MDP Project

Future Coastal Protection of Scheveningen

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by

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Civil Engineering Consultancy Project | CIE4061-09

at the Delft University of Technology,

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Project duration:	July 12, 2020 – October 1, 2020	
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Preface

In front of you lies the report of our multidisciplinary project "Future Coastal Protection of Scheveningen". This report is the result of two and a half months of hard work by three civil engineering students with different discipline background from the Technical University of Delft. Initially we had the chance to do a multidisciplinary project in Republic of Cuba. Unfortunately, due to COVID-19 this was not the case anymore. Instead we found a project in Scheveningen with help of the municipality of The Hague. The project was very challenging as the focus is more into research than technical design. Another challenging aspect was the self isolation due to COVID-19. Meetings where held digitally, and only in unusual circumstances we met while following the quarantine rules. Working from home was not the first thing that we had in mind when we started this project. However, in general everything went well and it was a great experience to work in a team with different disciplines. We could all say that we had learned a lot from each other.

Each writer of this report has a different background study namely Coastal Engineering, Construction Management & Engineering and Water Management. Each person has worked on all the chapters in this report. However, the leading role of each person depended on their background. Ka-Way Shek has a coastal engineering background, and has been focusing on the coastal related technical details of this report. Menno Tiesma has a Water Management background, and has played the role in studying the norms and policies related to the coast. Boris Kreike has a study background in Construction Management & Engineering. This specialisation connects different disciplines together in one research. As well as, deciding which aspects would be of importance to the project for the desired results.

We would like to express our gratitude to our supervisors Dr. Ir. Martine Rutten, Dr. Erik Mostert and Ir. Yan Liu for their support and feedback during the project. In addition we would also like to thank Arno Segeren and Mena Kamstra from Municipality of The Hague, because without them we would not had the opportunity to work on this project. Furthermore, we would like to thank Rinse Wilmink from Rijkswaterstaat, Pieter Otten and Job van Dansik from waterboard Delfland and Nikander Hartemink from project developer Scheveningen Pier to participate in shearing their knowledge.

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Delft, The Netherlands
October 2020

Abstract

Due to climate change a rise in sea level is expected, which is a threat to the coastline of the Netherlands. The area of the project focuses on the seaside resort of Scheveningen, and specifically on the area from the Morales boulevard to the start of the natural dunes. The reason for this specific area is because the municipality of The Hague has little information about what the consequences are in this area due to future sea level rise. Furthermore, the Grand hotel Amrâth Kurhaus and different kind of hospitality industries are situated here. The Amrâth Kurhaus is a monumental building with a lot of history, therefore the municipality of The Hague attaches great value to it. However, whether future sea level rise will really cause for a hazard for the Amrâth Kurhaus and its surroundings is not clear. The first aim is to investigate whether this is the case or not. The second aim is to find how it could be solved if there is a problem.

In order to answer the first question, we first did some research and performed interviews with stakeholders to get an idea what kind of sub-district Scheveningen is, and how the current coastal sea defence protect the area. According to the interviews, the Amrâth Kurhaus is located at a dune instead of a dike. In addition, the research also shows that the Amrâth Kurhaus is located in front of a boundary which is called "Landwaartse grens toegestane afslagzone" [1]. Everything in front of this boundary is where erosion can occur. Therefore, one can conclude that during a normative storm event, dune erosion could possibly have negative affect on the Amrâth Kurhaus and the surrounding area. However, whether the normative storm can actually create hazard for the Amrâth Kurhaus in the current situation or in the future is unknown. In order to answer this question, we dived deeper into this topic.

Based on the investigation, we found out that the current policy of Rijkswaterstaat works well to protect the hinterland against flooding. The current policy is to maintain the coastline (MKL) in order to satisfy the Basis Kustlijn (BKL), which is a theoretical line that determines whether maintenance is needed to guarantee the safety of the coast. The maintenance of the coast is done by strengthen the coastline with sand nourishment. This should prevent shoreline retreat by letting the sea bed grow along with sea level rise. However, this policy could be threatened by a fast sea level rise. According to Koninklijk Nederlands Meteorologisch Instituut (KNMI) sea level will increase exponentially this century, but how fast the sea level will rise is not sure due to different uncertainties. One thing is certain and that is when sea level rises, more nourishment is needed to prevent shoreline retreat. Due to more nourishment the cost will also increase, and will eventually make nourishment cost ineffective. Moreover, when sand nourishment cannot grow with the speed at which sea level is rising, the MKL will move behind BKL. This also means that the shoreline is retreating. One can conclude that when sand nourishment is not a solution anymore to maintain the same safety policy for BKL, extra safety measures need to be developed.

As mentioned before shoreline retreat due to sea level rise is a fact. However, when the shoreline will retreat is questionable, since the prediction of sea level rise is uncertain. Therefore, we decided not to look at when a specific sea level has reached. But we focused on three relative sea level rise scenarios that lead to different shoreline retreats. To get an idea how far the shoreline will retreat due to sea level rise, we used the analytical formula "Bruun Rule". According to the Bruun Rule, the shoreline will retreat significantly when sea level rises. For the situation in Scheveningen, especially for the Amrâth Kurhaus and the hospitality industry, this will increase the risk of damaging the facilities.

Before we really can say that shoreline retreat has a hazardous effect for the Amrâth Kurhaus, we decided to use a software tool called "MorhpAn". This tool contribute in computing the dune erosion, and assess the coastal safety with current normative boundary conditions. From the results of MorphAn, there could be concluded that under current normative boundary conditions and current coastline with a return period of 1:10000, that regular erosion already reached the dune. Therefore, there could be expected that dune erosion will reach further into the dune, if shoreline retreat will not be prevented. Based on the findings of the Bruun Rule and MorhpAn, there could be concluded that sea level rise due to climate change has certainly a negative effect or even create a hazard for the Amrâth Kurhaus and the surrounding area.

Design objectives are needed to come up with a new coastal defence concept. In order to find out what the design objectives are, there has to be looked at which stakeholders are living and operating in the area. A

qualitative well thought out concept should fulfill the required safety measures without disrupting the local area. Therefore, a stakeholder analysis has been performed.

From the investigation about stakeholders came forward that a decrease in visitors and tourists will result in a decrease in revenue for business operators, Amrâth Kurhaus and the Pier. A reduce in revenue leads to less job opportunity for local inhabitants. However at the same time tourists form a problem towards a living environment of the local inhabitants. Moreover, environmental organisations will try to block the project if it has an adverse effect on the Natura 2000 area, which situated next to the project area.

Based on all the early research that was performed, we created a SWOT & TOWS analysis that categorize all the threads, opportunities, weaknesses and strengths. These factors were weighted and coupled with each other to indicate design strategies and design objectives. The findings in the SWOT & TOWS analysis indicates that resilience against different water level predictions, sustainable economic development, quicker process and engaging with local inhabitants in an early phase are the most important strategies and design objectives to develop coastal defence concepts.

With the determined design objectives, we designed eight coastal defense concepts. These concepts were used to make three combinations, each fulfilling the design objectives towards a certain degree, namely:

- Combination 1 (Maximum Safety): sea grass, Additional shoreface nourishment and New dune
  This combination focuses on maximizing the safety of the coastal area in a partly ecological friendly matter but reduces tourism.
- Combination 2 (Sustain the Hospitality Industry): Pier as groyne, Biogrout and Venice
  A more expensive ambitious combination that accept partly coastal retreat due to sea level rise. This combination strengthens the dune to accept coastal retreat but still protects the hospitality industry.
- Combination 3 (Building with Nature): Groynes along the coast and Mega nourishment
  Combination 3 is the most ecological friendly combination. The combination consist of ways to protect the beach against sea level rise by only natural processes.

In order to know which combination is highly preferred. Two grading systems have been determined to decide which combination is desirable. The first grading system is based on how well they can fulfill each of the design objective, while the second grading system also focuses on the weight factor of each design objective. Therefore, it makes the second grading system more accurate to decide which combination is in favor. Based on the two grading systems, we found out that combination 3 scores in general better than combination 1 and combination 2. Thus, based on our study, we can finally conclude that combination 3 is the most favourable combination to defend the coastal area against future sea level rise, followed up by combination 2 and as last combination 1.

Contents

List of Acronyms

AHN	Actueel Hoogtebestand Nederland
BKL	Basis Kustlijn
DoC	Depth of Closure
KNMI	Koninklijk Nederlands Meteorologisch Instituut
MICP	Microbial Induced Carbonate Precipitation
MKL	Momentane Kustlijn
MSL	Mean Sea Level
POK	Provinciaal Overlegorganen voor de Kust
RIKZ	Rijksinstituut voor Kust en Zee
RSLR	Relative Sea Level Rise
SO	Strength/Opportunity
ST	Strength/Threat
WO	Weakness/Opportunity
WT	Weakness/Threat

Glossary

Beschermingszone	The area where no activities are allowed to take place that can harm the primary sea defence.
Foreshore	Also named Beach face is the zone between mean low water (MLW) and the upper limit of the wave run-up during high tide. The foreshore is wet under normal conditions so storm surges are excluded.
JARKUS-raaien	The Dutch coast is divided in 1463 sections each between 200 and 250 meter. Each year measurements are taken of the dutch coast, with this information the development of each JARKUS-raai is closely monitored. The numbers of the JARKUS-raaien start in the North of the Netherlands in Den Helder.
Landwaartse grens toegestane afslagzone	Is a boundary that is determined on the basis of the expecting dune erosion under heavy storm condition and the minimal required sand volume that is needed after the storm to prevent flooding. Everything in front of this boundary is exposed to dune erosion.
Profiel van Vrije Ruimte	The area that needs to be retained for further extensions of the dike in the future.
Shoreface	The shoreface profile, often called beach profile, is the cross-shore coastal depth profile extending from the low-water line to the closure depth.
Waterstaatswerk	The area where the primary sea defence is located.

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Introduction

Figure 1.1: District Scheveningen, The Hague

According to the Deltaprogram [10], Scheveningen is one of the locations in the Netherlands where attention needs to be paid to guarantee the safety of the coast for future sea level rise due to climate change. The Municipality of The Hague has commissioned our multidisciplinary project group to do a research about the specific area where the historical hotel Grand Hotel Amrâth Kurhaus is situated. The reason for this particular area is because there is little information about what the consequences are due to future sea level rise. Moreover, this area is important for several parties, since along the coast of Scheveningen many developments are taking place in the well known sea side resort. One of them is the Municipality of The Hague itself, who had invested 25 million euro to renovate the boulevard of Scheveningen [11]. The investment is meant to build attractive constructions which should make the beach and boulevard look attractive for consumers and increase the opportunities for investors.

At the moment the natural dunes are mainly the primary defence along the coast of Scheveningen. These dunes should prevent from flooding by the sea of the hinterland. For the dunes it is acceptable that dune erosion occurs to some degree. As stated in the "Legger of waterboard Delfland" [1], the Amrâth Kurhaus is located in front of the boundary what is called the "Landwaartse grens toegestane afslagzone". This boundary is determined on the basis of the expecting dune erosion under heavy storm condition and the minimal required sand volume that is needed after the storm to prevent flooding. One can conclude that everything in front of this boundary is exposed to dune erosion, which means that the area of the Amrâth Kurhaus could be damaged when a normative dune erosion occurs.

The aim of this research is to investigate whether future sea level rise due to climate change will have severe affect on the Amrâth Kurhaus and the boulevard in front. The answer to this question will lead to potential concepts for the possible problems that are founded.

In order to acquire the preferred results of this research, there has been come up with a methodology. An overview of this methodology is indicated in Figure 1.2. In the report the methodology is divided into chapters. The first few chapters (Chapter 2 through 4) are analysis and are aimed to give a better insight about this project. In chapter 2 (Study Area) the current circumstances of the project area are explained to give an idea why this area is important for the municipality of The Hague. The main objective of chapter 3 (Coastal Hazard Analysis) is to show how the Amrâth Kurhaus and the boulevard in front may be affected by sea level rise due to climate change. In order to know the investigate this, different modelling programs have been used. Chapter 4 (Stakeholder Analysis) is meant to identify the stakeholders in this project and classify what their goals and interest are. By doing this there can be looked at the path to construct design concepts with the least resistance. In order to do so there has to be come up with design objectives that are determined in chapter 5 were the the SWOT & TOWS are discussed. This chapter shows all important factors from the chapters: Study area, Coastal Hazard Analysis and Stakeholder Analysis. The findings of the three chapters are categorized in threads, opportunities, weaknesses and strengths to create a SWOT/TOWS analysis. These factors are weighted and coupled with each other to indicate strategies with the most promising results. Chapter 6 (Design Objective of a Coastal Defense System) shows all the design objectives that are required for the design of the concepts. The concepts and different concept combinations are discussed in chapter 7 (Design of Concepts for a Coastal Defense System). The last chapters of this report indicates the results of the whole research including discussions, limitations and recommendations for future research.

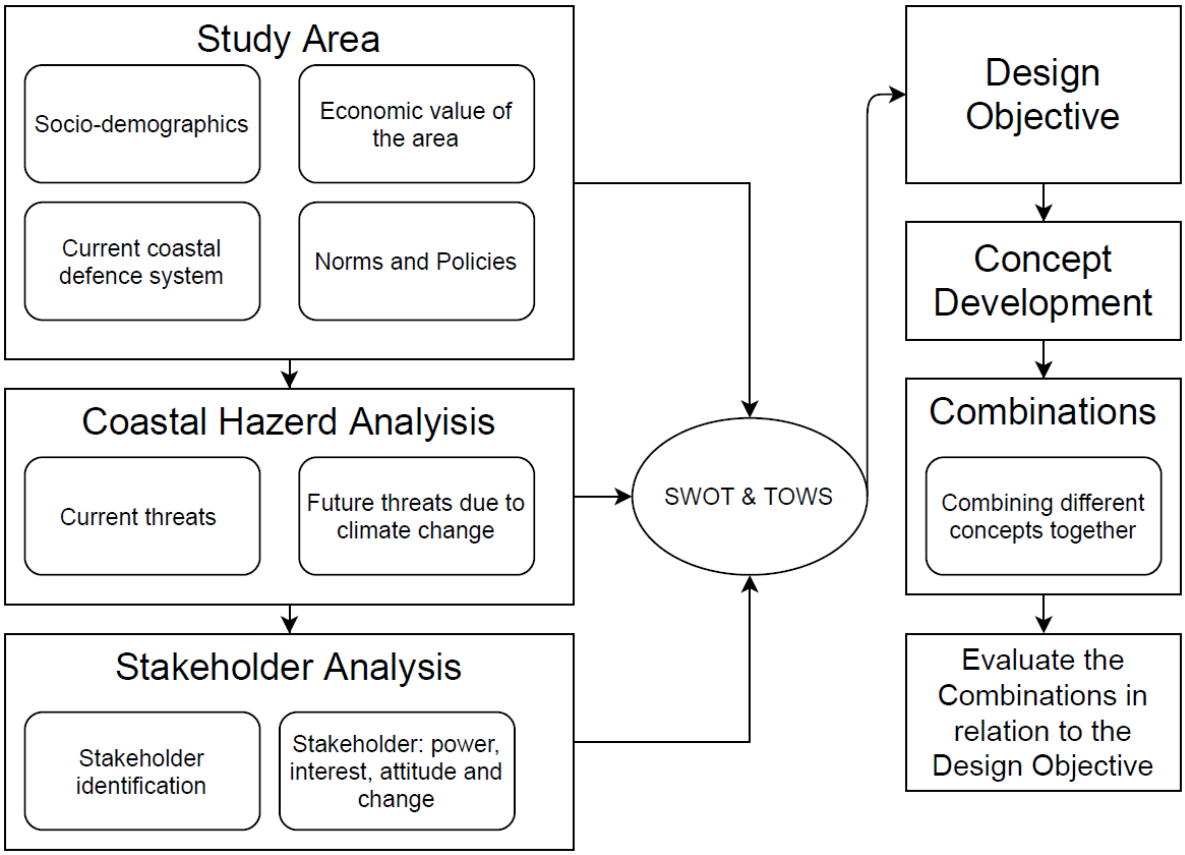

Figure 1.2: Methodology

2

Study Area

The area around the Amrâth Kurhaus contains many hospitality industries that are situated on and in front of the sea defence including Amrâth Kurhaus. Therefore, the future safety of this area was questioned by the municipality. But before going into future safety, which will be discussed in chapter 3 (Coastal Hazard Analysis) the current situation is explained in the study area. The purpose of this chapter is to gain knowledge about urban morphology, protection measures, norms and policies for the area in front and behind the surroundings of the Amrâth Kurhaus.

This chapter is constructed in the following stated manner. Firstly, the economic and socio-demographics are discussed in section 2.1. Secondly, the current applied protection measures at the coast of Scheveningen are indicated and discussed in section 2.2. Afterwards, the norms and policies designed to protect nature and the hinterland from flooding are discussed in section 2.3.

During the analysis of chapter 2 a couple things stood out:

- High economic gains in Scheveningen from tourists. (Dutch coast contributes to the settlement of companies in the Netherlands worth in total 1.3 billion euro, from this value 90 percent is provided by the district Scheveningen);
- Sea defence protects a densely populated hinterland which is of high economic importance for the municipality of The Hague;
- Large hospitality industry is located in the area on and in front of the sea defence, which provide job opportunities and revenues for the municipality of The Hague;
- In the current policy the BKL of Scheveningen is maintained by nourishment;
- The Amrâth Kurhaus and the surrounding area are situated on a Dune. Moreover, it is located in front of the line which is called "Landwaartse grens toegestane afslagzone". This means that the area in front of this line can experience erosion;
- High safety standards which result in a low chance of inundation of the hinterland;
- Buildings in front of the sea defence have a higher risk of flooding. In current policy these investors have accepted the risk and are not able to demand extra protection measures (side note: Delfland and Rijkswaterstaat have lower interest in protecting these areas while the municipality has higher interest in protecting this area since it has a large economical gain.);
- North and south of Scheveningen Natura 2000 areas are located. These areas have specific policies and should be taken into account when development can disturb a Natura 2000 area.

2.1. Urban Morphology

The dutch city The Hague is the capital of the province Zuid-Holland and is the largest urbanised city along the coast of the Netherlands. The coastal area is situated in district Scheveningen. This district can be divided into nine different sub-districts. The focus will be placed on the sub-district which is also called Scheveningen (see Figure A.1). The sub-district consist of the following areas: harbour, seaside resort and residential area. One of the reason that the focus has been placed on this specific sub-district is because it contains important valuable assets and locations such as Grand Hotel Amrâth Kurhaus, boulevard and residential area.

The monumental building Amrâth Kurhaus was build in between 1884 and 1885 along the coast of Scheveningen. This architectural building has an amazing history and is one of the most famous touristic highlights in the city The Hague. In front of the Amrâth Kurhaus a popular boulevard is located along the beach on the North Sea, which is very attractive to tourist. Many hospitality industries are located at the boulevard, which is part of the economic strategy of municipality The Hague. According to RIKZ, the coastal dune area along the Dutch coast contribute in settlement of companies in the Netherlands that worth in total 1.3 billion euro, from this value 90 percent is provided by the district Scheveningen. Also a lot of people are investing in residential buildings along the coast of Scheveningen. This is not strange since the buildings are located very well and have an amazing ocean view. Therefore, the municipality of The Hague cannot permit any harm to these assets to protect the historical values, economy and housing market.

As mentioned before, district Scheveningen has other sub-districts as well. These sub-districts are located in the hinterland and is important for the municipality. In fact many historical, governmental and residential buildings are located here. Some of the sub-districts are known as the area where the most embassies are located of the Netherlands. Furthermore, important international agencies, organisations and convention centres are established here. Such as International Criminal Police Organisation (ICPO), Organisation for the Prohibition of Chemical Weapons (OPCW) and World Forum. The other sub-districts are meant as residential areas, these areas will be expected to grow, since a forecast has been made by The Hague that shows that the number of inhabitants will increase in the upcoming years. One can conclude that the hinterland have also a lot of important buildings that should be protected. In order to protect the hinterland against flooding and inundation, the coastal dunes along the coast of Scheveningen are currently the primary flood defence.
For more information about the different sub-districts see Appendix A.

2.2. Current Coastal Defence Systems

The current coastal defence system of Scheveningen will be explained in this section. A good understanding of the current coastal defence system is important. Because this explains how well the area around the Amrâth Kurhaus is protected.

2.2.1. Coastal Protection by Nourishment

The sediment transport along the coast of the Netherlands causes the Dutch coast to retreat. To prevent this retreat sand nourishment is applied. There are different types of sand nourishment available to protect the coast. Currently the coastline of Scheveningen is maintained by beach nourishment ,foreshore nourishment and mega nourishment [12, 13]. For more information about the different types of nourishment see Appendix A, section A.7.

2.2.2. Protection at Amrâth Kurhaus

The current measured elevations of Scheveningen are determined with AHN [7]. Using a resolution of 0.5 m^2 a detailed top view with corresponding elevations is made in QGIS (see Figure 2.1). This top view can be divided into three sections: beach, boulevard and crest of the dune where the Amrâth Kurhaus is located. The three sections are determined due to the obvious elevation differences. The first clear elevation difference can be observed between the sandy beach and the boulevard. The elevation level of the beach suddenly increases from +4m NAP to +6.6m NAP where the Boulevard is located. The second clear elevation difference is the transition from the boulevard to the crest of the dune. Since there are many buildings and different entrances towards the beach the crest height differs. In Appendix A, section A.8 different cross sections from the entrances of the Amrâth Kurhaus were constructed. The lowest crest height was found at +9.5m NAP.

According to Rijkswaterstaat and waterboard Delfland, the area around the Amrâth Kurhaus serves as a dune. However, at the first sight this is not a standard dune compared to other dunes in the Netherlands. Many buildings such as Amrâth Kurhaus, roads and the boulevard are build on the dune. The boulevard in front of the Amrâth Kurhaus is designed to break down in pieces when storm surge will reach the boulevard. The pieces of the boulevard that come free during the breaking process will be an additional help to reduce the wave impact. However, the breakdown of the boulevard also makes dune erosion possible. The amount of dune erosion and damage to the buildings on the dune depends on the duration of the storm and the

magnitude of the wave impact.

The interviews from Rijkswaterstaat and the waterboard Delfland can be found in F, section F.4 and section F.1.

From Figure 2.1, one can observe that a black line marks the boundary of the flood defence along the coast of Scheveningen. This line is also called the "Landwaartse grens toegestane afslagzone" [8]. The location of this boundary is determined on two principles. The first principle is based on the expected dune erosion under heavy storm condition, while the second principle is based on the minimal required sand volume that is needed after the storm to prevent flooding.

In Figure 2.1, it becomes clear the Amrâth Kurhaus is located in front of the line, this implies that the Amrâth Kurhaus and other hospitality industries are part of the area where dune erosion can occur. This means in theory that during a normative storm the area in front of the sea defence can be damaged, while the hinterland is still protected. Other areas like the harbour and Morales boulevard do not contain this significant amount of constructions in front of the sea defence line (see Figure 2.1). To understand how important it is to protect this area, more research was done in the Stakeholder Analysis. More information about the protection measures at the Morales boulevard and the Harbour can be found in appendix A, section A.9 and Figure A.17.

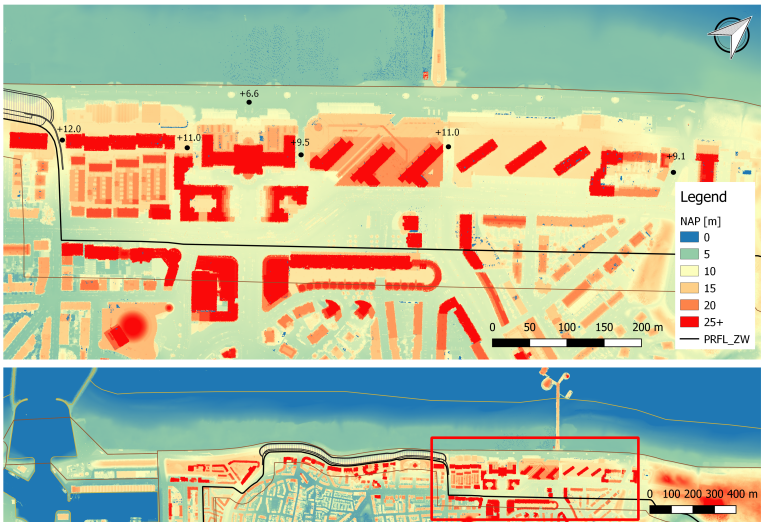

Figure 2.1: Elevation profile of the area around the Amrâth Kurhaus

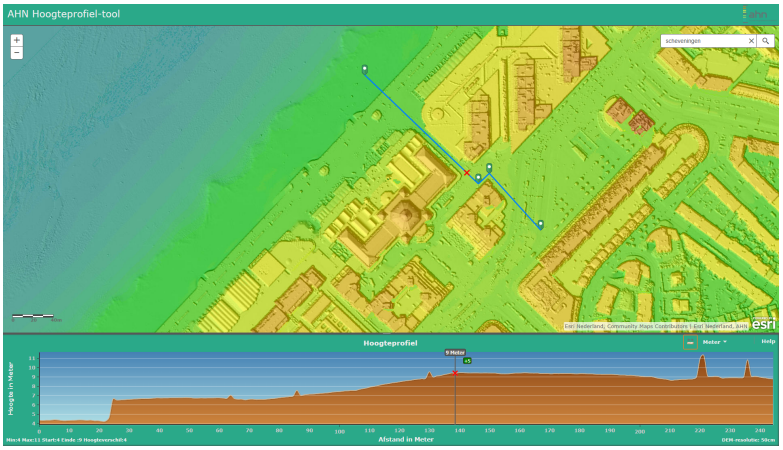

Figure 2.2: Elevation profile of the cross section

2.3. Water safety Norms and Policies for the Coast of Scheveningen

In this section the norms and policies of the Dutch coast in general and for Scheveningen specifically are discussed. Firstly, the safety norms to protect the hinterland are discussed. Here a short overview of the change in sea defence over the years is given followed by the current sea defence norms. Secondly the policies and management to meet those sea defence norms in Scheveningen are explained. The last paragraph focuses on the norms and policies for Natura 2000 area's.

2.3.1. Safety Norms to Protect the Hinterland

Before 1953 the dunes were increased to +4.3m NAP where necessary. After a large storm flooded parts of Zeeland in 1953 the norm for sea dikes increased to +7.65m NAP. From 1990 onward the construction management policy shifted from increasing the dune height towards maintaining the coastline by nourishment [14]. Besides this shift in policy also a norm was established, which does not specify a minimum dune height but provides the minimum safety to which the hinterland should be protected. The norm is expressed in an allowed statistical risk of exceedance (return period). Since, the impact of a sea defence failure in Scheveningen is extremely large, the established norm has a very low chance of exeedance (1:30000 years). More details on this topic can be found in Appendix A, section A.11. In the current situation, the norm is fulfilled in Scheveningen till 2050 [10]. However, since the sea level is rising extra measures might be needed to safeguard the norm in the future. Which measures should be used is not specified in the Waterwet.

2.3.2. Maintenance Policies for Dunes

In the Netherlands the goal is to maintain the dunes dynamically. This is done by sand transport which increases the strength of the dunes. Since dunes differ from each other in width, there are different types of dynamic coast management for the appearance of buildings and limited space [8]. Between the harbour and the Pier in Scheveningen, dynamic coast management is currently not possible because the beach is fixed to the wall of the boulevard [8].

2.3.3. Protection Norms for the Coastline

The sandy beach is the first protection measure which decreases the wave height significantly. To prevent erosion of the Dutch coast the government decided in the year 1990 to start protecting the coast and created the BKL. This line is still important today, since it is used as an important parameter to determine where nourishments are necessary. To determine whether erosion or accretion occurs at the coastline in respect to the BKL, Rijkswaterstaat measures the coastline every year. From measures over the last 10 years the linear trend of the coast is determined. From this trend it is estimated where the coastline is situated on the first day of January next year. The location of the current coastline is called the Momentane Kustlijn (MKL). When the MKL is situated landward of the BKL nourishment needs to be applied. For Scheveningen nourishment needs to be applied since the MKL of 2020 is situated landward of the BKL [15].

The BKL does normally not change. In special cases where the coast has changed by construction, the BKL can be changed. This is not based on technical or morphological calculations, but is purely a policy based decision. This happened during 2013 in Scheveningen, where the width of coastline was increased from 35 to 65 meters [16].

2.3.4. Construction Policies on and in Front of the Sea Defence

Construction policies for the coast of Delfland are focused on keeping buildings away from the coast [8]. The construction policies that are used, differ for areas outside or inside the urban area. Activities inside these area contours have less restrictions relative to outside the urban area. The beach of Scheveningen is situated inside the urban area contours. Only the rules will be discussed inside the urban area as this is the location of the project. Since the Area around the Amrâth Kurhaus is situated on a dune managed by Delfland the policy is explained.

The dune area is split up into two areas ("Waterstaatswerk" and "Beschermingszone") at which the policy differs. In Appendix A, section A.11 the location of the 2 areas is indicated graphically. "Waterstaatswerk" is the area where the primary sea defence is located. "Bescherminszone" is the area where no activities are allowed to take place that can harm the primary sea defence.

When buildings are in the area of the so called "Waterstaatswerk" the principle "no unless" is used. In the "beschermingszone" the principle of "yes if" is used [8]. Which basically means that gaining permission for buildings on the sea defence is easier in the "beschermingszone" compared to the area marked as "waterstaatswerk". In order to get permission it is important that the constructions do not cause harm to the primary sea defence during a storm surge. Further details of the construction policies can be found in Hoog Heemraadschap Delfland [17]. Other constraints for constructions are caused by Natura 2000 policies. This policy

can limit the construction of buildings when aeolian sand transport is blocked. The blocked sand transport can have a negative effect on the dune flora, this can happen when multiple buildings are build next to each other creating one big wall.

An other aspect of the construction policies is the maintenance policy. When areas need to be repaired after a storm, Delfland is allowed to point out areas that need to be broken down for repair and owners are not able to gain extra protection of beach nourishment [8].

2.3.5. Natura 2000

In the Netherlands, nature areas are protected by European law named Natura 2000. The green areas in Figure 2.3 shows the Natura 2000 areas on the north and south side of Scheveningen. The area between the Pier and the harbour is situated outside Natura 2000 areas. Although, the boulevard of Scheveningen is not located inside a Natura 2000 area, implementations of extra measures can still be limited by the laws applicable in Natura 2000 areas. For example when sand nourishment is applied in front of Scheveningen the conservation objectives in the Natura 2000 area north of the boulevard named Meijendel & Berkeheide could be effected [18]. Therefore, the policies and management of Natura 2000 areas in general and the policies specifically for Meijendel & Berkeheide are discussed here.

Natura 2000 Policy

For every Natura 2000 area specific policies are made, where the goals of the area are elaborated and the measures to protect the area are described. Furthermore, the management plans contain rules for activities in the area. The rules for those activities are set up in the same way for all areas by using three categories. First there are activities that cause no harm to the environment. These activities can be proceeded without getting a licence from the province. When some processes in the construction could have negative influence on preserving the area, but follow the restrictions that is given in the policy of the Natura 2000 area, it is still possible to start without a licence from the province. When there are activities where preservation of the area can not be safeguarded, permission from the province is required.

Natura 2000 Norms Applied for Scheveningen

Nourishment in Scheveningen is allowed without a licence of the province if negative influence on the preserving area follows the restrictions from Meijendel & Berkheide. A research done by Arcadis in 2018 shows that these restrictions can be met [18].

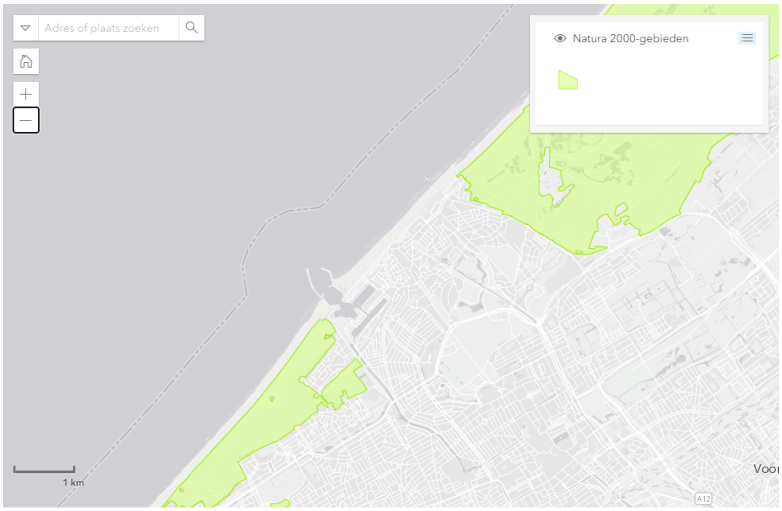

Figure 2.3: Natura 2000

3

Coastal Hazard Analysis

In this chapter different topics that can lead to coastal hazard will be explained. The last few decades the topic climate change has been discussed a lot, since scientists from different institutions have already warned that global warming is a fact and that it will result into sea level rise. In order to get an idea how the shoreline will retreat in Scheveningen, the Bruun Rule will be applied. The Bruun Rule is an analytical formula to estimate the magnitude of the sandy shoreline retreat with respect to the MKL due to relative sea level rise. Since the Amrâth Kurhaus is located at the dune crest, it is also interesting to know how far the dune erodes under current normative boundary conditions. In order to get an idea about how the dune erosion develops, the software tool MorphAn will be applied. With the results of The Bruun Rule and MorphAn it will give an idea whether coastal hazard will occur.

This chapter is constructed in the following stated manner. First of all the results of climate change that affect the sea level rise are indicated in section 3.1. Secondly, how the coastline will respond and shape due to sediment transport in cross and longshore direction is explained in section 3.2. The additional information of sediment transport about normative boundary condition and properties are given in Appendix B, section B.1.After that the explanation is given about why relative sea level rise is more important than sea level rise. This is explained in section 3.3. The shoreline retreat is determined with the Bruun Rule, this is explained in section 3.4. The detailed calculation is indicated in Appendix B, section 3.4. Finally, the result of dune erosion determined by MorphAn is shown in section 3.5.

During the analysis of chapter chapter 3 a couple things stood out:

- Depending on the global emission scenario, the Netherlands will have a temperature increase around 1.5° to 4.5° in the year 2100;
- Exact sea level rise is unknown, but it is in the range between +0.3 and +1 meter, according to the calculated scenarios of the KNMI. The sea reacts slowly to global warming and after the year 2100 sea level might still rise;
- Normative wind comes from north-west direction and will not increase or decrease in strength but stays in its normal deviation;
- Net longshore sediment transport moves in norther direction;
- Net longshore sediment transport at Scheveningen is large compared to other coastal areas in the Netherlands;
- The sea bed has to grow with sea level rise to maintain the coastline (BKL). Therefore, a fast rising sea level is a threat for the current nourishment policy, since the yearly quantity of nourishment will increase significantly;
- According to the Bruun Rule the shoreline will retreat inshore due to sea level rise, when no coastal protection measures are applied.

3.1. Climate Change

In the Paris climate agreement of 2016, the Dutch minister secretary signed with several other countries an agreement to reduce emissions and keep global warming below 2°. For the Dutch this means that they have to reduce their emission in 2030 with at least 49% [19]. However, this still means that the earth becomes warmer but the degree depends on the contribution of everyone.

3.1.1. Delta Scenarios

KNMI is a Dutch national data/knowledge institution that has calculated different future climate scenarios based on IPCC (Intergovernmental Panel on Climate Change). In the KNMI'14-climate scenarios there are four different scenarios presented for the Netherlands in terms of temperature, precipitation, wind and sea level [20]. The KNMI'14 scenarios presents four combinations of two different values for word wide increase of temperature. The scenarios display a temperature increase from moderate to warm and a change in air current pattern from low to high values. Figure 3.1 indicates the four scenarios where the big first letter indicates the increase in temperature and the smaller letter the change in air current pattern.

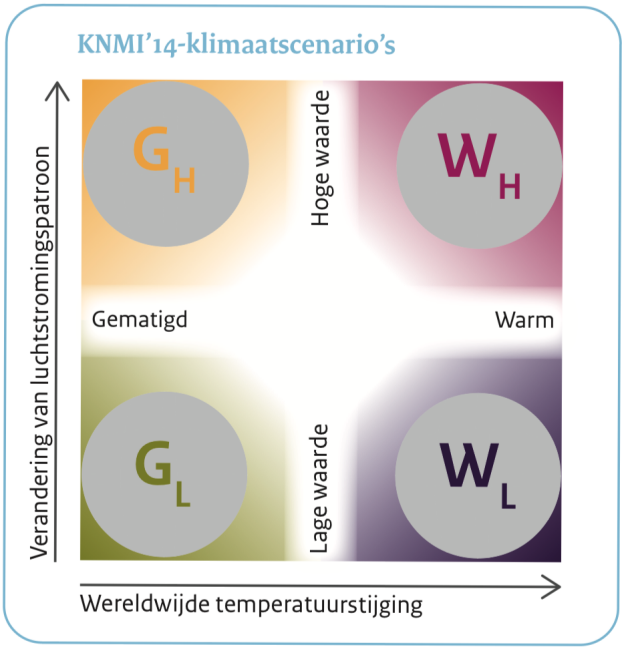

Figure 3.1: Delta scenarios

3.1.2. Temperature

The calculations based on an increase in temperature indicate the following results. In the G-scenario's the word wide temperature will increase with 1° in 2050 and 1.5° in 2085 compared to 1981-2010; in the W-scenario's the temperature increases with 2° in 2050 and 3.5° in 2085 compared to 1981-2010. Figure 3.2 indicates the different temperature increase for the future of the Netherlands. The IPCC have two greenhouse emission scenarios related to temperature. RCP (Representative Concentration Pathways) is the greenhouse emission exhaust word wide where RCP 4.5 means stabilisation of greenhouse emission while RCP 8.5 is high exhaust of greenhouse emission. The two RCP scenarios represents the different scenario developments in world population, economy and technology that in turn affects the exhaust of green house emission. Potential evaporation is difficult to estimate however the KNMI suggest that the theory of Makkink gives an indication. This theory suggest that in each scenario depending on the season the potential evaporation increases with 2% for each degree of Celsius the temperature increases. Note that the actual evaporation depends on the available water in the ground. Draught is another difficult factor to estimate. Draught has increased slightly in the Netherlands since 1951. Precipitation deficit will increase during 1st of April towards the 30th of September. In the G_H and W_H scenario this deficiency is larger that the G_L and W_L scenarios.

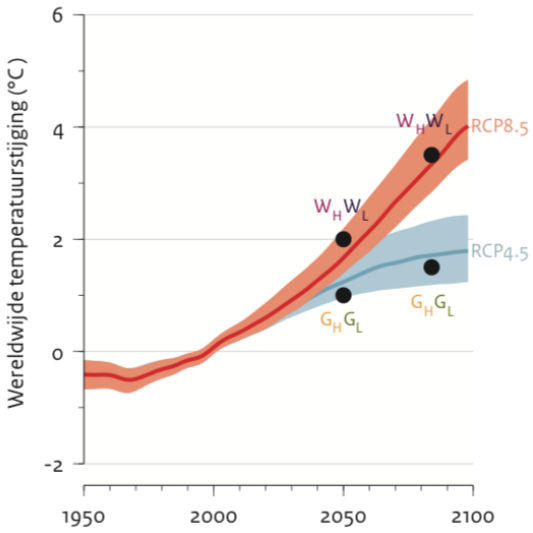

Figure 3.2: Temperature

3.1.3. Weather and Storm

Next to temperature increase there is also a change in the pattern of air flow. The small H indicates a scenario with a high value change meaning that the wind comes more often from the west in relation towards the small L-scenarios. In the small H-scenarios the weather will be softer and more wet. In the summer will the wind come out of the east and will the weather be more hot and dry.

In all four scenarios the precipitation will increase in all seasons except the summer [20]. The G_H and W_H scenario the summer precipitation will even decrease but extreme intensity of the precipitation will still increase in all scenarios for each season.

The highest water levels at the coast in the Netherlands occur when the wind comes from northwest direction in winter. Research of the IPCC has indicated that the different future scenarios not indicate an increase in frequency of wind from that direction nor a change in wind speed. The wind speed and direction through the years during winter stay within their natural deviation. Most storms come from south-west direction. However, the fetch length is an important factor and is the longest from north-west direction and therefore the significant storms are to be expected in the future as well in north-west direction [21].

3.1.4. Sea level

Oceans react slow towards the increase in air temperature. Therefore, the sea level in each scenario will not rise as much till the year 2050. However after 2050 the increase of temperature will have a larger influence on the oceans, even when the temperature becomes stable, the sea level keeps rising due to the lagged effects of the ocean.

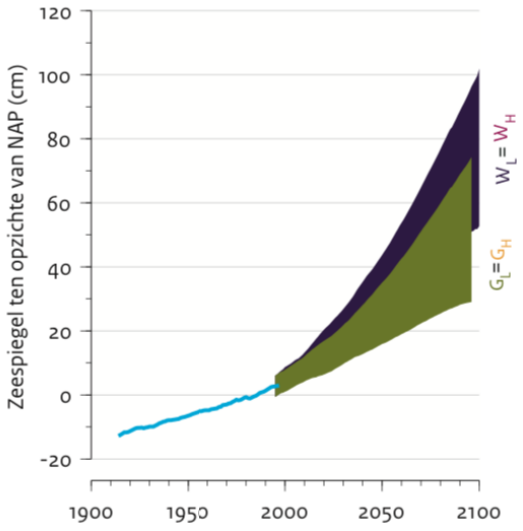

Figure 3.3: Sea level rise

There are a lot of factors that have an affect on sea level rise at the Dutch coast such as change in salt concentrations, loss of mass from icecaps but also the change in gravitational effect of the earth. Figure 3.3 indicates the different sea level rises at the Dutch coast for each scenario. Each scenarios will have a lower and upper limit but there is no differentiation between L and H-scenarios as the air stream pattern above Europe does not have an dominating effect on sea level rise in the long term.

3.2. Sediment Transport

Sediment transport can be defined in the cross-shore and longshore transport. Both transports are important, because it determine how the coastal profile will respond and shape.

3.2.1. Cross-shore Transport by Storm Impact

Storm impact is an important topic for coastal protection, since storms cause for erosion of the coast, which might leads to great damage to the properties along the coast. The erosion is mainly due to higher wind speed, increased wave height and wave actions along the coast. The erosion of the dunes take mainly place during a storm event. The storm will cause for storm surges that increases the mean water level, which will reach and impact the dune face. Often the erosion of the dunes will be described as a periodically avalanche process of the sandy dunes [22]. The eroded sand will be transported offshore by a strong return current. Eventually this sediment starts to settle further seaward. A new Foreshore has been developed during the storm. This new foreshore is more effective in dissipating the energy of the incoming waves as the storm progresses. Due the dissipation of the wave energy, the dune erosion rate will decrease throughout the storm event. The storm impact is mainly controlled by two categories: hydrodynamic boundary condition and geo-morphological properties. More details about these categories see Appendix B, section B.1.

3.2.2. Longshore Transport

As explained in appendix A, section A.7 the dutch coast is maintained by different types of nourishment. In this section is explained why those nourishments are necessary to maintain the coastline. To understand why nourishments are needed the forces which drive longshore sediment transport and cause for erosion will be explained. Next the quantities of net longshore sediment transport in the Netherlands found by different studies are discussed. In the last subsection the effect of climate change on the future of nourishments will be discussed.

Fundamental Forces Which Drive Longshore Transport

The balance between an increase or decrease of the coastline depends on the amount of sand that the coast receives or loses. When more sand arrives at the coast the beach grows and new sand planes are formed. Natural forces, including winds, waves, currents and tides interact with sediments to create sediment transport. The sediment will deposit when the net force that causes the movement becomes less than the force that tends to stop the motion.

Gradients in longshore sediment transport can be created by human interventions, since the interventions can change nearshore wave height and gradients in angle of incidence of the incoming waves [3]. Human interventions like groynes can cause accretion in front of the groyne. However, there is also erosion behind the groyne because sediment transport is blocked. An increase in wave height causes larger volumes of sand to erode due to a larger impact from the waves on the beach.An increase in gradients in respect to the coast causes an increase in erosion since the waves push the sand in a more longshore direction.

Quantitative Findings for Longshore Transport at the Dutch Coast

The dutch coast of the Netherlands is dominated by longshore transport processes [22]. This is due to the overall south-west current and wind direction which cause the overall sediment transport to move from the Shoreface area in northern direction [23].

In order to get a quantitative idea about the net longshore transport, different studies have been consulted. The amount of longshore transport are indicated in Figure 3.4 and Figure 3.5. In Figure 3.4, one can observe that the cross shore sediment transport was also calculated, but for this section only the dominating longshore transport is discussed. As can be seen in deeper waters -20m NAP the longshore transport is estimated to be significantly smaller than for -8m NAP, which can be explained by the waves which have less impact in these areas [24].

To compare the values of Figure 3.4 and Figure 3.5 the longshore net sediment transport of -8m NAP and -20m NAP of Figure 3.4 should be added together. On the x-axis of Figure 3.5 the numbers of JARKUS-raaien are shown. The location of the JARKUS-raaien can be found in Rijkswaterstaat [15]. The lines run between Scheveningen (10200 - 9975) on the left and IJmuiden (5750 - 5475) on the right side. In this graph large variations are found between different studies but for all of those studies except from Van Rijn (1995) a downward

trend is shown. This means the net longshore transport decreases from Scheveningen towards IJmuiden. Surprisingly the values in Figure 3.4 shows the opposite. A lower net sediment transport in Scheveningen and increasing net transport in north direction. Why longshoretransport rijn 1997 shows a opposite result is unclear.

From the studies of Rijkswaterstaat [15], the Jakus-raaien shows a landward trend between the harbour and the Pier in Scheveningen (10200 - 9975). Although the coast moves landward, the current coastline is mainly located seaward in respect to the BKL except from the location at JARKUS-raai 10025.

Since the Jarkus-raaien at Scheveningen shows a strong landward trend and multiple studies show strong sediment transport in Scheveningen, it is assumed in this study that Scheveningen has a relatively large net longshore sediment transport in respect to the rest of the Netherlands.

Cross-shore profile	Yearly averaged transport (m^3/m/year)			
	Cross-shore NAP-20 m	Cross-shore NAP-8 m	Alongshore NAP-20 m	Alongshore NAP-8 m
14 Callantsoog	5±10	0±10	75±30	150±60
40 Egmond	15±10	0±10	60±25	135±50
76 Noordwijk	10±10	0±10	35±15	85±45
103 Scheveningen	0±10	0±10	25±15	65±40

Figure 3.4: Computed yearly averaged total transport rates for [2]

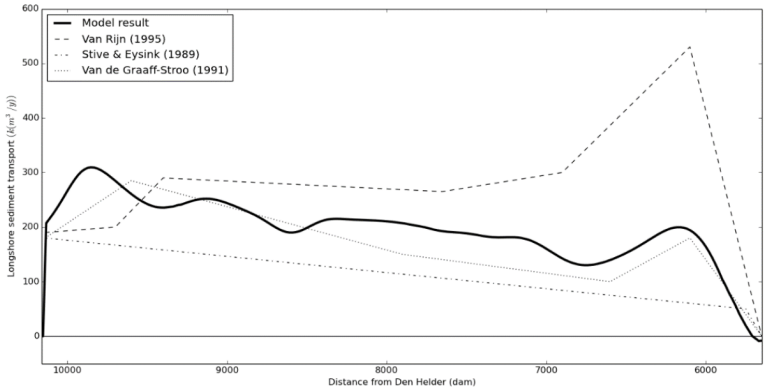

Figure 3.5: Longshore sediment transport [3]

The Effect of Sea Level Rise on Longshore Transport

An important parameter for sand demand is sea level rise. There are three main reasons why sand demand increases due to sea level rise. The first reason is simply because of the width of the coast increases with sea level rise [25]. Secondly, the increase of sea level rise causes high water levels to occur more often and thirdly, the government policy is to move the sea floor upward with the same speed as the sea level rice.

In Figure 3.6 the blue line indicates the current water level and the yellow line shows a sea level rise of 1 meter. The dashed green line shows the difference between the rate of occurrence between the blue and yellow line. A rise of 1 meter will cause an increase in frequency occurrence of +3 m NAP high water level. Which used to happen every 10 years will now appear 5 times a year in this situation. In normal conditions the sand which is moved seaward is moved towards the beach again in time, but when the recovery time is too short erosion will occur and the beach will move landward [4].

To prevent the beach from moving landward the sea bed has to grow with the rising sea level which demands sand nourishment. How much sand is needed each year to grow with the rising sea level is depending on the area and the speed at which the sea level rises. Deltares researched this and the results are indicated in Figure 3.7. The results give insight in the amount of sand needed to grow the sea bed with a rising sea level. Deltares used a surface of 4000 km^2 which is approximately the coastal foundation of the Netherlands without the Waddenzee, Ooster- and Westerschelde. When the coast foundation grows with a sea level rise of 1mm/year, 4 million m^3 sand is needed. Calculations of Deltares predict that the warmer scenario (+0.85m sea level rise in 2100 [26]) needs around 3 to 4 times more sand than the current 12 million m^3. When sea level rises faster even more sand is needed each year. this also significantly increases the cost as indicated in Figure 3.7. The significant increase in effort and cost makes nourishment a less attractive solution for fast sea level rise and can become cost ineffective.

To get a indication which amounts of nourishments are necessary in Scheveningen the study Simonse [3] was used. The study from Simonse [3], modeled the coastline between IJmuiden and Scheveningen till 2050. The model took the effect of nourishment, longshore transport and a constant sea level rise of 1cm/year into account. The model showed which amounts of nourishment at Scheveningen, Katwijk and Noordwijk were needed to prevent the coastline from moving landward. The results showed that to maintain the coastline 650,000 m^3 per 5 years were applied in front of Scheveningen. For Katwijk and Noordwijk a lower amount of nourishment was needed (approximately 200,000 m^3). The lower volume of nourishment in Katwijk and Noordwijk is due to a larger net longshore transport in Scheveningen [3]. It is interesting that these volumes are lower than the initial applied nourishment in Scheveningen, Katwijk and Noordwijk which was 700.000, 400.000 and 410.000 m^3 respectively [3]. Therefor it seems that nourishment for a sea level rise of one cm/year would stay manageable at Scheveningen.

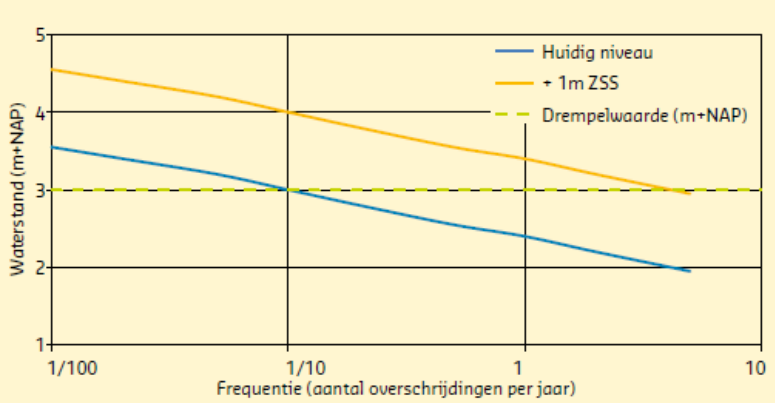

Figure 3.6: Effect from a increase of 1m for the frequency of exceeding +3 NAP [4]

Snelheid (mm/jaar)	Benodigde volume zand (miljoen m³ /jaar)	Kosten suppletie (miljoen euro)
2	8	28 - 40 €
3	12	42 - 60 €
5	20	70 - 100 €
12,5	50	175 - 250 €
30	120	420 - 600 €
40	160	560 - 800 €
60	240	840 - 1200 €

Figure 3.7: Correlation between the speed of sea level rise and needed nourishment [4]

3.3. Relative Sea Level

In the previous paragraph the subject sea level rise due to climate change has already been mentioned. According to KNMI the sea level will increase significantly after the year 2050. Moreover, it was mentioned that the sea level will increase differently for each climate scenario. In the worst climate scenario the sea level in the Netherlands will expected to rise with 1 meter in the year 2100. In order to know whether the shoreline is actually retreating or not, the relative sea level change is more important than the difference in sea level rise. Since, relative sea level is defined as the rise or fall of the sea level with respect to the land in a particular location. Therefore, the land deformation needs also to be considered. According to the website Bodemdalingskaart of NCG [27], subsidence is taking place in Scheveningen. The difference of subsidence over years is in the order of millimeters. This speed of subsidence will not change between the period 2018 and 2050. Moreover, even after the year 2050 the speed of subsidence will not hardly change according to report of Deltares [28]. After a century this means that the subsidence is in the order of 1 centimeter.

Based on the study of KNMI, the difference of sea level rise over years is in the order of centimeters. Thus, one can conclude that the subsidence does not contribute much to the relative sea level with respect to sea level rise. However, it is still important that subsidence is included in the relative sea level rise, because land subsidence increase the risk of coastal flooding and contribute to shoreline retreat.

The prediction of sea level rise become less accurate and more uncertain when predictions will be made for decades to centuries. A lot of research has already been made by institutions to predict the sea level rise. Yet there is still not a definite answer how the sea level will rise exactly over time. Therefore, for this project there is been decided to not look at when a specific relative sea level has reached. But just focus on three relative sea level rise scenarios that will affect the shoreline. The three scenarios are 1 meter, 2 meter and 3 meter relative sea level rise.

3.4. Shoreline Retreat with Bruun Rule

In order to get an idea how the shoreline will retreat in Scheveningen due to Relative Sea Level Rise (RSLR), the Bruun Rule is good solution. The Bruun Rule is an analytical formula to estimate the magnitude of the sandy shoreline retreat due to sea level rise. The idea behind the Bruun Rule is that there is a linear relationship with sea level rise and shoreline retreat. Therefore the shore face profile will maintain it equilibrium shape. Moreover, when the sea level rises the nearshore constant water depth will also be maintained, since the eroded sandy upper beach volume will be deposited offshore. This result in a landward retreat of the shore profile and rise in the nearshore bottom.However, the Bruun Rule has its limitations [22].

The limitations of the Bruun Rule are:

- only applicable to soft-sediment coast;
- assumes that it response to a rising sea level such than an equilibrium profile will be reached;
- assumes that all the eroded sediment will be redistributed along cross shore profile;
- the longshore sediment transport will not be considered for the erosion of the shoreline. The shoreline erosion is due to sea level rise alone.

One of the limitations above is neglecting the longshore transport. This limitation is one of the prominent criticized limitation. This limitation is acceptable, since it is assumed that the longshore transport is compensated by sand nourishment.

The mathematical equation of the Bruun Rule is indicated below:

$$Retreat = RSLR \cdot (\frac{L}{d}) \tag{3.1}$$

in which:

- $RSLR$ = relative sea level rise [m]
- L = length over which the erosion and sedimentation takes place [m]
- d = height over which the erosion and sedimentation takes place [m]

The mathematical Equation 3.1 shows three parameters. The first parameter is RSLR. The second parameter (L) is the length from the location of the closure depth till the new MSL that reach the coastline. The third

parameter (d) is the difference from crest height of dunes till the level of Depth of Closure (DoC).

Before Equation 3.1 can be used, first the DoC needs to be determined. The definition of DoC is according to Deltares: "the most landward depth seaward for a given or characteristic time interval of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore" van der Werf *et al.* [29]. In order to compute the DoC, the analytical equation of Hallermeier (1978) has been used. The equation of Hallermeier (1978) gives the inner closure depth at the seaward limit of the littoral zone.

The mathematical equation of Hallermeier (1978) is indicated below:

$$DoC = 2.28 \cdot H_s - 68.5 \cdot \left(\frac{H_s^2}{g \cdot T_s^2}\right) \tag{3.2}$$

in which:

- DoC = depth of closure [m]
- H_s = significant wave height [m]
- T_s = significant wave period [s]

Based on the literature from J. den Bieman [30] about wave properties of Scheveningen. The computed DoC value is 16.7 meter. The calculation approach of the DoC can be found in Appendix B, subsection B.2.1.

Since DoC has been determined, the retreat of the shoreline can be computed with Equation 3.1. The results of shoreline retreat for each relative sea level rise scenario is indicated in Table 3.1. For the calculation approach of the shoreline retreat per relative sea level rise scenario see Appendix B, subsection B.2.2.

In order to better understand and visualize how the shoreline retreat with respect to the MKL. The three determined shoreline retreat scenarios are indicated in the map with different colored lines along the coast of Scheveningen. The purple line is the MKL line, while the green, yellow and red lines indicates the shoreline retreat of 1, 2 and 3 meter relative sea level rise.

Table 3.1: Shoreline retreat, Scheveningen

Effect on the shoreline	
Relative sea-level rise [m]	Shoreline retreat [m]
1	70
2	130
3	170

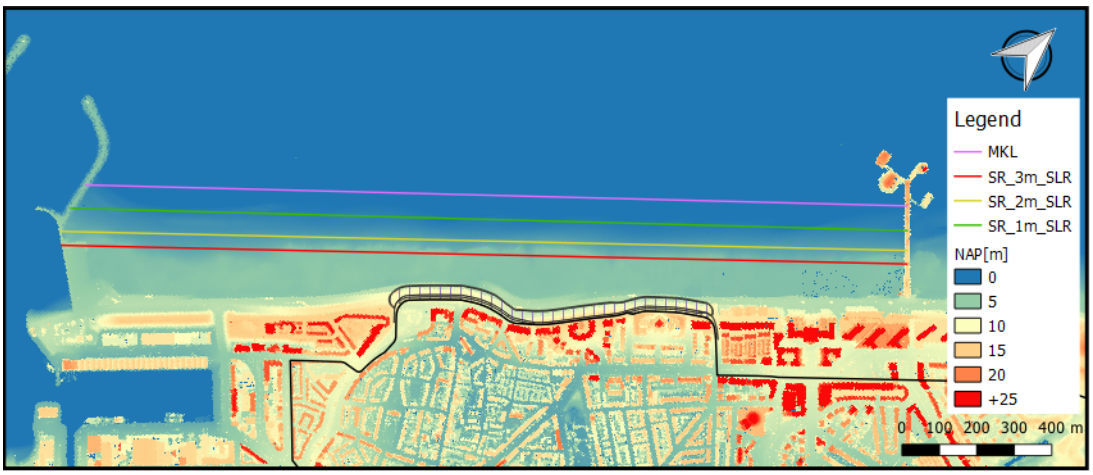

Figure 3.8: Shoreline Retreat with respect to MKL
SR:shoreline retreat SLR: Sea Level Rise

3.5. MorphAn Dune Erosion

MorphAn is an software tool for the analysis and assessment of the sandy coasts. For this project, MorphAn will be used to compute the dune erosion and assess the coastal safety with the normative hydraulic boundary conditions. The hydraulic boundary conditions is provided by Rijkswaterstaat and waterboard Delfland. With the dune safety model of MorphAn, the result of dune erosion at the section of the Amrâth Kurhaus can be determined. For calculating the dune erosion the model Duros+ must be performed. The erosion results are displayed in Figure 3.9.

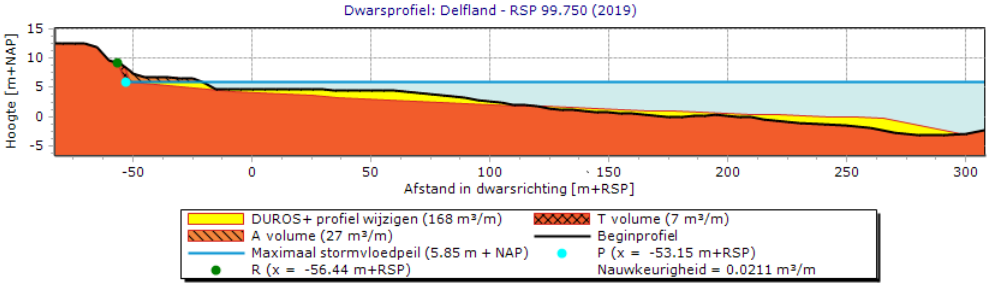

Figure 3.9: Erosion results of transect Defland - RSP 99.750 (Amrâth Kurhaus)

Figure 3.9 shows the cross section that starts from the sea to the dunes where the Amrâth Kurhaus is located. The following results are determined with MorphAn:

- A volume = regular erosion volume
- T volume = additional erosion volume due to uncertainty of the duration of high tide peak and the inaccurate results of DUROS+ model
- DUROS+ profiel wijzigen = erosion and accretion balance
- Begin profiel = current profile
- Maximaal stormvloedpeil = maximum storm surge level
- R = erosion point
- P = dunefoot

In Figure 3.9, one can observe where accretion and erosion will occur. For normative boundary conditions the maximum storm surge level will reach an elevation of +5.85m NAP. Above this elevation, regular erosion and additional erosion will take place. This eroded sediment is permanent and will not be resupplied by natural process. This means that the front of the dune will definitely be affected by erosion.

Figure 3.10 shows that the regular erosion reaches an elevation of approximately +8.5m NAP. This happens under current normative boundary conditions with a return period of 1:10000 year. Overall this means that erosion will definitely affect the boulevard in front of Amrâth Kurhaus. As been mentioned in the previous paragraphs future climate change has affect on sea level rise and relative sea level rise has affect on shoreline retreat. The combination of shoreline retreat and dune erosion that occur in the future should not be underestimated. If the shoreline retreat is not prevented, it is expected that dune erosion can reach further into the dunes and this will cause severe consequences for the buildings on top of the dune crest.

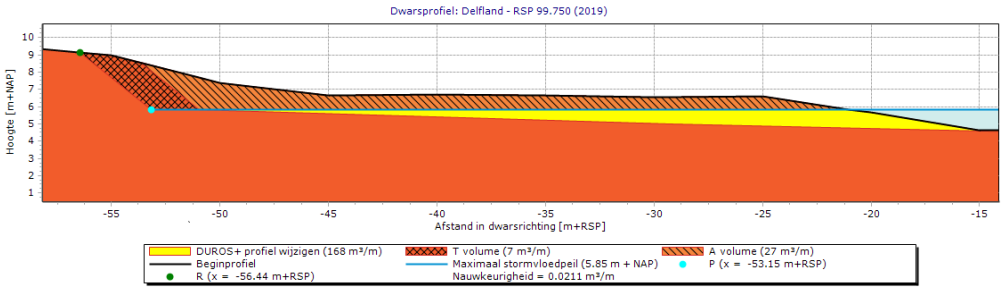

Figure 3.10: Regular and additional erosion results of transect Defland - RSP 99.750 (Amrâth Kurhaus)

4

Stakeholder Analysis

The threat of sea level rise calls for a design concept that strengthens the coast in Scheveningen. Such a design concept could have a major impact on the way of living, economical development and even ecology in the area. Therefore, it is important to take into account the stakeholders being affected by such a project. The Stakeholder Analysis contributes to a concept design that mitigate the negative impact and safeguard the values of each stakeholder. This is not only important but also necessary as it would be difficult to carry out a concept design without the consent of certain stakeholders.

This chapter is constructed in the following stated manner. Firstly the stakeholders involved in a new coastal defense system are identified in section 4.1. The complete result of the stakeholders interest, problem perception values and goals are indicated in Appendix C, section C.2. Secondly, each stakeholder has a certain power, attitude and degree of interest towards the project. In addition are some stakeholders more willingly to change their perspective towards the project than others and is discussed in section 4.2. Why some stakeholders score higher than other stakeholders in these different aspects are discussed in Appendix C, section C.4. As a result of these scores, stakeholders can be categorized by typology indicated in section 4.3. The typology of each stakeholder indicates how each stakeholder should be confronted and dealt with. The identification of typology of each stakeholder will contribute towards the behavioural response of a stakeholder towards certain design concept. Finally, in section 4.4 the relation dependence between stakeholders is indicated. With certain stakeholders it will be harder to convince the importance of the project. Therefore, it could be more effective to indirectly change their perspective by changing the attitude of other stakeholders they have a dependence relation with.

During the construction of chapter 4 couple things stood out:

- The comfort of living for the local inhabitants is negatively affected by tourists due to littering, aggression and excessive noise.
- Rijkswaterstaat is one of the biggest investors in coastal related projects and should be considered as one of the most important stakeholder for succession of this project. Their resources extend further than that of waterboard Delfland and the province Zuid-Holland.
- Province Zuid-Holland and municipality of The Hague share similar values in the protection of sea level rise and economic development. However the province does this on a provincial scale instead of more locally. This does not mean one solution fits all urban areas. The province strives towards a tailor made solution for each coastal area and in this respect cares about the municipal's values as well.
- Environmental organisation has a neutral standing point towards the project which will change depending if Natura 2000 areas are positively or negatively affected by the project. Their openness to change is small, meaning that it will be difficult to convince them when they make up their mind.
- Business operators, Kurhaus and the Pier are all dependent on tourists and tourists depend on the facilities these stakeholders offer. However, the direct power of tourists on the project is a lot lower; they are important towards the other stakeholders that have considerably more power.

4.1. Stakeholder Identification

This stakeholder analysis consists of two main components: Actor Identity and Actor Power. The Actor Identification takes the characteristics of each stakeholder into account, as well as their problem perception. Actor Power denotes the form and source of power per actor, with a following discussion.

Information gathered about the different kind of identity each stakeholder has been been done in several ways:

- Interviews: there has been a possibility to interview waterboard Delfland, municipality of The Hague, Rijkswaterstaat and the Pier. These interviews are located in F.
- Survey: a previous survey of Steda Research [31] among local inhabitants. The most exceptional outcomes of that research are located in subsection 4.1.1.
- Criminal statistics: the only survey about the inhabitants available is 12 years old and might not represent the current situation and has therefore be compared with current criminal statistics. These statistics are located in section C.1.
- Reports: unfortunately it has not been possible to interview each stakeholder and therefore reports have been used. There is for example no representative information available about interest and problem perception of the hospitality industry in Scheveningen. However, other touristic coastal areas such as Noordwijk and Katwijk, certain coastal defense measures have taken place already. Information about interest and problem perception of these new coastal defense measures are relatable to the situation of Scheveningen. An important source of information of these stakeholders is stated in "Kustverdediging Katwijk" [32]. The interest and problem perception of the province Zuid-Holland is relatively similar however where their views differ is stated in "Bestemmingsplan Duinen" [33].

4.1.1. Actor Interest and Problem Perception

The most important variables gathered on actors are the their interest and problem perception as this leads to their goals and core values [34].

Governmental Bodies

Any coast related subjects are often discussed by four different governmental bodies [35]: Rijkswaterstaat, waterboard, municipality and province. Rijkswaterstaat has for the coast of Scheveningen one particular role and that is being chief supervisor. As a chief supervisor Rijkswaterstaat takes the lead in preparing and determining what kind of policies are necessary to keep the coast and hinterland safe. Rijkswaterstaat also maintains the coastline in Scheveningen such as providing sand nourishment where necessary. Often Rijkswaterstaat is the largest investor for coastal protection.

When any coast related matters need to be discussed, minister of traffic and water will be advised by Provinciaal Overlegorganen voor de Kust (POK). POK represents the province, waterboard, Rijkswaterstaat and the coastal municipality. In this case the coastal municipality is The Hague. There are also other organisational bodies that are sometimes included in these consultations depending on the subject, such as nature preservationists, hotels, investors or water supply companies. Delfland (waterboard) has an advisory role towards the municipality of The Hague as well as Rijkswaterstaat. Delfland has a high amount of information and expertise about the coastal defense. Their daily roles are mainly focuses on administering and maintaining the hard structures that serve as coastal protection. The province Zuid-Holland plays a supervisory role, as well as coordination and integration of the policies determined by Rijkswaterstaat. This means aligning and testing of policies by Rijkswaterstaat between the waterboard and the municipality of The Hague. According to the report "Strategische Agenda Kust Zuid-Holland" the province wants to work towards a climate resistant coast. Their ambitions are based on the policy document "Provinciaal Waterplan and Provinciaal Structuur Visie" [33]. In this document it appears in context of coastal protection that the province in cooperation with Rijkswaterstaat, municipalities and waterboards want to work towards tailor made solution for each coastal area while also creating a quality impulse towards that area and therefore towards the province. For the municipality of The Hague it is important that the strategies that come out of these policies are aligned with their spacial plan and create value towards Scheveningen and their inhabitants. For the municipality of The Hague is the beach an important source of income and any changes or alterations made can have an indirect affect on this, such as less income from the hospitality industry.

Local inhabitants
Current information about how the local inhabitants are experiencing Scheveningen are difficult to find. There is a survey performed under the local inhabitants in 2008 [31]. However, that was 12 years ago and might not be as representative. Therefore, also criminal statistics in the area have been analysed. The criminal statistics over the years give a good indication about agitation in the area and can be located in Appendix C, section C.1. These statistics are aligned with previous results of the survey in 2008 as the recent values from drugs, guns and public crimes are similar towards 2008 or have even increased while sexual abuse, criminal and traffic crimes have seen a slight increase after a long decreasing trend. Therefore, the research done in 2008 can still be seen as valid due to the fact that most present values of the criminal statistics and the interviews are aligned with this research. In this research a 26% feedback was given out of a thorough interview with 200 households and 5000 surveys spread between Scheveningen Bad, Scheveningen Dorp, Havenkwartier and Duindorp. This research has been done by Steda Research [31]. From the number of inhabitants living in the coastal area of Scheveningen, 92% are enjoying their stay. However, there are some points of criticism that the inhabitants would like to have changed such as the following examples:

- Inhabitants are experiencing some provoking signals from young groups of loiterers;
- Since alcohol is prohibited at the Strandweg and the Boulevard these young groups are now causing trouble in other areas in Scheveningen, such as making excessive noise and littering;
- Visitors of the Boulevard are acting annoyed or even aggressive due to the fact that it takes too much time to find a parking spot;
- Inhabitants but also catering entrepreneurs are experiencing an unsafe feeling due to a threatening experience by groups of young adults. This experience are often associated with challenging and provocation. This tension creates irritations under the inhabitants and catering entrepreneurs;
- Inhabitants experience a lot of excess noise and littering from the entertainment audience going back from a night out. Also is public urination a common phenomenon;
- Inhabitants find the catering and shopping facilities unilateral and the price quality ratio of the catering out of balance;
- The catering facilities are too expensive for the younger inhabitants of Scheveningen;
- The ambiance and sea sight of the boulevard is disturbed by the excessive light pollution and billboards;
- There is a lot of littering due to a shortage of public garbage bins;
- Inhabitants feel that the police is not doing enough, when it comes down to excessive noise from car radios and catering facilities. But also, public urination and nuisance at the stairs of Vitalizee create irritation under the inhabitants;
- The municipal call-centre for excessive noise acts to slow on calls from the inhabitants.

However still 58% of the inhabitants are positive about the ambience of the Boulevard and feel safe while 30% find the current situation of the Boulevard reasonable.

Tourists
The 13-14 million tourist visiting Scheveningen is an important source of income for the municipality of The Hague. The facilities such as the seaside resort with long beach, promenade, Pier and lighthouse are popular places within Scheveningen to visit. Also are there prominent hotels available (such as Amrâth Kurhaus), restaurants and bars. All of the mentioned facilities above are factors that interests tourists to visit Scheveningen each year. In addition to this, tourists provide job opportunities for the Local inhabitants of Scheveningen. However, it also brings a less prosperous picture. Local inhabitants experience excessive noise, violence, public urination and littering. This is partly due to young group of loiterers but tourists as well.

Local Business Owners, Amrâth Kurhaus and the Pier
The hospitality industry located at the beach and boulevard are profiting significantly from the fact that Scheveningen attract so many tourists. For some of these companies their livelihood depends on it and it create job opportunities for locals. Depending on the climate scenarios predicted by the KNMI it might have severe consequences for business operators located in that area if no preventive measures are taken. Business operators that want to operate in that area have signed an agreement that they accept the risk of flooding, however in each scenario the risk of flooding increases.

Amrâth Kurhaus is one of the most iconic places in Scheveningen and is internationally famous for its architecture as well as its ocean view. Amrâth Kurhaus has lots of admiring visitors and any alterations or changes can have an affect on their income.

The access point of the Pier is located at the boulevard as they are partly located in the ocean. Also is the Pier an iconic place and the only one in the Netherlands. It is therefore not only important as a place for tourists to visit but also for the whole Netherlands as an iconic structure.

Nature Organisations
As explained in chapter Study Area, the surroundings between Amrâth Kurhaus and the Pier are not appointed as a Natura 2000 area. This makes the interest of environmental organisations having less of an impact on the development of the project. However, depending on the concept solutions they are still important to consider as for example large volumes of nourishment can still have an effect on the Natura 2000 area. This is because the area next to Amrâth Kurhaus and Pier is designated as Natura 2000 area (see Figure 2.3). Depending on the measures to defend against future sea level rise and its effect on the Natura 2000 area, a licence might be required by the province.

The following table is based on "The Basic Stakeholder Analysis Technique" written by Bryson in 1995 [34]. The table consist of the actors and their goals (see Table 4.1) . An extended version of the stakeholder identification table where interest, problem perception and values are included is indicated in Appendix C, Table C.1 and Table C.2.

Table 4.1: Stakeholder goals

Stakeholders	Goals
Delfland (Waterboard)	Supervising and care for the coastal defense system within the waterboard borders.
Rijkswaterstaat	Keep Scheveningen protected against flooding and to prevent the coast from eroding by policy making and investing
Province Zuid-Holland	Protecting Scheveningen against future sea level rise and increase the value of Scheveningen for the province
Municipality of The Hague	Economical growth and job opportunities for the inhabitants of The Hague as well as providing protection
Local inhabitants	Feeling safe and enjoying their living habitat in Scheveningen
Tourists	Enjoying their holiday and view of the ocean
Business operators (location boulevard)	Increase profit while staying protected against sea level rise
Business operators (location beach)	Operating throughout the whole year and increase profit while staying protected against sea level rise
Environmental organisations	Protecting the home of different species living at the coast of Scheveningen
Amrâth Kurhaus	Stay protected against sea level rise while increasing revenue and reputation internationally
The Pier	Increase revenue and reputation on national and international level

It is wrong to assume that stakeholders can be kept content by negotiating using their goals. Goals of actors can go beyond the range and limits of a project. In addition can actors have core values which not align with their goals. Therefore, the core values of actors will and must be protected in order to keep a favourable position, as it is not always possible to fulfill their goals [34].

4.2. Stakeholder Power, Interest, Attitude and Change

The next step for the stakeholder analysis is to gather information on the types and sources of power these actors have and what they intend to do with them. Their intention can also been seen as a form of attitude. It is important to know the flexibility of an actors attitude as it might be possible to change their views and demands. With this analysis a strategy can be developed considering all stakeholder their values and goals. The full results of the stakeholder interest, power, attitude and change is located in Appendix C, Table C.4. The results are based on the fact that alterations for the coastal protection at Scheveningen should be made. In Figure 4.1 the results of Appendix C, Table C.4 are transformed into a graph for a better indication. Why each result of Figure 4.1 is important is explained in this sub chapter.

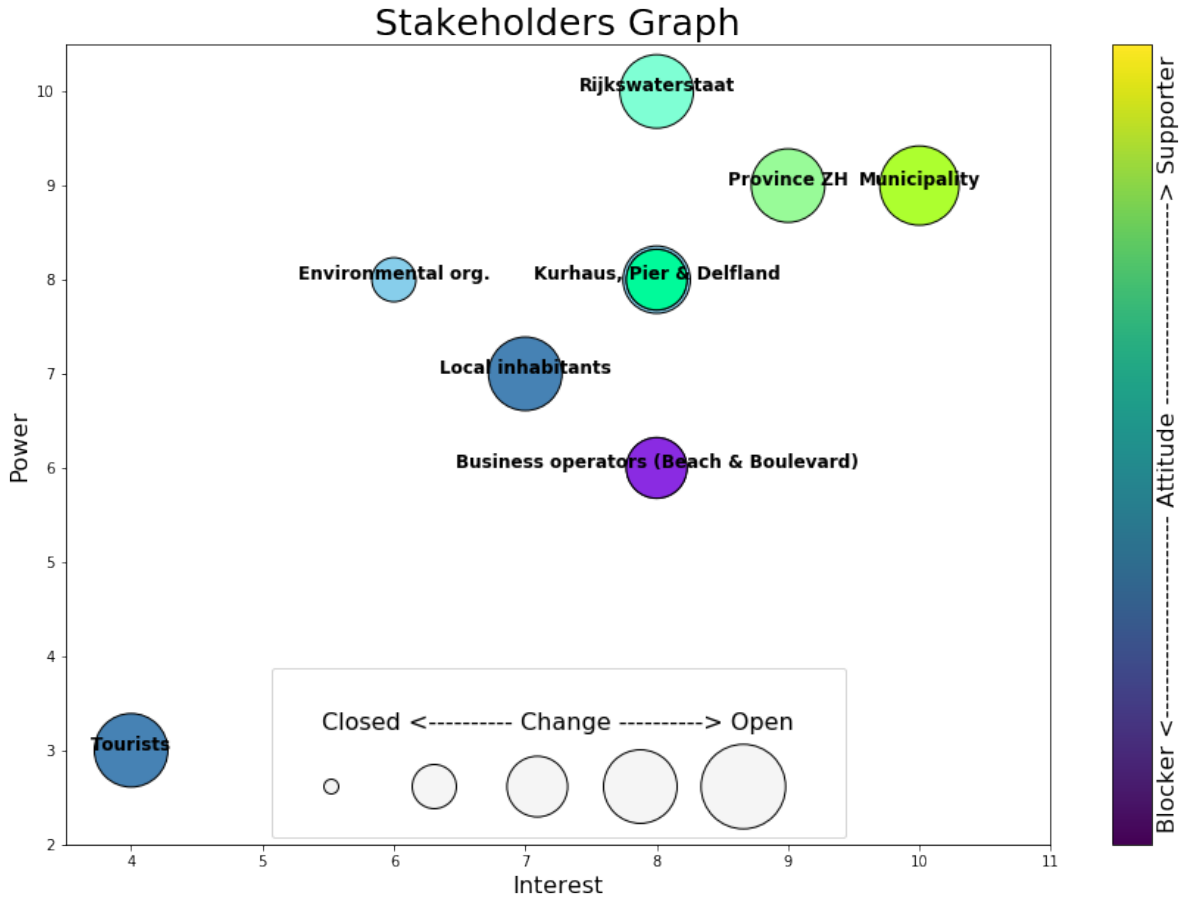

Figure 4.1: Stakeholders graph

4.2.1. Stakeholder Interest

The stakeholder interest refers to what extent a new safety concept is relevant towards an actor. An actor might think there is a gain or loss to be made and it is therefore important to include them in the negotiations of a new design concept. This all, however depends on how much they are interested in these new concepts and if it in any way affects them for good or worse. Their role is another important matter as an actor can be really interested but only plays a small role into the realization of the project. However, this does not mean that they should be excluded from any negotiations or should not be paid any attention to. Full explanation about the stakeholders interest score is indicated in Appendix section C.4, subsection C.4.1. Actors with the highest interest are:

- The municipality of The Hague: a design that is beneficial for the economic development of Scheveningen;
- Province Zuid-Holland: create value to the province;
- Rijkswaterstaat: a cost effective strategy based on their policy;
- Delfland: protection against flooding for Scheveningen;
- Business operators located at beach: increase their profit and stay open the whole year;
- Business operators located at boulevard: increase profit;
- Amrâth Kurhaus: increase profit and international popularity;
- The Pier: increase profit and national popularity;
- Local inhabitants: A better living environment.

4.2.2. Stakeholder Power

It is important to find the amount of power an actor has, as a powerful actor is not easily replaceable. Also can powerful actors make the development of a project much faster depending on their attitude. The full results of the stakeholder power is indicated in Appendix C, Table C.3. Full explanation about the stakeholders power score is indicated in Appendix section C.4, subsection C.4.2. Actors with highest amount of power throughout the process are:

- Rijkswaterstaat: governmental power and money source for the concept investment;
- Municipality of The Hague: power within the municipal borders and initiator of the concept design;
- Province Zuid-Holland: governmental power within the border of the province;
- Delfland: appointed governmental power within the waterboard borders.

Other stakeholders with a significant amount of power are:

- Environmental organisations: law & regulations;
- Amrâth Kurhaus: right to voice and have reputation even international;
- The Pier: right to voice and have reputation on national level;
- Local inhabitants: power of voice.

In the stakeholder power table (see Appendix C, Table C.3) the type of power and attitude are set out per actor, as well as the source and the level of power. The source of power is of interest for the dependency relations analysis while their level of power can be of significance to obstruct the project. The power per actor is rated from 0 to 10 with 10 being very powerful.

4.2.3. Stakeholder Attitude

Attitude is to be described as the mindset of a group/organisation toward the process goal or toward the initiating party itself. An actor may take one of the following stances [36]: negative, neutral or positive in attitude towards the concept design of Scheveningen. The types of power with regards to attitude are divided in three subgroups:

- Obstructive power (negative attitude): an actor will find means to obstruct or block the project as they have a negative attitude towards the design concepts;
- Productive power (positive attitude): an actor find the concept beneficial or solves a current issue for them. They then also might help realizing the project by for example investing or not causing any issues during the negotiations. These actors should be encouraged to be involved in the negotiations;
- Diffuse power: an actor a more neutral standpoint towards the design concept. They can help providing support when negotiations get stuck in the stakeholder engagement strategy. However a stakeholder with a more neutral standpoint might become a blocking power if not taking careful attention to as they can be influenced by stakeholders with a negative attitude.

Attitude is important to realize a design concept. Parties can appear very hostile or obstructive based if they do not feel heard, even when their goals and core values are aligned with the projects objective. These feelings can be based on negative past experiences in similar projects or with the same parties. Negative attitudes can also be caused by the natural opposition between some groups. In case an actor has a negative attitude a strategy should be made, so that the actor would still engage and cooperate with the plan. Full explanation about the stakeholders attitude score is indicated in Appendix section C.4, subsection C.4.3

Actors with the lowest attitude are:

- Local inhabitants: are worried about the fact that alterations made to the beach block their ocean view, access to the beach or increase the amount of tourist and therefore more noise and littering;
- Tourists: want to have quick access from their stays to the beach and ocean;
- Business operators located at boulevard: want to keep their view over the beach and ocean and keep the Mid boulevard, because it is the most important visiting place of Scheveningen;
- Business operators located at beach: worried that due to sea level rise they have leave or that alterations to the beach block the quick access visitors of the beach have towards these facilities.

4.2.4. Stakeholder Openness to Change

A stakeholder can have a certain interest, power and attitude. However, it is important to know how perceptive a stakeholder is to change its view. Certain stakeholders can be influenced by others. Openness to change can be good when a stakeholder has a low attitude towards the project; however, it might also means that other stakeholders that have a positive attitude are influenced negatively. This is of course not something what is preferred and should be paid close attention to. Full explanation about stakeholders openness to change score is indicated in Appendix section C.4, subsection C.4.4.

Actors who are not open to change are:

- Business operators located at boulevard: any alterations to the beach and boulevard will have an indirect effect on indirect effect on their revenue. Depending on if the Boulevard keeps its importance;
- Business operators located at beach: any alterations to the beach and boulevard will have a direct effect on indirect effect on their revenue. In terms of during construction and accessibility from the boulevard or beach but also after construction if one of these access points stays blocked;
- Environmental organisations: any negatively affected changes to the Natura 2000 areas needs to be heavily compensated to require a permit to build.

Actors who are open to change are:

- Municipality of The Hague: as they consider multiple values of different kind of stakeholders they are more likely to alter their perspective;
- Province Zuid-Holland: as a mediator between the waterboard and the municipality of The Hague they want to increase the value of Scheveningen as it increases the value of the province. As long as the values of waterboard and municipality are aligned and increases the value of Scheveningen the province will be open for change;
- Rijkswaterstaat: if the strategy suggested is conform the setup policy by Rijkswaterstaat they are open for suggestions as long as the strategy is cost effective and any alterations that are not coastal defense related are not financed by them;
- Local inhabitants: if the value of living increases by alterations and changes that need to be made, then the inhabitants of Scheveningen will more likely to support it. Most important aspect is to take the concerns away from the inhabitants;
- Tourists: access towards the beach and ocean is important to them and as long as this will be provided they might take a more neutral standpoint to alterations or changes made.

4.3. Classification of Stakeholders

The position of the actors based on power, interest, attitude is categorized by typology based on knowledge and interpretation from Murray-Webster and Simon [37]. Categorizing stakeholders into typology gains understanding in how to approach and deal with certain stakeholders. When developing a design concept its necessary that certain stakeholders values should not be negatively affected as they otherwise would become an obstacle to carrying out the design. Each typology has a certain meaning and also indicate which stakeholders should be paid extra attention to.

Figure 4.2 explains what categorization of each type of actor means according to Murray-Webster and Simon:

- Saviour: powerful, high interest, positive attitude or alternatively influential, active, backer. They need to be paid attention to and should do whatever necessary to keep them on our side. Attention should be paid to their needs;
- Friend: low power, high interest, positive attitude or alternatively insignificant, active, backer. They should be used as a confidant or sounding board;
- Saboteur: powerful, high interest, negative attitude or alternatively influential, active, blocker. They need to be engaged in order to disengage;
- Irritant: low power, high interest, negative attitude or alternatively insignificant, active, blocker. They need to be engaged so that they stop creating problems and influence other more significant stakeholders;

- Sleeping Giant: powerful, low interest, positive attitude or alternatively influential, passive, backer. They need to be engaged in order to awaken them;
- Acquaintance: low power, low interest, positive attitude or alternatively insignificant, passive, backer. They need to be kept informed and communicated with on a 'transmit only' basis;
- Time Bomb: powerful, low interest, negative attitude or alternatively influential, passive, blocker. They need to be understood so they can be 'defused before the bomb goes off';
- Trip Wire: low power, low interest, negative attitude or alternatively insignificant, passive, blocker. They need to be understood so you can 'watch your step' and avoid 'tripping up'.

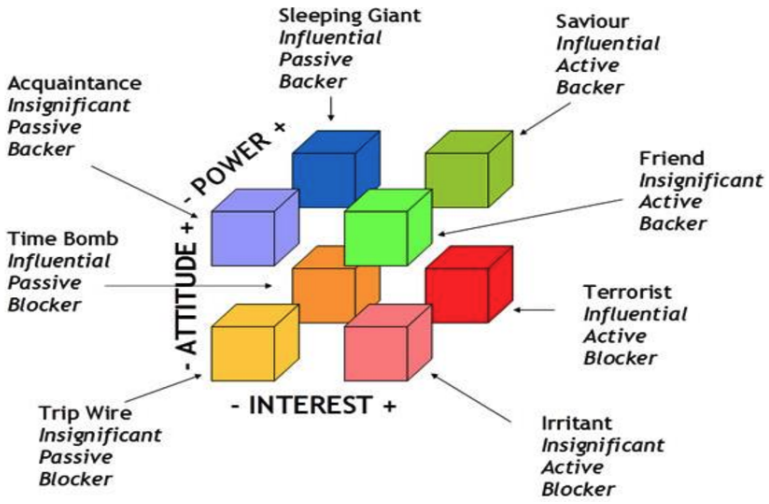

Figure 4.2: Making sense of stakeholder mapping

The stakeholders that play a major role in the project for the initiator are:

- Saviour: municipality of The Hague, Rijkswaterstaat, Delfland and province Zuid-Holland. Their governmental power are necessary to support the project;
- Saboteurs: Amrâth Kurhaus and the Pier. Their reputation give them a big stage and will have a significant affect on the project if they are not content. But also local inhabitants could have a significant negative impact on the development of the project if their way of living is negatively affected.

Other important categories for the typology of each stakeholder in this project are:

- Irritant: business operators as they have less power than Amrâth Kurhaus and the Pier but have still a high interest and negative attitude towards the project. These actors should be engaged;
- Time Bomb: environmental organisations: Their interest level is not high but will be when the concept design will negatively affect ecology and nature in the Natura 2000 area. This stakeholder should be understood to avoid the consequences otherwise it will have a large affect on the process of the project;
- Trip Wire: tourists have low interest and power in any saying in the design concept. However, if their values should be understood it will not become an issue.

4.4. Interdependent Relations

Interdependent relation between stakeholders could be utilized when obstacles such as opaqueness and sluggishness are performing harm to stakeholder negotiations. Mapping out the relation between stakeholders can also create an incentive of cooperative behaviour as the negative attitude of one stakeholder can be positively influenced by another. This sub chapter describes the different dependencies between stakeholders. Figure 4.3 indicates the dependence between different stakeholders.

The numbers indicated in Figure 4.3 displays a relation between two or multiple stakeholders and are as followed:

1. The municipality of The Hague relies on waterboard Delfland to maintain and alternate the flood defences at the coast. Delfland in turn relies on the municipality for approval that these alterations blends in with the city sight.

2. Rijkswaterstaat relies on the municipality of The Hague to transform policies into strategies. The municipality in turn relies on investments from Rijkswaterstaat to carry out these strategies.

3. Environmental organisations have a dependency with the municipality when it comes down to policy regulations for Natura 2000 area. The municipality has to require a permit when alterations are made in the Natura 2000 area. While the environmental organisations rely on the municipality for preserving the Nature 2000 area.

4. Province Zuid-Holland needs the municipality of The Hague to create value to Scheveningen as it in turn creates value to the province. The municipality of The Hague needs the province as mediator between them and waterboard Delfland to protect their values.

5. The municipality rely on economical growth trough taxes and permits what local inhabitants, Amrâth Kurhaus, tourists, the Pier and business operators provide. While they in turn rely on the fact that the municipality of The Hague protects their values such as comfort of living for the inhabitants, recreational area for tourists and licenses for business operators, Amrâth Kurhaus and the Pier.

6. Tourists rely of the facilities that the Pier has to offer and in turn this provides revenue for the Pier.

7. Tourists rely of the facilities and cultural history Amrâth Kurhaus has to offer and Amrâth Kurhaus on their reputation that attracted the tourist in order to make revenue.

8. Tourists are visiting the Boulevard and are making use of restaurants and other facilities provided by business operators which in turn provide revenue for these operators.

9. Tourists visiting the beach are making use of bars and other facilities provided by business operators at the beach which in turn brings revenue.

10. Local inhabitants are just as tourists enjoying the facilities offered by business operators located at the beach but also job opportunity that is often occupied by young adults. While business operators located at the boulevard rely on their spending.

11. Local inhabitants are just as tourists enjoying the facilities offered by business operators located at the Boulevard. It also creates job opportunity. While business operators located at the Boulevard rely on their spending.

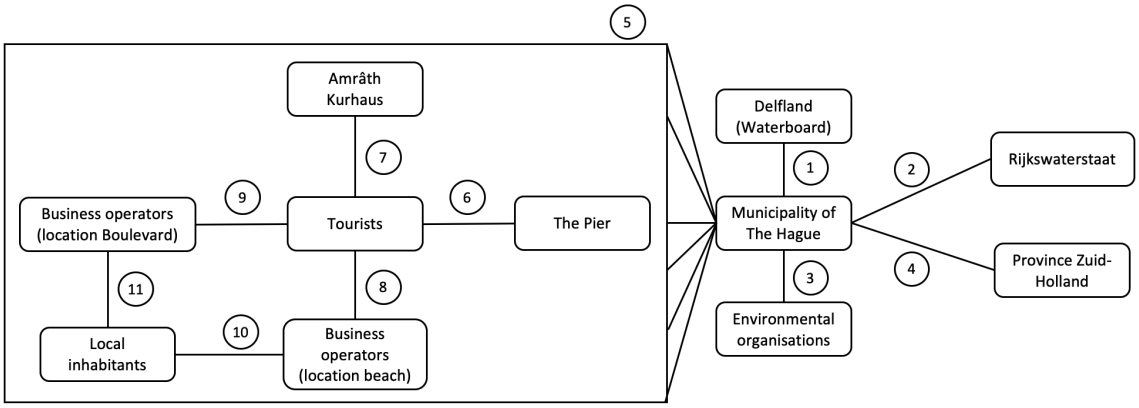

Figure 4.3: Relation dependence between different stakeholders

Out of the dependent relationships displayed in Figure 4.3 comes forward that next to the municipality of The Hague, tourists have a lot of dependencies between different stakeholders as well. If the number of tourists decreases due to change to boulevard and beach several stakeholders will be negatively affected as well in terms of a decrease in revenue what in turn decreases job opportunity. Even that tourists as stakeholder have not a lot of power in terms of influencing the project directly. There is an indirect sort of influential power trough stakeholders such as Amrâth Kurhaus, the Pier and local business operators.

5

SWOT & TOWS

SWOT is a situational analysis framework that is used to map out factors that are affecting the project [38]. All SWOT factors are based on chapter 2, chapter 3 and chapter 4. These factors came forward as most important in these chapters and have in the SWOT analysis been categorized in strengths, weaknesses, opportunities and threats in section 5.1. In addition have these categorized factors been given a certain weight. The weight difference between these factors is explained in D. In the TOWS analysis these factors are combined to work out strategies, see section 5.2. Then these strategies are being prioritized which in turn makes it comprehensible where more attention needs to be paid to in the concept design and stakeholder engagement strategy. Prioritization of the strategies are explained in subsection 5.2.1 The most important strategies that resulted from the the TOWS analysis are:

- Coastal defense system resilient against different sea level predictions.
- Quicker process.
- Stimulation towards sustainable economical development.
- Engage with local inhabitants early.

5.1. SWOT Analysis

The first step is to identify the SWOT factors; Strengths, Weaknesses, Opportunities and Threats. In defining these, the explanations of the SWOT factors from Dyson [39] will be expanded upon to be exclusive to this project. These are as follows:

- Strengths and Weaknesses: these are a form of internal examination of the project itself, focusing more on its distal outcomes and key objectives.
- Threats and Opportunities: these are formed more of external factors and come as more proximal and secondary outcomes.

After consideration; a range of factors were grouped and summarised in several key points of address. Their weights are indicated in Table 5.1, Table 5.2, Table 5.3 and Table 5.4. Full explanation how the scores are determined are located in Appendix D.

Table 5.1: Strengths

Strengths	Weight
1: Scheveningen is one of the largest coastal urban areas of the Netherlands.	3
2: Flood risk affects everyone involved.	4
3: Stronger coastal defense system.	3

Table 5.2: Weaknesses

Weaknesses	Weight
1: Tourist and visitors are negatively affecting the comfort of living for local inhabitants.	3
2: Exact numbers in how fast and how much the sea level rises are uncertain.	5
3: More sand nourishment required due to sea level rise.	4
4: Less development of coastal facilities.	4

Table 5.3: Opportunities

Opportunities	Weight
1: Increasing job and industry opportunity.	4
2: Increase ecological value in the area.	2
3: Increasing living environment for local inhabitants.	3

Table 5.4: Threats

Threats	Weight
1: Concept development is located near Natura 2000 areas.	3
2: Decrease of visitors and tourists in Scheveningen	4
3: Flooding of hinterland.	5

Strengths

1. **Scheveningen is one of the largest coastal urban areas of the Netherlands**
   The number of tourist visiting Scheveningen and the economical development created due to these visitors makes it one of the most important coastal regions of the province Zuid-Holland and even the entire Netherlands. This enables municipality of The Hague to become a more important player in decision making and taken into account their values by other higher tier governmental stakeholders.

2. **Flood risk affects everyone involved**
   The increase in sea level rise forms a problem for all stakeholders as everyone will be in a certain degree affected by flooding. A mutual problem amongst different stakeholders provide an incentive to cooperative behaviour during negotiations.

3. **Stronger coastal defense system**
   The concept design has as key objective to protect the hinterland against flooding in the future. The concept design will strengthen the coastal defense system and increase safety for in the future.

Weaknesses

1. **Tourists and visitors causing harm to the living environment**
   Even that tourists increase the economic developments in the area it also have increased for the local inhabitants problems with excessive noise, and littering. The living environment for the local inhabitants is negatively affected by this. If this problem is not being considered in the concept design it might even be worsened if economical development would increase.

2. **Exact numbers in how fast and how much the sea level rises are uncertain**
   KNMI calculated four climate scenarios that all depend on the decrease in emissions of the whole world. The degree and how fast sea level rises makes it difficult to estimate what strategies are effective and necessary to implement in the concept design.

3. **More sand nourishment required due to sea level rise**
   One of the current strategies implemented for the coast in Scheveningen is nourishment. However, this strategy will be financially not attractive in the future, when the volume of nourishment increases due to sea level rise.

4. **Less development of coastal facilities**
   Along the coast of Scheveningen there are a lot of restaurants and bars. A new concept design could possibly have a negative affect on the economic development in this particular area due to temporarily and permanent closure of these facilities.

Opportunities

1. **Increase job and industry opportunity**
   The Netherlands internationally renown for its expertise in coastal defense systems. Many tourists visit the "Afsluitdijk" and "Deltaworks" each year. A new coastal defense system in Scheveningen would increase its reputation in national and international level, which in turn would increase the number of visitors and tourists. In addition a new coastal defence along the coast of Scheveningen will stimulate the construction industry.

2. **Increase ecological value in the area**
   One of the benefits of building a coastal defense system according to a softer method is that it could improve the ecological value in the area. There have been more methods where building with nature has been incorporated such as the project "Ruimte voor de rivier". For the coastal defense project in Scheveningen it could incorporate a strategy that increases the ecological value in the Natura 2000 area for example.

3. **Increasing living environment for local inhabitants**
   Visitors and tourists are currently negatively affecting the environmental habitat for local inhabitants. However, when measures are involved in the concept design that reduce the problems related to visitors and tourists, it will increases the comfort of living environment.

Threats

1. **Concept development is located near Natura 2000 area**
   Appointed Natura 2000 areas are located next to the the area where the concept design should be constructed. Depending how and if Natura 2000 will be affected might create a major issue for the development of the project with huge delays and costs to consider.

2. **Decrease of visitors and tourists to Scheveningen**
   The location where the concept design will take place is of importance towards economic developments in the region as it is a touristic hub. Any negative affects towards the tourist industry in this area will have an affect in revenue on business operators, Amrâth Kurhaus and the Pier, which in turn decrease job opportunities for local inhabitants.

3. **Flooding of hinterland**
   If the current nourishment strategy continues the strategy comes ineffective while extra nourishment will be financial not attractive with future sea level rise. Even other strategies might be ineffective as it needs to be planned for future sea level rise and exact numbers of sea level rise are unknown. Therefore, there is still risk of flooding of the hinterland if the design does not take into account multiple scenarios for adaptation.

5.2. TOWS Analysis

The TOWS analysis involves the creation of a matrix of all the TOWS factors. This matrix will form a 2x2 solution space where strategic initiatives aim to combine two or more factors, based on Thiruchanuru [40]. The solution space is determined by combining factors such as Weakness/Opportunity (WO), Strength/Opportunity (SO), Strength/Threat (ST) and Weakness/Threat (WT). The definition of each solution space is given below:

- Strength/Opportunity (Maxi-Maxi or Attack Strategies): strategies that use strengths to maximize opportunity.
- Strength/Threat (Maxi-Mini or Defensive): strategies that use strengths to minimize threat.
- Weakness/Opportunity (Mini-Maxi or Attack Strengthening): strategies that minimize weaknesses by taking advantage of opportunities.
- Weakness/Threat (Mini-Mini or Defense Strengthening): strategies that minimize weaknesses by avoiding threats.

Table 5.5 contains the strategic initiatives found. The score for SO and the other strategies are determined as followed: The numbers X and Y correspond to the strength factor number and opportunity factor. The Z is the weighting, which is calculated by multiplying together the factor weights. Please note that the initiatives may combine more than two factors, the score is then calculated by the product of the greatest weights.

Table 5.5: TOWS analysis

		Strengths	Weaknesses
		1: Scheveningen is one of the largest coastal urban areas of the Netherlands. 2: Flood risk affects everyone involved. 3: Stronger coastal defense system.	1: Tourist and visitors are negatively affecting the comfort of living for local inhabitants. 2: Exact numbers in how fast and how much the sea level rises are uncertain. 3: More sand nourishment required due to sea level rise. 4: Less development of coastal facilities.
Opportunities	1: Increasing job and industry opportunity. 2: Increase ecological value in the area. 3: Increasing living environment for local inhabitants.	**SO:** **Stimulating economic development.** **(S3 & O1) (12)** **Improving environment and ecological value in future planning.** **(S1 & O2, O3) (9)**	**WO:** **Accommodate and control tourism.** **(W1 & O3) (9)** **Stimulation towards sustainable economic development.** **(W3 & O1, O2) (16)**
Threats	1: Concept development is located near Natura 2000 areas. 2: Decrease of visitors and tourists in Scheveningen. 3: Flooding of hinterland.	**ST:** **Quicker Process.** **(S2 & T1, T3) (20)**	**WT:** **Engage with local inhabitants early.** **(W1, W4 & T2) (16)** **Coastal defense system resilient against different water level predictions.** **(W2 & T3) (25)**

5.2.1. Prioritisation of Requirements

In Table 5.5 different strategies are considered based on the analyses of study area, coastal hazard analysis and stakeholder analysis. According to Dyson [39] it is important to prioritise a couple of those strategies with the highest score to use in in the process of the development of concepts. The four largest strategy scores are considered.

Coastal Defense System Resilient Against Different Sea Level Predictions (25)
One of the problems with developing a new coastal defense system is that in the long term it is difficult to predict how much the sea level will actually rise. The strategy needs to be considered that minimize weaknesses by avoiding threats. In this particular case is the threat the flooding of the hinterland and weakness the fact that actual future sea level rise is unknown. Therefore, a coastal defense system needs to be considered that takes into account multiple sea level rise scenarios. In this way a prevention is taken place that if the sea level rises further than first been predicted, an old coastal defense system would not become obsolete or have to be severely altered. The latter is often a costly measure.

Quicker Process (20)
All involved stakeholder are in some way affected by climate change and future sea level rise with as largest threat flooding of the hinterland. Some stakeholders are more negatively affected by flooding as others, because the risk of flooding is for each stakeholder prominent, it creates a mutual problem which will in turn becomes an incentive to cooperate with each other to prevent this. It might avoid sluggishness during negotiations as there is a form of time pressure as well as the sea level might rise to about 1 meter at the end of the century. With this strategy the strength of having a mutual problem can help minimize a time dependence threat.

Stimulation Towards Sustainable Economical Development (16)
Nourishment is the current strategy to retain the strength of the coastal defense system. However, erosion will increase when the sea level rises and therefore more nourishment is needed. This strategy becomes cost ineffective in the future and is considered as one of the weaknesses of the SWOT factor. Incorporating new strategies while considering ecology will increase the ecological value in the area. The development of the new strategy will also stimulate the economic development in the area as it increase job and industry opportunities. By changing the current strategy and at the same time stimulate the economy and ecology, this will minimize the weakness and take the advantage of the opportunities.

Engage With Local Inhabitants Early (16)
This approach calls for a defense strengthening strategy. A new concept design might increase or decrease tourists and visitors in the area. A decrease in number of visitors will in turn hurt the economical development and therefore the job opportunity of the local inhabitants in the area. It is a threat that should be protected as much as possible even if the threat might be partly beneficial for the local inhabitants. An increase in the number of tourists and visitors will increase the problems that local inhabitants are already experiencing. However, by involving local inhabitants at an early stage in the project it might be possible to accommodate more tourism and therefore minimize weakness and avoiding the threat of a decrease in the amount of visitors and tourists.

6

Design Objective of Coastal Defense System

In this chapter the design objectives will be discussed. The design objectives are based on findings of chapter 5 and are stated as goals what the design is meant to achieve. According to subsection 5.2.1, there are four objectives that will form the foundation for the concepts. The first two focus on actual design concepts and the latter on the behaviour of stakeholders.

6.1. Coastal Defense System

The two design objectives explained in subsection 6.1.1 and subsection 6.1.2 are mainly focused on how the concepts should be design to protect the coast and be beneficial for the surroundings where the concepts are located.

6.1.1. Coastal Defense System Resilient Against Different Water Levels

The concept should in essence be resilient against different water levels. It will be ideal when the new concepts can be executed in phases to safeguard the area on and in front of the sea defence. The idea is to make it financial attractive, since the investment has been distributed over time instead of an one time enormous investment, which is sometimes financially not feasible. Moreover, these new concepts could respond faster to any problem scenario, since the new concepts are not designed for a specific scenario.

6.1.2. Stimulation Towards Sustainable Economic Development

The concepts should also realize new job opportunities and increase the ecology in the area. This strategy is important to take into account as it safeguards and improves economical and sustainable values, which will benefit environmental organisations and the hospitality industry. By implementing this strategy the concepts are much easier to realize, without these stakeholders wanting to disrupt or stop the possible concepts.

6.2. Stakeholder Engagement in Coastal Defense System

The two design objectives explained in subsection 6.2.1 and subsection 6.2.1 are mainly focused on how the concepts should be designed to satisfy certain stakeholders.

6.2.1. Engage With Local Inhabitant Early

Inhabitants have a significant amount of power and could without proper involvement during the negotiations block the project. The positive prospects for the local inhabitants in the design objective are small and could even negatively affect their the values. When involving local inhabitants at an early stage in the negotiations and listen to their concerns with choosing a certain design. A plan could be made to protect their values by mitigating the negative affects.

6.2.2. Quicker Process

There should be a possibility to combine certain concepts in order to satisfy mutual values of several stakeholders. Since every stakeholder has their own perspective towards a design but can have dependencies with other stakeholders. In addition it is important during the negotiations to create the incentive of cooperation by mutual dilemma sharing.

7

Design of Concepts for a Coastal Defense System

In this chapter the focus is to find combinations of concepts that satisfy the design objectives, which is determined in chapter 6. In order to make the combinations, different concepts are analysed to get an indication how the concepts can be implemented. Each concept is described in section 7.1. After the concepts are described the combinations can be made. For this project there has been chosen to make three combinations. Each combination aims to satisfy design objectives. All three combinations have a specific target which makes each combination unique. Section 7.2 will explain the combinations in further detail and which design objectives will be satisfied. Finally a table is presented that concludes the summary of all three combinations.

7.1. Concepts

In the following section different concepts will be discussed. Every concept is an individual solution to achieve one of the design objectives. Here below a brief introduction of the important properties will be given. Moreover, it will be explained where the concepts will be located to give a good idea how the concepts should work. At the end of each concept a table is given with the pros and cons.

7.1.1. Sea Grass

Sea grass are flowering plants that evolved from the land back to sea a 100 million years ago. Just like most other plants, sea grass flowers once a year during their reproductive season. Pollination of the sea grass is normally done by marine creators like crabs or shrimp. These marine creators are burrowed in the sediments along the sea grass roots. Sea grass meadows extend their leaves towards the seawater surface. This slow down the sea currents that transport sediment and other particles. As a result sea grass basically catch this sand and causes a new sediment top layer without burying themselves. Prevention of burying themselves is the result of extraordinary level of adaption as it adjust its growth to the degree of sedimentation. By helping sand to accumulate, sea grass helps protecting the coastline from eroding but also reducing wave impact. Therefore, it could be useful to implement it in the design concept of Scheveningen as the coast at this location is eroding as well.

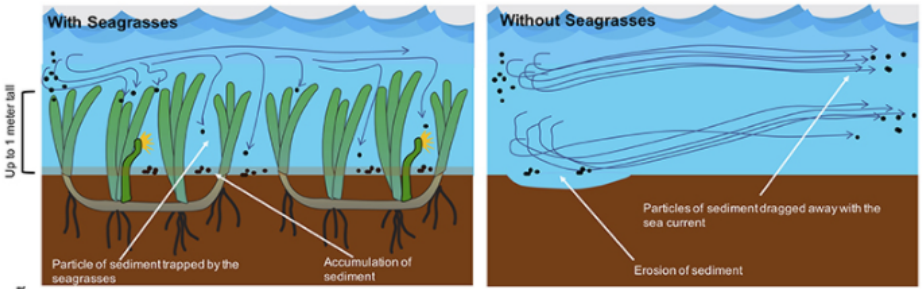

Figure 7.1: Sea Grass

Location

In Figure 7.2 it is shown that the sea grass will be located in the foreshore along the beach. In this way the sediment from long shore transport will be trapped by the sea grass. One can also observe that the sea grass is placed very close to the beach, this might be not so pleasant for swimmers and other water sport enthusiasts.

Figure 7.2: Location sea grass

Pros and Cons

Table 7.1: Pros and cons of sea grass

Topics	Pros	Cons
Safety Measurement	Sea grass can reduce wave impact by approximately 10-20%. Reduces the degree of erosion or even supplement the beach.	Sea grass is vulnerable to climate change.
Ecological value and Sustainability	Improves ecological value such as flora and fauna. Keep the coast clean.	
Stakeholders	Associated with a negative swimming experience for tourist and water sport enthusiasts as sea grass should be placed under sea level.	lee side of the groyne less beach for tourist and hospitality industry.
Flexibility	Sea grass can be implemented at any moment.	It is not very efficient for immediate beach widening.

7.1.2. The Pier as Groyne

The current Pier is used for amusement and can be seen as a extension of the boulevard. It has an length of 300 meter and is constructed at an elevation of +11m NAP supported by 187 concrete pillars. The Pier had to be constructed high since the pier has to withstand high waves during a storm event. For the new concept, the idea is to add an extra purpose to the pier. In this case a groyne will be integrated into the design of the pier, in order to create broader beaches and prevent shoreline retreat caused by longshore sediment transport. Another beneficial aspect of implementing a groyne at the Pier is that the method of preventing erosion is ecological friendly. In addition, a groyne provides also habitat for marine life. Groynes are often build perpendicular to the coast and usually interrupts the water and sediment flow and therefore limit the sediment transport, due to this phenomenon accretion will occurs in front of the groyne, while on the lee side of the groyne erosion occurs [22]. It is possible to implement the groyne in the current Pier, however during an interview with project developers of the Pier, it came forward that there are plans to create a new pier. The reason for creating a new pier is because it almost reaches the end of its designed life span. In order to keep the current pier extra major renovations are necessary. In order to implement efficiently the groyne into the pier, it will be recommended to implement the groyne during the renovations of the old pier or when a new pier will be constructed. The interview with the project developers of the Pier is indicated in Appendix F, section F.5.

Location

Since the groyne is integrated into the pier, the groyne is located below the pier and is perpendicular to the coast. Figure 7.3 shows that the groyne is indicated with a black line in . As mentioned the groyne will cause for accretion and erosion. Accretion is given with the color green and erosion with the color red. The lines of accretion and erosion are roughly drawn and should only be used as an idea where it approximately occurs.

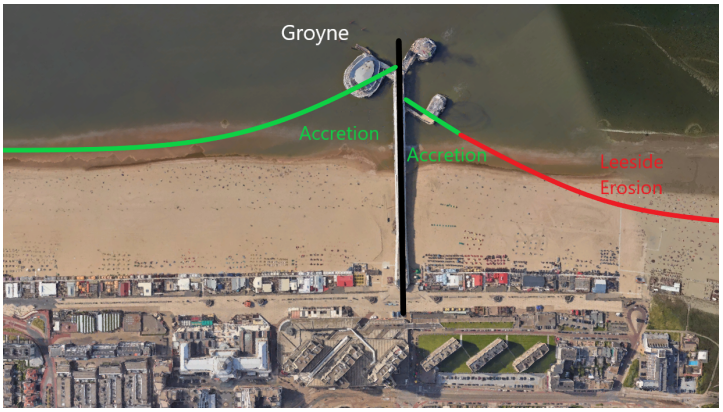

Figure 7.3: Location pier as groyne

Pros and Cons

Table 7.2: Pros and cons of the Pier as groyne

Topics	Pros	Cons
Safety Measurement	Sand accumulation in front of the groyne, which prevent shoreline retreat. The Amrâth Kurhaus and boulevard in front of the groyne have a wider beach which should reduce wave impact.	Erosion on lee side of the groyne, which cause for shoreline retreat on the other side of the pier.
Ecological value and Sustainability	The groyne is often good for biodiversity.	
Stakeholders	Wider beach, increases the opportunities for the hospitality industry. Less nourishment is needed in front of the groyne which is beneficial for Rijkswaterstaat.	On the lee side of the groyne, there is less beach for tourist and hospitality industry.
Flexibility	The groyne can be easily adjusted or extended.	

7.1.3. Groynes Along the Coast

A field of groynes can be constructed to trap sediment transport. The concept has the same function as the concept in subsection 7.1.2. It is effective in reducing the existing longshore sediment transport rate along a coast. The main purpose of this concept is to defend an eroding coast, widen a beach or to extend the lifetime of beach fills. Unfortunately also for this concept erosion will occur on the lee side of the groyne. Therefore, this concept consist of series of groynes that are often spaced at relatively short intervals along the beach to prevent this erosion. However, erosion will still occur on the lee side of the last groyne [22]. This is something to keep in mind. Just as in subsection 7.1.2 does this concept improve marine life along the coast in Scheveningen.

Location

Figure 7.4 shows how the concept "groynes along the coast" will looks like in Scheveningen. The groynes are perpendicular to the coast and the spacing between the groynes are short to avoid lee side erosion. By locating the groynes this way, the sediment from longshore transport can be trapped.

Figure 7.4: Location groynes along the coast

Pros and Cons

Table 7.3: Pros and cons of groynes along the coast

Topics	Pros	Cons
Safety Measurement	Broaden the beach and defend an eroding coast.	Lee side erosion will occur at the last groyne.
Ecological value and Sustainability	The groynes are often good for biodiversity.	
Stakeholders	Amrâth Kurhaus and Boulvard might be protected against dune erosion. Less nourishment is needed in front of the groyne.	May be not so pleasant for tourism to have compartments at the beach due to groynes.
Flexibility	The groynes can be easily adjusted or extended.	

7.1.4. Additional Shoreface Nourishment

Shoreface nourishment is a type of nourishment that has as implication to strengthen the coastal profile by increasing sand volume in the coastal zone. The idea behind shoreface nourishment is to add sediment in the foreshore and let the waves wash the sediment up onto the beach. It is known as economical and recreation-friendly nourishment compared to other types of nourishment such as beach nourishment. Because the sediment can be placed during calm wave conditions at the seaward edge of the surf zone where the navigational depth is sufficient for hopper dredgers. Shoreface nourishment is often executed through doors in the bottom of the dredger or through rainbowing which is a method to place sediment in shallow areas by pumping into the air through a hose with a nozzle [22]. For more information about nourishment see Appendix A, section A.7.

Location

In Figure 7.5, one can observe that shoreface nourishment is performed in front of the beach in the foreshore area. The reason to apply it along the whole coast of Scheveningen is to reduce the coastline erosion.

Figure 7.5: Location additional shoreface nourishment

Pros and Cons

Table 7.4: Pros and cons of additional shoreface nourishment

Topics	Pros	Cons
Safety Measurement	Broaden the beach and strengthen the coastal profile.	
Ecological value and Sustainability	It is a sustainable solution because the current will be used to transport the sediment from shoreface nourishment.	
Stakeholders	Wider beach which is good for tourism and hospitality industry Less expensive than beach nourishment and therefor beneficial to Rijkswaterstaat.	Financially not attractive anymore, when sea level is rising so fast, that a lot of sediment is needed.
Flexibility	Shoreface nourishment is a flexible measurement, since it can be easily scaled up.	It is not very efficient for immediate beach widening.

7.1.5. Dune Strengthening by Biogrout

Biogrout is currently an active field of research and requires some technical knowledge. In short the technique is explained and the pros and cons are named, a more in depth explanation can be found in the Appendix, E. As stated in the report "Tussennotitie kust", the Netherlands rather likes to strengthening the dunes by vegetation and naturally increase the dune by aeolian processes [8]. In case of Scheveningen this is not an option since the dune is covered by buildings and roads. The buildings also have an increased chance of becoming damaged during a storm surge since erosion can still occur in front of the sea defence. Now the basic idea of biogrout is to increase the binding between sand particles by calcite precipitation which should lead to a higher bearing capacity and reduce erosion [41].

Figure E.1 shows the effect cementification by biogrout could have. The sand maintains its shape after removing the bucket around it [9]. A significant decrease in erosion was also found when samples were treated with biogrout and tested on a small scale test setup [42]. This indicates the potential of biogrout, however the scale with testing of biogrout is small and further research is needed.

To which extent the strength is gained is depending on different chemical factors. Calcium is one of those factors which is present in abundance in the dunes [43, 44]. Besides the chemical process, the practical issues to execute the project needs to be taken into account. To strengthen the dunes below the Amrâth Kurhaus the whole dune should be increased equally in strength [9].

In the process of strengthening the dune with biogrout ammonium is produced as a by product. This could have a negative effect on the environment when a certain threshold is exceeded. There are different methods which could naturally or artificially remove the ammonium [43, 45, 46]. Furthermore, the durability of biogrout is an active field of research [43]. When biogrout is applied ammonia accumulation and durability should be studied in more depth.

Location

Figure 7.6 shows a yellow marked area where biogrout can be applied to increase the resistance against erosion at the dune around the Amrâth Kurhaus.

Figure 7.6: Location biogrout

Pros and Cons

Table 7.5: Pros and cons of dune strengthening by biogrout

Topics	Pros	Cons
Safety Measurement	Increased bearing capacity of the dune.	Not applied before to increase the bearing capacity of a dune.
Ecological value and Sustainability		Ammonia production is bad for the environment.
Stakeholders	Hospitality industry has lower risk of damaging their property during a normative storm event. Could be a low cost solution which will be beneficial for governmental organization who have to finance the project.	
Flexibility		Biogrout can be seen as a hard construction and is therefor low in flexibility.

7.1.6. New Dune

The concept "New dune" is a protection measure to counteract erosion and flooding. The idea is to construct the new dune at the end of the beach where the boulevard start. This new dune is meant as a first protection measure that should withstand partly the wave impact. Therefore, the dune is meant to erode offshore and settle down to form a foreshore that is more efficient in dissipating the incoming waves energy. Overall this should result in a decreasing rate of dune erosion during extreme storm event located at the boulevard and Amrâth Kurhaus.

Location

Figure 7.7 shows that the dune is located between the beach and the boulevard. The reason for this location is because the beach will first slow down the incoming wave by the drag of the bottom, this way the wave impact on the new dune will be reduced. Overall, this will lead to less erosion on the actual dune and therefore protect the boulevard and Amrâth Kurhaus.

Figure 7.7: Location new dune

Pros and Cons

Table 7.6: Pros and cons of new dune

Topics	Pros	Cons
Safety Measurement	Reduce the wave impact on the actual dune where the Amrâth Kurhaus and boulevard is located.	
Ecological value and Sustainability	Possibly positive affect on biodiversity.	
Stakeholders	Amrâth Kurhaus and boulevard is protected against severe wave impact.	The view of the sea will be blocked by the dune for the boulevard and Amrâth Kurhaus. This measure is expensive compared to nourishment.
Flexibility	Reinforcement of the dune is flexible.	

7.1.7. Venice

Venice is a very abstract idea with as goal to sustain a hospitality industry close to the beach during high sea level rise. To manage this the solution should be very flexible to move with the constantly changing water level and withstand wave impacts. The construction could for example be a hydraulic plateau on poles.

Location

Figure 7.8 shows where the possible Venice concept can be applied. The yellow marked area indicates the current locations of the restaurants at the beach. These restaurants will suffer first when the shoreline retreat due to sea level rise. Therefore, this concept will protect them when this happens.

Figure 7.8: Location Venice

Pros and Cons

Table 7.7: Pros and cons of Venice

Topics	Pros	Cons
Safety Measurement	Sustain a hospitality industry close to the beach.	
Ecological value and Sustainability	Low ecological impact.	
Stakeholders	Increase safety for the hospitality industry.	Financially expensive measurement which is negative for governmental organizations who have to finance the project.
Flexibility	The design should be constructed to withstand normative wave impacts and be adjustable to different sea levels.	

7.1.8. Mega Nourishment

An other relative new method is comparable to beach nourishment but uses a larger amount of sand. This nourishments is called mega nourishment and needs around 21.5 million m^3 of sand [47]. This method was introduced in 2011 by constructing the "Zandmotor". This fast amount of sand deposited on one spot will last longer and contribute to the strength of the coastline for a larger area. The Sand Motor should contribute to the protection of Hoek van Holland and Scheveningen for the upcoming 25 years [25]. Since this type of nourishment last longer the ecosystem has more time the recover compared to other nourishments. In addition, are cost differences between mega- and beach nourishments also small. Therefore, it is possible that more mega nourishments will be realised in the future [25].

Location

A mega nourishment needs a large amount of space and has a significant impact on beach experience. Therefore, it is recommended to construct a mega nourishment south of the harbour where the beach is less crowded. Moreover, the longshore current comes also from the south direction which is important to take into account, since this current will divide the mega nourishment along the coast of Scheveningen and thus broaden the beach. In Figure 7.9 an indication is given where a new mega nourishment could be constructed. It might also be possible to construct the nourishment further south. Construction of the mega nourishment in front of Scheveningen itself will cause a large change in the beach experience. Beach visitors will have to walk much further to reach the sea which could give a negative experience. Also the idea of strengthening Scheveningen by natural sand transport is not approved. Therefore, the location of the nourishment should not be constructed in front of Scheveningen.

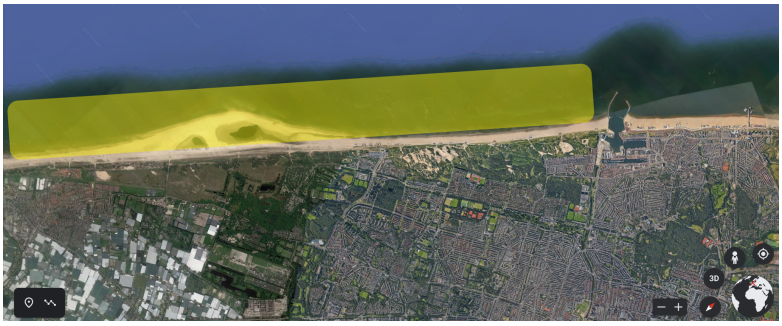

Figure 7.9: Location mega nourishment

Pros and Cons

Topics	Pros	Cons
Safety Measurement	Relative long durability (25 years) compared to traditional beach nourishment (5 years) contribute to the strength of the coastline for a larger area.	Not useful for increasing the width of the beach at specific locations.
Ecological value and sustainability	Lower ecological impact compared to beach nourishments since ecosystems have more time to recover.	
Stakeholders	Since a mega nourishment is executed before and no stakeholders are negatively effected, it is expected that most stakeholders will embrace the project.	
Flexibility	Nourishment are seen as a flexible solution since they can easily be increased in scale.	

7.2. Concept Combinations

This section explains how the three combinations are constructed based on the concepts. Section 7.2 shows the concepts of each combination including a pathway in which order they could be constructed. The three combinations consist of a pathway starting with the concept that could be implemented relatively easy to larger concepts which are expected to have a larger impact and are often more expensive. The idea is to first implement the small concept and when sea level increases further the second and eventually the third concept can be executed. The combinations are designed in such a way that they can fit together and strengthen each other. Furthermore, each combination is designed to support a specific vision related to the design objective. The fist combination was designed to focus on the maximum safety which resulted in negative effects for the hospitality industry and the beach experience. Combination 2 is designed to sustain the hospitality industry while developing protection against sea level rise. The last combination focuses on building with nature and has a low ecological impact.

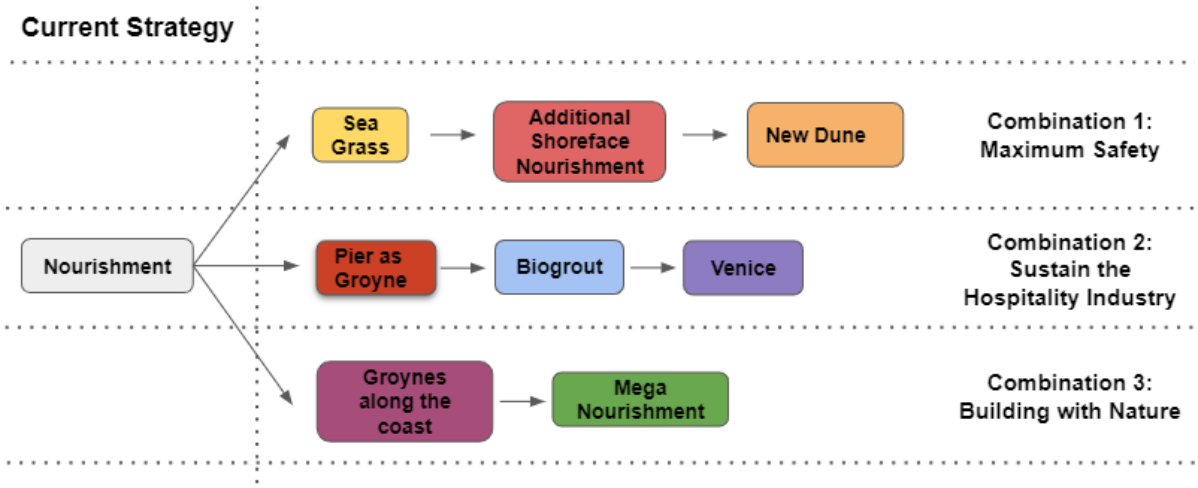

Figure 7.10: Concepts combinations

7.2.1. Combination 1 (Maximum Safety)

The main purpose of combination 1 is try to reduce the wave impact on the dune and therefore decrease the rate of dune erosion to protect the boulevard and Amrâth Kurhaus. The following concepts are combined to reach this purpose: Sea grass, Additional shoreface nourishment and New dune. The concept "Sea grass" is meant to reduce the wave impact. In order to enhance the sedimentation with sea grass, the next concept "Additional Shoreface Nourishment" can be combined. This shoreface nourishment has an other purpose than the general nourishment that has been applied every few years to compensate for sediment losses as a result of structural erosion. The shoreface nourishment is introduced to increase the chance to catch sediment by sea grass to broaden the beach. The next concept is "New dune", this concept can be be combined when the first two concepts can no longer adapt to the increase of the relative sea level rise. The concept is to add an extra smaller sandy dune along the beach to decrease the rate of dune erosion where the boulevard and Amrâth Kurhaus are located.

Most of the design objectives given in chapter 6 are achieved with the concepts combination. Design objective 1 (subsection 6.1.1) is satisfied, since the three concepts can easily be adjusted when the water level changes. In the multiple sea level scenarios the coast of Scheveningen is protected against flooding. This satisfies partly the core values of Delfland, municipality of The Hague, province Zuid-Holland and Rijkswaterstaat. For more information see Appendix C Table C.1 and Table C.2.

Moreover, the concept "Sea Grass" is adding ecological value to the area and therefore satisfy a part of the design objective 2 (subsection 6.1.2), which is the goal environmental organisations strive to accomplish. However, the concepts Sea Grass and New dune is not for every stakeholder acceptable. Sea Grass is possibly not attractive for tourist and local inhabitants. This means that tourism in Scheveningen will decrease. In Figure 4.3 is indicated that business operators, Amrâth Kurhaus and the Pier rely on tourists significantly. A decrease in the number of tourists is not good in an economic point of view. It reduces job opportunity and clash with the spatial plan of the province Zuid-Holland that sees Scheveningen as an tourist hub. One can conclude that some part of design objective 2 (subsection 6.1.2) has not been achieved. However, the ben-

efit is that a decrease in tourism reduces noise, littering and aggression and therefore it is beneficial for the local inhabitants in that respect. Since the level of tourism decrease in Scheveningen the local inhabitants are feeling less disturbed, more safe and enjoying their living habitat. Therefore, design objective 3 (subsection 6.2.1) has been fulfilled. When choosing for combination 1, it might be valuable to look at other methods to increase job opportunity to mitigate or even resolve the adverse effect that less tourism create. Another possibility would be to bring another kind of tourism to the beach to keep the business operations running, but this in turn does not favor the local inhabitants.

If local inhabitants are not as negatively affected by this combination, it is not necessary to engage with them in an early stage. This is only necessary if they are severely negative affected by this combination. There can be said that a reduction in revenue for the business operators can translate into less job opportunities for the local inhabitants, but this is an indirect relation and the severity will not be any major significance. Due to the fact that several stakeholders are negatively affected by the decrease of tourists, a quicker process to achieve a mutual understanding and realizing this combination will not be possible. Therefore, it does not fulfill design objective 4 (subsection 6.2.2).

7.2.2. Combination 2 (Sustain the Hospitality Industry)

The main purpose of combination 2 is to increase sand nourishment along the coast and keep the hospitality industry existent at the coast of Scheveningen. This combination should stimulate the attractiveness of the coast for investors and tourists, while it still develops its coast to withstand the threat of a rising sea level. Therefore, beach visitors should find no hinder at the beach and investors should be able to sustain their restaurants, hotels and bars close to the beach. The concepts: Piers as groyne, Biogrout and Venice were found as options to achieve this. The concept "Pier as a groyne" should stimulate accretion along the coast, while biogrout increases the strength of the dunes on wave impact. Overall, the goal is to create a coastline that erodes less and to make sure that the strengthen dune with biogrout can protect the assets on top and the hinterland. The risk of flooding becomes more prominent with this combination compared to combination 1 and combination 3, as the coast will retreat and therefore the concept "Venice" could be implemented to make sure that business operators can keep operating at the same location.

This combination fulfills design objective 1, design objective 2 and design objective 4. With this strategy the coastline will retreat but the hinterland stays protected. However, design objective 1 can be questioned here since the combinations deliver flexibility until a certain threshold. Therefore, it depends on how far the sea level will rise and on the different individual concepts to understand if this combination will hold. The groyne makes sure that the retreat of the beach will be not as significant in an ecological friendly manner. This will be a favorable protection measure towards the environmental organisations (see Table C.2). The concept "Venice" is meant to give business operators the chance to operate in front of the dune, when sea level rises and shoreline retreat. This satisfies design objective 2 as the hospitality industries core values are protected (see Table C.1). Each concept is a measure which increases the safety but it will be hard to increase the strength of the individual concepts after they are executed. In a way these concepts can be seen as hard construction measures which in general are not flexible. This combination keeps tourists able to visit the beach and use the coastal facilities. The concept "Venice" might even increase tourism as such concept is one of a kind. The combination satisfies most stakeholders, except local inhabitants as their problems with excessive noise, littering and aggression due to tourist will stay. It is therefore important to involve local inhabitants early and for example invite representatives of the area, such as local police and the municipality to see how certain concerns can be taken away. This can be done by for example extra surveillance and trash bins. But also to stimulate public transport to reduce excessive noise from cars.

7.2.3. Combination 3 (Building with Nature)

This combination focuses on building with nature. In order to reach the focus the following concepts are combined: Groynes along the coast and Mega nourishment. The combination of these concepts should strengthen each other and support the building with nature approach to reduce ecological impact.

The idea behind the combination is that sediment can be trapped by the groynes and hence less sand nourishment might be needed. The length of the groynes can be increased to trap more sediment when it is necessary. However, this is only applicable when there is enough sediment available in the North Sea. Extra sand can be supplied by nourishment. One of the new method is mega nourishment, which has a low ecological impact compared to other types of nourishment. Whether the amount of supplied sediment by mega nourishment is efficient enough to grow the beach with the uncertainty of the sea level rise more research is needed. This research is important in order to know how resilient the coastal defense system is against the rising sea level. Due to this research, it is not clear how far design objective 1 can be achieved. Therefore, it

assumed that it has a limited factor on design objective 1. Since the combination uses the idea of building with nature, the beach, boulevard and dune area might be sustained this keeps the hospitality industry safe. Moreover the combination is known for low maintenance. Therefore, this combination scores well on design objective 2.

The groynes might cause for a decrease in wave height which will probably not cause much trouble for beach visitors who just like to swim. It can cause resistance from water athletes since kitesurfers, windsurfers and wavesurfers are hindered by the groynes and will not appreciate blocking of waves. Since many of these surfers are local inhabitants and prefer surfing on there local spot it is important to take this group into account and engage them early in the process. Since only the water sport could be effected by combination 3, it is not expected that local inhabitants will largely block the process and therefore design objective 3 scores relatively high. Design objective 4 can be hindered by Rijkswaterstaat. In the current policy they do not want sediment transport to be blocked.Therefore, the resistance from this stakeholder can be expected. From the municipality and hospitality industry little protest are expected, since the current beach experience and economic development in the area are not expected to be hindered. Considering that the beach and dunes are not effected, it is not expected that the waterboard will have problems with this combination. All in all, most stakeholders are expected to embrace the combination except for Rijkswaterstaat. Because of the large power and influence of Rijkswaterstaat that needs to be taken into account, design objective 4 scores in the middle.

7.2.4. Grading the Combinations in Respect to the Design Objective

In the subsections above combinations 1, 2 and 3 are individually graded with the design objectives. In this section the combinations are summarised and graded in respect to each other, from which the results are shown in Table 7.8.

For design objective 1, combination 1 scores highest followed by combination 3 and combination 2 scores lowest. Combination 1 has the highest flexibility, since the dune height and nourishment can be increased. Furthermore, erosion is reduced by sea grass. Therefore, this combination scores highest on design objective 1. Combination 3 scores lower, since it can be questioned whether the mega nourishment could supply enough sediment. Combination 3 scores higher than combination 2, because it is hard to increase the strength of the individual measurements for combination 2 after constructions are made due to a decrease in flexibility.

For design objective 2, combination 2 scores highest followed by combination 3 and combination 1 scores lowest. Combination 2 scores highest, since the concepts are made in such a way that the hospitality industry can be sustained, and has therefore the lowest impact on economic development. Combination 3 scores in the middle, since it does not hinder the hospitality industry. However, there is also not specific measure to stimulate the hospitality industry. Although, combination 3 stimulates ecology. Combination 1 scores lowest, since the hospitality industry is largely hindered. Even sea grass has a positive effect on ecology it still does not compare to the negative effect on the tourism, since sea grass hinders swimming. Moreover, the new dune in-front of the hospitality industry will block the view.

For design objective 3, combination 3 scores highest followed by combination 1 and 2 which score equal. It is expected that the impact on local inhabitants will be smallest for combination 3, since they are hindered very little by the measurements involved with these concepts. Combination 1 and 2 score lower, because in combination 1 the beach experience is changed due to sea grass and the new dune. Combination 2 does sustains and develops its tourist industry, which was explained before that it has a negative affect on local inhabitants.

For design objective 4, combination 2 and 3 scores equal. For each combination certain stakeholders are expected to have resistance against the combination. In combination 1 the municipality, Amrâth Kurhaus, Pier and business operators are not expected to react well towards a new dune. In addition does sea grass negatively affects the hospitality industry. Combination 2 and 3 will probably find resistance from Rijkswaterstaat since current sediment transport is blocked by a groyne. It is expected that most stakeholders will not appreciate combination 1 due to a decrease in tourism. Therefore combination 1 has been given a lower score.

In Table 7.8 the design objectives and combinations are indicated with a certain score (+,++,+++). These scores indicate to what extend each combination fulfills a specific design objective. The lowest score is determined by a (+) and the highest score by (+++).

From Table 7.8, one can observe that combination 3 scores moderately in fulfilling each design objective compared to combination 1 and combination 2. When the total score of all the design objectives are summed up for each combination, it shows that combination 3 has the highest score. The second place is for combination 2 and combination 1 has the lowest score. Therefore, it can be concluded that combination 3 is most likely preferable when considering these design objectives.

Table 7.8: Scores for each combination in respect to the design objectives: 6.1.1 Coastal defense system resilient against different water levels 6.1.2 Stimulation towards sustainable economic development
6.2.1 Engage with local inhabitant early 6.2.2 Quicker process
Grading system of three points(+, ++, +++)

Design Objective	Combination 1	Combination 2	Combination 3
6.1.1	+++	+	++
6.1.2	+	+++	++
6.2.1	+	+	++
6.2.2	+	++	++

However, when considering the table above none of the design objectives have been prioritized. They all weigh equally. When summing up the plus signs for each combination, combination 3 scores the best but with a small margin with its competitors. When assigning the weight factors determined in chapter 5, subsection 5.2.1 the results are different.

From the list of subsection 5.2.1, one can observe that design objective 1 (subsection 6.1.1) has a weight factor of 25 points, design objective 2 (subsection 6.1.2) has a weight factor of 16 points and design objective 3 (subsection 6.2.1) has a weight factor of 16 points and design objective 4 (subsection 6.2.2) has a weight factor of 20 points.

In order to take into account the weight factors of the four design objectives, ratios have been determined. These ratios are based on how much plus signs are given for each combination per design objective. In Table 7.9, the ratios of each combination per design objective are shown.

Table 7.9: Weight factors and ratios for the grading

Design Objective	Combination 1	Combination 2	Combination 3
6.1.1 (25)	(3/3)	(1/3)	(2/3)
6.1.2 (16)	(1/3)	(3/3)	(2/3)
6.2.1 (16)	(1/3)	(1/3)	(2/3)
6.2.2 (20)	(1/3)	(2/3)	(2/3)

To make sure which combination is most preferable. It has been decided to determine a new grading score by multiplying each ratio factor with the appropriate weight factor that was assigned to each combination. By summing up all the grading scores for each combination, the total grading score can be determined for each combination. The total grading score should help to decide which combination is most preferable based on how much prioritized design objectives are achieved.

In Table 7.10, it can be observed that combination 3 scores the highest. Next is combination 2 and followed up by combination 1 as the lowest score. Therefore, one can conclude that combination 3 is still the most most likely preferable combination, when the priority of each design objective has been considered.

Table 7.10: Total score of each combination

Combinations	Combination 1	Combination 2	Combination 3
Total Points	42.33	43	51.33

8

Final Results of the Coastal Defense System

This last chapter of the report indicates the final results of this research. The chapter is built up in the following order. Firstly the most important results of each chapter is concluded in section 8.1. Secondly, the results of our conclusion of each chapter is discussed, see section 8.2. Thirdly, in section 8.3 is indicated the obstacles during this research. Finally, section 8.4 indicates where more research should be done to come up with a more conclusive and considered concept design.

8.1. Conclusion

Different analysis have been performed to find the answer to what problems occur with sea level rise in Scheveningen. A large part of the hospitality industry lays in front of the sea defense and is therefore not protected. In addition there is an important historical building "Amrâth Kurhaus" that is situated on a Dune. This means that during high water levels dune erosion can occur, which can damage the hospitality industry including the Amrâth Kurhaus, with as result an major impact on the economical development in the area.

Sand nourishment is currently used as coastal protection measure to protect the coast from eroding by maintaining the BKL. During the research, it came forward that the speed of sea level rise in this century is not clear due to a lot of uncertain factors. According to the current sand nourishment strategy the maintenance of the coast is economically unsustainable, if the degree of sea level rise increases significantly. Therefore, time plays an important factor. Calculations in this research with the "Bruun Rule" has indicated that not increasing sand nourishment with the current strategy, will result in a shoreline retreat of 70, 130 or even 170 meter, when sea level rises with 1, 2 and 3 meter respectively. Calculations with the software tool "MorphAn" indicates a dune erosion that reaches an elevation of +8.5 m NAP, when normative boundary conditions with a return period of 1:10000 years has been applied. This brings the Amrâth Kurhaus in a more dangerous situation as the historical building is situated at +9.5 m NAP. One can conclude, that coastal retreat and erosion of the dune increases flood risk for several stakeholders. These stakeholders are affected if the current coastal strategy will be maintained.

After a thorough stakeholder analysis considering the values of each stakeholder, while also taking into account the coastal safety that needs to be maintained, design objectives have been drawn up. These design objectives formulate strategies that form the foundation of the design concepts in this research. The following design concepts have been considered:

- Coastal defense system resilient against different water levels;
- Stimulation towards sustainable economic development;
- Engage with local inhabitant early;
- Quicker process.

The first two design objectives are related to actual concept that can be implemented while the latter relate to how stakeholders would behave under implementing these design concepts. Because multiple concepts can be assigned to the first two design objectives but reflect differently on stakeholders, three combinations have been constructed that includes multiple concepts.

- Combination 1 (Maximum Safety): Sea grass, Additional shoreface nourishment and New dune
  This combination focuses on maximizing the safety of the coastal area in a partly ecological friendly matter but reduces tourism. This would be in favor for local inhabitants but not for the hospitality industry. Local inhabitants do not have to be involved early during negotiations as they are not majorly affected by this strategy.
- Combination 2 (Sustain the Hospitality Industry): Pier as groyne, Biogrout and Venice
  A more expensive ambitious combination that accept partly coastal retreat due to sea level rise. This combination strengthens the dune to accept coastal retreat but still protects the hospitality industry. The ambitious combination might increases tourism which would favour the hospitality industry but not towards the local inhabitants. It is important to involve local inhabitants early to take away their concerns when implementing this strategy.
- Combination 3 (Building with Nature): Groynes along the coast and Mega nourishment
  Combination 3 is the most ecological friendly combination. The combination consist of ways to protect the beach against sea level rise by natural processes. This combination involves segmentation of the beach which might not be as favourable to tourists, but would not really impact the number of visitors each year. Usually the current environment stays the same for local inhabitants and the hospitality industry. As local inhabitants having issues with the current situation in terms of tourists it is important to involve them early when implementing this strategy.

Combination 3 has the most chance of succeeding as the summation of score of fulfilling the design objectives is the highest. The concepts do not cover strategies to reduce concerns of local inhabitants, however it is possible by making small measures to take away their concerns by protecting their core values. If the first three design objectives are fulfilled, the chance of a quicker process comes in grabbing distances as each stakeholder interest is for the most part covered. This give the incentive to cooperate with other stakeholders as it would benefit themselves as well.

8.2. Discussion

In the study area the main focus was on the area around the Amrâth Kurhaus which stretches from the start of the Morales boulevard to the start of natural dunes. When the project is zoomed out further, other stakeholders will become important like the fresh water supply company Dunea, the harbour at Scheveningen or maybe other cities. It can then be questioned if the combinations designed for this area would still find their way. Since the area around the Amrâth Kurhaus is very important in this research and is situated on and in front of the sea defence. When the study would be executed on a larger area, other criteria can become more important and it could be questioned to what extent the area around the Amrâth Kurhaus should be sustained.

An indication for the shoreline retreat was calculated with the Bruun rule. Since the dune at the Amrâth Kurhaus is not a traditional dune, it can be questioned if the calculation can be used. Moreover, it has been assumed that the value of depth of closure stays the same when sea level rises. This can also be questioned, since the equation of Hallermeier (1978) [48] uses the wave properties to determine the depth of closure. These wave properties can change when sea level rises due to climate change. If this is the case, the depth of closure will not be the same anymore, this will result in different shoreline retreats compared to what has been determined initially.

During the research, attempts have been made to interview each involved stakeholder. Stakeholder that have been interviewed are: The municipality of The Hague, local waterboard, Rijkswaterstaat and project developer of the pier (Kondor Wessels). Other important stakeholders in this research are: Amrâth Kurhaus, business operators, environmental organisations, local inhabitants, province of Zuid-Holland and tourists. Unfortunately due to limited available resources and time it was not manageable to get hold of them for an interview. Their knowledge was gained from other sources such as reports, statistics and ambition plans. These sources indirectly indicate the interests of these stakeholders. It can be questioned if this method of research satisfies the actual interest of each stakeholders. Because not all literature is up to date or aligned with the current situation. There has been aimed to find reports that are representative for this day and age but this was not always successful. Therefore, the decision has been made to compare certain information indirectly with other information such as complains from local inhabitants about disturbance and criminality from 2008 with current criminal statistics. If information about these complaints from 2008 are still aligned with the current criminal statistics the information from 2008 has been assumed valid to use for this research.

The combinations to satisfy the design objectives are based on new concept ideas. Since the concepts are not fully developed it is possible that some combinations might not be possible. Therefore, the findings need to be assumed as ideas that need further research and development. It is also possible that there are other concepts fulfilling the design objectives which are not mentioned in this research. Furthermore, there are more combinations possible with the mentioned individual concepts that could strengthen each other. This research indicates a first idea on how several concepts fulfilling the design objectives could be combined. At last, the combinations score a certain grade to which extend they fulfill the design objectives. This score was rather subjective and not executed from a very extensive and strict framework. Since the framework was not that extensive the score was made by a three point system (+, ++, +++). Again this table was only made to give an indication how well the combinations can score for the four different design objectives.

8.3. Limitations

During the research of this project several obstacles have have been experienced related to COVID-19 and time constraint.

Each restriction given by the Dutch government has been followed with care related to COVID-19. Risk of transmission of the virus has been kept to a minimum as communication between the writers of this report have been done mostly digitally. Digital meetings were not always considered as effective due to poor internet connections. This resulted in repeated miscommunication between the team members and it was sometimes difficult to get a point across. Fortunately, due to the good weather conditions, a couple physical meetings outside were planned. This has been done according to the 1.5m distance rule and with the necessary precaution measures.

Another problem that has partly to do with the global pandemic, but also time constraint was the fact that it was not possible to interview each stakeholder. The hospitality industry has been focusing on surviving the quarantine regulations and need all available man power as less employers can be on the work floor due to the restrictions. This made it difficult to get in touch with stakeholders like Amrâth Kurhaus. Replies from emails from other stakeholders were often delayed, which have limited our decision making on several subjects such as attitude of stakeholders and in designing concepts.

As a three man strong research group, reaching a certain quality standard have been difficult. The report is considered as an assignment for the Delft University of Technology with a certain due date. However, to make a well considered decision that benefits the client, municipality of The Hague, more time or man power would have been favourable. Some tasks of this report should have been further researched to make a well considered decision, such as which design concepts are an actual valid option, more available options and if the concepts economically suffice. Our research group has tried to uphold a certain quality threshold, but it cannot be ruled out that more investigation could slightly alter the results of this research.

8.4. Recommendation

In this research there can be questioned if the analysis to come up with the different concept combinations would actually suffice. Therefore it is recommended to do extra research in the following aspects for a more well considered problem that needs to be solved with a solution.

- Verify the stakeholder analysis and SWOT & TOW by interviewing the other stakeholders: Amrâth Kurhaus, other hospitality industries around the Amrâth Kurhaus, local inhabitants, environmental organisations, tourists and the province of Zuid-Holland.
- Broadening the scope of the project and take the whole coast of Scheveningen into account. This might implies there are elders more important problems of significance that change the design objective currently of this research.
- Investigate if there are more concepts which could be applied in Scheveningen, while fulfilling the design objectives used in this research.
- Research towards other possible combinations with current and new concepts.
- Additional research, whether the concepts could be implemented in Scheveningen.
- How well each concept or combination of concepts increase protection against sea level rise.

- Construct tipping points in the pathway for each combination for different water level predictions. For example at 1 meter sea level rice concept A can be implemented, 2 meter sea level rise concept B, 3 meter sea level rise concept C and D, etc.
- Research whether climate change can change the result of shoreline retreat due to a change in DoC value.

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Appendices

A

Study area

Appendix A, "Study Area" forms an extension of chapter 2. In this appendix different aspects are described about the district Scheveningen. The following important aspects are important: geography, socio-demographics, culture, tourism,transport, dunes, development of nourishment, height profiles and norms & policies. The analysis will give a better idea what type of district Scheveningen is and how the current coastal protection is maintained by the norms and policies

A.1. Geography

In this section the focus will be placed on the district Scheveningen. The district consist of 9 sub-district, see Figure A.1). Here below a brief explanation is given for every sub-district.

Figure A.1: Sub-districts of district Scheveningen

- The sub-district Scheveningen can be divided into the following sections: harbour area (Visserhaven), seaside resort (Scheveningen-Badplaats) and residential areas. The sub-district has a long beach along the North Sea, which is very attractive for tourist. The purpose of the Vissershaven is mainly for fishing and leisure. Also the new Molares boulevard is located in this sub-district.
- The sub-district Duinoord contains a designated area where monumental and historical buildings are protected by Dutch monumental law (Monumentenwet). Duinoord shares the borders with the sub-districts Zorgvliet and Geuzen- en Statenkwartier.
- The sub-district Geuzen- en Statenkwartier is largely built between 1810 and 1915. The district is mainly a residential area and is adjacent to the harbour of Scheveningen (Vissershaven). Moreover, it has a popular long shopping street called De Frederik Hendriklaan.

- The sub-district Belgisch Park is a district that is built around the twentieth century. Also this district may be protected by Dutch monumental law. Some of the famous highlights of Scheveningen are located in the so called Midden boulevard, such as the Scheveningen Pier on the North Sea and the Grand Hotel Amrâth Kurhaus Den Haag. The Belgische Park also offers another boulevard, which is the Noordboulevard. This boulevard is recently realized and provides a iconic new pavilion and restaurants.
- The sub-district Oostduinen is a small habitable neighborhood, that shares the borders with sub-districts Westbroekpark en Belgischepark. It has a long stretched beach on the North Sea with various hospitality industry in the Noordboulevard. The popular Carlton Hotel is also located there. Moreover, the subdistrict also offers a large dune with approximately an area of 37 hectares. This dune area serves as water abstraction point for the Haagse Duinwaterleiding to ensure water supply in The Hague.
- The sub-district Duindorp is a habitable neighborhood where most of the buildings are dated back to the period between 1915 and 1930. Duindorp is located next to the Verversingskanaal. This canal is used for inland vessels. Also this sub-district has a beach on the North Sea.
- The sub-district Zorgvliet is known as an embassies area. Around the sub-district many types of museums are located. Furthermore, important international agencies, organisations and convention centre are established here. Such as International Criminal Police Organisation (ICPO), Organisation for the Prohibition of Chemical Weapons (OPCW) and World Forum. The sub-district is also known for the villas in the neighborhood.
- The sub-districts Van Stolkpark and Scheveningen Bosjes can divided into three parts. The first part is where embassies and villas are located. In second part there is a miniature park (Madurodam), which is a popular tourist attraction in Scheveningen. The last part contains a large public park for human enjoyment and recreation.
- Westbroekpark en Duttendel is very similar with the previous sub-district. It has also a few embassies, a public park and some luxurious villas.

A.2. Socio-Demographics

According to the latest data, The district Scheveningen counts 58.227 inhabitants in 2020. It is the fourth most populous district of The Hague. ethnic makeup of The Hague is divided in a way that 63,8 % of the inhabitants are Dutch and 36,2 % of the inhabitants have an immigration background. Figure A.2 shows that the population of The Hague will grow till 2028 with approximately 600.000 inhabitants in total. After 2028 the growth of inhabitants will remain constant and in 2030 the growth will slightly decline.

Figure A.3 shows the number of inhabitants per sub-district. Unfortunately there is no data available for sub-district Oostduinen from the database of the Hague. Overall it is noticeable that the number of inhabitants of most of the sub-districts have a growing trend. For the sub-districts Duindorp and Van Stolkpark and Scheveningen Bosjes this is not the case. For the latter one the number of inhabitants even decline between the period 2015 and 2020.

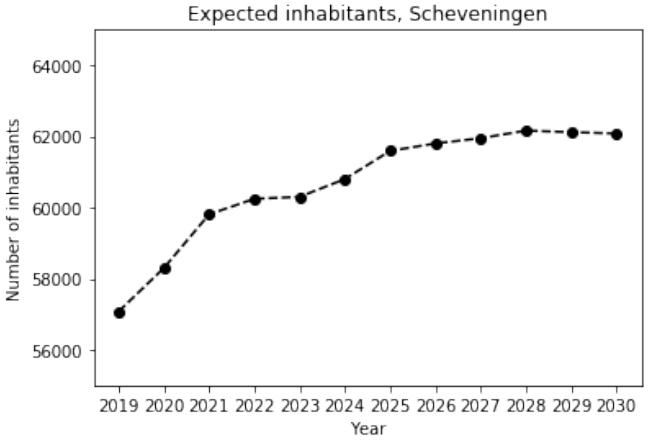

Figure A.2: Expected number of inhabitants of Scheveningen [5]

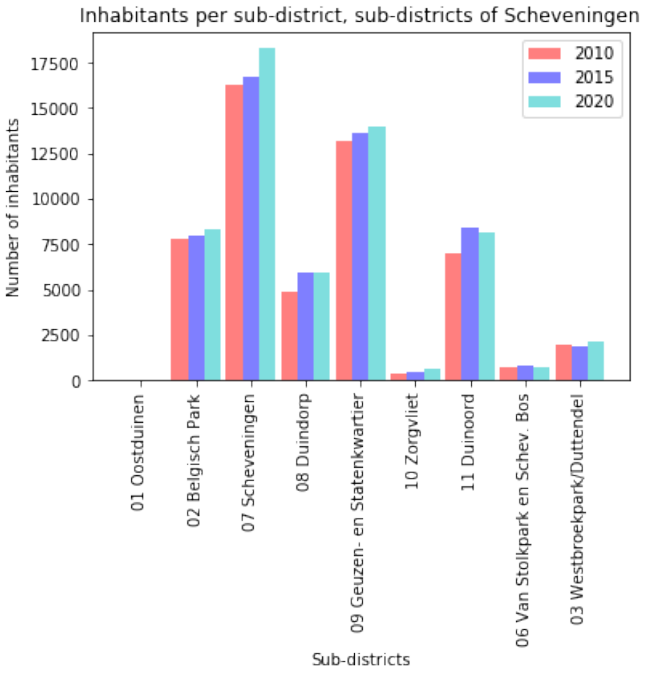

Figure A.3: Inhabitants per sub-district of Scheveningen [5]

A.2.1. Economy

In 2019, there was in total 7427 companies and institutions settled in Scheveningen. This number has significantly increased compared to the number of companies in the year 2000 (see Figure A.4)

Since the number of companies and inhabitants have increased over the years and Figure A.5 shows a decline in the number of registered persons for finding a job. One can conclude that the number of unemployment may have decreased.

In order to say something about economic growth more information will be needed, such as the GDP per inhabitant(gross domestic product) of the Hague. However, with the information above, one could say that the prospects of district Scheveningen are promising.

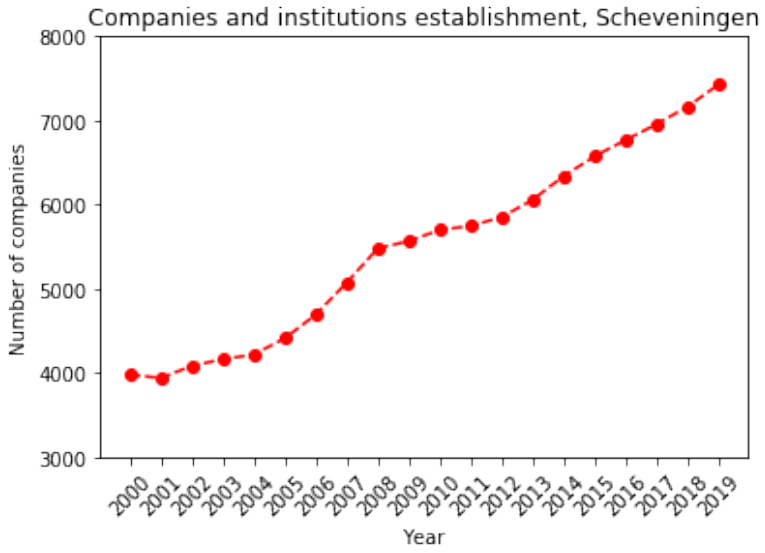

Figure A.4: Number of established companies in Scheveningen [5]

Figure A.5: Registered job-seekers, Scheveningen [5]

Sectors and Industries

Figure A.6 shows the number of employees per sector. The sector Government (organization) is the largest sector of district Scheveningen, even when this sector has declined over the years it is still the most dominant sector. Healthcare and retail industry are the second and third largest sectors. Both of these sectors have increased. The business service sector has also increased between the period 2009 and 2019. All the other sectors are significantly smaller and the number of employees of these sectors does not vary extremely. In Figure A.7 the employees per sector of each sub-district is shown.

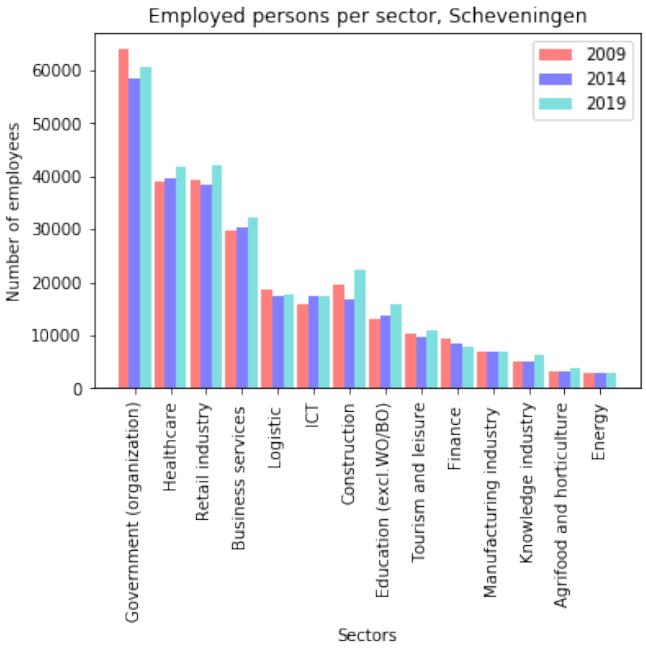

Figure A.6: Employees per sector of Scheveningen [5]

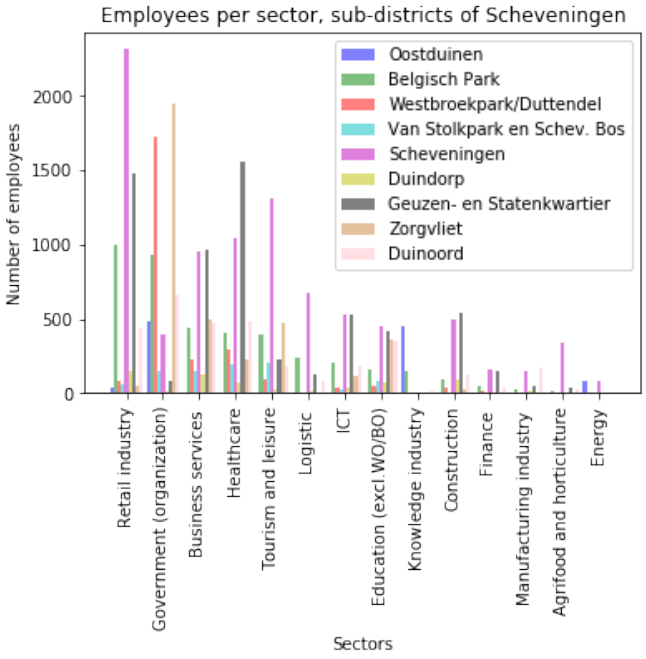

Figure A.7: Employees per sector of the sub-districts [5]

A.2.2. Housing Market

The housing market in The Hague has a growing trend after the year 2015. In Figure A.8, one can observe that in general the current average property valuation has increased significantly compared to 2010. This is also indicated in Figure A.9, the average housing prices have increased in every sub-district. The sub-districts Van Stolkpark en Scheveningen Bosjes and Zorgvliet have increased significantly the most compared to the others. The sub-district with the highest average housing prices is Van Stolkpark and Scheveningen Bosjes. The result is not unexpected since this area houses several villas. The average housing prices of this sub-district in 2020 is approximately €850.000, while the lowest average housing price is approximately €232.000, which is located in sub-district Duindorp.

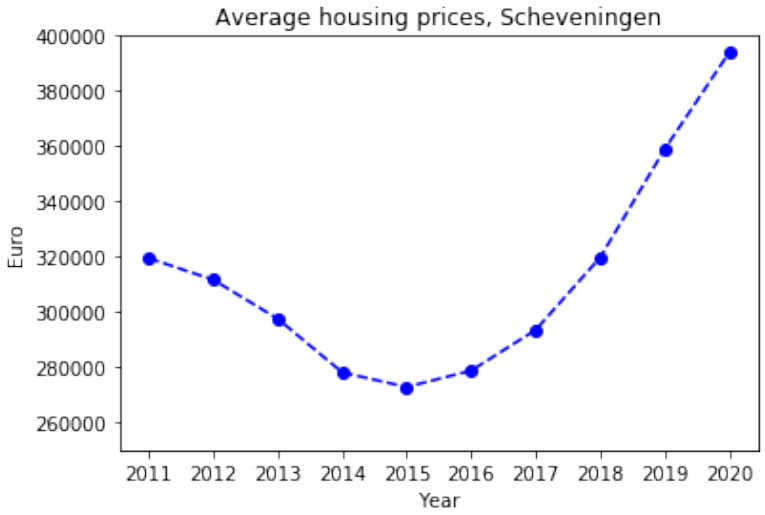

Figure A.8: Average housing prices of Scheveningen

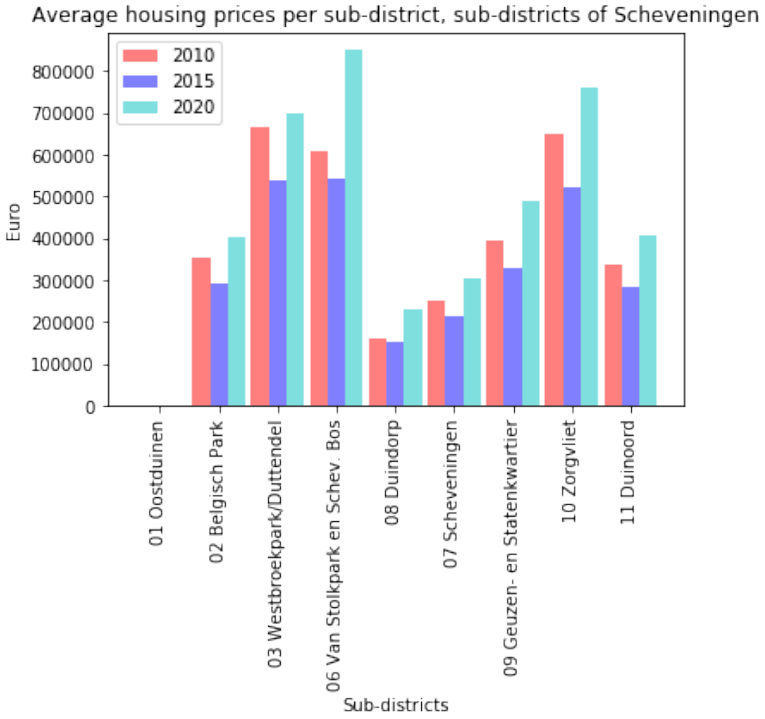

Figure A.9: Average housing prices per sub-district of Scheveningen

A.3. Culture

The district Scheveningen has their own culture, where the local inhabitants have their own district dialect and traditional clothing. However, nowadays the traditional clothing is not what people wear on a daily basis and the dialect is not very common to speak.

A.3.1. Cultural Inheritance

In Scheveningen Bad there are several historical monuments present. Some are visible and while others are not that obvious. In 2010, cultural and historical value is taken up into the spatial planning [49]. This leaded to the following cultural and historical objects present:

- Architecture: the current architecture and construction typology are mainly developed after the second world war and form a fracture with the past. Only the Amrâth Kurhaus and properties 105-110 at the seaside are important landmarks of architecture before the war. The flats on the Palace Promenade (seaside 92-102) including the jetty are reconstruction architecture. The Badhuisweg together with the

extended Kurhausweg functions as sight seeing area for the Amrâth Kurhaus. The properties in this area are constructed between the year 1900 and 1940.

- Protected city sight: The sub-district: Duinoord, Geuzen en Statenkwartier, Van Stolkpark en Scheveningen Bosjes, Scheveningen-Dorp and Zorgvliet are appointed by the municipality of The Hague as protected city sight.
- Monumental buildings: Amrâth Kurhaus is build in between 1884 and 1885 by architect J.F. Henkenhaf and F. Egbert. It was reconstructed in 1886-1887 after a fire. The Amrâth Kurhaus is an example of Neo-Renassaince architecture. In urban planning does the Amrâth Kurhaus fufill an important aspect of the sea side resort due to (from seaside) its protruding wings and dome, but also (from land side) marks the function as final destination that is formed by the Bashuisweg. The Amrâth Kurhaus is in operation as hotel and facilitates several kind of events.
- Characteristic buildings: The Pier of Scheveningen is constructed in between 1959 and 1961 by H.A. Maaskant. The Pier is unique in its kind as it is the only one present in the Netherlands. For the last 100 years, it has been an important visual highlight of Scheveningen. The design represents a business kind of style from the late fifties. The Pier has been renovated in 1964 and between 1999 and 2000. The Pier operates for leisure and business. There are three so called military case-mates (mitrailleurkazemat in Dutch) along the coastline in Scheveningen. Around 1939 during the mobilization, the Dutch coastline needed to be defended including Scheveningen. Only one case-mate is located in the area of Scheveningen Bad opposite of the Palace promenade.
- Archeology: Scheveningen Bad is according to the geological map of The Hague and Rijswijk located on a seawall covered with sand. In the 11^{th} century, aeolian sediment transport covered these seawalls with sand. Sea ridges are in general high in archaeological value as sea ridges used to be a favourable area for our ancestors. The oldest traces date back towards 1000 BC. when the area was still below sea level. Nowadays these traces could be located in the soil layer called Laan van Voorburg (0.5-3.5m) above NAP. Inside the area of Scheveningen Bad historical sights are still unknown, however along the Scheveningseweg a Roman military camp has been found.

A.4. Tourism

Tourism is one of the important sectors of Scheveningen. Each year there are about 13 to 14 millions tourists visiting Scheveningen. According to Rijksinstituut voor Kust en Zee (RIKZ) the coastal dune area along the Dutch coast contribute in settlement of companies in the Netherlands that worth in total 1.3 billion euro, from this value 90 percent is provided by the district Scheveningen. The district offers several attractive highlights. One of the popular highlights is the seaside resort with a long beach, promenade, pier and lighthouse. Moreover, Scheveningen also offers museum, attractions and historical buildings. The most popular annual events in Scheveningen are: Winter Swim (Nieuwjaarsduik), Flags festival and Fireworks festival [50].

A.5. Transport

Traveling trough and within a metropolitan area like Scheveningen is very convenient. The district Scheveningen is accessible by different means of transport. With the bus and tram the most visited areas are easily accessible. The cars are also accessible in Scheveningen. However, the the municipality of The Hague encourage people to take public transport, since cars are the main problems for greenhouse emission and the traffic jam in the city. Therefore, the municipality has a number of parking garages outside the city centre, where people can park their cars and travel further with public transport to the city centre or Scheveningen beach. Moreover, in order to make it more sustainable, Scheveningen has plenty of cycle route where people can ride on their bike.

A.6. Dunes

The primary use of the coastal dunes along the coast is to protect the hinterland of Scheveningen against the coastal flooding and inundation. The dunes are located in the following sub-districts: Duindorp, Scheveningen, Belgische Park and Oostduinen. In the sub-districts Duindorp and Oostduinen the upper shoreface consist of a beach and a dune. While the sub-districts Scheveningen and Belgische park has not only a beach and a dune, but also a boulevard. Moreover, at the dunes of the Belgische Park and Scheveningen buildings are build on the top.

A.7. Development of Nourishment

In the Netherlands there are different ways to protect the coast by using nourishments, in this subsection five types of nourishments are discussed: Dune nourishment, beach nourishment, foreshore nourishment [22], channel wall nourishment[51] and mega nourishment.

The fist type of nourishment that will be explained is dune nourishment. This type of nourishment is usually only applied when large parts of the dunes are damaged due to a storm surge. An exception was made during the project named "Zwakke Schakels" where some dunes were heavily reinforced [52]. When dune nourishment is applied it is often safer to increase the width of the dunes instead of the height. However, increasing the width of the dunes in landwards direction requires space, which is not always possible since constructions are sometimes made close behind the dunes. Increasing the width in seaward direction has the disadvantage that it can cause an increase in erosion. Beach nourishment was initially the most used type of nourishment [13]. Sediment from offshore is pumped through pipelines toward the beach where it is redistributed between the dunes and the low water line by bulldozers [3]. This traditional process uses medium volumes of sand ($2-5 million\ m^3$; typically $200-400\ m^3/m$) [53]. These local sand nourishment are designed to have a lifespan of five years. The first disadvantage of traditional beach nourishment is the high maintenance, since the process has to be repeated every five years. An other disadvantage is the disturbance of the ecosystem due to these nourishment [54]. Furthermore, the beach cannot be used for recreational purposes during the period of construction therefore this method of nourishment can not be considered recreational friendly [3]. A large advantage and the reason why beach nourishment was widely used, is the effectiveness in repairing the coast exactly where needed. Due to the disadvantages of beach nourishment and growing knowledge on coastal morphology, nowadays a shoreface nourishment is preferred and is used in approximately 70% of all cases as indicated in Figure A.10. Shoreface nourishments are also located further sea inward than beach nourishments. The benefit of nourishment sea inward it that the beach does not have to be closed during this process. Two distinctions can be made in shoreface nourishment: feeder berms and breaker berms. Feeder berms are constructed to move sand towards the beach over the years leading to an increase in sediment volume in the beach and dune zone [3]. The goal of breaker berm is to increase the strength of the foreshore and increase the friction for waves [13]. In both cases, but especially for the breaker berm, sand can settle behind the berm because of the reduced wave impact [55].

A relative new way of nourishment is applied on the walls of tidal channels which should stabilise the tidal channel migrating landwards. In 2005, channel nourishment was executed for the fist time in the Oostgat channel near Walcheren, Zeeland. This nourishment succeeded in stabilising the coast and is used as an example for three other channel wall nourishments in the Delta region [52].

An other relative new method is comparable to beach nourishment but uses a larger amount of sand. These nourishments are named mega nourishment and use around 21.5 million m^3 of sand [47]. This method was introduced in 2011 by constructing the Sand Motor. This fast amount of sand deposited on one spot will last longer and contribute to the strength of the coastline for a larger area. The Sand Motor should contribute to the protection of Hoek van Holland and Scheveningen for the next 25 years [25]. Since this type of nourishment last longer the ecosystem has more time the recover compared to other nourishments. The cost differences between mega- and beach nourishments are also small in the long term. Therefore, it is possible that more mega nourishments will be realised in the future [25].

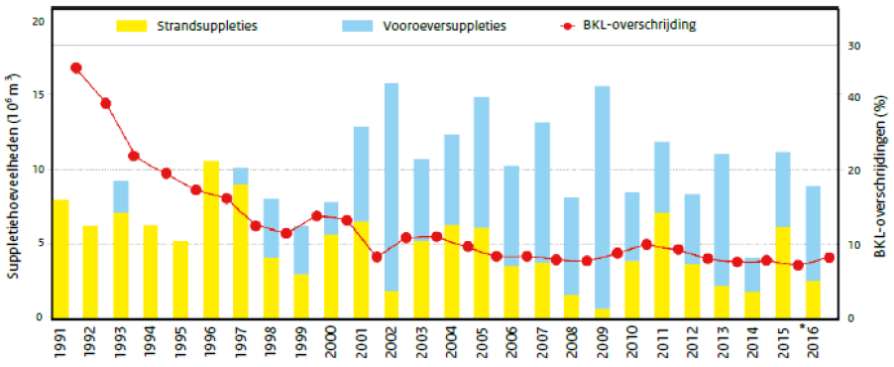

Figure A.10: Volumes of beach and shoreface nourishments of the past 25 years. [6]

Nourishment in Scheveningen
In order to increase coastal protection the beach line was increased to a minimum width of 75 meter with a height of +4.5m NAP [56]. Since wind and waves cause erosion the width was initially increased to 90 meters directly after construction. Currently the height of the beach is found to be between +4m and +4.5m NAP. To maintain the coast of Scheveningen there are new plans for nourishment in front of Scheveningen [18].

A.8. Elevation Profiles

The following figures are results of different cross-shore height profiles that is determined with the AHN tool. The cross-shore profiles are chosen to avoid buildings and are located from entrances of the dune to the beach. These five profiles are interesting, since they are situated around the Amrâth Kurhaus. For more details about the heights see the figures below. The figures are structured from the Noordboulevard towards the south end of the Morales boulevard.

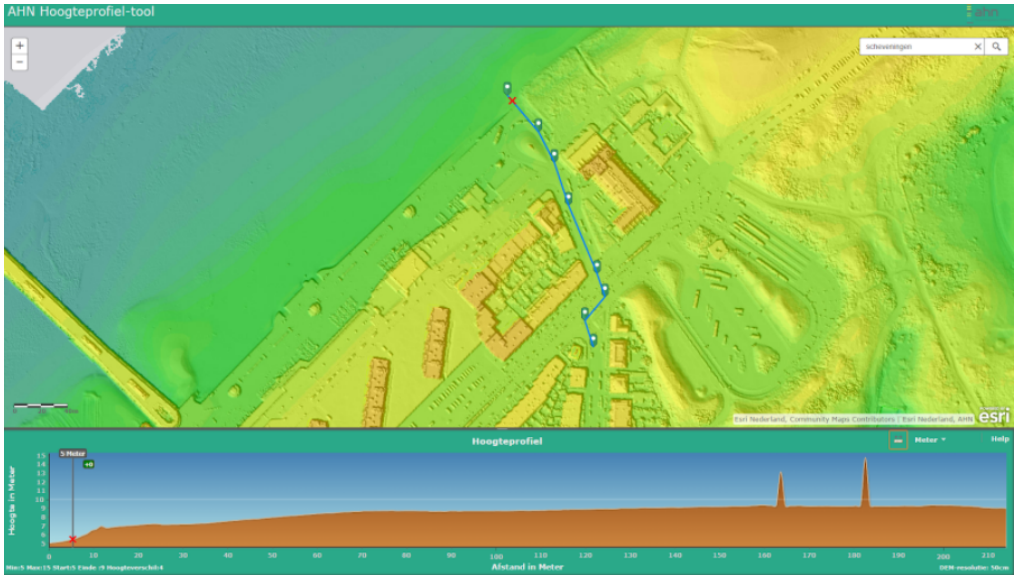

Figure A.11: Noordboulevard [7]

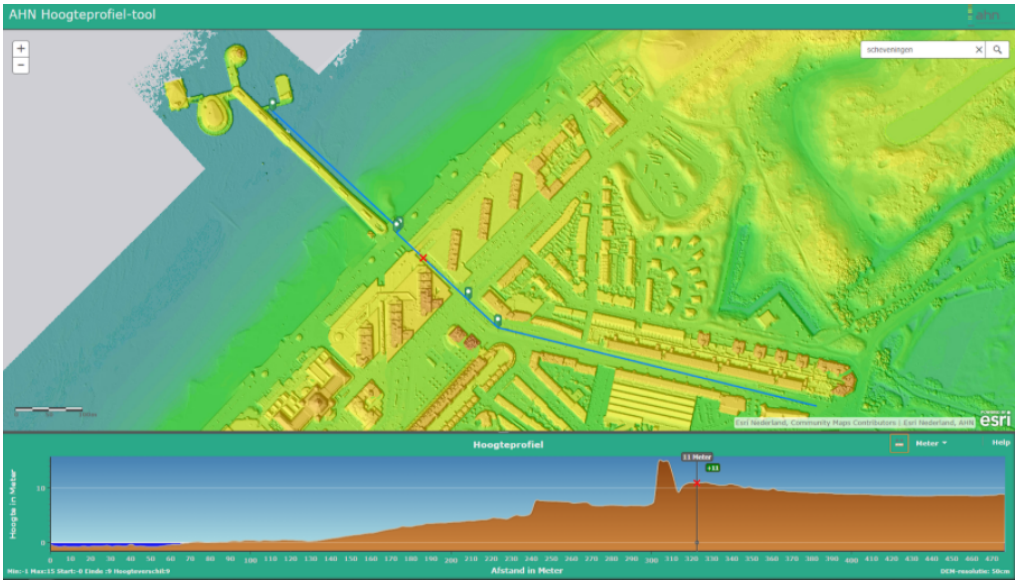

Figure A.12: Entrance Pier [7]

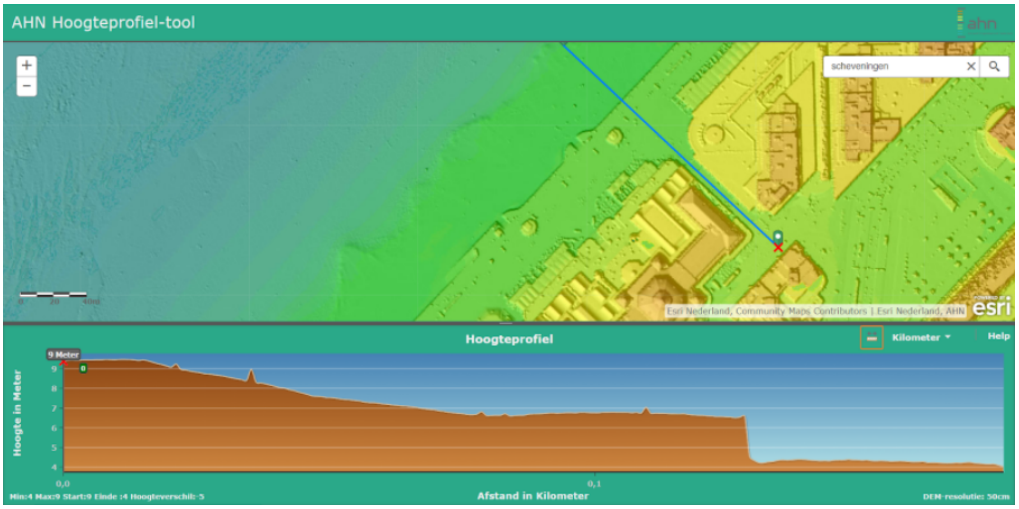

Figure A.13: Entrance Amrâth Kurhaus north [7]

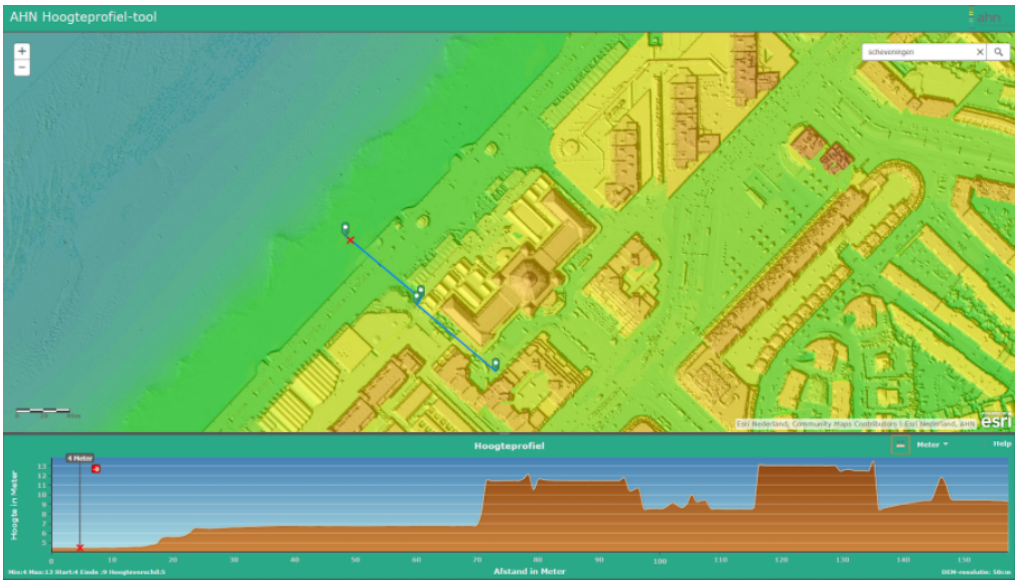

Figure A.14: Entrance Amrâth Kurhaus south [7]

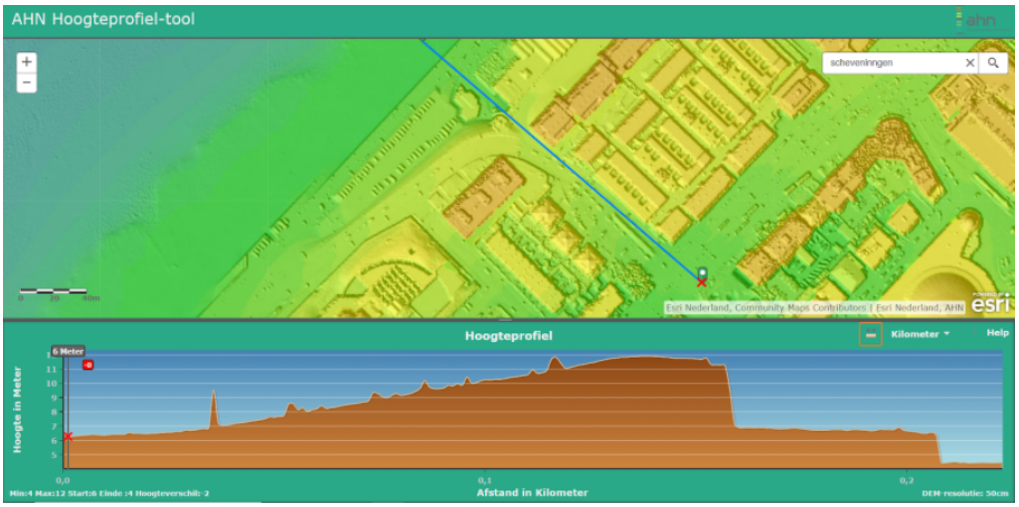

Figure A.15: Entrance at Morales Boulevard [7]

A.9. Morales Boulevard

For the Morales Boulevard the second protection measure behind the beach is the dike in the boulevard. In most places the height is around +10m NAP. At the Schuitenweg, the dike is constructed at +8.5m NAP. While, at Seinpost-duin the dike is constructed at +12m NAP [57]. This protection measure is a hard protection which has a smaller width than the dune at the area around the Amrâth Kurhaus. Therefore, the line "Landwaartse grens waterstaatswerk" is located much closer to the beach in this area.

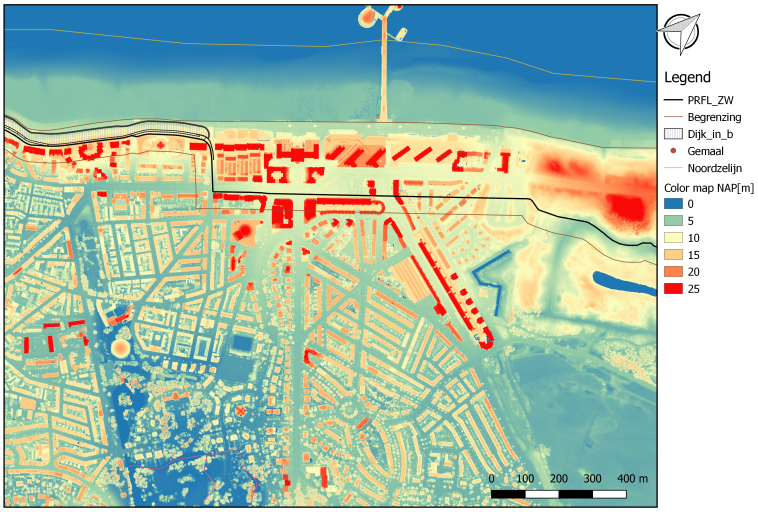

Figure A.16: Scheveningen bad

A.10. Harbour

Since ships need to be able to enter the Harbour there is less protection of the beach. The line of the primary dike is shown in Figure A.17. In the area outside the primary protection some location are situated below +5m NAP. From a report of Deltares inundation starts at a height of +4.42m NAP, which is considered as a risk with a return period of 1:1000 years [53]. In comparison with the beach this area is one meter higher.

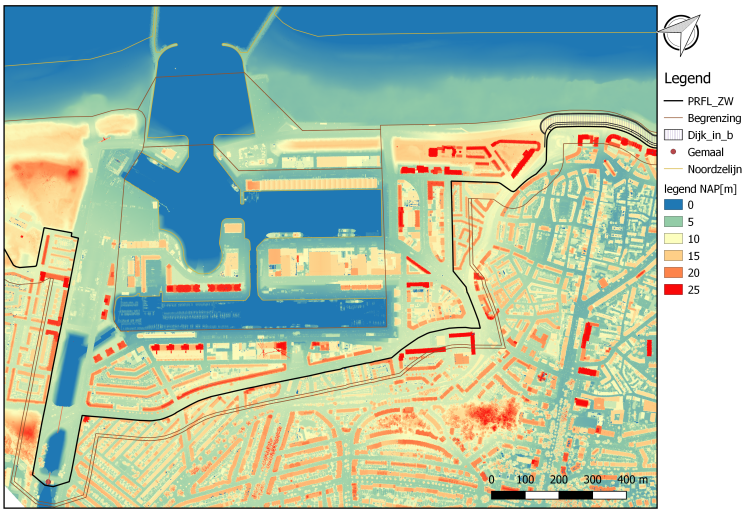

Figure A.17: Harbour

A.11. Additional Info Norms and Policies

Since December 2009, the norms for different water laws were put together in the Waterwet. In the Waterwet the norms for protecting the hinterland are expressed in statistical chances of exceedance. Those chances differ between dike sections which can be found in Appendix 1 of the Waterwet [58]. For the primary dike of Scheveningen the statistical risk of exceedance is 1:30000 years. This value is named "signaleringswaarde" which is three times higher than the minimum allowed risk [59]. Therefore, the lower limit is 1:10000 years. After increasing the strength of the coast by constructing the Morales boulevard and increasing the width of the BKL, Scheveningen will fulfills the norm till 2050 [10]. This means that Scheveningen at least fulfills the 1:10000 norm till 2050. Since the sea level rises due to climate change, it is possible that after 2050 the 1:10000 norm will not be safeguarded anymore.
More details about the policies of Delfland for the coast can be found in the "Tussennotitie kust" [8] and "Delflands algemeen waterkeringenbeleid" [60]. "Delflands algemeen waterkeringenbeleid" describes the policies and management of the dike. The "Tussennotitie kust" is a extension with specific manuals for different sea defence. The location of important areas and their boundaries are found in the Legger [1]. Important areas for the primary sea defence are:

- The area where the primary sea defence is located (Waterstaatswerk);
- The area where no activities are allowed to take place that can harm the primary sea defence (Beschermingszone);
- The area that needs to be retained for further extensions of the dike in the future (Profiel van Vrije Ruimte).

Dimensions for these different areas are shown in Figure A.18. The figure indicates that the "Beschermingszone" extents 50 meters behind the dike. On the seaward side of the "Beschemingszone", the bathymetry has a depth of -20m NAP. The dike height for 50 years is +6.0m NAP and for 200 years +7.8m NAP. The numbers for the dike height are not norms but give an indication what the height should be to fulfil the chance of exceedance for 1:10000 years.

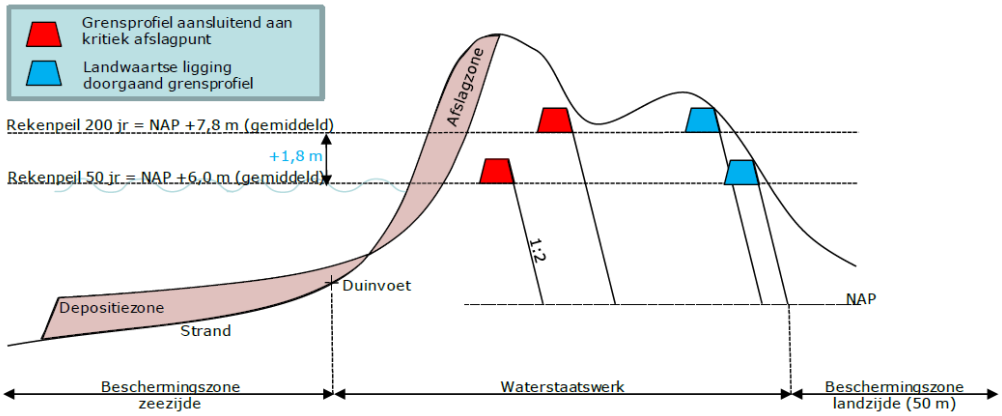

Figure A.18: Leggerzoneringen [8]

B

Coastal Hazard Analysis

Appendix B, "Coastal Hazard Analysis" forms an extension of chapter 3 and is divided into two parts. The first part "Coastal properties by storm impact" is about the determined hydrodynamic boundary conditions and geo-morphological properties from literature and the probabilistic assessment model Hydra-NL. The second part "Shoreline retreat with Bruun Rule" is an explanation about the calculation of the shoreline retreat due to relative sea level rise with the Bruun Rule.

B.1. Cross Shore Transport By Storm Impact

This section shows the different properties of the coast. The current and future hydrodynamic boundary condition are determined with Hydra-NL, see subsection B.1.1. The geo-morphological properties are mainly determined by literature, see subsection B.1.2.

B.1.1. Hydrodynamic Boundary Condition

The hydrodynamic boundary conditions consist of various aspects such as: storm surge properties, wave height properties and duration of the storm. In order to determine the current and future hydrodynamic boundary conditions a probabilistic model called Hydra-NL has been used. Hydra-NL is a probabilistic assessment model that determines the hydraulic boundary conditions to assess the flood defence of the Netherlands. The program is created by Rijkswaterstaat, Deltares and HKV lijn in water. For this project the hydraulic boundary conditions in the future are determined for different climate scenarios (moderate and warm) for the years 2023, 2050 and 2100.

The important hydraulic boundaries are indicated below:

- Surge height: the surge is an important property since it allows wave to propagate further on the beach to the dune. The storm surge are in the order of 3 to 5 meter;
- Water level: the water level in the oceans are expected to increase due to climate change. Therefore, the sea level will rise. According to Hydra-NL (probabilistic assessment program) the water level will rise in this century;
- Significant wave height: the significant wave height is defined as the mean wave height of highest third of the waves. According to Hydra-NL the significant wave height will increase this century;
- Peak period: the peak period is defined as the wave period associated with the most energetic waves in the total wave spectrum. According to Hydra-NL the peak period of the wave will increase slightly this century;
- Storm duration: the storm duration is an important factor, because it determines how the dune erosion will develop of time.

Current situation
The current hydrodynamic boundary condition is determined with the probabilistic assessment model Hydra-NL (WBI2017). The water level, significant wave height and significant wave period for the coast of Scheveningen are indicated in Table B.1

Table B.1: Wave properties, Scheveningen

Wave properties		
Water level [m]	Significant wave height [m]	Significant wave period [s]
5.2	8.04	11.5

Future situation
The hydrodynamic boundary conditions in the future are determined with the probabilistic model Hydra-NL. This model determines the water level, significant wave height and significant wave period in two climate scenarios for the years 2050 and 2100. The results of Hydra-NL are processed and illustrated in the graphs below.

In Figure B.1 one can observe three lines that indicate the water level. Each line represent a percentile. The percentile indicates the value below, which a given percentage of observations in a group. As can be seen, all the three lines are increasing throughout the years no matter what the climate scenario is. Moreover, from the year 2050 the slope of all the lines are steeper, which means that the rate of water level per year is enhanced.

Figure B.2 presents the significant wave height for moderate and warm climate scenarios till the year 2100. One can conclude that the type of climate scenario influences the significant wave height over the years. For a warm climate scenario the significant wave height in the year 2050 is 8.17 meter and 8.42 meter in the year 2100. While for a moderate climate scenario the significant wave height in the year 2050 is 8.06 meter and 8.17 meter in the year 2100. One can conclude that the significant wave height in the year 2100 with a moderate climate scenario has the same value as in a warm climate scenario in the year 2050. This shows that the warm climate scenario has clearly more effect on the rate of significant wave height per year.

Figure B.3 shows the significant wave period for moderate and warm climate scenarios till the year 2100. As can be observed the significant wave period is for both climate scenarios up to the year 2050 are more or less the same. However from 2050, the significant wave period during a warm climate scenario has increased significantly to the moderate climate scenario. What also can be observed is that in the year 2050 the significant wave period of the moderate climate scenario is the same as for the warm climate scenario. Which means that the warm climate scenario has clearly more affect on the rate of significant wave period per year.

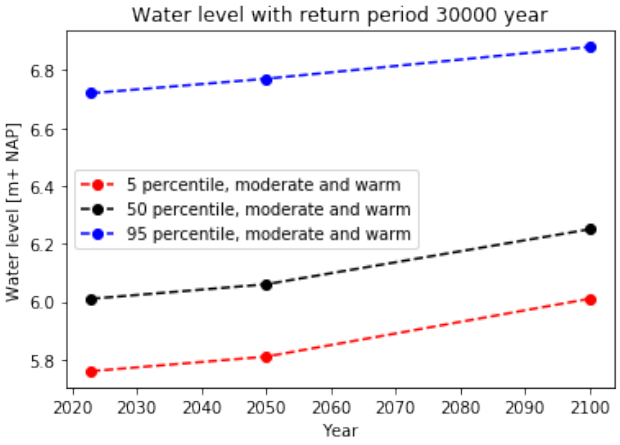

Figure B.1: Water level for the next century

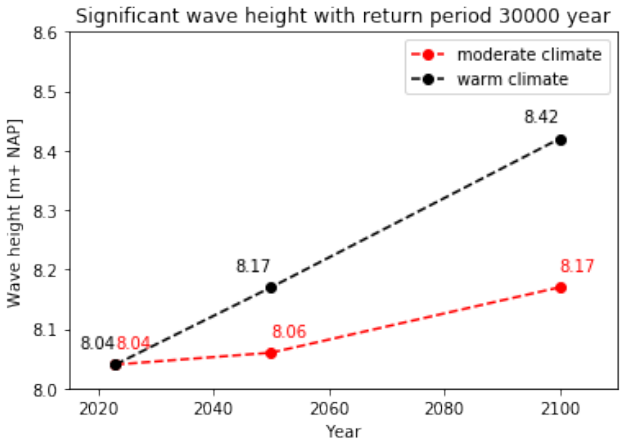

Figure B.2: Significant wave height for the next century

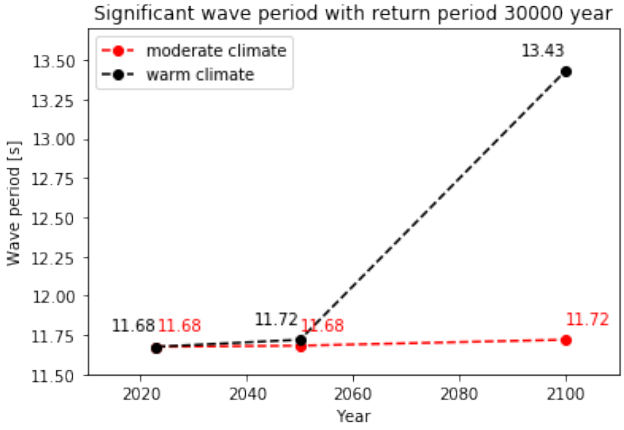

Figure B.3: Significant wave period for the next century

B.1.2. Geo-Morphological Properties

The geo-morphological properties of Scheveningen shows mainly the coastal plain properties. The following important property aspects are indicated below.

- Crest height dune: the crest height of the dunes are an important property, because it will determine whether overtopping and overflow of the dunes will occur;
- Sediment properties: the properties of the sediment (grain-size) is interesting to know, because the grain-size largely affect the resistance against storm erosion;
- Presence of structures: locations of structures are important to know in order to find potentially local hot spots of erosion near buildings.

Crest dune height

From the Actueel Hoogtebestand Nederland (AHN) [7], one can already observe that crest of the dune varies at every location. However, since the focus is on the Grand Amrâth Kurhaus it is decided with the AHN tool that the dune crest is at +9.5m NAP.

Sediment properties

For the grain size in the shoreface of Scheveningen it is decided to choose for the typical value for the Dutch coast. The grainsize (D_{50}) is 0.2 millimeter [29].

Cross shore profile

The coastal cross shore profile is indicated in Figure B.4. This cross section is obtained by EMODnet [61]. As can be seen at the x-axis, the slope of the profile is quite mild till 6 kilometer. From 6 kilometer and onward, the slope of the profile is getting steeper. One can also observe that 0m NAP starts approximately at seven kilometer. This is where the coast line is located. The boulevard starts at approximately 7.5 kilometer, since

the boulevard is at +4 meter NAP. This can also be observed in the graph where a jump occurs from 0m NAP till around +4m NAP. The Grand Amrâth Kurhaus is located at around +9.5m NAP. In the graph this is indicated with a next jump from the level at the boulevard to the crest height of the dune where the Grand Amrâth Kurhaus is located.

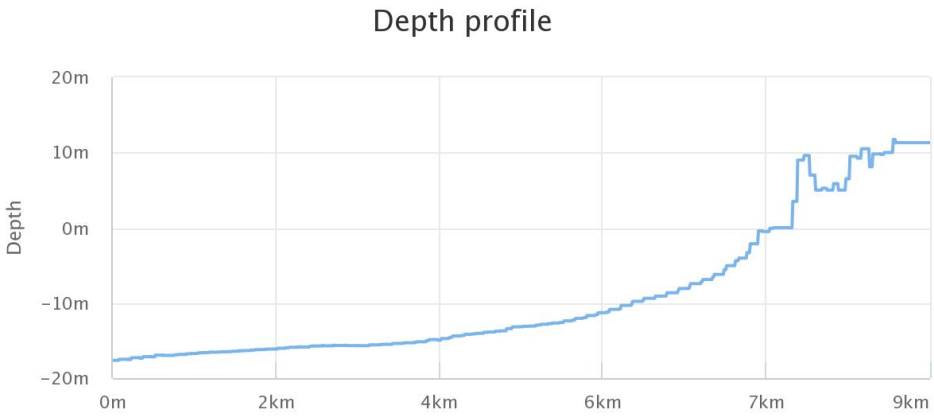

Figure B.4: Cross section of the coast at Scheveningen (Grand Amrâth Kurhaus)

B.2. Shoreline Retreat with Bruun Rule

For the shoreline retreat the Bruun rule will be applied. However, before this can be applied, firstly the depth of closure needs to be determined. Since this is one of the parameters in the mathematical equation of the Bruun Rule.

B.2.1. Depth of Closure

The depth op closure will be determined with the mathematical equation of Hallermeier (1978) [48].

The mathematical equation of Hallermeier (1978) is indicated below:

$$DoC = 2.28 \cdot H_s - 68.5 \cdot (\frac{H_s^2}{g \cdot T_s^2}) \tag{B.1}$$

in which:

- DoC = depth of closure [m]
- H_s = significant wave height [m]
- T_s = significant wave period [s]

Table B.2 shows the wave properties of Scheveningen that is needed to determine the closure depth. The value in this table is based on the model Hydra-NL (van der Werf *et al.* [29])

Table B.2: Current wave properties, Scheveningen

Wave properties	
Significant wave height [m]	Significant wave period [s]
8.04	11.5

Since all the parameters are determined, Equation B.1 can be applied.

$$DoC = 2.28 \cdot 8.45 - 68.5 \cdot (\frac{8.45^2}{9.81 \cdot 11.5^2}) \tag{B.2}$$

By filling all the values into Equation B.1, the DoC can be calculated. The result of the depth of closure is in this case 14.9 meter. This specific DoC value for Scheveningen is permanent and will not change when sea level rise. The explanation behind all of this is based on the Bruun rule, where an assumption is made that a new equilibrium profile will form due to the sand nourishment. This means that the profile will shift to an upward and landward position. Due to this new equilibrium profile, the location of the DoC will also shift to landward position.

B.2.2. Shoreline Retreat per Sea Level Rise Scenario

In the previous section, the depth of closure has been determined. The mathematical equation of the Bruun rule can now be applied. The mathematical equation is indicated below:

$$Retreat = RSLR \cdot (\frac{L}{d}) \tag{B.3}$$

in which:

- $RSLR$ = relative sea level rise [m]
- L = lenght over which the erosion and sedimentation takes place [m]
- d = height over which the erosion and sedimentation takes place [m]

One can observe that Equation B.3 consist of three parameters. Before parameters (L) and (d) can be determined the mean sea level reference and the height of the dune crest need to be known. According to the website of Rijkswaterstaat [62], the current mean sea level is in the order of 0 meter NAP. The crest height of the dune is +9.5m NAP based on NCG [27].

As mentioned in chapter 3, this project will focus on three scenarios. The scenarios are one, two or three meter relative sea level rise. For calculating the shoreline retreat by the first one meter relative sea level rise the current data will be used.

Calculation shoreline retreat by one meter relative sea level rise

In Figure B.5, all the values of the parameters can be observed. The new mean sea level reference is important to know to determine (L). The parameter (L) can be determined with a measurement tool of EMODnet [61]. Before the measurement can take place, a line needs to be defined on the map to show the bathymetry in the cross shore profile. According to the measurement tool, parameter (L) is 1700 meter when a new Mean Sea Level (MSL) of +1m NAP has reached. Since the current MSL is 0m NAP, the height between the dune crest and the depth of closure (d) is 24.4 meter. With all these values, the shoreline retreat can be computed. The result of the shoreline retreat due to 1 meter sea level rise is approximately 70 meter (see Equation B.4). This means that for this RSLR scenario the shoreline will retreat from the current MKL with 70 meter land inward.

$$Retreat = 1 \cdot (\frac{1700}{24.4}) \approx 70 meter \tag{B.4}$$

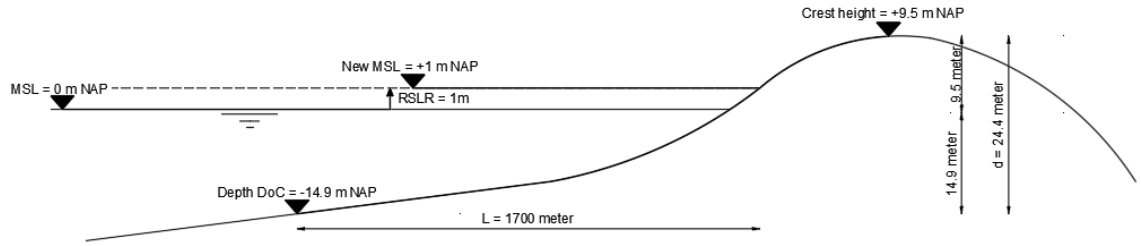

Figure B.5: Visualize 1 meter relative sea level rise

Shoreline Retreat by Two Meter Relative Sea Level Rise

The calculation for the shoreline retreat in this case is almost the same as the previous one. However to implement the two meter RSLR into the calculation of the shoreline retreat, the new equilibrium profile will be used due to the first one meter RSLR. In order to work with two meter RSLR, one extra meter has been added on the new MSL profile of +1m NAP. Moreover, due the new equilibrium profile , the location of the DoC will move in the direction of the shore until it is located at -13.9m NAP to ensure that the height of the DoC remains 14.9 meter. The rise of relative sea level will cause for a height reduction between the dune crest and the MSL. Overall this result in to a shorter height between the dune crest and the depth of closure. For this case parameter (d) is 23.4 meter. The parameter (L) will be determined in the same way. According to the measurement tool, parameter (L) is 1400 meter when a new MSL of +2m NAP has reached. With all these values, the result of the shoreline retreat due to another one meter sea level rise is approximately 60 meter (see Equation B.5). This means that for this RSLR scenario the total shoreline from the current MKL will now retreat with 130 meter land inward . For a better understanding of the parameters see Figure B.6.

$$Retreat = 1 \cdot (\frac{1400}{23.42}) \approx 60 meter \tag{B.5}$$

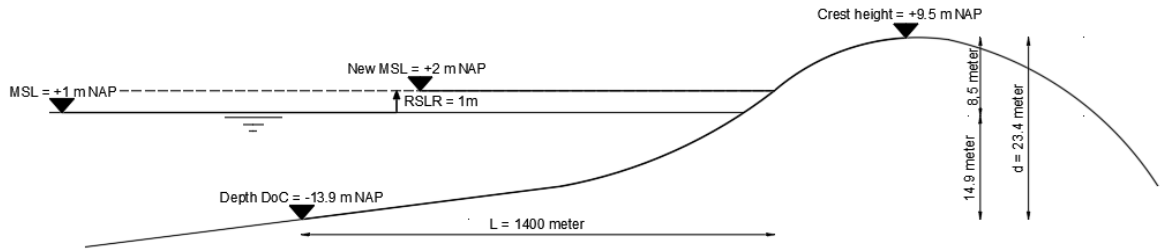

Figure B.6: Visualize 2 meter relative sea level rise

Calculation Shoreline Retreat by Three Meter Relative Sea Level Rise

For this scenario the same approach will be applied as for the shoreline retreat by two meter RSLR. Based on the same approach the parameter (L) is 900 meter and parameter (d) is 22.4 meter. With these values the result of the shoreline retreat due to another one meter sea level rise is approximately 40 meter (see Equation B.6). This means that for this RSLR scenario the total shoreline from the current MKL will now retreat with 170 meter land inward. For a better understanding of the parameters see Figure B.7.

$$Retreat = 1 \cdot (\frac{900}{22.4}) \approx 40 meter \tag{B.6}$$

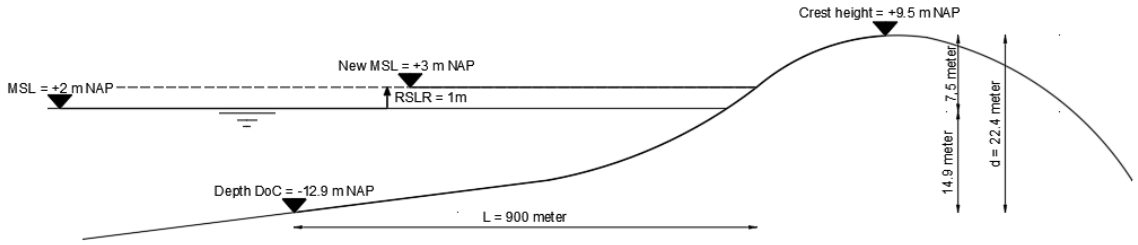

Figure B.7: Visualize 3 meter relative sea level rise

C

Stakeholder Analysis

Appendix C (Stakeholder Analysis) is divided in several sections and forms an extension of chapter 4. Firstly section C.1 indicates several crimes committed in The Hague over the years. As comparison to the complaints local inhabitants had from the survey results of Steda Research in 2008 [31]. Secondly, all stakeholders for this project are indicated in section C.2. As well as their interest, problem perception, goals and core values. Thirdly, the form and amount of power, attitude and change is indicated in section C.3 for each stakeholder. Finally, explanation of the scores given in section C.3 are elaborated in section C.4.

C.1. Criminal Statistics

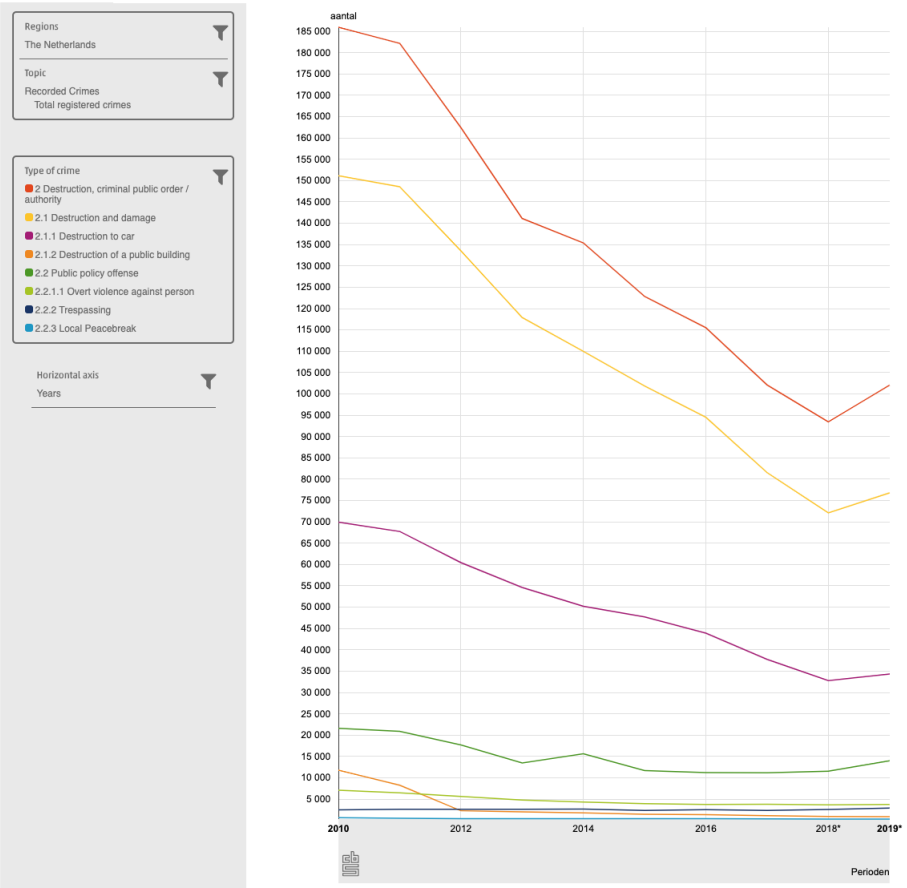

Figure C.1: Public crimes (1/2)

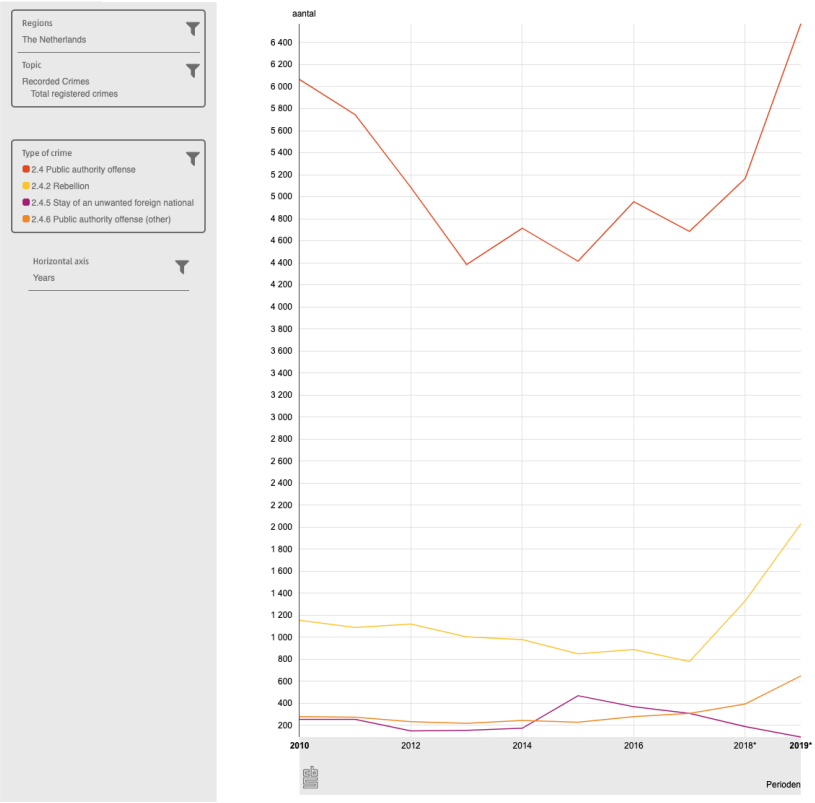

Figure C.2: Public crimes (2/2)

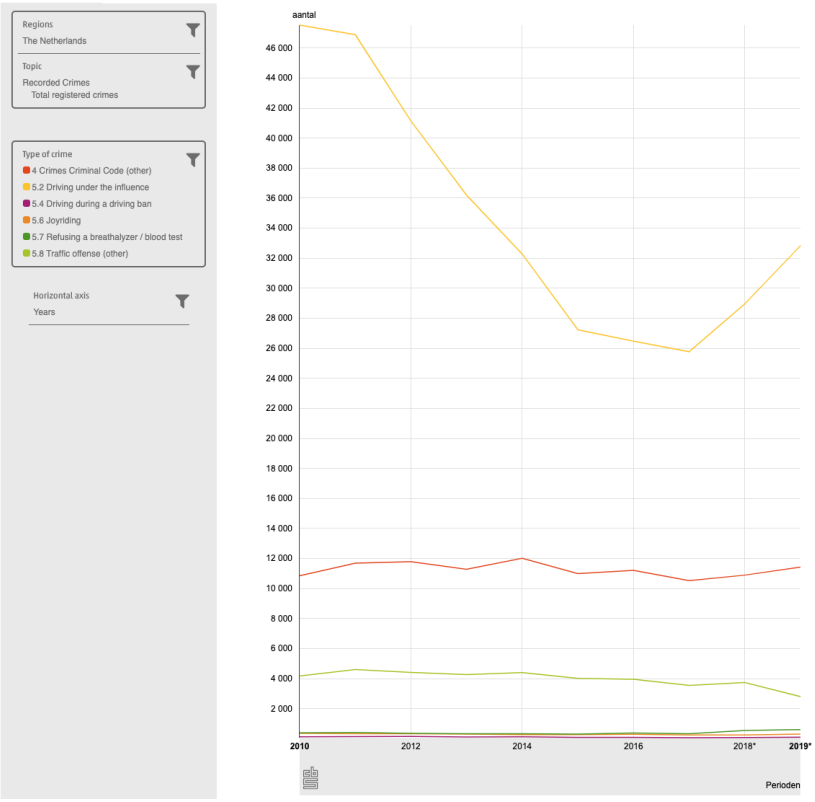

Figure C.3: Criminal and traffic crimes

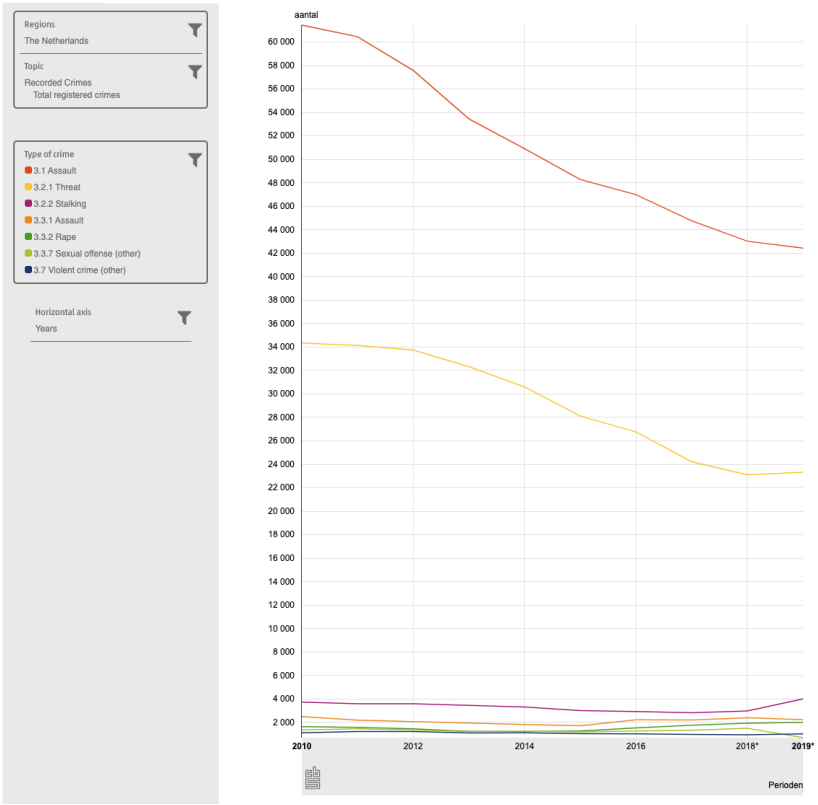

Figure C.4: Violent sexual crimes

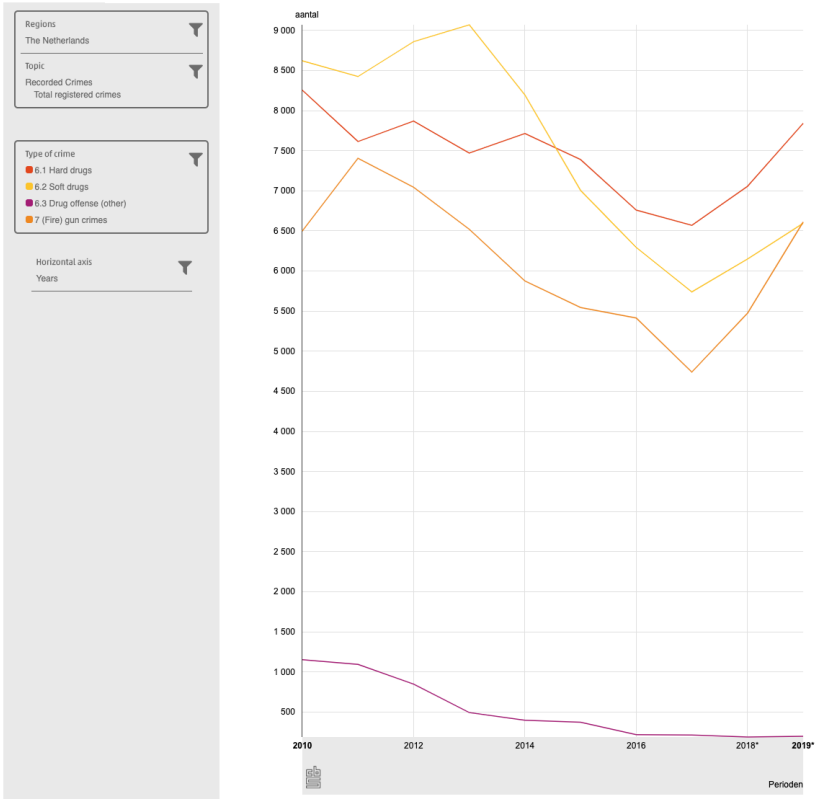

Figure C.5: Drugs and gun crimes

C.2. Stakeholder Identification

Table C.1: Stakeholder identification (1/2)

Stakeholders (1/2)	Interests	Problem perception	Goals	Core values
Delfland (Waterboard).	The physical effects on sea level rise and the effects on the coastal defense structure under their supervision.	Future sea level rise is unknown and one solution does not fit all scenarios.	Having a design for different scenarios for the protection against sea level rise.	Supervising and care for the coastal defense system within the waterboard borders.
Rijkswaterstaat	Coastal protection for the whole of the Netherlands by policy making and see over them to be transformed into strategies.	The strategies are expensive and do not suffice what is stated in the policies.	See their policy making transformed into cost effective .	Keep Scheveningen protected against flooding and to prevent the coast from eroding by policy making and investing.
Province Zuid-Holland.	Increase the importance of Scheveningen to add value towards the province.	Rijkswaterstaat policy does not align with the spacial plan of the municipality of The Hague.	Strategies are sufficient according to policy and fit within The Hague's spatial plan and creates value towards to province.	Protecting Scheveningen against future sea level rise and increase the value of Scheveningen for the province.
Municipality of The Hague.	Economically affordable option that blends in with the city sight while not obstructing the inhabitants of the area.	No designs concepts are available and if a design will have a large negative impact on the economic development at the coast.	Having a design concept that is safe and economically beneficial towards the area. The design should increase value towards Scheveningen.	Economical growth and job opportunities for the inhabitants of The Hague as well as providing protection.
Local inhabitants	Job opportunity and enjoying the view of the ocean. But also increase the comfort of living.	The increase in the amount of tourists but also if a new sea defense will block their view of the beach nor to be able to access the ocean.	Increasing their value of living in terms of clean, ambiances and safe environment.	Feeling safe and enjoying their living habitat in Scheveningen.
Tourists	Enjoying activities in the coastal area while having access and a good view of the ocean.	Blocking access and view of the ocean during and after construction.	Making use of activities Scheveningen provides and increasing their holiday experience.	Enjoying their holiday and view of the ocean.
Business operators (location boulevard).	Increase their profit and stay protected against sea level rise.	The use of the promenade functions as sight seeing of the coast, any alterations or blockage of view might effect consumers visiting that area.	Increase profit while staying protected against sea level rise.	Keeping their lively hood and increase the number of consumers.
Business operators (location beach).	Increase their profit and stay protected against sea level rise.	Depending on the concept design no more direct access for consumers to access the catering facilities.	Operating throughout the whole year and increase profit while staying protected against sea level rise.	Keeping their lively hood and increase the number of consumers.

Table C.2: Stakeholder identification (2/2)

Stakeholders (2/2)	Interests	Problem perception	Goals	Core values
Environmental organisations.	Ecology of the coast of Scheveningen.	Disturbing the ecology during construction and due to tourism.	Making the coastal design protection an opportunity to increase the habitable area for different species.	Protecting the home of different species living at the coast of Scheveningen.
Amrâth Kurhaus	Increase the number of tourists visiting the Amrâth Kurhaus every day and become more internationally known.	The concept design will have a negative affect during/after the construction on the amount of visitors and thus revenue.	Stay protected against sea level rise while increasing revenue and reputation internationally.	Providing a memorable experience for tourists and visitors while increasing revenue.
The Pier	Increase the number of tourists visiting the Pier every day and their reputation on national and international level.	The concept design will have a negative affect during/after the construction on the amount of visitors and thus revenue.	Increasing revenue and reputation on national and international level.	Providing a memorable experience for tourists and visitors while increasing revenue.

C.3. Stakeholder Interest, Power, Attitude and Change

Table C.3: Stakeholder power table

Stakeholder	Type of power	Source of power	Amount of power	Attitude
Delfland (Waterboard)	Productive	Governmental appointed organization, with representatives voted by the inhabitants.	Medium	Neutral
Rijkswaterstaat	Productive	Governmental power and large investor	High	Neutral
Province Zuid-Holland	Productive	Governmental power within the provincial borders.	High	Neutral
Municipality of The Hague.	Productive	Governmental power within the municipal borders & initiator.	High	Positive
Local inhabitants	Obstructive	Claiming the right to reject a plan Power of voice.	Medium	Neutral
Tourists	Productive	Providing source of income for the local community.	Low	Neutral
Business operators (location boulevard).	Obstructive	Right to voice their dissatisfaction and are renown in the area.	Medium	Negative
Business operators (location beach).	Obstructive	Right to voice their dissatisfaction and are renown in the area.	Medium	Negative
Environmental organisations.	Obstructive	Law & Regulations	High	Negative
Amrâth Kurhaus	Diffuse	Right to voice and have a reputation in the area and internationally.	High	Neutral
The Pier	Diffuse	Right to voice and have a reputation in the area on national level.	High	Neutral

Table C.4: Stakeholder Interest, Power, Attitude and Change

Stakeholder	Interest	Power	Attitude	Change
Delfland (Waterboard)	8	8	7	6
Rijkswaterstaat	8	10	6	7
Province Zuid-Holland	9	9	8	7
Municipality of The Hague.	10	9	9	8
Local inhabitants	7	7	4	7
Tourists	4	3	4	7
Business operators (location boulevard).	8	6	2	5
Business operators (location beach).	8	6	2	5
Environmental organisations.	6	8	5	3
Amrâth Kurhaus	8	8	5	5
The Pier	8	8	5	5

- Interest : Active (10) - Passive (1)
- Power : Influential (10) - Insignificant (1)
- Attitude : Supporter (10) - Blocker (1)
- Change : Open to change (10) - Closed to change (1)

C.4. Explanation Score Table C.4

Appendix section C.3 explains how Table C.4 has been constructed and why certain stakeholders have a different scores than others. Please note that these scores are subjective and might change depending on the finalized concept design. The scores are constructed to better visualise the effects stakeholders might have on the eventual concept design based on interviews and literature. Table C.4 is used as a reference in constructing the concept design as well as the stakeholder engagement strategy. The text is constructed such that the stakeholder with the highest score in interest, power, attitude and change comes first.

C.4.1. Interest

All stakeholders have a certain degree of interest when it comes down towards changing the beach and boulevard to increase coastal protection. The initiator of this project "the municipality of The Hague" has the most interest in this concept as they have many things to consider what stood out when interviewed. Not only is coastal protection important to them but also the environmental aspects of the local inhabitants in lands, city sight, and the economic development at the coast. Due to their concern over these multiple aspects their interest can be considered the highest compared with other stakeholders.

Province Zuid-Holland has a similar interest, out of the report "Bestemmingsplan Duinen" [33] written by the municipality of Katwijk, the Province of Zuid-Holland strives for a province where each urban coastal area is protected against future sea level rise in a sustainable way. They would like that in each urban coastal area that will be better protected against the sea it also creates value towards the Province. In the document it states that the strategy for each coastal urban area should be different to stand out. Their view towards Scheveningen, Noordwijk, Katwijk, Hoek van Holland and Brouwersdam is to develop more recreation and tourism for the international market while the other coastal urban areas would suffice a more regional function. The Province's multiple aspects of interest are in conformity with the interests of the municipality of The Hague but on a provincial scale. Therefore, their interest is high but not as high as the municipality of The Hague.

In an interview with Delfland came forward that their interest in coastal protection is high as the main sea barrier in the project area is under their jurisdiction. They are concerned with safety against flooding for the hinterland. When asking about the business operators in the coastal area in front of the main dune the safety perspective of flooding was different. Their statement was: "as they signed up for operating a business over there, business operators accept the risk of flooding".

The interview with Rijkswaterstaat had a similar perspective as Delfland. Their main focus is to create safety against sea water rise for the whole of the Netherlands. Rijkswaterstaat was interested in how their policy could be converted to a strategy and how much this strategy would eventually cost. If the strategy would blends in with the city sight or improves the environment of the local inhabitants was not part of their interests. However, they could understand that the municipality of The Hague wants to protect business operators that are working in front of the coastal safety defense but it is up to the municipality of The Hague to decide on this.

Business operators located at the boulevard and beach have similar interest with one and another. Both want to increase their profit and stay protected against sea level rise. Their perception of cost of the project, city sight, protection of the hinterland and environment are not part of their interest. They are more interested in increasing and protecting their livelihood, meaning that their interest score is lower than the ones of the province and the municipality of The Hague.

The interest of business operators are also aligned with the interest with Amrâth Kurhaus and the Pier. All want to increase their revenue by having more visitors. However, the difference between local operators, Amrâth Kurhaus and the Pier is that local operators are renown in the area. Amrâth Kurhaus and the Pier have a reputation larger than that. Their revenue does not only depend on local visitors but also on national and international visitors as well. The Pier is known nationally as the only pier in the Netherlands and want to increase on national and preferably also on international level while Amrâth Kurhaus wants to increase their reputation on international level. Increasing reputation on both national and international level will indirectly also increase the amount of visitors and thus revenue. Local business operators of course also profit from the national and international tourism. Even that the interest between business operators, Amrâth Kurhaus and the Pier differ slightly their main focus is increasing revenue and have therefore the same score.

Local inhabitants interests are expressed in their way of comfort and living. They want to stay protected against future sea level rise but it is not one of the things that first comes to their minds according to the survey by Steda Research in 2008 [31]. Their interest in a new design concept of the boulevard and coast are more into preventing problems with littering, excessive noise and feeling safe. Job opportunity and ocean view are also on their minds. However, job opportunity is indirectly related as tourism is only part of the economical growth in Scheveningen and the project only focuses on a part of the beach what makes ocean view unchanged in other areas of Scheveningen. Therefore their interest in a new concept design is slightly

lower than the ones of the business operators, Amrâth Kurhaus and the Pier.

Environmental organisations are not particularly interested in the changes a new concept design will bring, but it will if it has a positive or negative affect on the Natura 2000 areas on both sides next to the Boulevard. Therefore, their interest is not low, but also not high as there might be no affects due to construction of a new coastal safety protection.

Tourist have been given the lowest score of all stakeholders. There is an interest but less of importance than the other stakeholders. Tourists are more occupied with enjoying their holiday by taking part in activities, making use of facilities and access to the beach. The reason why the interest is not lower, is because the beach and enjoying the ocean view are important to them and is related to a new concept design. In addition, does a new concept design might change the amount of facilities and activities in this particular area. However, this does not mean their score should be higher as it is not the only part of the beach in Scheveningen where facilities, activities or access of the beach is possible.

C.4.2. Power

Rijkswaterstaat is a governmental body that creates policies for coastal protection of the Netherlands based on research. When it comes to coastal defense, Rijkswaterstaat is the biggest investor as well. Without consent of Rijkswaterstaat the project is prone to fail and is therefore given the highest score in terms of power.

Province Zuid-Holland has on a provincial scale the power to invest and align different values between their view and the ones of Delfland and municipality of The Hague. Therefore, their power is high but slightly less as the ones of Rijkswaterstaat as they are the policy maker and these policies need to be fulfilled. The municipality of The Hague has been given the same score as province of Zuid-Holland as they are an investor but have the power to alter the strategy based on the policy to fit it within their view of city sight. Still this score is less than Rijkswaterstaat as the strategy still should fulfill the requirements in the policy set up by Rijkswaterstaat.

The power of Delfland stretches withing the power of the Waterboard. They have the power to influence strategies based on the policies of Rijkswaterstaat within their jurisdiction such as when alterations need to be made in the flood structure on the primary coastal defense line of Scheveningen or when water quality might be affected by construction. This gives them power but slightly less than the ones of the municipality of The Hague and the province Zuid-Holland as their power does not reach out that jurisdiction.

Environmental organisations have a lot of power within their jurisdiction. If any nature 2000 area is negatively effected during or after construction they could withhold the project from happening. If this is the case a permit is required depending on several conditions see chapter Study Area for more information. Their power is however limited towards the ecological aspects of this project and are therefore considered lower than the municipality of The Hague and the province Zuid-Holland but at the same level as Delfland.

Amrâth Kurhaus and the Pier have also a significant power even if it is not governmental. They have a national and international reputation. They are important factors why tourist visit Scheveningen during the year and also creates a lot of other job opportunities and create revenue for local business operators. They have a large stage and their right to voice is of significance.

Local inhabitants might unite and will therefore have a fair amount of power as it can create reputation damage to all governmental bodies. Depending on the individual inhabitants some have larger power than others and might even be able to reject a plan. However, for this to happen their attitude should have to be really low, united and without being open to any change. Therefore, their score is slightly lower than the ones of Delfland when it comes down to coastal protection.

Both business operators located at the beach and boulevard are renown in the area what gives them a smaller stage and therefore have a less significant form of influence compared to Amrâth Kurhaus and the Pier. They still have influence on local inhabitants and even on Amrâth Kurhaus and the Pier as they in some form rely on customers and job opportunity. The reason their power score is not higher, has also to do with the fact that in order to operate in front of the coastal protection defense, they agree and accept the risk of flooding now and in the future.

Tourists are being considered the lowest amount of power. They have some sort of influence as tourist generate revenue and job opportunities within Scheveningen. But their influence on the design or withhold of the project are being considered small. However, it creates a dependence with larger stakeholders such as Amrâth Kurhaus, the Pier, local inhabitants and the municipality of The Hague.

C.4.3. Attitude

The municipality of The Hague is as initiator the largest supporter of the project. As long as the policies are converted into qualified strategies, blends in with the city sight and increases the economical development of Scheveningen they are the largest supporter of the concept design. They want as many of their values implemented in the concept design.

Province Zuid-Holland will also be a large supporter of the project however their scope is more focused on a provincial scale to create value. In the report "Bestemmingsplan Duinen" [33] states that they are focused on a tailor made solution for each coastal urban area. Their role in this process is also to be a mediator and align values between Delfland and the municipality of The Hague. What gives them a slightly lower support score but still high enough as their values are to some extend similar as that of the The municipality of The Hague.

From an interview with Delfland it came to notice that they have an positive attitude towards creating a safe coastal protection for Scheveningen. The coastal protection design has a high chance to fall in the Waterboard borders and they are eager to support solutions that will create safety for the inhabitants in lands. However, when talking about any other aspects such as the business operators in front of the dike they were less supportive. As these business operators accept the risk of flooding and see it as their own problem. Please note that economic development of tourism fall outside the waterboard borders. However, in their jurisdiction of the waterboard borders they where supportive and therefore still got an good score.

Rijkswaterstaat got a lower score than Delfland for several reasons. They are supportive towards the project and will probably be one of the biggest investors. But only when it comes down to coastal protection any other values such as economic development, sightseeing, environmental habitat are not considered. If these values are taken up into the concept design Rijkswaterstaat will probably not be the one wanting to pay for this and that it should come from the province Zuid-Holland and the municipality of The Hague according to the interview with Rijkswaterstaat.

Amrâth Kurhaus and the Pier have a similar score. They are not a blocker nor a supporter but depending on the concept design this might change for the better or worse. If the design stimulate tourism, more room for expansion, parking solutions, etc. they might have a positive attitude towards the project. However, if the design decreases the visits of tourists on those particular spots, blocking access to beach and ocean view their attitude can change pretty negatively. This came forward out of an interview with a spoke person from the the Pier.

Environmental organisations have a similar score as Amrâth Kurhaus and the Pier. They are not a blocker nor a supporter at the moment. But this might change depending on if the concept design affects the Natura 2000 area positively or negatively.

Local inhabitants and tourist have given a similar score and are more closely leaning towards a blocking attitude. The reason why local inhabitants do not score lower, is that they want to be protected against flooding in the future and might see potential of a more comfortable living due to the new safety design concept. However, the concept might also increase tourism leading to excessive noise, littering etc. Besides does the concept design might block access to the beach and view of the ocean.

Tourists enjoy the facilities Amrâth Kurhaus, the Pier and business operators have to offer as they are near the beach. Tourists and local inhabitants are concerned that the new concept design might block access to the beach and view of the ocean. But instead of the additional worry-some of local inhabitants about the comfort of living, tourists are more worried about the convenience of accessibility towards the facilities nearby if the beach in this particular area is blocked. Luckily there are also other facilities available at the rest of the coast of Scheveningen and therefore convenience is not seen as a big factor. Because proper guidance towards access to other parts of the coast in Scheveningen should satisfy tourists values. Thus the same score for tourists are given as the local inhabitants.

The worst attitude score is given to the local business operators as their livelihood depends on visitors and tourism. If blockage of ocean view or beach is implemented in the concept design their might be a big chance that their revenue decreases [32]. Local business operators may accept the risk of flooding as sea level rise is something that increases over a long period of time. It is not something they are worried about at this moment and when the risk of flooding might eventually happen they are often retired and someone else is running it.

C.4.4. Change

The municipality of The Hague has a lot of values to consider. Any other stakeholder has in some sort of way a dependency with the municipality. The municipality needs to prepare itself against future sea level rise and is to a large extend open to change. Their perspective depend on the values and goals of each different stakeholder as long as it still confirm the policies of Rijkswaterstaat and does not impact the economic development severely.

The province Zuid-Holland, Rijkswaterstaat, local inhabitants and tourists have been given the same score. They share the same openness of change but for different reasons. The province Zuid-Holland is according to "Bestemmingsplan Duinen" [33] open for a tailor made solution for each coastal urban area. This indirectly means that changes can be made depending on the different circumstances and involvement of stakeholders which give them still relatively higher score. However, this is lower than the one of the mu-

nicipality of The Hague as local stakeholders are of a relatively smaller importance towards the province than the municipality.

Rijkswaterstaat is open to change as long as the policy is transformed into a good strategy. However, if the safety concept design would be extra expensive due to a lot of non coastal related aspects their attitude might changes negatively. Therefore, Rijkswaterstaat score lower than the municipality of The Hague.

Local inhabitants are leaning towards a negative attitude, however if their comfort of living can be increased and the negative aspects that came forward in the survey by Steda Research in 2008 [31]. Their negative attitude would probably changes for the better and therefore has their openness of change still have been given a high score.

Tourists have been considered adaptable. Tourist seek enjoyment for their holiday and if this can still be provided their attitude might change as well. Such as new different facilities at the same place and elsewhere or make it in several ways accessible to still reach the ocean in this area.

Delfland is less open for change in perspective. Their focus will be on the flood defense structures representing the coastal defense and are open to some change. However, any implemented non related coastal concepts in the design are not something they are interested in. This feeling will only become stronger if they have to contribute towards these non related coastal concepts as well. Therefore, they have a bit less score to openness than the other before mentioned stakeholders.

Openness to change for the business operators is mediocre and actually depends on each business owner individually. General speaking most are reluctant if the concept design affects their livelihood in any way such as decrease revenue or even make them leave. However, flooding will stay on their minds and the concept design might even result in a positive impulse towards the tourist industry and therefore their revenue. Thus, they are in some sort of form on the verge between open and closed to change.

Environmental organisations are closed to change. Any negative effects on the Natura 2000 areas need to be researched and in some way compensated if that is indeed the case. The reason why they do not have a lower score in change has to do with the fact that it is still possible to get some form of permit if there is enough compensation towards the nature and ecology that benefits them severely.

D

Explanation SWOT Factor Weights

During the analysis of the study area, coastal hazard and involved stakeholders analysis several factors came to mention that could have been seen as strengths, weaknesses, opportunities or threats for the future project. These factors and weights are mentioned in section 5.1 in Table 5.1, Table 5.2, Table 5.3 and Table 5.4. How the weight of each factor has been determined for the coastal design concept is indicated here. Please note that the qualitative weights are subjective and based on knowledge gathered in the analysis.

D.1. Strengths

One of the factors that have an considerable amount of weight is "2. Flood risk affects everyone involved". When a project is being developed and some stakeholder is negatively affected by it there can be expected strong opposition from them. This will result in a difficult situation if this stakeholder has a significant amount of power as well. However in the concept design of Scheveningen their is a mutual problem that requires participation of all stakeholders to be solved. It increases participation between stakeholders as they all will in some form can benefit from this. The incentive to cooperate with each other is a strength that is significantly beneficial to the process of the project and have therefore been given the highest score in Table 5.1.

The other two factors "1. Scheveningen is one of the largest coastal urban areas of the Netherlands" and "3. Stronger coastal defense system" have been given the same weight for different reasons. In chapter 2 it has been clear that Scheveningen is a touristic hub from the Netherlands and generate an significant amount of revenue for the municipality of The Hague and is of value for the province Zuid-Holland. The footprint of Scheveningen makes the municipality of The Hague an important player from all coastal urban areas of the province. The province want to keep Scheveningen valuable and shall in this respect be more considerate with the goals and values of the municipality of The Hague. Therefore, it has been given a significant weight. The reason why this weight is less than number 2 of Table 5.1 is that not all values and goals the municipality can be considered as it would go beyond the limits of this project but also because the province is more considered with the goals and values the municipality does not mean they will accept all demands.

Number 3 of Table 5.1 is the main objective of this project as the hinterland needs to be protected against flooding. However, it does not consider any other categories if not incorporated such as living environment, ecology, job opportunity etc. Therefore on its own is a stronger coastal defense system considered as a strength but lower than the footprint the municipality has in the province.

D.2. Weaknesses

One of the weaknesses that come into play with creating a coastal defense system is that the rise in sea level is uncertain. There is a range in what is expected for this century but it depends on many factors that are beyond the dutch governments power. It might make a coastal defense system obsolete now or in 200 years. A coastal defense system is expensive and should be wisely spend and should fulfill its purpose in the future as well. Therefore, factor number 2 of Table 5.2 is considered the largest weakness of the whole concept design.

Two factors that have been weighted the same and considered important are "3. More sand nourishment required due to sea level rise" and "4. Less development of coastal facilities". Number 3 of Table 5.2 has been considered important is that nourishment is an effective strategy considering the degree of erosion that is taking place. Unfortunately to have the BKL staying in place with this kind of strategy will be a costly measure that comes almost unattainable if the sea level would rise 2 meter or 3 meter. Therefore, this factor has been

given an high weight but still less than number 2 of Table 5.2 as the degree of inefficiency and therefore weakness depends on how much the sea level will actually rise.

Less development of coastal facilities is also considered as an important factor. The municipality of The Hague relies on the revenue the coastal facilities create. Their role within the province is important due to their large footprint. Another important problem that occur with less coastal development is that it stabilize or even decrease the amount of tourists and visitors coming to Scheveningen which in turn decreases job opportunity for local inhabitants. It is therefore considered important but still less important than number 2 of Table 5.2 as the project is focused on a coastal defense system that keeps the inhabitants safe from sea level rise. Economical opportunity has been given a lower prioritization than safety in this matter.

Number 1 of Table 5.2 has been given the lowest weight. Local inhabitants have a certain degree of power and their relationship with tourists and visitors have been damaged due to the littering, excessive noise and aggression they have experienced. Their habitat has partly been negatively affected by these problems. A concept design that brings economic stimulation in the tourist industry would affect the local's habitat even worse when none of their problems would be considered in a new concept design and has therefore been considered a weakness but of less significance than the aforementioned weaknesses.

D.3. Opportunities

One of the largest opportunities considering a new coastal defense system, would be to stimulate the economy. A new coastal defense system will give a boost reputation nationally and internationally what will invite more visitors and tourists to Scheveningen. That in turn increases revenue for all coastal facilities. But also does the construction of a coastal defense system requires materials and labor. When these needs for the coastal defense system would be spend locally it stimulate the local economy as well. Therefore this opportunity have been given the largest weight.

Local inhabitants have a significant amount of power and to have them supporting the project will be important. Therefore, has increasing the living environment been given a decent weight in Table 5.3. However, increasing job opportunity and industry also adds value towards the local inhabitants in Scheveningen and at the same time stimulates the economy while number 3 only focuses on the inhabitants. Therefore, number 3 has been given a lower score than number 1.

Increasing ecological value in the area has been given the lowest weight. The methodology behind this is that the Natura 2000 areas should not be negatively affected by a new coastal defense system and is important. This does however not mean that ecological value should increase either but is still an opportunity that can be considered. Therefore, factor number 2 has been given the lowest weight in Table 5.3.

D.4. Threats

Flooding of hinterland can be considered the strongest threat of the whole project. Any coastal defense system should protect the hinterland against flooding and with the climate changing and sea level rising the current strategy would not suffice. Also a new concept design might be inefficient due to the fact that exact numbers of sea level rise are missing making a new concept design maybe obsolete in the future. Therefore, the threat of flooding has been considered as the most important factor in Table 5.4.

Also an important factor but slightly less than the threat of flooding is "2. Decrease of visitors and tourists in Scheveningen". The economic development for a significant amount of stakeholders involved in the project is important. Economic downfall due to a new concept design has therefore being considered as an important factor but less important than safety for the hinterland.

The factor of Table 5.4 with the least amount of weight is "1. Concept development is located near Natura 2000 areas". Any new coastal developments can affect the Natura 2000 areas in a negative way and is therefore really important. Environmental organisations have a lot of power but the threat factor has been given a lower weight. The reason behind this is is that the influence of a new concept design on a Natura 2000 areas is unknown. Also is it possible to require a license by compensation for any loss in the Natura 2000 area or by altering the concept design. The threat has also not given a larger weight due to the fact that if at the start of the project research indicates there is no actual negative affect but it turns out during construction there is, the construction of the project may continue. For more information about this matter see subsection 2.3.5.

E

Design of Concepts

E.0.1. Strengthening with Biogrout

As stated in the report "Tussennotitie kust" the Netherlands rather likes to strengthening the dunes by vegetation and naturally increase the dune by aeolian processes [8]. In case of Scheveningen this is not an option since the dune is covered by buildings and roads. The buildings also have a increased chance of becoming damaged during a storm surge since erosion can still occur in front of the sea defence. Bio-grout could have the potential to decrease the amount of erosion and therefor reduce damage to the buildings. There are also other methods to increase the strength of the dune structure with cement or chemical grouting. These methods are not suitable for Scheveningen since the high viscosity causes clogging to occur fast and can therefor only be applied for small scale purposes. Furthermore, they have a large negative ecological impact and decrease the permeability significantly. Finally, these solutions need large equipment and are often very expensive. This makes these methods unfeasible for large scale projects [9]. Recently, the basic idea of biogrout is to increase the binding between sand particles by calcite precipitation which should lead to a higher bearing capacity and reduce erosion [41].

As appointed in Liu *et al.* [42] Microbial Induced Carbonate Precipitation (MICP) has been the primary focus of research to date. MICP can be achieved through various pathways, both autotrophic and hetrotrophic, such as hydrolysis, sulfate reduction, and denitrification [63]. Yet, for applications in soil stabilization, most studies have focused on urea hydrolysis performed by ureolytic bacteria because of their widespread presence in soil and process simplicity. Figure E.2 shows how the fairly simple process works. Ureolytic bacteria produce an enzyme which hydrolyzes (separate a chemical by taking water) urea ((NH2)2CO) and produces carbon ions, accompanied by an increase in alkalinity (resistance to a change in Ph). If calcium is present calcium carbonate precipitation can be generated. The calcium carbonate preferentially accumulates at particle-particle contacts and thus contributes to the cementation between granular particles[42].

During the process of calcite precipitation ammonium is produced as a by product. This could have a negative effect on the environment when a certain threshold is exceeded. Nevertheless, due to denitrification process ammonia can be removed through volatization and microbial oxidation of ammonium to nitrite/nitrate[43]. If this is not sufficient, then an extra electro-kinetic or chemical method can be used to enhance removal of ammonium [45, 46]. The effect of the volatization process should also be studied since it could cause acidification which could lead to dissolving calcium carbonate and a partial loss of the gained strength [43]. For further development of the concept the durability and the production and removal of ammonia should be studied.

The strength which could be gained from calcium carbonate precipitation is still an ongoing research but some promising results are already found. In the study Van Paassen *et al.* [9] differently sized tanks filled with sand were injected with ureolytic bacteria to enhance calcite precipitation. The effect from this treatment is clearly shown in Figure E.1. The treated sand maintains it shape after removing the bucket around it [9]. Furthermore, an other research showed a significant decrease in erosion was also found for samples which were treated with biogrout and tested on a small scale test setup [42]. To which extent the strength is gained, depends on different chemical factors. Firstly, a large amount of Calcium is beneficial, since it is needed in the process to create calcium carbonate [43]. The Renodunaal district between Noord-Holland and Zeeland contains high concentrations of calcium. At the sea side of the dunes the calcium concentrates and the PH value are highest and decrease landward [44]. Therefore, calcium concentrations at Scheveningen are expected to be beneficial to increase the bearing capacity. Other chemical processes could also effect the cementification of the dunes for example high PH values have a positive effect on the precipitation of calcium carbonate and

should be studied when the concept is developed further.

Besides the chemical process the practical issues to execute the project needs to be taken into account. To strengthen the dunes below the Amrâth Kurhaus the whole dune should be increased equally in strength [9]. In order to achieve this the bacteria should be distributed equally and this will be hard. In current methods the bacteria are injected into the soil from where the bacteria can be transported through fine sands or coarser materials. During transport thru the sand particles bio-clogging could occur when bacteria are adsorbed or strained by the solid grains, which could result in limited treatment distance for ground reinforcement purposes [9]. However, in the largest experiment were a box with 100 m^3 of sand was injected by multiple injection tubes, the calcium carbonate was found to be distributed well over the box [9]. Therefore, it can also be expected that the strength increase is also well distributed.

Figure E.1: The spherically shaped cemented sand body [9]

$$(NH_2)_2CO + 2H_2O \rightarrow 2NH_4^+ + CO_3^{2-} \quad (1)$$

$$Ca^{2+} + Cell \rightarrow Cell - Ca^{2+} \quad (2)$$

$$Cell - Ca^{2+} + CO_3^{2-} \rightarrow Cell - CaCO_3 \quad (3)$$

Figure E.2: Calcite precipitation by ureolytic bacteria [42]

F

Interviews

In this chapter the interviews with the: waterboard Delfland, TU delft, Municipality of The Hague, Rijkswaterstaat and the project developer of the pier are reported. Each interview was originally in Dutch and is translated to English.

F.1. Waterboard Delfland

Date	04-08-2020
Time	15:00
Interviewed employers	Pieter Otten, Job van Dansik Policy advisors

In the first e-mail conversation we asked if Delfland would like to do an interview to answer certain questions which were provided in the e-mail. Delfland had replied that they would like to do an interview with us and gave immediately some answers by e-mail. Since some answers were gained by e-mail, new sub-questions were constructed which were answered during the online interview. The interview started with an open interview where Delfland gave information about their current research. After the open interview a more structured interview followed where Delfland answers the prepared sub-questions.

F.1.1. Open Interview

Since the time frame in which sea level rise is happening is unclear a new study is started commissioned by the government to investigate the physical effects of 1,2 and 3 meter sea level rise. Pieter Otten also said that although the time frame is unclear, the investigation focuses on the long term effect, and investigates the effect of sea level rise as far as 200 and even 300 years in the future.

From the ongoing research they could already tell that with a sea level rise of 1 meter they can protect the coast by increasing nourishments. However, an increase of 2 to 3 meters sea level rise, large measures will be necessary. During the interview, Pieter Otten and Job van Dansik named an idea to create a new dune in front of the current coast. For this measure huge amounts of sand will be needed.

F.1.2. Structured Interview

The questions and answers are indicated below.

Question: At the coast of Scheveningen the policies and interests of the waterboard, municipality and Rijkswaterstaat meet. What is the saying of the waterboard (Delfland) in this area?

Mail Answer: Delfland is the authorised supervisor for the water defences at the coast. Rijkswaterstaat has supervision over the management of the beach and the sea. At the beach the governmental organisations overlap. The waterboard also forms requirements for temporary and yearly construction at the beach, since they can influence the Water defences. The municipality and the province manage the spatial planning. Which contains things like environmental goals and buildings for recreational purposes. This is not the direct purpose of the waterboard but they can give certain requirements for the buildings and activities. e.g: if the municipality makes a spatial planning it does not directly mean that it satisfies all requirements of the

waterboard. For Delfland it is for example important that aeolian sand transport is not obstructed since this is important for the increase in Dune strength.

Question: Who makes the decisions?

Mail Answer: When it is about water safety the waterboard makes the decisions, these can be found in waterschapsverodeningen and the legger. The municipality manages the spatial planning of the area. They can make a decision which is in contradiction to water safety measures. The decisions should be discussed with the waterboard, but when decisions are not in line there is the possibility to object. In court the Raad van State determines (in most severe cases) if the municipality met the water safety requirements.

Sub-question: How are responsibilities arranged?

Interview Answer: Delfland is responsible for the sea defence systems and spatial planning support in cooperation with the municipality of The Hague.

Question: Does the waterboard help with the development plans of The Hague?

Mail Answer: Delfland is involved with a role as water manager. So Delfland considers which measures in spatial development are possible, while the primary sea defence still meets its requirements. In this way the water safety is safeguarded and constructions to increase the strength of the sea defence stay possible in the future.

Question: The Amrâth Kurhaus is situated in front of the sea defence border. For rivers a higher risk of exceedance is applied in front of the sea defence border. Is this also the case for the area around the Amrâth Kurhaus?

Question: If yes: what is the chance of exceedance?

Mail Answer: For the Amrâth Kurhaus no chance of exceedance is applied. As a Waterboard we maintain and manage the sea defences, it is not our duty to protect the area in front of the sea defence line.

Question: if not: why is this area located in front of the sea defence border.

Mail Answer: The Amrâth Kurhaus is situated on a dune which is part of the sea defence. The safety at a dune comes from the possibility that during extreme high water situations the sand can be taken by the sea. The dune on which the Amrâth Kurhaus is situated is designed to lose this sand to protect the hinterland against flooding. Since the Amrâth Kuraus is situated in the area where sand can be taken by the sea (''afslag-zone") the area is located in front of the sea defence border(''buitendijks"). From a water safety perspective it would be preferred to locate the sea defence border in front of the Amrâth Kurhaus. This is not an option since there is/was no space between the Amrâth Kurhaus and the current coastline, the height of this area (''maaiveld") is too low.

Sub-question: So the dike in fornt of the Amrâth Kurhaus is not a hard construction?

Interview Answer: The sea defence at the Amrâth Kurhaus is labeled as a dune not a dike. Dike is a hard protection Dune is a soft protection The buildings on the dune are not designed to prevent sand movement to the sea during a storm surge. The sea defence can be described as a sand dune with buildings on top.

Question: How does Delfland think the future of coastal defence systems will develop?

Mail Answer: Currently an exploratory research has started about water safety in the future. Increasing the current level of the dune in Scheveningen is very hard since buildings are situated on the dune. Economically it will probably not be possible to lift or break down the current buildings. It is preferred to increase the water safety with nourishments, since sand can grow with the requirements of water safety. If the municipality and civilians also agree on this method is unknown for now. There could become an extra barrier between the boulevard and the sea. Therefore negotiations with the municipality and civilians will be necessary. For now the coastal defence system meets the requirements, but since it is a highly complex problem stakeholders of different parties should be involved early on. In specific the municipality since they make the spatial

planning.

Question: Are there weak spots according to Delfland along the coast of Scheveningen? If yes, were?

Mail Answer: Currently there are no weak spots along the coast of Scheveningen. The water defences all satisfy the norms from the government.

Question: What would be a weak spot in the future?

Mail Answer: In the future Westduinweg would probably not meet the safety criteria. An other location which might not fulfill the safety criteria in the future is the Morales boulevard.

Sub-question: The area around the Amrâth Kurhaus is not a weak spot in the future?

Interview Answer: When sea level rises at some point all safety defence mechanisms in Scheveningen will not satisfy the safety norms anymore. The first spots which would not satisfy these safety norms are the Morales Boulevard and the Harbour. As explained before besides a failure of the dune also dune erosion is important to take into account. The Amrâth Kurhaus could find serious damage due to erosion while the dune still satisfies its safety requirements.

Question: Is it possible to keep the BKL in the future?

Mail Answer: Yes this is possible. Keeping the BKL is a duty for Rijkswaterstaat. When in the future the Dune would be widened the BKL line will be moved seaward.

Sub-question: Is the BKL shifted seaward after constructing the Morales boulevard?

Interview Answer: The BKL is moved seaward to fulfil the water safety norm during the construction of the Morales boulevard.

Sub-question: Is this the reason why a landward trend is shown for the MKL at Scheveningen [15]?

Interview Answer: no, this is because of erosion. At this location extra nourishment will be needed. It is not known by Pieter Otten or Job Dans that there is more erosion at Scheveningen then other places along the coast.

Question: Does delfland want to maintain the BKL at all cost or do you also consider other solutions?

Mail Answer: This is the responsibility of Rijkswaterstaat. If Delfland finds it necessary to shift the coast-line to increase safety, Delfand is going to negotiate with Rijkswaterstaat. In the past this happened with the Morales boulevard. The BKL was then moved seaward.

Question: How will the sea bed change in the future?

Mail Answer: In current policy the sea bed (till NAP -20m) has to grow with sea level rise. Rijkswaterstaat is doing a study (kustgenese 2.0) if the entire area till NAP -20m has to rise with sea level increase.

Question: Are there reports which explain how Delfland satisfies the water safety norms?

Interview Answer: Yes the policies are written down in: Tussen notitie kust [8]
Beleidsregels Medegebruik zeewering [17]

Question: The boulevard in front of the Amrâth Kurhaus is situated approximately at +6.5m NAP. At the boulevard a large hospitality industry is located. Does Delfland take this into account in there safety policy?

Interview Answer: The restaurants and other hospitality industries take a increased risk to loose their property during a storm surge. The owners are familiar with this risk and did sign papers that they accept the risk. The norms for areas in front of the sea defence can be found in the report "Tussennotitie kust".

Question: Besides the boulevard also many restaurants can be found on the beach. Is it possible that those hospitality industries can't stay in the future?

Interview answer: There are no plans to chance the current policy.

Question: To which failure mechanisms are sea defences tested?

Interview Answer:
Look up at the Hydraulic requirements indicated in Beoordelingsinstrumentarium (WBI).

F.2. Municipality of The Hague

Date	06-08-2020
Time	9:00
Interviewed employer	Arno Segeren & Mena Kamstra

The current update statement of our area analysis gave the municipality of The Hague insight in what we are doing and it also provided them with new information such as that the Amrâth Kurhaus is built on a Dune. After that we had a couple of questions based on our current findings, as well as how to continue the MDP when the project analysis has been finished.

F.2.1. Structured Interview

The questions and answers are indicated below.

Question: What are the different responsibilities in Scheveningen in terms of protection against sea water between Delfland, Rijkswaterstaat and municipality The Hague?

Answer: This was a difficult question to answer for the municipality as it was also unclear for them and really depends on the location and what kind of structure was considered. However they would like to see in the stakeholder analysis a separation between these governmental bodies. Also it is maybe interesting to look at how licenses are being approved for water defense structures as this gives you better insight into how roles are separated.

Question: What are important factors to consider for the municipality of The Hague?

Answer: The Amrâth Kurhaus has a big economical impact, important with spatial planning and is important as a city sight for Scheveningen. The municipality of The Hague focus mostly on the economical benefits, spatial planning and wealth for their citizens in the area. A part of their income comes from the restaurants that will be benefited from the tourists visiting the beach. This means that this economy should always be located close to the beach as it otherwise will decrease the income of those restaurants. As the defense coast of Scheveningen exists out of different structures it is difficult to determine for each scenario each soft or hard defense system what would you value as important you would like us to focus.

The Middenboulevard where the Amrâth Kurhaus is located as this part of the coast is an important part of the city sight of Scheveningen.

Question: There are different scenarios calculated by the KNMI in terms of sea level rise; the maximum of those sea levels is for a 1m rise in 2100. Is this the long term vision you want us to consider as well or do you prefer a more uncertain scenario, like what Delfland is doing such as 2 meter or 3 meter sea level rise?

Answer: For us it is important that we can work towards a plan in the future. If the sea level rises quicker or higher than the KNMI has predicted we need to prepare for it. Meaning that a quicker response towards a 1 meter sea level rise or considering a 2 meter sea level rise is preferable. A 3 meter sea level rise is a bit too pretentious and the whole coast of the Netherlands should then be considered, this is not interesting for us at the moment.

Question: As stated in our project plan we initially are not taking any contact with potential stakeholders only if the municipality of The Hague allows this. Would it be possible for us to meet with other stakeholders such as Rijkswaterstaat, Amrâth Kurhaus, Deltares and the Pier?

Answer: Yes it is possible to meet with these stakeholders if they want to be interviewed. We can try to bring you in contact with them.

Email of the contact person of Rijkswaterstaat: dick.visser@rws.nl

Contact information of other stakeholders will follow. It might be difficult to get into contact with the manager of the Amrâth Kurhaus as their focus is now on providing service to tourists and increase their revenue after the lockdown due to the COVID-19 pandemic

Question: Delfland has informed us that signing up on having your restaurant on the beach is at your own risk of flooding and is something that should be accepted. What is your opinion about this?

Answer: As economy and citizens are of great importance to us we do not want any of this to ever happen as it will have a big impact on our economy as well as the trust citizens and business owners have in us.

F.3. Delft University of Technology

Date	07-08-2020
Time	9:00
Interviewed employer	Jeremy Bricker Associate Professor

During the research we wanted to get in touch with a coastal engineer to get more insight in shoreline retreat processes. Furthermore we wanted to check if the "Bruun Rule" could be applied to get an idea how far the shoreline would retreat for 1,2 and 3 meter sea level rise. Jeremy Bricker from the TU delft helped us to answer these questions. Jeremy Bricker is a hydraulic and coastal engineer focused on the applications of fluid mechanics to engineering design.

F.3.1. Structured Interview

The questions and answers are indicated below.

Question: Can we use the Bruun rule for the coast in Scheveningen?

Answer: It is a good first step to use the Bruun Rule to get an idea how the shoreline retreats.

Question: How can we make an estimate what happens when the sea level rises 1 2 or 3 meters? Can we make a map and use the current coast line and how far does the dune retreat?

Answer: That is reasonable. As a rule of thumb the shoreline retreats is 70 meter for one meter sea level rise.

Question: How to cope with longshore transport (erosion), since this is not taken into account in the Bruun rule. Has sea level rise effect on the longshore transport?

Answer: Only affected if the slope or the direction of the wave changes.

Question: What is the effect of climate change?

Answer: Storms in the North Sea will change. But how the storm will change is not my expertise. Try to use helpdesk and waterandhydra.nl or use google and search for north sea storm.

F.4. Interview Rijkswaterstaat

Date	13-08-2020
Time	13:00
Interviewed employer	Rinse Wilmink

The person that we spoke with during the interview was Rinse Wilmink, he works for Rijkswaterstaat as a senior advisor for the department coast, river and sand transport. He finished his study 5 years ago at "University Twente" as coastal engineer and is till now working for Rijkswaterstaat. Rinse is now focusing on the knowledge development about his expertise.

F.4.1. Open Interview

After the introduction about us and himself, we talked about the general circumstances of the Amrâth Kurhaus area and how Rijkswaterstaat is involved in this area. Rinse started with explaining that on request of the Dutch politics, that Rijkswaterstaat should do research about 3 till 5 meter sea level rise. This has been requested due to a well known scientific paper that causes agitation. Moreover, Rinse explained that the Amrâth Kurhaus is located in an area which is meant for dune erosion during a normative storm. Also he explained that the boulevard is designed in a way that the boulevard can be eroded during a normative storm to protect the dune against further storm impact. During the interview Rijkswaterstaat also indicated that the expected wave conditions in the future will not change. At the end Rinse recommends us to use a model called MorphAn. With this model dune erosion at the Amrâth Kurhaus can be determined.

F.4.2. Structured Interview

The questions and answers are indicated below.

Question: Three parties (municipality of The Hague, waterboard Delfland and Rijkswaterstaat) are involved around the coast area of Scheveningen. Who is responsible for what around the coast of Scheveningen?

Answer: According to Rinse, the waterboard of Delfland is responsible for the flood defence, the maintenance of the coast is the responsibility of Rijkswaterstaat and the development of the area is the responsibility of the municipality of The Hague.

Question: How does Rijkswaterstaat maintain the coastal safety?

Answer: The MKL needs to satisfy the BKL, otherwise nourishment should be applied. If the combination of BKL and flood defence does not satisfy and the flood defence can not improve, an option is to move the BKL seaward.

Question: How does Rijkswaterstaat thinks about the future coastal defence of Scheveningen? What kind of protection measures does Rijkswaterstaat want to apply in the future?

Answer: There is no solid plan for now. In the current policy the shoreline needs to grow with the sea level rise with help of nourishment. Nourishment has often a promising effect on the dune. However, at the area of the Amrâth Kurhaus, where traditional sandy dunes are covered with buildings. Nourishment will not improve the dunes at this location. According to Rijkswaterstaat, nourishment could become more difficult when sea level rises more than 1 meter. The volume of nourishment will increase with sea level rise and therefore the cost of nourishment will also increase. which could make it financially not attractive anymore. Solution could be: moving the BKL landward and improving hydraulic structures.

Question: What type of flood defence is the Amrâth Kurhaus located on? Is it a dune or a primary dike?

Answer: According to Rijkswaterstaat, the Amrâth Kurhaus is located at a dune. And the boulevard in front of the Amrâth Kurhaus is designed for dune erosion.

Question: The maintenance of the BKL is a duty of Rijkswaterstaat. Is the current BKL sustainable in the future?

Answer: Nourishment is a very successful method for improving the dunes. However for the foreshore this is less the case. It takes longer to get the foreshore resupplied. Moreover, it results in a slope of the bathymetry. Beside, a lot of sediment is moving to the Wadden Sea. This is caused by the construction of the Afsluitdijk. However, the BKL will not change during the current circumstances. It is also not very common to move the BKL seaward, but this could be a solution. For now there is no plan to move the BKL in the future.

Question: Is there enough sand available in the North Sea to maintain the coastline?

Answer: According to Rijkswaterstaat there is enough sand available for the upcoming century. The Netherlands has his favor that there is enough sand, not everywhere in the world is this the case. The dutch government is thinking about expanding their wind park in the North Sea during this century. Therefore, the potential area for dredging sediment used for nourishment will decrease. However, according to Rijkswaterstaat this could be solved by good planning. The life expectancy of a wind park is approximately 50 years. If we can build this wind park somewhere else after 50 years life expectancy. We can dredge the sediment from the former wind park. Rijkswaterstaat is not making the decision which area should be dredged for nourishment. The decision is made by different dutch ministries.

Question: Does the coastline erode faster due to climate change?

Answer: Erosion increases with sea level rise. Therefore, the volume of nourishment will also increase. If the sea level rises the coast should also increase with this sea level. According to Rijkswaterstaat there is 12 million cubic meter per year nourishment needed to compensate for an 18 centimeter sea level rise per century. However, since for some reason the sediment is less transported, the current volume of nourishment that is needed, is 7 million cubic meter per year.

Question: Will subsidence be taken into account with sea level rise?

Answer: The answer is yes. Rijkswaterstaat is focusing on relative sea level rise, which means that subsidence will also be taken into account. However, the subsidence in Scheveningen is not significant.

F.5. Project developers of the Pier

Date	10-09-2020
Time	17:30
Interviewed employer	Nikander Hartemink (Real estate manager)

Erosion of the coast is already playing a part in Scheveningen for quite some time. Rijkswaterstaat prevents the coast from eroding by using nourishment. However, with increasing sea level rise this method would not become the most efficient method to use and other methods are needed. The Pier is located on a level sufficient enough not to worry about sea level rise yet. At the Pier there are different facilities such as bars and food tents. Also does the Pier contain sport facilities and activities.

F.5.1. Structured Interview

The questions and answers are indicated below.

Question: How do you see the future of the Pier and the role it is playing in the tourist industry of Scheveningen? Are there things you would like to see changed at the Pier and the coast of Scheveningen?

Answer: Well we want to attract more customers towards the Pier by becoming more interested for a wider public. One of the downfalls at the moment is that the part at the boulevard between Amrâth Kurhaus and the Pier, the current shops don't attract many customers and therefore don't walk up to the Pier. There are renovation plans already to create more shopping facilities there. In our opinion this measure will bring more customers to the Pier. One of the problems is that the Pier was built with a life expectancy of 50 years and we are already 10 years over that. There are thoughts about constructing a new Pier but maybe this would be expensive and a major renovation would be the best solution. If we are allowed to continue operating the Pier there are some ideas we are thinking about to facilitate such as a hotel, housing, congress space and museums.

Question: Did the Pier have problems with finding investors and what would you think is the issue?

Answer: Right now the Pier is fully operational but indeed in the past the Pier went bankrupt three times. This mainly had to do with underestimating maintenance and only focusing on a particular part of the customers. We try to make the Pier interesting to a variety of customers to prevent this problem.

Question: Is the Pier a more attractive place for investors than the boulevard or beach?

Answer: Due to the fact the Pier is so high located compared to the rest of the beach and boulevard you have a more gorgeous view over the coast. This attracts a lot of customers however one of the downfalls is that not everyone accesses the Pier as the interesting shops and restaurants are more located towards the Amrâth Kurhaus. The shops in between Amrâth Kurhaus and the Pier do not attract many customers and therefore withhold some of them accessing the Pier. However there are new parking facilities nearby and there is a plan to realize new shopping facilities at that part of the boulevard. Over time the Pier will become a more interesting place for investors when more tourists access the Pier we believe.

Question: We have been thinking about several protection measures against sea level rise of Scheveningen where one of them would be using the Pier as a wave breaker or for example widening the coast. Would this cause any issues you think with the attraction of customers?

Answer: Well we do not see much potential in this plan but that does not have to do with the fact it will attract less customers but we have done an investigation at Deltares about extending the pier. However, Rijkswaterstaat has indicated that any construction work should not block the sediment transport of the Sand motor as it is an important investigation for future coastal defense strategies as well. Furtehrmore, a new extension or any new facilities constructed at the Pier should be done in close cooperation with the local inhabitants. As Scheveningen originates from a fishing village and everyone knows everyone. Therefore local inhabitants want to be involved in any new development of construction work done in Scheveningen as possible.