



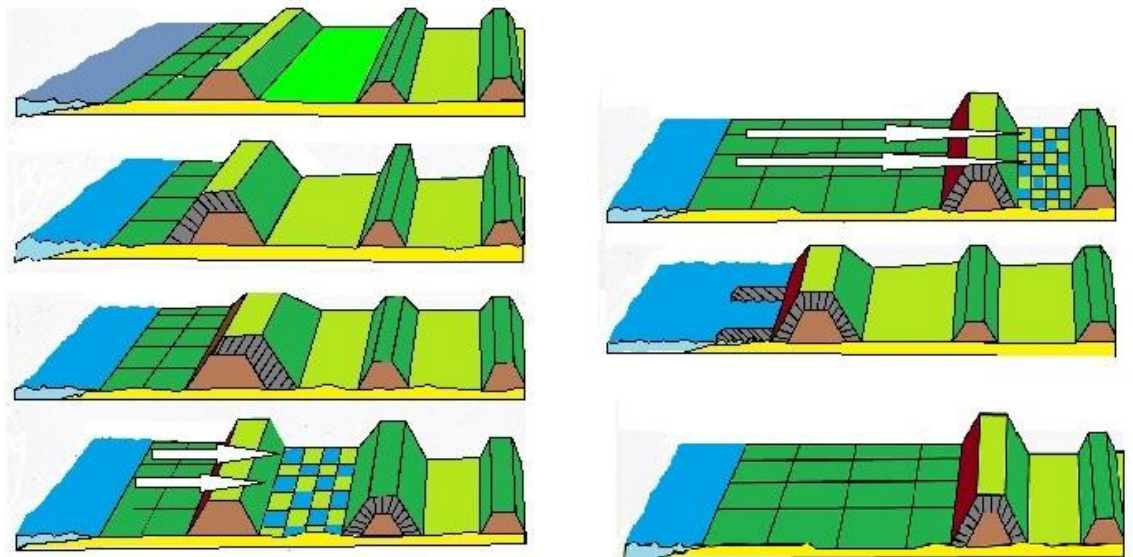
Hogeschool

VAN HALL  
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ONDERDEEL VAN WAGENINGEN UR

# Management Plan for Oldambt

„Climate buffers as a means to cope with sea level rise”



January 2013

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## Management Plan for Oldambt

### “Climate buffers as a means to cope with sea level rise”

In the scope of the module HKZ22 Integrated Coastal Zone Management

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## Preface

From November 26<sup>th</sup> until 28<sup>th</sup> a conference was held in Oostende, Belgium about the effects of sea level rise and subsidence. Our student research group of the study 'Integrated Coastal Zone Management' (ICZM) has been asked to represent the University of Applied Sciences Van Hall Larenstein by giving a presentation about the students view on sea level rise and subsidence in Groningen. The preparation for the conference and the presentation itself were also part of the module HKZ22 "Integrated Coastal Zone Management". The objective of the module is to write an integrated management plan. The topic of the management plan was set with the conference; after the conference it was decided, however, to focus on one municipality in Groningen and not on the entire province. The overall topic "Sea level rise" was kept but during the scope of the module it turned out that sea level rise is by far not the only problem in the chosen area and we were faced with the difficulty that a truly integrated management plan cannot just focus on one issue. Therefore it was chosen to broaden the focus to some extent so that the management plan can tackle a wider range of problems and their associated impacts.

Firstly we would like to give our thanks to Rob Misdorp of EUCC (Coastal & Marine Union) for inviting us through Van Hall Larenstein to the conference and providing us with the opportunity to gather information during an excursion together with student association 'Medusa' of ICZM. Also he provided us with the book "Climate of Coastal Cooperation" which served as a background for our research. Secondly we would like to thank Joop Marquenie, Albert Prakken, Tjark van Heuvel, Jaap de Vlas and Johan Krol for giving us the opportunity to consult them on these matters. And thirdly we would like to thank our supervisors Peter Smit, Leo Bentvelzen, our GIS adviser Ignas Dummer and facilitator Marlous Heemstra for their support and feedback.

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## Summary

Climate change reoccurs more or less every 10.000 years in Earth's history. There have always been glacial periods that were followed by interglacial times. The most noticeable impacts of climate change are on the coastal areas. This project focuses on the impacts of sea level rise as one of the consequences of climate change for the Municipality of Oldambt and to create an adequate management plan for its coastal area. Oldambt consists of a relatively sparsely populated area which is characterized by its large agricultural community. Currently a worst case scenario projects an increase of 130 cm in water level for the year 2100, resulting in an increased chance of dyke breaches from 1 in 4000 years to 1 in 100 years.

The aim is to develop an integrated management plan for a coastal area within the province of Groningen, the municipality of Oldambt is regarded as a suitable study area considering the possibilities to adapt to climate change while integrating the safety aspect with the ecological and socio-economic aspects in the area. Implementing coastal management in this area requires an integrated approach which creates 'win-win situations' for the safety, ecological and socio-economic aspects of the region. This is done by performing research in three phases; the Definition phase in which the problem has been assessed, the Decision/Planning phase in which approaches have been chosen for the implementation of management, and the actual Management phase in which a vision on the region has been made concrete.

The definition phase has been performed through applying the DPSIR for climate change as a global issue and a separate 'human activity based' DPSIR for each of the separate aspects in the region. The global driver is climate change which results in the pressure which is the melting of the ice sheets and glaciers, the resulting state of this is sea level rise. The impacts of sea level rise are: An increased flood risk, problems with discharging water, a loss of biodiversity, erosion of the coast and salt water intrusion. The necessary response for this is an integrated climate adaptation strategy. The adaptation strategy took form by looking at safety, ecology and economy separately whilst keeping the integration of these aspects in mind. The definition phase concluded that the following objectives were necessary to create an integrated management plan:

1. *The safety of the inhabitants has to be guaranteed.*
2. *The environmental quality has to be improved*
3. *Economic opportunities have to be created.*

For safety the protection standard of the coastal defences should at least be maintained to the current standard of a chance of a breach every 1 in 4000 years. Also the municipality should be able to adequately discharge excess water. For the ecological aspect of the area the drowning salt marshes should be prevented, the decline in biodiversity should be stopped and a way to cope with salt water intrusion should be found. And in regards to the socio-economic aspect the agricultural grounds and livestock should be protected from harm caused by flooding and/or salt water intrusion. Also Resident homes, businesses, settlements and infrastructure should be protected from an inability to discharge water channel and river based water, if these properties are flooded the loss of investment and the probable depopulation of the area will cause the economic situation of Oldambt to be impacted negatively. For all the aspects in the area, current policy should be taken into account as much as possible.

In order to take into account all aspects described in the definition phase for the creation of an integrated management plan, the planning phase concluded that three planning approaches were necessary: The Ecosystem based planning approach, the Adaptive planning approach and the Consensual planning approach. These planning approaches together ensure that the resulting management approach is sustainable, that the goals are measurable, that decision-making relies on comprehensive research, that it is recognized that ecosystems are complex, all aspects are interconnected and dynamic, it sees humans as a part of the ecosystem, and that the management approaches are adaptable to changing environments and accountable. It also ensures good cooperative relationships with all stakeholders involved in the region.

The management phase resulted into the assessment of implementation strategies for several coastal defence strategies designed through ecosystem based management, risk and hazard management and community based management. Seven conventional strategies are known and three of these were assessed to be the best option for the area. These three strategies included a:

- Landwards strategy with Storm surge wash over and sleepers dyke
- Landwards strategy, Storm surge wash over the first sleeper dyke and 2 sleeper sea dyke
- Increase salt marches landwards and make sleeper dyke sea dyke

For the implementation of these strategies four phases have been developed in a time frame starting in 2013 and running until 2035:

**Implementation phase 1-Awareness rising: 2013-2018**

The overall goal of the “Awareness rising” phase is to make the inhabitants of the municipality Oldambt aware of the problems that will come along with the rising sea level.

**Implementation Phase 2-Working Group Safety/Nature: 2018-2022**

“The safety of the inhabitants has to be guaranteed.” The aim is to firstly improve safety of residents that live directly at sea and secondly to improve safety of residents that live in the hinterlands of Oldambt.

“The environmental quality has to be improved”. The aim is three-fold: Firstly to improve the water quality and biodiversity of the Dollard, secondly to counteract salt water intrusion in the hinterland, and thirdly to allowing natural sediment supply at the coast.

**Implementation Phase 2-Working Group Socio-Economic 2018-2022**

The overall goal is to decrease the unemployment and stimulate sustainable local economy. This includes the improvement of professional education, to attract young people and to improve the future chances of agriculture.

**Implementation Phase 3: Decision 2022-2023**

In this phase of the implementation all working groups will come together, present their findings and make a final decision about the plans and strategies to be implemented.

**Implementation phase 4 - Implementing plan****2024- 2035**

The final implementation phase will be the actual implementation of the chosen strategies and plans.

During the phases as well as after the implementation evaluation has to take place. Several evaluation methods developed by the SUSTAIN partnership should be used. A self-assessment tool called 'DeCyCe-for-sustainability' based on an indicator set is used to make self-assessment possible for the municipality. A second evaluation method used is a participation method in which participants/stakeholders can give their scores on several parameters. The third and final evaluation method used is monitoring. Through monitoring situation changes can be assessed and if necessary policy can be adapted to fit the new situation better.

The definition phase, planning phase and implementation phase made it possible to develop an integrated management plan which takes into account all aspects of the area and wishes of stakeholders while also addressing the issue of climate change.

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# 1 Introduction

Climate change reoccurs more or less every 10.000 years in Earth's history. There have always been glacial periods that were followed by interglacial times. In that respect the current global temperature increase could be seen as just the next interglacial. However, the human emitted greenhouse gases speed up the process considerably with various possible consequences. The predicted increase of temperature ranges from 1,1°C to 6,4°C taking 1990 as a baseline [Bessembinder, 2012]. The most noticeable impacts on the temperature rise are on the coastal areas due to several factors as summarized by the Intergovernmental Panel on Climate Change (IPCC) to be found in Attachment I (Table I) [IPCC, 2012].

This project focuses on the impacts of sea level rise as one of the consequences of climate change. The cause for the increased sea level is twofold: the melting of land ice (glaciers and ice sheets) and the expansion of salt water due to global warming [KNMI, 2012]. Both the total amount of water in the oceans and the volume of the oceans' water increases [Katsman, 2009]. The threats of sea level rise differs between continents, countries and even between regions in the same country. Therefore also the scale of impacts will vary. There are, however, some general effects on coastal systems induced by an increased sea level; this refers to increased inundation, flooding and storms; increased erosion (a model by Bruun [IPCC, 2012] suggests a shoreline retreat of 50 to 200 times the rise in relative sea level); increased salinization due to a higher seepage flux; rising water tables and hampered drainage; and wetland change and/or loss [Staveren & Velstra, 2011][IPCC, 2012].

The Netherlands, already situated for a great part under the current sea level, will most likely be one of the countries most affected by a rise of the sea level due to climate change. The Royal Netherlands Meteorological Institute has stated different scenarios for the climate in the Netherlands for 2050 and 2100. The expectations for changes in climate relate to changes in temperature, precipitation, sea level rise and wind patterns. According to the most likely scenarios the global temperature in the world is increasing at a fast rate, the intensity of rain showers are likely to increase. For the coastal area, the institute expects a combination of periods of drought interspersed with short but heavy rain showers [KNMI, 2009]. Generally speaking climate change means warmer and dryer summers and wetter winters [Staveren & Velstra, 2012]. There are different predictions on the actual sea level rise for the Netherlands, for the study at hand it is chosen to handle the predictions till 2100 made by KNMI (85cm) and the Delta Committee (120cm) [KNMI, 2009]. The study is carried out for the province Groningen in the Netherlands. Groningen is the most North-Easterly province of the Netherlands. The same climate scenarios as for the Netherlands are, generally speaking, also applicable for Groningen. There is however an additional factor contributing to sea level rise in Groningen: Subsidence induced by gas mining. In the centre of the subsiding area (nearby Loppersum) the ground level has decreased with 30 cm (last measured in 2008) since the gas mining began in 1963. The Dutch gas production company NAM (Nederlandse Aardolie Maatschappij) estimates the subsidence to be about 47cm until 2070 [Commissie bodemdaling, 2012]. The subsidence in Groningen has influence on the absolute sea level rise in the area. The Delta committee assumes an absolute sea level rise of 130 cm for the Netherlands in 2100, taking the effects of subsidence into account [Deltacommissie, 2008].



Data coming from the KNMI show that in the Netherlands the average temperature, precipitation and the sea level increased since the beginning of the 20<sup>th</sup> century [Provincie Groningen, 2011]. The province of Groningen recognized the fact that the climate is changing and that this will have effects on the province itself [Provincie Groningen, 2011]. The province states that it wants to anticipate on climate change but does not see the urgency for substantial adjustments until 2015. The province wants to take adaption to climate change into account when new developments are planned [Provincie Groningen, 2011]. In Groningen, the effects of adaption to climate change will have effects on the planning of the sea defence structure, the management of water resources, the agriculture sector, the natural environment but also on infrastructure and the tourism sector.

The province gives priority to regional, area-specific approaches. In the document "Groningen op klimaatkoers" four priority areas are defined for the climate adaption strategy [Provincie Groningen, 2011]. These are Eemsdelta, Veenkoloniën, Lauwersmeer and Groningen-Assen. These regions are mentioned in the provincial spatial plan (Provinciaal Omgevingsplan) as regions with development challenges and that the role of the province should be the one of the developer [Provincie Groningen, 2011].

The municipality of Oldambt is a region which is not mentioned as a priority when it comes to climate adaption. However in the visionary document 'Ontwikkelingsperspectief 2030 – Appingendam|Delfzijl' the coastal defence zone in the municipality of Oldambt is described as a "Natural Coastal Zone" [Vliet, 2009<sup>e</sup>] with opportunities to combine the defence functions of the coast with nature targets and economic stimulation of the region. So far there are no integrated plans that consider those different aspects. It is expected that measures to adapt to climate change will only find support among the citizens when these measures are connected with the daily problems in the area [Provincie Groningen, 2011].

As the aim is to develop an integrated management plan for a coastal area within the province of Groningen, the municipality of Oldambt is regarded as a suitable study area considering the possibilities to adapt to climate change while integrating the safety aspect with the ecological and economic aspects in the area.

### **Main question**

The associated main question is:

"How can the municipality of Oldambt manage the challenges of sea level rise in the area taking into account the aspects of safety, nature and economy?"

### **Research questions**

The main question is divided in sub questions:

1. What is the issue in the municipality Oldambt with regard to sea level rise?
2. Which planning approaches are suitable in the municipality Oldambt with respect to safety, nature and economy, and why?
3. Which management approach or mix of approaches for implementation would have the most benefits for safety, ecology and economy?

## 2 Methods

The questions are according to the three phases presented in the introduction of the module Integrated Coastal Zone Management: definition phase, decision phase and implementation phase.

### Definition phase

The first sub question falls in the definition phase. In the study at hand it is chosen to focus on the driver climate change as described in the introduction. Next to climate change there are other drivers identified concerning the aspects nature and economy.

The issues playing a role in Oldambt are analysed with the 'Driving Force-Pressure-State-Impact-Response Framework'(DPSIR) framework as used by the European Environment Agency (EEA) [EEA, 2007] Figure 1).

The anthropic activities and processes that cause pressures on the environment in this coastal area are coming from the humans primary and secondary needs. These can be primary needs for shelter, food and water or secondary needs like the need for mobility, entertainment and culture [Kristensen, 2004]. The drivers lead to human activities in order to meet the demands of the society. Pressures on the environment can be classified as excessive use of resources, changes in land use and emissions to air, water and soil [Kristensen, 2004, p.2]. The state of the environment can be seen as the result of the pressures in the area. This is a combination of the physical, chemical and biological conditions due to the affection by the human activities carried out in the area [Kristensen, 2004]. The changes in the environment due to the pressures may have impact on the quality of the area. These impacts can affect the ecosystem, the life- supporting abilities, human health and the economic and social performance of society [Kristensen, 2004, p.3]. The response to the undesired impacts can be related to any part of the chain between driving forces and impacts. Responses can vary between changes in policy or regulation to responses of society [Kristensen, 2004, p.2]. The already existing responses are outlined in the definition phase. The analysis of the issues in Oldambt according to the DPSIR- model can be found in chapter 4.

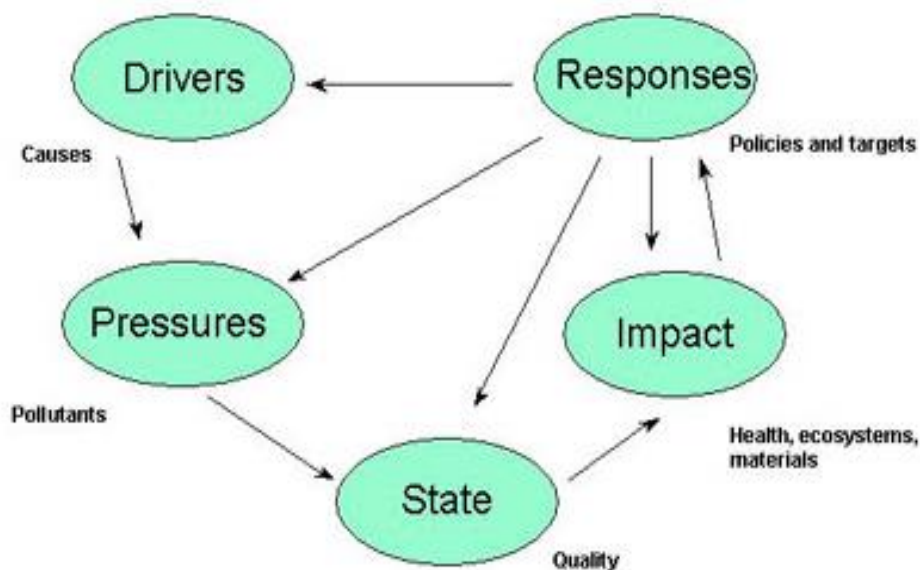


Figure 1: The DPSIR-model [Kristensen, 2004]

### **Decision phase**

Sub question two falls into the decision phase and is concerned with the planning approaches. For the choice of planning approaches, the book “Coastal planning and management” written by Kay& Alder is used to identify the most suitable planning approaches. The planning approaches are chosen so that the issues linked to the different aspects of safety, ecology and economy are taken into account. The decision phase is outlined in chapter 5.

### **Implementation phase/ management phase:**

The implementation phase uses management approaches coming from the book “Coastal planning and management” written by Kay& Alder [2005]. The choice for the management approaches is based on the findings from the definition and the decision phase. The implementation phase describes the response to the problems playing a role in Oldambt and is translated into an action plan.

### 3 Study Area

Oldambt is a new municipality. On the first of January 2010, the three municipalities Winschoten, Scheemda and Reiderland fused into the municipality of Oldambt. Back then the municipality counted 39.000 inhabitants.

The municipality of Oldambt (Figure 2, Table 1) is traditionally characterized by a large agricultural area, the Wadden area, a wide polder landscape with sleeper dykes and a few farms in every path of polder. Monumental farms and open agricultural hinterland form the major quality of the area [Gemeente Oldambt, 2012<sup>b</sup>].

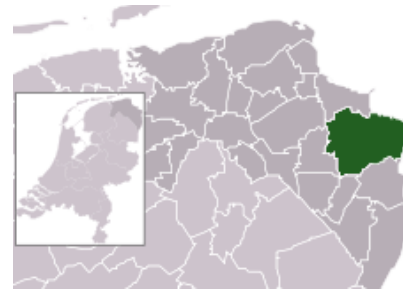


Figure 2: Municipality of Oldambt [Wikimedia, 2012<sup>b</sup>]

Municipality	Total area (incl. water) in km <sup>2</sup>	Water km <sup>2</sup> in	Semi - built in km <sup>2</sup>	Roads in km <sup>2</sup>	Forest and nature in km <sup>2</sup>	Agricultural area in km <sup>2</sup>	Recreation area in km <sup>2</sup>
Oldambt	296,4	61,6	14,3	7,1	16,4	194,1	2,8

Table 1: Land & water area percentages in Oldambt [Oldambt, 2012<sup>b</sup>]

The old villages Finsterwolde, Beerta, Midwolda and Oostwold fringe the “Blauwestad”, a new man made landscape where nature, living and recreation are intended to be combined. Winschoten is the economic motor of the region. Nearby Westerlee and Heiligerlee are forest and nature landscapes. Oldambt has 15 core settlements and a number of smaller hamlets. In comparison to other municipalities with comparable numbers of inhabitants, Oldambt is a sparsely populated municipality with 1,3 people per hectare (compared to 3,6 people per hectare in the rest of Groningen). If the management is not changed in order to counteract the decrease of inhabitants the expectations are that 35.200 people will live in Oldambt by 2025 [Gemeente Oldambt, 2012<sup>b</sup>].

The vision of the municipality describes Oldambt as a municipality for people, culture, landscape and history. The history of Oldambt formed the people who are living there. The settlers came from Germany and from the South. Monastery villages turned the landscape into fertile agricultural ground. Later on, trade caused the first division in rich and poor people. People had to defend their land against the influences of the sea. The dominance of the city Groningen was very strong and there was only little land given to smaller self-employees which lead to a distrust in the governmental forces. Nowadays people do not think very positive about Oldambt which results in the underestimation in the own forces of the people living in Oldambt [Gemeente Oldambt, 2012]. The culture is described as a culture of survival. The people are practical thinking, conservative but also open for new cultural elements [Gemeente Oldambt, 2012]. New developments are seen critical initially but the people try to make the best of it once the developments are set in place. They, however, want to know what is in for them when new developments are presented [Gemeente Oldambt, 2012].

## 4 Definition Phase

In order to define the problem of sea level rise in the municipality of Oldambt, the DPSIR model (Drivers-Pressures-State-Impact-Response) was chosen as a tool. This framework is widely adopted by the European Environment Agency [Kristensen, 2004].

### Using the DPSIR-model

The driving force is the global climate change and not as in other models specifically a human activity. However, climate change itself is partly driven by population, consumption, transportation, industry and other drivers. The pressure stresses the natural environment. Due to global warming, the land ice and glaciers melt which leads to sea level rise. Sea level rise is the state of the natural environment. An increased risks of floodings in the coastal area, caused by sea level rise, have consequences on the environment ,on the safety of the inhabitants and on the economic activities in the region.. These are impacts which rise from the changes of the state of the environment. Salt water intrusion for example as an impact on sea level rise has influence on the driver agriculture and safety in Oldambt.

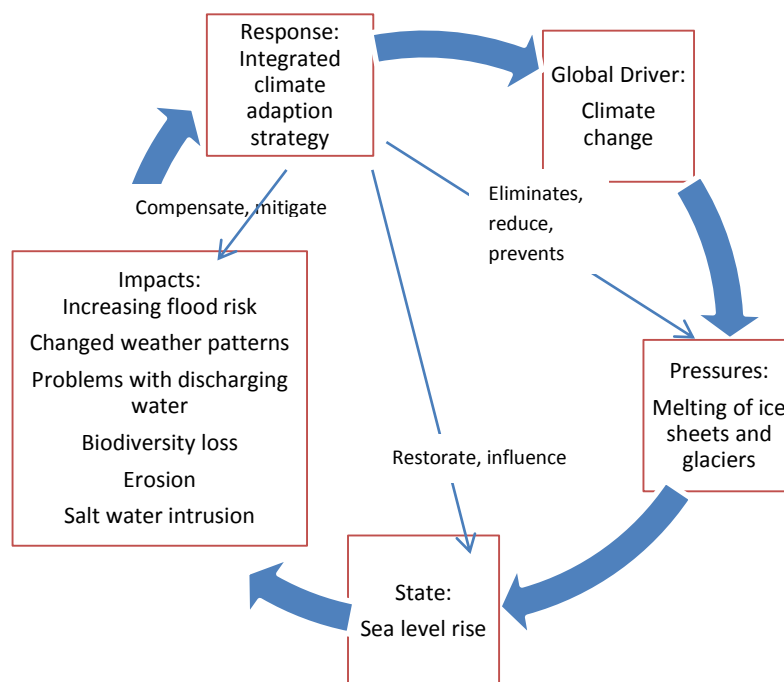


Figure 3: DPSIR model for climate change

Impacts of importance of sea level rise for Oldambt are the increased risk of flooding, difficulties with the discharge of the water from the hinterland into the Wadden Sea and salt water intrusion.. In the model for Oldambt, the drivers are human primary and secondary needs that lead to human activities. The pressures are changes in the environment due to human activities. This leads to a state which describes the condition of the natural environment. The changing state of sea level rise causes impacts on the environment and on the human system (Table 2).

<i>Related to climate change and sea level rise</i>	<b>Driver</b>	<b>Pressure</b>	<b>State</b>	<b>Impact</b>	<b>Current Response</b>
<b>Safety</b>					
	Protect people and hinterland	Building coastal defence	Sea level rise	Hazards from flooding increases	Surveillance of dykes, Consolidate dykes
	Necessity to uphold the safety standards	Building dykes weirs and locks	Parts of dykes do not meet the safety standard of 1/4000	Increased risk of dyke breach, people's life is endangered, economic loss in case of dyke breach	Emergency and evacuation plans
	Necessity to drain hinterland	Increase of heavy rain showers, especially in the winter	Increasing water nuisance, pumps have limited capacity	Increased risk of flooding of the land	Water storage areas, restoration of natural streams, emergency plans, heighten quays
<b>Ecology</b>					
	Climate change	Sea level rise	Higher speed of tidal currents, Changing morphology, receding coastal line	Sand banks and salt marshes inundated more often. Less primary production, loss of biodiversity, less space for breeding birds	Project "Dollard Salt marshes"
	Climate change	Higher seepage flux	Salt water intrusion	Shift in vegetation and fauna	No current response
<b>Economy</b>					
	Demand of fresh water for inhabitants and agriculture, especially in summers	Ground water extraction	Higher seepage flux	Salt water intrusion, less crops	Flushing polders with fresh water, restrictions on irrigation
	Climate change	Sea level rise	Increased risk of flooding	Economic loss in case of flooding	Consolidate dyke constructions

Figure 2: DPSIR model for Oldambt

## 4.1 Safety

When it comes to sea level rise and its effects, safety of the hinterland is maybe one of the major issues. Without safety in the region all aspects that are human related will suffer severely.

### Driver

The safety of the inhabitants in the area has to be guaranteed. The protection against the water and risk of flooding is a prerequisite for the people to live and work there. Safety is also a prerequisite for economic activities (agriculture, tourism) in the area. Therefore measures taken for adaptation to climate change need to include safety aspects. Climate change poses challenges by a rising sea level and from rising rivers by the increased rainfall. The combination will make the drainage of the rivers extra difficult.

### Pressure

In order to protect the people and the land against the sea, dykes were built. These activities protected the people and the land against the sea. With sea level rise the hazards from flooding increases, which is for the safety aspect the main pressure. The hazards come from the sea side when a severe storm occurs. To discharge water surplus, locks and weirs were built to regulate the discharge of the water. As a consequence of climate change, the intensity of rain showers are likely to increase. The discharge of the surplus of rainwater, especially in the winter period, will be more difficult with a rising sea level.

### State

The sea dyke between the polder and the Dollard is part of the dyke around Groningen and Friesland (Ringdijk 6) which is brought up to Delta height with a chance of breach of 1 in 4000 years in this area. The coastal defences in the area are of great importance to the safety for both inhabitants as well as ecological/economic values in the hinterland. The primary dyke in the Carel Coenraadpolder which lies in the project's area, does not meet the standard of 1/4000 anymore (Figure 4). The dyke has a hard / soft structure on the landside being covered by grass and a hard structure on the seaside made out of basalt.



Figure 4: Dykes that do not meet the Delta standard in the Ems-Dollard [Deltaprogramma Waddenzee, 2013]

On the landside the polders are bordered with the old dykes also called the sleepers dykes. These dykes are lower than the Delta dykes and covered with grass all around.

In the visionary document 'Ontwikkelingsperspectief 2030 – Appingendam | Delfzijl' the coastal defence zones are divided up into four different types as shown in Figure 5. The Natural coastal zone (blue) is situated to the east of Delfzijl and borders the Dollard. The visionary document states that the focus in this area should lie on nature development [Vliet, 2009<sup>e</sup>].

Another growing concern with the impending sea level rise is the discharge of water. With rising sea level it gets more difficult to discharge the water into the sea. In the last few years, the frequency that the area had to cope with water nuisance increased [Waterschap Hunze en Aa's, 2012]. The need of water discharge is especially necessary in case of major rainfall and melting water discharge coming from the Rhine delta and flowing up north towards the Wadden Sea. The municipality of Oldambt is situated within the water discharge area of the mainstream 'Ems' and the sub stream 'Nedereems'. The Nedereems discharge area is controlled by the *Water Board Hunze and Aa's* and the *Water Board Noorderzijlvest* two bodies of the surveying board of the dyke. For the Municipality of Oldambt the controlling body is the Waterschap Hunze and Aa [Rijksoverheid, 2012]. The pumps are having a limited capacity to drain the hinterland. Oldambt barely averted a high water disaster in 1998. In two weeks the water in Northern Netherlands rose to extreme heights and only because of the flooding of two polder areas other areas could be protected. After 1998 the Water Board Hunze and Aa's made several efforts to improve the situation. Since then no disasters occurred in the area [Waterschap Hunze en Aa's, 2012]. As shown in figure 6 all water outlets for Oldambt go through the Fiemel pumping station (E) and the sluice at Nieuwe Statenzijl (B).



Figure 5: Coastal defence zones [Vliet, 2009<sup>e</sup>]



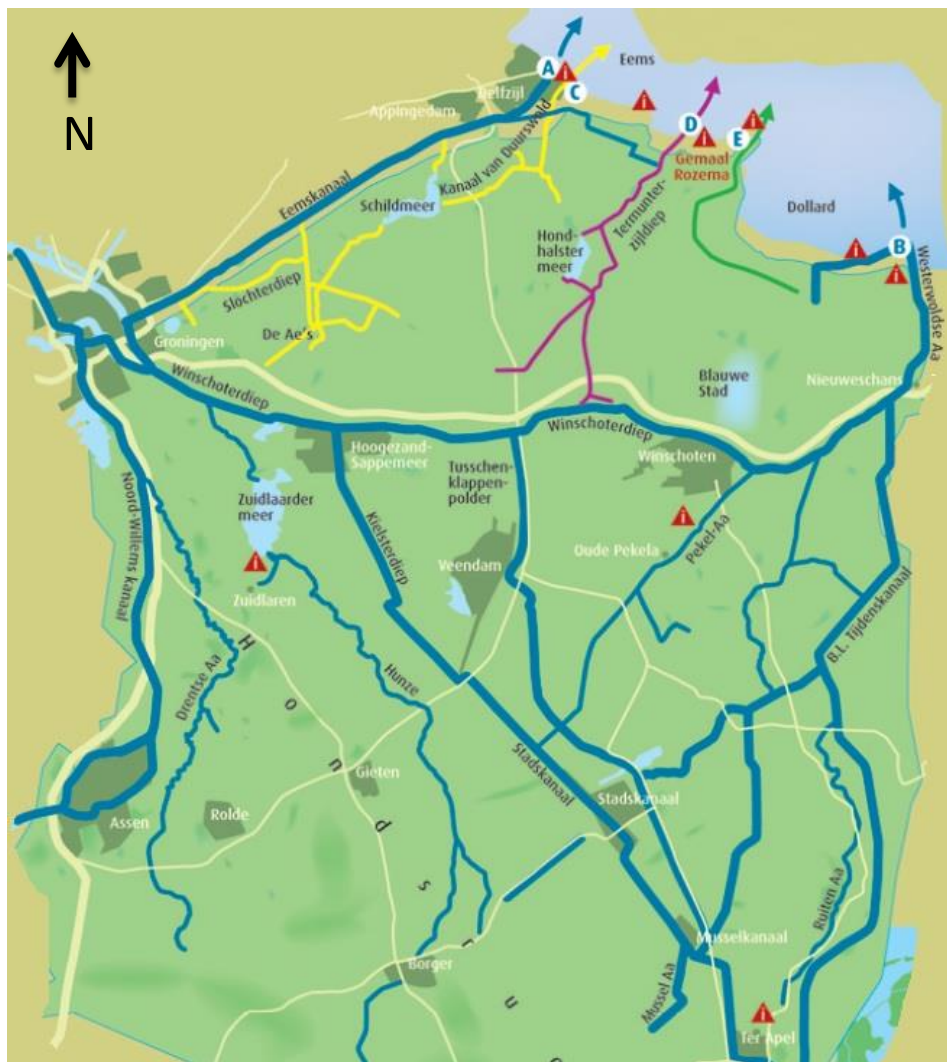


Figure 6: Reconstruction of water discharge map Nedereems [Waterschap Hunze en Aa's, 2012]

### **Impacts**

The construction of hard dykes and locks changed the Ems- Dollard from an open intertidal area into an estuary which is canalized. Floodplains and salt marshes were changed into polders so that the water has less space. In case of high water levels the water has only one way to move: upwards [Programma naar een rijke Waddenzee, 2012]. The Ems-Dollard is characterized by impoundment during floods. High amounts of fresh water are discharged into the estuary and with changing precipitation patterns (heavy rain showers) this could lead to changing circulation patterns and changed sedimentation. This might have impact on the defence against flood events because of the change of heights of the foreland [Deltaprogramma Waddenzee, 2013]. There are strong indications that the deepening of the water channels (for shipping) leads to a bigger tidal range and therefore to higher water levels in case of a storm flood [Deltaprogramma Waddenzee, 2013]. Due to building dykes, weirs and locks, the natural transition from fresh to salt water do not exist anymore. This has impact on the fish stocks. Migrating fish does hardly have the opportunity to migrate between the rivers and the sea (and vice versa).

Sea level rise itself has impact on the reliability of the dyke constructions. With sea level rise, the pressure on the dykes increases. Calculations show that the chance of a dyke breach rises with an

increased sea level. This affects the safety and lives of the inhabitants as stated above. The chance of a dyke breach can reach a norm of 1/100 years if nothing is done (Table 3).

Year	Chance of dyke breach (chance/year)
2000	1/4000
2050	1/1000
2070	1/400
2080	1/200
2100	1/100

Table 3: Chance of a dyke breach with a sea level rise of 130cm in 2100

The calculations (Figure I, Attachment II) are based on a scenario of 130cm sea level rise in 2100 and refers to water levels at Nieuwe Statenzijl. In case of a dyke breach people's lives and properties are in danger.

Flooding of the land could also occur when the discharge of water will not be possible anymore because of the rising sea level. In the water system plan Oldambt/Fiemel is stated that the capacity of the pumping station Rozema, which discharges water from the river Ems, will have to be improved in the years 2025 till 2030. Otherwise the water discharge cannot be guaranteed [Waterschap Hunze en Aa's, 2008]. In case of flooding the main impact will be the loss of the land for agricultural use which means economic loss.

#### **Current policy**

The current policy on safety is set to maintain a safety standard of the dykes of withholding a storm that statistically occurs once every 4000 years. The province and stakeholders have ordered an investigation in which the risks of a breach have been assessed. All projects in the region have to be weighed against the main objectives of the policies concerning conservation of nature (birds and habitats directive which are implemented in the Natuurbeschermingswet, see ecology). However the policy the "Derde Nota Waddenzee" applies to the Ems-Dollard region. Under this policy interventions to guarantee the safety of the inhabitants are allowed even when there are restrictions by nature policies.

Research in 2008 pointed out that the Netherlands is not ready for mass-evacuation in case of flooding. However the base ingredients are present to make sure the Netherlands is prepared. The most important aspect is making use of opportunities in self-reliance of inhabitants. To exploit these opportunities the inhabitants should be informed properly [Mohnen, 2008].

In reaction to this a 'Taskforce Management Overstromingen' has been set up to assess and improve the capabilities of coping with flooding in the Netherlands [Mohnen, 2008]. The province of Groningen has set up the Crisis Management Groningen (CMG) to assess and improve these capabilities for the province of Groningen. All 23 townships, the police, the fire departments and the healthcare help the departments in the region. The water board (body for maintenance and survey of the dykes), the province, the justice department and the ministry of defence are important partners of the CMG [Gemeente Groningen, 2012].

The CMG organizes public gatherings and has made publications like the 'risk index' brochure to inform the public what to do when a crisis occurs. They have done this for any crisis including

flooding. These risk indexes have information about how to stay up-to-date on developments during a crisis and several checklists of what to do and when to take action (Figure II, Appendix II)[Crisis Management Groningen, 2012<sup>b</sup>]. Aside from the self-reliance of inhabitants, the CMG has set up projects, policy development plans and drills. Through this crisis management can take place more effective so that all partners of the CMG can perform their tasks directly and adequately. Finally the CMG writes an annual report on disasters and how they were dealt with [Crisis Management Groningen, 2012<sup>c</sup>].

## 4.2 Ecology

The Ems-Dollard estuary is one of the last remaining estuaries in the Netherlands (along with the Westerschelde). The Ems-Dollard being part of the Wadden (translation: 'sand plates') Sea consists of shallow waters, sand plates flushed at high tide or spring tide and deeper trenches. The estuary coasts have natural and man-made salt marshes. The silting up of marshes in this region is between 7 and 10 mm each year [Dijkema & Duin, 2012]. The Dollard is the part of the estuary that is directly adjacent to the municipality Oldambt.

The Dollard is the salt and brackish shallow mouth of the estuary. In the Dollard salt marches were created the traditional way by constructing raster of 400 by 400 meters of small dams on dry falling grounds. These salt marches can be divided in high marches (on flood line) with sea aster (*Aster tripolium*) and bulrush (*Bolboschoenus maritimus*), fed upon by the wintering grey goose and low marches with pioneer vegetation as *Salicornia* (*Salicornia maritima*) growing between the ebb line and flood line. The shallow waters and sand banks of the Dollard are a habitat for the juvenile fish and foraging area for migrating birds and resting place for the grey seal (*Halichoerus grypus*) [Blew & Südbeck, 2005]. The issues concerning nature can be divided in issues which relate to sea level rise and issues which play a role in the area but are not directly linked to sea level rise. The environment, especially the adjacent Ems-Dollard estuary is already highly impacted by the shipping route which connects the "Meyer-Shipyard" in Papenburg with the Wadden Sea.

### Driver

Concluding from the literature study of impacts of sea level rise, it is likely that climate change and expected sea level rise will have impact on the coastal nature in the study area. Therefore it is a need to adapt to climate change in order to minimize the negative impacts on the nature. Besides the driver climate change, the most pronounced need for the waters adjacent to Oldambt, are not even caused by the Netherlands but are caused by Germany and derive from the mentioned shipyard. In order to keep enough water under the keels of the constructed ships with more than 300 meters of length, the shipping route, the Ems-Dollard is a site of extensive dredging. Weirs, locks and dredging make the fairway deeper than 9 meters all up to Papenburg.

### Pressure

Sea level rise may cause that intertidal sandbanks and saltmarshes will be inundated more often and there is the risk that sandbanks and salt marshes will drown. Salt marshes can fulfil a function of coastal defence because of their wave absorbing property. If salt marshes and sandbanks drown, the coast will be more vulnerable to flood events, the water gets muddier and therefore the primary production of the ecosystem will decline. The primary production takes place in the top layer of water column and on sand banks and is the base of the food chain of the ecosystem. Secondly the speed of the tidal current is already too high [Programma naar een rijke Waddenzee, 2012] and the disappearance of sand banks and salt marshes will contribute to this pressure. Inundation of salt

marshes also means less space for breeding birds. Furthermore sea level rise also causes salt water intrusion of the land nearby the coast.

Next to sea level rise, the changed morphology and the continuous dredging of the Ems-Dollard estuary put pressure on the ecosystem of the Ems- Dollard. Dredging causes increased turbidity of the water. In muddy waters light can hardly penetrate the water and so algae have less energy to reproduce. This causes also less productivity of primary producers such as algae [Programma naar een rijke Waddenzee, 2012]. Another pressure linked to the shipping activity in the Ems-Dollard is the release of toxic compounds deriving from the toxic anti-fouling of ships (banned in 2008 but the effects will linger on for decades) causing infertility for snails.

Sea level rise causes salt water intrusion of the fresh water lenses. This might have effects on the vegetation. Also animals that are not resistant against salt/brackish circumstances could be affected by salt water intrusion. On the other hand ,the salinization caused by salt water intrusion could increase bio-diversity as brackish grounds are seldom in the Netherlands and are inhabited by rare species.

### **State**

The current state of the water quality of the Ems-Dollard is poor. It is described as a degraded ecosystem due to the changed morphology. It results in high muddiness rates causing long term anoxic periods in some zones and in habitats that are limited in quality and quantity [Waddenvereniging, 2012]. In the Ems-Dollard estuary the German river Ems and the Dutch river Westerwoldse AA discharge.

At the moment there are 760 hectares of salt marshes. The salt marches are part of the Ecological Main structure connecting Natura2000 areas. Apart from the problems associated with dredging, the infertility of mollusc and snails has been reported. This is caused by toxic compounds such as Tributyltin (TBT) which is trapped in the mud and which originates from the anti-fouling of ships for years. Even though the use of TBT was forbidden in 2008, the effects will linger on for many years [Ministerie van Verkeer en Waterstaat, 2005]. A Red List of species can be found in Attachment III.

The land area between Termunten, Bad Nieuwenschans and Nieuw Statenzijl consists of polders created in the eighteens up to the twenties century (Figure III, Attachment III).

The polders consist of young sea clay and are mainly used for the agricultural cultivation of potatoes, beet and wheat. The polders are used by birds as the graylag goose (*Anser anser*) for foraging grounds and for breeding grounds by the Lapwing (*Vanellus vanellus*). The polders have been assigned as a special protection area for arable birds by the Provincie of Groningen [Kate, 2009].

### **Impact**

The impact of sea level rise on the environment include drowning of salt marshes, decline in biodiversity, flooding and salt water intrusion. The erosion of the salt marshes of the municipality is highly depending on the extent of the sea level rise. The capability of the salt marshes to grow with the sea level is restricted to 0,7 to 1 cm per year as mentioned above. A sea level rise of more than 70 cm per century could cause the drowning of the salt marshes in the Dollard with serious impacts on the fauna and flora species which depend upon the salt marshes and the sand banks. A decline in the total biodiversity will be the result. There has been a study on breeding birds to find out to which extent they are affected by sea level rise. Salt marshes of the Wadden Sea are important breeding sites for many birds (e.g. *Haematopus ostralegus*, *Tringa tetanus*, *Recurvirostra avocetta*, *Platalea leucorodia*, *Larus ridibundus*, *Sterna hirundo*, *Somateria mollissima*, *Alauda arvensis*, *Anthus*

*pratensis*). Due to climate change and sea level rise the flooding frequency of the salt marches has increased, even in the summer which is the main breeding period for most of the birds. The study revealed that the birds are already adversely affected which is noticeable e.g. in reduced breeding success. The expectation is that the negative effects will increase if the birds are not able to adapt to the changes [Pol *et al*, 2012]. To which extent the findings of this study applies to the Dollard region is not mentioned, it can be assumed, though, that sea level rise has similar impacts on the salt marshes of the Dollard.

Depending on the magnitude of flooding, fauna and immobile species can be affected through their intolerance to salt water or in case of soil destruction and drowning. Studies on salt water intrusion in the municipality are not available but it could cause a shift in the vegetation coverage from salt intolerant to brackish or salt tolerant species.

### **Current policy**

The Estuary of the Eems-Dollard has been appointed as Natura2000 preservation area under the Birds and Habitats Directives. It is regarded as a separate habitat type within the Natura2000 area described as “Estuary” (H1130) [Deltares, 2012]. These directives are implemented in the Dutch Nature Conservation Directive (Natuurbeschermingswet) and the Flora-and Fauna Directive.

The European Union demands the improvement of the Ems-Dollard ecosystem.

The Ems Dollard estuary being an inland water (till one mile out of the coast) is considered under the EU Water Frame Directory. The goals for EU water Directive for 2015 are the GET (Good Ecological State) and the GEP (Good Ecological Potential). For the Ems Estuary most of the goals for the GET and the GEP will not be achieved by 2015 [Grenswateren Commissie, 2005] In the European Water Directive a minimal amount of 700 hectares of salt marches in the Dollard are required. There are already initiatives to improve the quality of the Ems-Dollard estuary; one is the “Program for a rich Wadden Sea” (Programma naar een rijke Waddenzee). Bos *et al* [2012] describe seven feasible options to recover the estuary: re-construction of two shipping passages, opening of the summer dykes, development of the vegetation, relocation of a winter dyke, relocation of the barrier upstream of Herbrum, the re-connection of old rivers and secondary channels and the reduction of the depth of the shipping lane. One of the criteria in selecting the best options was climate durability.

## **4.3 Socio-Economic**

Even though the focus of the study lies on sea level rise, other pressures also play a role in the municipality of Oldambt regarding the economy. Therefore the focus is on the current socio-economic situation in Oldambt and in which way sea level rise could adverse this situation.

### **Driver**

One of the main driver for the municipality of Oldambt is a striving economy to ensure the well-being of its inhabitant. For the municipality it is important that the inhabitants can prosper and make a good living. If the economic situation is good for the inhabitants then they are reluctant to leave and look for work elsewhere. Other drivers concerning the aspect economy are the need to decrease unemployment and the aging population. Also agriculture is an economic driver in the area.

### **Pressure**

Pressures for the economy in Oldambt result from the aging population (19% of the inhabitants are older than 65 years in contrast to 14% national), quite high percentage of unemployment, international competition, and the low profile of the municipality which makes it unattractive for

potential investors (it was just established in 2010) [Gemeente Oldambt, 2011]. If there is no accretion of young people this means that the municipality will have less people who belong to the working population, which means less productivity. The pressure generated by agriculture derives from the demand of fresh water. With climate change dryer summers are expected and thus the demand for fresh water will increase. Fresh water is needed for irrigation. That means that the extraction of ground water will increase also.

### **State**

The municipality of Oldambt is traditionally characterized by a large agricultural area. Monumental farms and open agricultural hinterland form the major quality of the area [Gemeente Oldambt, 2012]. According to the municipality one of the reasons why the economic crisis did not hit Oldambt severely, was due to the employment in agriculture. When comparing the portion of the agricultural jobs with other employments in the municipality, the percentage of employment in agriculture is quite low (just 4%, including employment from forestry and fishery) [Gemeente Oldambt, 2013] Due to new developments of work, the professional education (located in Winschoten) does not fit the requirements of education needed in the area [Gemeente Oldambt, 2012<sup>c</sup>].

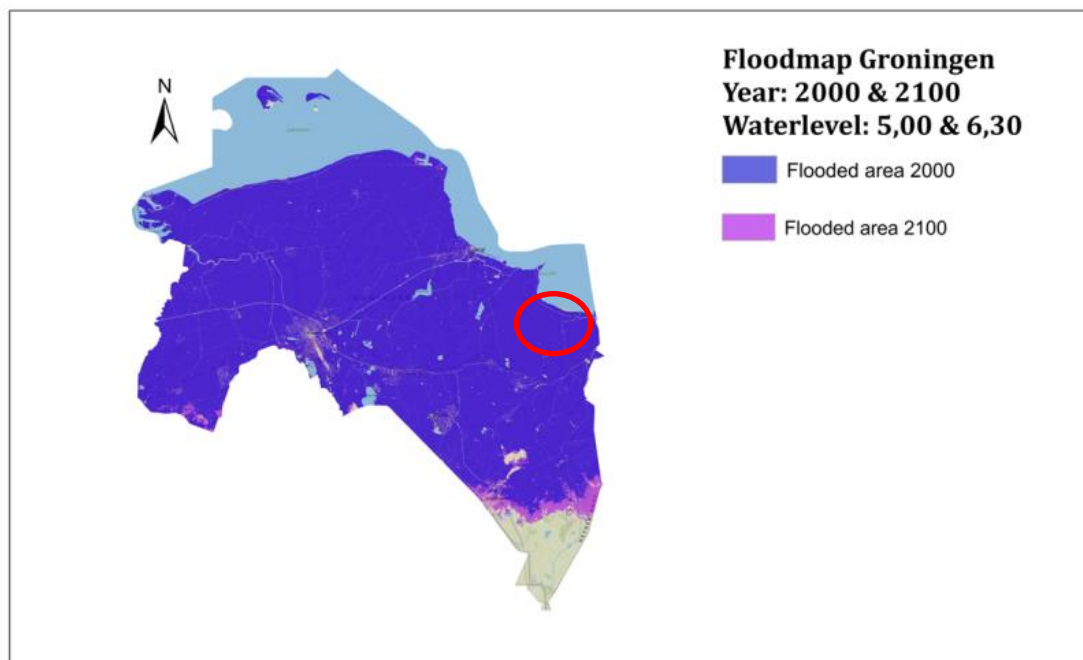
The current state of salt water intrusion could not have been investigated. Further facts concerning the socio- economic developments can be found in the attachment IV.

### **Impacts**

The impacts of sea level rise on the economy in the municipality of Oldambt could appear in two major forms: flooding through dyke breach and water discharge problems, and salt water intrusion.

Generally speaking the economy only faces serious problems if the protective measures fail. The map below (figure 7) was drawn estimating which parts of the Province of Groningen would be flooded in case of complete dyke breach of ringdijk 6 during a major storm and High Water of 5 meters above NAP (Normaal Nederlands Peil) The flooded area was estimated with the use of ArcGIS (Figure 7). The municipality of Oldambt in the North-Eastern part would be entirely flooded in the advent of such a storm (it has to be borne in mind, however, that the estimations are made on the assumptions that all dykes would breach at once and there are no sleeper dykes).

The impacts on the agriculture would be quite severe. The agricultural grounds could be recovered but the harvest would be at least partly or even totally lost for some future years due to salt intrusion. Additionally most of the livestock could most likely not be saved and the farms would be partly or entirely be destroyed. The same applies for other housings, business settlements, stores, etc. Depending on the magnitude of the flooding, the aftermath could lead to more rural depopulation and decrease of job opportunities. Flooding could also occur due to water discharge problems as described under 4.1 Safety. When the sea level rises, the difference between sea level and the water level of the rivers discharging into the Dollard will decrease, making it much more difficult to discharge water. In a worst-case scenario the discharge of water will not be possible, resulting in flooding of the hinterland because the river banks breach. Housings, business settlements and agricultural ground will be damaged or even destroyed.



**Figure 1: Flooded area in case of a dyke breach nowadays (blue coloured area), Red circle indicates the municipality Oldambt**

There is no literature available about the impact saltwater intrusion has in the municipality of Oldambt or to which extent it would influence the agriculture or other functions in the municipality. There have been studies for the entire Netherlands and to illustrate in which way it might have effect on the municipality, a short explanation follows. Sea level rise causes higher pressure coming from the sea on the upper layers of the groundwater. Combined with lower surface water levels in the sea level rise this will increase the saline seepage. Up to a sea level rise of 50 cm the consequences on the flux of saline seepage is limited and the functions such as agriculture or recreation of the area will not to be altered according to the steering group of the “Kustvisie” [Luttje, 2008]. The effects of sea level rise such as constrained possibilities to discharge water and rising seepage flux in combination with dryer periods as a consequence of climate change will, however, increase the chance of salinization [Staveren & Velstra, 2011]. Salt water intrusion can have also impacts on the availability of fresh water and drinking water.

### **Current policy**

For the municipality Oldambt and along the Wadden Sea coast, the province wants to support modern big scale businesses in the agriculture and horticulture sectors which take a pioneers role for the Netherlands and for Europe. The province supports the development of the production chain, innovations on cultivating, technic and processes. Furthermore the province wants to stimulate the cohesion of the agriculture and horticulture and the nature and landscape development; these businesses have to fit into the landscape. The adaption to the changing climate, the improvement of water management and soil quality and the sustainability of the production methods are further points of attention and are supported in form of subsidies. New establishment of agricultural businesses are only possible outside the Ecological Main Structure (Ecologische Hoofdstructuur) and



new livestock breeding farms are not allowed to have negative impact on Natura 2000 sites [Provincie Groningen, 2011<sup>b</sup>].

The municipality of Oldambt emphasizes the importance of sustainable economic growth. The means to achieve this is the attractiveness of the municipality as a place for living and working [Werkgroep Oldambt, 2007]. A new Health center in Nieuweschans and renovation of monuments did increase the number of tourists and the connection to the highway A7 also stimulated the economy. To protect the characteristics of the landscape it is thought of establishing internet companies or care centres in monumental buildings such as old characteristic farms [Werkgroep Oldambt, 2007]. The focus for the upcoming years is described in the Economic policy plan [Gemeente Oldambt, 2011] and lies, among others, on recreation and tourism, ecological activity and positioning of the municipality (a complete list can be found in Attachment IV).

#### 4.4 Response

The response to the problems in Oldambt is the development of a management plan. The management plan is set up as a means to make Oldambt climate durable and to prepare the municipality for the rising sea level while attempting to incorporate solutions for the current problems and issues of Oldambt as well.

The goal of the management plan therefore is:

*An integrated planning for the municipality of Oldambt in the North-East of Groningen to meet the challenge of sea level rise in this area. The spatial and integrated plan has to contribute to the safety, a healthy ecosystem and to a vital economy in the area.*

Following objectives are included:

1. *The safety of the inhabitants has to be guaranteed.*
2. *The environmental quality has to be improved.*
3. *Economic opportunities have to be created.*

The guiding principles that we chose thereby are:

- The principle of sustainable management should underpin the management decisions in order to cope with sea level rise. This includes a long term view.
- Safety: Considers options for flood defence which enables the “build with nature idea” while guaranteeing the safety of the inhabitants with regard to sea level rise.
- Environmental: Improves the quality of the estuarine area to increase the biodiversity in the area. The management plan preserves and improves the ecological quality of the area.
- Economic: Enables cooperation between different stakeholders in order to create new economic activities. The management plan explores the option for economic development of the area.
- Social/cultural: Create awareness for the challenges of the area and realise support to implement the management plan.



- Recreational: Reduce the impacts of recreational use and enhance development of new ideas for recreation and tourism in the area; to make use of the natural values without harming the environment.
- Collaboration with the coastal community and other stakeholders should be enhanced. The community and the stakeholders should benefit from the management approach.

## 5 Planning phase

The goal, objectives and guiding principles serve as the basis for the decision on the most suitable planning approaches. The focus lies on the “building with nature” idea. The planning approach should fit this idea while also taking into account the improvement of the water quality in the Dollard, the socio-economic development of Oldambt, the development of recreational activities and the enhancement of stakeholder collaboration. This requires a sustainable and holistic approach, taking into account the whole ecosystem.

### **Ecosystem-based planning**

The ecosystem-based planning is a holistic approach and hence applies for safety, nature and economy and is therefore suitable to achieve the objectives of the management plan. An ecosystem-based planning approach has several features, it is: sustainable, the goals are measurable, decision-making relies on comprehensive research, it is recognized that ecosystems are complex, interconnected and dynamic, humans are part of the ecosystem, and approaches are adaptable and accountable [Kay & Alder, 2005]. Especially three features apply to the objectives to be handled in Oldambt, namely sustainability, humans as part of the ecosystem and the adaptable and accountable approaches. Taking into account the definition of sustainability development by the Brundtland Commission (“development which meets the needs of current generations without compromising the ability of future generations to meet their own needs” [UNECE, 2013]) it implies that the developments that will take place in Oldambt have to be favourable for current and future generations, takes into account the inhabitants of Oldambt and additionally the approaches have to be adaptable to the rising sea level. Even though all this can be achieved with an ecosystem-based planning approach, it is chosen to reinforce this approach with two more approaches.

### **Adaptive planning approach**

The coastal region is very dynamic and this is why an adaptive planning is necessary as well. There is still uncertainty over the actual sea level rise and its exact impacts. If there are new scientific findings, it should be possible to include them in the planning and management of the plan. This is not only restricted to new scientific findings regarding sea level rise, but also applies to other findings. Therefore it is necessary that during the implementation process, nature processes, such as the amount of sea level rise, are monitored and the implementation is constantly evaluated. With this it is possible to react if anything changes in the environmental setting or if stakeholders are not content with the process. The outcomes of the evaluation enable the management to adjust the strategies. Both ecosystem-planning and the adaptive planning approach consider the input of stakeholders. For Oldambt, it is chosen to handle a third planning approach, explicitly aiming at involving the stakeholders.

### **Consensual planning approach**

A consensual planning approach implies that the inhabitants of Oldambt and other stakeholders take part in the planning process. The ultimate goal is that a win-win situation is created and that there is a mutual benefit for everyone [Kay & Alder, 2005]. Even though a mutual benefit for all stakeholders might not be possible, this approach will ensure that the objective- a collaboration of stakeholders with the aim to create benefits- is met. Furthermore this approach can be used to develop new economic and recreational activities in Oldambt.

## 6 Management phase

The choice of the management tools is based on the definition and planning phase. It is chosen to handle three management tools, namely ecosystem-based management, risk and hazard management and community-based management.

### **Ecosystem-based management**

The ecosystem-based management is the overall management tool and is used to integrate the risk and hazard management, as well as the community-based management. In fact, ecosystem-based management is the “integration of ecological, social, and economic goals” [Ecosystem-Based Management, 2010]. Concerning the safety issues the risk and hazard management is the primary tool to identify best practices to uphold or improve the safety standard. Ecosystem-based management in this regard plays a role because these best practices also take the environmental aspects into account. Strategies are identified with respect to possibly improve the water quality of the Dollard. Furthermore the community-based management is used to incorporate the opinions of the residents and to involve them in the decision making.

### **Risk and hazard management**

There are two hazards identified, the first one is a storm which creates such a pressure that the sea dykes in Oldambt fail and will result in the flooding of the municipality. The second hazard is that due to sea level rise the rivers will not be able to discharge into the Dollard anymore. As explained above the risk for both hazards is increasing with a rising sea level. In the former case, the chance of a dyke breach is estimated to increase from once every 4000 years to once every 100 years. The risk for flooding by problems with water discharge is not estimated and therefore the focus will primarily lie on the sea dykes. Risk and hazard assessment management can be used to assess and reduce or mitigate any risk which influences coastal planning [Kay & Alder, 2005], this may include stakeholder disagreement or an increased sea level rise scenario. In order to make changes in the area, good communication between experts and the public is necessary. Communication with and feedback from the public and other stakeholders may change the way policy is developed and implemented. Referring to Kay & Alder [2005], in present day coastal risk management the opinions and views of the public have to be included in the decision-making process. To fully achieve this, it is chosen to handle a second management tool, namely community-based management.

### **Community-based management**

The advantages of community-based management is that it incorporates environmental and resource management activities into the inhabitants’ everyday life [Kay & Alder, 2005]. The inhabitants become the “problem owner” and feel much more responsible for the management and its success. Affirmed by Kay & Alder [2005] this sort of management also contributes to the socio-economic development of the community. This is one major point discovered in the research, namely that the community of Oldambt is faced with two major problems: the rising sea level in the future and socio-economic problems nowadays. Additionally to this, the bad water quality of the Dollard is an issue. To tackle this problem, the ecosystem-based management is used as an overall tool.

## 6.1 Strategies for risk and hazard management

There are basically five strategies in risk and hazard management: avoidance, the reduction of the likelihood of occurrence, reduction of the consequences, transference, and acceptance [Kay & Alder, 2005]. The former two are not possible to pursue in the case of Oldambt. The residents cannot avoid the occurrence of storms or sea level rise, and neither can reduce the likelihood of occurrence. Therefore the focus lies on the latter three options. The reduction of the consequences can be achieved by adjusting the coastal defence of Oldambt. As mentioned before the focus lies on the “building with nature” idea and ecosystem-based management. An option to do this is the creation of climate buffers as described below. This will both include the transference of residents in some cases and the acceptance of changes being made.

### Climate Buffers

The current situation is that existing defense nowadays is a hard structure. It is a traditional dyke at “Delta” height with a stone shoulder on the direction of sea and a grass shoulder landwards. In the hinterlands are polders below the sea level consisting of young sea clay. At the seaside men made salt marshes have been formed. These marshes tend to grow about 1 mm a year what makes them grow with the sea level rise [Esselink *et al*, 2011]. The current dyke is designed with a safety breaching factor of 1 in 4000 years. This chance will grow drastic with sea level rise and will become unacceptable if nothing is undertaken (see calculation on base of a rise of 130 cm in 2100 in attachment II). A general strategy against climate change is to aim for a decrease of CO<sub>2</sub> emissions (the Kyoto treaty) and the creation of climate buffers. Climate buffers are nature areas specially designed to reduce the consequences of climate change. In these areas both water and nature are given more room. Climate buffers will not only guard against flooding but will also store water for dry periods. In this way, these areas can offer the Netherlands security, attractive natural settings for plants, animals and people, and a healthy economic climate [Climate Buffers, 2012]. Salt marshes are considered as excellent climate buffers as they adapt to sea level rise. If sub tidal shores are further enhanced by mussel and oyster banks and sea grass fields this will slow down wave energy and function as a bio builder [Slim & Löffler, 2007]. There are different strategies which are outlined below (Figure 8).

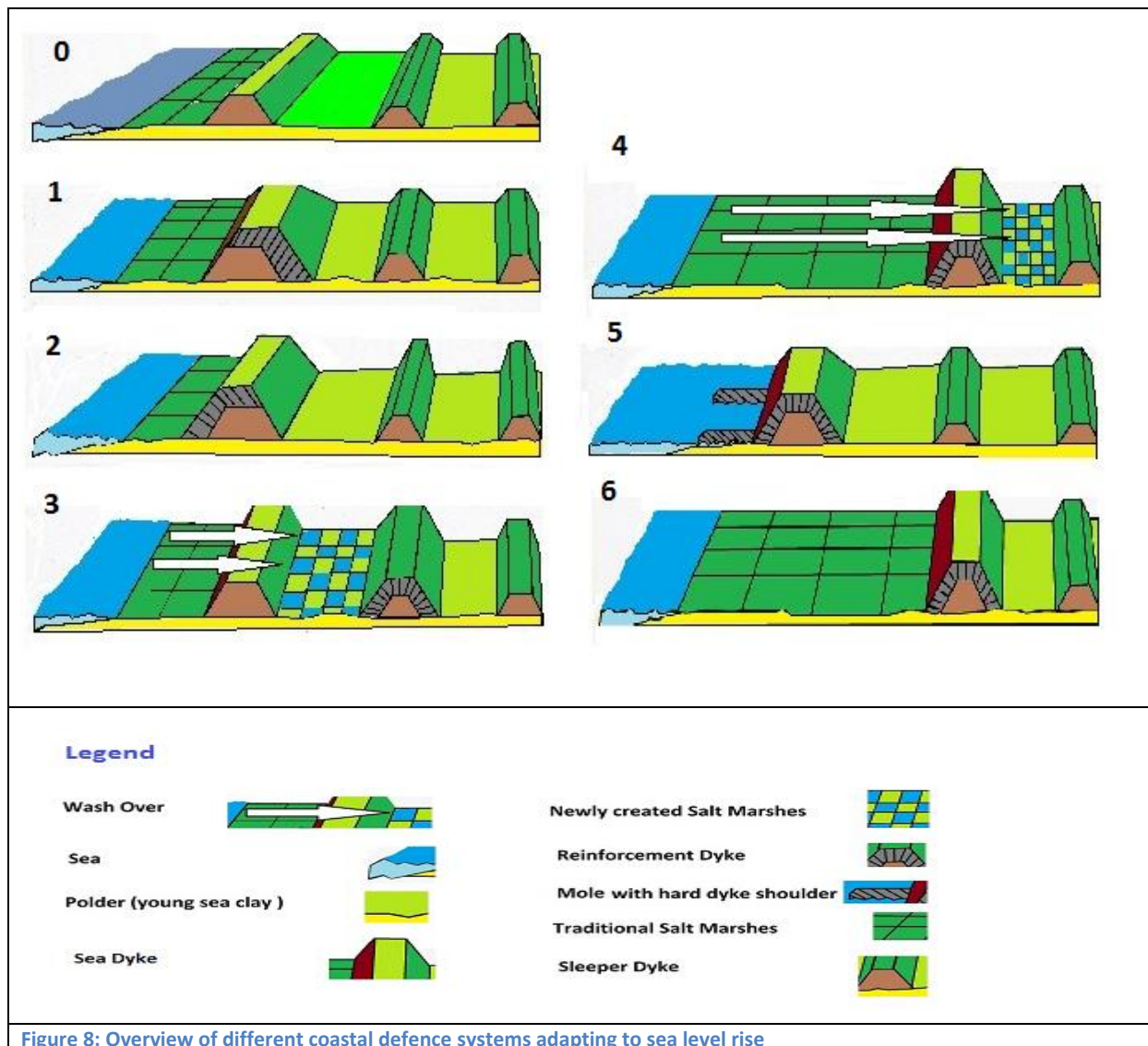


Figure 8: Overview of different coastal defence systems adapting to sea level rise

Several strategies can be deployed to safeguard man, nature and economics against the pressure of sea level rise. These strategies need to be applied on the coastal zone. The strategies differ in traditional hard defenses landwards (figure 8, drawing 1) and seawards (figure 8 drawing 2 and 5), landwards with a climate buffer and natural silting up of salt marshes created by the wash over of the sea dyke or sleeper dykes (figure 8 drawing 3 and 4) or seawards with a climate buffer by extending the existing man made marshes (figure 8 drawing 6). To be able to evaluate the advantages and disadvantages and encourage the discussion with the stakeholders, an overview is provided (figure 8). A first initial rating of the strategies on their effects on nature, habitat, economics, tourism, national and European nature protection legislation, sustainability and their capability to form a climate buffer has been conducted (figure 9). The reasoning is explained further on in this chapter. Combinations of strategies can be formed but are not rated here. To create efficient climate buffers one needs to keep in mind that the subsidence of the inland used to be silted up by the rivers. This is at this moment not happening as the rivers have been canalized for a great part and have weirs, locks and dykes with hard shoulders. A climate buffer will be more efficient if the rivers are capable to silt up their borders and estuaries as well from the land side. There for a combined strategy of coastal defense and the creation of space for rivers are best

combined and will create a safe and attractive environment with a good quality of habitat for men, flora and fauna for now and future generations. The regeneration of bio builders as oyster beds and mussel banks and sea grass fields in the sub-tidal area will help decreasing the stronger wave energy created by climate change and help silting up the coast. Uncertainty about the speed and amount of sea level rise asks for an adaptive approach which is prepared for the worst but working towards the best. The creation of salt marshes is already included in the Ems-Dollard management plan [Het Regionaal College Waddengebied, 2011].

### Different strategies and their merits

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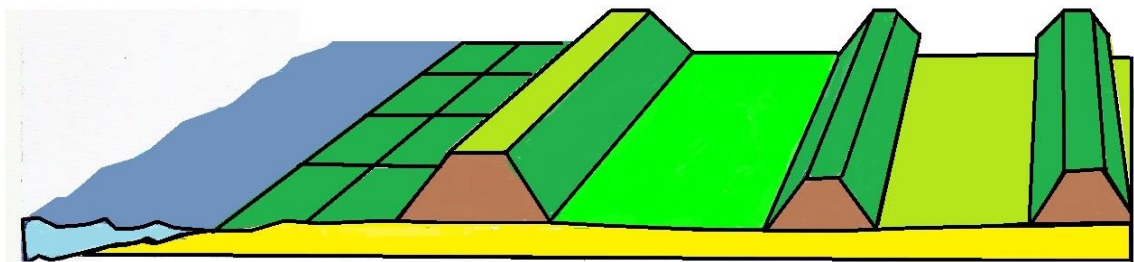


Figure 9: Current situation, strategy 0

The baseline is a traditional dyke at “Delta” height with a stone shoulder on the direction of sea and a grass shoulder landwards. In the hinterlands are polders below the sea level. The soil is young sea clay. At the seaside men made salt marshes have been formed. There is about 760 hectares of salt marshes now in the Dollard region [Esselink *et al*, 2011].

1.

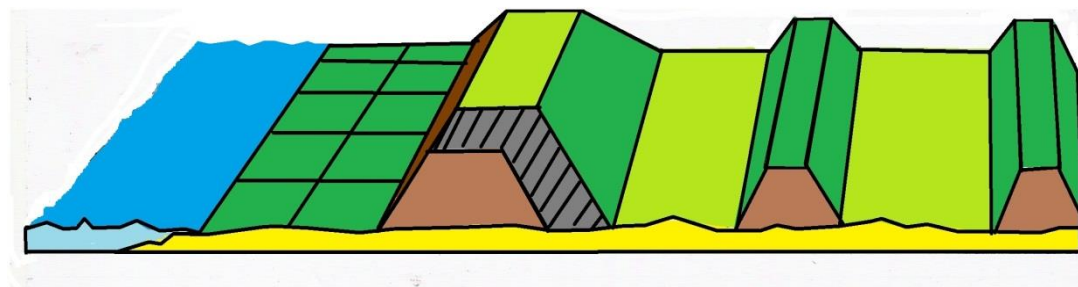


Figure 10: Reinforcement with traditional landwards dykes (strategy 1)

Consolidation with ‘traditional’ landwards dykes is coping with sea level rise and stronger storm surges by raising the dyke in height. As the dyke becomes higher it needs a broader base. The base is broadened landwards. It has as an advantage that it is reasonable easy and one knows exactly the costs in time and money. The disadvantage is that it does nothing for the salinization and that the rivers have more difficulties to flush their water to the sea. The difference of height between the land and sea increases. It does not allow the principle of growing with nature and will be negative on the long term for a holistic view for nature. No climate buffer is created.



2.

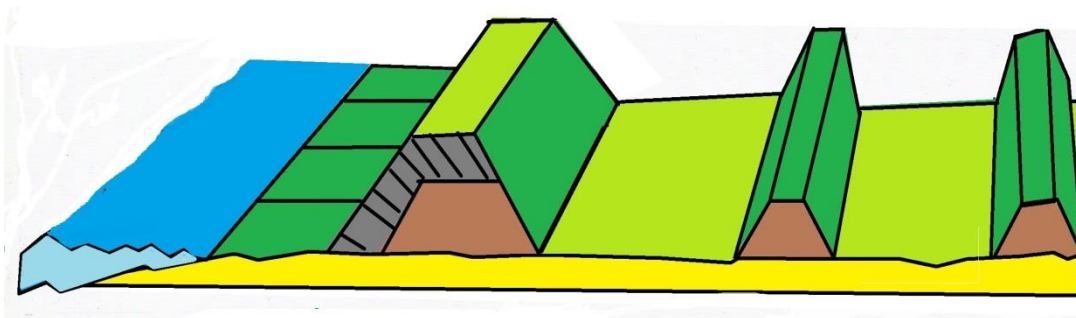


Figure 11: Reinforcement with traditional seawards dykes (strategy 2)

Consolidation with 'traditional' seawards dykes is coping with sea level rise and stronger storm surges by raising the dyke in height. The broadening of the dyke base is seawards. This is more costly as the broadening the dyke landwards as it needs more fundament and the new or recycled outside boulder of hard substrate is needed. Often the stone is basalt which needs to be imported. It has a more negative effect on nature as it further narrows the basin of the estuary and parts of the salt marshes will be lost. Further negative consequences are the same as for landwards traditional dykes salt upwelling will get stronger with subsidence and sea level rise. The rivers have will have more difficulties to flush their water into the sea because of the increasing height difference between land and sea. It does not allow the principle of growing with nature will there for be negative in a holistic view for nature. No climate buffer will be created.

3.

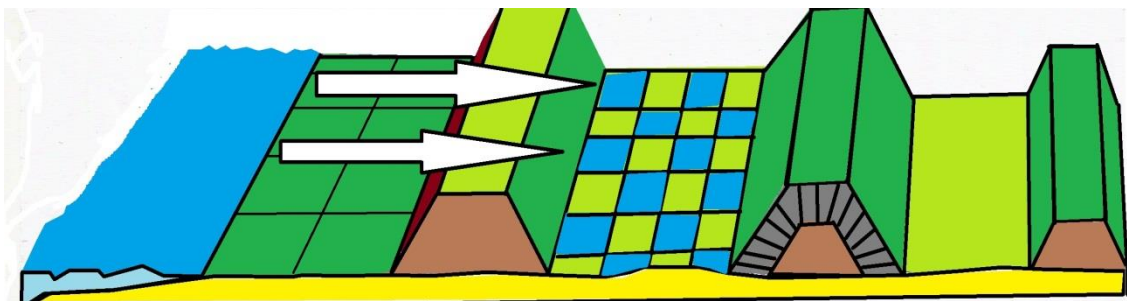


Figure 12: Landward strategy with storm surge wash over sea dyke and first sleeper dyke for protection

Strategy 3 is a Landwards strategy with storm surge wash over the current sea dyke while the first sleepers dyke is reinforced and is maintaining the safety against the flush overs. The current sea dyke stays at the same height. With sea level rise there will be wash over with high tides and storm surges. The wash overs are not getting further than the first sleeper dykes. This will create a brackish environment between sea dyke and sleepers dyke. The sleeper dykes which are now captured on several places need to be restored. Farms lying in the area need adaptation or move to higher grounds. Brackish nature is quite rare and will create new and important habitats [Trilateral Monitoring and Assessment Group, 2009]. The newly created saltmarshes will grow every time a little with the silt coming in with the wash overs. This will not be enough to cope with maximum scenario of relative sea level rise but does help. The Dollard will get more space. The costs of maintaining will be higher than with the traditional dykes as there is a double set of dykes to maintain. The newly brackish marshes work as a climate buffer. The landscape will be more divers

and could attract more tourists and the salt fresh gradient could be used for energy creation (membrane technology) which could be beneficial for local economy.

4.

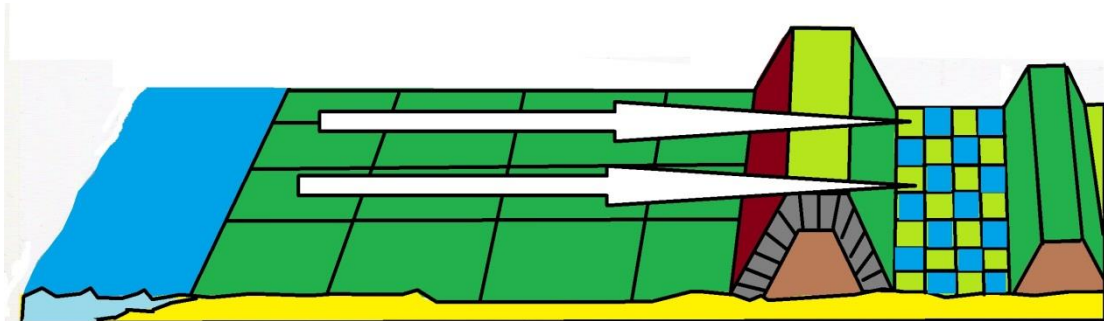


Figure 13: Landward strategy, sea dyke is removed, storm surge wash over first sleeper dyke second sleeper dyke protects against wash over (strategy 4)

This is a Landwards strategy where the sea dyke is removed to increase the salt marshes for protection against sea level rise. This is the same strategy as number 3 with the difference that the current sea dyke is taken down, the first sleeper dyke will become the reinforced sea dyke with wash over. That wash over is kept by the second sleeper dyke. The effect is that the building with nature is maximized. The polder, which is given back to the estuary, can silt up with the seal level rise. The land between the two dykes will be brackish and contain salt marches. The positive effect on nature will be greater than in strategy 3. It is more costly as two rows of sleeper dykes need restoration and the first needs to get at a height that will only allow wash over or to allow a moderated tide. The possibility for (ecological) tourism will increase. The area will function a large climate buffer for this and future generations. More farms and houses need adaptation or to move to higher grounds. There are possibilities for saline culture and the creation of energy by membranes.

5.

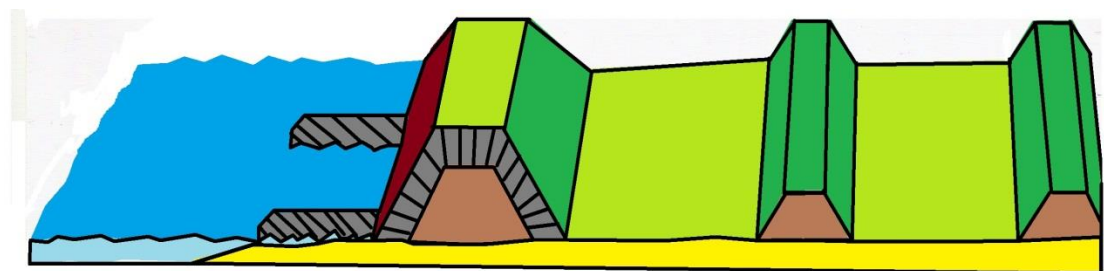


Figure 14: Seawards strategy with moles strategy 5

The Seawards strategy with moles is consolidating and enforcing the current sea dyke and creating moles in front of it to break the wave energy coming with storm surges. This will good for safety and could be regarded as an extra on top of strategy 1. However it will further disturb the natural sand distribution. It will destroy and or alter the current salt marshes. Possible salt marshes could restore and the moles could be a good substrate for mussels and oysters which could then function for slowing the water down. For possible positive effect much is uncertain and extra research would be needed. It will change the morphology of the estuary by narrowing it and change the water dynamics. It will damage the natura2000 salt marshes.



6.

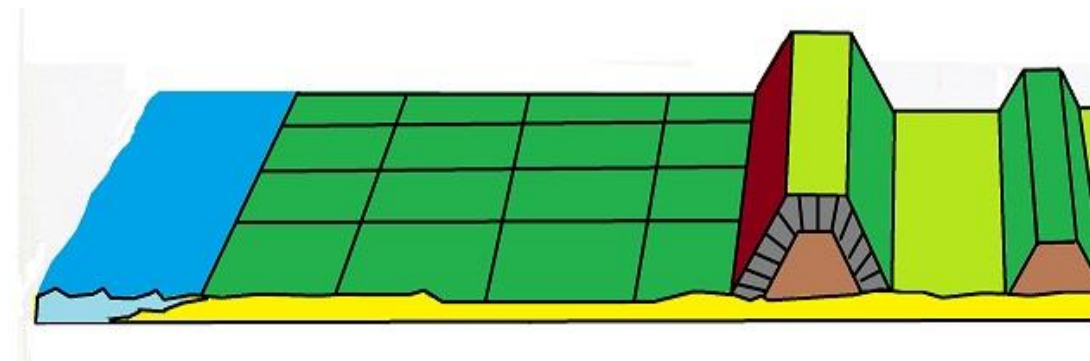


Figure 15: Increase salt marshes landwards and make sleeper dyke sea dyke (strategy 6)

The strategy of increasing the salt marches seawards and consolidating and reinforcing the traditional dykes is actively increasing the salt marshes by using the old polder methods to silt up the land. This is done by creating two seaward, 400 meters squares with a filter of willow poles vertically and horizontally along the coast which then keeps the silt positioned there by the wash over during high tides. This will create larger salt marshes and makes it possible that these saltmarshes grow with nature. The natural silting up in that region is about 1 mm per year. It would increase the nature values partly because new marshes get created and the muddy Dollard water could get clearer. On the other side it would further narrow the estuary and would be against Natura2000 and the Birds Directive. It would have an impact on the wave energy but will have a limited impact as a climate buffer.

7.

Landwards strategies with sea inlets are possible in combination with variant 1, 3. As it is a combination of different strategies the ratings depends on the combination. The combination with strategy 1 will be cheaper and less “green”. Combining it with 3 or 4 will be more positive on the green side but more costly and could encounter more resistance of the habitants. These combinations have not been rated here but could get a rating if such a combination might be the outcome of the consultative and or consensual planning.

### Evaluation of the climate buffers

The strategies that are outlined above are evaluated considering their long term effects on the natural, economic, touristic values and on infrastructure and housing. The evaluation format has been adapted to Oldambt from Smit [Smit *et al*, 2005] who did a similar research on polders in another area of the Netherlands. The questions for evaluating the strategies are:

1. Has variant effect on nature values of region?
2. Has variant effect on nature values of the Dollard?
3. Has effect on the economic values in the region?
4. Has effect on the touristic values in the region?
5. Has effect on species and habitats which are protected by Nature2000, Birds and Habitat Guidance and Ecological Main Structure?
6. Has effect on existing infrastructure (roads and dykes)?
7. Has effect on excising housing?
8. Has effect on sand transport in the Dollard?
9. Has effect on the salt marshes?
10. Sustainability (future generations)?
11. Climate buffer?

		Long Term Effects										
	Coastal Defence Variant	1	2	3	4	5	6	7	8	9	10	11
1	Consolidate with traditional landward dykes	-	-	0	0	-	-	0	-	0	-	0
2	Consolidate with traditional seaward dykes	-	--	0	-	--	-	0	-	-	-	-
3	Landwards strategy with Storm surge wash over and sleepers dyke	+	+	+	+	+	-	-	+	+	+	++
4	Landwards strategy, Storm surge wash over the first sleeper dyke and 2 sleeper sea dyke	++	++	+	+	++	--	--	+	++	++	++
5	Seawards strategy with moles	-	-	0	0	-	-	0	-	-+	-	0
6	Increase Salt marches seawards and consolidate Sea dykes	+-	+-	0	0	-+	0	0	+-	+	+-	0
7	Increase salt marches landwards and make sleeper dyke sea dyke no wash over	+	+	+	+	+	-	-	+	+	+	+

After "Casus Hondsbossche Zeewering", Smit et al, 2005

(-- = strong negative effect; - = decrease or negative effect; 0 = no effect; + = increase or positive effect; ++ = strong positive effect; -/+ = decrease and increase; ? = unknown/unclear).

### Space for the river

A strategy, already in use in the Netherlands, to reduce the consequences of flooding from rivers, is to give more space to them. This is also a possible strategy to pursue in Oldambt to reduce the risk and consequences flooding by problems with water discharge in the future. In fact, the climate buffer could be best combined with giving more space to the river in the municipality. On the border between The Netherlands and Germany a small river used to run into the Dollard. The name is the "Westerwoldse AA". It would be extra profitable to evaluate the reopening of that river to the Dollard. Nature would flourish as this would form a rare soft gradient between the salt and fresh water giving opportunities for fish to migrate up and down the sea. Climate change does make rainfall more severe and giving space to the rivers could protect from flooding from the interior. More research needs to be done on this subject to evaluate the inclusion of it in the integrated approach of this management plan.

### Conclusion risk and hazard management

One option for risk and hazard management is the creation of climate buffers to reduce the consequences of sea level rise in Oldambt. The evaluation of the different strategies in creating climate buffers showed that the landward strategy with storm surge wash over and sleeper dykes (Strategy 3), the landward strategy with storm surge wash over the first sleeper dyke and the 2<sup>nd</sup> sleeper dyke becoming the sea dyke (Strategy 4), and the increase of salt marshes landwards and the sleeper dyke becoming sea dyke (Strategy 6), are the best options. Creating climate buffers in these strategies means that (a part of) the polder, in agricultural use, has to be given back to nature. This is rather controversial in the Netherlands. Reopening the Westerwoldse AA could help the effectiveness of a climate buffer and could positively influence the recreational values in the area and give an impulse to economy by connecting the area with the hinterland (e.g. with the "Blue City"). Both the climate buffers and space for the river can enhance the safety of the residents and

contribute to the natural value and quality of the area. However, risk and hazard management only, achieves little when local stakeholders are not involved. The idea therefore is to give the different strategies and their evaluation to the local stakeholders to involve them in the decision-making process. Before this can be done, however, a more thorough study of the different strategies should be undertaken, also regarding their impacts on the environment. This can be achieved with an environmental impact assessment.

## **6.2 Environmental Impact Assessment (EIA)**

Environmental Impact Assessments are used to identify the impacts of a management plan or proposed development in the beginning of the decision-making process [Kay & Alder, 2005]. Environmental refers to the biophysical, social as well as economic aspects. The proposed strategies will have impacts on all these aspects. The evaluation of the strategies as described above should be seen as a preliminary research. A thorough environmental impact assessment, however, has to be undertaken, so that the inhabitants and stakeholders can then decide on a strategy with the best information available.

## **6.3 Strategies for community-based management**

Community-based management is used to involve the stakeholders in Oldambt. Therefore an Action Plan is developed. This plan consists of four phases: the Awareness Rising phase, the Work Group phase, the Decision phase and the Implementation phase. The idea is to present the different strategies, enhanced with the environmental impact assessment to the stakeholders. They can use this to base their decisions on it. Limiting factors of community based management are the legislation and rules coming from an European or National level such as the European Water Directives and the Natura2000 directives and the national directive of maintaining of the basic coast line [Ministerie van Verkeer en Waterstaat, 2004]. Seaward strategies will violate the European Water Directives and the Natura2000 rules. Therefore these facts will be used in the awareness phase so that the people realize that seaward options are not feasible under current legislation. The choice of a feasible strategy within current legislation (being strategy 1, 3, 4 and 6 and possible 7) is upon the stakeholders. They can base their decisions on their objectives supporting integration of the goals for safety, economy and nature. There is a list of stakeholders in attachment V which can be involved. Furthermore there is also a list of policies which are applicable to Oldambt and have to be taken into account by the stakeholders. The environmental impact assessment can be conducted at the same time as the awareness rising phase, so that at the end of the awareness rising phase the results of the EIA can be handed over to the stakeholders to take along in the planning and decision-making process.

### Implementation phase 1-Awareness rising: 2013-2018

As mentioned above, an environmental impact assessment should be conducted in the same time frame.

Action	Form	Participants	Topic	Aim
1.Start Assembly	Presentation from scientists	All inhabitants of Oldambt	Climate change and sea level rise	Participants are informed about the topic
2.Follow-up assembly	Presentation from Scientists, discussion	Business associations and agricultural businesses of Oldambt	Sea level rise in Oldambt	Participants know which problems sea level rise will cause in the municipality
3.Third assembly	Presentation from the municipality/scientists	Educational centers in Oldambt	Possible strategies for Oldambt	Participants know which possibilities exist to cope with sea level rise
4. Fourth assembly	Working groups	Scientists	Current problems Oldambt	Participants realize that through the adaption to sea level rise also current problems in the municipality maybe solved
5.Closing assembly awareness rising phase	Discussion		Working groups	Working groups are formed per aspect (safety & nature, economy)
<b>Tool</b> to let people know about the assemblies: Notes in the newspaper, announcements in a local TV channel, leaflets and posters in shops, schools, public facilities.				

**Table 4: Action plan awareness rising phase**

The overall goal of the “Awareness rising” phase is to make the inhabitants of the municipality Oldambt aware of the problems that will come along with the rising sea level. Furthermore the above mentioned strategies will be presented to give the inhabitants an idea what possible counter measures are. An underlying aim is to take the inhabitants along to the second phase where they can participate in the planning and decision-making so that the greatest possible support from the inhabitants can be achieved. Therefore all interested inhabitants should be invited. This can be done by distributing leaflets, flyers or posters in the main public places such as in supermarkets, schools and public facilities, publishing notifications in the newspaper or announcements on local TV channels. The awareness rising phase should end up with the forming of working groups. It will be up to the participants to decide which groups are formed in particular, it is suggested, however, to form two working groups, one for nature and safety and one for economy and therefore the Working Group phase is divided into Working Group Safety/Nature and Working Group Socio-economic.

## Implementation Phase 2-Working Group Safety/Nature: 2018-2022

The choice of the right strategy will be up to the stakeholders. However, the mentioned goals and objectives should be handled. They will be given to the participants of the work groups.

### Action plan safety/nature

The following goal and aims should be handled by the participants of this work group in their decision on a suitable strategy.

#### Overall goal Safety

“The safety of the inhabitants has to be guaranteed.” The aim is to firstly improve safety of residents that live directly at sea and secondly to improve safety of residents that live in the hinterlands of Oldambt.

#### Overall goal Nature

“The environmental quality has to be improved”. The aim is three-fold: Firstly to improve the water quality and biodiversity of the Dollard, secondly to counteract salt water intrusion in the hinterland, and thirdly to allowing natural sediment supply at the coast.

Action	Form	Participants	Aim
Inviting stakeholders	Invitation	Scientists, engineers, representatives of Oldambt (inhabitants), representatives from the municipality and the province, NGOs	Involvement of essential stakeholders
Assembly	Work groups		Formation of four sub groups
Assemblies group safety/nature	Work groups		A strategy is chosen that ensures the safety and contributes to the environmental quality
Assemblies group funding	Work groups	Engineers, scientists, representatives inhabitants, municipality, province, EU, NGOs	Funding opportunities are researched
Assemblies all four work groups	Presentations of work groups	Engineers, scientists, representatives inhabitants, municipality, province, NGOs	Update
Assembly all work groups	Presentations of work groups, Discussion		Outcomes are presented and discussed
Closing assembly work group nature	Discussion		Final decision about plan safety/nature

Table 5: Action plan Safety/Nature

The start-off of the second implementation phase will be an invitation to other stakeholders, not necessarily coming from the municipality Oldambt. Those stakeholders are mostly experts (in the field of engineering and environmental science) and from regional, national and international governmental authorities. They will be invited to an assembly with the working group safety/nature. The aim of the assembly will be the formation of sub groups. The participants will decide which sub groups are formed, a suggestion is to divide it into subgroup safety/nature and funding. The work groups will then assemble apart in several meetings. The working groups should update each other frequently. Such they can also inform each other when the respective group is ready to present their findings. This will be the following assembly. In the closing assembly a final decision on which strategy to choose will be made by all attendees.

## Implementation Phase 2-Working Group Socio-Economic: 2018-2022

The stakeholders will develop in conjunction the best strategies to reach the goal for the socio-economic development of Oldambt.

### Action Plan Socio-economic

The overall goal is to decrease the unemployment and stimulate sustainable local economy. This includes the improvement of professional education, to attract young people and to improve the future chances of agriculture.

<b>Improve professional education</b>			
<b>Action</b>	<b>Form</b>	<b>Participants</b>	<b>Aim</b>
Inviting stakeholders	Invitation	Campus Winschoten	Involvement of essential stakeholders
Assembly	Discussion, workshop		Formulation of Starting Note
Assembly	Workshops, Discussion	Groningen Seaports	Identify demand of professions needed, identify resources and possibilities
Assembly	Workshops	Business associations of Oldambt	Develop strategy to respond to demand of professional education
Consultation education specialist	Investigation	Stakeholders from the agricultural business	Develop new education programs
<b>Attract young people</b>			
Assembly	Presentation of the municipality Oldambt, Discussion	Province of Groningen	Information and information exchange
Develop Questionnaire, Carry out questionnaire, analyse data	Questionnaire	Municipality of Oldambt	Identify young people's needs and wishes
		Young people	
Evaluate options	Presentation of outcome questionnaire, Working groups	Municipality of Oldambt	Identify bests options
Carry out feasibility study	Investigation	Young people	Define which options are feasible
<b>Improve future chances of agriculture</b>			
Inviting stakeholders	Invitation	Province of Groningen	Information exchange
Assembly	Discussion	Municipality of Oldambt	Identify willingness to explore possibilities for transition to saline agriculture
Assembly	Working groups	Stakeholders from	Investigate possibilities for aquaculture

Assembly	Working groups	the agricultural business	Create vision for transition of agriculture
<b>Enhance development for new ideas for recreation and tourism in the area</b>			
Inviting stakeholders	Invitation	Province of Groningen	
Assembly	Discussion	Municipality of Oldambt	Information and information exchange
Assembly	Working groups	Stakeholders from the tourism sector	Develop new activities and attractions for tourist which go together with nature and safety
		Inhabitants	

Table 6: Action Plan Socio-economic

### Implementation Phase 3-Decision: 2022-2023

In this phase of the implementation all working groups will come together, present their findings and make a final decision about the plans and strategies to be implemented.

Action	Form	Participants	Aim
Assembly of working groups	Presentation and Discussion	Working groups from safety, nature, economy	Decision on one common strategy

Table 7: Decision Phase

### Implementation phase 4-Implementing plan: 2024- 2035

The final implementation phase will be the implementation of the chosen strategies and plans.

#### Action Plan Safety/Nature

The actual implementation phase is much depended on the outcomes from the consultancy and working group phase, also with regard to especially the funding and the ones that are responsible for implementing the actions.

#### Action Plan Socio-Economic

Action	Aim/Reasoning	Who	Funding	Time scale
Introduce education programs	Meet the need of the industry of well-educated people	Campus Winschoten	EU + government + province	Starting point: 2022/2023
Presentation of improvement for young people	Make the province attractive living area for young people	Municipality of Oldambt	Province+ municipality Oldambt	2022
Presentation of vision for agriculture	Give direction to future policy, encourage new initiatives	Municipality of Oldambt, agricultural sector	EU + government + province + municipality + private	2022

Table 8: Action Plan for the implementation of socio-economic

## 6.4 Recommendation for the evaluation

It is recommendable to use some form of evaluation already during the first implementation phase. This is in line with the adaptive planning/risk and hazard management which requires a constant monitoring and evaluation so that the management can adapt to changes.

### **Self- assessment by the municipality**

For the evaluation of the management plan it is recommended to use the indicator based methodology and scoring system which is developed by the SUSTAIN project, funded by the European Regional Development Fund. It is a policy tool for local and regional authorities to evaluate their sustainability performance. The aim is to improve the management of coastal zones [SUSTAIN, 2012]. The product of the project is a policy tool called “DeCyDe-for-Sustainability” which makes self-assessment possible. Based on indicator sets concerning policy, economics, environmental quality and social well-being the state of the sustainable development is assessed by generating a numeral score. The DeCyDE –tool is available on the internet and easily implementable. The first assessment has to be carried out by the municipality of Oldambt in the beginning of the first implementation phase, so that the working groups can consider the outcomes of the assessment. This tool can also be used during the whole implementation phase in order to see if the measures help to improve the sustainability of the region. The moments on which the assessment should be carried out depends on the realization of the actions of the action plan. The final assessment can be done after completing the last implementation phase.

### **Participation**

During the work-shops with stakeholders, the parameters developed by the SUSTAIN partnership can be used to understand the merits of the good practice in its different dimensions. The stakeholders give scores to the different parameters. The participants discuss the impact of the good practice following the questions for the so-called pillars of sustainability which are economy, environmental quality, social well-being and governance. The aim is to gain new insights in the views of the different stakeholders [SUSTAIN partnership, 2012]. The person who carries out the analysis has to take into account what the effects of the good practice is for each parameter, the perception of what sustainable development means and the process of the group to achieve consensus about the score given [SUSTAIN partnership, 2012]. The group gives a score from 0 to 10 for each parameter. The score 10 indicates a greater contribution to sustainability and 0 is the minimum score. The four values for the different pillars give an aggregated score. This tool can be used to develop best practices together with the stakeholders and to evaluate the state after implementing actions. The numeric score is an indication for effectiveness of a good practice, but the discussions around the questions are maybe even more valuable for the process of participation. The indicators can be found in the attachment VI.

### **Monitoring**

Sea level rise is closely observed by the KNMI, IPCC panel and Rijkswaterstaat. Oldambt needs to be ready for an eventually accelerated sea level rise and needs to take preparations. The creation of the proposed climate buffers need to be measured to be adapted when the situation changes. The effectiveness of the climate buffers needs to be measured against the silting up, transparency of the Dollard water and further against the European Water Directives at least every three years as this is a very dynamic environment. The status of the Natura2000 and Birds



and Habitat Directive needs to be guarded and improved. If the reopening of the Westerwoldse AA is chosen as an option by the participants of the work groups, the success of it can be measured in the occurrences of the anadromous and catadromous fish.

Before starting the project a common baseline needs to be drawn on all objectives to measure the effects upon later on the timescale.

Monitoring scheme	
<b>Baseline measurements before any (man-made) changes are undergone</b>	Measurement of: <ul style="list-style-type: none"> <li>- Silting up</li> <li>- Transparency of the water</li> </ul> Assessment of: <ul style="list-style-type: none"> <li>- biological community</li> <li>- the hydrological characteristics</li> <li>- the chemical characteristic</li> </ul> (According to the EU Water Directive [European Commission, 2012])
<b>Monitoring every three years</b>	Same as for the baseline measurement

Table 9: Monitoring scheme for environmental processes in the Dollard

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## Attachment

## Attachment I: Climate drivers

Climate driver (trend)	Main physical and ecosystem effects on coastal systems
<b>CO<sub>2</sub> concentration (increasing)</b>	Increased CO <sub>2</sub> fertilisation; decreased seawater pH (or 'ocean acidification') negatively impacting coral reefs and other pH sensitive organisms
<b>Sea surface temperature (increasing, variable between regions)</b>	Increased stratification/changed circulation; reduced incidence of sea ice at higher latitudes; increased coral bleaching and; pole-ward species migration; increased algal blooms
<b>Sea level (increasing, variable between regions)</b>	Inundation, flood and storm; erosion; saltwater intrusion; rising water tables/impeded drainage; wetland loss (and change).
<b>Storm intensity (increasing, variable between regions)</b>	Increased extreme water levels and wave heights; increased episodic erosion, storm damage, risk of flooding and defence failure
<b>Storm frequency &amp; storm track (uncertain, variable between regions)</b>	Altered surges and storm waves and hence risk of storm damage and flooding
<b>Wave climate (uncertain, variable between regions)</b>	Altered wave conditions, including swell; altered patterns of erosion and accretion; re-orientation of beach plan form.
<b>Run-off (variable between regions)</b>	Altered flood risk in coastal lowlands; altered water quality/salinity; altered fluvial sediment supply; altered circulation and nutrient supply.

Table I: Climate drivers and their main physical and ecosystem effects on coastal systems [IPCC, 2012]

## Attachment II: Safety features of Oldambt

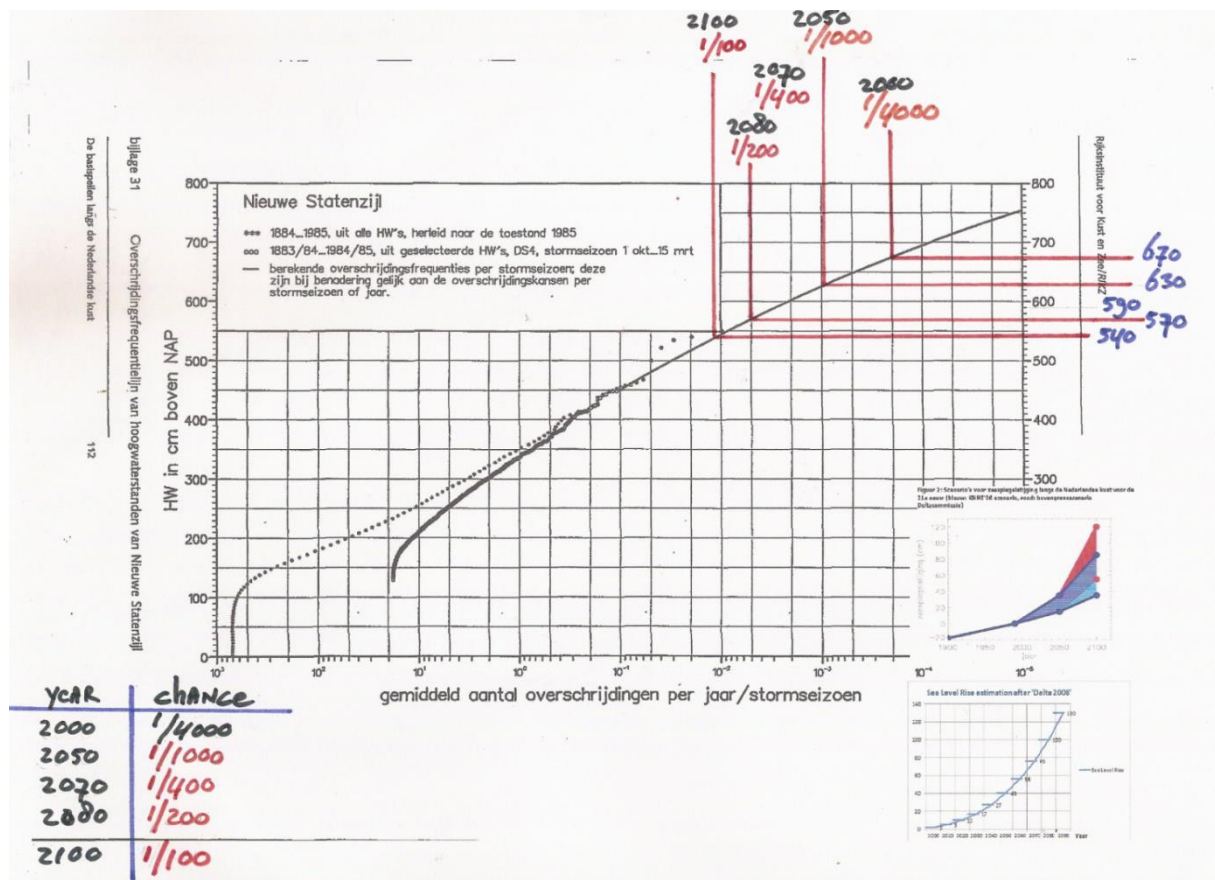


Figure I: Calculation of the chance of dyke breach until 2100 based on water levels measured at Nieuwe Statenzijl

The calculations (Figure I) are based on a scenario of 130cm sea level rise in 2100 and refers to water levels at Nieuwe Statenzijl. The calculations were made by drawing a straight line from the Y-axis to the curve plotted and then straight down to the X-axis. The number on the X-axis represents the chance of water exceeding the dyke and the exceeding water causes the dyke to breach. As can be seen in table X the chances of a dyke breach are not linear in time.

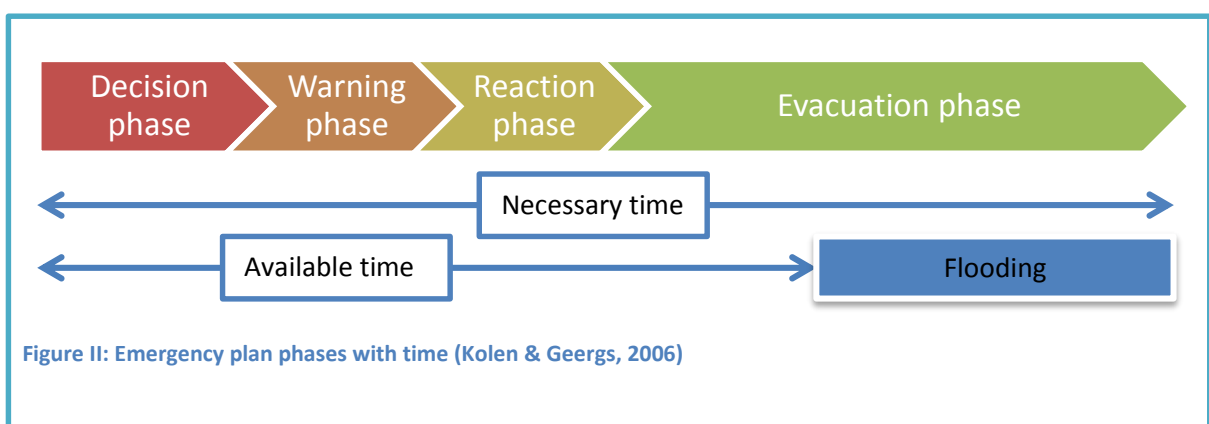


Figure II: Emergency plan phases with time (Kolen & Geergs, 2006)

## Attachment III: Environmental features of Oldambt

### Red List Species

The Natura2000 area of the Eems-Dollard Estuary comprises several fauna and flora species that are registered on the Red List. This includes fish, birds and flora species.

The Red List Fish has reference to anadromous fish (fish that migrate up rivers from the sea to breed in fresh water) such as the river lamprey (*Lampetra fluviatilis*) and the twait shad (*Alosa fallax*) and to catadromous fish (fish that migrate from rivers to the sea to breed in salt water) such as sea lamprey (*Petromyzon marinus*), the three-spined stickleback (*Gasterosteus aculeatus*), smelt (*Osmerus eperlanus*) and elvers. For both anadromous and catadromous a connection between the open sea and the inland is vital [Fiet et al, 2012].

The Red List for Birds includes species for which the Eems-Dollard estuary and the surrounding areas are important feeding and resting grounds. For migratory birds the Wadden Sea and thereby the Ems-Dollard estuary, is an important resting area, where they can rest and forage on their long route from north to south and vice versa. The value of the Wadden Sea to migratory birds is eminent. A maximum of some 6.1 million birds are present in the international Wadden Sea *at the same time* [Blew & Südbeck, 2005]. Each year on average 10 to 12 million birds migrate back and forth between their breeding grounds in Siberia, Scandinavia, Greenland and North-East Canada and their wintering grounds in Europe and Africa. These birds use the Wadden Sea for a short stay, as a major stop-over site for refueling or as a wintering area [Blew & Südbeck, 2005]. Birds on the Red List that breed in the Ems-Dollard region are amongst others the pied avocet (*Recurvirostra avosetta*), the red shank (*Tringa tetanus*) and the common tern (*Sterna hirundo*). Wintering birds as the peregrine falcon (*Falco peregrinus*), the rough-legged buzzard (*Buteo lagopus*) and the snow bunting (*Plectrophenax nivalis*) [Natuurmonumenten, 2012].

The Red List Flora includes Eel grass (*Zostera marina*) and Sea Aster (*Aster tripolium*).

### Polders

The polders in Oldambt behind the dykes are the following;

- The Johannes Kerkhaven polder created 1924 with a surface of 1200 ha, is maintained by the “Johannes Kerkhovenpolder b.v”
- The Carel Coenraad polder created in 1924 is privately owned
- Beiderwolder polder created in 1874 is privately owned
- Stadspolder created in 1740 is maintained by the “Waterschap” “Hunze en AA”

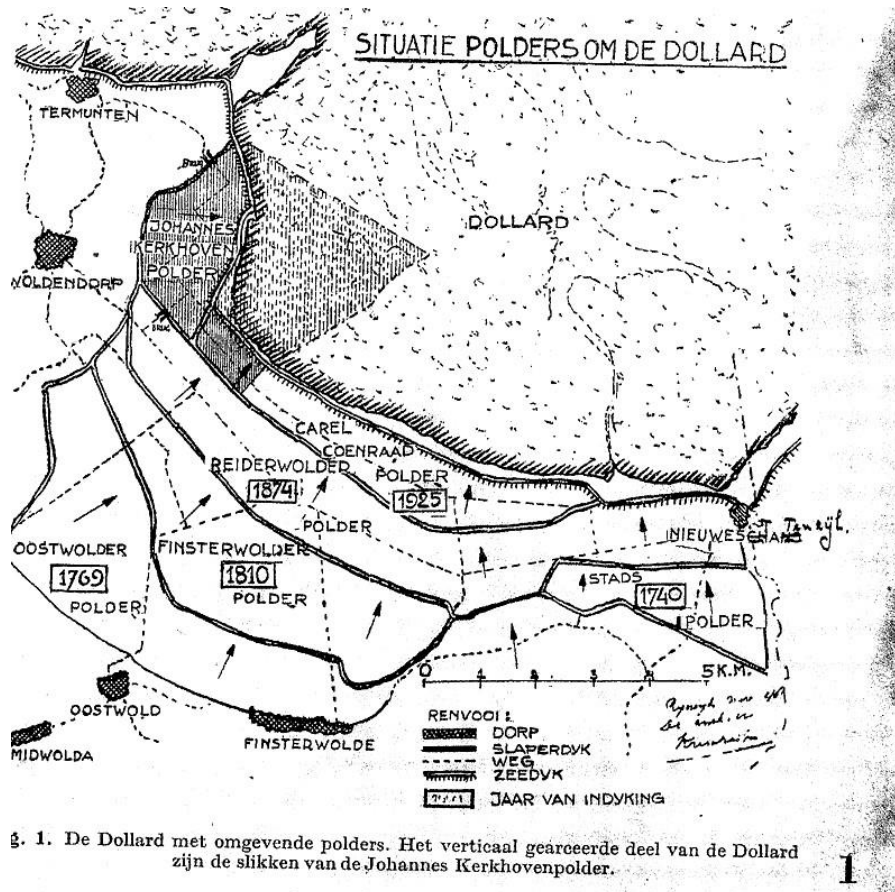


Figure III: Polders in the municipality Oldambt [Kate, 2009]

## Attachment IV: Economic features Oldambt

### Socio-economic development in Oldambt

The average income in Oldambt is lower compared to other municipalities (comparable with respect to number of inhabitants), but in general the fixed charges are also lower in the province of Groningen compared to for example Utrecht or Amsterdam [Gemeente Oldambt 2012<sup>b</sup>]. In the economic successful year 2006, the difference in average incomes was very high. In this year the average income was 26.600 Euros compared to 32.300 Euros in other comparable municipalities. The biggest sectors for employment are non-commercial services (governmental management, health care, culture and recreation), industry and building business [Gemeente Oldambt, 2012<sup>b</sup>]. The unemployment rate is high, in 2009 when the national average stood at 3,0% the unemployment rate in Oldambt was 7,3% [Gemeente Oldambt, 2012<sup>b</sup>].

The municipality Oldambt regards unemployment as the problem number one in the region. 14 % of the unemployed (and thus looking for work) people are younger than 27 years, 50 % of the unemployed people are between 27 and 50 years old.

The majority (51,6%) of the unemployed people have received average education, 39,5 % are low educated and 8,9% are high educated. 16,2 % of these people are longer than 36 month without work [Gemeente Oldambt, 2012<sup>d</sup>]. Further socio-economic problems in the municipality are: a decreasing population, housing problems, lack of cohesion in the community, and insufficient professional education. There is a tradition of entrepreneurship in the villages, but the alteration of the consumer's behaviour and a decreasing population exercise pressure on the enterprising attitude [Gemeente Oldambt, 2012<sup>c</sup>]. The number of young people between 15 and 24 years is expected to

be stable (10,3 %)but the percentage of old people (> 65 years) is expected to rise with few percentages. The average age is 42 years (in other comparable municipalities (with respect to number of inhabitants) the average age is 40,3 years). The process of population aging has compared to other municipalities already begun. The potential working population (between 15 and 64 years) was in 2008 66,2%. The accretions of young people under 14 years is stagnating, in 2008 16,0 % of the population were younger than 14 years [Gemeente Oldambt, 2012<sup>b</sup>].

The decreasing population is also the reason that buildings are left empty. At the same time, however, there is still a demand for housing which seemingly cannot be met by available housing space. Namely, the available housing space is located in uniform-built neighborhoods from specific construction times and these are demanded anymore [Gemeente Oldambt, 2012<sup>c</sup>]. Some of the residential areas do not fulfil the social requirements and in those areas the cohesion of the community is under pressure. The professional education which is located in Winschoten does not always correspond with the requirements of education needed in the area due to new developments of work opportunities.

The infrastructure of Oldambt is good, compared to comparable municipalities( with respect to number of inhabitants), Oldambt scores higher when it comes to supermarkets, bakeries, drug stores, post offices, banks, hospitality facilities, community centres and sports clubs [Gemeente Oldambt, 2012<sup>b</sup>].

#### **List of economic priorities of the municipality [Gemeente Oldambt, 2011]**

- 1 Conservation and development of economic activity
- 2 Re- development of the themes
- 3 Water-related activities
- 4 Recreation & Tourism
- 5 Agricultural and
- 6 Ecological activity
- 7 Oldambt as a pioneer town, with respect to culture and monuments
- 8 Positioning Oldambt as an area of entrepreneurial activity
- 9 Connecting role in developments
- 10 Cross-border business development
- 11 Education and businesses
- 12 Labour market-related developments
- 13 Strengthen the regional function,
- 14 Balance between home and work,
- 15 Strengthening the regional function

#### **Attachment V: Stakeholders and relevant policies in Oldambt**

##### **Stakeholders**

In this section first an overview is given of the stakeholders that play a role in the municipality of Oldambt or have impact on the municipality and second an overview of the policies that have to be taken into account by any plans.

### **European Union**

The European Union plays a role because it has set up Directives which each of its member states have to implement. In the municipality of Oldambt four Directives are applicable considering sea level rise and its effect on nature: Birds Directive and Habitats Directive (commonly known as Natura 2000 sites), the Water Framework Directive and the Directive on the assessment and management of flood risks.

In the Netherlands the Ministry for Infrastructure and Environment (Rijkswaterstaat) is the responsible authority for the implementation of the EU Water framework Directive [Rijkswaterstaat, 2009]. Natura 2000 areas in the Netherlands have to be officially assigned by the State Secretary for Economic Affairs. The management of the Natura 2000 area of the Dutch Ems-Dollard part falls under the jurisdiction of the Province of Groningen which will have to establish a management plan in cooperation with other stakeholders and also in accordance with the municipality of Oldambt [Provincie Groningen, 2011<sup>a</sup>]. The implementation of the Directive on the assessment and management of flood risks lies in the hand of several entities in the Netherlands, both national and regional. Responsible parties are among others: Rijkswaterstaat, the provinces, and safety regions [Stowa, 2013]. If cooperation is sought with Germany, the responsible authority would be the Ministry for Environment, Energy and Climate protection, and the Lower Saxon State ministry for water management, coast-and nature protection in the federal state of Lower Saxony. The former Ministry is responsible for the implementation of the European Water Framework Directive and the Natura 2000 Directives, the latter for the implementation of the Directive on the assessment and management of flood risks [Niedersachsen, 2013<sup>b</sup>].

### **Collaboration Germany-Netherlands**

The Dutch and German governments have worked since the end of 2010 in conjunction to develop an integral management plan (IMP) for the Ems-Dollard region. The project group is responsible for the delivery of a Dutch management plan Natura 2000 and a Dutch-German IMP. Additionally there are contributory groups that consist of experts from governments and interest organizations and which give professional advice [Natuur en Milieufederatie Groningen, 2011]. The Lower Saxony government emphasizes that the nature conservation should include the interests and concerns of the Water Framework Directive, the maritime navigation, the flood and coastal protection, industrial and commercial uses and of the agriculture and fisheries [Niedersachsen, 2013<sup>a</sup>].

### **Shipping industry**

The shipping industry plays quite an important role in the Dollard because it is the main causer for the bad water quality. The Meyer shipyard in Papenburg is therefore a stakeholder that has to be considered. On the website of the Meyer shipyard, the Ems is mentioned and also that they want “an intact, mud-free and navigable river” [Meyer Werft GmbH, 2013]. However, there are no proposed actions or suggestions on how to improve the quality of the Ems and the effect the shipyard has on the Dollard is not mentioned at all.

### **NGOs**

One of the most active NGOs in the Ems-Dollard region is the Dutch “Waddenvereniging”. This NGO set up a plan to rescue the Ems (“Red de Eems”). The plan aims at sustainable management of the area also with regard to economic and safety values. Furthermore the Waddenvereniging emphasizes that cooperation between government, businesses and NGOs is vital for the success of the plan. The plan itself is already a cooperation between various NGOs, namely the foundation “Het

Groninger Landschap”, “It Fryske Gea” (a Friesian NGO), “Landschap Noord-Holland”, “Natuurmonumenten”, “Staatsbosbeheer”, “Stichting Wad”, the association “Vogelbescherming Nederland” (Bird protection) and the Waddenvereniging [Coalitie Wadden Natuurlijk, 2010]. The foundation Het Groninger Landschap in cooperation with the “Water Board Hunze en Aa’s” was also responsible for the opening of the Delta Dyke abreast the Polder Breebaart in the South of Termunten. A damped tide was allowed and the polder have become a salt marsh [Het Groninger Landschap, 2013].

### **Water Board Hunze en Aa’s**

The “Water Board” is responsible for the safety of the water systems of Oldambt and Fiemel. In the plan they set up for these areas is stated that the strategy and measures to be chosen should not be fixed ones as there is large uncertainty how the processes like climate change and subsidence will turn out. Further it is also stated that the safety of the water systems will only be affected by increased precipitation and climate change. The focus for the upcoming years will be on the improvement of the ecological state of the waters in these areas. The specific tasks of the water board are:

- Providence of (primary) dams
- Providence of quantity and quality of surface water management and regulation of the (quantitative) phreatic (shallow) groundwater
- Providence of waterways that are part of the B-Akwa agreement between the province Groningen and the former “water boards” Dollardzijlvest, Hunze and Aa and Emszylvest
- Purification of sewage water [Waterschap Hunze en Aa’s, 2008]

### **Municipalities**

Apart from the municipality Oldambt, other municipalities in the province should also be considered as stakeholders. This is mainly to their greater economic significance. The urban and commercial area of the municipality of Delfzijl for example is of big importance to the northeast of Groningen. Together with surrounding municipalities as Appingendam, Eemsmond and Loppersum the municipality of Delfzijl provides facilities for health care, education, cultural enrichment, sports and other commercial facilities which are of great social and economic importance for the region [Vliet, 2009<sup>b</sup>].

Furthermore the Groningen Seaports, even though the ports of Delfzijl and Eemshaven are not located in Oldambt, influence the municipality Oldambt by generating employment and being centers for economic activities for the entire province of Groningen. Both ports are managed by the Groningen seaports Authority. Shareholders are the province of Groningen (60%), the municipality Delfzijl and Eemsmond with respectively 20% [Gemeente Eemsmond, 2012<sup>a</sup>]. Eemshaven is described as the most important energy port of the country. Two additional energy companies, NUON and RWE, will settle in Eemshaven. Together with the other energy producers they will produce circa one third of the national electricity production (35%). Delfzijl is rather important for the chemical industry, that port contributes 15% to the national chemical industry [Groningen Seaports, 2011]. The port of Delfzijl lies south of the port of Eemshaven and is the largest economic input for the region. The port area creates a lot of job opportunities and in the upcoming year this is projected to increase. In the upcoming 10 years 50% of the employees currently working in the port will retire and this will create vacancies and job opportunities for younger people [Vliet, 2009<sup>b</sup>].



### **Business associations and education in Oldambt**

The Dutch Chamber of Commerce lists several business associations in the municipality of Oldambt. The trade and industry association of Bad Nieuweschan aims at representing the interests of the entrepreneurs settled in Bad Nieuweschan [Nieuweschan, 2011]. The entrepreneurs association Reiderwolde wants to stimulate the business of Beerta and Finsterwolde [Ondernemersvereniging Reiderwolde, 2007]. Another association is Parkmanagement Oldambt which represents the common interest of its members while conserving the spatial and functional quality of the business premises in the municipality of Oldambt [Vereniging Parkmanagement Oldambt]. Most likely the largest association in this area is the entrepreneurs circle East-Groningen which has a membership of about 180 businesses in the region [Ondernemerskring Oost-Groningen, 2013]. The Foundation Marketing Town Winschoten aims at making the town more attractive through the organization of activities; the board of the foundation includes members from the trade and industry association, the Royal Catering and Hospitality industry Netherlands Department Oldambt, and the municipality of Oldambt [Winshoten, 2013]. Furthermore Winschoten is the most important economic center of Oldambt as already mentioned in the introduction and it has an educational center.

The educational center in Oldambt is Campus Windschoten. It is a school for professional education in six sectors: social, business, digital, technical, gastronomy, and environment. It is described as a school where citizenship and community involvement is seen as a high esteem as the campus wants to be an active member of the society. This is also the reason why the school cooperates with businesses and institutions. Furthermore new educational programs are constantly new developed to address societal needs [Campus Winschoten, 2013].

### **Agricultural business**

Agriculture is one of the biggest economic sectors in the municipality of Oldambt and therefore this sector poses an important stakeholder. Table II depicts a list of the agricultural businesses that fall within the study area.

Name	Sector	Employees	Place
Partnership R., I.E., T.A., C.D. and L.I. van Wieringen	Cultivation of grains, legumes and oilseeds	3-4	Finsterwolde
Partnership Oldenziel	Cultivation of grains, legumes and oilseeds	3-4	Finsterwolde
Partnership B., A.G. en G.F. Siertsema	Cultivation of grains, legumes and oilseeds	3-4	Finsterwolde
M.J.W. van der Meijden	Breeding and keeping of dairy cattle	3-4	Nieuwolda
Johannes Kerkhovenpolder B.V.	Cultivation of grains, legumes and oilseeds	5-9	Woldendorp
Landbouwloonbedrijf Westerhof	Services for the agri- and horticulture	3-4	Woldendorp
Rombouts	Cultivation of grains, legumes and oilseeds	3-4	Drieborg
Fa. H. de Graaf en Zn.	Agri- and horticulture with breeding and keeping of animals	5-9	Drieborg
Maatschap Beukeboom	Breeding and keeping of dairy cattle	3-4	Finsterwolde
Partnership H.E. Evers, T.K. Evers, N.J.D.	Cultivation of grains,	5-9	Finsterwolde

Evers, A.J. Evers-de Jong and D. Evers	legumes and oilseeds		
Partnership van Langen	Breeding and keeping of dairy cattle	3-4	Finsterwolde
Loonbedrijf Boven V.O.F.	Services for the agri- and horticulture	10-24	Finsterwolde
Partnership J.C.W. and H.S.J. van Vilsteren	Cultivation of potatoes, sugar-beet and other roots and tubers	5-9	Oostwold
Landbouwbedrijf Ten Kate	Cultivation of grains, legumes and oilseeds	5-9	Nieuwolda
V.O.F. Knottnerus	Cultivation of ornamental plants	5-9	Nieuwolda

Table II: Agricultural businesses in the study area [Regiobedrijf, 2013]

### **Inhabitants of Oldambt**

The inhabitants of Oldambt are already partly mentioned in the sections businesses and agricultural businesses but in general all of them will be affected by sea level rise. Further it could be difficult to convince them of changes, as already mentioned in the introduction. The inhabitants are described as skeptical to new developments but also that they try to adapt to changes when they understand the necessity and the benefits that may come along.

### **Overview policy**

- **Beleidslijn kust:** Important for the reservation of space for the future endorsement of the sea defence structures with respect to sea level rise (future 200 years), in conflicting situations the PKB Waddenzee is determinative [Ministerie van Verkeer en Waterstaat, 2007]
- **PKB Derde Nota Waddenzee:** Spatial policy: Human activities to uphold the safety of inhabitants are in principle allowed, the Wadden Sea does not belong to the coastal fundamen
- **Waterschapswet:** Determines the responsibility of the Rijk and the water boards concerning the management and maintenance of the flood defence structures (dykes and dams) and the water management. The water board tests the possible effects of planned activities concerning coastal defence. The test leads to a decision of permit [Ministerie van Verkeer en Waterstaat, 2007].
- **Wet op de waterkering:** Determines norms for primary sea defence structures and dunes. The manager of the structure is responsible for testing the structure on the norms (like exceeding chances). The ministry for Infrastructure and environment (former Ministerie van Verkeer en Waterstaat) supports this procedure with hydraulic preconditions, guidelines and technical guidelines [Ministerie van Verkeer en Waterstaat, 2007].
- **EU Water Frame Directory:** The Ems Dollard estuary being inland water (till one mile out of the coast) is considered under the EU Water Frame Directory. The goals for EU water Directive for 2015 are the GET (Good Ecological State) and the GEP (Good Ecological Potential).
- **Natuurbeschermingswet 1998:** Rules concerning the protection of the environment and the protection of species. The international EU- legislation the Birds Directive and the Habitats Directive for the conservation of birds and habitats are implemented in the Natuurbeschermingswet [Natuurbeheer, 2012]. Activities that could disturb the Natura 2000 areas, can only be carried out with a permit based on the Natuurbeschermingswet [Ministerie van Verkeer en Waterstaat, 2007].

- **Flora en Faunawet:** Manages the conservation of species and determines the protected species. The conservation regulations concerning species of the Habitats Directive and the Birds Directive are implemented in the Flora en Faunawet [Ministerie van Verkeer en Waterstaat, 2007].
- **Ecologische Hoofdstructuur:** Beach, dunes and coastal sea is part of the Ecological Main Structure (EHS) and is implemented in the Nota Ruimte. New plans in or nearby the areas of the EHS are only allowed if the core values are not endangered by the new activity. Exceptions are that there are no alternatives to realize the plans elsewhere and that the common interest requires the new activity/plans. For activities that fit the criteria, it is obligated that damage is restored or compensated [Ministerie van Verkeer en Waterstaat, 2007].
- **Wet op de Ruimtelijke Ordening en Woningwet:** Legal Framework for the governmental authorities concerning spatial plans.
- **Provinciaal Omgevingsplan Provincie Groningen:** Lines out the spatial policy for the province of Groningen.

## Attachment VI: Parameters for the evaluation of the process

Economics, Analysis parameters/ score 0 to 10	score
The good practice, supports the local economy, promotes products and local and regional economic cycles?	
The good practice is a job generator and improves employment quality?	
The good practice takes into account the higher local impacts generated on other local and even distant regions?	
The good practice will be a lever to enhance entrepreneurship and development of new products and production processes?	
The good practice improves location's centrality and attractiveness?	
The good practice increases economic benefits while reducing resources consumption?	
The good practice promotes sustainable coastal business?	
Promotes environmental friendly processes and products?	

Environmental Quality, Analysis parameters/ score 0 to 10	score
The good practice increases energy efficiency?	
The good practice reduces consumption of non-renewable resources and stimulates materials reuse and recycling?	
The good practice benefits natural areas near urban areas and supports environmental friendly rural activities?	
The good practice supports natural habitats, biodiversity and their quality?	
The good practice supports sustainable mobility?	
The good practice reduces environmental risks and prevents air, water and soil pollution?	
The good practice promotes an awareness of sustainable management of resources?	
The good practice contributes to increase environmental awareness of the population?	

<b>Social well-being, Analysis parameters/ score 0 to 10</b>	<b>score</b>
The good practice contributes to reduction of poverty?	
The good practice improves the quality of life?	
The good practice supports education and life-long learning?	
The good practice promotes social justice and equal opportunities for all members of society?	
The good practice promotes social inclusion and inter generations communication?	
The good practice supports citizens welfare, health, responsible consumption and citizenship?	
The good practice contributes to crime prevention and increase perception of safety among population?	
The good practice promotes communication, cooperation between citizens and local authorities and other institutions?	

<b>Governance, Analysis parameters/ score 0 to 10</b>	<b>score</b>
The good practice has a long term financial commitment in place?	
The good practice has a long-term political commitment in place?	
The good practice has sustainability targets and is regularly reviewed or is implementing part or all of a sustainability strategy/ Plan/Policy?	
The good practice demonstrates multi-stakeholder partnership working on coastal sustainability issues?	
The good practice communicates coastal sustainability issues, and information about management of those issues, to stakeholders and the wider coastal community?	
The good practice encourages multi-stakeholder and community involvement in management of coastal sustainability issues?	
The good practice promotes local stakeholder participation on planning processes and implementation?	
All stakeholders involved in delivering the good practice are aware of how the practice fits into the local sustainability plan, strategy or policy?	