Economic valuation of ecosystem services

Increasing the feasibility of coastal development project Eemszijlen by valuing its ecosystem services

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Abstract

The background of this research is to value the ecosystem services derived from the Eemszijlen project, a coastal development project in the north-eastern part of the Province of Groningen, the Netherlands. Its objective is not only to create an attractive area for living, working and recreation, but also to realise an area that is prepared for the effects of climate change, where sufficient space can be offered for economic development and restoration of ecological values. However, the financial costs of the Eemszijlen project are not all certain to be covered. With a higher economic value of the project, a further investment could be leveraged. Since not all the included benefits are expressed, the total value of this project was not completely quantified. Ecosystem services are such benefits, but their importance to humankind is often underrepresented in decision making.

The objectives of this thesis research are threefold: 1) to express the economic value of ecosystem services that arise within the Eemszijlen project, 2) to provide recommendations towards enhancing the feasibility of the project through the added economic value of ecosystem services, which can increase the support base of the project, and 3) to provide empirical evidence that can facilitate the adoption of ecosystem services in decision-making. These research objectives contribute to the objectives of the Eemszijlen project by increasing the likelihood that the Eemszijlen project succeeds.

Through interviews and documents reviews, eight ecosystem services were identified as follows: freshwater supply, coastal protection, carbon sequestration, coastal town experience, fish migration, awareness-raising and primary production. In this research, their value is mainly expressed in qualitative terms. Nonetheless, emphasizing the values of ecosystem services can be determinative in decision-making since alternatives can be better weighed with advantages and disadvantages. This means that the feasibility of Eemszijlen project, in which various valuable ecosystem services arise, increases by valuation. The two suitable methods for ecosystem service valuation in this research were the cost-based approach, in which the cost of alternatives is valued, and the contingent valuation method, an economic technique for the valuation of non-market resources through obtaining information about 'willingness to pay;.

However, the valuation of ecosystem services is not a common practice, as some barriers exist, such as high costs, since ecosystem service valuation studies are comprehensive and multiple specialists are needed. Benefits that fall in the public good shall ensure that initial investors do not receive the economic benefit themselves what makes them less interested, and the fact that many benefits just like biodiversity don't have market price makes it difficult to convert them into a monetary value. Altogether, besides increased project feasibility, the findings of this research also contribute to the adoption of ecosystem services in decision-making.

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1 Introduction

For too long, water managers utilized human-built or “grey” infrastructure to solve water-related issues and improve water systems (UNESCO, 2018). Consequently, they overlooked the traditional knowledge that embraces green infrastructure which uses natural or semi-natural systems to provide water management options with the same benefits as conventional water infrastructure. Moreover, working with nature, instead of against it, would reinforce the appreciation of natural capital and its value. Besides, greener approaches support a circular economy in which resources are utilized efficiently. Such nature-based solutions (NBS) can be cost-effective and besides their initial purpose simultaneously provide additional social, economic, and environmental benefits. These three interwoven benefits contribute to the respective dimensions of sustainable development (UNESCO, 2018). NBS are defined as “solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.” (European Commission, 2020a). The European Union’s research and innovation policy aim for a leader position in innovating with nature to accomplish more sustainable and resilient societies (European Commission, 2020b).

Rising sea levels, increased river discharge and heavier rainfall as a result of climate change increase the risk of flooding in the North Sea Region, including The Netherlands. These effects threaten the communities and the economy and therefore they call for new measures (Rijkswaterstaat, 2021). Traditionally hard infrastructure such as dikes covered with stones and concrete dams were used to protect the Netherlands from flooding. But in recent years the NBS gained widespread attention in the Netherlands. Already a variety of small-scale projects have been implemented, making use of natural processes to keep humans safe against flooding and coastal erosion where both people and nature benefit from (Interreg North Sea Region Building with Nature, nd). One of the best examples is the ‘sand engine’. As Dutch shorelines are suffering from erosion, a manmade sandy island was constructed off the coast that naturally spreads along the shoreline and ensures a gradual growth that protects the country against flooding (Ministerie van Infrastructuur en Waterstaat, 2021).

An advantage that comes along with the use of NBS is ecosystem services. Ecosystems deliver services that economically benefit humans. Valuation of such ecosystem services can be useful to conserve them and for integration in policy decisions, however, their importance is often underrepresented (Horlings, et al., 2020).

1.1. Empirical background

The Eemsdollard estuary is located in the Dutch province of Groningen and the northern Dutch-German border area. It is a unique nature reserve for two reasons. Firstly, it is one of the very few places where freshwater and saltwater come together in the Netherlands. Second, it is the only area in the Wadden Sea with a natural fresh-salt transition. Therefore, this area contains a unique diversity of plants and animals that are bound to brackish water (Sweco, 2020). The estuary also serves as a nursery area for fish that move to the North Sea when they are older (Deltares, 2010). The estuary has a mesotidal regime with a tidal range of approximately 3.3 meters and a mean high tide of 1.55 NAP (Normal Amsterdam Level) (Esselink, 2000). The constructed coastal defence mechanisms to protect the land are two dikes, each with its purpose. A primary dike is located along the coastline, whereas a sleeping dike is a reserve dike located inland (Provincie Groningen, 2013).

The estuary has also become important for various economic activities. It is close to three important industrial zones, namely Delfzijl and Eemshaven in the Netherlands and Emden in Germany. These zones are developing rapidly (Sweco, 2020). Other significant activities in the estuary include shipping routes, deep drilling activities, recreation, and fisheries (Deltares, 2010). These economic activities also come with a downside since the natural processes in the area have been disturbed. In the past centuries, vast lands around the estuary were reclaimed and too little space has been left for fine sediment to settle. Shipping lanes were also deepened and broadened, causing the water that is going inland to be much stronger than the water that flows back to the sea. Hence, more fine sediment accumulates in the estuary and less can settle. These morphological changes, together with dredging to maintain shipping lanes and harbours accessible, cause the fine sediment particles constantly to whirl up. As a result, the Eemsdollard estuary water has become turbid (Eemsdollard 2050, 2021a). This negatively impacts the entire food web and disturbs the natural balance of the area (Eemsdollard2050, 2021b).

To tackle the above problems, the Eemsdollard 2050 Programme was set up by the national government and the authorities in the region. This programme aims to balance economic activities with ecological protection by setting several ecological targets. These are an estuary of appropriate dimensions and natural dynamics, healthy habitats and gradual transitions, natural turbidity, and sufficient food at the base of the food chain. Additionally, the achievement of Natura 2000 and Water Framework Directive objectives are also part of the ecological targets (Eemsdollard2050, 2021b). Within the Eemsdollard 2050 programme, various projects are carried out to achieve the set targets. The measures of the projects can be divided into three tracks. The first one is the vital coast, in which natural habitats are created and recovered in combination with dike improvements. The second one is the useful application of fine sediment, in which the fine sediment is captured to ensure a lower concentration of particles in the water and potentially use it to strengthen dikes or heighten agricultural land. The last track is hydro morphological improvements, in which the water flow system needs to be improved in order to reduce the amount of fine sediment entering the estuary (Eemsdollard2050, 2021c).

In addition to the problems caused by human interventions, several challenges are faced in the coastal area between Termunten and Delfzijl due to climate change. One major challenge is sea-level rise, which requires robust flood defences along the Eemsdollard area. Rising sea level raises the seepage by extra pressure and aggravates salt intrusion. The region also deals with soil subsidence due to not only gas extraction, peat oxidation and local salt extraction, but also autonomous settlement. There are large local differences in soil subsidence since peat distribution varies. The region of Eemszijlen is the lowest-lying part of the province of Groningen, as shown in Figure 1, and therefore more vulnerable for dike breaches. If a dike breaks, the water will directly find its way to the city of Groningen. Additionally, in this area freshwater flows naturally to the sea. Therefore, this vulnerable zone is the first to be considered for restoring a robust fresh-salt transition (Sweco, 2020).

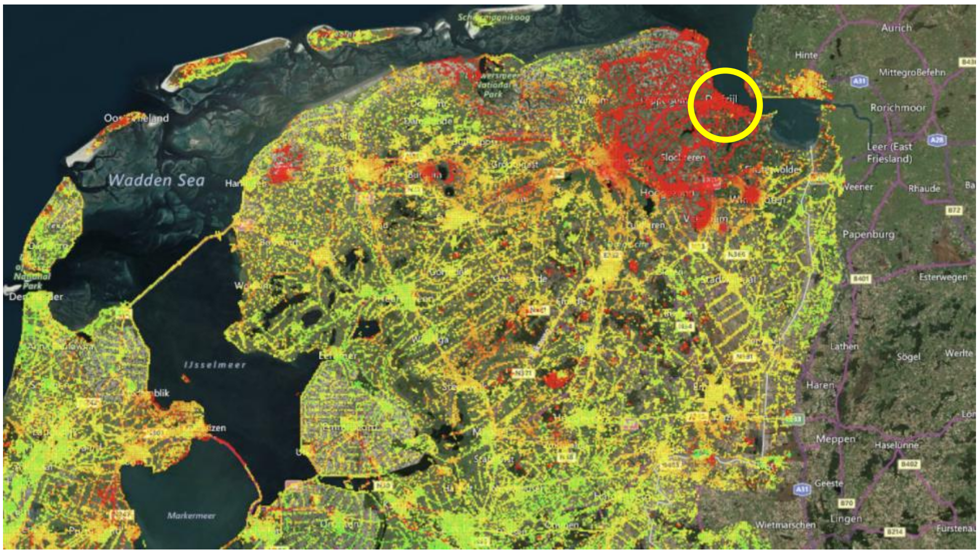

Figure 1: Surface subsidence in the north of the Netherlands (Skyegeo, 2019).

The Eemszijlen project is part of the “vital coast” track within the Eemsdollard 2050 programme. Figure 2 shows the individual projects that are part of this track. The challenge is to create an attractive area for living, working and recreation, to realize an area that is prepared for the effects of climate change and where sufficient space can be offered for economic developments and restoration of ecological values (Sweco, 2020). The most important measures that are planned within the Eemszijlen project are converting the current sluice that is used for flushing to a recreation sluice and the current flushing sluice will be moved to the Pier van Oterdum where a new fresh-salt transition can be constructed with provision for fish migration. This transition area is combined with the Groote Polder project, an area designated to become a brackish zone suitable for various birds and fish to rest before swimming up the canal. Furthermore, various initiatives will be boosted in order to make the area experienceable for visitors, create a new tourist destination and use the area for education and creating awareness. The centre of Delfzijl will become part of the continuous recreational shipping route and in combination with a variety of recreational opportunities, the livability of the area will be increased (Sweco, 2020).

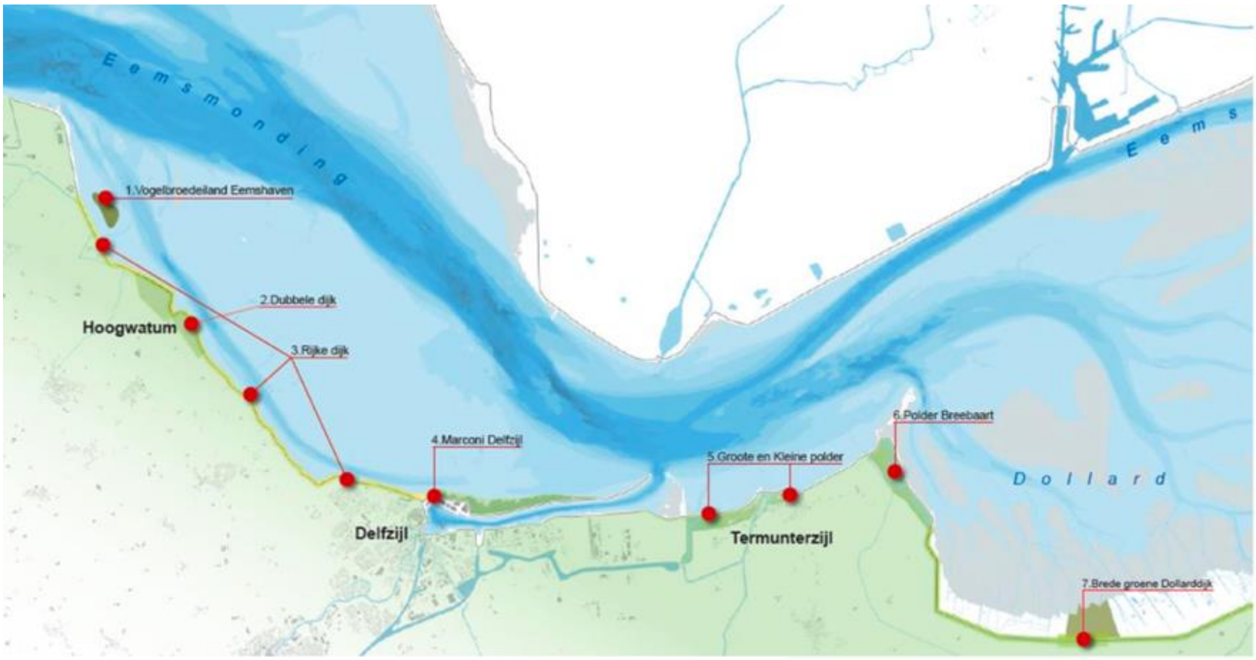

Figure 2: Vital coast projects (Sweco, 2020)

1.2. Problem statement

The funding demand of the Eemszijlen project is extensive. The required investment is estimated to be approximately 72.6 million Euros. Therefore, several funding sources are used. These vary from, the Waddenfonds, the national program Groningen, the Programmatische Aanpak Grote Wateren (PAGW) and sources within the region such as the province of Groningen, municipality of Eemsdelta and Groninger landschap. By combining multiple funds, the realization of an economically and ecologically robust, recreationally interesting, and climate-proof coastal zone could be accelerated (Sweco, 2020).

Several benefits are expected from the project. These benefits are mainly related to the spatial quality impulse and the development of nature. The ecosystem services identified yet are expressed in higher property value, benefits for tourists and holidaymakers (also resulting in expenditure and higher employment) and saved costs for dredging. The overview of benefits and their monetary valuations are shown in Table 1.

Table 1: Expected benefits of the Eemszijlen project (Sweco, 2020)

Description of benefits	In millions of Euros
Commercial and recreational shipping	5
Tourism	14
Liveability	29
Provoked private investment	-
Saved dredging costs	2
Total benefits	**50**

The biggest bottleneck currently faced is that not all financial expenses are certain to be covered yet. In Table 2 the financing coverage is shown. The required investment will be approximately 72.6 million Euros, of which 23.2 million is secured for certain. There are 35 million Euros in total on request, which is not yet completely certain to be covered. Nonetheless, there is still 14.4 million Euros that needs to be covered. Therefore, the collaborating parties of the project should explore whether and which additional contributions or savings are possible and negotiable. They also consider private investments in the business community (ecological mitigation or compensation), capitalization of planned management and maintenance costs of current infrastructure and water system/drainage, and possible sources from the coupling opportunities mentioned in this project plan.

Table 2: Total coverage of the Eemszijlen project (Sweco, 2020)

Total coverage	Coverage in millions of Euros (sum)
Required investment	**72.6**
Committed funding	23.2
Total to request	35
still to be covered	**14.4**

Since the financial expenses of the Eemszijlen project are partially covered, the project requires additional funding from investors. With a higher economic value of the project and more attention from investors and other organizations that feel connected with the project, a further investment could be leveraged. However, the total value of this project is not completely quantified yet, since not all the included benefits are expressed. Ecosystem services are such benefits but need to be identified and subsequently expressed in their economic value.

1.3. Research objectives

In this section, firstly the objectives of the Eemszijlen project are given as a basis to provide an overall view. Subsequently, the relationship between these objectives is explained. Then the objectives of this research are given and the potential contributions to the Eemszijlen objectives are elaborated.

The Eemszijlen project has four interrelated objectives:

1. Realizing a fresh-salt transition area with fish migration.
2. Raising the coastal zone naturally by allowing silt from the Eemsdollard to settle in a zone within the dike.
3. Guaranteeing freshwater availability in the longer term by preventing salt intrusion.
4. Strengthening the liveability in the city of Delfzijl and the villages of Borgsweer, Termunterzijl and Term through the design of a green buffer zone in combination with an attractive environment and reinforcement of the recreational facilities.

By tackling these issues from an integrated approach in which various aspects are linked, it can be possible to combine multiple solutions, such as improving the fine sediment load, the accessibility of the port of Delfzijl and the flood protection. The harbour of Delfzijl must be dredged regularly as a result of fine sediment sedimentation. By creating de Groote Polder, this fine sediment could be used to naturally raise the coastal zone and simultaneously reduce the amount of settled fine sediment in the harbour. By constructing a separate recreation lock for the recreational boating, more space is created for the sea lock and traffic safety for all boating increases. Furthermore, specific tasks can be connected to the long-term vision for maintaining water safety by the adjacent waterboards (Sweco, 2020).

The objectives of this thesis research are threefold: 1) to express the economic value of ecosystem services that arise within the Eemszijlen project, 2) to provide recommendations towards enhancing the feasibility of the project through the added economic value of ecosystem services, which can increase the support base of the project, and 3) to provide empirical evidence that can facilitate the adoption of ecosystem services in decision-making. These research objectives contribute to the objectives of the Eemszijlen project by increasing the likelihood that the Eemszijlen project succeeds.

1.4. Research questions

To achieve the research objectives, the following main research question was formulated:

How can ecosystem services increase the value of the Eemszijlen project?

In order to answer this main question, three sub-questions are formulated as follows:

1. *Which ecosystem services arise from the Eemszijlen project?*
2. *What are the economic values of the ecosystem services in the Eemszijlen project?*
3. *In what ways do the economic values accelerate the adoption of ecosystem services by decision-makers?*

1.5. Thesis Outline

Chapter 2 elaborates on existing knowledge and the conceptual model. Chapter 3 explains the research method and data collection and analysis. Chapter 4 presents the results of each sub-question. Chapter 5 is the discussion and conclusion to answer the main question and argue the limitations of this research, and in chapter 6 recommendations are given for both the Province of Groningen and the National Government.

2. Conceptual Framework

This chapter elaborates on the existing scientific knowledge about different types of ecosystem services, the challenge of ecosystem service valuation, the application of ecosystem services and nature-based solutions for coastal protection in the Netherlands and the different types of valuation methods. The conceptual model is introduced and explained in the last section.

2.1. Ecosystem services

Ecosystems provide various benefits to humans, some of which are visible and others often less visible. These benefits are called ecosystem services and can be divided into four categories: provisioning services, regulating services, cultural services and supporting services. Table 3 shows the different services with corresponding examples (MEA, 2005a).

Table 3: Types of ecosystem services (MEA, 2005a)

Provisioning Services	Regulating Services	Cultural Services
Products obtained from ecosystems	*Benefits obtained from regulation of ecosystem processes*	*Nonmaterial benefits obtained from ecosystems*
■ Food	■ Climate regulation	■ Spiritual and religious
■ Fresh water	■ Disease regulation	■ Recreation and ecotourism
■ Fuelwood	■ Water regulation	■ Aesthetic
■ Fiber	■ Water purification	■ Inspirational
■ Biochemicals	■ Pollination	■ Educational
■ Genetic resources		■ Sense of place
		■ Cultural heritage

Supporting Services		
Services necessary for the production of all other ecosystem services		
■ Soil formation	■ Nutrient cycling	■ Primary production

Provisioning services are products that can be obtained from ecosystems such as food products derived from animals and plants, and a vast range of materials and other products such as wood, fuel, and genetic resources. Regulating services are benefits obtained from the regulation of ecosystem processes such as air quality maintenance by adding and extracting chemicals, water regulation by providing water supply and climate regulation by sequestering greenhouse gases. Cultural services are non-material benefits obtained from ecosystems through, among other things, cognitive development, spiritual enrichment, and recreation. Supporting services are different from the provisioning, regulating and cultural services in that they occur over a long period and underpin all other ecosystem services and their impact is indirect. Typical examples of supporting services include soil formation, nutrient cycling, and primary production (MEA, 2005a).

2.2. The challenge of ecosystem services valuation

Various factors contribute to the global deterioration of ecosystems. Pollution, land-use change, and overexploitation are among the main reasons for a global decline in ecosystem services. Nevertheless, in financial decision-making processes, the importance of ecosystem services to mankind are often underrepresented. This is mainly a result of not valuing the ecosystem services (PBL, nd).

Currently, there are no specific policies on ecosystem services, but existing policies are increasingly focusing on the importance of ecosystem services and their recovery. The Convention on Biological Diversity (CBD), a multilateral treaty, targets to preserve biodiversity and includes targets to secure ecosystem services (Bullock, et al., 2011). These targets are translated to the EU Biodiversity Strategy to 2020 by the European Commission (European Commission, 2020c). Additionally, the Dutch government has developed national policy measures to promote the sustainable use of ecosystems. These are included in the Natural Capital Agenda and the Dutch National Nature Vision 2010 (PBL, nd).

Despite a growing literature on ecosystem services, many challenges remain on integrating these services into management (Groot, et al., 2010). Valuing the contribution of ecosystems demands robust methods to quantify their services. Thereby also decision-making and policy that aim for sustainability goals can be improved (McKenzie, et al., 2011). There are various studies on ecosystem services and how to map, quantify and model such services, however, a lot of inconsistency such as an unclear distinction between ecosystem services and functions and a inconsistent classification of services causes a challenge to develop robust decision-making (Groot, et al., 2010).

2.3. Application of ecosystem services in coastal protection

In the Netherlands, "the sand engine" is one of the first applications on a large-scale nature-based solution and is designed to protect the coast and to provide ecosystem services (Oudenhoven, et al., 2018). There is currently a negative balance between the supply and demand for sediment along the Dutch coast. This is a result of sea-level rise and extreme weather events and thereby the coast is eroding rapidly. In order to compensate for this, the sand engine was developed in 2011, in which sand is added through supplementations. The objective of the sand engine is to combine longer-term safety with more room for nature and recreation (Mulder & Stive, 2011). Once the sand is nourished, it relies on natural processes guided by tides, currents, and wind to gradually distribute along the Dutch coast. And as the supplementation for the sand motor only occurs once in 20-30 years, it is a more sustainable intervention than traditional supplementation that occurs every five years. Besides its purpose to offer coastal protection, various other ecosystem services are derived such as increased biodiversity, nature-based recreation and nursery grounds for juvenile fish and birds (Oudenhoven, et al., 2018).

2.4. Ecosystem services valuation methods

Ecosystems are under pressure worldwide, and over 60 per cent of global ecosystems are declining. Nevertheless, ecosystems maintain life on earth and provide the services humans need to satisfy in material and non-material needs. As people derive utility from ecosystems and the provisioning, regulating, cultural and supporting services directly or indirectly it means that ecosystems have economic value. This is an anthropocentric approach in which the value is based on the principles of humans' preference satisfaction. As a matter of convenience, this approach commonly attempts to measure all ecosystem services in monetary terms because this well-recognized unit saves great effort converting values expressed in other terms. The most common reasons for ecosystems service valuation are to assess their contribution to economic and social well-being, guide decision-making through assessing the relative impact of alternative actions and understanding how and why ecosystems are used by economic actors (MEA, 2005b).

Figure 3 shows the Total Economic Value (TEV) framework, which is widely used for investigating the utilitarian value of ecosystems. The TEV distinguishes between 'use values' and 'non-use values'. Use values refer to the value of ecosystem services that is used by humans for production purposes or consumption. Non-use values refer to the value of knowing that a resource exists even though the resource is not used (MEA, 2005b).

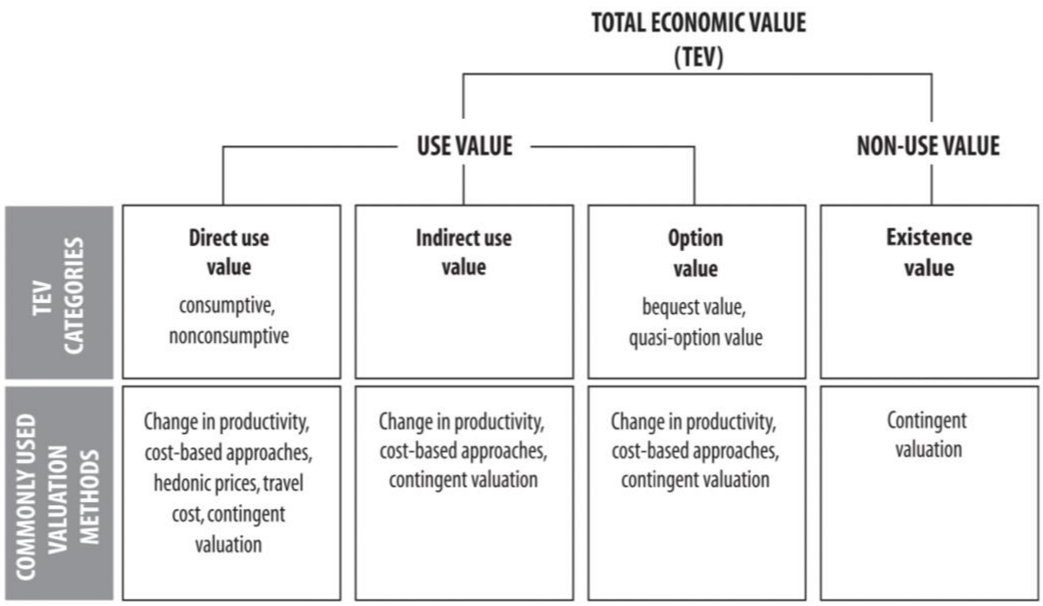

Figure 3: Total Economic Value Framework (MEA, 2005b)

Use values can be divided into three categories: direct use values, indirect use values and option values. Direct use values are derived from the actual use by humans of an ecosystem such as timber (consumptive) or recreation (non-consumptive). Indirect use values such as carbon sequestration or air filtration are human benefits produced through the natural functioning of an ecosystem. Option values refer to the willingness to pay to retain the option to use a resource in the future. Non-use values are the value humans ascribe to knowing that a resource exists. Non-use values are also divided into three categories (not shown in Figure 3); knowing that something exists, knowing that somebody else benefits or knowing that the resource may be used by future generations (Horlings, et al., 2020).

Common methods to estimate the value of ecosystem services are shown in Figure 3 and include the change in productivity, cost-based approaches, hedonic prices, travel cost and contingent valuation. The change in productivity approach estimates the value of ecosystem services or products to the production of marketed goods. The cost-based approaches generally value services at the cost of replacing them with an alternative. The hedonic price method requires vast amounts of data and aims to break down the price paid for a service. The travel cost method is developed to measure how much visitors pay to visit sites such as protected areas. Finally, the contingent valuation method applies to any issue and is a survey-based economic technique for the valuation of non-market resources (MEA, 2005b).

2.5. Conceptual model

In this research, it is investigated how the expression of value for ecosystem services can enhance the feasibility of the Eemszijlen project and explain the causal relationship between expressing this value and the adoption of ecosystem services in decision making. In order to demarcate the research subject and to formulate the assumed relationships between the core concepts, the research perspective takes the form of a conceptual model as shown in Figure 4.

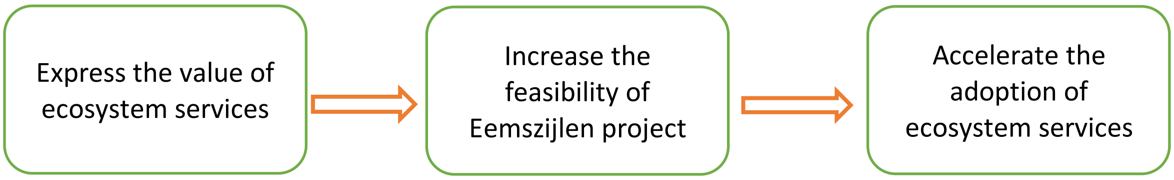

Figure 4: Conceptual model

The model flows from left to right and consists of core concepts ("boxes") and relationships ("arrows") between the core concepts (Verschuren & Doorewaard, 2010). If ecosystem services can be valued (box 1), this value will lead to higher project feasibility (Silvis & Heide, 2013) of the Eemszijlen project (box 2), and, in turn, will accelerate the adoption of ecosystem services in decision-making (box 3) (Horlings, et al., 2020).

3. Research Design

This research investigated how ecosystem services can contribute to the feasibility of the Eemszijlen project and how this approach can be used in decision-making. The type of data that is used in this research consists of primary and secondary data. Primary data was collected directly from the source, for instance by interviewing respondents, whereas secondary data created by others was collected by desktop research (Paperpile, nd).

The first two sub-questions were formulated dedicated to the Eemszijlen project, whereas the third sub-question was a more general question on how the outcome of the research can be used in further decision-making. As the flowchart in Figure 5 shows, sub-question 1 and 2 were executed partly simultaneously and thereafter sub-question 3 was carried out. Finally, the answers to the sub-questions were used to answer the main question.

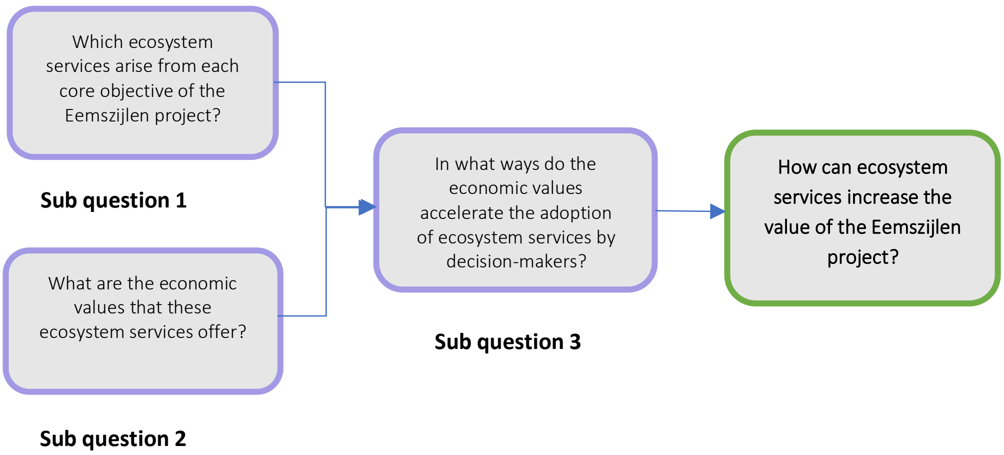

Figure 5: Flowchart of the research questions' sequence

3.1. Data Collection and Analysis

The following sections provide an elaboration on the data collection and analysis for each sub-question.

3.1.1. Sub-question 1: *Which ecosystem services arise from the Eemszijlen project?*

To identify all the potential ecosystem services that arise within the project, I conducted desktop research and interviews. Some ecosystem services were already partly mentioned in the project plan document. However, there could be more that weren't yet identified. Within the Eemsdollard 2050 programme, various similar projects have similar ecosystem services that are corresponding to Eemszijlen. Therefore, the participants of these projects might have already identified these ecosystem services. These participants can elaborate on the identified ecosystem services to gain a better insight.

To answer this sub-question, the first step was to ascertain the appropriate respondents that were suitable to approach and provide the correct data. This was done by asking the project managers of Eemszijlen whom to approach within the Eemsdollard 2050 programme and the different project partners within the Eemszijlen project. The relevant project partners included Groninger Landschap, municipality of Groningen, Ministry of Agriculture, Nature and Food Quality, Natuurmonumenten, and consultancy companies such as Royal

Hashkoning DHV and Witteveen en Bos. The respondents that were interviewed and their affiliation with the project can be found in Table 4.

Table 4: Interview respondents and their affiliation with the project

Code	**Name Respondent**	**Organization**	**Affiliation with the project**
Interviewee 1	Oscar Borsen	Groninger Landschap	Project partner
Interviewee 2	Melissa Onwezen	Provincie Groningen	Project partner
Interviewee 3	Wim Schoorlemmer	Ministerie van Landbouw, Natuur & Voedselkwaliteit	Project Blue Carbon (carbon sequestration)
Interviewee 4	Fred Haarman	Royal Haskoning DHV	Project useful application of fine sediment (fine sediment captivity)
Interviewee 5	Rob Nieuwkamer	Witteveen en Bos	External expert on valuing)
Interviewee 6	Paul Vertegaal	Natuurmonumenten	Expert water and nature; project partner

In order to find the right respondents, the snowball sampling method was used. To elicit their knowledge, semi-structured interviews were conducted through a Microsoft Teams connection with experts, in which there was room to elaborate on certain questions during the interview (The interview questions can be found in Appendix 2 and the invitation letter in Appendix 4). The interviews took 45 to 60 minutes, and they were conducted in Dutch, because all respondents were from the Netherlands. The respondents were informed about the recording of the interview and were asked to sign a consent letter prior to the interview. (See Appendix 1 for the interview protocol and Appendix 3 for the consent letter). After the interviews, the various ecosystem services and corresponding descriptions were analysed and written down, which was based on the different four categories of ecosystem services. When the data collection was complete, a clear and comprehensive overview of derived ecosystem services in the Eemszijlen project was obtained and sub-question one was answered.

3.1.2. Sub-question 2: *What are the economic values of the ecosystem services in the Eemszijlen project?*

The second sub-question was a rather theoretical question, through which the value of ecosystem services was expressed so that the project's feasibility could be increased by for example leveraging further investment.

To answer this question, a comprehensive literature review and input from experts was needed. The first step was to describe the current situation for each ecosystem service without the implementation of the project. Next, the new situation was described for when the project is realised. And last, the difference between these situations was analysed and a suitable valuation method was chosen. Thereby, the overview of derived ecosystem services from sub-question one was expanded with the corresponding economic values. As a result of data availability and uncertainties, the corresponding values are expressed in mainly qualitative terms.

3.1.3. Sub-question 3: *In what ways do the economic values of ecosystem services accelerate the adoption by decision-makers?*

The third sub-question was about applying the expressed values of ecosystem services, and thereby increasing the total value of the project to accelerate the adoption of ecosystem services in further decision-making in the Netherlands.

I followed two main steps to answer this question. The first step was to identify how the expressed value of derived ecosystem services could increase the feasibility of the Eemszijlen project. During this step, there was already attained a clear overview of the ecosystem services and their value, but not how this data could enhance the feasibility of the Eemszijlen project. The literature review covered how the valuation of ecosystem services could improve project feasibility. Additionally, the interviews also included a question on how ecosystem services could increase the project's feasibility. In the second step, I investigated why the adoption of ecosystem services is lagging. I identified the main barriers and solutions on how the adoption of such ecosystem services could shift towards a common practice.

3.2. Data validation

In this research, multiple sources of data were used to assure the validity of the information gathered. In this way, the outcome of the research is not dependent on a small proportion of available data. By combining desk research with interviews, triangulation has prevented obtaining a singular or biased perspective on any of the research questions.

3.3. Ethical statement

It is hereby declared that the data in the thesis is the author's own work and in the case of using secondary data, there is referred to the rightful author(s). This also accounts for primary data acquired from interviews, which also is correctly referred to the right respondent. This research includes interviews, and each respondent was provided with a consent form before executing an interview. Participation in interviews was confidential and voluntary, and therefore the respondents could stop the interview at any time. The information and data obtained from the respondents were only accessible by the researcher and safeguarded in a secure place. Additionally, data and information were deleted after the finalization of the research when necessary. This research respects Research Ethics Policy from the University of Twente. Accordingly, before the interviews were conducted, an approval was obtained from the Ethics Committee.

4. Results

In this chapter, the results of the research are presented. Each sub-question is answered in a separate section, starting with the first sub-question in section 4.1, the second sub-question in section 4.2 and the third sub-question in section 4.3.

4.1. Ecosystem services within the Eemszijlen Project

This section presents the results from the identification and categorization of ecosystem services.

To distinguish the different types of ecosystem services, this research uses the four categories of ecosystem services prescribed by the Millennium Ecosystem Assessment (MEA) (MEA, 2005a). It should be noted that some ecosystem services can be placed in multiple categories. But in this report, ecosystem services are put into categories based on how the ecosystem service is ultimately used or expressed. As shown in Table 5, eight different ecosystem services are identified under these categories, which are further elaborated below.

Table 5: Identified ecosystem services

Types of ecosystem services	Identified ecosystem services
Provisioning	- Fine sediment captivity - Freshwater supply
Regulating	- Coastal protection - Carbon sequestration
Cultural	- Coastal town experience - Fish migration - Awareness-raising
Supporting	- Primary production

4.1.1. Provisioning services

Fine sediment captivity: Fine sediment is a product obtained from the ecosystem and therefore this ecosystem service falls under the provisioning services (MEA, 2005a). The Groote Polder, consisting out of 40 hectares of land will be able to capture approximately 500, 000 tonnes of fine sediment annually (Sweco, 2020), and the polder has great potential for upscaling in the future. Within the project “VLOED”, useful application of fine sediments is explored to make the practice and necessity of capturing fine sediments profitable. Since the area is one of the lowest areas in the Province of Groningen fine sediment settled and accumulated in the Groote polder could potentially be used to raise the surrounding farmland. Hence, Eemszijlen contributes to project VLOED by capturing fine sediment in a natural way (Sweco, 2020).

Freshwater supply: Salt intrusion, climate change and higher consumption rates put pressure on freshwater availability. Currently, 15 million litres of water from the Ijsselmeer are used every year to flush the Eems Canal and stop salt intrusion (Sweco, 2020). Closing the salt leak at the locks eliminates the salt intrusion and as a result, the quantity of freshwater needed for flushing the Eems Canal with freshwater remains limited and dependency on freshwater from the Ijsselmeer diminishes (Sweco, 2020). More efficient water management also means an increased amount of freshwater supply can be used for other purposes such as drinking water, agriculture, and nature (Kennisportaal Klimaatadaptatie, n.d.).

4.1.2. Regulating services

Coastal protection: This is a benefit obtained from the regulation of ecosystem processes like fine sediment settlement and therefore this ecosystem service falls under the regulating services (MEA, 2005a). The area of Eemszijlen, and the Groote Polder in particular, is dealing with a rising sea level and a falling seabed. By converting the Groote polder into a zone that can gradually grow and accumulate at the same pace of sea-level rise, a robust fresh-salt connection will be created. This can be realised by fine sediment sedimentation, which preserves the mudflats and salt marsh areas. The natural fine sediment sedimentation thereby provides coastal protection (Sweco, 2020).

Carbon sequestration: Carbon sequestration by salt marshes is considered as an important potential as a climate change mitigation measure (Tamis & Foekema, 2015). The ability to capture carbon is a benefit obtained from the regulation of ecosystem processes that regulate the climate (MEA, 2005a). Saltmarsh development in the Groote Polder and outside the primary dike is within the scope of the Eemszijlen project. Through the sedimentation process within the Groote Polder, the coastal zone can grow along with sea-level rise, by which salt marshes are preserved (Sweco, 2020). Such salt marshes can sequester large quantities of carbon from the atmosphere and store it in the coastal ecosystem, in either biomass or buried sediments.

4.1.3. Cultural services

Coastal town experience: The liveability of the coastal town and its experience is a nonmaterial benefit partly obtained from the ecosystem and therefore this ecosystem service falls under the cultural services (MEA, 2005a). Delfzijl and its immediate surroundings will have the experience of a harbour and coastal town where people like to live, work, and recreate. A place where residents and visitors can enjoy the town, ocean, and nature. The characteristics of the natural or cultivated landscapes are tightly bound to human values (Sweco, 2020).

Fish migration: The presence of diadromous fish that run between distinct environments gives a sense of place and identity to the area which is essential to the quality of life. Therefore, this ecosystem service is a nonmaterial benefit obtained from the ecosystem (MEA, 2005a). Recovered fish migration possibilities allow endangered native fish species to move between saline water and freshwater and reach their spawning and nursery areas. Such species of fish like the three-spined stickleback, smelt, river lamprey, glass eel and flounder larvae belong to historically important landscapes (Sweco, 2020). This ecosystem service could also be categorised as a provisioning service or a supporting service. If the restored fish populations will serve as an economic resource to exploit (to market) it can be seen as a provisioning service. And when it is seen from the viewpoint that fish migration fulfils an important role in the vitality of the ecosystem as a whole which is needed to support the rest of the food web the ecosystem service can be categorised as a supporting service. However, this ecosystem service has no intention to be marketed and falls under cultural services since it is the most dominant category for economic value in this project.

Awareness-raising: The possibility for education is a nonmaterial benefit obtained from the ecosystem (MEA, 2005a). The area will be suitable for educational purposes. For instance, children can experience the mudflats by telling them about it, but also by letting them discover it by playing with water, sand, and silt. The coastal ecosystem and its components and processes offer the opportunity to create awareness about the importance of the dynamic system among the youth. Furthermore, a walking path through the Groote polder, landscape art and the cultural experience make the area a unique environment for visitors to become aware (Sweco, 2020).

4.1.4 Supporting services

Primary production: This is a service necessary to produce all other services and therefore this ecosystem service falls under the supporting services (MEA, 2005a).
The Eemsdollard and its ecology suffer from high concentrations of fine sediment in the water column. The turbid water causes sunlight hardly to penetrate the deeper water, resulting in barely any primary production. The 40 hectares big Groote Polder designed to capture fine sediment contributes, together with other projects adjacent to the Dollard, to reducing the unnaturally high fine sediment concentrations in the system. The improved water quality will increase the primary production and the whole food path will be strengthened (Sweco, 2020).

4.2. The economic value of ecosystem services

In this section, the economic value of identified ecosystem services is quantified. For this purpose, each ecosystem service is again placed in the four categories. Economic valuation is done in three steps. First, the current situation is described (so when the Eemszijlen project is not implemented). Second, the new situation is described for when the Eemszijlen Project is realised. And third, the changes between the current and new situations are analysed. Here we describe the intervention, the physical effect, and the social impact. The social impact is the effect on people and communities that arises from the ecosystem service. Only the social impact is economically valuable. This value represents the added economic value of the ecosystem service. To quantify the economic value of these changes, different valuing methods are required and recommended depending on the specific types of ecosystem service.

4.2.1. Provisioning services

Fine sediment captivity

Current situation: The Groote Polder is an inner dike area located between Oosterhorn and Termunterzijl. This area can be indicated as the lowest part of Groningen, directly behind the dike (Eemsdollard 2050, 2021d). In the Groote Polder, it is expected that large parts are more than two meters below NAP (Normal Amsterdam Level). To date, the area is used for nature conservation purposes. The region is known as the most low-lying part of the province and when a dike breaks, the water will reach the city of Groningen in no time. Furthermore, fine sediment settlement in the marina of Termunterzijl (adjacent to the right side of the Groote Polder) is a recurring problem, resulting in undesirable lasting costs for dredging.

New situation: The Groote Polder, consisting out of 40 hectares, will collect approximately 500,000 tons of consolidated fine sediment annually. The polder has great potential for upscaling in the future. And the Groote Polder potentially serves the project “Vloed” which aims to increase the surrounding agricultural farmland (Provincie Groningen, n.d.). This practice could preserve valuable agricultural land for future generations from the effects of soil subsidence, peat oxidation and salinization (Provincie Groningen, n.d.). Finally, water safety could also be improved because of increased agricultural land.
Changes: The intervention is a new intertidal zone of 40 hectares in the Groote Polder. The physical effect is that this intertidal zone captures up to 500,000 tons of fine sediment annually. And the social impact is threefold. First, a reduced need for dredging activities arises as a result of fine sediment settlement. The savings in dredging costs are an estimated two million euros (Sweco, 2020). Second, fine sediment settles in the Groote Polder can be removed to potentially raise low laying agricultural land (Sweco, 2020). This could result in less height difference between land and water, preserving agricultural land for the future, less salinization of agricultural land, better water management and higher crop yield (Provincie Groningen, n.d.). In this case, the replacement cost method is most suitable. With this method, the difference in costs compared to an alternative situation with no fine sediment resource is the economic benefit. Third, a more robust and safer zone that arises from increased agricultural land could reduce damage costs when a dike break occurs. The difference in costs compared to the current situation with the replacement cost method is an economic benefit (MEA, 2005b). These three economic benefits represent the value of this ecosystem service. The saved dredging costs of two million euros were already calculated in a quick scan. The value of the captured fine sediment can be quantified by identifying the difference in costs when an alternative material is used. And the value of water safety can be quantified by identifying the damage costs of a dike break in the new situation compared to the current situation.

Freshwater supply
Current situation: The Eems Channel plays an important role in the main water system of the North of the Netherlands. Besides the Lauwersmeer, it is the main canal through which water from the lower Drenthe and Groninger hinterland is discharged out in the centre of Delfzijl (Sweco, 2020). However, the area is dealing with salt intrusion and chloride levels regularly exceed the permitted limits. Most of the saltwater enters the Eems Canal through the sea sluices and on average, 15 million litres of water from the Ijsselmeer are annually used to flush the canal to prevent further salt intrusion. Furthermore, water demand is expected to increase in the coming decades as a result of both climate change and human consumption, putting freshwater supply under pressure (Sweco, 2020). Climate change also influences the amount of rainwater that needs to be discharged, whereas the current discard capacity is limited (Nationaal programma Groningen, n.d.).
New situation: The flushing sluice and the discharge of water are located at the Groote Polder via the Oosterhorn Canal with enough capacity for bigger quantities of water to discharge. The Oosterhorn Canal used to be saline because of the shipping through the old lock. Now there is pressure on the salt intrusion that was caused by the locking. At the transition of the Oosterhorn canal and the discharge canal, a system is in place that can let in water in and out. This has an important function in both water level management and the fresh-salt transition of the Groote Polder and the salt intrusion of the Eems Canal.

Consequently, the salt intrusion in the Eems Canal is more stable or might be even improved (Sweco, 2020).
Changes: The intervention is the diversion of the flushing sluice to the Groote Polder via the Oosterhorn Canal with a larger capacity of water to discharge. The physical effect is less salt intrusion into the Eems Canal and the reduced need for flushing fresh water from the Ijsselmeer. The social impact is twofold. First, freshwater availability is managed more efficiently. This ensures sufficient future freshwater supply not only for economic purposes such as agriculture, industry, and human consumption but also for ecological purposes like a fresh-salt transition and a freshwater lure for fish migration (Sweco, 2020). Second, the new flushing sluice has the capacity to discharge higher water quantities and therefore offers a more robust setup in the context of climate adaptation. It is difficult to predict the economic value of this ecosystem service because the amount of freshwater saved needs to be calculated and it is subject to uncertainties, but in the alternative situation demand for freshwater could exceed the supply at a certain point. This would lead to increased salt intrusion and damage to nature, crops, and accelerated soil subsidence through peat oxidation (Waterschap Noorderzijlvest, 2020). Nevertheless, two economic benefits represent the value of this ecosystem service. The savings in damage costs represent the first economic benefit of the new water management situation. The second economic benefit is the cost savings for the reconstruction of the old flushing sluice to a higher water discharge capacity.

4.2.2. Regulating services

Coastal protection
Current situation: The Province of Groningen is dealing with strong soil subsidence caused by autonomous subsidence and human activities on the one hand, and by rising sea levels on the other hand. The area of Eemszijlen is one of the lowest-lying parts of the province. Therefore, a major challenge arises to raise flood defences along the Eemsdollard (Sweco, 2020). In a natural situation without dikes, incoming fine sediment along the coast would have raised the land. Large parts of Groningen were created through sedimentation. But now the difference in height between sea level and a part of North Groningen is increasing because the coast is no longer growing (Provincie Groningen, n.d.).
New situation: The Groote Polder functions as a brackish inner dike zone where fine sediment can settle. Through sedimentation of fine sediment, the mudflats and salt marshes in the zone can gradually grow with the rising sea level and hereby creating a robust fresh-salt connection.
Changes: The intervention is an inner dike brackish zone through softening the edges of the estuary, the physical effect is that sedimentation leads to a coastline that gradually grows with the sea level rise and the social impact is a safer situation in which the difference in height between sea level and land decreases. The difference in costs compared to the current situation in which dikes need to be reinforced is an economic benefit. The cost savings for dike reinforcement represent the value of this ecosystem service.

Carbon sequestration
Current situation: In the past centuries' vast areas of land surrounding the Eemsdollard were reclaimed by humans. This resulted in too little space for fine sediment to settle and subsequently a coastline that was not growing through sedimentation of fine sediment

anymore, hence the loss of salt marshes (Eemsdollard 2050, 2021a). Such marine vegetated habitats are considered as blue carbon sinks (the carbon stored in marine and coastal ecosystems) that can capture large quantities of anthropogenic Co2 emissions. The loss of these important salt marshes not only means the loss of natural carbon sinks and its ability to remove carbon emissions from the atmosphere but can even release carbon emissions back into the atmosphere when these ecosystems are degraded (Tamis & Foekema, 2015).
New situation: In the new situation salt marshes are restored both in the Groote polder and before the primary dike and they can grow at the same pace as sea-level rise (see Figure 6) (Sweco, 2020). Although coastal habitats cover less than 2% of the total ocean area, they account for approximately half of the total carbon sequestered in ocean sediments (The blue carbon initiative, n.d.). The restoration of these vegetated habitats enhances blue carbon, supporting the Dutch goals to reduce greenhouse emissions (Tamis & Foekema, 2015).
Changes: The intervention is 32 hectares of restored and newly developed salt marshes at the edge of the estuary, the physical effect is that additional carbon will be stored compared to the current situation and the social impact is that the carbon sequestration contributes to the goal to limit greenhouse emissions in the atmosphere. To quantify the value of this ecosystem service the change in productivity method is suitable as there is a market price for carbon. First the volume of additional annual carbon storage should be calculated compared to the current situation. Next, the price of one m3 stored carbon needs to be estimated and subsequently, there is a calculation to determine the monetary value of this ecosystem service per year (Interviewee 3, 2021). To earn money back from this ecosystem service, there is the possibility to apply for carbon certificates at the National Carbon Market Foundation, which offers a system for the certification of CO2 emission reduction via Dutch projects. These certifications are intended for organizations that want to make a voluntary effort to contribute to emission reduction in the Netherlands (Stichting Nationale Koolstofmarkt, 2021). In this case, the certificates could be purchased by the various companies that operate at the border of the world heritage Wadden Sea that want to contribute to mitigating climate change or just to promote their license to produce. (Interviewee 3, 2021).

Figure 6: Restored/ constructed salt marshes (Sweco, 2020)

4.2.3. Cultural services

Coastal town experience
Current situation: In the second half of the last century, Delfzijl no longer had the character of a typical port city like it used to be. This was due to, among other things, large scale

industrialization and a large hard dike between the estuary and hinterland (Eemsdollard 2050, 2021e) The municipality of Eemsdelta works on the project Marconi to improve the quality of life and make the city more attractive since 2009. This is done by removing existing barriers between the centre of Delfzijl and the port so that the atmosphere of a typical coastal town can be better experienced (Sweco, 2020).
New situation: In the new situation, Eemszijlen adds another contribution on top of the measurements taken by the Marconi project. The recreation sluice is be moved to the centre of Delfzijl replacing the old flushing sluice. This brings recreational boating back to the old city centre and thereby stimulates centre and port development and increased tourist value of the centre. Through this development, the southern part of the centre becomes more attractive to live and recreate. Furthermore, the conversion of Groote polder brought back the coastal dynamics and its characteristics such as the tides and the fresh-salt transition. Thereby the relation with the Wadden Sea is strengthened since it is more accessible and experienceable for visitors and residents.
Changes: The intervention is the conversion from the recreation sluice to the city centre and pulling the estuary and its dynamics into the Groote polder, the physical effect is that the area is more connected to the estuary and the Wadden Sea World Heritage. And the social impact is increased liveability because the city is now more attractive for residents, visitors, and investors. The MKBA that was already carried out, indicated that the total benefit of the investment is 50 million euros, and 48 million consisting of housing, tourism, recreation. Housing represents a benefit of 29 million euros as living pleasure is boosted and house prices increase. Tourism represents a benefit of 14 million euros and recreational boating represents a benefit of 5 million euros. And these are expressed in higher tourism spending and higher employment in the area (Sweco, 2020). The last two million euros represent the saved dredging costs and are assigned to ecosystem service fine sediment captivity.

Fish migration
Current situation: The current flushing sluice, located at the centre of Delfzijl, which discards fresh water into the sea is not accessible for fish to migrate between salt- and fresh water. Whereas the discharge creates a lure current of freshwater that diadromous fish can smell, the fish cannot access the hinterland water systems (Sweco, 2020). Such structures, just like weirs and pumping stations in the water systems are barriers that cause problems such as the closure of migration routes, damage and killing of fish by pumping stations, compartmentalization/ fragmentation of compartments habitat and insufficient exchange between fish population which affects the populations' vitality (Ruim baan voor vissen, n.d.).
New situation: In the new situation, the discard route goes via the Oosterhorn channel, and the flushing sluice is in the Groote polder (See Figure 7). Next to the flushing sluice is a separate facility for fish to pass. The passage is as natural as possible since it is a free passage that gives the fish the possibility to pass just by themselves during a certain time window at specific tides. For the rest of the time, the passage is closed. After the fish make their way through the passage, they enter brackish water where they can rest before continuing their migration. The discard channel is located on the border between industry and rural areas and therefore has a straight bank on the industrial side and a natural bank on the east side. This nature-friendly layout of 37.5 meters wide, offers the opportunity for fish to rest, forage and spawn. Subsequently, the fish can swim up to the Drentse Aa en Hunze.

Changes: The intervention is a new fish passage located at the Groote Polder. The physical effect is that diadromous fish are able to migrate between the sea and the hinterland waters again. And the social impact is that endangered native fish species are allowed to move between salt and fresh water and reach their spawning and nursery areas resulting in a recovered fish stock (Sweco, 2020). One suitable method to quantify the economic value of this ecosystem service is the contingent valuation method. In this case, the ecosystem service brings benefits, however, its value is difficult to estimate since it is not subject to sale. Therefore, the contingent valuation method takes the form of a survey among respondents with the objective to obtain information about their willingness to pay for this ecological service (Lipinska, Klopotowska, & Wlosek, 2019).

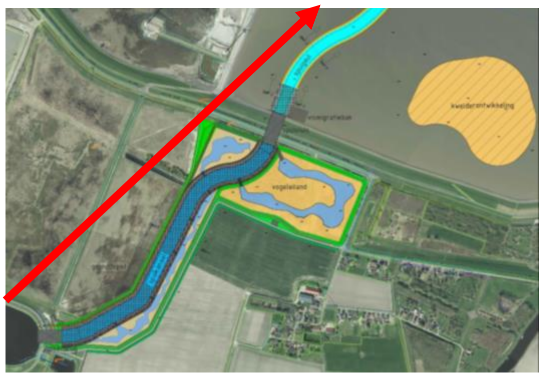
Figure 7: Fresh-salt transition sketch (Sweco, 2020)

Awareness-raising
Current situation: A dominating large hard dike between the estuary and the hinterland has ensured that people no longer feel connected with the estuary and its dynamics. (Sweco, 2020) This also makes people less aware of how important a healthy estuary is for both nature and humans as humans benefit from the ecosystem services produced by the estuary ecosystem.
New situation: In the new situation the estuary is more accessible and attractive for people to visit with new walking paths. The area is also used for educational purposes and children can experience the mudflats, not only by telling them about it but especially by letting them discover it by playing with the water, sand, and silt.
Changes: The intervention is an easier-to-access estuary. The physical effect is that more people visit the area. And the social impact is that both children and adults become more aware of the importance of the dynamic system and the corresponding ecosystem services that benefit them. To identify the economic value of this ecosystem service the travel cost method could be used to estimate peoples' willingness to pay to visit this site. The price is represented by the time people invest to get to a specific site as well as the travel cost expenses (Ecosystem valuation, n.d.).

4.2.4. Supporting services

Primary production
Current situation: In the current situation the estuary contains unnaturally high concentrations of fine sediment in the water column as a result of among other things deepened shipping lanes and reclamation. Figure 8 shows the annual average fine sediment concentrations from 1990 to 2010 at two locations in the Dollard. With an average of

approximately 100mg/litre of fine sediment in 1990 and an average of 160 mg/litre in 2010 at a specific location, a significant increase can be observed (Taal, et al., 2015). The ecology suffers from this high turbidity of fine sediments as sunlight no longer penetrates the deeper water, resulting in barely any primary production.

New situation: In the new situation the 40 hectares of conversed Groote polder contributes to capturing fine sediment from the estuary together with other projects adjacent to the Dollard. Together they help to reduce the unnaturally high fine sediment concentrations. The improved water quality increases the primary production and the whole food path is strengthened.

Changes: The intervention is 40 hectares of conversed Groote polder that captures fine sediment, the physical effect is lower turbidity in the water column. And the social impact is restored primary production and corresponding biodiversity of the estuary. The economic value of restored primary production and corresponding biodiversity depends on peoples' willingness to pay and therefore takes the form of the contingent valuation method (Lipinska, Klopotowska, & Wlosek, 2019).

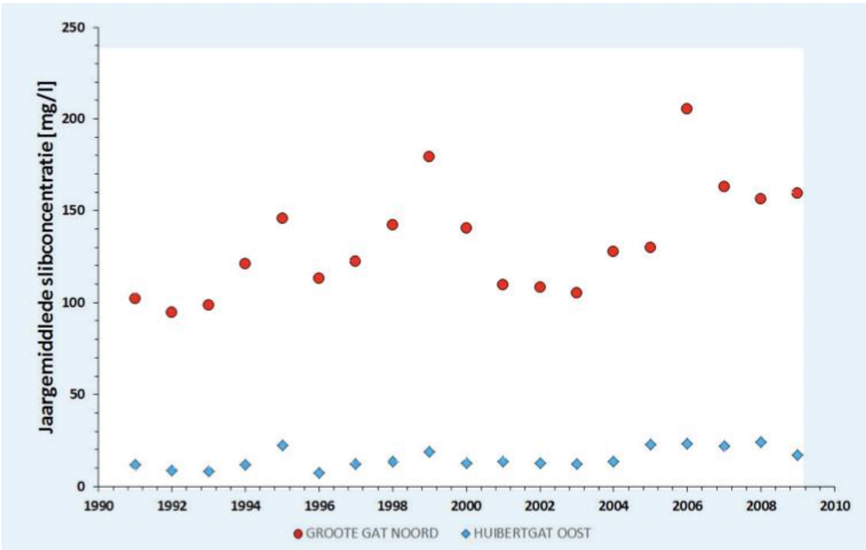

Figure 8: Annual average fine sediment Dollard (concentration in mg/litre) (Taal et al., 2015).

4.3. Accelerating the adoption of ecosystem services through valuation

This section elaborates on how the identified added values of ecosystem services could increase the feasibility of the Eemszijlen Project and the main barriers of ecosystem service valuation.

4.3.1. Increased project feasibility

The economic valuation of ecosystem services can provide useful information regarding the consequences of specific changes on an ecosystem. Therefore, valuation can add to estimating the value of natural capital and this value can be reflected in policy decisions such as the coastal development project Eemszijlen. The outcome of ecosystem service valuation can be used to compare alternatives and can be determinative in the decision-making process (Horlings, et al., 2020).

An example in which ecosystem services have made a difference is the Sigmaplan in Belgium. This is a project of the Flemish government that aims to reduce the risk of flooding around the Scheldt and its tributaries. One of the alternatives was to convert a primary river dike land inwards to give the river more space and this would turn surrounding agricultural land into tidal swamps (Interviewee 5, 2021). These tidal swamps would provide various ecosystem services that were not there before, such as biodiversity, fine sediment captivity, carbon sequestration, water purification and also reduced water damage costs (Sigmaplan, 2017). This alternative carries the highest nature benefits; however, these benefits are not direct cashflows but public benefits. And in this case, the government chose this specific alternative in which ecosystem services were determinative. On the other hand, the outcome of ecosystem service valuation can also be lower than expected and thus it is important to consider ecosystem services in a project decision (Interviewee 5, 2021).

The importance of the Eemszijlen project for the local economy, residents and nature can be emphasized by showing the consequences of its lack of implementation. For instance, the restoration of fish migration is just a single operation, but the consequences are enormous as an area is reached from the North Sea to the waters of Drenthe. If this is placed next to the goals at the national and European level and it is demonstrated to what extent the project contributes to these goals, it could be acknowledged as a priority project and subsequently result in a higher support base (Interviewee 1, 2021).

Emphasizing the values of ecosystem services can thus influence the decision-making for a project in which different alternatives are considered. This means that the project feasibility of Eemszijlen, in which various ecosystem services arise, increases through ecosystem service valuation.

4.3.2. Main barriers of ecosystem service valuation

The valuation of ecosystem services is not a common practice yet, and some barriers hinder the adoption of ecosystem service valuation. A distinction is made between barriers regarding decision-makers and barriers regarding the non-market nature of ecosystem service values.

There are five main barriers regarding the perceptions of decision-makers. First, required financial funding's. Second, ecosystem services that fall in the public good. Third, unwanted valuation results. Fourth, the name ecosystem service itself. And fifth, the confusion between economic value and intrinsic value.

Financial

ecosystem service valuation is expensive and comprehensive since a team of specialists is needed with expertise in different disciplines to assess and value ecosystem services. Multiple specialists might be needed even for the valuation of a single ecosystem service. For instance, with ecosystem service capturing fine sediment, it should be estimated how much fine sediment can be captured, which requires the expertise of a hydrological engineer or a morphologist. R. Nieuwkamer mentions that there must be thought about what will happen with the obtained fine sediment, so if it is marketed what will the market price be. Then R. Nieuwkamer argues that for a single ecosystem service there is already a need for multiple experts with specialised knowledge. Consequently, ecosystem service valuation is knowledge-intensive and therefore expensive. This means that the decision-makers will only execute such studies for bigger projects with important investments. For small projects, the investments for a comprehensive ecosystem service valuation are often too high to be undertaken (Interviewee 5, 2021).

Ecosystem services that fall in the public good

Some ecosystem services that arise in certain projects are public goods, such as biodiversity, carbon sequestration or improved water quality. This means that the initial investors do not receive the economic benefit themselves, and therefore they are not interested in the ecosystem services that only benefits the public goods (Interviewee 5, 2021). There is currently no system in place that solves this issue (Interviewee 6, 2021).

Unwanted valuation results

In some cases, ecosystem service valuation can reveal unwanted results. For example, if a specific project aims to restore fish migration routes and subsequently the ecosystem service valuation report argues that there is no benefit since there is another obstacle like a dam that hinders the migration route. A project developer is not waiting for this result because it means that the project will not make a significant difference for fish migration in this case. Therefore, unwanted answers from ecosystem service valuation is another major barrier since it can thwart a whole project. (Interviewee 5, 2021).

The name ecosystem services

For some practitioners, the concept of “ecosystem services” is a fancy name for multiple functions and costs and benefits, but on the contrary, it isn’t about the word itself. When working with multi-criteria cost and benefit analyses (“MKBA” in Dutch), then the benefits of ecosystem service can also be taken into account. However, for national administrators who make decisions, the term MKBA potentially sounds more appealing than ecosystem service. The term ecosystem service is not only a lesser-known word but also has the word “eco” in it that could frighten the right-oriented administrators since they can see it as a bottleneck that costs extra time and money and therefore make it come across less powerful. On the other hand, the word MKBA sounds already very different since it is widely recognized among administrators. Yet, R. Nieuwkamer thinks that directors are becoming aware of the fact that they shouldn’t only calculate from the viewpoint of what will it cost and what will it bring. But that they will also take into consideration the social values, and then it doesn't matter whether the term ecosystem service or an MKBA is used (Interviewee 5, 2021).

Economic value versus intrinsic value

People have different perspectives on ecosystem services. Some people say the value of nature is unlimited and therefore people cannot express its value. The mistake they make is that the valuation of ecosystem services is an economic subject. When looking at an ecosystem service it is typically an economic view of nature, so what benefit does the ecosystem service provide to humans and society. A nature lover or a specific political party would say that nature needs to be protected because we must. Then it becomes an ethical or philosophical discussion and is about the intrinsic value of nature. The intrinsic value of nature is, by definition, not measurable. Ecosystem services are an anthropocentric view of matter and therefore humans cannot say anything about the intrinsic value of nature. Consequently, there will always be people that are against the valuation of ecosystem services because of the intrinsic value of nature (Interviewee 5, 2021). On the other hand, assigning an economic value to ecosystem services gives rise to some ethical and cultural concerns. It can be argued that the monetary valuation of ecosystem services turns nature into a commodity to be used by humans. This could mean that attempts to monetize the value of nature detract from its true (intrinsic) value, and that imputed non-market values are misleading (Horlings, et al., 2020).

There is one barrier regarding the non-market nature of ecosystem service valuation which is that many ecosystem services do not have a market price.

Nonmarket value of ecosystem services

There is one main barrier regarding the non-market nature of ecosystem service values. Many benefits such as biodiversity do not have a market price and therefore no price exist for them. To estimate their economic value a survey is needed, in many cases this method is too time and money consuming. The alternative is to use data from older studies which is often not sufficient anymore since it will be seen as outdated data. So, on the one hand, a lack of data could get in the way and on the other hand data is seen as outdated (Interviewee 5, 2021).

5. Discussion & Conclusion

The findings of this research show that valuation of ecosystem services can increase the value of the Eemszijlen project, and influence decision-making in future projects. This outcome is in line with the expectation that ecosystem services have an economic value. At present, the economic value of ecosystem services is in many cases difficult to quantify, despite its importance as it can be determinative in decision making.

In this thesis research, I investigated how ecosystem services can increase the value of coastal development project Eemszijlen in the Netherlands. To answer this main question, I formulated and answered three sub-questions that focused on ecosystem service identification, economic ecosystem service valuation and ecosystem service implementation. The objective was threefold: 1) to express the economic value of ecosystem services that arise within the Eemszijlen project, 2) to provide recommendations towards enhancing the feasibility of the project through the added economic value of ecosystem services, which can increase the support base of the project, and 3) to provide empirical evidence that can facilitate the adoption of ecosystem services in decision-making.

A total of eight different ecosystem services were identified. Ecosystem services were categorised into four types of ecosystem services that are provisioning, regulating, cultural and supporting services. The eight identified ecosystem services are fine sediment captivity, freshwater supply, carbon sequestration, coastal town experience, fish migration, awareness-raising and primary production. These ecosystem services will arise over time when the Eemszijlen project is finished and do have a specific economic value.

To quantify the economic value of these ecosystem services a three-step approach was used in which the current situation was described, then the new situation was described for when the project is realised and subsequently the changes between these situations were analysed to identify the economic value with the appropriate valuation method. The most recommended ecosystem service valuation methods are the cost-based approach, travel cost method and contingent valuation method. Though, the economic value was mainly expressed in qualitative terms because ecosystem service valuation is comprehensive and therefore needs much data and a variety of specialists with expertise.

The outcome of ecosystem service valuation can be used to compare alternatives in a project and thus influence the decision-making for a project in which different alternatives with and without ecosystem services are considered. This means that the project feasibility of Eemszijlen, in which various ecosystem services arise, increases through ecosystem service valuation. Despite this benefit, there are still some barriers that hinder the adoption of ecosystem service valuation such as its comprehensiveness and associated costs, ecosystem services that fall in the public goods and therefore initial investors do not receive the economic benefit themselves and the fact that many benefits do not have a market price.

Ecosystem service valuation can undoubtedly be a helpful tool in decision making and be determinative when different alternatives are considered, but not yet very accessible to date because of a few barriers. To summarize, ecosystem services can increase the value of the Eemszijlen project through economic valuation and with that increase the projects total economic value.

In this thesis, the economic value is mainly described in qualitative terms which means that the total economic value of the project including the ecosystem services is still unclear. This limitation results from the fact that a lot of expertise in different disciplines is required for only estimating the value of a single ecosystem service. Besides that, there could theoretically be other smaller ecosystem services within Eemszijlen that are not identified. However, to demarcate this research, only the most present and most valuable ecosystem services were considered.

Another limitation of this research is that ecosystem services are firmly interconnected which makes economic valuation subject to double-counting. In this case, the pitfall of double-counting especially applies to the cultural services, including coastal town experience, fish migration and awareness-raising. The MKBA that was carried out earlier indicated that 48 million Euros worth of benefit could be assigned to housing, tourism, and recreation. So, this monetary benefit covers all three cultural services. This means that the economic value of restored fish migration, which is a cultural service as it gives a sense of place and identity to the area, shouldn't be calculated separately again, and added, as it is already included in the 48 million Euros. This also applies to coastal town experience and awareness-raising. Nonetheless, as I mainly described the ecosystem service value in qualitative terms, instead of quantitative terms, double-counting is not a major threat to the results of this research.

The findings of this research contribute to the feasibility of the Eemszijlen project, as a more complete picture of the project benefits arises and support base could grow, and potential investors might become more interested. Furthermore, the findings also contribute to the adoption of ecosystem services in future decision-making as the results explain that ecosystem service valuation can be determinative when multiple alternatives with and without ecosystem services are considered. However, administrators might still prefer hard numbers rather than qualitative expressions.

Avenues for future research could include exploring whether ecosystem service valuation in qualitative expressions can be powerful enough to convince administrators. Monetary valuation is often not feasible in terms of comprehensiveness and financial funds, and this especially applies for small-scale projects. Another future research direction could be to conduct a quantitative valuation study to explore to what extent ecosystem services increase the total economic value of a project and how big the ecosystem service share may be.

6. Recommendations

In this chapter a distinction is made between recommendations to the Province of Groningen regarding the Eemszijlen project and recommendations to the National Government regarding the adoption of ecosystem services in future decision-making.

7.1. Recommendation for the Province

This research showed that ecosystem service valuation increases the feasibility of the Eemszijlen project. Therefore, it is recommended to the province to shift the reputation of the project towards a coastal development project that includes valuable ecosystem services. This allows partners, administrators, and investors to better visualise the project and the valuable ecosystem services that come with the project. One of the actions that could be taken is to redesign table 5 in the project plan. This table shows the benefits from the project which is important to present to partners, administrators, and investors. Currently, the table is split into a section with benefits that are expressed in monetary terms and a section with benefits that are, by definition, non-monetary. This second section could better be called "Ecosystem services that arise from the project" because it clarifies for the reader that the project includes multiple types of ecosystem services with significant added value. Furthermore, the phrase that benefits are not monetary valuable is incorrect since every ecosystem service has an economic value to humankind, which should be emphasised. To make it complete, the table should also be supplemented with the ecosystem services identified within this research.

7.2. Recommendation for the National Government

This research also highlighted several barriers that hinder the adoption of ecosystem services in decision-making. One major bottleneck is that ecosystem services that arises often fall in the public good. When initial investors do not receive the economic benefit of such ecosystem services, it makes them less interested. To solve this issue, it is recommended to the national government to create a system in which they establish a national fund that provides subsidies to projects when they can demonstrate that they contribute to the public interest. This national fund could be fed by revenues from cash flows that arise indirectly from the benefits of such projects. An important example is the tourism tax, which now flows to the general resources of a municipality. A part of this tax could be allocated to this national fund. Likewise, the regional water boards could also make a collective effort through contributing financially to the national fund since such projects, for instance, have benefits that have a positive effect on tackling drought in a specific area. To date, such a fund is not established since it requires legislative changes and is difficult to implement in practice. However, the rising awareness of the importance of working with ecosystem services and integrated solutions make it more feasible that some form of a national fund idea becomes reality.

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Appendices

Appendix 1: Interview Protocol

The respondents for this interview will be approached through an email (Appendix 4). In this email I will introduce myself and explain that I am a MEEM student, then subsequently I will introduce my research topic, the context of my thesis research, and that I am interviewing experts. After they accept to be interviewed and a meeting is scheduled, I provide the interviewee with the consent form (Appendix 3) and receive their signature before the interview.

During the interview, I will follow the interview guide as presented in Appendix 2. I will start by introducing myself and I ask the interviewee to introduce themselves. After we both introduced each other, and I briefly explained the content of the interview, I will start asking the prepared questions. After asking each question, I allow the interviewee to talk and elaborate on certain topics.

When the interview is completed, I ask the interviewee whether they want to receive the transcript of the interview immediately or to wait for the thesis report to be finished. And I will let the respondents know that I keep them informed about the probable release date of the thesis report.

The table below presents an overview of which questions belong to which research questions. On the left side of the table, the three sub-questions are given and on the right side, the related interview questions are presented.

Sub research question	**Related interview questions**
Introductory	1-3
Sub question 1.	4-6
Sub question 2.	7-12
Sub question 3.	13-14
Closing	15

Appendix 2: Interview Questions

Introduction

Q1. Could you please introduce yourself?

Which organization do you work for? For how long?

What is your disciplinary background?

What is your role in the Eemszijlen project?

Awareness of ecosystem services

Q2. Are you familiar with the concept of ecosystem services?

If yes, could you please explain?

Q3. Do you use or apply ecosystem services in your work?

If yes, in what ways? How often? Can you give a specific example?

Q4. The description of the ecosystem services is limited in the project plan. See Table. Can you name further ecosystem services that could arise from the Eemszijlen project?

Q5. Can you describe these ecosystem services in more detail and indicate their size?

Q6. What kind of ecosystem services do these ecosystem services fall under? (Provisioning services, regulating services, cultural services or supporting services)

Valuation of ecosystem services

Q7. Do you have experience in calculating or expressing the value of ecosystem services?

If yes, could you please elaborate?

Q8. How do you think the value of ecosystem services can best be expressed within this project?

Q9. To what extent do you think that the added value of the ecosystem services can increase the chance of success of this project?

How would this apply to similar projects?

Q10. Do you know whether the approach of valuing ecosystem services is already being applied in practice in the Netherlands?

If yes, could you please elaborate?

Q11. How do you think expressing the value of ecosystem services for these types of projects can be done best?

Improving the adoption of ecosystem services **valuation**

Q12. In your knowledge and experience, what are the main barriers to expressing the value of ecosystem services and using them in decision-making?

Q13. What measures are needed in the field of legislation and regulations?

Q14. Are you familiar with a project that attempts to value ecosystem services in your area?

Closing

Do you have further information that is of interest to this research?

Q15. Could you refer me to someone who is also knowledgeable about this subject?

Thank you for your answers. Do you have any questions?

Appendix 3: Informed Consent Form

Title research or acronym: *(title, names and dates can be prefilled by the researcher)*

I declare to be informed about the nature, method, and purpose of the investigation. I voluntarily agree to take part in this study. I keep the right to terminate my participation in this study without giving a reason at any time.

My responses may be used solely for the purposes of this study. In its publications, they may *(please tick one of the options):*

O be cited with my name or function revealed

O be cited anonymously, thus without identifying context

O only used as an information source

During the course of the interview, I keep the right to restrict the use of (some of) my answers further than indicated above.

Name participant: ……………………………………………………………………………………………………..

Date: ………………….…………… Signature participant: ….………………………………………………….

I declare to fully adhere to the above.

Name researcher: ………………………………………………………………………………………….………..

Date: ……………………………….… Signature researcher: ……………….……………………………………

Appendix 4: Interview invitation letter

Geachte Heer/ Mevrouw,

Mijn naam is Olivier Amersfoort. Ik studeer aan de Universiteit van Twente als Master of Science in 'Environmental and Energy Management' en momenteel ben ik bezig met mijn eindscriptie. Ik voer een onderzoek uit voor de provincie Groningen bij het Eemszijlen project. In mijn onderzoek wil ik de verschillende ecosysteem diensten die ontstaan binnen het project identificeren en vervolgens de waarden van deze diensten uitdrukken. Deze toegevoegde waarden verhoogt de totale waarde van het project en kan mogelijk de kans van slagen verhogen sinds nog niet alle financiering rond is. De ecosysteem diensten die zijn geïdentificeerd zijn nu beperkt beschreven in het projectplan. Om de verschillende ecosysteem diensten te identificeren en beschrijven wil ik een aantal interviews houden met onder andere de verschillende betrokkenen en project partners van het project. Mijn vraag is of u zou willen deelnemen met een interview zodat ik met hulp van betrokkenen een zo volledig overzicht aan ecosysteem diensten kan maken voor het Eemszijlen project.

Dit interview is eenmalig en bestaat uit een aantal open vragen (semi-structured) waar tijd is om dieper in te gaan in bepaalde vragen. Ik zou dit in verband met de huidige situatie online willen doen via bijvoorbeeld een Zoom of Skype-verbinding. Het interview zal maximaal 45-60 minuten duren. Ik zou graag een audio opname willen maken zodat ik het achteraf terug kan luisteren en de antwoorden kan uitschrijven. Na beëindiging van het onderzoek, 31 augustus of iets later, zullen deze opnames permanent worden verwijderd. Verder vraag ik iedere respondent een toestemmingsbrief te ondertekenen waarmee akkoord gegaan wordt voor het gebruiken van de gegeven informatie in het onderzoeksverslag. Na afloop kan ik u een samenvatting van het transcript sturen van het interview.

Omdat ik beperkte tijd heb voor dit onderzoek zou ik het waarderen als het lukt om binnen een paar weken een interview afspraak te maken!

Ik hoor graag een reactie en ik wens u een fijne dag!

Ps. Als u een vraag heeft kunt u mij altijd bellen of mailen.

Met vriendelijke groet,

Olivier Amersfoort

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