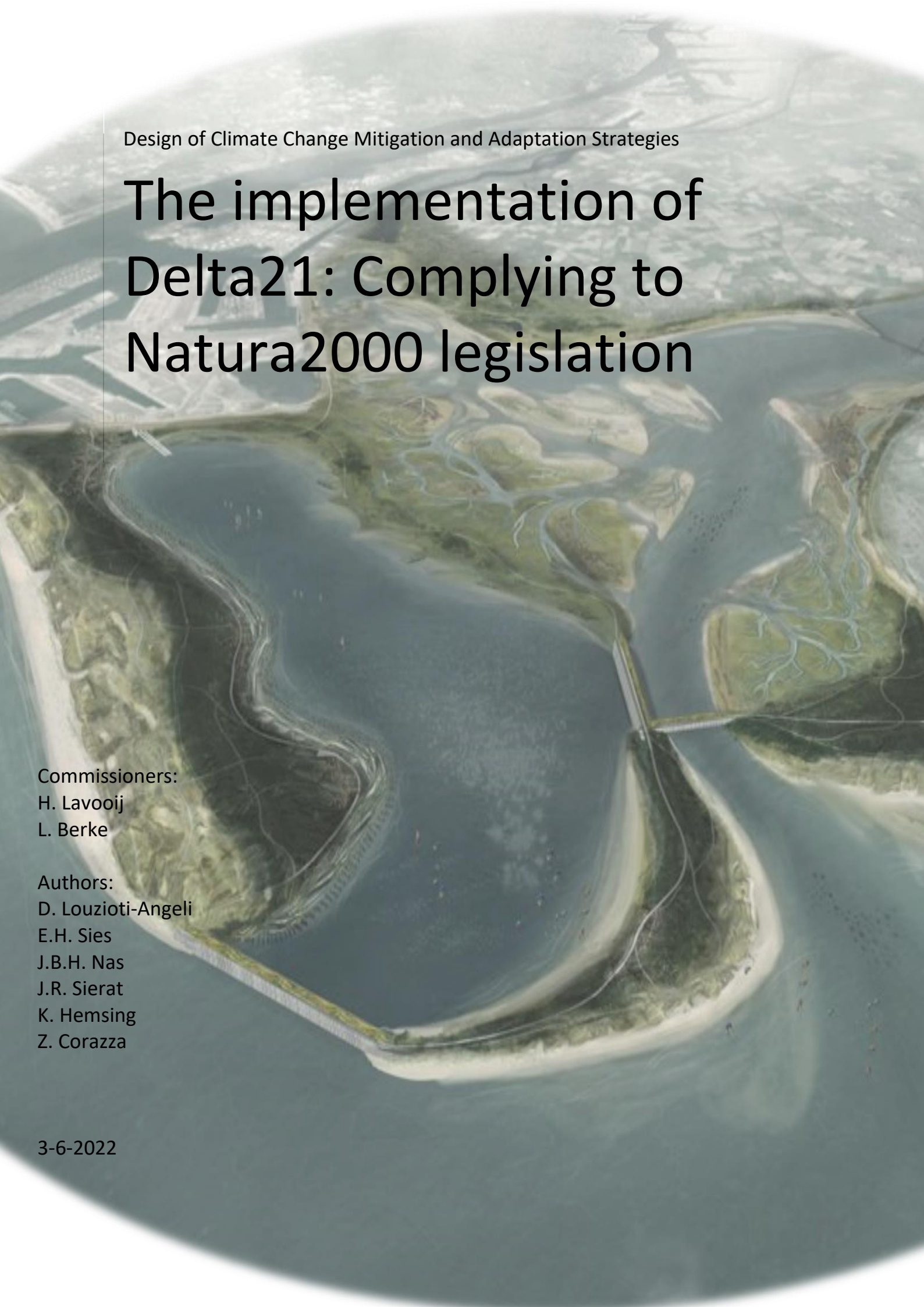

Design of Climate Change Mitigation and Adaptation Strategies

The implementation of Delta21: Complying to Natura2000 legislation

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3-6-2022

Preface

This report is created by six students of Wageningen University as part of their master's program, Figure 1. The goal of the ACT course is to bring theoretical knowledge and experience together in this real-life situation. The real-life situation is based on the implementation of Delta21. Delta21 is a project that focuses on water safety, energy storage and nature conservation in the Voordelta, which is a protected area. The challenge is to implement the project following the Natura2000 legislation. The project aims to investigate how Delta21 fits into the Natura2000 legislation.

The group contains a diverse knowledge base as each student has their speciality.

- Janey Sierat (Project leader): Master Climate Studies, Specialisation Water and Climate management
- Karlijn Hemsing (Contact person): Master Climate Studies, Specialisation climate adaptation and water management
- Danai Louzioti (Secretary): Master Climate Studies, Specialisation in Environmental Physics
- Jelmer Nas (Secretary): Master Climate Studies, Specialisation Climate Adaptation
- Leannah Sies: Master Earth and Environment, Specialisation (geo) hydrology
- Zeno Corazza: Master Climate Studies, Specialisation human-environment interaction & Master in Forest and Nature Conservation, Specialisation Management

Figure 1: The team

We are thankful to the commissioners Huub Lavooij and Leen Berke for providing us with the opportunity to work on this project and the guidance during the project. Special thanks for taking us on a field trip to the research area where we enjoyed a day full of knowledge and joy.

Thanks should also go to our Wur supervisor Emmanuel Attoh for providing us with feedback throughout the project.

We had the pleasure of working with different experts who shared their experience and knowledge with us. Special thanks to Pieter Jong who is a lecturer on Landscape Architecture and Spatial Planning. Pieter Jong pointed us to valuable literature and brought us new insights into the implementation phase.

At last, we would like to recognize the other ACT groups for their peer-review of our project.

Executive summary

1.1 Introduction

Climate change is an inevitable environmental problem of the current century, which has numerous effects on the planet such as biodiversity loss, temperatures increase, extreme events and sea level rise. Sea level rise threatens the Netherlands as 26% of its surface lies below sea level, while the KNMI foresees an increase of 1.2m in sea level by 2100 (KNMI, 2021). Currently, the delta commission almost exclusively uses dike reinforcements and sand supplementation on the coast to guarantee water safety (Jeuken et al., 2021). The Delta21 project aims at increasing flood protection, sustainable energy, and nature conservation. The project will rise at the Haringvliet mouth, and it includes an Energy storage lake, a pumping station, a spillway, and a storm surge barrier. However, the Delta21 will influence four Natura2000 areas: the Voordelta, the Haringvliet, the Voornes Duin, and the Duinen Goeree & Kwade Hoek. Thus, the conservation goals of each area must be considered.

1.2 Aim of the project

The project aims to investigate how the Delta21 project fits in the Natura2000 framework to protect nature in the upcoming decades. The research question of this project is: *"How can Delta21 comply with the Natura2000 legislation and preserve the natural value of the area considering the ongoing morphological dynamics and climate change?"* To answer this question, the following sub-research questions are formulated and framed around the ADC-test, which is needed to comply with the Natura2000 standards.

1.3 Methods

The research is structured in two phases, the orientation phase, and the research phase. The orientation phase included a traditional literature study to acquire the background knowledge necessary to develop the study. The stakeholder analysis can be useful to understand the interests and power dynamics of the different stakeholders. The research phase included a structured literature review focused on Climate change, Natura2000, The Haringvliet mouth and Delta21. Semi-structured interviews with experts on Natura2000 are conducted. The interview is recorded and then transcribed into words to contribute to answering the research questions.

1.4 Results

1.4.1 Challenges of Natura2000 legislation

The largest part of the legislation is on the interaction between humans and nature and the habitat directive specifies which projects can take place in a Natura2000 area. However, many more processes have an impact on the natural value of the area regardless of the Natura2000 goals, such as climate change and morphological dynamics. Preparing for the future means having more dynamic Natura2000 goals in terms of natural processes and the human response to these processes.

1.4.2 A – Alternatives

To the authors' knowledge, the alternative to not implementing Delta21 is to leave the area as currently managed. The Voordelta has been in constant morphological change due to the alteration of the natural processes by human intervention, due to the construction of three infrastructures in the past: The Haringvliet in the 1960s, the Maasvlakte I in the 1980s and the Maasvlakte II in 2010 (van der Spek & Elias, 2021). First, the Maasvlakte I and II sheltered the Voordelta, leading to the siltation of the Hinderplaat and the siltation and expansion of the Slikken van Voorne. Resulting in the Slikken van Voorne becoming a suitable nesting place for coastal birds. Second, the Haringvliet locks caused a decline of most catadromous and anadromous species that used to populate the area. Next, sea level rise is going to influence the Hinderplaat and the current projection foresee an increase of

+1.2 m by 2100 (KNMI, 2021). The sandbanks have a height between NAP +0,7/0,9 m, which makes them likely to be submerged even during low tides due to sea level rise. Lastly, the Hinderplaat is also moving landward which will continue for roughly 30-40 years until the sandbanks will disappear

1.4.3 D – Imperative reasons

Results show that Delta21 includes four of the imperative reasons identified by guidance art.6 (European Commission, 2007).

First, for water- and public safety Delta21 offers an emergency water storage of 10,000 m^3/s of water, which can be pumped back into the sea. When closing the Measlantkering and using Delta21 it would take fifty hours before the area within the dikes is in danger.

Second, there are multiple beneficial consequences for the environment, like the dunes surrounding the energy storage lake as their surface can be used to promote biodiversity (Jacquemin, 2021). In addition, the landward movement of the Hinderplaat will be stopped, saving this habitat from colliding with the coast. The "sandbanks" (H1140B habitat) will change in favour of the "silt and sandbanks in the intertidal area" (H1140A habitat). This will not be favourable for seals as they will not be surrounded by water, but it can be favourable for the development of grasses, fishes, seagrasses, birds, worms, crustaceans, and mussel species. Slikken van Voorne is expected to increase in size with the implementation of the project, due to the area becoming more sheltered from waves (Deltado, 2020). Delta21 could create a new sandbank in front of the estuary with the habitat characteristics of the Hinderplaat and become a valuable area for seals and migrating birds (Ijntema, 2021 & Deltado, 2020). The last beneficial consequence for the environment is the creation of a fish migratory river repristinate the presence of catadromous and anadromous species in addition to adding significant natural value to the Haringvliet (Hoek et al., 2021).

Third, the imperative reasons of economic concerns can be divided into the energy storage lake, flood protection and Regional financial interest. The annual revenue of the Energy storage lake is estimated to be approximately €200 million (Delta21, 2021). Delta21 can replace two conventional power plants due to a generating capacity of 9 GW, thereby contributing 10-15% to the climate agreement. (Delta21, 2021). The current strategy for flood protection is estimated at 7.4 billion euros for 800 km of dikes by 0.8m. With the implementation of Delta21 6.3 billion euros will be saved on dike strengthening by 2100 (Delta21, 2018). The importance of the region of interest is also accounted for activities like recreation, tourism, fishery, and other outdoor activities (Ferguson & Wolff, 1984).

Lastly, the imperative reason of social concerns focuses on the tourism sector. Delta21 can provide an area on the western barrier of the Energy storage lake to decrease the pressure on already existing recreation areas.

1.4.4 C – compensation measures

The challenges, impacts of Delta21 and potential compensation measures are discussed for four habitat types.

Embryonic dunes (H2110) and white dunes (H2120) are threatened by recreation, nitrogen deposition and the potential vegetation succession caused by the inland movement of the Hinderplaat. Delta21 can stop vegetation succession by fixing the Hinderplaat but also reduces salt spray and windspeeds leading to enhanced vegetation growth. For compensation, the focus should be on the sand drift, making rest areas and area expansion on the outer barriers of the storage lake.

Grey dunes (H2130) including moist dune valleys (H2190) are also sensitive to nitrogen leading to the decline of species that thrive under nutrient-poor conditions. Delta21 may increase the nitrogen deposition and again cause unwanted vegetation succession. In compensation, Delta21 can use the outer barriers of the storage lake to restore the dunes and valleys and ensure habitat for the prioritized species: the Norwegian Vole and the *Liparis loesellii* (Groenknolorchis). Also, Delta21 might act as a sand engine for dune areas more north.

Mudflats and sandbanks (H1140) and permanently flooded sandbanks (H1110) are impacted by the Maasvlakte II and the inland movement of the Hinderplaat. The implementation of Delta21 is expected to reduce the area size of H1110 due to the formation of an erosion gully, changes in the tidal range and overlap in locations. For H1440 an increase is expected. In compensation, the study by Rotterdam Harbour on effective compensation measures must be watched. Also, research on the effect of Delta21 on the tidal range is advised.

The estuary is currently non-existent in the area of Detla21. However, the tidal lake can serve as an artificial estuary compensating for what was lost with the closure of the Haringvliet. Ideas on how to realize this concept are listed.

1.5 Discussion

The Natura2000 legislation is a strong juridical framework, valuable for the preservation of the environment. The legislation's initiative to keep the specific characteristics of the protected areas untouched, will not be fulfilled in the long run. However, efforts to state the misfits of the legislation or go against it will not guarantee or support the project's implementation. Therefore, paying too much attention to these weaknesses will not help the realization of the vision. Instead, the focus should be on how to fit in the exceptions of the European regulations and national framework. The ADC-test can facilitate this procedure as it consists of alternative solutions, imperative reasons, and compensatory measures. The A of alternative solutions can be debated as it is not clear what is considered an alternative. The D of imperative reasons can be discussed as it is not clear what arguments are considered compelling. In defining what is of public interest, again different interests play a role. In that context, the extensity and flexibility of the project can provide benefits for many different domains and stakeholders. The C of compensatory measures questions like within what period should nature be compensated, what is the time length of the compensation responsibility if the promised measures are taken, and what is considered as compensation do not have a subjective or clear answer.

1.6 Conclusions

To conclude, the Natura2000 regulation is protecting Europe's nature and biodiversity however, it consists of a static approach and does not always rhyme with the dynamics of nature.
Delta21 will have a significant impact on the area, however, it represents an opportunity to preserve the natural value of the Haringvliet in the upcoming decades. It will save valuable ecosystems such as the Hinderplaat from disappearing. In addition, it will represent an opportunity to increase flood safety at a lower price compared to rising dikes, promoting the energy transition and the local economy. Nevertheless, the project must be able to bring forth well-structured argumentations for the ADC test. This study confirmed that Delta21 has some solid basis to pass the test. However, a specific investigation in each compartment must be done, especially regarding the impacts and compensation measures for each specific habitat type.

1.7 Recommendations

Four recommendations for further research are made. The first recommendation is to make a roadmap, which illustrates the recommended steps in chronological order. A first step is made in this, but a more detailed version should still be developed. Second, additional interviews with ADC experts should be conducted of which a list of questions is already created. Third, a further investigation that focuses both on the quantity and quality of the compensation measures for each Natura2000 habitat should be conducted. Fourth, an investigation on the disappearance of the Hinderplaat due to sea level rise and the role of Delta21 should be conducted.

Table of Contents

1. Introduction

1.1 Climate change

Climate change is an inevitable environmental problem of the current century, which has numerous effects on the planet. These effects include biodiversity loss, temperatures increase, extreme events and sea level rise (Appendix A). The latter is a global issue threatening coastal communities all over the world and in the past decades, the mean sea level has increased by 1.7 mm/year (Murfin and Spiegel, 2020). Nevertheless, this trend is increasing, and oceans are expected to increase by 0.3 m to 1.8 m by 2100 depending on the degree to which our civilization will tackle climate change (Murfin and Spiegel, 2020).

The Netherlands must perform long term planning to decrease its vulnerability to climate change issues. Sea level rise represents one of the biggest threats as 26% of the country lies below sea level (Haasnoot et al., 2020). The Koninklijk Nederlands Meteorologisch Instituut (KNMI) projects a possible sea level of 1.20 m at the end of this century (KNMI, 2021). Currently, the delta commission almost exclusively uses dike reinforcements and sand supplementation on the coast to guarantee water safety (Jeuken et al., 2021). However, this alone does not seem to be a winning strategy in the long term.

Regarding the climate conditions, precipitation patterns and atmospheric moisture are going to change leading to the Netherlands becoming wetter (Beersma et al., 2021). However, drought is going to intensify as well, examples are the summers of 2019 and 2020 which are the 4th and 5th place of the summers with the largest precipitation deficit (Sjoukje et al., 2020). Hence, river discharges are expected to increase seasonal fluctuations, reaching new unprecedented peaks. By 2085, the Rhine discharges could increase up to 40% in winter and 30% in summer. Whereas the Meuse discharges could increase up to 20% in winter and 60% in summer (Klijn et al., 2015). Moreover, the annual flood damages in the municipality of Dordrecht alone are foreseen to increase from a current €0.1 million to €8.1 million by the end of the century (Klijn et al., 2015).

Also, the Netherlands counts approximately 36,000 species of animals and plants, which is 23% of the total European species (Ministerie van Economische Zaken en Klimaat, 2017). Though according to the *Dutch National Dashboard for Biodiversity* (n.d.), the Netherlands has the highest number of endangered species among the European countries. Along with all the European countries the Netherlands also committed to protecting 30% of its land, rivers, lakes, and wetlands by 2030 and most of the habitats have been declared nature reserves. However, animal and plant populations are still decreasing rather than flourishing (van Strien et al., 2016)

Considering this, additional measures must be taken to increase water safety, climate change mitigation and protect nature. One solution to tackle all these issues is represented by the Delta21 project.

1.2 Delta21

The Delta21 project aims at increasing flood protection, sustainable energy, and nature conservation. The project will rise at the Haringvliet mouth and it includes an Energy storage lake, a pumping station, a spillway and a storm surge barrier (see Figure 2). However, Delta21 can have an effect on different Natura2000 area's, namely the Voordelta, Haringvliet, Duinen Goeree & Kwade Hoek and Voornes Duin. Therefore it must comply with the Natura2000 legislation. This represents a challenge for the

implementation of the project but also raises some questions on the Natura2000 legislation and its effectiveness in protecting the constantly changing environment of the Haringvliet. This area is currently affected by human-driven morphological changes, and it will be highly impacted by climate change and sea level rise in the future.

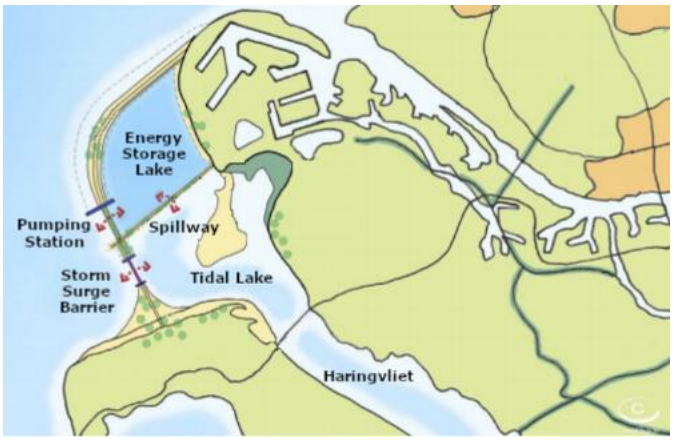

Figure 2: Layout of Delta21. The project includes a Tidal lake, spillway, pumping station, Energy storage lake and a storm surge barrier (Donkers, 2021).

1.3 Natura2000 and ADC-test

Natura2000 is a network of protected areas covering Europe's most valuable and threatened species and habitats (The Natura 2000 Protected Areas Network, 2021). In the Netherlands, Natura2000 is intertwined with the nature conservation act which can be subdivided into habitat and species protection (Ministerie van Economische Zaken en Klimaat, 2021). The art. 6 of the habitat directives state that:

- EU member states need to take measures to prevent the decrease in the quality of their Natura2000 areas.
- Every plan or project needs an impact assessment including conservation goals. This excludes the plans for the Natura2000 area management.
- If a project has a negative impact the ADC-test must be fulfilled. If the area has prioritized habitat or species, only arguments related to human health, public safety, and environmental improvements can be provided.

The last deliberation relates to Delta21 as the project will have a considerable impact on the area. This means that the project will have to pass the ADC-test to be implemented. Before taking the ADC-test, projects should consider three other steps that need to be taken: intern nitrogen net balancing, extern nitrogen net balancing and a passive assessment. According to the European Commission (2007), the ADC-test is formed by three different sections: (Appendix B):

1. Alternative solutions (A): The alternatives to the project must be evaluated. Alternatives refer to both the presence or absence of alternative projects/plans and their consequences on the environment.
2. Imperative reasons (D): *imperative reasons of overriding public interest* are considered as reasons of public interest that justify the implementation of a certain project/plan, regardless of the negative environmental impact. The guidance identifies five imperative reasons: Imperative reasons of social or economic nature, human health, public safety, beneficial consequences of primary importance for the environment and other imperative reasons.
3. Compensatory measures (C): These offset the negative impacts of a project. Thus, they have to be comparable in terms of habitat and species to the negative impacts. Compensatory measures have to be in the same biogeographical region to provide functions comparable to the original site.

Authorities must consider the balance between ecological value affected, imperative reasons and compensatory measures. A project cannot be implemented if it is not able to give adequate arguments to pass the ADC-test. Delta21 will influence four Natura2000 areas: the Voordelta, the Haringvliet, the Voornes Duin, and the Duinen Goeree & Kwade Hoek. Thus, the conservation goals of each area must be considered (Appendix C).

1.4 Aim of the project

Fulfilling the Natura2000 is a basic requirement for the implementation of Delta21. Therefore, this study aims at investigating how the Delta21 project fits in the Natura2000 framework to protect nature in the upcoming decades. The research question of this project is:
How can Delta21 comply with the Natura2000 legislation and preserve the natural value of the area considering the ongoing morphological dynamics and climate change?

To answer this question, the following sub-research questions are formulated and framed around the ADC-test, which is needed to comply with the Natura2000 standards.

1. What are the challenges of the Natura2000 legislation?
2. What are the alternatives to the Delta21 project and their consequences on the area?
3. What are the imperative reasons for the implementation of the Delta21 project?
4. What compensatory measures should be considered if Delta21 is implemented?

1.5 Reader's guide to the content

- Chapter 1 provides the background information on climate change, Delta21 and Natura2000. Then, the research question is formulated, and five sub-research questions are identified.
- Chapter 2 explains the methods used to address the research question.
- Chapter 3 provides the results obtained through the literature review and the interview. This chapter is divided into three sections. Section one addresses the business as usual scenario. Section two explains the imperative reasons for the implementation of Delta21. Section three explains the compensatory measures that the project has to consider.
- Chapter 4 discusses the results obtained according to the ADC-test and it addresses the sub-research questions.
- Chapter 5 provides an answer to the research question and draws a conclusion.
- Chapter 6 provides recommendations for future research.

2. Method

The research is structured in two phases: the orientation phase and the research phase.

2.1 Orientation phase

Preliminary research is needed to acquire basic knowledge for in-depth analysis. In this phase, a traditional literature review and a stakeholder analysis are done. Scientific articles, as well as governmental documents, are studied to acquire the background knowledge necessary to develop the study. The preliminary research is focused on climate change globally and nationally, morphological changes in the research area, the Natura2000 areas and the legislation, and the ADC-test. Then, the stakeholder analysis can be useful to understand the interests and power dynamics of the different stakeholders. The stakeholders are picked based on previous research on the Haringvliet, and Delta21, see Appendix D. During the stakeholder analysis, each stakeholder is placed in the following matrix based on its power and interest (Figure 3).

Figure 3: Stakeholder Analysis Matrix

2.2 Research phase

In the research phase, the answer to the research question is provided through qualitative research. The methods that are used are a structured literature review, an interview, and a societal evaluation report. In addition, an excursion is organized to get insights into the area.

Literature review

A traditional literature review is done to analyse the current knowledge on the topic critically and objectively. Literature from recent years was preferred and prioritized however, due to the specific characteristics of the area of interest some aspects could only be addressed through older research. The literature review focuses on the following topics:

- Climate change: global and national trends of climate change and their implications, as well as adaptation measures that are required.
- Natura2000: the functioning of the Natura2000 legislation and how it tackles climate change and dynamic ecosystems. The goals of the Natura2000 areas are impacted by the implementation of Delta21. Also, the ADC-test is investigated because that is the last resort for such projects to be implemented.
- Haringvliet mouth: The ongoing morphological dynamics and the different habitat types currently present. The consequences of the construction of the Haringvliet locks, the Maasvlakte I and Maasvlakte II.

- Delta21: The impacts that the project would have on the morphology and ecology of the area. The relevance of the project for the local communities and the national economy.

The review is based on the following documents and studies: The most recent IPCC report; the official reports from the Delta21 webpage; governmental documents on climatic trends and Natura2000 legislation; Delta21 reports made by previous ACT groups; thesis projects on Delta21 by the students of the Technische Universiteit Delft; previous studies of the Haringvliet area. The scientific articles are searched on Google Scholar, Research Gate and ScienceDirect, while available ACT reports and thesis projects are searched on Google Scholar and the website of Delta21 (link).

Sequentially, the relevant articles and reports among this vast ensemble were selected and saved in a folder used for the background information the research required. Then those documents were further processed to identify links and combine information to grasp the complete image of the issues present, in a useful for the deduction of results manner. Namely, the content was critically handled and addressed through different dimensions and perspectives. This aims to productively construct the base of the group's reasoning and validate the thinking processes that later formed the results of the project.

Interviews

The interview is held to increase the knowledge and understanding of the Natura2000 legislation. The discussion consists of a semi-structured interview, as this provides a guideline of open-ended questions. Hence, it allows a conversation between the interviewer and expert within a given framework. The interview is held face-to-face to avoid miscommunication (Sahu, 2013). Moreover, this allows improved interaction and communication with the expert. Thus, the interviewer can further investigate relevant aspects that emerged from the interview directly with the expert.

Specifically, experts on Natura2000 are contacted, such as the Rijk. However, due to their availability and the time constraints of this project, only one interview can be organized. The interview is held with an expert on legislation in the Netherlands, Pieter Jong from Wageningen University & Research. The interview is recorded and then transcribed into words to contribute to answering the research questions. In other words, the summary and focus points from the communication are used to fill important gaps in the thinking process of the research. The transcription and the findings are also sent back to the expert to check that the information is correctly described (Appendix E). Lastly, with the approval of Pieter Jong, the remarks are used to support the conclusions of the report's arguments and provide recommendations for future research.

Societal evaluation report

The societal evaluation report is used to expand our knowledge of the societal context of our study and to investigate our position as researchers on the societal issue to which the project relates. First, the main societal aspect of our research problem is identified. Next, our position relating to the societal aspect of the problem and the additional points associated with that are stated. The results have been broad together in a separate report which can be found in Appendix F.

Excursion

The excursion took place at the research area on the 10th of May. It was planned to show the big picture about the issue of implementing Delta21. The location of the excursion is at Oostvoorne and the Kwade Hoek area. The observations and discussions that transpired were used to understand in-depth the information acquired from the literature review. Also, the excursion brought outside the box thinking on compensation measures as well as arguments to facilitate the project's realization.

The qualitative data and ideas were then noted and processed to both be validated and supported through the already gathered and new literature.

3. Results

This chapter describes the qualitative results obtained from the literature review and an expert interview. The results consist of the Challenges of Natura2000 legislation and the ADC-parts, with A-Alternative: business as usual, D-imperative reasons with great public interest, and C-compensatory measures. At last, the added value the project will have on the Natura2000 areas is described.

3.1 Challenges of Natura2000 legislation

As becomes clear from the introduction on Natura2000, the nature conservation law combined with the Natura2000 network plays a large role in land management. However, this juridical framework also introduces some issues.

The largest part of the legislation is on the interaction between humans and nature and the habitat directive specifies, which projects can take place in a Natura2000 area. The impact of these projects is investigated in detail. However, many more processes have an impact on the natural value of the area besides human interventions, regardless of the Natura2000 goals, such as climate change and morphological dynamics. This means that areas that are designated to serve as a specific habitat type might be no longer suitable to hold the same habitat type in the future for example, due to sea level rise. From this, some might conclude that a logical consequence would be changing the Natura2000 goals to fit the new dynamic conditions. However, this is not considered within the current juridical framework. The goal to preserve habitat types contradicts the dynamic character of natural processes and might even lead to nature management and safety measures lagging. A changing climate requires human intervention to limit the changes. However, when human intervention disturbs Natura2000 areas it cannot easily be implemented. Preparing for the future means having more dynamic Natura2000 goals in terms of natural processes and the human response to these processes. In appendix F, more can be read on the ethical discussion on the preservation of dynamic nature.

Besides the internal challenge of the Natura2000 legislation, the legislation also requires projects to complete the ADC-test. However, it is already a struggle to fully understand what the ADC-test asks from a project. Questions that can be asked to come to a better understanding of the ADC-test can be found in Appendix G. The key results of the interview with Pieter Jong are presented below and a more elaborate transcript can be found in appendix E.

To gain a better understanding of the Natura2000 legislation and the ADC-test Pieter Jong suggests looking at reference projects, not only in the Netherlands but also in the rest of Europe as all projects include European regulation, compensation and stakeholders. Projects that used the ADC-test are Maasvlakte II, IJburg, Sand engine and the Kerf. For further interviewing it is advised to interview Rene Vrugt about Maasvlakte II and to interview Hans Woldendorp to gain more information about the Habitat Directive.

The interview also stressed that with good reasoning much can be accomplished. Through compensation, an exception can be made to the regulations. However, the compensation must be planned properly and concrete as in the same area is best defendable. Besides, including stakeholders at the beginning of the thinking process will help to implement the project.

This suggests that although Natura2000 introduces some challenges, the challenges can be overcome. However, additional challenges not related to Natura2000 are mentioned. The political-administrative process should not be forgotten due to its importance in gaining support. If there is no momentum not much will happen. The practical advice given is to make a timeline of the phases that Delta21 needs to go through and decisions that are to be made.

3.2 A – Alternative: business as usual

Results show that the area around the Haringvliet mouth is dynamic. It has been undergoing and will continue to undergo morphological changes. During the research phase, no alternative project to Delta21 could be found. Therefore, according to the authors' knowledge, the current natural dynamics will continue as such in the upcoming decades. Moreover, water safety will be tackled with dike strengthening. Hence, a business-as-usual scenario. The result from this section is the changes that will happen in the area considering the business-as-usual scenario.

The Voordelta has been in constant morphological change since the creation of the Haringvliet locks. The closure of the delta has drastically reduced the river discharges, altering the tidal currents. As the inlet was closed, the tidal movements started modifying the Hinderplaat. (Figure 4). High tides transport a greater amount of sediments into the delta than low tides can bring out.

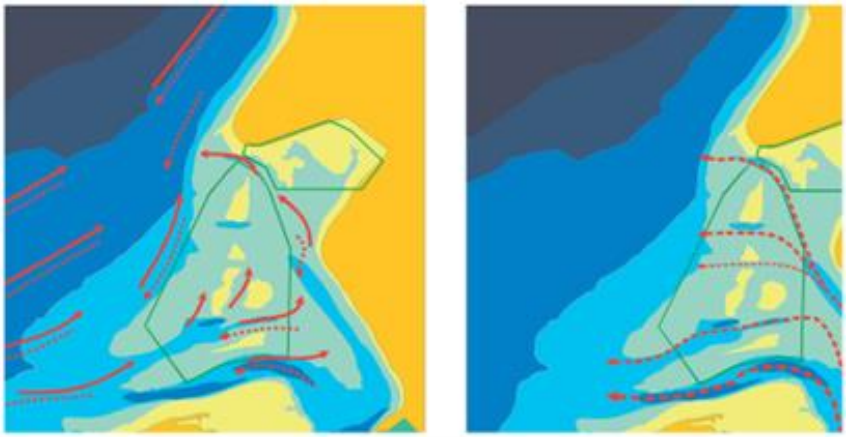

Figure 4: Overview of the tidal currents. Right: Freshwater flow with the opening of the Haringvliet locks. Left: Saltwater movement in the delta. Solid arrows represent high tide, dashed arrows represent low tide (Deltado, 2020).

Resulting in the ebb-tidal delta eroding while the eastern side has been silting up. This has been promoted with the creation of the Maasvlakte I and Maasvlakte II, which sheltered the Haringvliet mouth. The area close to the shoal laying above -2.2 Normaal Amsterdams Peil (NAP) increased from 6 km^2 to 16 km^2 between 2001-2012. At the same time, the Hinderplaat has decreased in width and increased in height and length (van der Spek & Elias, 2021). In conclusion, the Hinderplaat is migrating landward (Figure 5) at an average rate of 30 meters per year for the northern part and slower for the southern part (Kater et al. 2007). This process will continue for roughly 30-40 years until the sandbanks will disappear becoming a part of the coast (Arcadis, 2022). According to Arcadis (2022), the siltation of the Hinderplaat is not expected to create new habitat types. However, the Groene Punt could become more influenced by wave dynamics and salt spray. Mudflats and salt marshes might increase, and a new primary dune valley could arise. Nevertheless, the sandbanks are going to become part of the coast and the future habitat might require management efforts and costs (Arcadis, 2022).

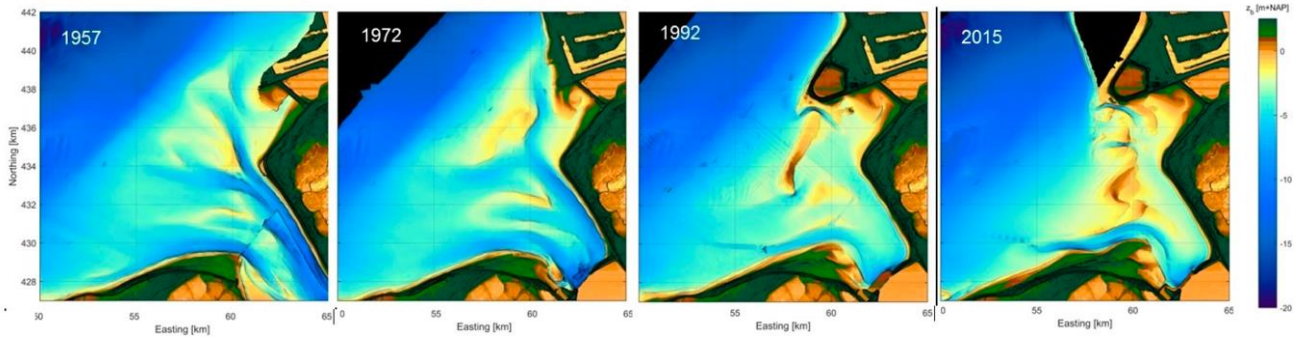

Figure 5: Landward migration of the Hinderplaat. Overview from before the Haringvliet's closure (1957) and after (1972-2015) (Piña, M. I. Z., 2020).

The Slikken van Voorne is not expected to decrease in natural value during the upcoming decades. The Maasvlakte I and Maasvlakte II have promoted siltation and expansion of the Slikken van Voorne. Hence, it has become a suitable nesting place for coastal birds. The Hinderplaat evolved from just a resting place for seals and cormorants to an important intertidal area also for ducks and waders (Arts et al., 2016). These sites are among the five most important resting sites in the Netherlands for migrating birds, as they are the most northern site in Voordelta where birds can rest during migrations (Arts et al., 2016).

The business-as-usual scenario could entail a risk to the restoration of fish migration. The Haringvliet is an important site for fish migration and reproduction. However, the Haringvliet locks created a physical barrier to fish migration and a net separation between fresh and saltwater, eliminating the brackish ecosystem of the estuary. Moreover, it reduced the tidal movements drastically, which influence relevant ecosystem factors (Nienhuis, 2008). This has led to the decline of most catadromous and anadromous species that used to populate the area before the Haringvliet locks were built. While catadromous and anadromous species have struggled with the creation of the locks, freshwater species such as the zander (*Sander lucioperca*) have been able to colonize the Haringvliet (Hoek et al., 2021). Therefore in 2018, the Kierbesluit was found which consists of the opening of some locks during rising tides to restore fish migration. However, the efficiency of this measure is still discussed and according to Bas Roels from Wereld Natuur Fonds, a permanent brackish zone for foraging and reproduction is not yet formed (Wesseling, 2021). Hence, fish migration is still not being restored and the Kierbesluit could be not a sufficient measure for the future.

Sea level rise will impact the depth of the water column unless sedimentation goes as fast as sea level rise (Arcadis, 2022). Arcadis (2022) claim that this is likely to happen until 2050. Afterwards, the increase of the sea level might prevail over the sedimentation, increasing the water depth. Sea level rise is also going to influence the Hinderplaat and the current projection foresee an increase of +1.2 m by 2100 (KNMI, 2021). However, greater increases up to +2.0 cm are also possible. Nevertheless, such an increase in the sea level rise will impact the Hinderplaat. The sandbanks have a height between NAP +0,7/0,9 m with constant morphological changes (van der Spek & Elias, 2021). Nowadays, the shoals are flooded with high tides and emerge with low tides. In the future, they are likely to be submerged due to sea level rise even during low tides. Different scholars suggest a non-linear interaction between tidal movements and sea level rise, meaning that is not simply possible to add the average sea level rise to the current tidal amplitude to understand the future sea level fluctuations (Khojasteh et al., 2021; Khojasteh et al., 2022; Pickering et al., 2017). Nevertheless, there is agreement that the increase will lead to higher sea levels also during low tides compared to the current level. Hence, the Hinderplaat and its natural value are at risk of declining.

To conclude, the Hinderplaat is protected by Natura2000 as it has a great natural value. However, the shoals are going to disappear in the upcoming decades due to morphological changes and future sea level rise if the approach remains as business as usual. Hence, birds and seals will not be able to live on the Hinderplaat leading to the loss of biodiversity. The Arcadis report (2022) claims that some of the existing habitats could expand; however, it gives no assurance, and they would come at the expense of the great natural value of the Hinderplaat. Moreover, Arcadis (2022) claims that the mudflats, marshes, and primary dunes would require great management effort for their maintenance. Therefore, it is necessary to act now to preserve the great natural value of the Hinderplaat as one of the most important resting sites in the Netherlands and achieve the goals of Natura2000 to protect and preserve nature.

3.3 D - Imperative reasons with a great public interest

Results show that Delta21 includes four of the five imperative reasons identified by guidance art.6 (European Commission, 2007), namely: Beneficial consequences of primary importance for the environment, imperative reasons of social or economic nature, water- and public safety. This section will address each of the imperative reasons in detail.

3.3.1 Water- and public safety

In the current situation, the water barriers can offer enough public safety by withstanding an impoundment of the sea by 4.5 meters. However, if the barriers are closed for a long period and there is a high river discharge at the same time, then there is a risk of flooding from the river side. Besides water barriers, dike strengthening is currently also used for water safety. Dikes have a high risk due to the complex management of hundreds of kilometres. Dikes have heterogeneous subsoil and conditions that make them high-risk objects. Delta21 is choosing a central approach to increase water- and public safety. The main public safety related to the implementation of the project is water safety. Delta 21 will increase public safety in the inland area by improving flood protection. There are two scenarios when the Tidal Lake and Energy storage lake are being used for water safety in the Delta21 project: (Delta21, 2018).

1. During extreme weather events, but without impoundment of the sea.
2. During the sea level rise, with or without high river discharge.

The extra quantity of water needs to be held, stored and drained out of the urban and rural areas. Flood events cause a decrease in quality of life and public safety, especially in downstream areas. Mainly the areas of Dordrecht and Rotterdam are at risk in case of extreme weather events with river discharges of >5,000 m^3/s combined with the closure of the Maeslantkering. In case of extreme weather events, the water is drained into the Tidal Lake and Energy storage lake. This way, the Delta21 prevents the water level at Dordrecht and Rotterdam from exceeding +2.5 m NAP. The objective of Delta21 is to manage the water level in the downstream area as low as possible (Delta21, 2018).

Delta21 offers the administrators a large control facility, which makes the further raising of the dikes unnecessary and reduces the risk of flooding. The Energy storage lake can store 10,000 m^3/s of water and can pump it straight into the sea. Even if the Maeslantkering is closed, the water level at Dordrecht would rise less than four centimetres per hour. Combined with Delta21 it would take another fifty hours before the area within the dikes is in danger.

3.3.2 Beneficial consequences for the natural environment

Delta21 offers to create an area with high natural value. The dunes surrounding the energy storage lake will be between NAP -5 m to NAP +10 m and their surface can be used to promote biodiversity (Jacquemin, 2021). Vegetation can develop on the highest part of the dunes, while sand dunes will prevail closer to the sea level. Nevertheless, there is the need to calculate the exact surface available to nature.

Next, the project will stop the landward movement of the Hinderplaat, saving this valuable habitat from colliding with the coast. However, the Hinderplaat will silt up becoming like the Slikken van Voorne, because waves will not be able to access the tidal lake due to its narrow inlet. Consequently, sand will be deposited on the outer part of Delta21 and only silt will enter the tidal lake due to its lighter mass.

The “sandbanks” (H1140B habitat) will change in favour of the “silt and sandbanks in the intertidal area” (H1140A habitat). This will not be favourable for seals as they will not be surrounded by water, but it can be favourable for the development of grasses, fishes, seagrasses, birds, worms, crustaceans, and mussel species (Deltado. ,2020 & Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2008).

Moreover, it must be remembered that without Delta21 the Hinderplaat as currently known will disappear as it is collapsing to the coast.

Delta21 will likely increase the nature value of Slikken van Voorne. Both Deltares and Svašek Hydraulics claim that the Slikken van Voorne is expected to increase in size with the implementation of the project, due to the area becoming more sheltered from waves (Deltado, 2020). The Slikken van Voorne is used by different species of waders, and it is of great natural value as other resting and foraging areas are declining (Rijkswaterstaat, 2016).

Delta21 will also impact the sand deposition in the area and its morphological development. It could create a new sandbank in front of the estuary (Figure 6) with the habitat characteristics of the Hinderplaat and become a valuable area for seals and migrating birds (Ijntema, 2021 & Deltado, 2020).

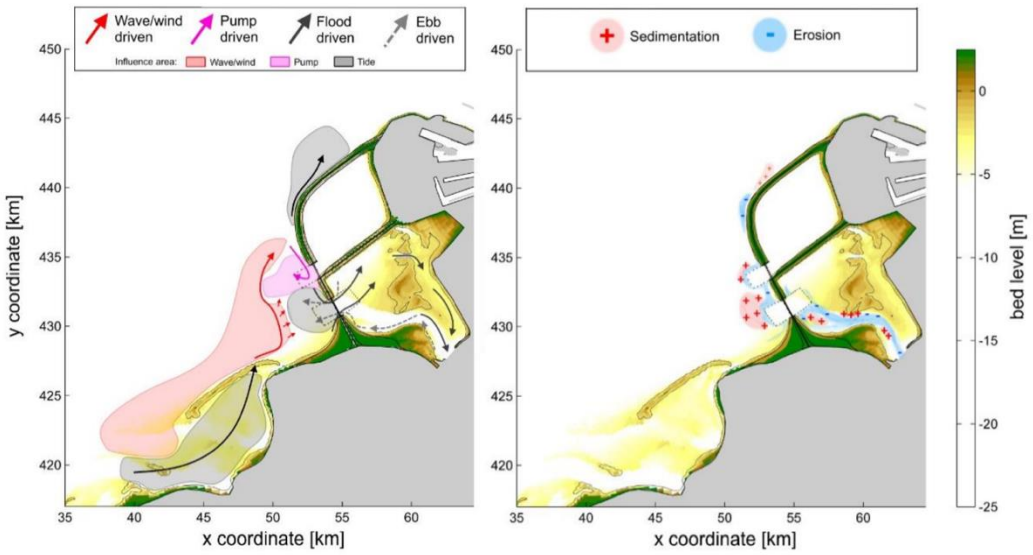

Figure 6: Sedimentation and deposition dynamics after 0 and 5 years from the implementation of Delta21 (Ijntema, 2021).

The project represents an improvement in fish migration. The fully opening of the Haringvliet is unlikely to happen as salt intrusion would impact the inland industry (Hoek et al., 2021). Therefore, Delta21 offers to include a fish migratory river to repristinate the presence of catadromous and anadromous species in addition to adding significant natural value to the Haringvliet (Hoek et al., 2021). These species include the European eel (*Anguilla Anguilla*), European Flounder (*Platichthys flesus*), Twaite shad (*Alosa fallax*), Atlantic salmon (*Salmo salar*), Atlantic sturgeon (*Acipenser sturio*) or the European river lamprey (*Lampetra fluviatilis*) (van Emmerik, 2016). Finally, the fish migratory river could improve the effectiveness of the Kierbesluit.

3.3.3 Imperative reasons of economic nature

The Delta21 project will have a significant contribution to the local and national economy and goals. The benefits of Delta21 concern 2 things. First, by changing the current policy of heightening the dikes financial resources will be saved. Next, revenue will be generated by the energy production, while taking the country one step closer to achieving its goal of sustainability. In addition, with the implementation of the project and the natural value of the area increasing, the creation of opportunities for activities like ecotourism will flourish. All those factors foresee important economic benefits and high interest for the region from the Delta21 project realization.

Energy storage lake

The contribution of the project to the energy sector is one of its most important aspects. The current situation of the Netherlands regarding the energy system consists of mainly gas and coal consumption, renewable energy constitutes only 11% of the total energy consumed (*Netherlands – Energy*, 2021). However, this study assumes that by 2030 75% of the total used energy in the Netherlands will be from a sustainable source (Delta21, 2021). This requires a coordinated effort targeting investments in big scale renewable energy systems. Such an opportunity exists in the Delta21 plan with the Energy storage lake. A combination of hydropower production, energy storage and further additions in terms of wind, solar, thermal, and blue energy can be realized.

In the pumping and energy systems' implementation, the lake can be a storage of hydropower energy and release it when there is a shortage due to weather conditions that impact the other renewable energy forms. The Netherlands already makes great use of hydropower through undersea transmission cables reaching Norway, which proved to be able to operate at a competitive product cost. (Meeus et al., 2005). The turbines can deliver an average of 1012MWh during the filling of the lake which takes 12 hours (Delta21, 2018). Moreover, 40 wind turbines can be included and 500 ha of fixed or floating solar panels to provide a reliable contribution due to the geography of the area (Delta21, 2018). Additional investments can include a heat storage basin, which can be used to warm buildings in the winter. Certain types of membranes can be installed to exploit the mixing of salt and the freshwater of the delta by the process of osmosis (Delta21, 2018).

Overall, the opportunities the Energy storage lake contributes are significant for the energy sector. This claim is justified by making a comparison between the potential contribution of the project in terms of energy production and the total production of renewable energy forms in the country.

The expected revenue of Delta21 outweighs the expected cost of construction and maintenance of the project, which is €5 billion in total. The annual revenue of the Energy storage lake is estimated to be approximately €200 million (Delta21, 2021). With the energy storage lake of Delta21, the needed energy capacity can be decreased by 9 GW which saves €16 billion. Thereby contributing 10-15% to the climate agreement. (Delta21, 2021). Therefore, the project will have an undeniable positive effect on the energy transition and the economic development of not only the area but the whole country.

Flood protection

The current plan of heightening and strengthening the dikes can be partly replaced by Delta21 which will save money and land. If the inevitable sea level rise is considered, the current system including mainly the dike system, sea barriers and dams will not have the capacity to protect the inland in the future (Wang et al., 2014), whereas Delta21 has taken this contribution into account. The total costs of the dike heightening program are estimated to be €7.4 billion for 800 km of dikes by 0.8m. With the implementation of Delta21 €10 billion will be saved on dike strengthening by 2100 (Delta21, 2018).

Regional financial interest

The importance of the region of interest is also accounted for activities like recreation, tourism, fishery, and other outdoor activities (Ferguson & Wolff, 1984). With the implementation of Delta21, the natural value in terms of biodiversity and landscape interest will increase. Therefore, the creation of more interest in such activities will possibly follow. These activities are also partly contributing to the tourism sector. Overall, the economic benefit and the local interests are considered in the long run by facilitating this no regret alternative.

3.3.4 Imperative reasons of social nature

Due to increased siltation on the beaches of the Voorne area, the number of visitors will decrease in the near future (Arcadis, 2022). The opportunities Delta21 can provide in the tourism and recreation sector are clearly shown in the design of van Eeden (2021). The border of the Energy storage lake with the sea creates a unique environment where different types of recreation can be combined (Figure 7). With the increasing number of tourists coming to the region each year, Delta21 will create additional space to spread out the distribution of tourists. This can help to reduce the pressure on nature during peak moments in summer.

Figure 7: Recreation possibilities on the Energy storage lake border (van Eeden, 2021).

3.4 C - Compensatory measures

In this section, the results are given on what the impact of Delta21 will be on the Natura2000 habitats and how this impact can be compensated. In addition, it will provide some examples of added value that can help with the implementation of delta21. All the compensatory measures are graphically summarized in Figure 8. A more detailed description of the different habitat types, as well as the reasons for compensation, are given in Appendix H. The section starts with figure 8 which provides a clear overview of the chapter.

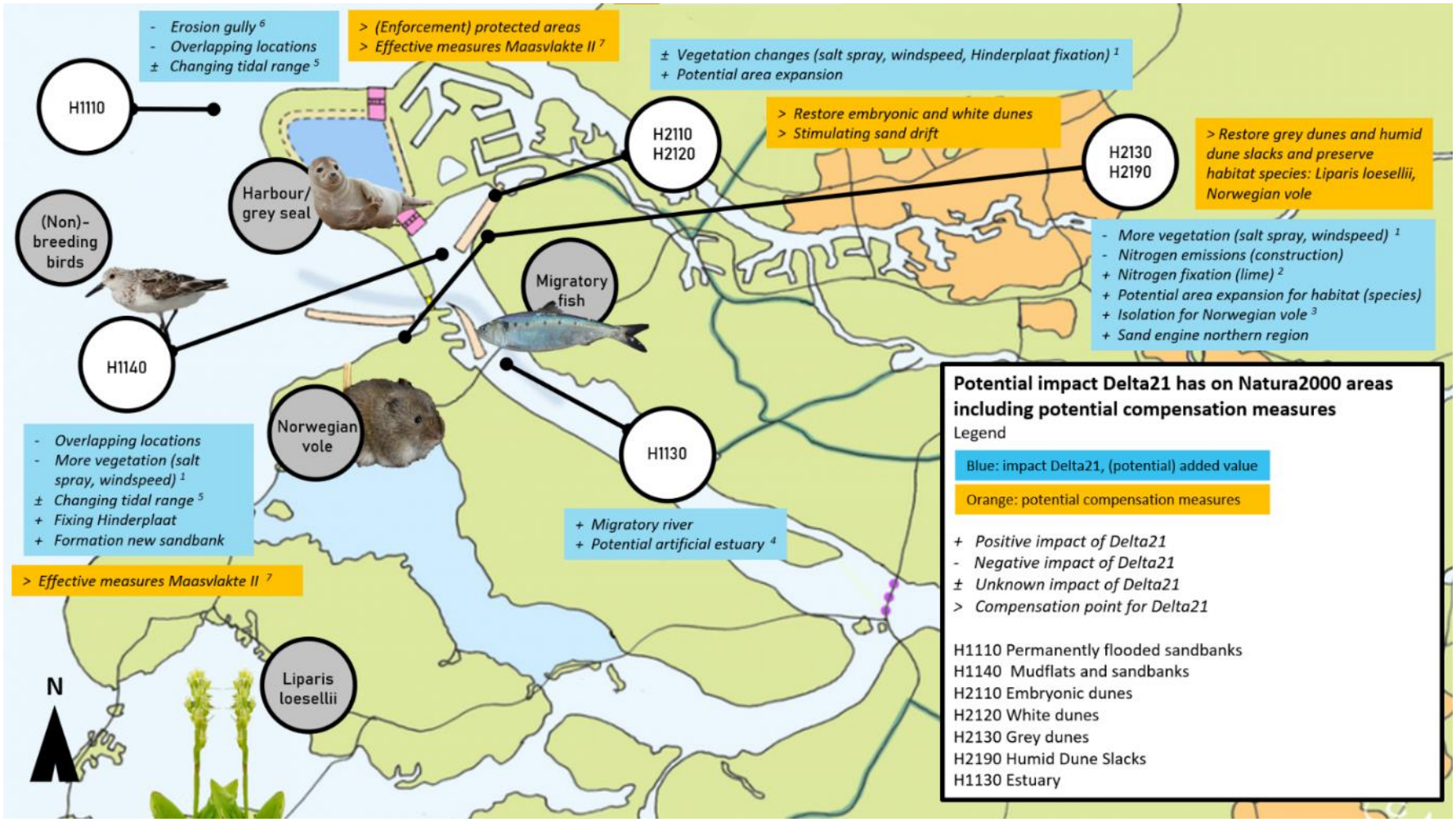

Figure 8: The potential impact Delta21 has on Natura2000 areas including potential compensation measures. In the grey circles, important species are depicted. Each white circle stands for one of the habitat types discussed below. For each habitat type, in blue is the impact Delta21, and added value. Picture retrieved modified from Background: (Delta21, n.d.), Norwegian Vole: (Noordse woelmuis, n.d.), Harbour/ grey seal: (Getty images, 2019), (Non)-breeding birds: (McPherson, n.d.), Liparis loesellii: (De Kraker, n.d.).

3.4.1 Embryonic dunes (H2110) and White dunes (H2120)

Passive Assessment Delta21

Delta21 can have a positive effect on the preservation of Embryonic and White dunes. The Hinderplaat will stop moving inland, this can reduce vegetation succession as described in the introduction. However, the expansion of land planned by Delta21 may also have negative consequences for the existing Embryonic and White dunes. It can lead to reduced salt spray (salty sea breeze) levels and reduced wind strengths which results in an overgrowth of vegetation, making compensation necessary.

Compensation & added value

Even though expansion of this habitat type is not necessary according to the conservation objectives for habitat types (see appendix C), Delta21 can play a role in maintaining this habitat type. Compensation could be needed if Delta21 reduces the area of embryonic and white dunes for example, due to nitrogen deposition. Delta21 can compensate Embryonic and white dunes at the outer barriers of the storage lake and northwest of the Goeree and Kwade Hoek dune area.

The coastal dynamics of wind, sea and sand are of great importance for the development of dunes. This dynamic can be found in this area due to its exposure to the dominant wind direction and sea current. The following advice and requirements for dunes proposed by Deltide (2022) should be taken into account. The ideal width of 900m is essential for the dynamic character of Embryonic dunes (Deltide, 2022). The beach must be wide enough to dry the sand particles. After drying out, sand can be carried by the wind and accumulate into dunes. To prevent the succession of vegetation, nitrogen-poor sand must be used (Deltide, 2022). The possibility of sand drifting is very important to achieve a natural supply of lime and should not be forgotten (NatureToday, 2020b). Not only do the habitat types of embryonic dunes and white dunes benefit from drifting, but also the calcareous grey dunes (Provincie Zuid-Holland, 2015). This is further discussed in the next section. Finally, moving public/recreational activities can contribute to the protection of embryonic dunes, to respond to one of the largest threats to this type of dune.

3.4.2 Grey dunes (H2130), Including Humid Dune Slacks (H2190)

Passive Assessment Delta21 (impact)

The required construction work to implement the Delta21 plan may lead to additional nitrogen depositions. This harms the very sensitive existing Grey dune areas (H2130A/C) and Humid Dune Slacks (H2190) in the Natura 2000 areas Voornes duin and Duinen Goeree & Kwade hoek.
The increase in barriers in the sea could lead to reduced salt spray levels and a decrease in the wind dynamics, possibly resulting in further vegetation overgrowth. Meaning that nature compensation is needed.

Compensation & added value

Delta21 can play an important role in achieving the Natura2000 goals (see appendix C) that have been drawn up for habitat types H2130 and H2190. First of all, it can contribute to the expansion of the surface area of Grey dunes (calcareous). This area can be created on the outer barriers of the energy storage lake, but also to the northwest of the Duinen Goeree & Kwadehoek (Figure 10). These habitat types must be behind the Embryonic dunes and White dunes. Also, the different stages of dune formation must be taken into account to create a dynamic dune system (Figure 9)(van Eeden, 2021, p.95).

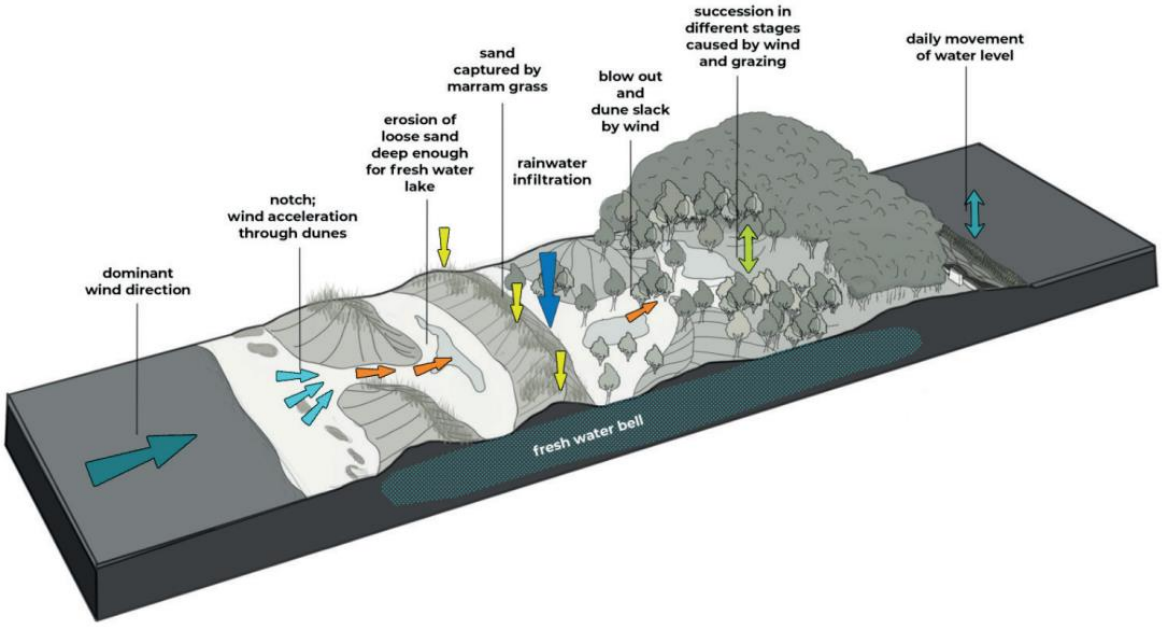

Figure 9: Natural processes that shape the landscape (van Eeden, 2021).

The importance of sufficient sand-drift should not be forgotten. This is important for adding lime to the dunes. This can be sand which comes from the embryonic and white dunes, but also by adding dust pits (stuifkuilen). Mobile parabolic dunes and dust pits are a prerequisite for long-term conservation and, in the short term, are conducive to the recovery of roughened grasslands (Natura2000, 2008).

From the dust pits which are ‘empty’, Humid Dune Slacks can arise. To maintain and expand the range of dune valleys in the long term, new 'young' valleys must be constantly added. This concerns valleys with bare soil or vegetation-free water. Part of the rainwater sinks into the soil in the dune area. This creates a freshwater bubble at the bottom of the dune system above the brackish/saline groundwater (Natura2000, 2009).

The wet dune valleys are important for the prioritised Norwegian Vole. The Norwegian vole lives in wet and occasionally flooded reed and brush vegetation and grasslands. The new dune areas are isolated from other dune areas from which the Norwegian vole benefits. Thereby, a contribution is made to the goal: Expansion of size and improvement of habitat quality for population expansion for this priority specie (Provincie Zuid-Holland, 2015).

In addition to the Norwegian vole, the *Liparis loesellii (Groenknolorchris)* also benefits from the expansion of Humid Dune Slacks. To slow down or stop the decline of the *Liparis loeselii*, an extension of the surface of calcareous Humid Dune Slacks is desirable. Expansion of those valleys is already planned for the longer term (7 - 20 years) (Province of South Holland, 2016). Delta21 can respond to this by also emphasizing this in their project.

Finally, the area may still be valuable as a sand engine for the areas to the north of the area. It would be desirable for the current Sand Motor off the coast of Ter Heijde to be imitated in other places (Omroep West, 2011). Delta21 could play a role in this by positioning the dunes to the west of the ESL, but the possible consequences for shipping at the port must be properly investigated.

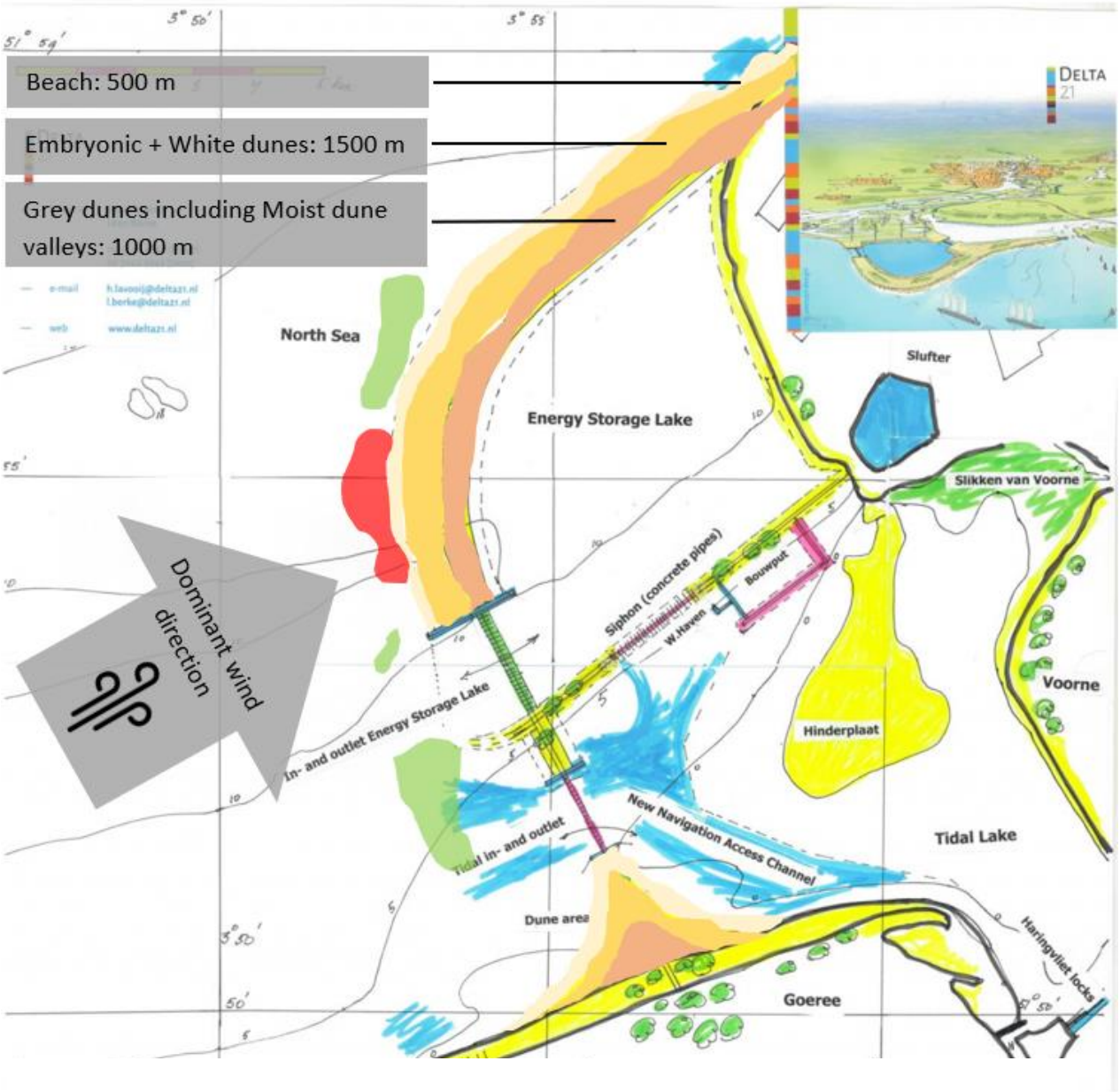

Figure 10: Possible compensation dune area (IJntema, 2021).

3.4.3 Permanently flooded sandbanks (H1110)

Passive Assessment Delta21

The implementation of Delta21 will result in a decrease in the size of the area with permanently flooded sandbanks (H1110) due to three main factors (Werkgroep C4, 2014). First, Delta21 will take up space that overlaps with the current permanently flooded sandbanks. Secondly, Delta21 will form a bump on the Dutch coastline. This will cause the water current parallel to the coast to increase in speed leading to the formation of an erosion gully. If the erosion gully exceeds a depth of 20 meters, permanently flooded sandbanks are lost. Thirdly, according to a study done by Mary Piña Zaldivar (2020), Delta21 with the Haringvliet locks open will increase the tidal range inside the basin. An increase in tidal range means a seaward shift of the low water line leading to a decrease in the area of permanently flooded sandbanks.

Compensation & added value

In compensating for the lost area of permanently flooded sandbanks a lot can be learned from the current process on the Maasvlakte II. For the Maasvlakte II it was found that physical compensation by the creation of new permanently flooded sandbanks was not realistic (Minister van Landbouw, 2022). Instead, compensation was focused on improving the quality of already existing nature by 10% in an area that is ten times the size of the area that was lost. This was done by protecting parts of existing permanently flooded sandbanks. Partly due to a lack of enforcement the compensation measures taken for Maasvlakte II are not working. Therefore, for Delta21 similar required compensatory measures are expected but more focus should be on enforcement. On top of this, conclusions that will be drawn from research done by Rotterdam Harbour on what measures will be effective will also hold for Delta21 (Minister van Landbouw, 2022).

3.4.4 Mudflats and sandbanks (H1140)

Passive Assessment Delta21

In contrast to the permanently flooded sandbanks, the area of the mudflats and sandbanks will increase with a seaward shift of the low water line. Furthermore, Delta21 will stop the current movement of the Hinderplaat allowing birds and seals to thrive there (Ijntema, 2021). However, habitat type H1140 will not only be extended. Part of the Delta21 will be constructed on current mudflats and sandbanks and the damming of the Haringvliet mouth might lead to the reduction of salt spray and therefore enhance the unwanted vegetation growth on the sandbanks.

Compensation & added value

If despite the fixing of the Hinderplaat and the formation of new sandbanks too many mudflats and sandbanks are disturbed, more insight into the expected tidal range after implementation is needed. If the low water line would move seawards this would automatically increase the area size of sandbanks and mudflats. When this is not sufficient, the seaward movement of the low water line would also result in more potential locations where compensation can happen.

Whether the drawbacks and opportunities outweigh each other needs to be determined in the official impact assessment.

3.4.5 Estuary (H1130)

Passive Assessment Delta21

Because the opening of the Haringvliet locks leads to debate the current design for Delta21 is to not change the current lock management. However, Delta12 proposes a fish migratory river. According to the research group DDFMR (2021), this artificial river with a gradual salt gradient should allow an open passage for migratory fish.

Compensation & added value

In the current situation, this habitat type does not exist in the four Delta21 related Natura2000 areas. This means Delta21 does not have to compensate for this habitat type. However, offering to compensate for what was lost years ago can be a valuable and feasible selling point. In the current design of Delta21, the tidal lake acts as an artificial estuary. Not only is there tidal movement, but the relatively small inlet for seawater could also potentially restore the characteristic tidal gullies. In addition, tidal creeks can form that could serve as good spawning locations. Also, new banks are created that are exposed to the tidal dynamics. These more dynamic banks can serve as the perfect spot for the threatened Norwegian vole.

Unfortunately, for the tidal lake one obstacle remains: an estuary is also largely influenced by freshwater. According to the habitat type description, an estuary has a large and constant supply of freshwater (Natura2000, 2016c). With the current management of the Haringvliet locks, this is not the case. The tidal lake might provide a solution:

In the current situation, restoring the estuary would mean letting saltwater intrude into the Haringvliet. However, this salinization leads to debate. When Delta21 is implemented, creating an estuary means letting fresh water intrude into the tidal lake. The latter is much less debated but practically more challenging. Below some ideas are presented that together might offer a solution.

<u>Saltwater threshold</u>

Because saltwater is denser than freshwater it flows underneath the discharged river water (*Zoutdrempel tegen verzilting | Nieuwe Sluis Terneuzen*, 2021). This process is used in the concept of a saltwater threshold. By placing a threshold on the bottom of the seafloor freshwater can continue flowing into the tidal lake but saltwater is blocked in its movement towards the Haringvliet. If some saltwater would still flow into the Haringvliet a salt trap might help. The salt trap is a hole on the bottom floor where salt accumulates. The accumulated salt can be flushed away with high discharges.

<u>Management change Haringvliet locks</u>

In a natural estuary, the discharge of the river is not constant and therefore the salt conditions vary slightly over time (*NOAA National Ocean Service Education: Estuaries Tutorial*, n.d.). By changing the management of the Haringvliet locks such that this natural pattern is mimicked the natural value of the artificial lake can be increased. The inflow of saltwater into the Haringvliet needs to be monitored.

<u>Engines</u>

A third idea is using engines to pump fresh water from the Haringvliet into the tidal lake to create a permanent brackish zone. The pumping can also control salinity and mimic natural fluctuations in discharge.

<u>Fish migratory river</u>

The fish migratory river might play a role. Designing it such that mainly freshwater moves towards the tidal lake might lead to a permanent brackish zone at the mouth of the fish migratory river.

4. Discussion

This study focuses on how Delta21 can comply with the Natura2000 regulations in a dynamic area. The Natura2000 legislation is a strong juridical framework, valuable for the preservation of the environment. Although some challenges in the legislation were identified from the research, these features do not mean Delta21 does not have to comply with the Natura2000 regulations. Meaning that even though extensive pressures will be imposed on many ecosystems due to factors like climate change and the ongoing natural dynamics, the framework cannot be undermined. This was also emphasized during the interview process. Therefore, the legislation's initiative to keep the specific characteristics of the protected areas untouched, will not be fulfilled in the long run. However, efforts to state the misfits of the legislation or go against it will not guarantee or support the project's implementation. Paying too much attention to these weaknesses will not help the realization of the vision. Instead, the focus should be on how to fit in the exceptions of the European regulations and the national frameworks. A process facilitating this procedure is the ADC-test, which consists of alternative solutions, imperative reasons, and compensatory measures.

About the first compartment of the ADC-test, the potential alternatives need to be evaluated. However, this is a difficult matter to address. Namely, what is considered an alternative can be debated because determining this requires balancing the interests and comparing often unequal objectives. Therefore, paying too much attention to these weaknesses will not help the realization of the vision. Instead, the focus should be on how to fit in the exceptions of the European and national regulations and the national frameworks. A process facilitating this procedure is the ADC-test, which consists of alternative solutions, imperative reasons, and compensatory measures credible considering all the different aspects of several projects. Thus, a complicated situation is created. Another important factor connected to this is the maximum acceptable societal burden these alternatives impose. For instance, dike heightening could be considered as an alternative measure for water safety, but nature preservation and sustainable development are not considered in this case. The dike strengthening might also take the space of nature. This also has an impact on society by degrading the quality of their environment and causing health and other implications in the long term. Hence, the process of comparing different alternatives, especially in the case of an integrated big scale project such as Delta21, is challenging. Nevertheless, according to the authors' knowledge, no alternative projects are tackling both water safety and the goals of Natura2000. Therefore, the alternative to implementing the project is leaving the area to develop under the natural dynamics keeping the same management constituting the ''business as usual'' scenario. It is found that doing nothing or strengthening dikes are both not favourable alternatives, because the area is going to be impacted severely and its currently stated value will be degraded. For Delta21 this means that, if no other alternatives are introduced, the project can pass this part of the ADC-test. It is worth mentioning that Delta21 is also flexible in integrating alternatives within its plan and compartments, thus an optimum version can be reached.

Regarding imperative reasons, much can be discussed on what arguments are considered compelling. In defining what is of public interest, again different interests play a role. In that context, the extensity and flexibility of the project can provide benefits for many different domains and stakeholders. The economic profit, beneficial consequences for the natural environment, contribution to sustainable development, increase in health quality and people's safety from sea level rise and high river discharges, are the most important examples. Using this information can support the project's implementation. It can help in building toward cooperation and communication with stakeholders. Also, it can increase awareness about the positive contribution Delta21 will provide. Nonetheless, contradicting incentives and worries about the changes linked to Delta21 will be brought up, but the

overall benefits and priorities should be taken into consideration. For instance, securing safety from flooding and economical profit for the region and country is one of the most important reasons considering nowadays situation. Moreover, the several imperative reasons for implementation should be combined in a way that they will complement and not contradict one another. For instance, the fact that tourism will be promoted in the area after the project's implementation is positive for the society and economy but might have negative implications for ecosystem preservation. Therefore, besides the identification of the different imperative reasons, attention should be put into combining, balancing, enforcing and managing them in a proper manner. The importance of good argumentation and support becomes clear from the interview as well. It is found that the justification used by other projects that were allowed to build in Natura2000 areas is similar to the imperative reasons for Delta21. This suggests that the reasoning for Delta21 will be sufficient for overcoming the ADC-test.

One of the most important arguments for the project is that besides the advantages of the human factor constituting the imperative reasons, Delta21 also creates opportunities for adding environmental value to what is currently present in the area of implementation. Even a new concept can be formed by proposing the Tidal Lake addressed and managed as an artificial estuary, thus providing in the area what has been lost with the Haringvliet construction. However, it is worth mentioning that according to the results, the line between beneficial consequences for the environment and the compensatory measure is not well defined. This is mainly because there is no clear definition of imperative reason and compensation measures (European Commission, 2007). Hence, some of the environmental imperative reasons could become compensatory measures and vice versa. This mainly depends on how the information is framed and whether Delta21 necessitates imperative reasons or compensatory measures. For instance, the dunes of the Energy Storage Lake can be framed as an added ecological value, but they can also be used to compensate for the losses of other dunes' environments. Namely, compensation and added value in nature are complementing one another even though are two separate things.

Furthermore, the ecosystems of an area that are impacted by the project should be quantified to make clear what compensation is required. The quantity and quality of those habitats need to be considered. But also, aspects like the potential of an area, the ability to restore itself and the feasibility of compensating for the same habitat require attention. Besides these, time in terms of both accurate and feasible planning of the compensation part is important. Questions like within what period should nature be compensated, what is the time length of the compensation responsibility if the promised measures are taken, and what is considered as compensation do not have a subjective or clear answer. However, the existence of those gaps does not change the fact that Delta21 will have to compensate for the impact it will have on the nature in the area. Luckily, there is potential for compensating for the affected habitats. Namely, the different dune types that are going to be affected can be recreated in the outside part of the barriers of the Energy storage lake, securing the important dynamic processes of sand drifts. The compensation process is not simple and attention should be directed to properly performing this procedure. This becomes clear considering that the results of compensation efforts might not live up to the initial goal, or the necessity of support from the government since the private sector cannot address all relevant dimensions of the issue unilaterally. However, this is a very important step in the Delta21 implementation procedure, since a lot of emphases is dedicated to this exact part and bad experiences related to other projects' performances may influence the impression and judgment the project will receive.

The research identified some limitations associated with the process followed. First and foremost, the investigation of the Natura2000 legislation went into depth. However, due to the extent and specialized context of the content, many details were not addressed thoroughly. In other words, such a specific framework needs to be addressed by experts in the environmental law department to get a holistic and complete overview in the future. Moreover, even though experts in several domains were

contacted, including the fields of environmental law and ADC-test, the limited time and work overload from all the parties, resulted in fewer interviews than planned. Hence, from conducting more interviews more valuable arguments can be obtained. The time limit was also important for the scope and boundaries set concerning the research. For instance, an equally important part of the ADC-test is the three steps that need to be taken before. Specifically, investigating the concerns around the intern nitrogen net balancing, external nitrogen net balancing and passive assessment is necessary for the future. Finally, an important factor limiting the research's accuracy is scientific uncertainty related to the future impacts, scale and extent of climate change and natural dynamics that were taken into consideration. The exact impacts and benefits of the Delta21 project cannot be quantified accurately as well. Even though this matter was tackled by combining multiple and favourably most recent scientific sources, it is still important to be considered as a limitation. Lastly, because not all group members speak Dutch, the lion's share of the sources could not be read by everyone. This limited the group in assigning the tasks.

5. Conclusion

To conclude, the Natura2000 regulation is protecting Europe's nature and biodiversity. However, it consists of a static approach and does not always rhyme with the dynamics of nature. External interventions regardless of their origin, such as human-driven nitrogen deposition, climate change and ongoing morphological dynamic processes affect the areas that the framework request to remain untouched. These processes cannot be stopped, but humans can influence the final scale of their pressure in the ecosystems, through different kinds of management technics, measures, and projects. However, for the Natura2000 areas, this is not easy to realize since the regulation restricts all kinds of interventions. Hence, projects that aim to amplify nature dynamics to deal with those factors and preserve nature, biodiversity, or the exact current state of the environment the legislation counts as valuable, are burdened by its strictness.

Therefore, to answer the main question: *"How can Delta21 comply with the Natura2000 legislation and preserve the natural value of the area considering the ongoing morphological dynamics and climate change?''* it is important to state that Delta21 can't go past the regulations but must comply. The regulations are even more strict because the Delta21 implementation area covers prioritized habitat types and their species. However, when looking at reference projects such as Maasvlakte II it becomes clear that despite the impact on nature, projects can still be implemented when exceptions in the European regulations are used. To get to implementation and still comply with the Natura2000 regulations the steps below need to be taken (see Figure 11 for an illustrative overview).

The first step that should be taken is an internal net balancing of emissions to resolve nitrogen within the project. If internal nitrogen balancing appears to be not feasible external net balancing should be done. Next, a passive assessment should be done, to ensure that the project will not affect the ecological characteristics of the area. If the project does have an impact on the ecological characteristics, as is expected for Delta21, the ADC-test should be done.

Addressing the alternatives, there seem to be no comparable options to the Delta21 besides a business-as-usual scenario. Hence, if Delta21 is not implemented, the Hinderplaat will disappear in 20-30 years which affects the resting place of migrating birds and seals. Also, mudflats and salt marshes might increase, and a new primary dune valley could arise.

Furthermore, the imperative reasons for implementing Delta21 include multiple factors. First and foremost, water safety is secured without further heightening the dikes. Even with the business-as-usual scenario, the danger of flooding in the future increases due to sea level rise and climate change impacts in general. Therefore additional measures and different management will be beneficial. This is also connected to the financial imperative reasons, according to which Delta21 will contribute to the local and national economy and goals. The benefits concern saving expenses associated with the current policy of heightening the dikes and generating a profit by producing and restoring energy. Important is that the project will contribute to the preservation of the ecosystems belonging to Natura2000 and will provide additional natural value as well. Namely, Delta21 will protect the Hinderplaat and increase the nature value of Slikken van Voorne. Socially, the project will create a sustainable environment for recreation as the current future projections are not favourable. Finally, health-wise Delta21 will increase the quality of life in general.

Nature that is lost because of the implementation of Delta21 needs to be compensated. For embryonic and white dunes, the biggest threats nowadays are nitrogen deposition, the inland movement of the Hinderplaat and uncontrollable recreation activities. To compensate for these habitat types, opportunities are provided in the same area, which is more easily defendable for the facilitation of the project's realization. Specifically, space can be created at the outer barriers of the Energy storage

lake and northwest of the Goeree and Kwade Hoek dune area. Grey dunes and Humid Dune Slacks are threatened by nitrogen deposition and desiccation, eutrophication and an increase in thickets and acidification due to continued succession. Delta21 can expand the surface area of both habitat types and have a positive effect on the sand engine. The mudflats, sandbanks and permanently flooded sandbanks are under threat due to morphological changes resulting from the implementation of Maasvlakte II. In that context, Delta21 will cause a further decrease in permanently flooded sandbanks. Contrarily, the area of mudflats and sandbanks might increase with a seaward shift of the low water line and inside compensation is possible. Another potential selling point for Delta21 is the Tidal Lake which could serve as an artificial estuary and compensate for what was lost since the creation of the Haringvliet locks.

6. Recommendations

This chapter suggests recommendations for future research:

1. A first step is made in the creation of the Roadmap Delta21: Complying to Natura2000 (Figure 11), which illustrates the recommended steps in chronological order. However, a detailed version should be developed, such as adding a timeline and adding the important stakeholders that have high power or interest in the project. This could decrease their concern about the project. Also, they can include their ideas in the project.

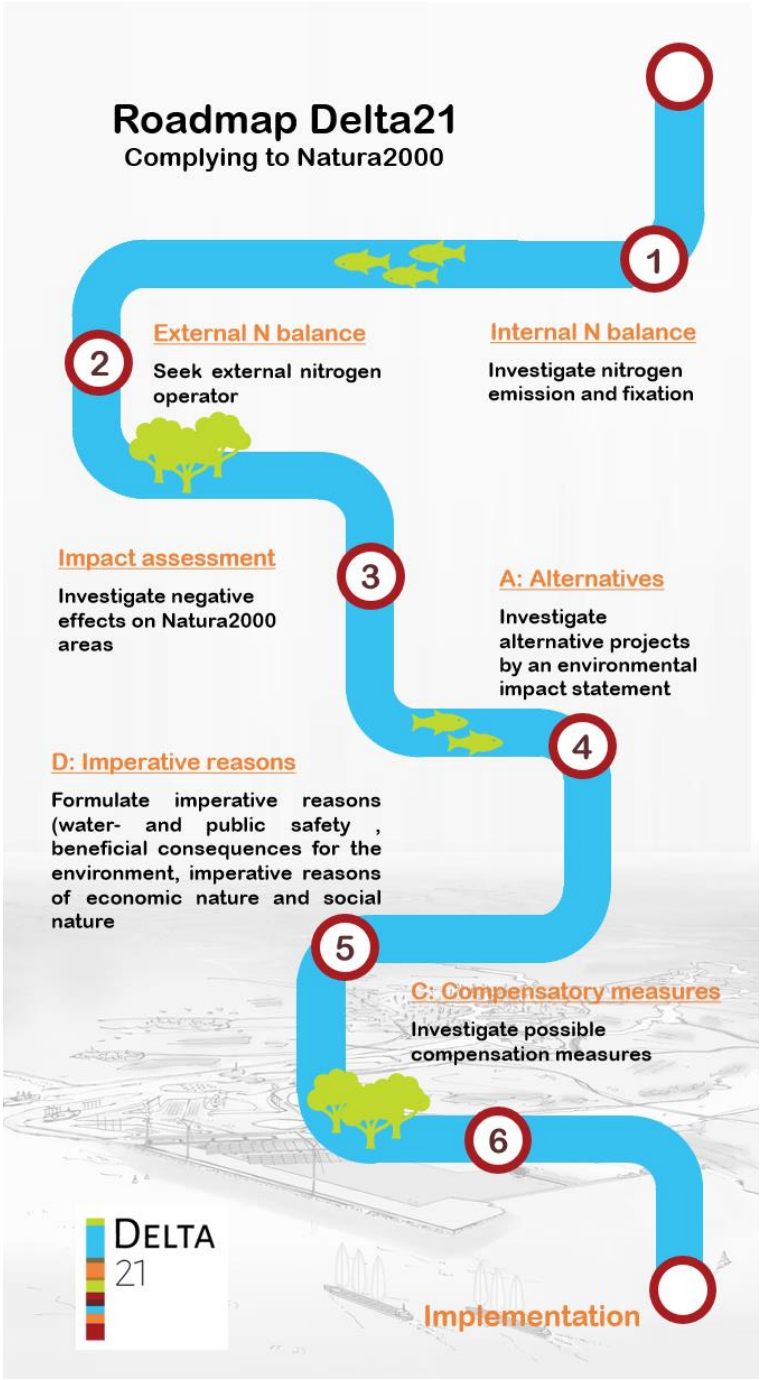

Figure 11: Roadmap for Delta21

2. Due to time restraints and organization, we were able to perform only one interview. However, we suggest more interviews with Natura2000 experts and ADC experts to understand how other projects framed their ADC test. This could improve the chance of Delta21 being implemented. An expert on nature is BIJ12. They are an organisation that supports provinces in the care of the environment. They do not have insights into the projects that have been solved through the ADC test. Competent authorities (provinces) are responsible for granting permits and accomplishing an ADC test. Through the authorities the information is available. The contact details of the authorities can be found on the BIJ12 website (link). Moreover, a list of relevant questions is found in Appendix G. The questions are focused on the Natura2000 areas and the ADC-test.
3. It is also important to assess the consequences that Delta21 will have on each specific habitat type of the Natura2000 area and compensatory measures. There should be a further investigation that focuses both on the quantity and quality of the compensation. In this regard, we suggest analysing in-depth the following solutions:
    - Allow sand drift on the coastal barrier to start dune formation.
    - Stimulate the formation of dunes habitats on the coastal barrier of the storage, namely embryonic dune, white dune, grey dune and/or Humid Dune Slacks.
    - Determine the tidal range with the Haringvliet locks closed, to properly estimate how much of the habitat types H1110 and H1140 will be lost.
    - Investigate the opportunity of framing the Tidal lake as an artificial estuary. Hence, the following message could be promoted: Delta21 is a project able to create a river estuary, instead of losing it due to morphological dynamics and climate change.
4. At last, according to the KNMI sea level rise will occur. This could lead to the disappearance of the Hinderplaat. We recommend investigating if Delta21 will be able to prevent this from happening, besides stopping the landward movement of the sandbanks.

To sum up, the key message of the research is that exceptions are possible to be made regarding the Natura2000 legislation. However, compensation measures should be considered and planned properly and concretely. This first initial research about compensation measures indicates that compensation in the same area is best defendable. Moreover, a critical view of other projects that went through the same procedure consisting of European regulation limitations, compensation and stakeholder contradicting interests, will be valuable (Maasvlakte II, IJburg, Sand engine, de Kerf). Additional hindsight can be acquired from interviewing Rene Vrugt to gain more information about the Maasvlakte II and interviewing Hans Woldendorp to gain more information about the implementation of the Habitat Directive. What also important is, is the planning of the timeline of phases that need to be implemented and decisions that need to be made. Finally, it is important to put effort into getting support from the political-administrative process. With good reasoning and framing of the project as a no-regret measure and emphasizing its potential to create again what is lost in terms of the estuary, this can be facilitated. Overall, there are possible solutions to realize the Delta21 plan despite the strong influence of Natura2000 legislation, but accurate and thorough research and argumentation should be provided.

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Appendices

- Appendix A - Climate change IPCC Report: provides additional information to Chapter 1.1 Climate change by providing information from the latest Intergovernmental Panel on Climate Change (IPCC) report and other sources.
- Appendix B – Additional information ADC-Test: Provides the three different sections of the ADC-test, according to the European Commission (2007), see also chapter 1.2.
- Appendix C - Natura2000 areas & goals: Gives information about the conservation goals and core tasks of the four Natura2000 areas. The (compensation) measures are based, among other things, on these goals.
- Appendix D – Stakeholder analysis: This defines the purpose, interest and power of various stakeholders in the area. Chapter 5: Methods refers to the stakeholder analysis.
- Appendix E – Interview dr.Mr. P (Pieter) Jong (Landscape Architecture and Spatial Planning): It includes a transcription of the interview with Pieter Jong. The interview helps to gain a better understanding of the Natura2000 legislation and the ADC-test.
- Appendix F – Societal Evaluation Report:
  The moral part of the project implementation is investigated. It is about the information on the ethical discussion on the preservation of dynamic nature.
- Appendix G – Interview questions for follow-up research: Due to various reasons, we were unable to ask all the interview questions we had in mind to various experts. Although it was not possible to arrange an interview, we would like to share the questions. This mainly concerns Natura2000 legislation concerning the ADC test. The questions are focused on the Natura2000 areas and the ADC test.
- Appendix H - Additional information Compensation:
  A more detailed description of the different habitat types, as well as the reasons for compensation (challenges the habitat types are facing), is given in Appendix H, this helps by understanding the compensation measures.

Appendix A: Climate change: IPCC Report

Climate change is an inevitable environmental problem of the current century. The Paris agreement set the target of limiting global warming to well below 2 °C, and the Intergovernmental Panel on Climate Change (IPCC) has stated that drastic actions are required to reach this goal. The Sixth Assessment Report includes the most recent developments in the state of scientific, technical, and socio-economic knowledge on climate change and it highlights the higher-than-expected rates of escalation. Namely, changes are visible, measurable, and happening fast, entailing a danger for institutions and infrastructure which might not be able to withstand and cope with them for as long as is now expected.

The water cycle is changing, the sea level is rising, precipitation patterns are changing, and river discharges fluctuate stronger. According to the IPCC (2019) report, the global mean sea level rise increased from an average rate of 2,3 mm per year over the period 1971-2018 to 3,7 mm per year over the period 2006-2018. Hence, the global mean sea level will rise between 18 cm and 23 cm by 2050 compared to the early 2000s. By 2100, the expected rise is in the range of +29cm to +110 cm compared to the current levels. This depends on the current levels depending on the emission reductions (Figure 1). Moreover, local variation must be considered.

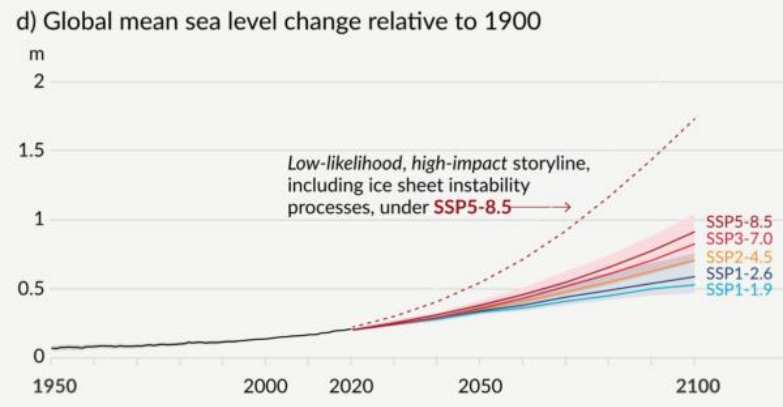

Figure 1: Global mean sea level rise change relative to 1900 according to the five Shared Socioeconomic Pathways (SSPs): IPCC AR6 (IPCC,2019)

Tidal flooding events that occurred once per century in the recent past will occur annually or even more often in most tidal gauges worldwide by 2100. In this context, high tide flooding events that used to occur five times per year between 1960-1980 happened more than eight times between 1995-2014 and most likely this number will continue to increase.

Precipitation will also be affected as globally wet regions will become wetter, while the dry regions will become drier. The extreme phenomena intensify in frequency and intensity with every increment of global warming. Therefore, civilizations must quickly prepare and provide for future challenges considering the potential magnitude of the disasters projected (Knutti et al., 2015).

Biodiversity is impacted by climate change as it's the main driver of species reduction (Bálint et al., 2011). According to the Living Planet Index 2020 during the period 1970 to 2016, the population sizes of amphibians, birds, fish, mammals and reptiles sustained a 68% decrease, while the number of endangered species continues to grow (WWF, 2020). Models show the extinction rate could qualify as the sixth mass extinction in the earth's history (Bellard et al.,2012).

Appendix B. Additional information ADC-test

The ADC-test is the last resort for a project after an appropriate assessment has shown that significant negative effects on the Natura 2000 areas cannot (completely) be excluded. Before a project can perform an ADC-test, the project plan should have proceeded in three steps.

1. Take measures to achieve a small emissions discharge, including an internal net balancing (BIJ12, 2022a). Internal net balancing is a measure that resolves nitrogen within the project. A project cannot expand or be implemented if that will result in more deposition. The extra deposition has negative consequences on the nitrogen sensitive area within the Natura2000 areas (BIJ12, 2022d).
2. If the compensation cannot be balanced through internal net balancing then the project should buy nitrogen rights through an entrepreneur. This is called external net balancing. This means that a project takes over the nitrogen space of a company that completely or partly stops (BIJ12, 2022c). In general, the project should include mitigation measures to reduce emissions (BIJ12, 2022a).
3. The passive assessment is focussing on the significant negative effects of the increase in nitrogen deposition (BIJ12, 2022a). The passive assessment is to ensure that the project will not affect the ecological characteristics of the area. This is the case when there is no reasonable scientific doubt that there will be no adverse effect. The passive assessment takes into account the mitigation measures, such as external net balancing. When there is still a significant negative effect on the Natura2000 area according to the Nature Protection Act then should be considered the ADC-test (BIJ12, 2022b).

The ADC-test is a strict framework from the Nature Protection Act. Three aspects are necessary for a project:

1. A: There are no other alternatives
2. D: There are imperative reasons with a great public interest
3. C: There are compensatory measures that ensure and protect the coherence of the Natura2000 (BIJ12, 2022a).

A-No other alternatives

The A stands for no alternatives. This means that there cannot be a realistic alternative that causes no or less harm to the ecological characteristics of the Natura2000 area and still reach the goals of the to be implemented project. The alternatives are considered by the environmental impact statement (EIS). Potential alternatives are alternatives with a different location, or determination from other designs (BIJ12, 2019).

D-Imperative reasons with a great public interest

The D stands for ‘dwingende redenen’ which are imperative reasons with the great public interest. The ADC-test can only be approved if the project is necessary due to imperative reasons with the great public interest and is well supported. Points of attention are:

1. The reasons should be of public interest and supported by a commercial are privet initiative.
2. The interest in the project should in the long term be greater compared to the lost nature value.
3. The interest should explicitly be weight against the importance of nature protection.
4. The consideration should be supported by recent data.

If a project influences a prioritized habitat type or species and the project has no significant importance in human health, public safety or environmental benefits, implementation is only allowed

after advice is given by the European Commission. The prioritized habitat types and species can be seen in the table1, in bold are the prioritized species that are impacted by the Delta21 project. The advice of the European Commission can be ignored however, an explanation with counterarguments is expected from the national institutions. The advice from the European Commission could take up to 1 year for easy cases and multiple years for complex ones (BIJ12, 2019).

H2130	**Grijze duinen**
H2140	Duinheide met kraaihei
H2150	Duinheide met struikhei
H6110	Pionierbegroeiingen op rotsbodem
H6120	Stroomdalgraslanden
H6230	Heischrale graslanden
H7110	Actieve hoogvenen
H7210	Galigaanmoerassen
H7220	Kalktufbronnen
H91D0	Hoogveenbossen
H91E0	**Vochtige alluviale bossen**
H1340	**Noorse woelmuis**
H1078	Spaanse vlag

Table 1: Priority habitat types or species by the European Commission (BIJ12, 2019).

C- There are compensatory measures that ensure and protect the coherence of the Natura2000

The C stands for compensatory measures. The compensatory measures aim to offset the negative effects of the plan which remain after article 6 lid 3 of the Habits Directive. The compensating measures should represent natural values equal to the lost nature values and should not be a part of the implemented project (Toestemming 'Handelingen met gevolgen voor beschermde natuurgebieden', n.d.). Compensation measures are measures that are taken in addition to the normal obligations under the Birds and Habitats Directive. Compensatory measures are the 'last resort' for the Natura2000 area. The legal requirements for compensation are (BIJ12, 2019):

- The compensatory measures are only applied when the other protection measures are ineffective for the Natura2000 area.
- The guideline for nitrogen deposition is difficult. Nitrogen has a more negative impact than the disturbance of noise or loss of surface area. There are compensatory measures available for nitrogen deposition, but this has a small impact on a larger surface. There is a different approach required for sufficient compensation (BIJ12, 2019).

The compensation needs an effective ecological argumentation, which can be done by an area analysis. This will be the case for licensing without the PAS (Programma Aanpak Stikstof). A part of the area analyses is no longer usable because they are based on assumptions from the appropriate assessment of the PAS. The PAS includes a description of the habitat types- and species, and the relevant constraints for the ecological assessment. The compensation should be about the extent of the area, the coordination with the leader of the management plan of Natura2000, and the obligation to notify compensating measures to the European Commission (BIJ12, 2019).

Appendix C: Natura2000 areas and goals

Various conservation objectives and core tasks have been set for the four Natura2000 areas. Management plans have been drawn up based on these goals. Both are important steps in the implementation of the European Natura2000 network in the Netherlands. Below is a short description of each of the four Natura2000 areas and the most important core tasks are mentioned. In addition, the main targets for habitat types, species and birds in general. Also, a more detailed overview of the goals will be described in a table.

Voordelta

The Voordelta is a shallow sea bordering the beaches along the coast of Zeeland as well as the southern part of South Holland. This area is characterized by the presence of intertidal areas and beaches. It is the transition zone from the open sea to the estuary and from saltwater to freshwater. These characteristics provide a unique habitat for species. Since the (partial) closure of the estuaries by the Delta Works, the Voordelta has drastically changed for instance sandbanks formed at river mouths; tidal gullies got shallower and fish migration was disturbed (Ministerie van Infrastructuur en Milieu et al., 2016).

Goals

The habitat directive designated 6 habitat types and 6 habitat species to protect in the Voordelta). Also, some non-breeding birds are designated for the area, as shown in Table 3 (Ministerie van Infrastructuur en Milieu et al., 2016).

Natura2000 conservation objectives for habitat types and species in the Voordelta		
Code	**Name**	**Type of goal**
H1110	Permanently flooded sandbanks (Permanente overstroomde zandbanken)	Area conservation, quality conservation
H1140	Mud flats and sandbanks (Slik- en zandplaten)	Conservation, poor quality, may decrease in size to promote H1310/H1330
H1310	Zilte pionierbegroeiiingen	Area conservation, quality conservation
H1320	Slijkgrasvelden	Area conservation, quality conservation
H1330	Schorren en zilte graslanden	Area conservation, quality conservation
H2110	Embryonic dunes (Embryonale duinen)	Area conservation, quality conservation
H1095	Sea lamprey (Zeeprik)	Population growth, habitat conservation
H1099	River lamprey (Rivierprik)	Population growth, habitat conservation
H1102	Allis shad (Elft)	Population growth, habitat conservation
H1103	Twait shad (Fint)	Population growth, habitat conservation
H1365	Harbor seal (Gewone zeehond)	Population growth, habitat: area conservation, quality improvement
H1364	Grey seal (Grijze zeehond)	Population and habitat conservation
	Non-breeding birds	Habitat area and quality conservation

Table 2: Natura2000 goals for habitattypes (orange), habitatspecies (blue) and birds (green) in the Voordelta (Ministerie van Infrastructuur en Milieu et al., 2016).

Haringvliet

The Haringvliet is a former estuary in the Rhyne-Meuse Delta with a surface area of 110 km2 (Rijkswaterstaat, 2022`). In 1970, the Haringvliet sluices were completed and the estuary was no longer directly connected to the sea. Only via the Spui through the Oude Maas, and the Nieuwe Waterweg seawater can enter the Haringvliet making the latter a freshwater basin. Since then, there is also no tidal motion in the Haringvliet. Instead, the water level is controlled by the Haringvliet sluices and the upstream weirs. With the low tide and high discharge, the Haringvliet sluices are open to discharge 70% of the water flowing into the Netherlands at Lobith and Borgharen (Rijkswaterstaat, 2022`). Since the Kierbesluit in 2018, a few locks are also opened with high tide to favour fish

migration. For this, the salt intrusion is strictly monitored to prevent it from surpassing the line between the Spui and Middelharnis (Natura2000, n.d.).

Goals

The habitat directive designated 3 habitat types and 9 habitat species to protect in the Haringvliet. Also, multiple breeding and non-breeding birds are designated for the area, as shown in Table 3 (Ministerie van Infrastructuur en Milieu et al., 2016).

Natura2000 conservation objectives for habitat types and species in the Haringvliet		
Code	**Name**	**Type of goal**
H3720	Slikkige rivieroevers	area expansion, quality conservation
H6430B	Ruigten en zoen	area expansion, quality conservation
H91E0A*	Vochtige alluviale bossen	Area conservation, quality improvement
H1095	Sea lamprey (Zeeprik)	Population growth, habitat: area conservation, quality improvement
H1099	River lamprey (Rivierprik)	Population growth, habitat: area conservation, quality improvement
H1102	Allis shad (Elft)	Population growth, habitat: area conservation, quality improvement
H1103	Twait shad (Fint)	Population growth, habitat: area conservation, quality improvement
H1106	Salmon (zalm)	Population growth, habitat: area conservation, quality improvement
H1134	(Bittervoorn)	Population conservation, habitat conservation
H1163	(Rivierdonderpad)	Population conservation, habitat conservation
H1337	Beaver (bever)	Population conservation, habitat conservation
H1340*	Norwegian vole (Noordse Woelmuis)	Population growth, habitat: area expansion, quality improvement
	Breeding birds	Habitat: area expansion, quality improvement
	Non-breeding birds	Habitat: area expansion, quality improvement

Table 3: Natura2000 goals for habitattypes (orange), habitatspecies (blue) and birds (green) in the Haringvliet (Rijkswaterstaat Zee en Delta et al., 2016).

Voornes duin

The Voornes Duin is 14,32 km^2 and it consists of a young dune and beach deposits with a high lime content. The dune area with dune valleys was largely created in the 19th and early 20th centuries by cutting off the beach plain as a result of the creation of new sea bars (rows of dunes). Whereas the southeastern part of the Voornes duin area dates from the late Middle Ages.

The dune area of Voorne has a large variation in landscape types and consequently, a large variation in flora and fauna. It consists of a dune area with two large dune lakes (Breede water and Quackjeswater) and several small pools, swamps, large areas of forest and scrub, dune grasslands and wet dune valleys. Moreover, in the inner dune area, there are several forests with special (stinze) flora (Haskoning Nederland BV, 2016).

Goals

Dune areas, open dune grasslands, scrub and forest are valuable habitats for plants and animals and therefore the area Voornes Duinhas special natural values. This concerns marram dunes (helmduinen), calcareous and calcareous poor dune grasslands, dune thickets, dune forests and water areas.

Some core tasks have been formulated for the species and habitats. For the area of Voornes Duin, a "Sense of Urgency" has been assigned to habitat types H2130A (calcareous grey dunes) and H2130C (heavy grey dunes).

For grey dunes (H2130) expansion and restoration of the quality is important. This can be done by the prevention of grassing. For the habitat type of dry dune forests (H2180A), expanding the surface area (also on the foreshore) and improving the quality (structure variation and richness of species) of dry dune forests is a core task. Finally, the open Humid Dune Slacks (including moist dune forests). It is important to maintain the surface area and restore the quality of Humid Dune Slacks (calcareous (H2190B)) for this type of habitat. In addition, the preservation of Humid Dune Slacks (H2190) as habitats for the spoonbill (A034), arctic vole (H1340), narrow snail (H1014) and *Liparis loeselii (*Groenknolorchis (H1903)) (Haskoning Nederland BV, 2016).

Natura2000 conservation objectives for habitat types and species in Voornes duin		
Code	**Name**	**Type of goal**
H2120	Witte duinen (white dunes)	Preserve surface and quality
*H2130A/C	Grijze duinen (grey dunes)	Expansion of surface area and improvement of quality grey dunes (calcareous, subtype A) and grey dunes (heischraal (ravelling, subtype C)
H2160	Duindoornstruwelen (Sea buckthorn thickets)	Preserve surface and quality. Some decline in the area in favour of habitat type H2120, H2130 or H2190 is allowed.
H2170	Kruipwilgstruwelen	Preserve surface and quality. Any decline in the area in favour of habitat type H2190 is permitted.
H2180A/B/C	Duinbossen (dune forests)	Maintain surface area and quality of Dune forests (moist, subtype B), dune forests (inner dune edge, subtype C) and maintain the surface area and improve quality of Dune forests (dry, subtype A). Some decline in the area in favour of H2130 or H2190 is allowed
H2190A/B/D	Vochtige duinvalleien (Humid dune valleys)	Maintain surface area and quality of Humid Dune Slacks (open water, subtype A0 and Humid Dune Slacks (high wetland plants, subtype D) and expansion of surface area and improvement of quality Humid Dune Slacks (calcareous, subtype B)
H1014	Narrow hive snail	Preservation of habitat size and quality for population conservation
* H1340	Norwegian vole	Expansion of size and improvement of habitat quality for population expansion
H1903	*Liparis loeselii* (Groenknolorchis)	Expansion of size and preservation of biotope quality for population expansion
	Breeding birds	Conservation

Table 4: Natura2000 goals for habitattypes (orange), habitatspecies (blue) and birds (green) in Voornes Duin (Haskoning Nederland BV, 2016).

Duinen Goeree & Kwade hoek

The area "Duinen Goeree & Kwade Hoek" consists of several dune areas northwest of the island of Goerree Overflakkee. The Kwade Hoek is the northernmost part of the (intertidal) area of the Voordelta and forms the transition from salt marsh to beach plain. Due to the construction of a drift dike in the 1960s and the Haringvliet dam, sea currents and channels were deflected seawards. This created a concentration of sandbanks off the coast, which mostly dry up at low tide and continue to grow every year. On the seaward side, the area consists of a beach, where dunes and mudflats (slikken) have spontaneously formed. Moist primary dune valleys have developed behind the dunes. This makes it a varied and dynamic landscape with primary dune formation, mud flats, salt marshes, valleys and dune thickets (duinstruweel) (Ministerie van Landbouw, Natuur en Voedselkwaliteit, n.d.).

Goals

Three core tasks have been formulated for the Natura 2000 area Duinen Goeree & Kwade Hoek. This is within the following main ‘ types’: 'Zeereep', 'dune valleys (secondary) and beach plains (including moist forests)' and 'inner dune edge (transition to polders, including moist forests)'.

The first core task relates to the white and embryonic dunes. Natural sand drift is important for white dunes (H2120) and embryonic dunes (H2110). Also, as a habitat for the ringed plover (A137) and sand

plover (A138). For open Humid Dune Slacks (inclusive moist dune forests), preserving the surface area and restoring the quality of Humid Dune Slacks (calcareous) (H2190B) is important. Preserving Humid Dune Slacks is important as a habitat for the spoonbill (A034), Norwegian vole (H1340) and the narrow hive snail (H1014). For grasslands, the development of grey dunes (heischraal) (H2130C) at promising locations is important.

Natura2000 conservation objectives for habitat types and species in Duinen Goeree & Kwade hoek		
Code	**Name**	**Type of goal**
H1140 A	Slik- en zandplaten (Mudflats and sand flats	Preserve surface and quality
H1310 A/B	Zilte pionier begroeiingen (Salty pioneer vegetation)	Preserve surface and quality
H1320	Slijkgrasvelden (Mud laws)	Preserve surface and quality
H1330 A	Schorren en zilte graslanden (Salt marshes and saline grasslands)	Preserve surface and quality
H2110	Embryonale duinen (embryonic dunes)	Preserve surface and quality
H2120	Witte duinen (White dunes)	Preserve surface and quality
H2130 A/B/C	Grijze duinen (Grey dunes)	Expansion of surface area and improvement of quality Gray dunes (calcareous, subtype A) and grey dunes (ravelling = heischraal), subtype C)
H2160	Duindoornstruwelen (Sea buckthorn thickets)	Preserve surface and quality. (Some decline in the area in favour of habitat type H2120, H2130 or H2190 is allowed.)
H2190	Vochtige duinvalleien (Humid dune valleys)	Maintain surface area and quality of Humid Dune Slacks (open water, subtype A0 and Humid Dune Slacks (high wetland plants, subtype D) and expansion of surface area and improvement of quality Humid Dune Slacks (calcareous, subtype B and non-calcareous subtype C)
H6430	Ruigten en zomen	Preserve surface and quality
H1014	Narrow hive snail	Preservation of habitat size and quality for population conservation
* H1340	Norwegian vole	Expansion of size and improvement of habitat quality for population expansion
	Breeding birds	Conservation
	Non-breeding birds	Conservation

Table 5: Natura2000 goals for habitattypes (orange), habitatspecies (blue) and birds (green) in the Haringvliet (Provincie Zuid-Holland & Ministerie van Infrastructuur & Milieu, 2015).

Appendix D: Stakeholder analysis

Below the power, interest and aim of the stakeholder are explained. The interest refers to how much the stakeholder can exploit the project or how much interest they have in the area. The power is defined as which tools or measures the stakeholder has to delay, prohibit or stimulate the project Delta21. With the information about these three aspects, the stakeholders are placed in the stakeholder analysis matrix, see figure 2.

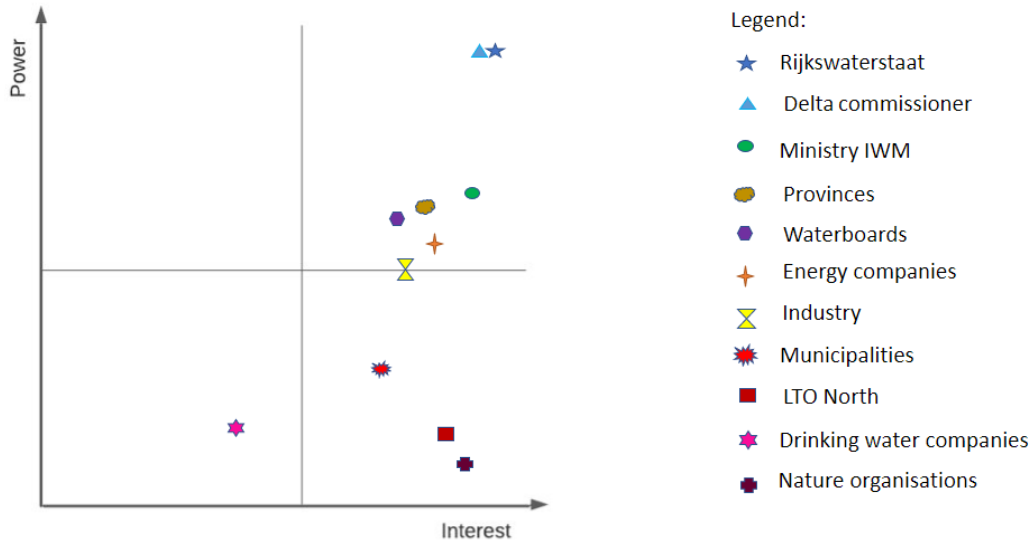

Figure 2: Stakeholder analysis for Delta21

Rijkswaterstaat:

- Aim: ''Rijkswaterstaat is the implementing organisation of the ministry of infrastructure and water management. They manage and develop the national roads, waterways and waters and w aim for a sustainable living environment'' Ministerie van Infrastructuur en Waterstaat (2021).
- Interest: The interest of Rijkswaterstaat in the project is high. Currently, different measures are already taken by Rijkswaterstaat like adding sand to the coast, removing vegetation from the floodplains and checking the current flood protection. Rijkswaterstaat is interested in new developments in the water sector which make the Netherlands safer. They also make the management plans for the Natura2000.
- Power: Rijkswaterstaat could take part in the implementation process of the Delta 21 plan. According to Jos Wieggers Rijkswaterstaat could invest up to 30% of the cost if the delta 21 plan is coupled with flood protection and nature preservation.

Delta commissioner:

The delta commissioner is an independent government commissioner in charge of the national delta program.

- Aim: The goal of the delta program is to make the Netherlands climate and water-resistant by 2050. The Delta Commissioner is assisted by employees, who stay in contact with smaller regions and make sure the research of knowledge institutes connects to the Delta Program.
- Interest: The Delta commissioner needs to be convinced about the importance of this project as an addition to the overall. They have a high interest due to the protection of the Netherlands by the high water levels.

- Power: They have high power because they can change the Delta project and coordinate many employers and relevant stakeholders. They can approve or reject the project Delta21.

Ministry of infrastructure and water management

- Aim: '' IenW is committed to a safe, accessible and liveable Netherlands. That is why the ministry is working on strong connections by road, rail, water and air. And protecting against flooding, ensuring the quality of air, water and soil and realizing a circular economy.'' Ministerie van Infrastructuur en Waterstaat (2022).
- Interest: To make the Netherlands more climate-resilient the Ministry of Infrastructure and Water has an important coordinated and stimulating role in this approach. The protection against climate change is from two programs: the National Climate Adaptation Strategy (NAS) and the Delta program. The National Climate Adaptation Strategy describes the consequences and adaptation tools available for climate change in different sectors such as agriculture, infrastructure, water and energy. In the NAS execution program are the plans and actions explained for the most important climate risks, such as living labs (Ministerie van Algemene Zaken, 2022). The Delta program focuses on the making of a climate adaptative Netherlands. The program consists of measures against flooding, enough fresh water, and the organisation of a climate-adaptive Netherlands for example, the improvement of dikes, or the construction of bioswales. The Delta Plan Spatial Adaptation (DPRA) is a part of the Delta program. The DPRA include seven ambitions for a water robust and climate adaptative Netherlands in 2050. Not only measures are available in the DPRA but also projects that ensure water robust and climate adaptive Netherlands (Ministerie van Algemene Zaken, 2022).
- Power: The ministry of infrastructure and water management arranges the Delta program and NAS. They determine the measures and goals for the Netherlands of 2050.

Provinces:

- Aim: The province is an independent organ that can independently make spatial planning decisions and execute national laws. The province has different tasks for example the facility of roads, industrial and agricultural areas, creation of new nature areas, supervising the waterboards, municipalities and the environmental laws about air, water and soil (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021b).
- Interest: The interest of the provinces is high due to their involvement in the Natura2000 areas. The Delta21 has an impact on the Natura2000 area.
- Power: The province determines new nature areas and also has a high interest in retaining the current nature (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021b).

Waterboard Hollandse delta

- Aim: The waterboards are responsible for managing the dikes and regulating the water levels for every other sector including nature. They are responsible to regulate the water fairway and strive for a sufficient amount of fresh water in the delta area. In the past compensation, measures have been done to ensure this quality (Brühl et al., 2020).
- Interest: Within the waterboard, there is a discussion about the future track that needs to be taken. In the first track, the waterboards want to keep investing in the strengthening and heightening of the dikes to keep the Netherlands safe. In the second track, strengthening and heightening the dikes is not seen as a sustainable option and alternative adaptation strategies need to be found. Therefore, the interest of the waterboard in the Delta 21 plan is dependent on the future track they see themselves going on.
- Power: The waterboard has power due to the taxes money they receive from the citizens. The waterboard receives two kinds of taxes: The water system charge and purification costs. The

water system charge is used to manage weirs, dikes and surface water. Not receiving funds from the government to carry out their tasks gives them the status of an independent party.

Energy sector: Deltawind

- Aim: Goeroe Overflakke wants to become a front runner in sustainable energy.
- Interest: Currently there is a lot of overproduction of green energy due to the irregular pattern. This is compensated by transferring energy to Norway during peak production hours to pump water up and letting water flow down in low production hours to generate energy. With this transaction, 5% of the energy is lost each way. Implementing the Delta21 plan will be beneficial for energy companies investing in the project as green energy can be used more efficiently.
- Power: The energy sector has financial power.

Industry

- Interest: Some industries need fresh water in their production process. If due to the Delta 21 plan the water becomes saline damages can occur in the pipelines. The water in the Haringvliet is not only important for the industry located around this area but also for industry at the Nieuwe water weg. The Nieuwe water weg is saline which means that the freshwater that is needed is extracted from the Haringvliet and transported to this area.
- Power: The power of the industry is high when looking at economic/financial power.

Municipalities

- Aim: Just like the province, the municipalities are independent policy organs. The difference is that they focus on the interest of their citizens and farmers. The tasks are:
    - Maintain the citizens in the Basisregistratie Personen (BRP)
    - Give official documents, such as identity card (ID) and passport
    - Makes zoning plans for houses, a part for nature and industry (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021a)
- Interest: Municipalities have different opinions on the project Delta21. The municipality of Goeree Overflakkee and the municipality of Hellevoetsluis are against the opening between Haringvliet and the sea due to a negative effect on the farmers, mostly due to the Kierbesluit issues in the past (Brühl et al., 2020).
- Power: The municipalities are focused on the citizens and less on natural areas.

LTO North (farmers)

- Aim: The LTO North aims to keep the Haringvliet fresh to maintain agricultural activity as it currently is. The LTO North however does not represent the individual farmer but the collective opinion of all farmers.
- Interest: The interest in the Delta21 project is dependent on the decision to either open the Haringvliet or keep the current Kierbesluit. With the current Kierbesluit farmers are negatively impacted by the saltwater coming from the sea. However, this is still manageable. Opening the Haringvliet completely would mean major adaptations in the agricultural sector as salinization will occur. The original Delta21 plan proposed to open the Haringvliet, but after complaints from different stakeholders, it was decided to keep the Kierbesluit.
- Power: Just like the citizens, the farmers can also demonstrate against the plan of Delta21.

Drinkwater companies: Evides, Brabant Water

- Aim: Water companies aim to deliver clean and sufficient water 24/7 to the citizens and industry. To do so water is purified by nature in different nature areas of which one is located near the Delta21 project.

- Interest: The interest to invest or getting involved in the Delta 21 project will be low as there are no benefits for the drinking water companies. However, drinking water companies need fresh water to pump into the nature areas and therefore strive for a fresh Haringvliet. With the current implementation of the Delta21 plan, the Haringvliet will keep its Kierbesluit and therefore no changes for the water companies will happen.
- Power: The power of drinking water companies is low unless major threats to water security will arise due to the project. As this is not the case as is known so far, drinking water companies will not have a big say in the execution of the project.

Nature organisations

There are several nature organizations active in the Haringvliet, such as Staatsbosbeheer, Natuurmomenten, WWF, ARK Natuurontwikkeling, and Vogelbescherming Nederland.

- Aim: Nature organisations aim to protect, manage, maintain and sustainably utilize nature (Staatsbosbeheer, n.d.). The organisations aim to access nature with the focus on sustainability, climate adaptation and recreation for the hikers without harming the flora and fauna. The target is to increase the vegetation and the animal life in nature areas. Besides, they also want to increase the interaction with the society to expand the sustainable nature area (ARK Natuurontwikkeling, n.d.).
- Interest: The nature organisations have a different perception of the future of the Haringvliet. Their interest is high due to the importance of the nature area. The outcome of the Delta21 has consequences on the nature in that specific area and maybe want to have some compensation for the lost nature. At the same time, the Delta21 was promoted by nature organisations and farmers because of the return of sturgeon fish species in the Haringvliet and upstream part. Nature organisations strive for the restoration of an estuarine environment in the Haringvliet. The five nature organisations and the Royal Dutch Angling Association have been collaborating on the 'Droomfonds Haringvliet'-project. In this collaboration, the organisations have promoted various plans which focus on the restoration of the unique estuarine environment. This project was from 2015-2019 (Natuurmonumenten, n.d.).
- Power: Nature organisations are reassigned to protect the specific nature area. Their power is focused only on these specific areas. However, nature organizations can also have a social impact on Delta21. Nature organizations have/want a connection with society, and could put pressure on the Delta21 with e.g. a demonstration and court.

Citizens of the municipality and near the Delta

The citizens choose the political party of the municipality. The municipality represents the citizens, but the citizens can demonstrate to Delta21.

Appendix E: Interview dr.Mr. P (Pieter) Jong (Landscape Architecture and Spatial Planning)

This appendix includes the transcript of the interview with Pieter Jong - an expert on legislation

Interview

Other projects that had an issue with Natura2000 areas:

- De Kerf: coastal management near Bergen aan Zee.
- The project aimed to make a hole in the primary water barrier. The agreement under stakeholders was important, especially the decisions that had to be taken.
- IJburg : the residential area near the Ijsselmeer (Amsterdam).

➢ Elaborative on Natura2000 and European law

Nature and environment laws are given in the Netherlands. For a large portion that is just European law. In Delft, Pieter wrote a chapter about European law in which the Voordelta and the Maasvlakte II (Maasvlakte II) are used as an example (F.A.M. Hobma & P. Jong, Planning and Development Law in the Netherlands, 2016, chapter 7) The main factor is that Natura2000 areas are protected, through the habitat directive and other European directives such as the "SEA directive" directive. All those directives require an environmental impact assessment (MER). These impact assessments are also done for the implementation of the Maasvlakte II. That project is in a protected area, a habitat test is done and European laws are to be followed. You simply can't go past the Natura2000 legislation. But in practice, this does not mean implementation is no option. IJburg, the residential area near the IJsselmeer is implemented, Maasvlakte II is implemented etc. With Nature compensation a lot is possible. You can't go past the law. Stakeholders, companies, and environmental organisations can all invoke these rules. It is not wise to go past the Natura2000 legislation but there are still enough opportunities for projects to be implemented. With nature compensation a lot is possible. So the main question is how to compensate for nature. With nature compensation, there is an exception to this important European rule. art 6.4 of the habitat directive gives the possibility of making an exception to the main rule if nature is compensated.

You can see explicitly that when human health or public safety plays a role and when nature compensation is sufficient projects can be realised in Natura2000 areas. So try to properly plan nature compensation and then chances are that something can happen in implementation. It is not only Nature protection all the way, nature is protected but projects can be implemented. Think of the Maasvlakte II, the nature in the Voordelta is strongly protected but still, a harbour could be created because the compensation measures were sufficiently planned:

I read that 34 ha of the new dune area is created to compensate for what was lost with Maasvlakte II. Something is changed in the existing nature area and something similar in worth needs to be returned. For Maasvlakte II this was 34 ha of the new dune area. Where there was water first, there are now new dunes.

➢ "Should compensation always be in the same area?"

It is the most logical to do so. These same questions also played a role in the project IJburg. It is most logical to keep compensation close to the area. Things are changed in the existing nature and things have an impact on the existing nature. Therefore, it is most logical to also take compensation measures that are beneficial for the existing nature.

- "But is it then really mandatory?"

Look, the European framework is strict. Without nature compensation, a project will not be implemented. You need to show concrete and sufficient compensation plans. That is easiest when the measures have a relation with the already existing area. It is never stated that compensation should happen within a certain radiance. The stronger the relationship with the existing area the easier the compensation plans are to defend. That is a matter of logical reasoning and good arguments.

- "Do you have any insight into how this went for the Maasvlakte II?"

I see questions on that. The project leader was Rene Vrugt, you can find him on LinkedIn. He is the Program Director of Rijkswaterstaat and is currently working on something else, the connectivity of South Holland. For the Maasvlakte II, an extensive reference is made to the Environmental impact assessment. Also, a monitoring and evaluation programme is running. Of course, there are always uncertainties when decisions are made but the plan needs to be sufficiently concrete for the European juridical process.

It is always compensation and mitigation in the environmental law.

The question is what are the first upcoming juridical decisions that have to be made. That needs to be prepared. Is that a decision of the Province? There are primary flood defences involved, you can't go past Rijkswaterstaat. Before any decisions are taken I would advise agreeing, like an administrative agreement. Because a lot is involved in this project.

For such a big project many decisions need to be made: the province, water safety, natura2000, Rijkswaterstaat. Many decisions before something can be done.

The core is, that there are exceptions possible. If compensation and mitigation are done well Delta21 has potential.

In theory, it is about following the law. In practice, it is about bringing parties together and gaining support, a momentum is needed. Without the cooperation of the minister of infrastructure and water management, nothing will happen and for the energy part, the cooperation of the minister van economic affairs and climate is needed. So maybe the province pulls the process forward, without the cooperation of the actors from infrastructure and economic affairs nothing will happen.

- You already worked on a project in which you brought seven parties together, how did you do this?

Well, that needs a lot of talking. The tip is to make a master plan. Which decisions need to be made and by whom? What are the roles, responsibilities, and functions of involved actors?

Politicians need to score in four years. So they have their priority lists and they think about what dossier they want to score. So how to get Delta21 on the priority list, on the national agenda.

The process is really important, a collaboration between actors is needed and conferences/meetings need to be organized. That is even more important than thinking about how to overcome the theoretical framework. If there is no support nothing will happen. So try to get it as high as possible on the national agenda by providing good arguments and involving each actor. The involved actors need to take it from here.

“How to get further in the implementation process?”

Make use of reference projects such as Rotterdam and IJburg. Use those for inspiration. Also, don’t only look at projects within the Netherlands. Abroad they deal with the same issues. Also in Germany, they look for effective compensation measures and also in Germany climate adaptations, energy transition etc. play a role.

Your questions are focused on the content of natural law but focus on the exceptions.

- Where do you think Delta21 will face difficulties in the implementation process:

It is a little too early to ask this question. There are multiple phases to go through. Make a timeline of these phases. At a certain point in time, a draft decision needs to be made. If the initiators want to go to the next step decisions need to be made. In agreement with parties such as Rijkswaterstaat.

Implementation starts when the plan is established and decisions are made.

- To conclude/ last tips

For more information look at reference projects. The most important piece of advice is to not forget the administrative process. How to collaborate with the most important stakeholders?

In the area, some citizens and stakeholders like to call on European regulations. They want it to remain as it is now and they make good use of existing nature regulations. On the other hand, the initiators also try to make use of these rules but focus on the exceptions that are needed to make changes. In this, you look for sufficient reasoning with good arguments in which the interest of nature is considered. With good reasoning, much can be accomplished. But you need to go through the political-administrative decision making process and it needs to be judgment proof. Meaning that it follows the European nature and environmental regulations. Concrete decisions and thorough research are needed to accomplish this. So also all the negative impacts of Delta21 need to be clear and communicated transparently as in an MER.

Think of Rotterdam (Maasvlakte II). It costs nature, but also new nature has been created.

There is enough literature available. The most important thing is to think the process through. What steps need to be taken.

Last tip:

The Hinderplaat makes me think of the Sand Engine. With the Sand engine, the natural processes are stimulated and more dynamics are added in favour of flood protection. Also, fewer costs are made in sand suppletion. With the Hinderplaat the goal is to have fewer natural dynamics.

Everything is possible as long as it has good reasoning and can be tested. Support is needed in the political-administrative process and the judge needs to test it to European regulations. Following those rules is a minimum requirement.

Appendix F: Societal Evaluation Report

Here the moral part of the project implementation is investigated. Namely, the extent and importance of the construction and intervention of Delta21 to the environment are also addressed in relation to moral concerns and debates humanity struggles with. However, it is important to state that the reasoning behind this evaluation is based on the group's discussions, opinions and reasoning.

Reflection on the social aspects of the problem

The Delta21 is expected to have some positive effects on nature and biodiversity in the mouth of the Haringvliet (Arcadis et al., 2022). The area is protected by Natura2000 legislation due to its significance for nature and biodiversity. In that context, the project will preserve the current ecosystem structure and species by limiting external interventions that will cause large landscape changes in the future, like the sea level rise. In other words, it will provide nature with a wider area to develop and thus preserve its natural value. The other scenario with human-driven impacts will cause major changes in the area's characteristics and potentially ecosystems' degradation. However, this construction will also affect the existing ecosystems and natural dynamics that have been developing, shaping, and gradually changing the morphology of the area. Whether the change is positive or negative is up to human judgement. Therefore, the project raises some ethical questions concerning the ongoing debate about whether humans should intervene in nature dynamics or not.

Ecosystems are degrading worldwide, the climate is changing, and biodiversity has been decreasing at such a rate that the 6th mass extinction is on its way. These events are caused by the human impacts on the environment (Wake & Vredenburg, 2008). Therefore, the modern age society has not only undeniable responsibilities for the constant degradation of nature but also the duty to protect the natural environment, since the extent of the pressures is more than what nature can absorb (Crist, 2007). Nevertheless, nature is a dynamic system constantly changing due to both natural ongoing processes like morphological dynamics and constant human influences like nitrogen deposition. This raises the question of which approach humanity needs to follow to protect the ecosystems.

Should we protect nature by leaving ecosystems on their own, or should we intervene in preserving the current state of nature even at the expense of the ongoing natural dynamics? If so, when should the standard be set and whose opinion and interest should be taken into consideration?

The ongoing debate

There is controversy concerning the ethical dimension of intervening in nature dynamics to protect a certain version or structure of an ecosystem at the expense of other possible evolutions and interactions. On the one hand, the primary duty of humanity towards ecosystems, species and habitats is to respect their integrity and stability. The most efficient way to achieve this is by limiting the interventions and letting the systems follow their internal dynamics (Michael, 2002). On the other hand, climate change has the characteristics of a "moral storm" imposing many contradicting ethical factors which pressure individual and collective action toward nature preservation. Like the responsibilities, humanity has for the current state of events (Gardiner & Hartzell-Nichols, 2012). However, climate change consists of multiple factors that threaten the human's ability to behave ethically, imposing different but important moral problems, such as moral corruption (Gardiner, 2006). The corruption, in this case, can be linked to aspects like how discounting the future compared to the present is happening, and how to compare the worth of ecosystems that are not identical. It can also refer to self-deceptive initiatives that might influence decision-making and the actual interventions made, due to the complexity and multidimensional character of the problem. To sum up, reasoning whether interventions to earth's system are ethical or not given the present conditions relates to both supportive and adjective arguments.

To begin with, there are many arguments in favour of interventions aiming to help nature to deal with all the nowadays pressures. First and foremost, changes in the earth system are mainly human driven. The cause behind the most important environmental problems is the profit-driven and industrialized development humanity is pursuing, which results in unsustainable habits, nature's pollution, and degradation of ecosystems (Dasgupta, 2021). In this context, civilization has the responsibility to contribute to the solution of these problems. The civilization is capable to do this through the development and technological innovations it has produced. Furthermore, the magnitude of human-related pressures is such that the environment may not maintain favourable levels for current life forms (Smith et al.,2001). Thus, some interference from the human side could be necessary to assist and amplify nature's dynamic processes, preserve biodiversity, and manage the pressures. Also, the current biodiversity and ecosystems are considered part of the legacy the current generation will pass to the future ones. Meaning that ecosystem services should be preserved for future generations as well (Lawrence, 2014). Therefore, civilization in the present is also responsible for what the new generations will inherit and in part the quality of their lives. Thus efforts to preserve the ecosystem quality are also oriented to those future generations.

In addition, not intervening in nature areas to keep their integrity, while continuing with a "business as usual" manner of development is inefficient as well. Human influence is significant even if humanity provides space and possibilities for nature to evolve (Ecosystems and Air Quality, 2022). Like, the transportation of pollution by air and water, alterations of the feedback mechanisms and chain effects will continue to cause ecosystem degradation. For instance, nitrogen deposition will continue to be a serious problem along with pollution of the ground, water and air compartments if societies do not take measures for ecosystem preservation. In that context inaction towards the ecosystems may cause an increase in their vulnerability rather than just providing space for the natural dynamics to evolve. Overall, the debate about whether civilization should facilitate interventions in earth's dynamics to preserve its worth, relate to both responsibilities, capabilities, and moral concerns.

On the other hand, intervention in nature's dynamics is also connected to negative or worrying factors. To begin with, human knowledge about the earth system and its countless dynamic processes and feedback mechanisms is limited. In other words, civilization does not have the insight to foresee the changes with absolute certainty. Therefore an intervention to its balance could cause a negative result, or even worsen the situation (Sörqvist & Langeborg, 2019). Moreover, changes in the global climate, ecosystems and species are present throughout the earth's history (Elewa & Abdelhady, 2020). Specifically, extinctions have already happened before and the global climate is continuously changing due to both internal natural processes and external interventions. In that context, the earth is a dynamic always changing system and the efforts to maintain the current conditions over the future life forms that may follow are both difficult and morally questionable. Overall, the multiple factors influencing the planet and thus changing its conditions independently from human will and actions, combined with the uncertainty and lack of complete understanding, state efforts to control the alterations in the system are controversial.

The group's reasoning process

To sum up, whether it is ethical to intervene in nature's processes and balance is a difficult matter to solve. However, most of our group members agree that interventions are necessary considering the state ecosystems are in the present and to avoid further degradation of biodiversity. The proper way to implement this reasoning though is not easy to address. Specifically, setting the standard for valuing the present biodiversity compared to what it was or could be, includes many moral aspects. For instance, an important issue is how far in the past humanity should search for this baseline, considering that the interventions have already started with industrialization. An indicator for measuring changes both in terms of improvement and degradation is not easy to produce. An optimal situation could be set as a past time when human interventions were minimal or in the present

favouring the current life forms. Besides the preferable time, the stakeholders whose interests and opinions should be taken into consideration are also unclear. To be specific, ecosystems' functions and species' importance, differ for different groups of people and among countries. For example, priorities and incentives diverge between farmers and environmental groups, making reaching of consensus difficult. As a result, the decision about a standard value for measuring ecosystems' conditions is a demanding matter to address.

In that context, the group agrees that setting a fixed standard is not possible. Different opinions and reasonings have emerged. Some argue that the standard should be revised according to knowledge and information advances, to meet the requirements of a meaningful evaluation. Others say that the standard should be set in a way that prioritizes the protection of natural dynamics, with less focus on human needs and preferred conditions. Finally, it was mentioned the opinion of setting the standard in the present, since it is a critical moment for the ecosystems and biodiversity and action for limiting ecosystem devastation is necessary. Hence, creating a measure for the ecosystem's situation is closely linked to moral values and differs between individuals. However, there was unanimity related to the fact that this indicator should be dynamic as the system that it represents.

Contrary, it is important to state that the method and reasoning process the group followed to reach a conclusion, is neither the correct nor the only existing one. To start, the different backgrounds combined in the group in general consist of natural sciences, and social science initiatives are lacking. Thus, the group's orientation towards the protection of the region's natural value may also originate from the educational background, which points to favouring interventions over moral debates. If these dynamics were different, another thinking process and result might have been the outcome instead. Moreover, the lack of knowledge concerning the ethical dimensions of climate change and human interventions despite the intentions also influenced the opinion about the project. Lastly, the extent of the project's potential and benefits predisposed the group's view about it in a positive direction, without considering the possible unanticipated effects it may impose. The moral process and research perspective, therefore, are not unbiased since different values and priorities are present more or less in the procedure the group followed, showing that objectivity is hard to accomplish (Van Koppen, n.d.)

In conclusion, according to the group's perspective the Delta21 project's implementation, aiming to protect the rich biodiversity of the area and limit the danger associated with flooding, while producing renewable energy, is considered to be worth the risk. The process started with the realization of the fact that the project itself concerns a big scale intervention to natural dynamics, even though it will result in the preservation of the current biodiversity and processes. The group faced a dilemma concerning whether the scale of the intervention is ethical considering also the possible unanticipated consequences that might occur. However, considering the impacts climate change and human driven pressures have on the Hinderplaat, the intervention is necessary. Even though there was consensus about that, in the group the opinions about when the standard for evaluation related to the ecosystem's condition should be set differed. Overall, processes associated with ethical dilemmas like the one Delta21 presents are difficult to be cleared. Nevertheless, current conditions limit the time and room that such debates can evolve since the urgency to act becomes gradually more intense. Thus, projects like this might be a necessity despite their link to ethical doubts in the near future.

Appendix G: Possible interview questions for follow-up research

Unfortunately, we as a group were unable to interview a few key people during the study. However, we were prepared for these interviews and therefore we prepared some questions. Although it was not possible to arrange an interview, we would like to share the questions so that they can be used by, for example, research groups in the future. This mainly concerns Natura2000 legislation with regard to the ADC-test. The interview questions about Natura2000 are:

1. Natura2000
   a. What do you think about Natura2000?
   b. To what extent is climate change/morphological processes considered in Natura2000 legislation?

2. Nature preservation/ compensation
   a. Would you say a nature area deserves extra protection/ is more important to preserve?
   b. What struggles are there regarding the goals do you see in Natura2000 legislation in the areas of Voornes Duin, Duinen Goeree and Kwade Hoek (Haringvliet)
   c. What are the requirements to compensate a Natura2000 area?
   d. Do you have experiences or difficulties regarding compensation?
      What project did succeed in compensating a Natura2000 area?

3. Maasvlakte II
   a. What has been the impact of the Maasvlakte II on nature?
   b. Do you think that with more drastic compensation measures these effects could have been negligible/minimized?
   c. What would be sufficient compensation?
   d. In compensation, I can imagine the quantification of what is lost is difficult. Not only nature area but also nature quality plays a role. Do you have any ideas about if and how this is done?

4. Delta21
   a. What do you think Delta21 would have an impact on?
   b. What might help to reduce this impact?
   c. What can be done to stimulate these species/habitats?
   d. If the implementation of Delta21 appears to be unavoidable, do you think nature is dynamic enough to flourish in another protected area?

5. Finalizing conversation - (ADC-test)
   a. According to the law, before Delta21 can be implemented in a natura2000 area, alternative solutions should be ruled out. Can you think of any alternative solutions? Do you think dike strengthening is enough?
   b. What do you think the added value of Delta21 could be?
   c. Do you have any more questions or remarks on Delta21, the Maasvlakte or the Natura2000 area?
   d. Do you have any documents that can help us with our project?
   e. What information can't we use in our report?

f. Can we use your name in the report or do you want it to be anonymous?

The other interview questions focus on the ADC-test.

1. Which projects succeeded in the ADC-test?
2. What steps were taken to be successful?
3. The A is for alternatives:
    a. How is it defined what alternative is reasonable?
4. The D is for Dwingende redenen.
    a. What are the requirements for determining the size of public interest?
    b. How is varying interest taken into account?
    c. What are examples of arguments that would allow disturbance of Natura2000 areas?
    d. Do you have tips on how to formulate a large Natura 2000 disturbing project such that receiving permission is more likely?
5. The C is for compensation:
    a. How is nature quantified to make sure that what is lost is also compensated? (Quality vs area).
    b. What is the fixed timescale for the compensated nature to reach the pre-disturbed value?
    c. Is the timescale of compensation depending on the habitat type or fixed?
    d. What are the consequences of insufficient compensation?
    e. To what extent is the disturber reliable for failing compensatory measures, eg. The Rotterdam harbour?
    f. Does the responsibility for compensation have a statute of limitations?
6. Are there any papers or documents you know of that could help us further in our research?

Appendix H: Additional information 3.4 C - Compensatory measures

Embryonic dunes (H2110) and White dunes (H2120)

General description
An Embryonic dune is a dune that is in the early stages of dune formation. When sand is blown against the object or watermark an embryonic dune can be formed. Sufficient wind dynamics are important for the long-term preservation of the dunes. This, in combination with the supply of sand (so more sand has to be deposited than is removed). Favourable conditions occur on a growing sandy coast, in areas with sand nourishments and sheltered parts of the coast (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2008).
White dunes with “marram” vegetation naturally arise where Embryonic dunes drift so far that the plant growth is beyond the reach of saline groundwater and flooding seawater (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2008). White dunes are related to the Embryonic dunes and face the same difficulties. Also in many cases the Embryonic dunes and White dunes occur in zones next -and as successive stages of each other.
These types of dunes occur in the areas of Voornes Duin and Duinen Goeree & Kwade Hoek. For this habitat type, preservation of the surface area and quality of this habitat type are the goals.

Challenges/ trends
This habitat type is appointed special attention by the EU. There is no need for expansion of area or improvement, but there are some challenges in the preservation of surface and quality. The most important challenges are seen below.

Recreation is one of the largest threats to embryonic dunes. The Dutch beach is generally freely accessible. The zone where the embryonic dunes form is in many places leased to operators of beach bars or private individuals for beach houses (OBN Natuurkennis, n.d.).
Also, nitrogen is one of the challenges in achieving the Natura2000 goals. This concerns the consequences of nitrogen deposition from agriculture, traffic and industry on nitrogen-sensitive habitats. In the dune areas, a large part of the nitrogen precipitation from ammonia comes from the sea (Provincie Zuid-Holland, n.d.). The amount varies from place to place but overall has increased in the past decades, causing a significant overload of nitrogen deposition. It provides a more nutrient-rich soil, while the dunes contain many plants and animals that can cope with nutrient-poor soil. The overload of nitrogen deposition reduces the area of calcareous dunes. A nutrient-rich soil provides more vegetation, which reduces the chance of sand drifting and prevents a natural supply of lime (NatureToday, 2020b). This challenge is important for this habitat type due to the reduction of sand drift may result in fewer embryonic and white dunes.
Because of the inland movement of the Hinderplaat, it can eventually make a connection with the Voornes dune area. This can lead to further grassing in the existing dune areas. However, it is not known when and where exactly the Hinderplaat makes a connection with Voornes Duin. For many years a channel may remain near the ‘Groene punt’, which prevents the Hinderplaat from merging with the area of Voornes Duin (Arcadis et al., 2022).

The sandy beach on Voornes Dune can become silty if the precipitated silt remains for a longer period. This development can be beneficial for certain types of breeding and non-breeding birds (Arcadis et al., 2022). However, high silt content can cause vegetation like sea buckthorn to more quickly overgrow these areas. Human applied sand contains also a high silt concentration, which causes sand drift to be impossible (Haskoning Nederland BV, 2016).

Grey dunes (H2130), Including Humid Dune Slacks (H290)

General description
This habitat type concerns mostly the dry grasslands of the dune area, consisting of various species-rich vegetation. Grey dunes arise behind the foredune in places where the wind dynamics are low which provides a suitable environment for herbs and mosses. Grey dunes can be divided into different subtypes. Only the subtypes Calcareous Grey dunes (H2130A) and Grey dunes (heischraal) (H2130C) are important for the four Natura2000 areas. This habitat type is a prioritised habitat for the Natura 2000 areas Voornes Duin and Duinen Goeree & Kwade hoek. Expansion of surface area and improvement of quality are important goals for those habitat types. This could potentially be an opportunity for Delta21 (STOWA & Rijkswaterstaat, n.d.).

The habitat type of Humid Dune Slacks (H2190) concerns open water, moist grasslands, low swamp vegetation and reed beds. It occurs in valleys in the dunes. They can arise from dust pits (stuifkuilen) drifting down to the groundwater level (Natura2000, 2009). For the Voornes Duin and Duinen Goeree & Kwade hoek Natura 2000 area, the goal is to increase the surface area and improve quality. It is also a valuable habitat type for various species.

Grey dunes can be divided into different subtypes; Calcareous Grey dunes (H2130A), non-calcareous grey dunes (H2130B) and grey dunes (heischraal) (H2130C). Subtype H2130C consist of vegetations that occur on relatively acidic and nutrient-poor soils. Often the transition area between dry grasslands and Humid Dune Slacks vegetation (H2190) (Natura 2000, 2008). For the four Natura2000 areas (see chapter 1), only subtypes A and C are important.

Challenges/ trends
A major challenge for these habitat types is the very high sensitivity to nitrogen deposition. This has caused the quality and surface to decrease further. The undesired consequence is a coarsening of the dune grasslands and an increase in thickets (struikgewas). As a result, the surface area has declined sharply over the past decades (Natura2000, 2008). There is also a sharp decline in Humid Dune Slacks (H2190) over the past decades. The most important causes are desiccation, eutrophication, an increase in thickets and acidification due to continued succession (Natura2000, 2009).

The *Liparis loesellii* (Groenknolorchis) that occurs in wet, nutrient- and nitrogen-poor places has declined quickly in recent decades. The Voornes Duin is of great value for the national population of *Liparis loesellii* as it houses about five percent of the target population. The main causes of the quick decline are natural fluctuation in groundwater levels, a limited presence of suitable sites and grazing or mowing management (Provincie Zuid-Holland, 2016).

Many species that occur in the dunes are well adapted to a more extreme and dynamic environment. But because of the increase of extremes due to climate change, is also the main reason for the decrease in Humid Dune Slacks. In addition, wet sand can prevent sand drifts from happening (NatureToday, 2020a).

Compensation (additional information):
Different stages of dune formation must be taken into account to create a dynamic dune system:
First, the sand is placed in the first dune row with notches, the second dune row in parabolic dunes and then the third dune row. After that, the continuous dune row for the forest dunes is placed. In the second stage, in the areas where the sand must stay in place, vegetation is planted. In the young dune area marram grass, and in the old dune area grass, shrubs and trees. The third stage is done by wind, rain and succession. The wind blows out sand and creates a freshwater pond just beyond the notch. The places where the marram grass is planted will capture the blowing sand and will move to

the next stages of succession. The vegetation and the low lying areas between the dunes capture and infiltrate the rainwater. After a few years, a freshwater bell will form in the subsoil. When this happens, freshwater ponds with rare flora and fauna will occur (van Eeden, 2021, p.95).

Mudflats and sandbanks (H1140) and permanently flooded sandbanks (H1110)

General description
A permanently flooded sandbank is a sandbank that is in the shallow sea, normally not deeper than 20 meters (Natura2000, 2014). Locally hard substrates can exist for example peat, rocks or shell banks. The border between permanently flooded sandbanks and habitat type H1140 is determined by the lowest astronomical Tide (Natura2000, 2008a). Above this low water line, the sandbanks are not permanently flooded but sometimes fall dry due to the tides. In the North Sea, the sandbanks are a different protected subtype, with coarse sand and rarely any vegetation. Seals and migrating birds make use of the mudflats and sandbanks.

Challenges/trends
The construction of the Maasvlakte II has led to the loss of permanently flooded sandbanks. As a result, the foraging area for the common tern and the sandwich tern is reduced. The nature conservation law required the Dutch government to compensate for this loss by introducing a seafloor protection area of 24.550 ha, where intensive bottom trawling is no longer allowed. However, from monitoring it can be concluded that the measure is not effective; bottom trawling was already minimized before the protection area was set up; shrimp fishing has increased, and the food production for fish and birds is insufficient (Provincie Zuid-Holland, 2016). More effective conservation measures are now being investigated by the Harbour of Rotterdam (Minister van Landbouw, 2022). Due to the ineffectiveness of the compensatory measures six nature organisations have recently sued the Dutch government (NOS, 2022).

Besides the construction of the Maasvlakte II, the sedimentation processes and the inland movement of the Hinderplaat are also expected to reduce the area of permanently flooded sandbanks. Consequently leading to the loss of foraging areas of non-breeding bird species (Arcadis, 2022). Also, it is expected that morphological changes will impact the populations of harbour seals and grey seals as the inland movement will cause a decline in rest due to tourism.

Estuary (H1130)

General description
An estuary is the downstream part of a river that is influenced by seawater and tidal movement (Natura2000, 2016c). Through the interaction between river water and seawater, there is a gradient in salt concentrations. The habitat type H1130 consists of a mosaic of marine and brackish ecotopes including permanently flooded sandbanks (H1110) and mudflats and sandbanks (H1140). In the estuary, benthic species thrive and serve as food for many birds. Also, many species such as migratory fish spend different parts of their life cycle in different subareas of the estuary.

Challenges/ trends
Before the Haringvliet was closed off in 1970 it was an estuary. Since the closure, many species decreased in number. For example, benthic species thrive in a brackish zone (Natura2000, 2016a). Some species are surviving at the mouth of the Haringvliet, but the strongly fluctuating salinity levels make it hard for them to survive. This then indirectly impacts the bird population in the region.

Besides, the Norwegian vole (Noorse woelmuis) is impacted by the closure of the Haringvliet locks. This species thrives in a dynamic context. However, because of the reduction in estuarian dynamics,

the Norwegian Vole is threatened by the more common earth mouse and field mouse. To ensure a better future for the Norwegian vole nature-friendly banks are created. The focus is on the scorching (verruiging) of the area by implementing tidal nature and experimenting with different management forms like stopping the grazing or removing trees (Natura2000, 2016b).

Also, migratory fish such as the Twait shad and the Allis shad are affected as due to the closure of the Haringvliet migrating is hardly possible. If the fish have migrated their ideal spawning spots are reduced in quality due to the levelling of the Haringvliet bottom floor and the lack of a permanently brackish zone.

Since 2019, the Kierbesluit allows the opening of a few locks during high tide to let migratory fish enter. However, according to Bas Roels from the World Wildlife Fund (WFF), a permanent brackish zone for foraging and reproduction is not yet formed (Wesseling, 2021). Also, when the locks are opened during low tide to release the build-up of freshwater into the sea, fish that entered the Haringvliet flow back to the sea due to the strong currents. To accomplish the set Natura2000 goals, more drastic changes are needed. However, opening the Haringvliet locks is a highly debated topic as the current freshwater basin offers lots of opportunities to e.g farmers and industry.

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