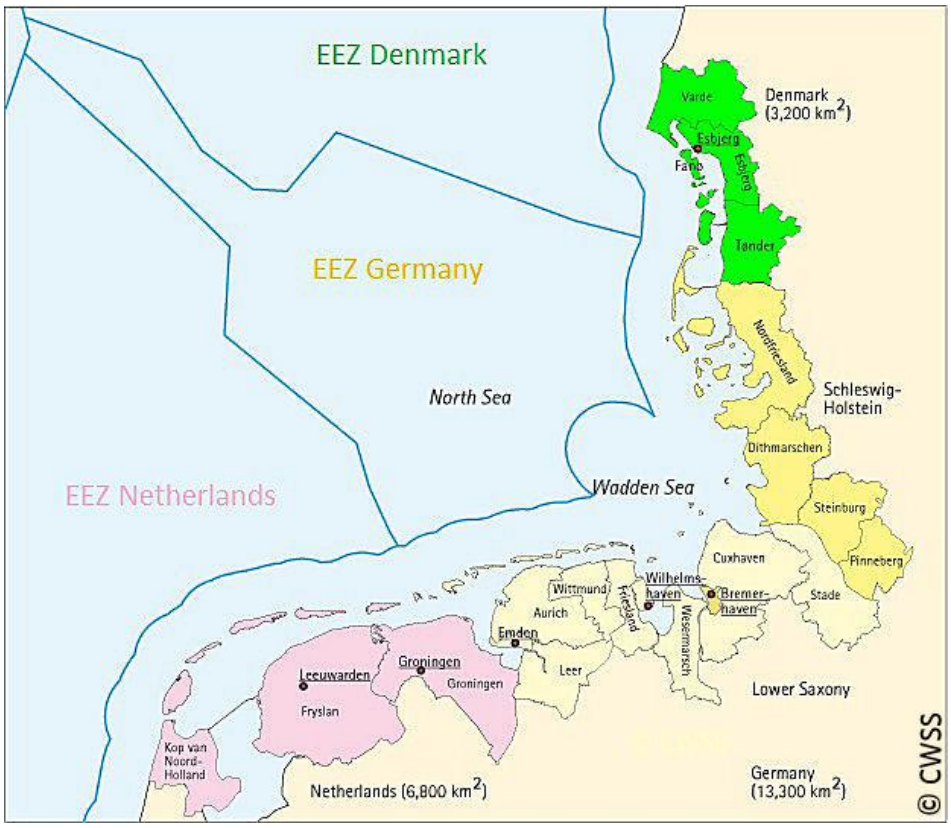

Figure 1 The Wadden Sea Region, as defined by the Wadden Sea Forum
Sources: Common Wadden Sea Secretariat (CWSS) EEZ: Exclusive Economic Zone

During the past years[2], a population decline can be observed in most of all Danish municipalities and German counties ([Land]Kreise) (2009-2011[3]). A slight population growth can be observed only in the Dutch provinces. With regard to demographics, the Wadden Sea Region has a relatively small share of young inhabitants (15-24 years, compared to the total national population[4]). Exceptions can be found e.g. in Groningen, which is most probably due to the existence of the university (Sijtsma & Mehnen 2013). Nevertheless, even the number of young inhabitants is decreasing in the Dutch Wadden Sea areas. In contrast, the share of older inhabitants in relation to the total population increased (2003-2011) in the whole Wadden Sea Region.

1.3 Cooperation history in the Wadden Sea

Since 1978 the three countries along the Wadden Sea have cooperated in the Trilateral Wadden Sea Cooperation (TWSC) in order to protect and manage the common ecosystem of

[2] years 2002, 2009-2011 are evaluated
[3] available data for specific research area from WSF
[4] data from 2003-2011, Source WSF, based on Statistics Denmark, Statistics Netherlands, Regionaldatenbank Germany

the Wadden Sea. In 1982 a Joint Declaration of Protection of the Wadden Sea was agreed on and the Common Wadden Sea Secretariat was established five years later for its coordination (Reise 2013). The three countries declared their intention to coordinate their activities and measures for the protection of the TWSC Wadden Sea Region (Kabat et al. 2012). Although it is a ministerial declaration at a national level, the Joint Declaration of Protection of the Wadden Sea is not legally binding. Agreed measures and tools have to be incorporated into national policies and implemented according to national laws (in Germany at the federal state level). The Trilateral Wadden Sea Cooperation has the aim of protecting and conserving the Wadden Sea as an ecological entity by implementing shared policies and management strategies with the main focus on conservation issues. Collaborations with national and regional authorities as well as scientific institutions have been established by the Trilateral Cooperation. Results on ecosystem studies and conducted monitoring and assessment programs formed the basis for the Wadden Sea Quality Status report (1991) and influenced the adaptation of the trilateral management plan which was adopted in 1997 and updated in 2010 (Kabat et al. 2012; CWSS 2010).

In 1985 and 1986 parts of the German Wadden Sea were declared as National Parks (Reise 2013). In 2009 the UNESCO included the Dutch and German part of the Wadden Sea on the World Heritage List (CWSS 2010, Enemark 2005, Vollmer et al. 2001).

Over time, the main targets of the Trilateral Wadden Sea Cooperation protecting and restoring the Wadden Sea ecosystem were framed into a broader collaboration for sustainable development beyond the trilateral cooperation area. Stating that "there was an imbalance between nature protection and the social and economic development of the region and that nature protection rules and regulations would hamper socio-economic developments" (Wadden Sea Forum 2005, p. 8), the TWSC decided to establish a cooperative forum for governmental and non-governmental stakeholders. In 2005 the Wadden Sea Forum (WSF) was established in order to elaborate proposals for sustainable-development scenarios and strategies respecting the existing protection level and ensuring economic development and quality of life in the Wadden Sea (Wadden Sea Forum 2005). The WSF acts to support environmental protection and nature conservation activities by bringing together stakeholders from different sectors. These stakeholders represent those who live, work and recreate in the area and are willing to endow its protection (Wadden Sea Forum 2011).

An active cooperation between governmental authorities in the Trilateral Wadden Sea Cooperation has been in existence for more than 30 years. Stakeholder cooperation meanwhile can look back on a history of almost 10 years of established Wadden Sea Forum work. The ENHANCE case study will tie in on this long-lasting cooperation, which has primarily focussed on nature conservation and integrated coastal zone management in the area. As a project partner, the Wadden Sea Forum provides extensive experience in stakeholder participation. This experience is taken as the basis for increased collaboration as well as for work on successful multi-stakeholder partnerships.

2 Hazard, vulnerability and risk assessment

The Wadden Sea Region was created by and has always been affected by hydrological events. Single events of increasing water level based on specific meteorological conditions affected the area as well as long-lasting continuous changes in hydrological conditions such as an increasing sea level. For centuries, settlements and agricultural land were subjected to storm surges and other extreme natural events. Simultaneously with the process of continuous enhancement of protection facilities (dwelling mounds, ring dykes, closed dyke lines) there was an increase in population and the related increase of goods and values stored in this region. These processes resulted in a continuously increased vulnerability. Even today, where dykes and other coastal protection facilities are built under consideration of high safety standards, residual risks still remain – no one facility can ensure total safety. The risk assessment of the area and the current status of vulnerability must include not only an analysis of the up-to-date composition of population, settlement and economics in the Wadden Sea Region (see 1.3 and 2.4) but also the mental, institutional and technical capabilities of managing future hazardous events.

2.1 Storm surge hazards

Storm surges represent particularly high water levels at a coastline caused by specific meteorological conditions. In general, the development and characteristic behaviour of a storm surge is related to specific wind directions and a specific track of cyclone activity. If these conditions are given, strong landward directed winds "force" the water to the coast and cause an accumulation of water masses, i.e., a rise in water level (Gönnert 2003).

The Wadden Sea Region has been affected by periodic storm surge events of different characteristics and destructiveness over the centuries. And human-induced transformations, e.g. embankment of flood plains, increased the risk of damages and losses. Some of the most important historic storm surge events are listed in Table 1. These events caused enormous losses of lives, livestock and land.

Table 1 Summary of important historic storm surge events at the North Sea Coast (extract from NLWKN 2007)

Date	Impacts
16 January 1219	1st Marcellus flood; 36,000 casualties, huge flooding in the River Elbe area and elsewhere; first historically transmitted eye-witness account
16 January 1362	2nd Marcellus flood / "Grote Mandrenke"; 100,000 casualties; first embayment of the Dollart; destruction of a huge part of North Frisia
11 October 1634	2nd "Mandrenke"; island of "Strand" destroyed, islands of Nordstrand and Pellworm remained, approx. 8,000 casualties
24/25 December 1717	Christmas flood; 11,150 casualties in the Netherlands, Germany and Denmark; highest and most disastrous storm surge event of its time

3 / 4 February 1825	800 casualties along the North Sea Coast; many dyke breaches and heavy losses of dunes on islands; marked the highest storm surge level (e.g. in Hamburg) until 1962
31 January/1 February 1953	Holland flood, which caused a huge loss of lives on the Dutch (1835 [5]), British (307 [6]) and Belgian (28 [7]) coast
16/17 February 1962	February flood 1962 / 2nd Julian flood, which cause 340[8] deaths on the German North Sea Coast and in Hamburg (315)
3 January 1976	Highest storm surge level at many tidal gauges along the German North Sea Coast, dyke breaches along the coast of Schleswig-Holstein and the Elbe river, in some places damages on dykes and smaller dyke breaches; no casualties
24 November 1981	Heaviest storm surge on the Danish coast line in the last 80-100 years: 24 November 1981: in some parts up to 15m coast line were lost[9]

2.1.1 Historic development of coastal protection

Development of human settlement in the Wadden Sea Region induced an important change through active adaptation measures to changes in sea level and impacts of storm surges. After centuries of passive adaptation (settlements of river banks and heights) the farming population in the late Bronze Age started to modify their settlement area (Lotze et al. 2005, Knottnerus 2005). Dwelling mounds and artificial rising of single farmyards, which helped to secure the farm against high water level, were the first active adaptation elements in the Wadden Sea Region (Knottnerus 2005). Some of the earliest dwelling mounds are dated to the time of 700-600 BC in the area of West Frisia. Protections of small fields against floods have been observed since the first century BC, first in the Province of Frisia (The Netherlands) (Wadden Academy 2013). In these early historic times, when small-scaled coastal facilities such as dwelling mounds were built, it was relatively easy to deal with the dangers related to storm surges. Limitation of flood defence to the small housing area and sparse population offered large areas which could be flooded and decrease the water level of the storm surge event in the affected area (von Storch & Woth 2008).

The situation changed with the implementation of increased dyke lines, which embanked more and more marsh land. The first ring dykes were built around the 10th century. Excavations on these elements can be found in West and East Frisia (Oost et al. 2012, Wadden Academy 2013, Ooste 1995, Ey 2010). Since the 10th century, systematic embankment and drainage of the coastal marshes and inland moors have induced a large-scaled transformation in the ecological system of the Wadden Sea Area (Lotze et al. 2005). An almost closed, linear coastal protection facility provided an enormous boost of increased population and increased agriculture use (Kabat et al. 2012). This exclusion of water enabled

[5] Rijkswaterstaat
[6] Met Office UK(http://www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood)
[7] Met Office UK
[8] Petersen, M. und H. Rohde (1977)
[9] LSBG-report (2012) p. 57

an intensive use of the areas behind the dykes. As a result of this intensified use, vulnerability of the Wadden Sea area increased at the same time, due to the fact that a storm surge frequently caused dyke breaches and flooding and in consequence caused huge damages in the used and populated areas (von Storch & Woth 2008). Blocking storm surge water level from the marshes came along with the necessity of increased maintenance and improvement needs of these facilities, in order to prevent uncontrolled dyke breaches (Kabat et al. 2012). In addition to the development on the mainland of the Wadden Sea Region, the barrier islands were (semi-)permanently inhabited from the beginning of the second millennium (Oostet al. 2012).

Beside the effect of protecting the population and goods in the low-lying areas, dykes received a second function in land reclamation: by enclosure. Using these strategies, by the end of the 16th century most of the land losses from the 12th and 13th centuries caused by disastrous storm surge events with high numbers of casualties and losses of land were able to be regained (FAK 2009, Oost et al. 2012). Lower dykes constructed in the Middle Ages were continuously replaced by stronger dykes which strengthened a separation of land and sea. The landscape was almost completely transformed during this time to cultivated land (Lotze et al. 2005). The more solid dykes reduced risk and led to a growing number of farms and increased agricultural use in the salt marshes (Knottnerus 2005). Population growth accelerated in this period; the coastal population doubled from 15-25 to 30-50 inhabitants per km² in the 16th century in comparison to the population of the Middle Ages (Lotze et al. 2005).

Intensified agricultural use as well as large-scale exploitation of peat land generated a transformation of environmental conditions in the Wadden Sea Region. Beside an increased transformation into a man-made landscape, peat exploitation together with peat oxidising caused a lowering of the level of the mainland behind the dykes. In contrast to the intertidal areas at the side of the dyke open to the North Sea, no sedimentation processes took place behind the dykes anymore. Lowering the level of the mainland became a permanent challenge for drainage, in order to facilitate successful agricultural use (Kabat et al. 2012).

On-going strengthening of dykes in the 19th and 20th century increased the protection of coastal areas against storm surges and went hand in hand with a continuous increase in population. This resulted in another doubling of the population (75-100 inhabitants / km²) in the 19th century (Lotze et al. 2005).

Regional differences in the historic development of marsh settlement and dyke constructions could be observed with regard to a general increase in population growth based, among other things, on the important factor of continuous protection against storm surges and rising sea levels. Compared to the Dutch and German part of the Wadden Sea Region, most diking in Denmark started in the 19th and 20th century and some undyked fragments still exist today (Vollmer et al. 2001). A main reason for this was the narrow extent of coastal marshes which made marshland settlement less necessary than in other parts of the Wadden Sea coast (Vollmer et al. 2001; Lotze et al. 2005).

2.1.2 Storm surge events 1953 and 1962 and the current state of storm surge protection

In recent years, the last storm surge events which caused huge losses along the Wadden Sea Coast were the Holland flood in 1953 and the flood of February 1962. Both events involved significant transformations in storm surge management, especially in the Netherlands and in Germany (comp. von Storch et al. 2008, Gerritsen 2005, FAK 2009).

For the Dutch North Sea Coast, the storm surge of 31 January/1 February 1953 caused disastrous losses and damages and marked an important change in coastal management and its related policy. The event underlined different weak points in the applied coastal protection strategy during the 1940s and 1950s. Many dykes in the Netherlands were in poor condition due, among other things, to military use of the dykes during the Second World War, less maintenance in post-war times as well as unstable construction (high dyke levels and steep slopes). In addition to these technical failures, difficulties in communication about the risk had considerable influence on the course of the event. Responsibilities concerning dyke defence and evacuation were unclear, for example, and no evacuation plans existed. Communicating the hazard to the population in low-lying areas was difficult. Traditional radio communication, in which warnings were broadcasted as part of the weather bulletin, stopped at midnight – however, the peak of the surge arrived at the Dutch North Sea Coast between 3.00 and 4.00 a.m. (Gerritsen 2005).

After these experiences in 1953, the Delta Committee was installed in order to develop prevention methods for such disastrous events. Based on the suggestions of the Delta Committee, the new Dutch coastal policy turned to a predefined safety level (van Koningsveld & Mulder 2004; Gerritsen 2005). Its implementation took place in the Delta Project, which included comprehensive construction measures to straighten the dyke line, constructing storm surge barriers and dams to close tidal inlets and improve existing dyke lines. These measures were put in place during the 1960s, 1970s and 1980s (van Koningsveld & Mulder 2004).

With regard to the high vulnerability of the Dutch low-lying areas, the state called for a second Delta Committee in 2008 in order to analyse how the Netherlands can be protected against increased risks related to future climate change (Delta Committee 2008).

Similarly to the development in the Netherlands after 1953, changes in coastal protection management were initiated along the German North Sea Coast primarily after the storm surge of 16/17 February 1962. This event caused a number of dyke breaches along the German North Sea Coast, especially in Lower Saxony and the Elbe River (Petersen & Rohde 1977).

The former heights of the dykes in 1962 were aligned with water levels of the past storm surge events (maximum storm surge level was marked by the event of 1825). Since there was only one severe storm surge in 1855, no dyke improvement seemed necessary for nearly 100 years (von Storch et al. 2008). Furthermore, dyke maintenance had been neglected in these times, especially during the First and Second World Wars. Then in 1962, the poor conditions of the coastal facilities, together with a lack of risk perception among the

people living behind the dykes, were the major factors for the disastrous consequences[10]. There was a predominantly wrong perception of safety among the people which had increased their vulnerability (von Storch et al. 2008; Petersen & Rohde 1977). Following the numerous failures in dyke stability in 1962, a new dyke maintenance program was adopted in the federal states of Lower Saxony, Schleswig-Holstein, Bremen and Hamburg. It included modifications of the dyke line (reducing and straighten the dyke line, enlarging the bottom of the dykes etc.) and changed legal regulations.

On February 1, 1976 a very high storm surge caused the highest observed water level at the North Sea Coast so far – but the comprehensive coastal protection programs, which were established after the catastrophic events of 1953 and 1962, resisted. Until today, the technical superiority of coastal protection measures has had an important influence on storm surge protection measures in German and Dutch coastal protection management.

Along the Danish Wadden Sea Coast, the storm surge events of 1953 and 1962 did not impact that much such as in the Netherlands and in Germany. The water level of the storm surge of 31 January/1 February 1953 did not reached a relevant storm surge height along the Danish Wadden Sea Coast. Consequently, the event had not been recorded in the official storm surge time series. The storm surge event of 16/17 February 1962 caused high water levels at the Danish Coast (officially recorded as a storm surge event). However, the water levels of 1962 did not belong to the most disastrous or highest storm surge level. In contrast to the German North Sea Coast and along the Elbe River, damages were much smaller along the Dutch Coast. Significant changes in the Danish coastal protection strategy are related to the storm surges of 1 February 1976 and 24/25 November 1981. Following, the Danish government decided to reinforce the existing dykes thoroughly and build an advanced dike in the Tønder marshland (Kystdirektoratet 2012).

Managing the risk of storm surges along the North Sea Coast is currently strongly based on statistical and probabilistic methods to calculate the risk (calculation of the design level of storm surge protection facilities). For these methods, the data base of storm surges is quite good[11]. Current coastal protection facilities are based merely on statistic or probabilistic risk calculation schemes. For the Dutch urban areas, the dimensioning of coastal protection facilities is defined by the probability of a very high storm surge event with an occurrence at 1:10,000 (one event in 10,000 years) (comp. Delta Committee 2008). However, comprehensive flood protection programs have to deal with residual risks by including additional management elements like improved risk communication to the general society as well as to stakeholders, early warning systems etc. Numerous research projects[12] have been working on the topic of storm surge management along the North Sea Coast, taking into account the current and future climate and its potential changes, as well as the improvement of storm surge management strategies.

[10] After the storm surge event in 1953, the lowest points in the German dyke lines were strengthened in the course of a dyke program (Petersen & Rohde 1977). Construction works had been running in 1962.
[11] Single storm surge heights are available from historic records and high water marks. Continuous tidal gauge data series are available earliest from the beginning of the 20th century (tidal gauge Cuxhaven, LSBG 2009)
[12] Safecoast, FLOODsite, ComRisk etc.

Mathematical calculations pretend to be rational and accurate. But calculating occurrence probability is based on technical, political and not the least cognitive assumptions and varies along the Wadden Sea administrative areas. Furthermore, risks can also be seen as mental constructions resulting from the perception of the affected persons as well as their interpretations and responses depending on social, political, economic and cultural contexts and judgments (comp. Luhmann 1993). Different cultures form different risks based on specific cognitions. These cognitions result from a network of experience, knowledge, and culturally framed perception (comp. Ratter 2012, 2013). There is a certain danger that the success of the recent technical measures and technical-mathematic approach lead to a "perception of security" (von Storch et al. 2008) among the affected population and stakeholders. This situation describes a mental lock-in, where continuous, successful investment in construction measures creates an illusory feeling of safety and hinders a broader view on alternative adaptation measures and strategies. This case study wants to analyse this current state of perception, especially in terms of increased use of the Wadden Sea Area, increased accumulation of population and values in urban coastal areas and, last but not least, increased impacts of climatic changes. Vulnerability has notably risen, but is this reflected in the people's mind-set? In face of construction limits in coastal protection, the case study wants to create a dialogue including stakeholders and the general society about potential ways to handle risks in the Wadden Sea Region, especially storm surges. Regarding multiple differences in interpretation of risks and their impacts between different actors as well as between different sectors or institutions, it is important to include different points of view in the process of successful risk management processes.

2.2 Additional environmental threats in the Wadden Sea Region

Aside from storm surges, the Wadden Sea Region is exposed to additional risks from natural hazards and long-term changes in environmental conditions. Storm events can also affect the Wadden Sea area without creating high water levels but causing major damages to settlements, infrastructure and economic sectors. The Wadden Sea area was amongst others affected by the winter storms Lothar (26 December 1999) and Kyrill (18/19 January2007), which caused severe damage in Europe.

An additional hydrological hazard threatening the Wadden Sea Region results from inland flooding events. In the Wadden Sea Region, different rivers run into the North Sea, affecting the area if there is flooding resulting from huge inland run-offs. In the Netherlands, there are the Ijssel and the Reitdiep, the river Ems at the border between the Netherlands and Germany, in Germany the Weser, Elbe and Eider rivers and in Denmark, the river Ribe Å has already caused some flooding events in the past. Flooding in the Wadden Sea area can also result from heavy rain events. This kind of hazard might occur on a very local scale but can cause heavy damage. Especially with regard to climate change, many future scenarios project an increase in heavy rainfall events in Northern Europe (IPCC 2007).

An additional long-term development increasing risk in the Wadden Sea Region is related to the intensive historical embankments and reclamation of marshes. Reclamation included an intensive drainage of the areas behind the dykes as well as continuous peat cutting. These

processes resulted in a constant subsidence of the marsh areas in contrast to the level of the tidal mudflats (areas beyond the dykes, where steady sediment accumulation takes place) and the higher parts of the adjacent *Geest,* or moraine. These developments cause problems especially in terms of high groundwater and an ever increasing need of drainage. The problems are intensified by increased run-off from the hinterland, passing through the marsh land in order to discharge into the North Sea. Especially in situations of increased water level on the external side of the dyke (facing the North Sea) caused by storm surge events, the increased amount of discharge cannot be drained off through tidal gates and water accumulates in the low-lying marshes.

All these hazards may not be exclusively specific to the Wadden Sea Region; nevertheless, the case study will include them in its research questions. How do stakeholders deal with uncertainties with regard to environmental hazards in the Wadden Sea Area? In addition, what can we learn from applied risk management strategies for different kind of hazards? Improved risk management strategies might include multi-functional measures or tools, in order to deal with different kind of hazards. Furthermore, improved risk management strategies might bear opportunities to improve risk management facing multi-hazard events. In this respect, for example, a simultaneous occurrence of a storm surge and increased run-off rates (or floods) will put high stress on the Wadden Sea Region. This multi-hazard will cause a high potential for damages and losses due to the fact that the huge amount of run-off must be stored in the area, because drainaging the area is getting more and more difficult due to the high water level on the seaside.

2.3 Future environmental risks

With regard to enhancing successful long-term risk management strategies in the Wadden Sea Region, it is necessary to include projections of potential future changes in the area. Future changes might be assumed in socio-economic development of the Wadden Sea Region as well as in terms of climatic changes. Detailed analysis on future scenarios on both levels will be developed in the work process of the case study (part of the future deliverable 7.3). A brief description will highlight the potential future risks and uncertainties resulting from future environmental hazards.

The scientific community agrees predominantly on an existing increase in mean sea level during the last decades and an on-going increase for the coming decades. Past development of sea level rise is documented on many tidal gauges. Over the 20th century, the global mean sea level increased on an average of 1-2 mm/year (Church et al. 2001). On the regional level, the estimated increase in sea level rise along the North Sea Coast varies between different localities. Along the Dutch coast, Katsman et al. (2008) estimate an increased sea level rate of about 2.5 mm/year in the 20th century. Other authors concluded that there is no identified acceleration within the recent decades (Weise et al. 2012). From analyses of German tide-gauge measurements, rates over the 20th century show considerable variability with relatively high values within the most recent decades. Compared to earlier periods, no outstanding acceleration could be inferred (Wahl et al. 2011).

A future increase in the mean sea level will mainly be induced by ocean thermal expansion and increase freshwater input by accelerated melting of inland glaciers and icecaps (IPCC 2007, Weise et al. 2012). The IPCC (2013) projected a mean increase in global sea level of 26-82 cm by 2100. However, sea levels will not rise uniformly around the globe. Examination of research results at a regional level on the North Sea coast by Gönnert et al. (2010) emphasizes a range of projections from (-5) up to +115 cm for the North Sea region up until 2100. On a local scale, Katsman et al. (2011) project a mean sea level rise of between 0.40 and 1.05 m on the Dutch North Sea Coast under high-end conditions up until 2100. Increased sea-level rise will impact not only affected coastal protection schemes in terms of increased steady coastal water levels. The trilateral expert group for Coastal Protection and Sea Level Rise – established as a result of the 10th Governmental Wadden Sea Conference – mentioned additional impacts of increased sea level through salt intrusion, reduced drainage capabilities of the lowlands and rising groundwater levels (CSLR 2008). Knowledge about rising sea levels has to be taken into account as well in terms of future near shore processes such as erosion as wave set-up and run-ups (Weise et al. 2012).

Sea level rise could also affect the future storm surge water level at the North Sea Coast. Numerical research shows that there might be a slight increase in extreme storm surge water levels. Woth et al. (2006) describe an increase in the western part of the continental coast which is primarily a result of more frequent extremes. Especially in the German Bight, projections show a significant increase of extreme storm surge heights by 20-30 cm, which corresponds to a rise of around 20% in surge heights (Worth et al. 2006). The mean number of severe storm surges could result in an increase of about two events per year in the period 2071–2100 compared to 1961–1990 (Woth et al. 2006). These differences would have different implications for coastal protection which then has to resist not only increased stress from more frequent events but higher extreme storm surge events as well.

2.4 Vulnerability to natural hazards in the trilateral Wadden Sea Region

Extended settlement and intensive use (agricultural and economic) increase the vulnerability in the Wadden Sea Region. Different concentrations of population (densely populated cities, sparsely populated rural areas) and a diverse accumulation of values (high accumulation e.g. in harbour areas, areas of industrial use) create different levels of vulnerability. Large parts of the Wadden Sea Region lie at sea level or even below sea level. These areas are highly vulnerable to damages caused by storm surges, should coastal protection facilities fail. At present, an estimated 3.5 million inhabitants live in the Wadden Sea Region (comp. 1.3, Figure 1). Many of the rural areas are sparsely populated while a higher concentration of inhabitants can be found in small and mid-size towns along the coast.

In the Netherlands, nearly half of the country would be affected by flooding in case of eventual dyke breaches or without the present coastal protection facilities (Gerritsen 2005). Nine million people live in areas below sea level where 70% of the Gross Domestic Product is earned (Molder et al. 2011). In the Wadden Sea Region alone approximately 1.6[13] million

[13] With regard to the year 2011, Source WSF, Statistics Netherlands

inhabitants are protected against storm surge events. The Netherlands in general are highly vulnerable to an increased sea level rise in the future (Delta Committee 2008).

Along the German North Sea coast, an area of approximately 9,000 km² is covered by the strategic storm surge management plans[14] (areas up to a height of +5 m above sea level). The height of marsh land in Lower Saxony lies approximately between +1.4 m above sea level up to 0.5 m below mean sea level. In older parts of the marshes sometimes a decrease of –2 m below mean sea level has been measured (NLWKN 2007). Approximately 2.0[15] million inhabitants live and work in all the German low-lying areas.

The Danish Wadden Sea Region is by far the smallest area affected. Only 600 km² are characterized along the Danish Wadden Sea coast as low-lying areas[16] (< +5 m above mean sea level). Nearly 207,000 inhabitants live in these low-lying, storm-surge prone areas[17].

Traditionally, the Wadden Sea Region has been an important agricultural area which has been developed over centuries (Kabat et al. 2012). Additional important current economic sectors in the Wadden Sea Area are tourism, the energy sector (on-shore, off-shore wind and solar energy) as well as fishery and port industry and management. The impacts of hazard events such as storm surges, heavy rainfall events or storm surge events on these sectors could occur directly and indirectly.

Agriculture and fishery are spatially still highly pronounced in the Wadden Sea Region with an employment share of 5% of the working population. The majority is employed in the agricultural sector. High concentration of agriculture sectors are situated in Fryslân (NL), Groningen, Kop van Noord-Holland (Netherlands), and the "Unterelbe" area and Schleswig-Holstein (Germany) (Wadden Sea Forum 2004).

Tourism is an important economic sector, on the mainland and explicitly on the islands, with an important share of the regional employment level. In addition to tourism, the service sector is heterogeneous and represents different economic sub-sectors such as wholesale and retail trade, business services, education, health service and social care and public administration (Wadden Sea Forum 2004).

The production industry in the Wadden Sea Region comprises the key sectors of food processing (ca. 40,500 jobs), metal and engineering (ca. 36,700 jobs) and chemical industry (ca. 23,300 jobs) (Wadden Sea Forum 2004). These three most important sub-sectors cover over 50 % of the total industrial capacity of the Wadden Sea Region. The current industries are closely linked to the historic and current port facilities. Important ports within and close to the Wadden Sea Region, namely the German ports of Hamburg, Bremerhaven/Bremen, Wilhelmshaven, the Dutch port of Eemshaven/Delfzijl and the Danish Esbjerg harbour have influence on the economic and social development in the Wadden Sea Region (Kabat et al.

[14] Generalplan Küstenschutz Lower Saxony (2007): 6.600 km² in Lower Saxony; Generalplan Küstenschutz (2012) Schleswig-Holstein: 2,400 km² coastal lowland is protected against storm surges (area of the Tideelbe is not included)
[15] With regard to the year 2011, Source WSF, based on Regionaldatenbank Germany
[16] CPSL 2010
[17] With regard to the year 2011, Source WSF, based on Statistics Denmark

2012). Big cities which are closely situated to the Wadden Sea Region and have a huge impact on the economic and social system of the Wadden Sea Region are Hamburg, Bremen, Oldenburg, Leeuwarden and Groningen (Wadden Sea Forum 2005).

In general, the employment level is subject to fluctuations[18] in the Wadden Sea Region. Seasonal variations are typical for the tourism sector. The annual employment growth indicates a negative trend. General employment growth in the Wadden Sea Region is very low. In the German part of the Wadden Sea Region, employment rates have nearly stagnated during the last few years (2008-2012). Employment rates decreased in the Danish part as well as the Dutch part of the Wadden Sea Region. The GDP in purchase power standard (PPS) per inhabitant for 2012 is: Denmark: 32 000 PPS (127 % of the EU 27 average), Germany: 31 300 PPS (122 % of the EU 27 average), Netherlands: 32 800 PPS (129 % of the EU 27 average).[19]

The conditions and facts described above constitute the level of vulnerability in the Wadden Sea Region. The level of vulnerability will increase in the area with regard to future changes in socio-economic as well as in climate conditions. Improved risk management strategies which take the challenges in different sectors into consideration, will bring opportunities to cope with these future challenges and might increase the level of future vulnerability.

[18] With regard to the years 2008-2012, Source WSF, based on Statistics Denmark, Statistics Netherlands, Regionaldatenbank Germany

[19] http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/main_tables

3 Risk reduction measures in storm surge management

In general, storm surge protection is a part of coastal protection management. And in addition, coastal protection includes protection against coastal erosion. Both issues are closely linked and are often managed by the same strategic measures. Current storm surge protection in the Wadden Sea Region is highly characterized by technical measures on a high engineering standard. The key issue of all these strategies, especially in the Netherlands and in Germany, is based on the philosophy of keeping the water out of the low-lying areas. This close-off includes the periodic changes in water level related to tidal cycles of high and low waters as well as excessive water levels in terms of storm surges. Strategies which include controlled flooding in order to give space to increased water levels in terms of storm surges are rarely implemented along the Wadden Sea Coast and unthinkable for most of the adjacent population and stakeholders. Nevertheless, cautious steps are being taken to implement these kinds of strategies with a large number of different ideas. These ideas refer to traditional historic small-scale protection measures like dwelling mounds for single houses or small groups of buildings. The implementation of this kind of strategy so far is only applied on a small scale in sparsely or unsettled regions, for example on the German *Halligen*. In addition, discussions about individual projects on dyke removal or transfer are currently taking place. The opening of individual polders as one potential measure to increase the extent of flooding areas during tidal high waters could increase the sedimentation rate and consequently increase the land level. Intentional opening of polders during a storm surge bears an opportunity to buffer high water levels. Implementing these improved coastal protection management schemes to a larger extent would have to include an intensive cooperation with society at large and the stakeholders. Precondition for these kinds of changes is a change in the mind-set of the people and a handling of their reservations and fears.

3.1 Coastal protection techniques

In general, coastal protection techniques can be distinguished between hard/structural and soft/flexible protection measures. Hard measures include constructions like dykes, flood barriers and sea walls. These facilities are implemented to prevent high waters from ingressing into the low-lying areas and fixing the existing coast line. The heights of these facilities are defined by calculated design levels[20] and are based on specified safety standards[21]. Both factors currently already include an extra range for anticipated future sea level rise. Dykes, polders, barriers etc. are also characterised as passive coastal protection measures.

[20] The design level is defined as the highest water level (tide and wind surge is included) which cause maximum stress to a construction facility. In order to estimate the highest water level, different methods (statistical, determinist, risk-based) are available.

[21] The safety standard expresses the maximum acceptable flood probability in a specific area. Estimating this standard is dependent on the applied method and the included facts (e.g. population density, accumulated goods and values, experiences from historic events etc.)

In contrast, active coastal protection measures have the aim of intervening as early as possible in hydrological processes on the seaside, in order to prevent or reduce destructive impacts before the waters reach the coast line (e.g. preservation of the Wadden Sea and forelands).

Soft protection strategies are implemented in order to prevent erosive forces from reaching the backshore. These strategies include e.g. beach nourishment, polders, reliance on and maintenance of natural elements like sands, dunes etc. Sand nourishment is applied as an option for an "economically viable way of protecting the mainly sandy coastline" (Misdorp 2011, p.40) especially in the Netherlands.

Table 2 gives an overview of the exposed coast line, coastal protection facilities currently being applied and future alternative ideas about coastal protection strategies in each of the three Wadden Sea states.

Table 2 Country-specific overview on characteristics of currently applied coastal protection strategies and measures

Country	Coast of the Wadden Sea Region	Characteristics of applied strategy	Applied measures	Important acts
Nether-lands	Ca. 400 km (divided into Delta coast in the South, central Holland coast, northern Wadden Sea coast)[22] Length of the Wadden Sea Coast: 200[23] km Characteristic for Wadden Sea Coast: barrier islands.	Basic principle remains: 'soft where possible, hard where required'[24] In general, landward retreat of the coastline will be prevented by the state, as far as it is needed for maintaining safety. Protection function of the coast is endangered by increasing erosion; in near future NL is highly vulnerable to increased sea level rise[25].	- Sandy dunes (75% of NL shoreline)[26] - Dykes - Polders - Flood barriers and dams -Sand nourishment: Policy of "Dynamic preservation": adopted by the government 1990 in order to stop structural erosion.	In the Coastal Protection Act (*Wet op de Waterkering*) specific safety standards are established safety standards[27] for all flood defences including dunes: established by laws: Delta Act 1958, Flood Defence Act 1996; Water Act 2009[28] Preservation of the coast line: Flood Defence Act, Water Act

[22] Mulder et al. 2011
[23] CPSL 2010
[24] Delta Commissie 2008
[25] Mulder et al. 2011 cited Nicholls and de la Vega-Leinert 2008
[26] Mulder et al. 2011
[27] Mulder et al. 2011
[28] Mulder et al. 2011

Germany – Lower Saxony	Length of main dyke line ca. 610 km [29] A second dyke line is installed in some areas.	Behind the dykes there is a land strip of 50m which is reserved for coastal protection.	- Dykes (sea dykes on mainland & islands) - Storm surge barriers - Main facilities on the islands: Dunes -Storm surge warning management by the federal state and by the Federal Maritime and Hydrographic Agency (whole German North Sea Coast)	Legal basis: Lower Saxony Dyke Act, which contains regulations for design, maintenance, management and use of coastal defence structures, such as dykes, dunes and forelands, as well as defining the responsibilities of the authorities and the water boards. Master plan coastal protection management *Generalplan Küstenschutz* (2007)
Germany - Schleswig-Holstein	553 km [30] (297 km on main land; 195 km on islands; 61 km on *Halligen*) Second dyke line: 570 km	The implemented integrated coastal management strategy takes care of different (and divergent) interests/belonging to coastal protection affairs[31].	- Sea dykes (364 km) - Dunes, - Flood Barrier (Eider flood barrier) Storm surge warning management of the Federal Maritime and Hydrographic Agency (managing the German North Sea Coast)	Coastal defiance regulated by State Water Act Master plan coastal protection management: *Generalplan Küstenschutz* 2001 was based on a comprehensive participation program. Last update in 2012
Denmark	Length of Wadden Sea Coast line: 110 km[32] Mainland ca. 71 km dyke line, islands of Fanø, Mandø, Rømø: 28 km sea dykes[33]	Overall principle regarding the implementation and financing of coastal protection: the persons who profit bear the responsibility. Hence, measures need to be initiated, financed and implemented by landowners or arranged with municipalities	-Grass dykes (clay-covered grass dykes with sand core) - Dunes Salt marsh areas are maintained for coastal protection purpose Storm surge warning management established in cooperation with the police and municipalities	Coastal Protection Act: regulates coastal protection and other types of terrain changes along the coast Storm flood scheme, (*stormflodsordningen)* implemented by government for covering damages and losses resulting from storm surges. Payment of compensation could be claims when different conditions are appropriate.

[29] NWLKN 2007
[30] Hofstede 2008
[31] Hofstede 2008
[32] Personal information T. Piontkowitz (DCA)
[33] CPSL 2010

3.2 Insurance against storm surges and floods

Especially with regard to future projections, where the probability of most types of extreme weather events is expected to increase significantly (IPCC 2012), continuous improvement of coastal protection and disaster management strategies is needed. A potentially useful tool in this context might be an increased coverage of disaster risk insurance. Insurance can provide an opportunity to spread the risks and provide a way of dealing with damages in economic context (European Commission 2013; Botzen & van den Berg 2008). The following section describes the current state of insurability against storm surges, floods and storm events and highlights the existing problems.

The Netherlands

In the Netherlands, private flood insurance is generally not available, neither for storm surge damages nor for damages resulting from fresh flood events. The Calamities and Compensation Act (WTS) has been in existence since 1998. This law handles governmental compensation of disaster losses, including flood damages. Unfortunately, there is no clear definition of which damages will be covered. In addition, the WTS only provides compensation when a flood results in a considerable disruption of public safety. Moreover, compensation of storm surge damages is excluded from the WTS, because of considerable losses which might be difficult to estimate beforehand. The decision about the implementation of compensation payments lies with the government. An initiative of the government to extend private insurance coverage was rejected by the Dutch insurance sector in the mid-1990s (Botzen & van den Berg 2008).

Additional information concerning insurance on damages related to storm events: 'The Netherlands' insurance is not bundled to any policy, but it can be bought as an optional extension of basic policies. Also in the Netherlands the penetration rate is very high (90%) (Maccaferri et al.2012).

Germany

In Germany, storm surge damages are not insurable. Both building insurance and home content insurance officially exclude damages from storm surges. The general terms and conditions of residential building insurance explicitly mention the exclusion of storm surge damages[34] (VGB 2008). The same exclusion is mentioned in the terms and conditions for home content insurance[35] (AStB 2008).

Insurance companies point out different reasons for the non-insurability of storm surge damages in Germany. First, experts mention the effect of so-called "adverse selection" processes (Munich Re 2012). "Adverse selection occurs when high-risk individuals are more likely to demand insurance coverage than low-risk individuals. As a consequence, insurance companies will suffer losses when premiums are based on the average probability of losses" (Botzen & van der Berg, 2008, p. 419). In this case the divergence between the interests of

[34] See Paragraph A § 4 Abs. 4 a) aa)) VGB 2008; Paragraph A § 5 Abs. 4 a) aa)) VGB 2008
[35] Paragraph A § 1 Abs. 4 a) aa)) AStB 2008

potential insurants and the insurance companies is too strong. Second, the frequency of occurrence of storm surge events as well as inadequate data records provides an inadequate data basis for internal cost-calculations (Munich RE 2012). Third, the insurance companies worry about a regional cumulative risk. This term describes the risk of co-occurrence of several risks at the same time: namely the risk of damages from storm and floods. The fourth argument mentioned by insurance experts focuses on the lack of influence of the insurance companies on the safety of dykes and other coastal facilities (Munich RE 2012).

In contrast, damages resulting from inland floods are insurable in Germany. These damages are defined as natural perils (damages from natural hazards); they are insurable by supplemental insurance against natural hazards. These insurances bundle damages from different natural hazards (storm surges are explicitly excluded) and are a supplement to home content or building insurance (Botzen & van den Bergh 2008). But the acceptance of this supplement insurance is relatively low in Germany. Thieken et al. (2006) showed that in today's market penetration of flood insurance are only about 10 % for private households. In terms of industrial risks, the market penetration is even smaller (Thieken et al. 2006). Experience from the flood event in 2002 confirmed that in Germany a larger portion of flood damages is covered by governmental funds and donations than by insurance companies (Botzen & van den Berg 2008).

Additional information on insurance on damages related to storm events: In Germany, insurance is not bundled to any policy, but it can be bought as an optional extension of basic policies (Maccaferri et al. 2012). These damages are included in the supplemental insurance on natural hazards. A penetration rate of 90 % indicates an extensive coverage of potential storm damages in Germany (Maccaferri et al. 2012).

Denmark

The legal background for coastal protection issues is the "Law for coastal protection", which was passed by the Danish parliament in 1988. Practical implementation of this law is conferred to the Danish Coastal Authority (Kystdirektoratet - DCA). The law for coastal protection enables municipalities to implement coastal protection measures.

In general, a direct right for owners on coastal protection for their property does not exist. Funding, construction and maintenance of coastal protection measures are generally related to the users of these structural facilities. In many cases there is a cooperative funding of coastal protection facilities by private and public users, who share the same interest of protecting themselves / their belongings / landscape (LSBG 2012). In relation to these circumstances, any minimum standard for coastal protection facilities (design level for dimensioning or safety standard) is available in Denmark.

In the mid-1990s, the Danish government implemented a storm flood scheme, called *stormflodsordningen*, to cover damages and losses resulting from storm surges. Payment of compensation could be claims when different conditions are appropriate. The wind must be of gale-force, the water level must reach a height above a level of a return period of 1:20 years, the flooding event has to affect a larger area and an exceptional wave height has to be observed during the storm surge event (LSBG 2012). The public storm surge scheme is

the only way in Denmark to cover damages from storm surges; a private insurance including these damages is not available. The storm surge scheme[36] is financed by a yearly fee (€ 4.00 / DKK 30.00 per year). These fees are included in the fire insurance policy (Nordic Insurance Association 2013).

Additional information on insurance on damages related to storm events: In Denmark storm insurance is not bundled to any policy, but it can be bought as an optional extension to basic policies (Maccaferri et al. 2012). A high penetration rate[37] of 90% for storm insurance was identified in the study of the European Commission (Maccaferri et al. 2012). This high penetration rate constitutes a comprehensive coverage of damages related to storm events.

[36] Since October 2012 the storm surge scheme has covered a total amount of storm surge damages of € 76 Million / DKK 567 Million (Nordic Insurance Association 2013)

[37] "Penetration rate" measures the percentage of global insurance premiums over a country's gross domestic product (Maccaferri et al. 2012)

4 Risk Governance

Coastal protection along the North Sea Coast including the Wadden Sea Region in the Netherlands, Germany and Denmark is mainly controlled by governmental institutions. In all three countries, responsibility for coastal protection issues lies predominantly in the hands of ministries on national or regional/federal levels. Based on a long-lasting historic development of coastal protection in the North Sea area, an important impulse in coastal protection affairs in the 20th century was released by the disastrous storm surges of 1953 and 1962 (see section 2.1). In consequence, the Netherlands and Germany implemented improved coastal protection strategies and administrative structures were strengthened as well.

4.1 Governance in managing coastal protection issues

In order to analyse the capabilities of the existing management structures in coastal protection in the Wadden Sea Region, the state-of-the art for each country is described briefly.

Current state of managing coastal protection in the Netherlands

In the Netherlands, approximately 60 % of the state area is vulnerable to flooding; most of the areas are low-lying areas below the mean sea level. Nine million people live in this area and two-thirds of the Dutch Gross Domestic Product is represented by this area (Delta programme 2013). These facts reflect the importance of coastal and flood protection in the Netherlands, and underlines why coastal protection is a federal matter. The Ministry of Transport, Public Works and Water Management is responsible for coastal protection. Close cooperation is practiced with the Ministry of Agriculture, Nature and Food Quality, which is responsible for nature conservation, and with the Ministry of Housing, Spatial Planning and the Environment which composed the guidelines for local and regional plans in a national directive (the PKB-Waddenzee)(CPSL 2010). The state, in terms of the responsible Ministry of Transport, Public Works and Water Management, is responsible for the overall strategy (an important part is the Delta plan and the related Delta Commission as important consortium) in Dutch coastal protection. Additionally, the Ministry of Transport, Public Works and Water Management is responsible for important flood barriers and coastal protection of the islands. Separate from the above-mentioned specific tasks, the role of the state / the Ministry of Transport, Public Works and Water Management is to supervise flood defence and coastline management at the regional level (Mulder et al. 2011). Along the sandy coast, which is the most common type in the Netherlands (75%, Mulder et al. 2011) four regional coastal provinces are responsible for coordination and integration of coastal policy and day-to-day management. For these tasks, they are supported by seven Coastal Water Boards. In addition to these actors, several municipalities work at the local level to implement coastal policy into practice (TAW 2002).

Collaboration between authorities at state/national, regional and local levels is embedded in the Delta Programme. The Delta Programme is a national program in which the central government (responsible ministries), the provinces, municipalities and water boards collaborate with civil society organizations, the business community and knowledge

institutes. These actors work together in dual tasks of protecting against flooding (storm surges and inland flooding) and supplying fresh water. Social organizations, business community and knowledge institutes are also involved in the working process. Although the population in included in the collaborative processes within the Delta Programme, the Programme is still under state supervision and dependent on its supervision. Characteristic for this state supervision is the submission of the Delta Programme (done by the Council of Ministers) to the House of Representatives together with the national budget. The House of Representatives has the final say.

Current state of managing coastal protection in Germany (federal states)

Coastal protection is a preventive strategy. The Basic Constitutional Law of the Federal Republic of Germany identifies coastal protection as an issue of concurrent legislation[38]. Thus the Basic Constitutional Law identifies the federal states responsible for coastal protection; the German state is involved in this process and contributes to these tasks if they are important for the entirety and helps to improve living conditions (Art. 91a Basic Constitutional Law). Along the German North Sea Coast, federal state responsibility is exercised in Lower-Saxony by the Ministry of Environment, Energy and Climate Protection; in Schleswig-Holstein it is exercised by the Ministry for Agriculture, Environment and Rural Areas.

In Lower Saxony, the Agency of Water Management, Coastal Defence and Natural Conservation Agency (NLWKN) is in charge of conceptual and technical planning and supervising maintenance works. For maintaining the coastal facilities, mostly dykes, the Agency supervises 22 dyke communities who are responsible in specific areas. Exceptions to these tasks are implemented in case of difficult protection facilities like coastal protection on the islands and on flood barriers (like the Ems barrier). In these cases the state, represented by the NLWKN, is responsible (NLWKN 2007).

In Schleswig-Holstein, the Ministry for Agriculture, Environment and Rural Areas is responsible for strategic planning of coastal protection issues. Supervision of construction and maintenance of coastal protection facilities are performed by Schleswig-Holstein's government-owned Company for Coastal Protection, National Parks and Ocean Protection (LKN). In terms of maintenance of coastal facilities, the LKN guides and supervises the water boards and land communities, who do the practical work in their respective area of responsibility (MLR 2001).

The dominant, supervising position of the national and regional governments on coastal protection issues becomes apparent on close inspection of funds for coastal protection. 70% of costs are paid by the German government, 30% are paid by the federal state (NLWKN 2007). These conditions are mainly given on the main dyke line. Maintenance of dykes and other coastal protection facilities are paid by the federal state in Schleswig-Holstein.

[38] Concurrent legislation in coastal protection means that the Federal States have the power of legislation processes in coastal protection issues as long as the state does not make use of its (superordinate) right of legislation on this issue.

Current state of managing coastal protection in Denmark

In Danish coastal protection, the overall principle regarding the implementation and financing coastal protection is: the persons who profits, bears the responsibility. Hence, landowners or municipalities have to initiate, finance and implement measures if they are needed (Kystdirektoratet 2012). Related to this principle, landowners do not have an immediate right to protect their property. If new defence measures have to be initiated (by landowners or municipalities), a submission of request must be preceded by an application to the DCA and by inquiry to the relevant municipality body (if the applicant is not a municipality) (Kystdirektoratet2012).

Coastal protection along the Danish North Sea Coast is supervised by the state, as in the Netherlands and Germany. The Danish Coastal Authority, *Kystdirektoratet* (DCA), is the official coastal and port government agency. It is a division of the Danish Ministry of Transport. DCA is responsible for policy and strategic planning in coastal protection, such as supervising the compliance of coastal defence laws, providing advice with regard to coastal defence facilities and issues and for providing regional and private plans for coastal protection work. A second major role of the DCA is in storm surge warning along the west coast of Jutland, from Thyborøn to Nymindegab and in the southern part of Jutland (Esbjerg to the German border) (Kystdirektoratet 2012). Practical implementation of the coastal protection act and maintenance of coastal protection facilities are performed by the Danish municipalities, which are supervised and get advice from the DCA. On strategic issues, municipalities collaborate with local Danish governments. For the practical implementation of coastal protection, the DCA and municipalities coordinate associations of dyke land owners, who are responsible for dyke maintenance; the DCA provides additional technical advice here.

A characteristic of Danish coastal management is a clear split between the areas of "land" and "sea", which can be considered as a weakness of the current coastal management scheme. Coastal protection is the only issue that links both of them. There is no definition or delimitation of the coastal zone in any part of the national territory. The provisions of the Danish Planning Act only regulate the activities and the exploitation of resources which take place landwards along the shore line, irrespective of the close relations which often exist between activities on land and at sea (Anker et al. 2004).

4.2 Analysing governance processes in coastal protection management in the Wadden Sea Region

Partnerships to increase resilience represent a governance structure that may favour the management of particular stakes in a collaborative process. A theoretical framework was developed in the ENHANCE project in order to analyse the current state of successful governance processes and investigate current weaknesses in existing collaborative processes in storm surge management. This framework is presented in deliverable 2.3 and 2.4 of Work Package 2. Based on the "capital approach" of E. Ostrom, the framework introduces capitals as capabilities providing partnerships with the desirable output of being able to react to environmental hazards. A "capital" is understood as the assets, capabilities, properties or

other valuables which collectively will represent the good functioning of a partnership. The capital approach differentiates among five capitals: financial, social, human, political and environmental (Ostrom 1990, 2005). The current management situation in coastal protection management has been analysed based on the presented governance factors and their related indicators.

Social capital

A description of the current applied risk management in storm surge management and coastal protection highlights the fact that there is a dominance of governmental stakeholders. Decision-making processes are organised in a hierarchic order as top-down decisions. The dominance of governmental stakeholders from ministries, agency, provinces and municipalities leaves less room for other stakeholders from different sectors. The hierarchic structure also leaves less room for equitable treatment of all partners, especially from other sectors than the governmental/federal states. In regard to communication as an important key element of governance processes, communication between partners of the involved authorities/local governments does take place, but there is room for improvement. Especially communication between actors from different federal or national states has to be improved in order to exchange knowledge and increase coordinative actions. Communication between the involved governmental actors and other stakeholders as well as the public takes place in most cases only in terms of obligatory "participation" processes (applied in plan approval procedures). Improvement is needed here.

Opportunities for increased collaborative processes are given: Existing networks and platforms, where stakeholders from different sectors in the Wadden Sea Region come together, could be used for initial communication about potential stakes and interests with regard to cooperative multi-sector management of coastal protection issues. For example, ICZM projects could be used as potential communication platforms. In addition, existing networks and platforms of cooperative processes in the Trilateral Wadden Sea Region (e.g. the Trilateral Wadden Sea Cooperation, Wadden Sea Forum) could be used to bring together different stakeholders from the different countries. Moreover, the case study could learn from these networks about how (multi)stakeholder involvement might be operated in the Wadden Sea Region across the three countries.

Based on a huge amount of research programs and existing networks working for decades on specific research questions about the Wadden Sea Region, there is a high state of knowledge on mainly regional aspects concerning the Wadden Sea Region (including coastal protection).

Human capital

In addition to "scientific" knowledge, long-lasting cultural-historical development in coastal protection frames a common perception of risks resulting from frequent storm surges along the coast. Risk awareness influences coastal protection strategies. An important element in the Wadden Sea Region is the older generation's personal experience of disastrous storm surge events (e.g. 1953, 1962). In general, it is important to mention that a deep awareness of risks resulting from former storm surges exists among the Wadden Sea

population (comp. Ratter et al. 2009 for the German North Sea Coast). This experience and awareness frame risk perception in society and form the basis for the acceptance of risk management strategies. A high level of education in all three (highly developed) countries supports a comprehensive and fruitful discussion about risks.

Financial capital

The current state of funding for coastal protection measures is regulated in different ways in the three countries. In Germany and the Netherlands coastal protection and storm surge management are funded by the state/federal states. In Denmark there is an opportunity to commit "persons concerned" to payment of new coastal constructions. In general, no insurance against storm surge damages is available - neither in the Netherlands nor in Germany, and in Denmark only with restrictions. In terms of covering damages and losses resulting from storm surges, a special fund in Denmark provides an opportunity to receive compensatory payments under specific restrictions. In the Netherlands funds exist for compensating damages from flooding but not from storm surges. In Germany, in general federal funds are often established after an event (e.g. flood event 2013).

Political capital

As mentioned above, coastal protection and storm surge management are highly dominated by governmental actors. Most of the regulatory framework is governed by laws and binding agreements (which in most cases are communicated transparently). In addition to binding national rules and laws, binding EU policies are implemented where cooperation between countries is also mandatory. In the case of the North Sea region, the Water Framework Directive, the EU Flood Directive as well as Natura2000 need to be mentioned here. The EU Flood Directive has been installed in national and federal (Germany) law and requires risk maps for flood risks, especially for inland floods, but coastal regions have yet to be integrated. These demands are handled differently on each national level. By 2015 the Directive mandates risk management "approaches"/ maps, which must focus on measures for each specific region. These strategic maps could provide a basis for improving coastal management.

In terms of cooperation between governmental actors in the trilateral region which are facing the same risks resulting from storm surges, cooperative processes are rare. Each country implements its own strategy without any or with little collaboration with its neighbour countries. In Germany cooperation between the federal states need improvement, too. Each federal state implements its own coastal protection strategies (resulting in different dimensioning of coastal protection measures, such as dykes).

Existing cooperation between countries within the Trilateral Wadden Sea Region, such as binding elements as the World Heritage Area could provide a best-practice example how to implement cooperation. The case study will include such analysis in the work process on MSPs.

Environmental capital

The Wadden Sea Region is characterized by a high protection level on the seaside, where protected areas, national parks and not least the UNESCO World Heritage areas are installed. These protection zones offer a high potential for sustainable nature development. A healthy Wadden Sea ecosystem including a free flux of sediments increases the capacity of the Wadden Sea as a natural protection mechanism towards storm surge events. In addition to this, the barrier islands, which are part of the World Heritage Area, are important "natural" protection elements. Therefore, maintenance of these protective elements is important.

Regarding currently applied coastal protection strategies, different strategies result in different influences on the ecological system. For example, the strategies of sand nourishment result in a more near-natural impact on the ecosystem than blocking the water from tidal areas by dykes or barriers. In general, coastal protection must be taken into account in terms of nature conservation laws (Natura2000 etc.).

4.3 MSPs in coastal protection and storm surge management

Storm surge protection and coastal management along the Wadden Sea coast is predominantly in the hands of the public sector (comp. section 4.1 and 4.2). In all three countries actors of the respective public sector institutions – e.g. ministries, authorities, municipalities etc. – hold exclusive responsibility for coastal protection. In all three countries coastal protection has priority over other concerns on the coasts. There is a high technical standard based on an extended financial input for construction programs, scientific and technical enhancement. Trust in engineering measures is common among the population in all three countries.

Existing partnerships for storm surge management include the ministries in charge, (federal) authorities, local governments and/or municipalities, dyke associations and water boards in each Wadden Sea country. These partnerships do not actually meet the definition of MSPs in accordance with ENHANCE. These existing partnerships are not open to stakeholders from the private sector, although there are stakeholders with a vested interest in coastal protection and management.

Potential capacity for new or improved MSPs in coastal protection and storm surge management is given, especially due to the need for developing new protection strategies. Future challenges resulting from climatic and socio-economic changes in the Wadden Sea Region bring the opportunity to integrate stakeholders in a comprehensive management concept in which storm surge protection will still play an important role. Especially since strict engineering approaches will reach their limits, future challenges in risk management should consider an inclusion of the private and civil sector. The traditional statistical approach to defining risk (probability of occurrence resulting from "hazard vulnerability") will be challenged and new visions confronting future challenges in coastal protection and management are in demand.

Stakeholder communication and cooperation in other fields are not new to the area, neither on a national nor a trilateral level. Stakeholders from different sectors already work together in environmental management (e.g. in TWSC) and in Integrated Coastal Zone Management (ICZM) issues. This might provide an initial platform for developing new strategies in coastal protection including multi-sector interests. The existing stakeholder platform Wadden Sea Forum provides an opportunity to enhance the discussion on adequate handling of future risk and uncertainties.

The case study will analyse this existing partnership and detect different stakeholders' existing interests in coastal protection. Learning from experiences in stakeholder involvement might help potentially to integrate existing networks or partnerships and enhance the dialogue on new MSPs in storm surge management. A selection of existing partnerships and networks can be found in

Table 3. All of these partnerships and networks can be considered in the broader context of sustainable and successful management of the Wadden Sea Region.

Table 3 Preliminary list of partnerships in the Wadden Sea Region which are potentially relevant for research of the case study

Country / Region	Name	Short description
GE	Insel- und Halligkonferenz *(conference on islands and halligen)*	An association for the population on the North Frisian Islands, Helgoland and the North Frisian Halligen. It represents common interests of the North Frisian Islands and Halligen to the government of Schleswig-Holstein (2012: 29 participants). It is an association of public authority representatives; coastal protection is one of their topics.
GE	Ostfriesland schmeckt nach Meer e.V.	A regional partnership to foster regional identity through regional cooking, marketing regional products and reinforcing regional economics. It is a private initiative.
GE	KüstenKontor	Established in 2009 in the OURCOAST Project as a central point of contact in CZM for stakeholders at different government and non-government levels. It supports coordination, communication and transfer of knowledge between stakeholders. The current level of activity has to be identified by the case study as well as their potential input.
NL	The Netherlands Water Partnership (NWP)	An umbrella organization for the public sector, companies, knowledge institutions and NGOs aiming to increase knowledge and expertise on water, policy development and market opportunities. It is an information network, but also coordinates and executes projects for its members, organize conferences etc. The relevance of multi-sector cooperation in coastal protection issues as well as flood management has to be researched in case study 3.
NL	Delta Alliance	An international knowledge-driven network aiming to improve the resilience of the world's deltas. The Delta Alliance is a collaborative network where expertise and experiences can be exchanged. (Climate Coastal Cooperation, Full report 2011) A scientific network; not a partnership in terms of ENHANCE. The potential of knowledge exchange with international partners (learning from each other) might

		be an additional element for improved MSPs in coastal protection management.
NL	Regie College Wadden-gebied (RCW)	A coordination platform for policy, management and investments. The members of the RCW have their own administrative and social responsibility in the Wadden Sea Region. Coastal protection is one topic amongst others but especially in terms of multi-facetted interests, the network might be an important partnership to evaluate needs and requirements of different actors.
NL / Trilateral Wadden Sea Region	Wadden Academy	The Wadden Academy provides the scientific basis for the management of the natural and social values in the Wadden Sea Region. Its goals are to identify knowledge gaps, develop network(s) for information exchange, and connect their research agenda with ministries and organizations in order to ensure inclusion in planning. This kind of network provides an additional platform to contact and integrate potential partners for improved MSPs in handling hydrological risks in the Wadden Sea Region.
North Sea Region	North Sea Coastal Manager Group (NSCMG)	The NSCMG is an informal group of coastal managers, advisors of government and public authorities from France, Belgium, The Netherlands, Germany, United Kingdom, Scotland and Denmark. Participants from these countries exchange experiences and knowledge and they discuss common problems such as improved communication to the general public (Kystdirektoratet 2012).
Trilateral Wadden Sea Region	Wadden Sea Forum (WSF)	The WSF is a stakeholder forum for actors in the trilateral Wadden Sea Region. It is a voluntary commitment between actors of public authorities, private enterprises, science and civil society. For detailed description and relevance for improving MSPs see 4.3.1.

4.3.1 Wadden Sea Forum: a stakeholder forum

The Wadden Sea Forum, partner of ENHANCE case study 3, is a stakeholder forum of actors in the trilateral Wadden Sea Region. It was established in 2002 following a decision by the 9th Governmental Conference of the Trilateral Wadden Sea Cooperation. The Wadden Sea Forum is made up of representatives from the sectors of agriculture, energy, fisheries, industry and harbour, nature protection, tourism, as well as local and regional governments. National governments are represented as observers. The mission of the WSF is to foster sustainable development and integrated coastal zone management in the Wadden Sea Region. Forum activities comprise the exchange of knowledge and experiences between stakeholders and authorities who are involved in different sectors in the Wadden Sea Region. The aim of the WSF is to bring together members with different interests, to initiate and implement projects and activities on topical issues. The WSF also serves as a consultant body for governmental authorities regarding the development of advice for European and national governmental authorities.

The WSF is a voluntary commitment between actors of public authorities, private enterprises, science and civil society. These actors are brought together by the intention to contribute to an advanced and sustainable development of the trilateral Wadden Sea Region. This international cooperation aims at an integration of cross-sector and trans-boundary strategies, actions and techniques. Based on this network of voluntary partners from

different sectors, different issues of ecological, economic or social interest can be addressed. The multi-sector network provides a base to learn from each other about different interests, to initiate cooperation and common projects as well as to prepare advice for governmental and non-governmental institutions working in the trilateral Wadden Sea Region. The long-lasting cooperation of stakeholders in the WSF allows for successful processes of building confidence between partners, sensitizing actors for the interests and positions of other partners and enables the participants to invest in short- and long-term cooperation, even beyond specific funding periods (e.g. for national or international research projects).

The joint cooperation between the WSF and the Trilateral Wadden Sea Cooperation enables the actors to communicate with the two boards: the Governmental Council and the Wadden Sea Board. The Governmental Council consists of the ministers from the responsible ministries (from Denmark and Germany: the Minister of Environment, from the Netherlands: the Minister of the Ministry of Economics, Agriculture, and Innovation). The Wadden Sea Board represents the internal guiding committee of the trilateral cooperation.

For the case study work, the WSF represents a fundamental, cross-sector network and cooperative consortium in the North Sea region. The WSF is based on voluntary participation (a joint declaration with no legal obligations) and provides an opportunity for stakeholders and actors to present their interests and support decision-making processes. For the ENHANCE project, the Wadden Sea Forum provides a direct link to stakeholders in the Wadden Sea Region. Moreover, the case study will learn from the experiences of the WSF in stakeholder involvement, especially in terms of conservation and sustainable development issues in the Wadden Sea Region. The cooperative process of the WSF will be accompanied throughout the course of the ENHANCE project. A dialogue on vulnerability and adequate risk management will be fostered with several workshop meetings. The intention is to engage the WSF in an exchange about the future development of coastal protection and storm surge management. The intention is to test the shared goal of the WSF and to analyse the potentials for an adequate MSP for the reduction of vulnerability and the handling of future risks and uncertainties in the Trilateral Wadden Sea Region.

5 Research plans (inception report)

The current state of storm surge management presented above underlines the necessity of reframing risk management along the Wadden Sea Coast in order to increase resilience, especially with regard to future climate changes. Improved handling of risks and uncertainties resulting from hazardous events (storm surges, heavy rainfall events, storm events) and from long-term sea level rise caused by climate change are in need of a shift in mental concepts about risks, new integrative protection schemes as well as an increased discussion about it. Because of the observed mental lock-in among the people and the construction limits in coastal protection, the case study wants to create a dialogue including stakeholders and society about potential ways to handle risks in the Wadden Sea Region.

In the first step, it is the aim of the case study to analyse currently involved stakeholders (governmental) and potential partners (non-governmental stakeholders from different sectors) and their collaboration in terms of handling risks and uncertainties in the Wadden Sea coastal area. Detailed analyses of historic development in coastal protection management will be performed in order to highlight the development and changes in jurisdictions and responsibilities in coastal protection management during the last centuries. These detailed analyses will enable the case study to identify important cultural framings of risk, important turning points and important events in coastal protection management as well as to identify weaknesses and potentials for improvement. In addition, important stakeholders currently involved in coastal protection, and potentially interested stakeholders currently not involved, will be identified for the on-going work process.

Reframing risk management strategies in the Wadden Sea Region needs to explore and open new boulevards of thought in order to develop opportunities for partnerships between governmental and non-governmental actors. To analyse current risk awareness, points of view in risk management as well as ideas and visions in future coastal protection, stakeholder interviews will provide basic information for starting a communication process between different stakeholders. Interviewees will be chosen:

i) from public institutions (local government, authorities) who represent the currently involved stakeholders (especially in coastal protection management) and

ii) from other sectors which might be included (new or more in-depth) in future development of coastal protection management.

In relation to multiple differences in interpretation of risks and their impacts between different actors as well as between different sectors or institutions, it is important to include different points of view in the process of successful risk management processes.

Parallel to stakeholder interviews, the case study will analyse the performance of stakeholder involvement which has taken place in other fields than coastal protection in the Wadden Sea Region. Including the expertise of the Wadden Sea Forum project partner, the work of the Trilateral Wadden Sea Cooperation and the work of the Wadden Sea Forum itself will be analysed in order to learn from their experience. Findings will support the evaluation of currently involved and potential stakeholders in the Wadden Sea Region for an adequate management of risks from storm surges, heavy rainfall and storm events as well as

increased sea level rise. Both analytical steps, stakeholder interviews and the analysis of stakeholder performance in the Wadden Sea Region might detect strengths and weaknesses in the long-standing cooperation processes. Findings will improve the understanding of cooperative processes in the Trilateral Wadden Sea Region.

In close cooperation with the Wadden Sea Forum, communication among different stakeholders will be initiated in the form of workshops. A series of workshops at the WSF will enable the case study to create communication processes and foster a dialogue about differences in risk perception in order to understand diverging standpoints and motivations. Communication and discussion is needed in order to initiate changes in mental constructs and reframe risk management in coastal protection – abandoning construction-dominated strategies for more flexible and multi-facetted risk management strategies. The first workshop intends to address the following issues:

i) Perception of different stakeholders towards (future) risk in the Trilateral Wadden Sea Region: To which extent are actors and the lay population in the Wadden Sea Region aware of risks from storm surges, floods, heavy rain events etc.?

ii) Requirements from the perspective of the stakeholders (financial, technical, socio-economic etc.) in terms of (future) development of risks in the region?

The workshop results will be evaluated (report). Communication and discussion of these results with involved stakeholders (governmental actors on different governmental/public levels) will be organized. This evaluation supports the process of developing visions which can be advanced into feasible adaptation approaches in order to handle current and future risks and uncertainties in multi-sector partnerships.

Further communication and stimulation for the establishment of MSPs will be given in a second workshop. Input will be presented through the report and the result of discussions with authorities. The aim of the second workshop is to create communication and potential cooperation between stakeholders from different sectors (different to current responsible institutions in coastal protection) with regard to practical ideas on how to reframe current risk management strategies to handle uncertainties and risks in coastal areas. A continuation of the dialogue process is intended and will be supported during the course of the project.

Outcomes of the workshop, the interviews and the accompanying stakeholder dialogues will be fed into the findings of the case study analysis and the development of MSP prototypes in general in the ENHANCE project.

6 References

Anker, H. T., Nellemann, V. and S. Sverdrup-Jensen (2004), 'Coastal zone management in Denmark: ways and means for further integration', Ocean and Coastal Management, 47, 495–513.

Birkmann, J. (2012), 'Risk', in Borowsky, T. (eds.), Encyclopedia of natural hazards, Dordrecht, Heidelberg, New York, London, pp. 856-862.

Botzen, W.J.W., and J.C.J.M. van den Berg (2008), 'Insurance against climate change and flooding in the Netherlands: present, future, and comparison with other countries', Risk Analysis, 28 (2), 413-426.

Church, J., Gregory, J., Huybrechts, P., Kuhn, M., Lambeck, K., Nhuan, M., Qin, D. and P. Woodworth (2001), Changes in sea level. In: Houghton, J., Ding, Y., Griggs, D., Noguer, M., van der Linden, P., Dai, X., Maskell, K., Johnson, C. (eds.), Climate Change 2001: Working Group I: The scientific basis, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

CPSL (2010), CPSL Third Report The role of spatial planning and sediment in coastal risk management, Wadden Sea Ecosystem No. 28, Common Wadden Sea Secretariat, Trilateral Working Group on Coastal Protection and Sea Level Rise (CPSL), Wilhelmshaven, Germany.

CWSS, Common Wadden Sea Secretariat (2010) Wadden Sea Plan 2010, Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

Deltacommissie (eds) (2008), Samenwerken met water, Deltacommissie, http://www.deltacommissie.com/doc/2008-09-03%20Advies%20Deltacommissie.pdf [last access August 2013].

Delta Programme 2013; Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, Agriculture and Innovation, (2012), Working on the Delta – the road towards the Delta Decisions, The Hague, Netherlands.

Enemark, J. (2005), 'The Wadden Sea protection and management scheme – towards an integrated coastal management approach?', Ocean and Coastal management, 48, 996-1015.

European Commission, (2013), Green Paper on Insurance of Natural and Man-made Disasters 2013, final, Strasbourg.

Ey, J. (2010), 'Initiation of dyke-construction in the German clay district', Wadden Sea Ecosystem 26, 179-183.

FAK, Fachausschuss für Küstenschutzbauwerke (2009), 'Küstenschutzstrategien Bericht der FAK-Arbeitsgruppe', in: Die Küste, 76, 1-74.

Gerritsen, H. (2005), 'What happened in 1953? The big flood in the Netherlands', Philosophical Transactions of the Royal Society A, 363, doi: 10.1098/rsta.2005.1568 [last access November 2013].

Gönnert G. (2003), 'Sturmfluten und Windstau in der Deutschen Bucht - Charakter, Veränderungen und Maximalwerte im 20. Jahrhundert', Die Küste, 67, 185-365.

Gönnert G., Jensen J., von Storch H., Thumm S., Wahl Th. and R. Weisse (2010), 'Der Meeresspiegelanstieg - Ursachen, Tendenzen und Risikobewertung', Die Küste, 76, 225-256.

Hofstede, J. (2009), 'Strategien des Küstenschutzes', paper presented at Fachausschuss Küstenschutzwerke Sprechtag: "Laufende Arbeiten und künftige Projekte", 11 February.

IPCC; Intergovernmental Panel on Climate Change (2007), The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K.B.; Tignor M.; and H.L. Miller (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC; (2012), Changes in climate extremes and their impacts on the natural physical environment in managing the risks of extreme events and disasters to advance climate change adaptation, Chapter 3.

IPCC, (2013), 'Summary for Policymakers`, in: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Stocker, T. F., D. Qin, G.- K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IRGC; International Risk Governance Council (2005), Risk governance: Towards an integrative approach, White paper No 1, Geneva.

Kabat, P., Bazelmans, J., Dijk, van J., Herman, P. M. J., Oijen, van T., Pejrup, M., Reise, K., Speelman, H. and W. J. Wolff (2012), 'The Wadden Sea Region: Towards a science for sustainable development', Ocean & Coastal Management, 68, 4-17.

Katsman, C., Hazeleger, W., Drijfhout, S., van Oldenborgh, G. and G. Burgers (2008), 'Climate scenarios of sea level rise for the northeast Atlantic Ocean: a study including the effects of ocean dynamics and gravity changes induced by ice melt' Climate Change, 91, doi: 10.1007/s10584e008e9442e9 [last access September 2013].

Katsman C.A., Sterl A., Beersma J.J., van den Brink H.W., Church J.A., Hazeleger W., Kopp R.E., Kroon D., Kwadijk J., Lammersen R., Lowe J., Oppenheimer M., Plag H.P., Ridley J., von Storch H., Vaughan D.G., Vellinga P., Vermerrsen L.L.A., van de Wal R.S.W. and R. Weisse (2011), Exploring high end scenarios for local sea level rise to develop flood protection strategies for a low lying delta – the Netherlands as an example, Climatic Change, 109, 3-4, 617-645.

Knottnerus, O.S. (2005), 'History of human settlement, cultural change and interference with the marine environment', Helgoland Marine Research, 59, 2-8.

Kystdirektoratet (2012), The Danish Coastal Authority, Lemvig, Denmark, available at: http://www.masterpiece.dk/UploadetFiles/10852/36/EUfolderuk_web.pdf [last access October 2013].

Lotze, H.K., Reise, K., Worm, B., Van Beusekom, J., Busch, M., Ehlers, A., Heinrich, D., Hoffmann, R.C., Holm, P., Jensen, C., Knottnerus, O.S., Langhanki, N., Prummel, W., Vollmer, M. and W.J. Wolff (2005), 'Human transformations of the Wadden Sea ecosystem through time: a synthesis', Helgoland Marine Research, 59, 84-95.

LSBG, Agency for roads, bridges, and waters, Free and Hanseatic City of Hamburg (2012), 'Internationaler Vergleich der Bemessungsverfahren im Küstenschutz', LSBG report 11, Hamburg.

Luhmann, N. (1993), Risk: A Sociological Theory, Berlin.

Maccaferri, S., Cariboni, F. and F. Campolongo (2012), Natural catastrophes: Risk relevance and insurance coverage in the EU, European Commission, Joint Research Centre, Scientific Support to Financial Analysis Unit, Institute for the Protection and Security of the Citizens (eds), Ispra.

Misdorp, R. (eds) (2011), Climate of Coastal Cooperation, Coastal & Marine Union - EUCC, Leiden, Netherlands.

MLR; Ministerium für ländliche Räume, Landesplanung, Landwirtschaft und Tourismus des Landes Schleswig (2001), Generalplan Küstenschutz – integriertes Küstenschutz-management in Schleswig-Holstein. Kiel, Germany.

Mulder.J.P.M., Hommes, S. and E.M. Horstmann (2011), 'Implementation of coastal erosion management in the Netherlands', Ocean & Coastal Management, 54, 888-897.

MunichRe, (2012), Press dossier: 50th anniversary storm surge Hamburg, press dossier, Munich, Germany.

NLWKN; Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (2007), Generalplan Küstenschutz Niedersachsen/Bremen Festland, Norden, Germany.

Nordic Insurance Association (2013), Weather related damages in the Nordic countries – from an insurance perspective', Report of participants from the Nordic insurance associations June 27 – 2013, available at: http://admin.forsikringogpension.dk/Documents/Klima/Weather%20related%20damage%20in%20the%20Nordic%20countries%20%28final%29.pdf [last access: September 2013]

Oost, A.P. (1995), 'Dynamics and sedimentary development of the Dutch Wadden Sea with emphasis on the Frisian Inlet; a study of the barrier islands, ebb-tidal deltas and drainage basins' Thesis, Utrecht, Geologica Ultraiectina, 126, 518.

Oost, A.P., Hoekstra, P., Wiersma, A., Flemming, B., Lammerts, E.J., Pejrup, M., Hofstede, J., Van der Valk, B., Kiden, P., Bartholdy, J., Van der Berg, M.W., Vos, P.C., De Vries, S. and Z.B. Wang (2012), 'Barrier island management: Lessons from the past and directions for the future. Ocean and Coastal Management', 68, 18-38.

Ostrom, E. (1990), Governing the commons: The evolution of institutions for collective action, Cambridge.

Ostrom, E. (2005), Understanding institutional diversity, Princeton University Press, New Yersey.

Petersen, M. and H. Rohde (1977), Sturmflut: Die großen Fluten an den Küsten Schleswig-Holsteins und in der Elbe, Neumünster, Germany.

Ratter, B.M.W. (2012), 'Complexity and emergence - Key concepts in non-linear dynamic systems', in Glaser M., Krause G., Beate M.W. Ratter, Martin Welp (eds), Human-nature interactions in the anthropocene - Potentials of social-ecological systems analysis, New York, pp. 90–104.

Ratter, B.M.W. (2013), 'Surprise and uncertainty - Framing regional geohazards in the theory of complexity', Humanities, 2(1), 1–19.

Reise, K. (2005), 'Coast of change: habitat loss and transformations in the Wadden Sea', Helgoland Marine Research, 59, 9-21.

Reise, K. (2013), A natural history of the Wadden Sea – riddled by contingencies, the Wadden Academy, Leeuwarden.

Renn, O. (2008), Risk Governance: Coping with uncertainty in a complex world, London, Earthscan.

Renn, O., Klinke, A. and M. van Asselt (2011), 'Coping with complexity, uncertainty and ambiguity in risk governance: A synthesis', AMBIO, 40, 231-246.

Sijtsma, F. and N. Mehnen, (2013), Analysis of Sustainability Indicators Trilateral Wadden Sea Region – concept update, working paper Wadden Sea Long-term Ecosystem Research, unpublished.

TAW, Technische Adviescommissioevoor de Waterkerningen (2002), 'LeidraadZandigeKust', in: Technische Adviescommissievoor de Waterkeringen (Technical Advisory committee on Water defenses), Delft, Netherlands.

Thieken, A., Petrow, H., Kreibich, H. and B. Merz (2006), 'Insurability and mitigation of flood losses in private households in Germany', Risk Analysis, 26 (2), 385-395.

UN/ISDR; International Strategy for Disaster Reduction (2004), Living with Risk - A global review of disaster-reduction initiatives Volume II, New York, Geneva.

Van Koningsveld, M. and J. P. M. Mulder, (2004), 'Sustainable Coastal Policy Developments in The Netherlands - A Systematic Approach Revealed', Journal of Coastal Research, 202, 375-385.

Vollmer, M., Guldberg, M., Maluck, M., Marrewijk, D. and G. Schlicksbier (2001), 'Landscape and cultural heritage in the Wadden sea region - project report', In: Wadden Sea Ecosystem, vol. 12, Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.

Von Storch, H. und K. Woth (2008), 'Storm surges, perspectives and options', Sustainability Science,3; 33 - 44.

Von Storch, H., Gönnert, G. and M. Meine (2008), 'Storm surge - An option for Hamburg, Germany to mitigate expected future aggravation of risk', Environmental Science & Policy, 11, 735-742.

Wadden Academy (2013), The Wadden Sea Region – a World Class Cultural Landscape, Rosendahls Print Design Media, Denmark.

Wadden Sea Forum (2004), Sector-specific analysis and perspectives for the Wadden Sea Region.

Wadden Sea Forum (2005), Breaking the ice, Ijsselstein, Netherlands, available at: http://www.waddensea-forum.org/index.php/strategy/breaking-the-ice.html.

Wadden Sea Forum (2011) Legally valid - Non-Profit Society Bylaws, Wilhelmshaven, Germany, available at: http://www.waddensea-forum.org/images/archive/society/wsf%20bylaws%20final%20signed-web.pdf [last access October 2013]

Wahl, T., Jensen, J., Frank, T. and I. Haigh (2011), 'Improved estimates of mean sea level changes in the German Bight over the last 166 years', Ocean Dynamics, doi:10.1007/s10236e011e0383ex [last access October 2013].

Weisse, R., von Storch, H., Niemeyer, H. D., and H. Knaack (2012), 'Changing North Sea storm surge climate: An increasing hazard?', Ocean and Coastal Management, 68, 58-68.

Woth, K., Weisse, R. and H. von Storch (2006), ‚Climate change and North Sea storm surge extremes: an ensemble study of storm surge extremes expected in a changed climate projected by four different regional climate models', Ocean Dynamics, 56, 3-15.