Valuing nature

Consultancy report

Valuing ecosystem services of the Lutkemeerpolder
The importance of green space in relation to the city Amsterdam

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Seedling Consultancy

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Ecosystem Services of the Lutkemeerpolder

Recreation
1.5-7.5 million €/year

Agriculture
117.600 - 194.400 €/year

Air quality
270.000 - 915.00 €/year

Aesthetics
450-1.800 €/m2 property

Biological Pest Control
11.500-16.100 €/year

Pollination
18.200 - 26.500 €/year

Irrigation
1.700-7.200 €/year

Carbon Sequestration
11.800 - 47.200 €/year

Water Quality

Raw Materials

Habitat

Spiritual

Water Retention

Care Service
52.000 - 83.200 €/year

Services provided by the Boterbloem

Educational Service

Seedling Consultancy

Executive Summary

The city plans to turn the urban green space 'Lutkemeerpolder' in the western part of the municipality of Amsterdam into a business park, which has been met with resistance from citizens who care about the Lutkemeerpolder area. In the present, the area consists of a mix of nature, urban area and agriculture. This report values the ecosystem services of the Lutkemeerpolder to demonstrate its value in its current form to aid the argumentation of the citizen resisting the business park plans. It also presents predictions for how these ecosystem service values will change in the business park scenario, as well as in the case of green development of the area into a *biopolder*. We identify recreation, air quality, and crop production as the most highly valued ecosystem services of the Lutkemeerpolder. We estimate the total monetary value of services we could quantify to be between €1.565.000 to €8.609.800 per year and conclude that there is significant potential to develop these services and so increase their value in a *biopolder*. Based on our research we recommend acquiring further local data to refine our estimated ranges and to use our estimates in evaluation of the zoning plans for the Lutkemeerpolder's future.

Samenvatting

Door de komst van een tweede bedrijventerrein dreigt er stadsgroen in de Lutkemeerpolder in Amsterdam Nieuw-West verloren te gaan. Het behoud van de huidige staat van de polder, met een oppervlakte van 220 hectare, wordt door tegenstanders van de bouwplannen verdedigd vanwege de lokale landbouw, de mogelijkheden voor recreatie en de potentie voor de ontwikkeling van een "*biopolder*". De opgelopen spanning tussen de betrokken partijen heeft ertoe geleid dat zij verschillende visies op de inrichting en waarde van de polder hebben gepresenteerd. Een eerder onderzoek, uitgevoerd door Bos et al. (2019), heeft getracht de huidige waarde van de Lutkemeerpolder vast te stellen door de verschillende ecosysteemdiensten die het gebied rijk is te beschrijven. Ons onderzoek bouwt voort op die resultaten door met behulp van het TEEB-kader (The Economics of Ecosystems and Biodiversity framework) schattingen te maken van de monetaire waarden van verschillende ecosysteemdiensten in het gebied. Deze waarden stellen ons in staat om de verschillende opties voor het bestemmingsplan tegen elkaar af te wegen en zo aanbevelingen te doen richting de opdrachtgever. Uit dit onderzoek blijkt dat mogelijkheden voor recreatie, het reguleren van luchtkwaliteit, akkerbouw en de esthetiek van het landschap de meest waardevolle ecosysteemdiensten van de Lutkemeerpolder zijn. De totale waarde van de ecosysteemdiensten in de polder wordt geschat op €1.565.000 tot €8.609.800. In het geval dat het bedrijventerrein daadwerkelijk zal worden gerealiseerd, zullen deze waarden vermoedelijk dalen, waar zij in het geval van "*biopolder*" juist toenemen. Alhoewel het vergaren van meer lokale gegevens voor verder onderzoek wordt aangeraden, zouden de resultaten van dit onderzoek kunnen bijdragen aan een eerlijk debat over de verschillende toekomstscenario's van de Lutkemeerpolder.

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Acknowledgements

We would like to thank our commissioner, Jeroen Schütt from the WUR science shop, for giving us the opportunity to assist with the research on the Lutkemeerpolder. We would also like to express our appreciation to Jettie van den Houdt for her guidance and support in the team process. We are thankful to Bas Amelung, who advised us in the methodology for the valuation of the ecosystem services. And finally, we are grateful that Florentijn Vos, Alies Fernhout and local farmers provided us with the necessary background information on the Lutkemeerpolder.

1. Introduction

The Lutkemeerpolder is an area of 220 hectares and is located in the western part of the municipality of Amsterdam (figure 1). This consultancy report covers the ecosystem services of the Lutkemeerpolder. 'Ecosystem service' is an environmental economic term referring to the societal benefits that nature and ecosystems provide to humans (Chan et al., 2006). This report serves a number of purposes, such as; informing the commissioner on further research that can be conducted and providing arguments to the involved citizen organisations. Hence, it can be read in different ways based on what the readers' needs are, which we accounted for in the structure of the report. We distinguish two different stylised readers and suggest how these could approach the report:

Figure 1 Location of the Lutkemeerpolder in Amsterdam (basemap from OpenStreetMap).

- The research-interested person: For this person, the sections on the individual ecosystem services, the recommendations, the discussion, and the appendix (where critical information to the methods and calculations are found) are most informative.
- The content-interested person: For this person, the introduction, overview of results, recommendations and conclusion sections will be most informative.

However, reading the entire document gives the most complete information and we therefore encourage it. Overall, the report is structured in the following way: we firstly outline background information on the Lutkemeerpolder and describe the scenarios, scope and goal of this report. Secondly, we give an overview of our results and then demonstrate the valuation of the Lutkemeerpolder per ecosystem service. Thirdly, we give several general and specific recommendations to increase the value of the services identified in the polder and provide guidelines for the interpretation of our results. Finally, we finish the report by discussing the effectiveness of the applied framework and address some methodological concerns.

1.1 Background

The Lutkemeerpolder is a prime example of current day societal dilemmas within the growing city of Amsterdam (Verhoeven, 2009). It is located next to Schiphol Airport on the edge of the municipality of Amsterdam. Schiphol wants to develop more business areas whilst the local inhabitants are trying to improve local green areas and have an increasing demand for locally sourced food (Terragni et al., 2009). With the Lutkemeerpolder being the last agricultural area within the municipality (Bos et a., 2019), tension is rising over the plans for Schiphol to turn this area into a business park (Khaddari, 2019).

The Lutkemeerpolder is a polder that was created between 1850 and 1865 (figure 3). At the time, the city of Amsterdam needed more food to keep up with its growing population. They created the polder by damming in the Lutkemeer and other small lakes and channels. It maintained its use as an agricultural area until 1970. Lowering demand for local food decreased its usefulness as an agricultural area. In 1970 the memorial park and graveyard Westgaarde was built. This can be seen as the moment it began taking on a more urban city function.

At the turn of the century, a plan was conceived to build a business park here for Schiphol Airport to expand its services. The first business park was completed in 2019 and plans for a second business park were developed. It was around this time that the nature area was also being developed and the polder started to become more diverse in its functions. It went from just agriculture to fulfilling different functions for the city of Amsterdam.

The current situation in the polder has become a mix of nature, urban area and agriculture (figure 2). The western side of the polder has become a nature reserve area and is part of the ecological network of the province of Noord-Holland. The centre and

the north side of the polder have maintained their agricultural use for more than 150 years. This area is also the last rich clay field in the municipality of Amsterdam (Bos et al., 2019). On the south side the first business centre of the Lutkemeerpolder has been built. The eastern side of the polder consists of the crematorium and memorial park Westgaarde.

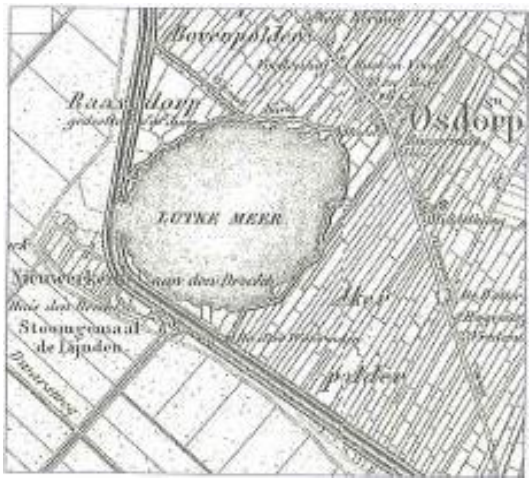


Figure 3 Lutkemeerpolder ~1850 (Zoning plan, Amsterdam)

Figure 2 Current situation (Google Maps)

The plans for Lutkemeerpolder were created 20 years ago. People are now, however, valuing locally produced food more highly, as well as the openness of the area. This has led to the local initiative to create a *biopolder*, where organic agriculture takes place in the polder, instead of a new business park. This conflict demonstrates the dichotomy of growth of the city versus preservation of green areas in urban neighbourhoods.

Currently, plans for the construction of a business park on site are underway. The first phase of the business park has been completed. The second phase was planned to be finished in 2020, but has been halted by the citizen-led initiative *Behoud lutkemeer*, whose goal is to change the zoning plan of the Lutkemeerpolder to a *biopolder*, focussed on local food production (Bos et al., 2019).

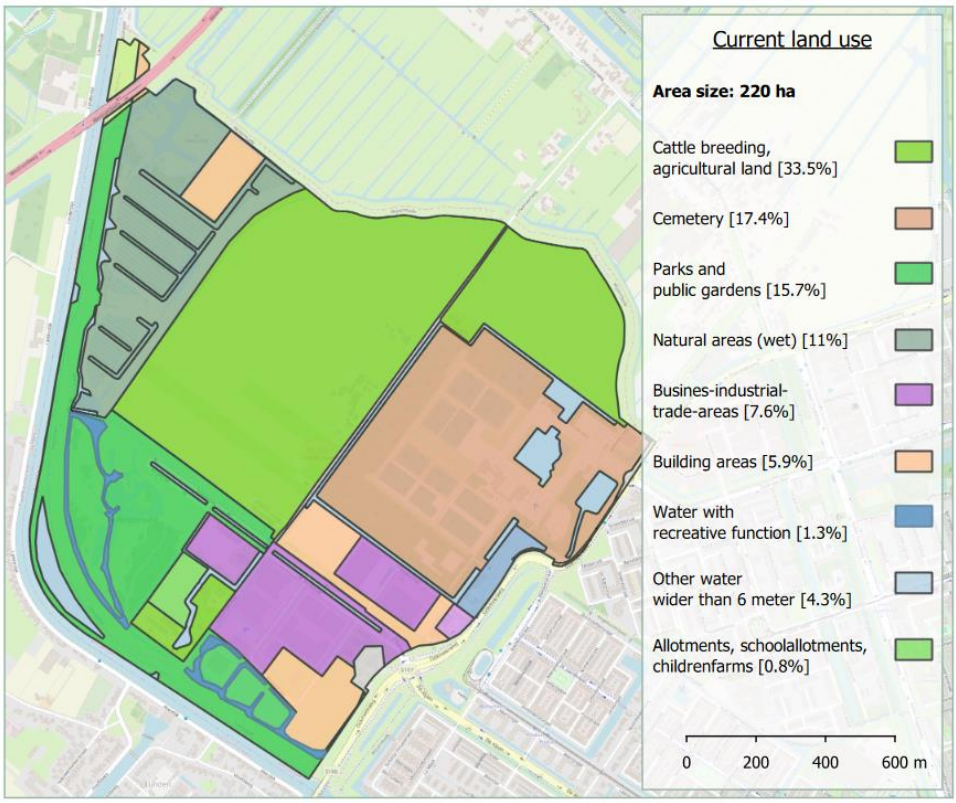


Figure 4: Map of the current land use of the Lutkemeerpolder. Data from OWS Amsterdam. The LGN7 land use map gives more detail on the agricultural activities in appendix 9.6.

1.2 Scenarios

As stated above, there are currently two competing purposes for the Lutkemeerpolder. One is the purpose of business park as has been outlined in the zoning plan, which is the purpose desired by the development company and the majority of the city council. The other is the purpose of *biopolder* as stated by the citizen-led initiative *Behoud lutkemeer*, which is characterized by organic food production for the city of Amsterdam. In this section, we will briefly describe the two scenarios.

Biopolder

Entrepreneurs in the Lutkemeerpolder have designed an alternative destination plan for the polder named 'the Biopolder'. The vision for the *biopolder* is to provide food for the city of Amsterdam and make its inhabitants aware of the process of food production, with a focus on locally grown food (*Behoud lutkemeer*, 2018).

The plan has been proposed by members of the citizen movement *Behoud lutkemeer* as an alternative for the purpose of a 'business park' for the agricultural area of the polder. Since the land in the agricultural area of the polder is owned by the municipality of

Amsterdam, altering the zoning plan of the area enables the municipality to enforce a certain type of activity. Altering the destination plan to one that gives space for the *biopolder* would imply that all agricultural activities undertaken in the area take place in accordance with the principles as defined in the *biopolder* plan. These core principles, as designed by *Behoud lutkemeer*, include local food production, education, biodiversity maintenance and exposure to nature.

As outlined in the pamphlet on the *biopolder* by *Behoud lutkemeer*, the *biopolder* would have several characteristics that involve these principles (*Behoud lutkemeer*, 2018):

- **Locally sourced food**: the produced food is mainly destined for inhabitants of Amsterdam, as well as restaurants or other entrepreneurs from the city.
- **Maintenance of landscape value**: the wide, open landscape of the Lutkemeerpolder is preserved and agricultural activities will be adapted to fit the landscape, in order to preserve the historical landscape of the area.
- **Accessibility to the public**: walking and cycling paths would be constructed to make the polder more accessible to a diverse range of visitors. Furthermore, educational activities for all age groups would be organised to promote knowledge about the production of food, such as harvest festivals and 'open farm days'.
- **Organic agriculture**: All crops produced will be (certified) organic, with production taking place 'in collaboration with nature'. This will be reflected in the choice of fertilizer and crop, as well as the method of farming (e.g. 'agroforestry').
- **Reinforcement of natural value**: by producing food 'within the boundaries of nature', the agricultural activities will be aimed towards preserving the natural value of the polder. Farming practices will thus contribute to soil quality and the maintenance of biodiversity.
- **Cooperative entrepreneurship**: farming companies operating in the Lutkemeerpolder will share a collective vision (consisting of the elements above), and collaborate in terms of personnel, material and distribution.

Business Park

The increasing housing demand in the Amsterdam city centre has caused businesses to move to the outskirts of the city (SADC, 2017). For this reason, the zoning plan of the Lutkemeerpolder was altered in 2013 so that the land could be used for the construction of two business parks: Business Park Amsterdam Osdorp (BPAO) phase 1 and 2. BPAO phase 1 is located in the south of the polder and has already been built. BPAO phase 2 was planned for 2020 but has been delayed due to public resistance. The area is suitable

for businesses in environmental category 3.2 and the lots are issued by the Schiphol Area Development Company, the municipality of Amsterdam and construction and contracting company SEKU.

Even though the zoning plan was changed, there is no final version for the urban planning for BPAO phase 2 available. This means that it is hard to make an estimation of what the area will look like in the future. The local newspaper of Amsterdam, Het Parool, stated in august 2019 that a logistics centre of about 5.5 hectares will be constructed at this location (van Zoelen, 2019). According to the SADC, the location near the highway, the Amsterdam harbor and Schiphol Airport is ideal for this purpose.

The municipality and SADC demand from GEM Lutkemeer B.V. (the developer of the area) that the public spaces in the area are built in a circular manner. According to the municipality, the business park should integrate green, businesses, urban agriculture, catering industry and societal functions so that these can strengthen each other. Also, the area should produce surpluses of energy that can then be returned to the energy grid and for heating a local aquifer thermal energy system should be used. Nature inclusivity should play an important role, meaning that the local ecology should be taken into account. The business park should be integrated into the landscape and recycled materials are required in the construction.

The aim of SADC is to attract wholesale and logistics businesses and manufacturing industry for fashion and food. This business park should facilitate economic activity that supplies the city with locally produced sustainable goods (Gemeente Amsterdam, 2018). According to GEM Lutkemeer B.V. there are several companies that would like to build on the BPAO phase 2 area.

In the plans of the municipality for the polder, some land has been reserved for agricultural purposes for ‘de Boterbloem’. In the current plan for the business park scenario, 3 hectares of land will stay available for the farm to engage in minor agriculture and to fulfil its function as a care farm (van Doorninck, 2018).

Furthermore, a part of the polder that is now agricultural land is destined to become a nature area as part of the Tuinen van West (Looman, de Ruijter & Vos, 2008). However, very little is known about how this nature area will be designed and when it will be realised. Therefore, we will assume that this area remains agricultural land in the business park scenario. This way, we are better able to estimate the impacts explicitly associated with the construction of a business park.

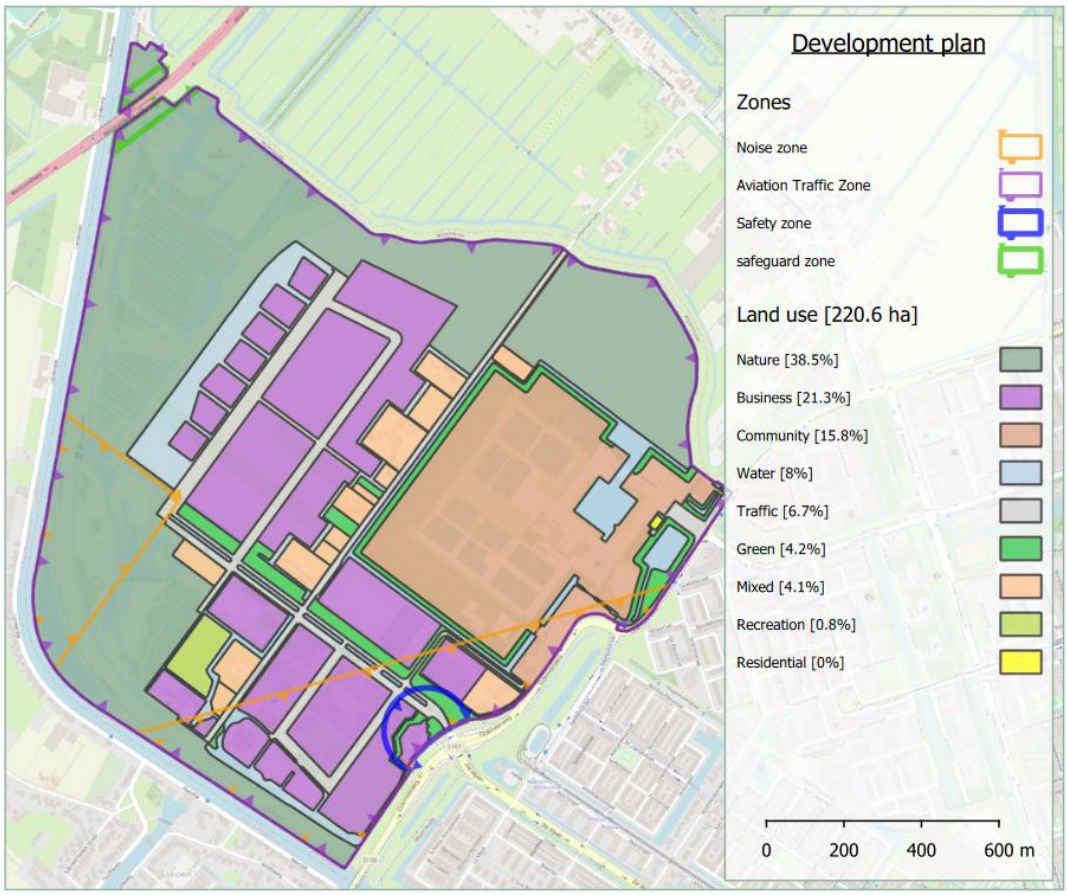


Figure 5: Business park according to zoning plan (Ruimtelijke plannen, Amsterdam)

1.3 Research Context

The commissioner's group of the WUR Science Shop was tasked in 2019 by *Behoud lutkemeer* to aid them with arguments in their discussion with the municipality of Amsterdam to change the zoning plan into a design for a *biopolder*. The approach of the WUR Science Shop is to aid *Behoud lutkemeer* in the discussion of the zoning plan by estimating a monetary value for the ecosystem services of the Lutkemeerpolder[1]. Since the benefits of a business park are easily calculated, and those of the ecosystem services not, in which this research also provides equality in information within the discussion regarding the zoning plan. A previous study in 2019 has already done research on the ecological and social characteristics of the Lutkemeerpolder (see Bos et al., 2019).

[1] A more comprehensive list of stakeholders besides Behoud Lutkemmer can be found in appendix 9.5.

This research thus presents a subsequent step to Bos et al.'s (2019) research by assessing the value of the ecosystem of the Lutkemeerpolder. The goal of our project is to estimate monetary values for the ecosystem services provided by the Lutkemeerpolder as well as give indications for how these ecosystem services will change for the business park and the *biopolder* scenarios, as well as to consult our commissioner on how to move forward with their case. For this, we will first present an updated and more complete list of ecosystem services of the Lutkemeerpolder. Second, we provide monetary values for these services where applicable. We then elaborate on how these ecosystem services change in the scenario of a *biopolder* and business park. Finally, apart from the valuation, this report provides consulting advice to the commissioner on the used methods, further study recommendations and conclusions from our valuation. These four pillars form the scope of this project. This report is one of three products encompassing the scope of this project. The other two are an infographic of the ecosystem services and their values, and a presentation which focuses on providing consultancy directly to the commissioner based on our obtained expertise from the research presented in this report. The outputs of our project can then be integrated into the broader project of the Science Shop's commission group to consult the citizen initiative, "*Behoud lutkemeer*".

We address a specific knowledge gap with our research, as the ecosystem services value of the Lutkemeerpolder is currently unknown. While it has been determined that the Lutkemeerpolder provides recreational and agricultural opportunities, as well as a habitat for fauna and flora, a quantitative estimate of the value of these services is lacking. This is especially needed for services that do not have direct monetary value, such as biodiversity, cultural history, recreational possibilities and climate. Closing this knowledge gap, as our objective, will aid the commissioner in demonstrating the value of the Lutkemeerpolder, which in turn will help the citizen initiative *Behoud lutkemeer* to argue their case for the conservation of the Lutkemeerpolder.

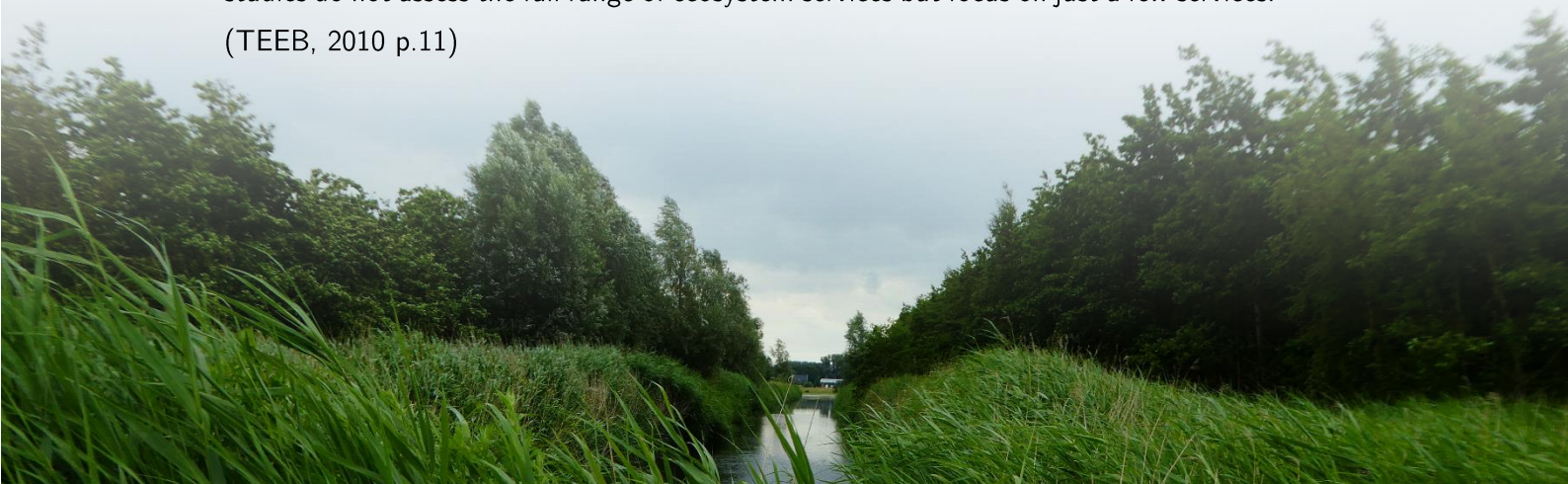
Based on this scope and objective, our main research question is: What is the monetary value of the Lutkemeerpolder's ecosystem services?

This question encompasses the following sub-questions:

1. Which ecosystem services are most important in the current situation of the Lutkemeerpolder?
2. What is the monetary value of these most important services of the Lutkemeerpolder in the current situation?
3. What is the monetary value of the most important ecosystem services of the designed *biopolder* and business park scenarios of the Lutkemeerpolder?

2. Methodology

We seek to produce monetary values for services that do not necessarily have direct economic market value, such as air quality, pollination, and recreational possibilities which still provide benefits to humans. They also include direct market goods, such as food grown in the ecosystem. As it stands, the Lutkemeerpolder area acts as a source of multiple ecosystem services in a mostly urban area. Many of the ecosystem services provided by the Lutkemeerpolder would change through land use changes. Therefore, the most appropriate way to express the value of the Lutkemeerpolder is through the individual valuing of its different ecosystem services. For that, a combination of different valuation methods is applied. There are a number of frameworks and methods to value different ecosystem services, as the ecosystem services approach has been popularised in recent decades (see for example De Groot, Wilson, & Boumans, 2002). We use the 'The Economics of Ecosystems and Biodiversity Framework' (TEEB), a global ecosystem services framework focused on making the value of nature apparent. The framework is based on three key principles, (1) **recognizing the value** of the ecosystem by describing ecosystem services, (2) **demonstrating this value** by monetizing these values and (3) **capturing the value** by introducing mechanisms that take ecosystem services into account in decision making (TEEB, 2010). In this project, we will focus on the first two principles, as we present a list of ecosystem services of the Lutkemeerpolder and demonstrate the value of feasibly quantifiable services. In doing this, we hope to provide direction to decision makers to capture the value of the services. The TEEB framework identifies four categories of Ecosystem Services, which we work with: provisioning services, such as agricultural production; regulating services, such as carbon sequestration; habitat services, such as biodiversity preservation; and cultural services, such as recreational benefits (TEEB, 2010). We use these as guiding categories for the structuring of our valuation (figure 6). In our methodological approach, we aimed to quantify all services found. However, for some, we anticipated data gaps or other obstacles and hence in our methodology we aim to quantify as many as possible. This is a recognised approach within the TEEB framework, where "In practice, most valuation studies do not assess the full range of ecosystem services but focus on just a few services." (TEEB, 2010 p.11)



To identify and value the Ecosystem Services of the Lutkemeerpolder, we conduct semi-structured expert interviews and secondary data searches. We then produce an aggregate annual and aggregate stock value of the identified and quantified services for further use by the commissioner and other stakeholders, such as the citizen initiative *Behoud lutkemeer*. Specific methods for each valuation are found in the subsections for each ecosystem service identified.

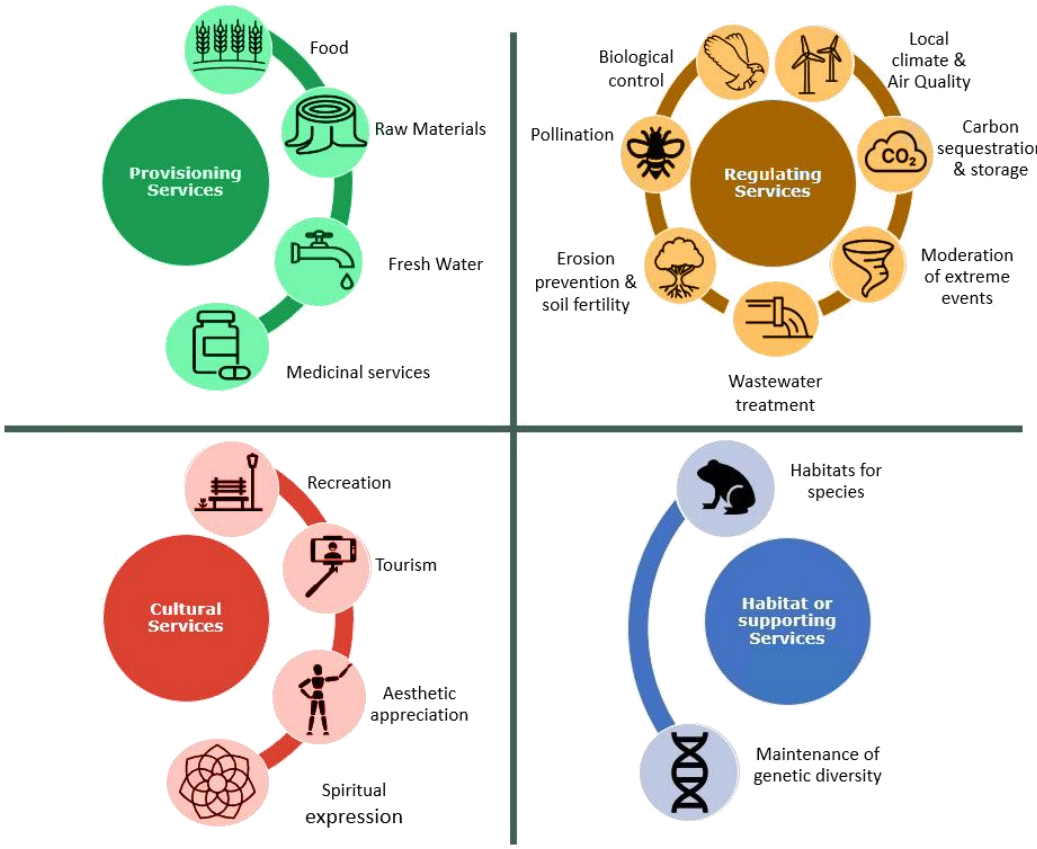


Figure 6 Overview of ecosystem services according to the TEEB framework (adapted from TEEB, 2010)

3. Overview Results

Based on literature research, interviews with experts, spatial- and data analysis, we categorised, ranked and estimated the value of the ecosystem services of the Lutkemeerpolder in their contribution to human well-being. Our results are shown in figure 7, 8 and table 1, services which we couldn't monetize as a yearly value are shown in table 1 and do not appear in figure 7 and 7. This also excludes initial (construction) cost such as changing the water system.

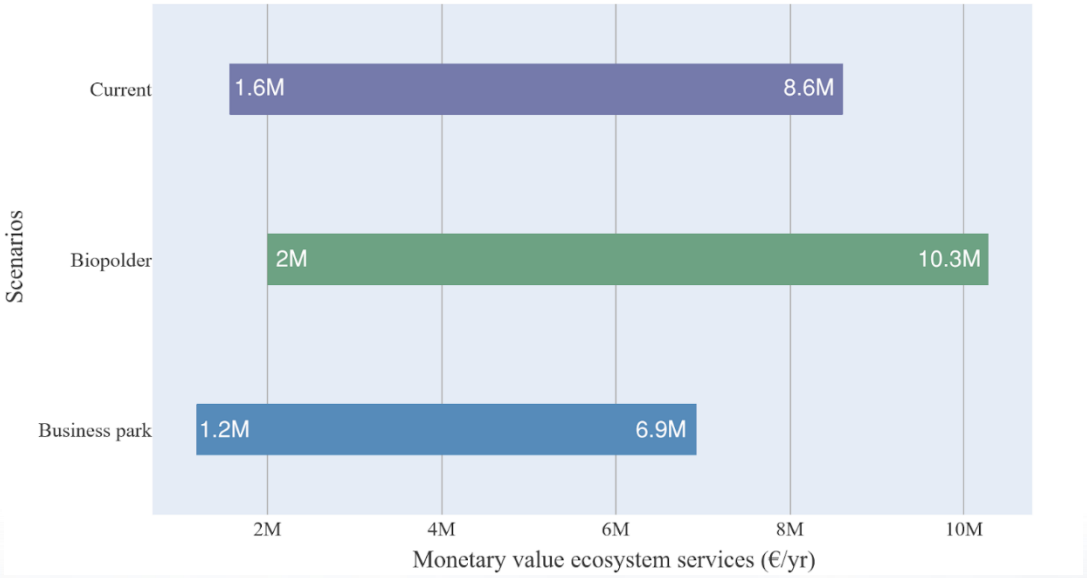


Figure 7: Total monetary value per scenario

The *biopolder* showed an increase in almost every ecosystem service and thus results in the highest total value. The business park has the least value from ecosystem services.

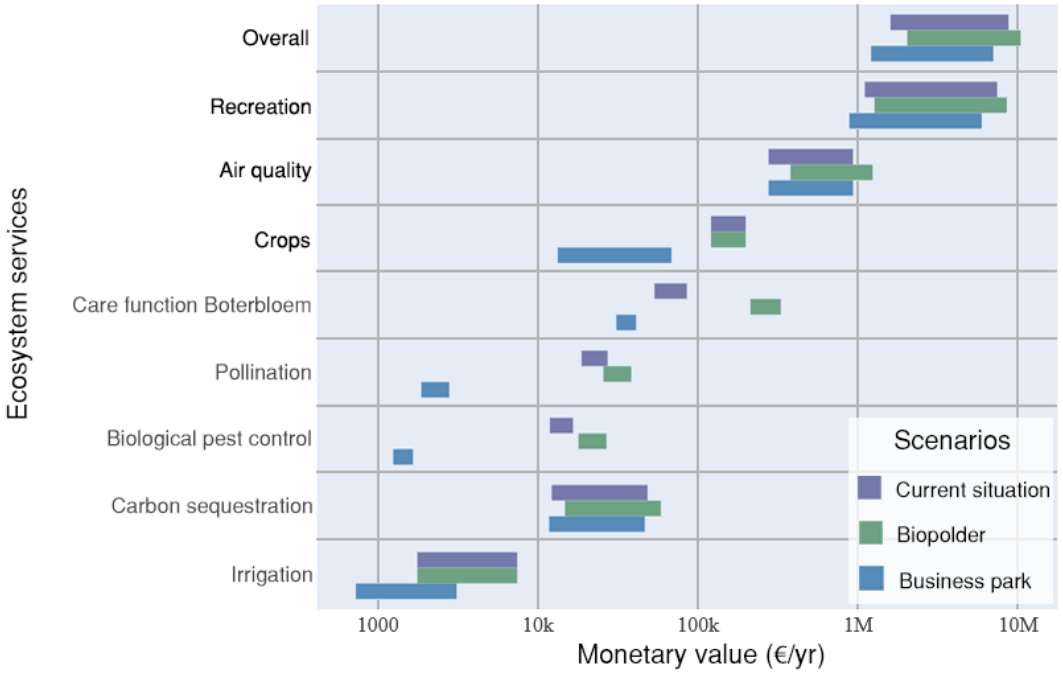


Figure 8 Overview of all ranges of valued ecosystem services of the Lutkemeerpolder on a logarithmic scale.

The valuations show a clear variation, recreation, air quality and food production have the highest impact, while irrigation and carbon sequestration have a lesser impact on human well-being in the Lutkemeerpolder. The *biopolder* scenario shows a significant increase in the aggregate value. In the case of the business park, there is a clear decrease in aggregate value. All valued services show a decline in value with some losing all their value in this scenario.

The large ranges of the estimates are due to uncertainties or limited data. In the recommendations we suggest ways to reduce the ranges. Details per ecosystem service are explained in the next chapter. Summaries and details of the interviews can be found in appendix 9.1.

Table 1 Overview of ecosystem services of the Lutkmeerpolder

	Ecosystem Service	Valuation Method	Most Applicable Lutkemeer Area	Value Range [€/yr]	Possible Value in *Biopolder* [€/yr]	Possible Value in Business Park [€/yr]
Provisioning services	Crops	Direct market pricing	Agriculture	117.600 - 194.400	117.600 - 194.400	12.900 - 66.600
	Provisioning of water (irrigation)	Replacement cost	Agriculture	1.700 - 7.200	1.700 - 7.200	700 - 3.000
	Raw materials	Direct market pricing	Forest, wetlands	Negligible	Possible increase in case of agroforestry	slight decrease
Regulating services	Pollination	Direct market pricing	Agriculture	18.200 - 26.500	24.900 - 37.300	1800 - 2700
	Improve air quality	Benefit transfer	All	270.000 - 915.000	370.000-1.215.000	270.000 - 915.000
	Improve water quality	Benefit transfer	All	Negligible	-	-
	Water retention against floods and droughts	Avoided costs	All	Negligible	-	-
	Climate regulation (Carbon sequestration)	Benefit transfer	All	11.800 - 47.200	14.300 - 57.200	11.400 - 45.400
	Biological pest control	Direct market pricing	Agriculture	11.500 - 16.100	17.400 - 26.100	1200 - 1600
Cultural services	Recreation	Preference based Travel Cost Method (TCM)	All	1.082.200 - 7.320.200	1.244.500 - 8.418.200	865.700 - 5.856.200
	Aesthetic	Benefit transfer/Hedonic Pricing	All	450-1.800 per m2 of property	450-1.800 per m2 of property	210-1.180 per m2 of property
	Spiritual	-	Cemetery	-	-	-
Habitat services	Maintenance of genetic diversity	Habitat services valued through other ES	All	-	-	-
	Habitat for species	Habitat services valued through other ES	All	-	increase	moderate decrease
Boterbloem function	Recreational function	-	Boterbloem	Captured in recreational value	Captured in recreational value	Captured in recreational value
	Care function	Direct market pricing	Boterbloem	52.000 - 83.200	208.000 - 322.800	30.000 - 40.000
	Educational function		Boterbloem	Negligible	sharp increase	decrease
Overall				**1.565.000 - 8.609.800**	**1.998.400 - 10.278.200**	**1.185.800 - 6.927.800**

4. Ecosystem service valuations

4.1 Cultural ecosystem services

Cultural ecosystem services are defined as "the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (Sarukhán and Whyte., 2005). The TEEB framework identifies three main categories of cultural ecosystem services:

- Recreation
- Aesthetics
- Spirituality

In this chapter, we describe the aforementioned ecosystem services based on their relevance to the Lutkemeerpolder. When the service is deemed relevant for the area, a suiting monetization method is proposed and executed.

Recreation

Recreation is one of the main aspects of cultural ecosystem services provided by many ecosystems, increasing human well-being by spending time in these ecosystems (TEEB, 2010). The Lutkemeerpolder is a frequently visited outdoor site, where we observed visitors engaging in various recreational activities, most notably dog walking. Outdoor recreation in the Lutkemeerpolder creates physical and mental health benefits for visitors. A long list of recreational activities making up the recreational service in the Lutkemeerpolder was compiled from survey data in 2019 by Bos et al., (2019). Most importantly, these are: visiting farms, walking, biking, and gardening.

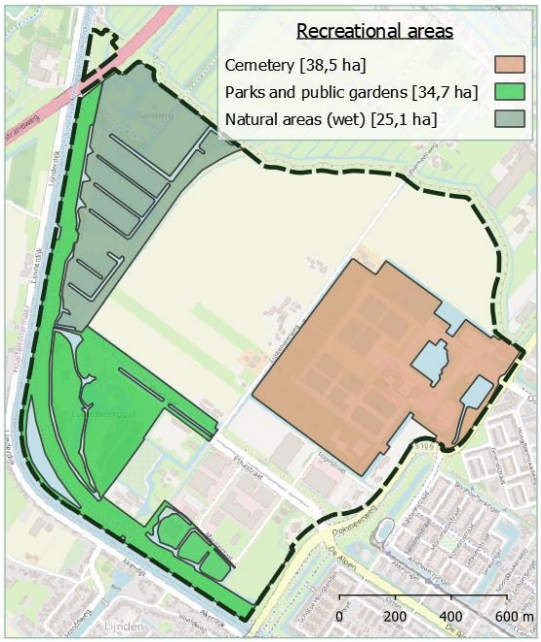


Figure 9 Highlighted recreational areas in the current land use of the Lutkemeerpolder

Relevance

Recreation, as part of cultural ecosystem services, is a major service provided by the polder, as over 40% of the Lutkemeerpolder is outfitted with hiking or walking paths and

dog walking opportunities (see land use map, figure 4). Especially in urban environments, such as Amsterdam, where the Lutkemeerpolder is located, the ecosystem service 'recreation' is important for green spaces within or close to the city, improving the quality of life of residents (Fischer et al., 2018; TEEB, 2010). Hence, including recreation in the quantification of ecosystem services of the Lutkemeerpolder is important.

Method

Valuing recreation as an ecosystem service involves valuing the polder from a visitor's perspective. It is a direct use, non-consumptive service, and as the polder provides public goods in recreational opportunities, no direct market valuation is possible (de Groot et al., 2010). Thus instead, a revealed preference method is used. The travel cost method (TCM) is the most common to estimate the value of recreational areas (TEEB, 2010). This method relies on site visits and travel costs to the area to determine a monetary value for recreation as an ecosystem service (see Ward and Loomis, 2003, for in depth description of method). To estimate the recreational value of the Lutkemeerpolder, we employ this valuation method. We use data collected by Bos et al. (2019), data from the municipality of Amsterdam, and well as contextual input from expert interviews. As many of the variables are estimates, we calculate a range of values, taking uncertainties into account.

The TCM takes expenditure data from visitors to the recreational site to approximate the value of the ecosystem service 'recreation' (Gundimeda, Markandya, & Bassi, 2018). The model then gives the average travel cost per visit. In a subsequent step, this value is multiplied by the number of visits, which we obtained from municipality data and on which we performed several validity tests (appendix 9.2). An approximate number of yearly visits to the Lutkemeerpolder was calculated by making use of municipality data[2]. Multiplied with the cost per visit obtained from the travel cost method, we get a figure indicating the recreational value of the Lutkemeerpolder per year. We combined and slightly adapted a TCM formula from Wheatley (2011) and Garrod and Willis (1999) to fit the case of the Lutkemeerpolder[3]:

[2] Notes on data used: Due to COVID-10, we cannot collect additional survey data to do primary research for this method, hence we rely on previously collected primary data collected by Bos et al., 2019, and supplement the data for the TCM with data from the municipality of Amsterdam (2018).

[3] In the future, this model should be used as the basis for a regression with more data to account for e.g. differences in mode of transportation to travel to the area

$$V_{per\ visit} = (T * w) + (D * v) \quad (1)$$

$$V = V_{per\ visit} * V_a \quad (2)$$

Where:

T	Travel time to the Lutkemeerpolder	hr
w	Average wage rate	$€ * \mathrm{hr}^{-1}$
D	Return distance from the Lutkemeerpolder	km
v	Marginal vehicle operating costs	$€ * \mathrm{km}^{-1}$
V_a	Average number of visits per year	yr^{-1}
$V_{per\ visit}$	Monetary value per visit	€
V	Total value output of the model	€

Travel time and distance was determined by Bos et al. (2019) through their surveys. For the average wage of the Noord-Holland province, we used data from the CBS (2019). For vehicle operation cost we used the commonly used indicator mileage reimbursement cost (see Wheatly, 2011) usually used for business, which is €0,19 per kilometer for the Netherlands (EuroDev, 2019). This indicator includes costs like fuel and maintenance of a vehicle. The average number of visitors was calculated from data by the municipality of Amsterdam (Gemeente Amsterdam, 2019; see remarks below).

Valuation

Based on different scenario estimates for the number of visitors, we obtained a high, a low, and a point estimate, where the latter is our expert estimate. We think the actual value of recreation is close to the point estimate, as the calculation is highly sensitive to the number of visits to the polder, which is a number we are confident in due to validity tests we performed (appendix 9.2). Hence, if the number of visitors we calculated is correct, then the value of the Lutkemeerpolder will be higher than the lower-bound estimate, and this point-estimate is the value we are most confident in.

For formula (1), value per visit, we get €7 per visit for the lower-bound estimate, €15 for the upper-bound estimate, and €14 for the point estimate per visit (which is due to number of visitors). Recreation as an ecosystem service of the Lutkemeerpolder has a monetary value of €1.082.200 - €7.320.200 per year, and our point estimate is €5.630.900 per year as calculated through the TCM. This is based on costs per visit as output of formula (1) multiplied by number of visits in formula (2). Calculations with different numbers of visitors, different wage weights, and travel modes are found in output tables in appendix 9.2 which show how this range was constructed.

Discussion

Due to a lack of location-specific data, we made several assumptions which influence the results of our analysis:

Firstly, the numbers of visitors (V_a) is uncertain, as there is no direct municipality data or other data available for the exact area. We calculated the number of visitors based on data from the municipality of Amsterdam for the entire Tuinen van West area, which includes the Lutkemeerpolder (Gemeente Amsterdam, 2019). We have made a low, a high, and a mid-range estimate of the proportion of visitors to the Lutkemeerpolder based on different levels of popularity of the Lutkemeerpolder compared to the other parts of the Tuinen van West. We have performed several tests to validate these numbers (see appendix 9.2) and conclude that these numbers are valid. The estimated visitor number of the Lutkemeerpolder lies between 10.593 and 20.966 unique visitors per year. Calculations for these can be found in appendix 9.2.

Secondly, the identified visitors visit the Lutkemeerpolder with different frequencies, for which only qualitative indicators have been included in the survey by the municipality (Gemeente Amsterdam, 2019). We used conservative quantifications for the lower-bound, and a higher number of visits, for the mid- and upper-bound.

Thirdly, the cost of traveling to the polder might vary by mode of transport. Based on our own observation and expert insights from interviews (appendix 9.1), we know that only an (unknown) share of visitors drive to the polder and thus have vehicle operation costs as is included in the TCM model. Other visitors walk or bike to the polder, which are free modes of transportation. Hence, for the lower bound estimate, we split the model so that only 20% of visitors fall in the 'driving cost category'. For the point estimate, we judge that 50% of visitors drive to the Lutkemeerpolder. For the higher bound estimate, we use a 100% driving rate as is intended in the basic TCM. These are only preliminary expert guesses on our part, and this should be refined by further data collection in the future.

Fourthly, there is academic debate surrounding using the full wage as a measure of opportunity cost in the TCM formula (see Douglas & Johnson, 2004). For the lower-bound estimate, we therefore use half of the average wage per hour for a more conservative estimation of opportunity cost that feeds into the above formula for cost per visit.

As the data from the municipality regarding the number of visitors as our basis does not include children and neither do any of our validation studies (appendix 9.2), we exclude children from our number of visitors and calculations in the TCM. As children also do

not generally earn a wage or use costly modes of transportation, their visits and thus the ecosystem service value for directly the children is omitted here. This could be revised in future calculations too.

For future valuation

To calculate a more precise figure for the recreational value of the Lutkemeerpolder, we recommend collecting further data, especially primary data in survey form to obtain area-specific values. This data is currently missing. Obtaining this data would allow for calibration of the model through a statistical regression, leading to more accurate results. The data needed here is:

- Modes of transport to the polder: how many people drive (and how many per car), take public transport, or use free modes of transportation
- An updated figure for average distance and time spent traveling to the Lutkemeerpolder from a representative sample
- The average wage for Amsterdam (opposed to province of Noord-Holland, as we currently use in our analysis)
- Survey questions to estimate how many visitors would alter their visiting behaviour in the *biopolder* or business park scenario (see below: scenarios)
- Accurate number of visitors in the polder (through representative sampling over all seasons for example)

Scenarios

It is challenging to estimate changes in visitor numbers in the business park or *biopolder* scenario, therefore it is also hard to estimate how the value of recreation would change. Although the numbers are uncertain, we can conclude that the attractiveness and accessibility of recreational benefits in the Lutkemeerpolder would decrease in the business park scenario, and increase in a *biopolder* scenario, where more of the polder is accessible to the public (e.g. walking paths through agricultural fields).

Business park

We estimate a 0-20% decrease in visitor numbers for the business park scenario from expert interview insights. The city ecologist estimated that the breakup of the openness of the landscape will influence the visual attractiveness of the Lutkemeerpolder landscape (appendix 9.1). Furthermore, one can expect noise pollution, more traffic, and a drop in visitor numbers to the Boterbloem farm. However, the main recreational areas, as identified by us through observation, are the memorial park and the dog walking area, which would not change in the current zoning plan for a business park, which is why we judge the drop in visitor numbers not to exceed 20%. Therefore, in the business park

scenario, the range of values would decrease to €865.700 - €5.856.200 per year (for a 20% decrease in visits). For the point estimate, this means a drop from €5.266.100 to €4.212.900 per year, which is a loss of €1.053.200 per year in case of a 20% decrease in visits.

Biopolder

For the *biopolder*, we can estimate a conservative 0-15% increase in visitor numbers, based on assumptions that the area will be both more accessible and attractive. However, as there is currently no survey data available on this, we use this conservative range which should only be understood as an indicator and in the future calculations should be repeated with data on how visitors react to a change to the *biopolder*. With a 15% increase in visits, the recreational value would increase to €1.244.500 - 8.418.200 per year for the range, and for the point-estimate from €5.266.100 to €6.056.000 per year, which is a gain of €789.900 per year if visits increase by 15%.

Aesthetics

In highly urbanized western countries such as the Netherlands, the general public is highly attracted to natural and rural landscapes (De Groot & Van den Born, 2003). Surveys conducted in the Netherlands showed that 90% of the participants recognise the value of nature and value it based on its aesthetic appeal, often regardless of its direct uses and functions to humans (Van den Born et al., 2001). In urban areas where natural attractive landscapes exist, alterations in this landscape can result in significant demographic and economic change (Howley, 2011). Attractive landscapes are also likely to influence people's residence preference as well as housing prices. Thus, houses close to attractive environments tend to increase in value compared to houses in less favorable locations (Luttik, 2000) and are thus part of ecosystem service valuations.

Relevance

The Lutkemeerpolder lies in Amsterdam Nieuw-West, between Schiphol Airport and the Amsterdam city center. The Lutkemeerpolder acts as an attractive green landscape for Amsterdam Nieuw-West. Together with the memorial park, it stands as an attractive landscape for the surrounding residential areas. Therefore, it has socio-economic value to nearby residents. A link between economy and ecology is found in the premium that houses in an attractive, green setting receive compared to houses in a less favourable location (Luttik, 2000). Policy priorities often fail to reflect the socio-economic value of attractive landscapes. When looking at the property pricing map of Amsterdam, one can see that the properties north and east of the area, with a view of Lutkemeerpolder, have different prices depending on their location. This could be the result of a premium cost. This premium in housing prices may be used as the guiding principle for monetizing how the public values the attractiveness of the landscape of the Lutkemeerpolder.

Method

When attempting to put a monetary value on the aesthetics of the landscape of an area, past studies such as the one by Brookshire et al. (1982) often used ‘hedonic pricing’ methods, while others like Cruz and Benedicto (2000) used a contingent valuation method in the form of a survey. The most common way of deriving a value for the attractiveness of landscapes is through the use of property pricing and demand, in relation to the existence of a nearby rural landscape.

Due to the recent COVID-19 crisis and the regulations by which the Wageningen University and its students operate, conducting accurate surveys to use a contingent valuation method is not possible. Similarly, a hedonic pricing method where we gather data from the study area ourselves is also not possible. Therefore, the approach to valuing this ecosystem service of the area of the Lutkemeerpolder involves the use of data from past studies of other areas in the Netherlands. One such study is the one by Luttik (2000) which determined the increase in housing prices in the form of an added "premium" when houses in urban areas were built near natural reserves. Based on the findings from this study and the public available data for property pricing in the different areas of Amsterdam, a mix between a benefit transfer and a hedonic pricing approach is employed to determine the value of the Lutkemeerpolder's landscape attraction. A direct pure benefit transfer approach is not applicable in valuing landscape attractiveness as it is nearly impossible to find studies whose findings can accurately reflect the situation of another area.

Valuation

The main hypothesis behind the valuation is that houses near an attractive rural setting will have an added premium in price compared to houses in a neutral setting. The attractiveness of a landscape can be determined based on the presence of open areas, water bodies, natural settings, etc. Residents tend to value those differently and thus each aspect contributes differently to the housing price. In our case, the residential areas of maximally 800 meters away from the Lutkemeerpolder are taken into account. This is used as a realistic vicinity where house premiums are potentially affected by the presence of the Lutkemeerpolder. This distance is based on the range of distances where houses still attract a premium in the study by Luttik (2000). The distance is calculated from the edges of the Lutkemeerpolder, similarly to the aforementioned study. In order to value the attractiveness of the Lutkemeerpolder, the average range of property prices for the housing areas surrounding the Lutkemeerpolder was used. The premium acts as a bonus percentage to the initial price of property and therefore is already included in these price ranges. These can be seen in (figure 10).

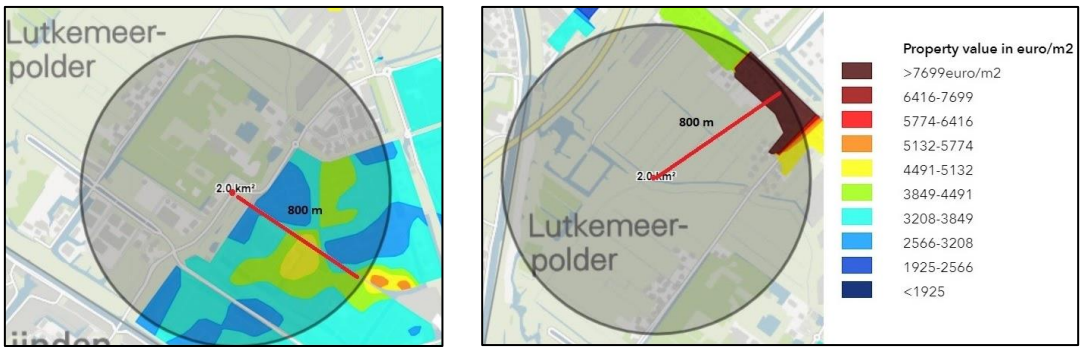


Figure 10 Visual example of an 800m radius scan for the nearby residential areas. Their colours correspond to a housing price the legend of which can be found on the right. The coloured areas represent the residential areas. Grayed out built areas are not residential areas. Business centres and other businesses are not included and are thus not coloured. Maps edited from Maps Amsterdam., (n.d.).

For each of the areas, several possible factors affecting a house premium are identified based on the effects described by Luttik (2000). The premium percentage is then subtracted from the total property price of each surrounding area and is used to represent the monetary value of the Lutkemeerpolder's landscape attraction. If multiple effects are present, then they are added as a total premium to the housing price. Below, a list of all different identified premiums is presented alongside the percentage they contribute to the property value (table 2).

Table 2 Premiums offered by the Lutkemeerpolder and the % they contribute to property price of nearby houses (Luttik, 2000).

Premium	**Contribution to property price**
No effects	0%
Park Nearby	6%
Park view	8%
Attractive landscape with water features	7%
Open View	9%

First, the residential area east of the Lutkemeerpolder is examined. Property value in this area ranges from a lowest of €2566/m^2 to a highest of €5132/m^2. Property value is expressed in euros per square meter and is derived from 2018 data from the official property value map of Amsterdam (Maps Amsterdam., n.d.). Houses in the eastern residential area of the Lutkemeerpolder are in close vicinity to the park adding a premium of 6%. In addition, the majority of the houses also have a clear view of the park, thus adding an extra premium of 8%, raising the total to a 14% premium. The Lutkemeerpolder as a whole exists as an attractive landscape with water features thus adding a 7% premium, raising the total to 21%. The east side of the Lutkemeerpolder is

home to the cemetery and most of the building areas and malls as can be seen by the current land use map (figure 4). Thus, it is safe to assume that the open view of the fields behind the cemetery and the buildings is heavily obscured. Therefore, this premium is not taken into account for the Nieuw-West residential area. This leaves us with a likely 21% house price premium for the Nieuw-West residential area. This premium represents the number of euros per square metre of residential area that residents were willing to pay in order to be near the Lutkemeerpolder. Since the premium is already included in the property price, we account for that in the calculation. Using this info, we make the following calculation:

- Minimum price range: 2.556 * 0,21/1,21 = €445,34/m^2
- Maximum price range: 5.132 * 0,21/1,21 = €890,67/m^2

Therefore, for the Nieuw West residential area, the value of the Lutkemeerpolder's landscape attraction ranges from 445,34-890,67 euros/m^2. We round that up to 450-890 euros/m^2.

Similarly, to the Nieuw-West residential area, the northern residential area of Osdorp is examined. It is important to note that while it falls within the 800m radius from the Lutkemeerpolder, there are other factors (ex: 2 more polders present nearby) affecting the house prices in this area so price ranges here might be skewed. However, for the scope of this study and with the current limitations, we assume that this area is also representative of the value range of the Lutkemeerpolder's landscape attraction. Property value in this area ranges from a lowest of €1925/m^2 to a highest of >€7699/m^2. The northern area of Osdorp includes all of the premiums mentioned for the Nieuw-West area with the addition of an open view since the northern area of the Lutkemeerpolder is visible from Osdorp without the view being obscured. Thus, both the agricultural lands and the natural areas are visible (figure 10). This raises the total to a 30% premium. This premium represents the number of euros per square metre of residential area that residents were willing to pay to be near the Lutkemeerpolder. This led us to the following valuation.

- Minimum price range: 1.925 * 0,30/1,30 = €444,23/m^2
- Maximum price range: 7.699 * 0,30/1,30 = €1776,69/m^2

Therefore, for the Osdorp residential area, the value of the Lutkemeerpolder's landscape attraction ranges from €444,23-1776,69/m^2. We round that up to €450-1800 /m^2.

Assuming all the data above, the calculated range of the value of the Lutkemeerpolder's landscape attraction in euros/m^2 of residential property can be seen in the table 3 below:

Table 3 Steps toward the final value range of the Lutkemeerpolder's landscape attraction.

Residential area	Minimum property value (€/m²)	Maximum property value (€/m²)	Premium (%)	Aesthetic value range (€/m²)	Final aesthetic value range (€/m²)
Nieuw-West	2.556	5.132	21 %	450-890	450-1.800
Osdorp	1.925	> 7.699	30 %	450-1.800	

The aesthetic value of the Lutkemeerpolder appears to be one of the important ecosystem services as it affects property premiums and the resident's enjoyment of their local surroundings. The aesthetic value we calculated for the Lutkemeerpolder is a stock value reflecting the perceived value people put on the polder based on housing property premiums from the surrounding area. However, due to our limited resources and the lack of a proper research of the affected property area, we cannot draw firm conclusions about the aesthetic value of the Lutkemeerpolder based on our analysis. It is important to note that a survey that was performed in Nieuw-West revealed that, of all the people who considered green in their neighbourhood to be important in choosing their house in Amsterdam, 52% of them preferred investments to go to a green neighbourhood environment rather than to recreational areas (Gemeente Amsterdam, 2019). This means that the housing premiums for the area might differ, but we currently lack the means of performing a proper hedonic pricing to determine more accurate housing premiums that directly relate to the presence of the Lutkemeerpolder. Therefore, we recommend using the calculated value in the following manner:

Future studies should aim to use a full hedonic pricing approach where local data is acquired from the area through the means of surveys. Additionally, the actual m² of property that is affected by the presence of the Lutkemeerpolder needs to be assessed in order to properly derive an aggregate value for this service. This requires proper research on the area to acquire data on the size of property affected by the presence of the Lutkemeerpolder and more accurate property premiums for the specific affected area.

Biopolder scenario

Should the Lutkemeerpolder be upgraded to a *biopolder*, it is unlikely that the value of the landscape's attraction would be significantly impacted based on the aforementioned premium percentages. The premiums that make up a portion of the current property price are likely to stay the same as both the view of the polder and the open view from Osdorp will remain as they are. The same can be said about the premium based on the presence of an attractive landscape with water.

Business Park scenario

In the case where the plans for a business park are realised, the value of the landscape's attraction will be negatively affected. The current business park plans state that the business park is to be built on the area that is currently occupied by agricultural land (figure 2, 5 and 14). In this case, the open view from the Osdorp residential area will be lost, thus losing its premium. This will not be the case for the Nieuw-West area as the open view is already blocked by trees there. At the same time, a logistics park is likely to attract more traffic and noise. According to the study by Luttik (2000), traffic noise results in a 5% reduction of a property's premium. Finally, while part of the park such as the public gardens will remain as it currently is, it is likely that the premium associated with an attractive landscape with water features will go down as a direct result of the business park. For houses whose view will be blocked by the buildings of the business park, the total premium will be reduced by 7% (Luttik, 2000). This would result in a possible 12% total reduction of the aesthetic value of the Lutkemeerpolder to €210-1180/m2. It is worthwhile to note that this potential reduction of the housing premium is irrespective of the rising house prices in Amsterdam due to inflation.

Spiritual

A location's spiritual value is connected to the historical and societal meaning of a place, as it arises along with the local culture and habits. That is why, in most cases, spiritual services provided by nature have evolved over a long period of time (De Lacy, & Shackleton, 2017).

Relevance

For this research, the area of concern is a polder, which means that it was man-made and relatively new. That is why there were not many significant spiritual elements in the Lutkemeerpolder originally. However, in 1971 the memorial park Westgaarde was opened. This is one of the largest cemeteries in the Netherlands. A cemetery has spiritual value, as the relatives have a place to go to and honour and remember their loved ones. Additionally, this memorial park also contains several works of art and a monument for the Tenerife airport disaster, where 583 people died. Together, these aspects increase the spiritual value of the location. The park is surrounded by tall trees and dense vegetation and, together with the lack of outside noise, this gives the area a sense of serenity.

We recognise that there is also emotional value in the fact that the last clay grounds in Amsterdam are located in the Lutkemeerpolder and that the historical polder landscape is considered as typically Dutch. Their appreciation, however, is hard to quantify without

doing extensive surveying among the visitors, which was not possible due to the COVID-19 regulations. Although we might have not covered the full sentiment that reflects the 7.272 signatures of the petition for the preservation of the area, we believe that a large part of these values is already covered in other ecosystem services such as recreation and provisioning services.

Valuation

In this section we aimed to recognise the spiritual service provided by the Westgaarde cemetery. However, it is both ethically and methodologically challenging to quantify this spiritual service for the area, hence we refrain from doing so. Furthermore, as the cemetery will remain in its current form in all diverging land use plans, the qualitative recognition of its spiritual importance and value suffices here.

However, the cemetery as a land use area of the Lutkemeerpolder is included in other ecosystem service values provided here, as the cemetery is also a lush green space, important for e.g. habitat for species such as bats, for recreational walks and regulating services. The bike lanes and pedestrian areas make the cemetery an attractive and easily accessible part of the Lutkemeerpolder. Quinton and Duinker (2019) analyse these various ecosystem services provided by urban cemeteries and conclude that it serves functions "beyond those of interment and mourning." (p.252), hence we take up the cemetery's values other than its spiritual value elsewhere in this report.

Biopolder scenario

The spiritual value of the Lutkemeerpolder is projected to stay the same in the case of a *biopolder*. The cemetery, which is the main land-use affecting the spiritual value of the polder, will not change at all following the plans of the *biopolder*.

Business park scenario

If the plans for a business park are realized, the spiritual value of the Lutkemeerpolder is likewise expected to remain unchanged. The plans for the business park do not involve building on the land that is currently used for the cemetery. However, since the business park is planned to be built right next to the cemetery, it is possible that its presence will negatively affect the people's desire to visit the cemetery for spiritual reasons due to increased noise pollution.

4.2 Regulating ecosystem services

The regulating ecosystem services cover the benefits for human well-being which are obtained from regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases (UNEP, 2004). This broad category is divided by the TEEB framework into the ecosystem services described below and ranked according to their value. Water regulation, maintenance of soil fertility and water purification are not valued and thus not ranked.

- Air quality regulation
- Pollination
- Biological control
- Climate regulation (carbon sequestration)
- Water regulation
- Maintenance of soil fertility
- Water purification and waste treatment

In this chapter, all the above-mentioned ecosystem services are described, as well as their relevance to the Lutkemeerpolder. When the service is deemed relevant for the Lutkemeerpolder a suiting monetization method is proposed and where possible, executed.

Air quality regulation

Small changes in chemical balances in the biosphere can have serious implications on social and economic processes (de Groot et al., 2002). The influence ecosystems have on air quality regulation is defined both by the emission of chemicals to the atmosphere (i.e., serving as a "source") as well as the extraction chemicals from the atmosphere (i.e., serving as a "sink") (MA, 2005; UNEP, 2004). The value of air quality for human well-being is often measured by benefits in lower health-care costs. This definition does not limit the ecosystem service to the benefits of the ecosystem but also gives room for the ecosystem to cause a decline in air quality (i.e. vegetation fires that cause ground-level ozone and volatile organic compounds). Exposure to air pollution is estimated to cause

3,5% of the total burden of diseases, which is comparable to obesity (3,7%) (van der Zee et al., 2019). Next to this, air pollution also causes harm to the ecosystem due to a loss in biodiversity (Hettelingh et al., 2017). Effects due to leakage of nutrients into (ground)water are mentioned in water purification and waste treatment.

Relevance

Previous studies mention nitrogen oxides (NO_X), sulphur dioxide (SO_2) and fine dust particles like PM_{10} as most important for air quality in Amsterdam (van der Zee et al., 2019). The nature areas, cemetery, parks and public gardens add value by their cleansing capabilities, especially near urban areas like Amsterdam. The vegetation in these areas thus filter these damaging particles and thus contribute to mitigating air pollution. The relevance in the redesign is less significant since the redesign involves mostly changes of agricultural areas which are considered less effective in their uptake of pollutants. The loss in value due to the increase in traffic and energy use is not valued and further discussed in the business park scenario.

Valuation

The benefits of the ecosystem to air quality regulation of the entire study area are valued between €270.000 and €915.000 annually (table 4). A complete overview of the methods and an overview of the outline by Ruijgrok and de Groot (2006) is provided in appendix 9.3. Note that larger vegetation is more valuable for air purification. Vegetation types like grassland, "kwelders" and coastal vegetation are considered insignificant for air purification.

Table 4 Monetary values air regulation of the current land use

Land use	**Area (ha)**	**Price (€/ha/yr)**	**Total benefit (€/yr)**
Wet nature	25	5.000 - 8.000	125.000 - 200.000
Parks public garden	35	1.000 - 5.000	35.000 - 175.000
Forest (Cemetery)	11 - 27	10.000 - 20.000	110.000 - 540.000
Total:			**270.000 - 915.000**

Biopolder scenario

The *biopolder* scenario has the most potential in air purification when forest or bigger vegetation is planted. An area of 15 ha deciduous forest, a little smaller than the planned business park, can add a value by uptake of pollutants from € 147.700 to € 231.700 annually depending mostly on the uptake of PM_{10} dust particles. Pine trees can create value up to € 431.200 annually for their purification function compared to the current design. An overview of the benefit of the different land uses is given in appendix 9.3.

Business park scenario

The change to a business park will not decrease the current air purification services significantly since the change only applies to agricultural areas. However, emissions from the business park could increase air pollution in the area. Changes in air concentration as mentioned in the zoning plan are shown in table 5. The possible function as a logistic centre does not seem to be taken into account here, validation of this data is needed before translating it to monetary valuations. The changes of pollution concentrations as shown in table 5 are within the national and regional boundaries according to the zoning plan. The authors note that the calculations were done using high traffic numbers and strict limits. In this research we did not conduct a validation or a translation from the increase of the pollution concentrations to a valuation and thus these additional effects are not taken into account in the monetary valuations.

Table 5 Projected emissions of the business park (zoning plan, 2013)

Development	**Contribution NO_x ($\mu g/m^3$)**	**Contribution PM_{10} ($\mu g/m^3$)**
GCN-background concentration (max)	32.7	26.1
New hotel and catering industry	0.11	0.03
Construction projects	0.85	0.23
Nature areas and bastion	1.06	0.28
Supporting facilities	0.54	0.14
Other traffic attracting interaction	1.06	0.28
Changed contribution by business park	0	0
Total:	**38**	**27.5**

The pollution concentrations are within the national and regional boundaries. The authors note that the calculations were done using high traffic numbers and strict limits. In this research we did not conduct a translation from the increase of the pollution concentrations to a valuation and thus these additional effects are not considered in the monetary valuations.

Pollination

Many flowering plants depend on pollination for the reproduction of the species. There are two main types of pollination namely wind and animal pollination. Wind pollination is not present in agricultural species and is therefore not relevant in this research. Animal pollination can happen through multiple species of animals of which insects are the most important. Some common pollinators are bees, butterflies and moths. Pollination is a very costly service to replace and is therefore always maintained as much as possible (Melathopoulos et al 2015). A more nature inclusive farming method improves crop yield due to more intense pollination by different functional insect groups (Bartomeus et al 2014).

Relevance

The agricultural crops of the farms in this area depend on pollination for the successful growth of their products. The boterbloem also has an active colony of honeybees which pollinate many crops in the surrounding area. Pollination can also increase agricultural yield based on the amount of pollination that is done. The Boterbloem is an organic farm and will likely experience higher pollination benefits than the other farms.

Method

The valuation of the pollination service is done by using a market price-based approach. For this it is important to look at the increase in crop yield due to pollination. In The reviewed literature an average increase of about 15% is reasonable in an average agricultural field (Bartomeus et al., 2014; Hogendorn et al., 2006; Walters et al., 2006). However, if a lot of measures are taken to promote the number of pollinators it can rise up to a 25% increase in yield (Bartomeus et al 2014). The yield is then calculated from the total yield per year and multiplied by the market price to obtain the yearly value. The value obtained for this ecosystem service roughly amounts to €12.500 – 18.800 euros per year.

Biopolder scenario

In the *biopolder* the effects of pollination can significantly increase if a more nature inclusive route is taken. By increasing habitat for wild pollinators, the functional diversity of bees will increase which in turn leads to an increase in pollination intensity and biodiversity. The agricultural crops will also have increased yields making the land more profitable. The total value in this scenario amounts to €21.000 – 31.400 euros per year.

Business park scenario

In the business park scenario almost all of the agricultural land will disappear and thus the value of pollination will also disappear. The pollination will still happen in surrounding

areas, but the amount of habitat is significantly decreased and might lead to loss of certain bee species. The calculated value becomes zero as the service no longer provides feasible human benefits.

Biological control

Predation is the main interaction between species in food webs. The predator uses resources from another species which experiences negative effects as a result. In agriculture this often has a negative effect on the production of plants. Therefore, quite some resources are invested to control the amount of predation and parasitism of agricultural crops. Ecosystems also play a role here as they have a natural controlling mechanism for the control of predation and parasitism (Tschumi et al., 2016).

Relevance

The agricultural fields are an easy target for predators of these crops, but the ecosystem helps to keep the amount of predation on the agricultural crops low if it harbors the natural enemies of the predators (Geiger et al., 2010). Thus, the presence of for example birds will lower the number of insects predating on the crops and increase the yield. 'De Boterbloem' is an organic farm and will thus rely on biological control as they cannot use pesticides.

Method

Similar to pollination, the method used to value biological control as an ecosystem service is based on a market price-based approach. Biological control can increase yield in agricultural systems and based on the yield percentage, you can calculate a value for the biological control. Literature indicates that a 10% yield increase is quite common (Sutter et al., 2016; Ostman et al., 2003; Geigar et al., 2010). In the case of an organic farm with a higher focus on nature, the yield increase can amount to 17,5% (Sutter et al., 2016; Tschumi et al., 2016). The total yield increase per year is then calculated and multiplied with the market price of the goods to obtain a yearly value. The value of the service in the current state is €10.800 - €16.200 per year.

Biopolder scenario

In the case of a *biopolder*, there will be a higher reliance on biological control, as all farms will be organic and pesticides cannot be used. By planting flower strips, the amount of natural predation will increase, leading to larger yields as the crops take less damage (Tschumi et al., 2016). There is also a possible synergistic effect with pollination, but this would require further research into the relation between pollination and biological control. The total value for the biological control services of the *biopolder* would amount

to €18.900 - €28.300 euro per year. The values used for the calculation can be found in appendix 9.4.

Business park scenario

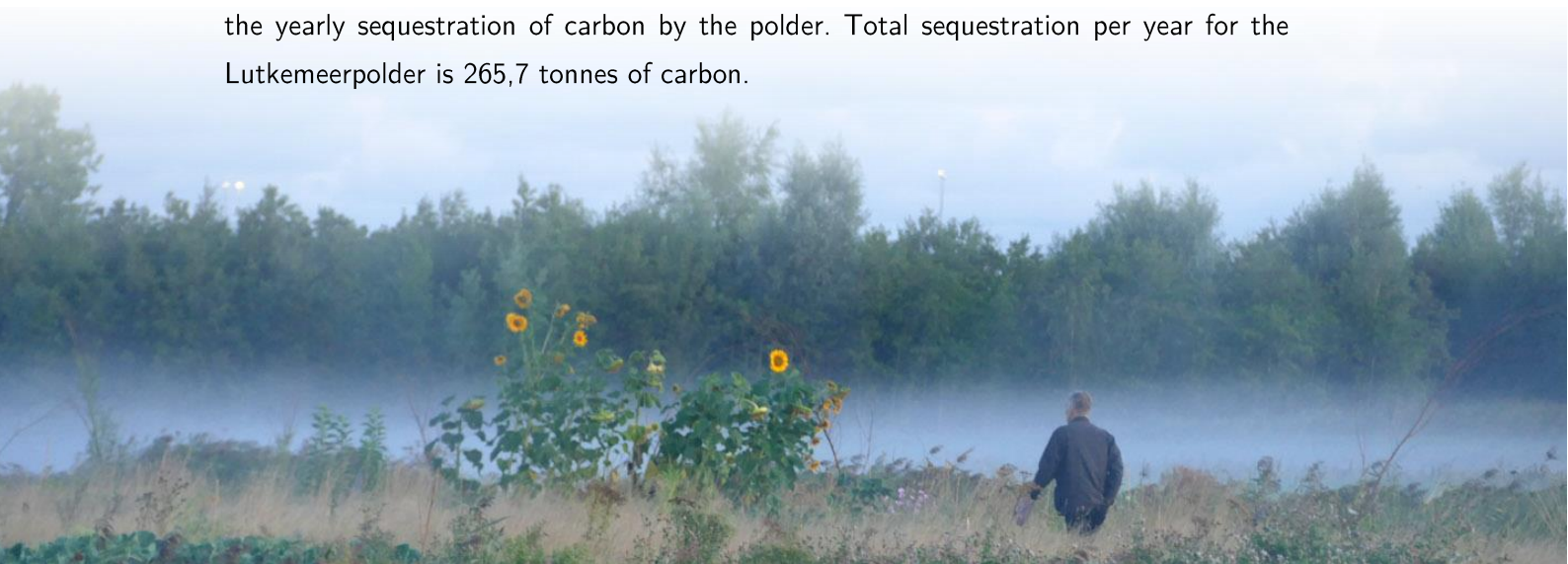
In the business park scenario, the value of biological control would disappear as it is no longer relevant to humans. There might still be beneficial effects, such as a reduction of the amount of pest insects (e.g. mosquitos). However, this would be very low in value and thus not of significant relevance anymore. The value for this scenario then becomes zero.

Climate regulation through carbon sequestration

The Earth's climate is regulated naturally by the planet's 'greenhouse effect', which ensures the possibility for life to develop on the planet under favourable surface conditions. Over the past couple years, the planet's climate is changing and the temperature on Earth is rising. This change mostly occurs due to increases in concentrations of 'greenhouse gases', such as carbon dioxide and methane, in the Earth's atmosphere. Changes in land use can cause concentrations of these gases to increase. The amount of greenhouse gases that an ecosystem can store (i.e. act as a 'sink') is determined by the type of land use. An ecosystem thus provides a service by storing carbon dioxide (carbon sequestration), thus increasing the Earth's ability to regulate the planet's climate (TEEB, 2010, Chapter 2).

Relevance

In the Lutkemeerpolder, several types of land use can be distinguished (grassland, cropland and forest). Each type of land use has a different ability to sequester carbon. For grassland, estimates range from 2 tonnes of carbon per hectare per year for normal grassland to 2,87 tonnes per hectare per year for fen. Deciduous forest is able to store 1,37 tonnes of carbon per hectare per year (Ruijgrok & de Groot, 2006). Furthermore, cropland that uses an organic farming system is able to store 0 to 0.5 tonnes of C p/h p/y (Freibauer et al., 2004). In this paper, we use 0,2 tonnes of carbon p/h p/y. In the table below, hectares per land use type in the Lutkemeerpolder are shown to calculate the yearly sequestration of carbon by the polder. Total sequestration per year for the Lutkemeerpolder is 265,7 tonnes of carbon.



Method

To value this sequestration potential of the Lutkemeerpolder, we use a benefit transfer method. We chose this method because there is reliable data available on efficient carbon prices that reflect the value of the sequestration of carbon. To calculate the economic benefit of this sequestration, we use the number provided by the Dutch Planning Agency (Centraal Planbureau) regarding the valuation of CO_2-benefits in doing environmental cost-benefit analysis (Aalbers, Renes & Romijn, 2016).

Valuation

Several carbon prices are presented in the document named above, namely the ETS price (which is not realistic due to issues with the program), as well as the market-efficient price for two policy scenarios (Aalbers, Renes & Romijn, 2016). In this report, we will provide a range of values from the most conservative estimate of an efficient carbon price, to the more ambitious price in case of a tightened global climate regime. For the lower bound of the valuation range, we use the 2015 effective price of CO_2 in the most conservative scenario at €12 per tonne of CO_2. Using the 3.67 carbon to CO_2 ratio we thus estimate the price of carbon at €44,04 per tonne at its lower bound. For the more ambitious scenario, we use the 2015 effective price of CO_2 in case of high international cooperation, estimated at €48 per tonne of CO_2. This translates to a price of carbon at €176,16 per tonne as the upper bound. The total value of the carbon sequestration service of the Lutkemeerpolder thus lies within the range of €11.700 - €46.800 per year.

Table 6 Total yearly sequestration of carbon in the Lutkemeerpolder

	Hectares	**Yearly sequestration (tonnes C p/h)**	**Total yearly sequestration (tonnes C)**
Cropland	62	0,2	12,4
Grassland (grass)	73,2	2	146,5
Grassland (fen)	24,3	2,87	69,8
Forest	26,9	1,37	36,9
Total	-	-	**265,74**

Biopolder scenario

In the *biopolder*, carbon sequestration is likely to increase. Plans for the *biopolder* indicate a higher presence of trees, which have a higher sequestration ability than cropland. Furthermore, organic farming practices often involve measures that increase the ability of the cropland to contribute to climate regulation. Examples of such measures include 'conservation tillage', where the ground is ploughed less often to promote retention of carbon in the ground (Power, 2010). It is thus to be expected that the agricultural section of the polder will be better able to provide climate regulation services in the *biopolder*

scenario. If the entire polder engages in organic farming, we estimate that the carbon sequestration potential of the farmland increases to 0,8 tonnes of carbon per hectare (Power, 2010).

Furthermore, there are also plans for the planting of trees in the polder. There is thus potential in increasing the carbon sequestration value for the polder, which depends on the design of the *biopolder*. To construct a range for this value, we use as a lower bound the conversion of 5% of agricultural land to forest, and as an upper bound the conversion of 20% of the polder to forest and 20% to grass, which we perceive to be the maximum amount of land that could be dedicated to this purpose in the *biopolder* scenario (to conserve income from agriculture). This results in a range of sequestration ability of 304 - 325 tonnes of carbon per year. For the range, we use as the lower bound the 304 tonnes of carbon per year multiplied by the price of carbon in the low-effort scenario, and as the upper bound the 325 tonnes of carbon multiplied by the price of carbon in the high effort scenario. This leads to a range of values of €14.300 - €57.200 per year.

Business park scenario

The building of the business park involves transforming the agricultural section of the polder into concrete surfaces and buildings. Since this type of land use is not able to sequester carbon, this ecosystem service will most likely slightly decrease in value if the business park is built. If the business park is built, 39 hectares of the agricultural land will be converted to concrete. This will result in a reduction of the value of the carbon sequestration service by €400 - €1.800, resulting in a value of the service in the business park scenario of €11.400 - €45.400 per year.

Furthermore, the construction of a business park also increases the temperature in the area where the business park is built due to the 'urban heat island effect'. This relates to the retention of heat by concrete structures. This effect is very local and will thus most likely not cause the temperature to increase in surrounding areas as well, but it could have an effect on the temperature in the business park itself and possibility in its immediate surroundings (such as the houses located next to the business park). Since the size of this effect is unknown, we estimate no monetary value for it.

Water regulation

The water regulation of the ecosystem influences the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape (MA, 2005). Paved surfaces limit de infiltration capacity and increase runoff which lead to higher discharge peaks compared to unpaved areas. In figure 11, an overview of the water system as it was before the recent closing of

waterways is shown. The water levels for the natural areas can fluctuate to stimulate natural conditions while the agricultural and paved areas have a lower fixed water level throughout the year. The average surface level is -4,5 m NAP in which only the cemetery is elevated to -1,7 m NAP. The pumping station for the polder is located south-west and can also serve as an inlet during high river levels outside the polder. The inlet south-east is the main inlet to the polder. Due to the artificial water management and design of the polder, no irrigation is needed throughout most of the year and the main problem lies in wet soil that prevents entering the land with tractors or other heavy equipment. The Water Board Amstel, Gooi and Vecht mentions high groundwater pressure due to seepage in this area which can lead to the bursting of waterways if they are too deep (zoning plan, 2013).

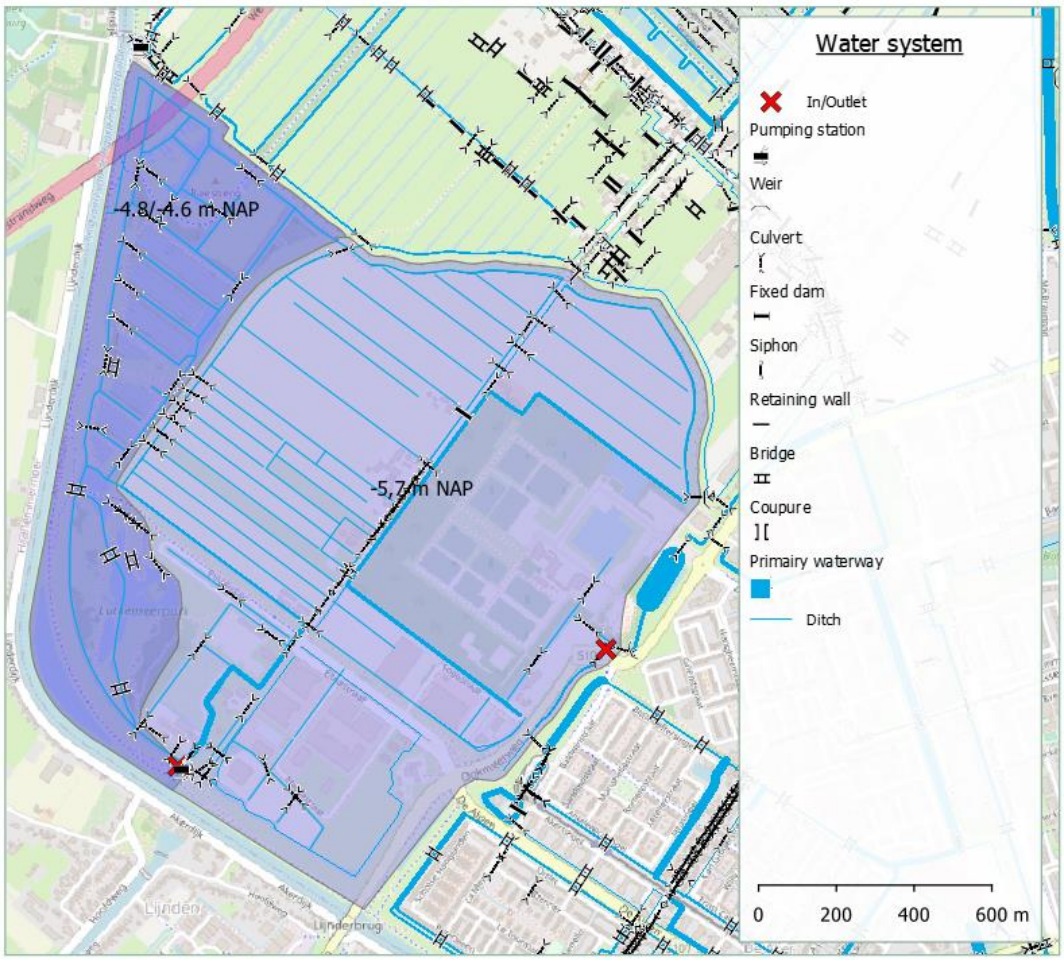


Figure 11: Water system Lutkemeerpolder. Surface levels in nature areas are allowed to fluctuate.

Relevance

The relevance is based on the value of the replacement water system to compensate for the business park. The elevation of the agricultural fields is around -4,6 m NAP which leaves around 1,1 m for local water management. The business park decreases the available soil to temporarily retain water, decrease infiltration, decrease evapotranspiration and increase runoff due to the paved surfaces. This impact will be smaller than a change from sand to paved, since the infiltration of clayfields is limited. The effects on water regulation due to the new zoning plan for the business park are recognized by the municipality and the waterboard. The actions to mitigate these effects are as follows (Zoning plan Lutkemeerpolder, 2013):

- At least 10% of the increase of paved surfaces must be compensated with open water
- Waterways which are planned to be closed have to be compensated fully within the same water system

The zoning plan mentions compensation for the loss of soil storage, evapotranspiration, and infiltration by placing green solutions such as green roofs, but these measures are not required. The mandatory measures do not compensate for the loss of soil storage nor the decrease in infiltration or evapotranspiration. In 2012 the Water Board Amstel, Gooi and Vecht recalculated the new design and did not find issues with the water management of the business park (AGV, Watergebiedsplan Amsterdam-West, 2014). The cost for changing the water system by closing waterways, creating them elsewhere (figure 5), researching the risk from pressure due to seepage, higher pumping station costs and costs of any green roofs are not known. These plans show a contrast with the Amsterdam rainproof initiative, vision from the waterboard as well as national and European strategies on retaining water locally.

Method

The municipality and the water board show clear actions to mitigate the effects of the construction of a business park on water regulation. A replacement cost method thus seems most suited to value the current design. This value is likely to consist of a very high initial, short-term cost, and low long-term costs. This research did not run the replacement cost valuation due to limited information on the costs of reworking the water system.

Valuation

To give some insight into the benefits of the current water system, we outline here the following actions that are planned by the municipality and the waterboard to ensure there is no harmful effect when building a business park:

- Modelling new water system
- Research into seepage pressure
- Creating new waterways
- Potential green solutions
- Higher pumping costs

The first four are short term expenditures, for the long term the higher pumping costs in combination with increased area of paved surfaces are considered negative since it will lead to problems or additional costs elsewhere in the water system.

Biopolder scenario

The *biopolder* scenario will not change the water regulation significantly. The vegetation and nature areas might evaporate more depending on the new design and land use, which might lower pumping costs and affect water retention. In the long term, this scenario enables an easier transition to a change in function to limit flooding due to climate change in surrounding urban areas.

Business park scenario

In this research, valuation of the replacement costs for water regulation for the business park is not conducted. The replacement costs have an initial construction- and research cost and extra long-term pumping costs. The municipality and the waterboard do not require green roofs or other green solutions to mitigate the loss in water retention and evapotranspiration. Potential green solutions could drive loss further but mitigates some of the extra pumping costs.

The long-term effects of this scenario do not solely consist of increased pumping costs. More paved surfaces in urban areas also give rise to a 'locked up' state where it is harder to go back to a more natural state and create more space for water retention. The usage of sand to cover clay soil enhances the locked-up state by limiting other use after the business park.

Water purification and waste treatment

The role that the Lutkemeer ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes describe the water purification and waste treatment

services within the Lutkemeerpolder (MA, 2005). Ruijgrok and de Groot (2005) mention that these purification techniques only contribute to human well-being if the water is used in a way that requires a certain quality or if additional purification costs are avoided in the process.

Relevance

Various documents mention the quality of the surface water of the Lutkemeerpolder. The water board mentions the water quality of the Lutkemeerpolder as reasonable in "Watergebiedsplan Amsterdam-West" (2016) and the (ecological) water quality as insufficient in "Waterbeheerplan 2016-2021" (Waterbeheerplan 2016-2021 (2016). The water quality here is determined primarily by land use, fertilization methods and the water quality of incoming seepage water. The (ground)water is not used as drinking water, the water is not in need of purification before pumping it to the 'Ringvaart', neither is the area gaining significant benefits due to recreational activities such as swimming or fishing. Because of these reasons, we concluded that the water quality is less relevant for human well-being in the Lutkemeerpolder in the current scenario. Other topics such as the use for agriculture is mentioned in the discussion of the provisioning ecosystem services.

The effects of agricultural areas on water quality depend heavily on fertilization methods and might cause harm by leaking nutrients in waterways or in the atmosphere. 'De Boterbloem' uses fertilizer based on mushrooms which is high in organic matter, low on phosphate and releases its nitrogen slowly throughout multiple years (see Appendix 9.1). The other farms use less sustainable fertilization methods which might damage the water quality by leaking pollutants. Here the same note as mentioned above applies where a lower water quality is considered only a significant loss when direct factors such as recreation or purification are affected.

Method

The value to human well-being in the current situation is not apparent. The water board assumes that the surface run-off of the business park is of a good enough quality to discharge it directly to the surface water. When the water quality is insufficient due to their activities, the water needs to be purified (Gemeente Amsterdam, 2013). This extra purification step can be calculated using a replacement cost method. When water would be used for drinking water, fishery, swimming or other direct uses a benefit transfer analysis using the overview provided by Ruijgrok and de Groot (2005) would be a better approach.

Valuation

The current benefits on the water quality, excluding benefits for food and recreation, is valued as insignificant due to the low effect on human well-being and is thus left out to avoid double counting.

Biopolder scenario

In case of the *biopolder*, the change in fertilization methods will improve the water quality and might improve the surrounding nature areas by increasing biodiversity. To make the transition from this increase in biodiversity to an increase in human well-being seems like a lower priority compared to food production, changes in openness of the landscape and changes in traffic and is thus not further studied in this research. In this scenario, a slight insignificant value increase for water purification and waste treatment is thus estimated in case of a *biopolder*.

Business park scenario

If the assumption that the surface run-off from the business park is not polluted more than regulations allow, the costs are limited to a potential loss in biodiversity in the natural areas, which might lead to a decrease in recreation or food production. The value of the water quality in this scenario depends on the activities in the business park and the measures implemented to mitigate potential pollutants. The municipality of Amsterdam and the water board require certain measures based on certain activities (Zoningplan Lutkemeerpolder, 2013). This leaves a value range for the business park from insignificantly low, when the surface run-off is of good enough quality, to considerable when purification plants, or bigger measures need to be taken into account to mitigate the activities of the business park, which could raise annual costs.

Maintenance of soil fertility

The 'maintenance of soil fertility' ecosystem service is best described as the role that ecosystems play in sustaining the biological activity, diversity and productivity of soils, as well as in regulating and partitioning water and solute flow and finally in storing and recycling nutrients and gases. This is most commonly reflected in ecosystems through the form of soil retention and soil formation. Soil retention refers to the maintenance of arable land and erosion prevention through healthy water systems while soil formation refers to the maintenance of the productivity of arable lands and naturally productive soils (Brenner, 2007). Soil biodiversity, through the benefits soil organisms generate for farmers directly relates to soil fertility and agricultural production (Brady et al., 2015).

Relevance

The soil in the Lutkemeerpolder is a calcareous clay soil (figure 12). The soil consists of 30 cm of clay, which covers a 90 cm bottom layer of clayey sand (DINOloket). Clay soils consist of fine soil particles and typically have great water and nutrient retention but reduced drainage potential. The soil of the Lutkemeerpolder has been cared for organically throughout the years and has the potential to be very fertile and suitable for agriculture. According to the people who own the farms in the area, one major advantage provided by this soil is that no irrigation is needed in order to maintain crop production (see Appendix 9.1). The soil retains the water, providing natural drainage. The only problem is that there is often difficulty in entering the land due to the soil moisture. However, this flooding problem is only temporary.

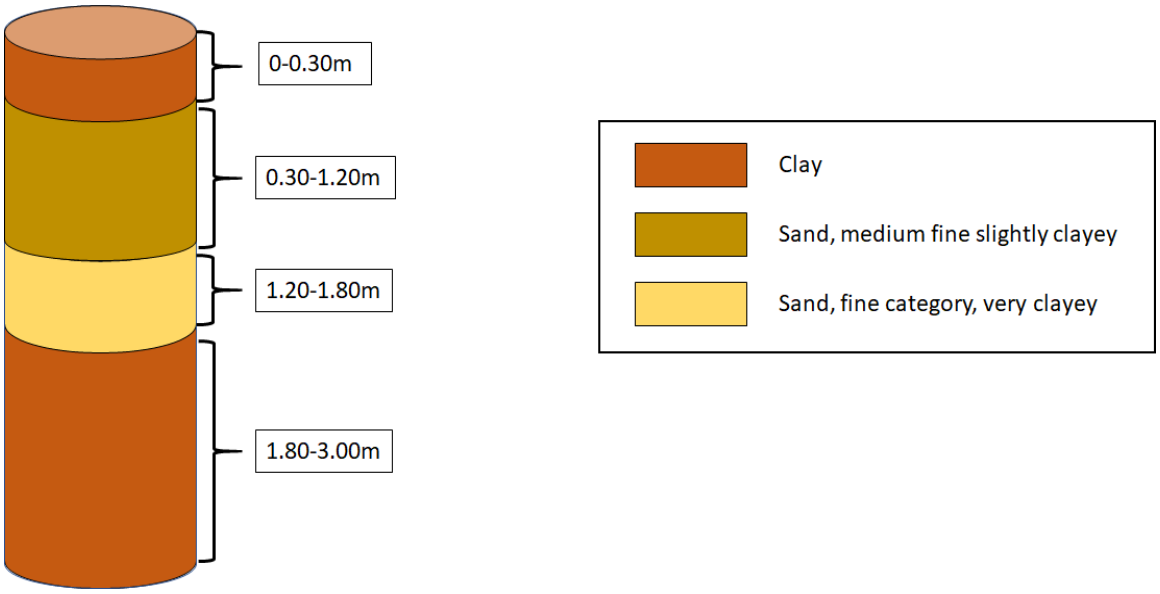


Figure 12 Soil profile of the Lutkemeerpolder. The information for the sample was derived from DINOloket.nl.

Method

Typically, the method we would use to value soil fertility would be a direct benefit transfer based on methods from other studies who would have measured similar types of soils. One such study is the one by Xue and Tisdell (2001) who valued the fertility of the soil based on its ability to conserve water, protect against erosion, store CO2, cycle nutrients, absorb pollutants and prevent disease and pest control. However, based on the services distinguished through the TEEB framework, the services mentioned above are already being valued as separate ecosystem services, with the exception of erosion prevention. Erosion prevention is an ecosystem service that cannot be measured for the Lutkemeerpolder as we lack the comparative data to measure it and therefore lies out of

the scope of this report. However, a plan on how one could value erosion prevention can be found in the section below.

Valuation

In order to properly value erosion prevention in the Lutkemeerpolder, we would first need data on the total amount of soil loss from each land-use of the Lutkemeerpolder compared to land outside of the Lutkemeerpolder. That way we could estimate the total amount of soil loss for each land-use type using the following formula (Xue & Tisdell, 2001):

- Total amount of soil loss per land-use type = erosion difference between Lutkemeer specific land-use type and non-Lutkemeer equivalent land use × area of specific land-use type inside the Lutkemeerpolder

We would then need to use the total amount of eroded soil to calculate the estimated abandoned land area. For that we would use the average soil thickness of each land use type for the Lutkemeerpolder (e.g. 0,30m for arable land). Therefore, the estimated abandoned land area could be calculated using the following formula (Xue & Tisdell, 2001):

- The abandoned land area per land-use type = total amount of soil loss per land-use type / average soil thickness per land-use type (m)

Therefore, the value of avoided soil erosion would for each of the Lutkemeerpolder's land-use types would be calculated as follows (Xue & Tisdell, 2001):

The value of avoided soil erosion = estimated abandoned land area per land-use type × opportunity production profit per land-use type

- The total value of avoided soil erosion would include the added avoided soil erosion value from all the land-use types within the Lutkemeerpolder.

It is important to note that this approach works under the assumption that the abandoned land would not have any economic value and thus could overestimate the actual economic cost of soil erosion.

Biopolder scenario

In the case where the Lutkemeerpolder is upgraded to a *biopolder* it is possible that soil fertility will increase as the soil will continue to be cared for organically and crops will continue to be planted and harvested. This assumes that the arable land of the Lutkemeerpolder takes advantage of practices such as crop rotation and conservation tillage which are vital for preventing soil erosion.

Business park scenario

If a business park is built in the place of the Lutkemeerpolder, soil fertility in some land-use types would entirely disappear under the aforementioned valuation method. The soil will no longer be used to grow crops which directly relate to the production profit of the Lutkemeerpolder and would therefore be heavily devalued as an ecosystem service.

4.3 Provisioning ecosystem services

Of the different types of ecosystem services, provisioning services are those that relate mostly to the material outputs of the ecosystem. These services thus involve resources that humans can extract from the ecosystem. In the case of the Lutkemeerpolder, which can be characterized as an agroecosystem (among other types), these services play an important role. In the polder, mainly the production of agricultural products and the provisioning of (ground) water can be distinguished as provisioning ecosystem services.

Agricultural production

For ecosystems where there is a strong presence of agriculture, so called agroecosystems, crops that are grown 'in' these ecosystems are an obvious ecosystem service. The land provides the opportunity to grow crops or keep livestock by its provisioning of, among other things, fertile soil and groundwater. The ecosystem thus provides a service by providing us with food.

Relevance

In the Lutkemeerpolder, 33% of the land is currently used for agriculture. The land is farmed by five farms in the area, which use the fertile clay soil of the polder to produce crops. Since the ecosystem provides the possibility of producing food in the area, the production of crops can be seen as a provisioning ecosystem service by the Lutkemeerpolder.

There are five farms operating in the polder. One farm engages in organic farming: the ecological care farm 'de Boterbloem'. On the land of this farm, several small-scale agricultural activities take place: an orchard, a vegetable garden, and pasture for livestock, next to the production of barley, marrowfat peas, and mustard seed. The other two farms in the area of the Lutkemeerpolder that is planned to become a business park, engage in conventional farming. One of these farms produces potatoes and wheat in a rotational system and has 15 hectares of arable land. The other farm in this part of the polder uses 13 hectares for the (rotational) production of wheat, corn and sugar beets (see Appendix 9.4). The main types of crops in this part of the polder (by value of yield) are illustrated in Figure 13.

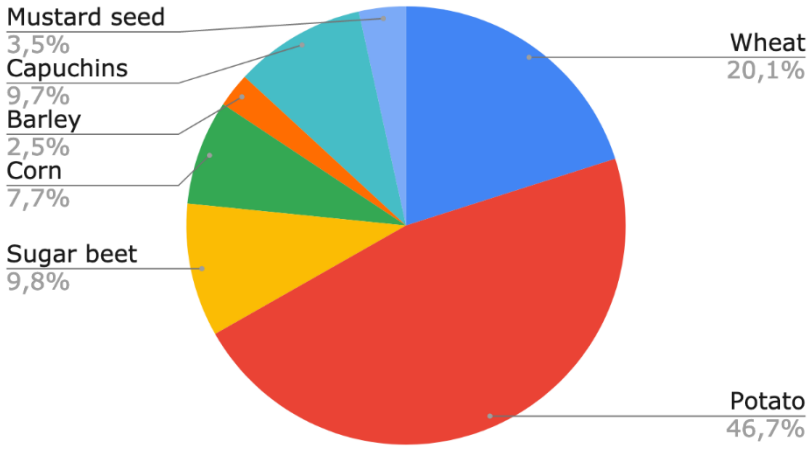


Figure 13 Annual value of crop yield in the Lutkemeerpolder in the 39ha destined for the business park

In the north of the polder, there are two more farms whose production is unknown (see Figure 14). These areas have been marked 'nature areas' in the zoning plan for the Lutkemeerpolder and the plans for these areas are outlined in the 'Tuinen van West' program developed by the municipality (Looman, de Ruijter & Vos, 2008). Although production is not known, we will still take up these areas in the calculation of the agricultural value by assuming two different scenarios for agricultural production there.

Method

The value of crops grown in the polder can be determined by using a direct market valuation approach. This approach values the ecosystem service by determining the value of the crops or livestock that is produced within the agro-ecosystem.

In this way, the services of the polder are reflected in the market price of the crops that are grown on its land (Power, 2010). In the case of the Lutkemeerpolder, we will use the aggregate value of the output of the five farms in the polder to demonstrate the value of the crops provided by the agro-ecosystem.

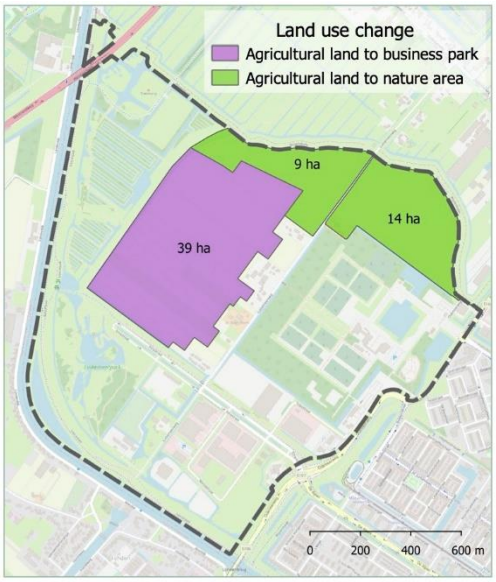


Figure 14 Map of agricultural land, divided by land use in the zoning plan

Valuation

To calculate the aggregate value of the agricultural output of the polder, information is needed on average yearly yields and market prices. We computed the average yearly yield by determining the number of hectares devoted to one crop and multiplying this with the average yield per number of hectares. This produced an estimate of the yearly production of each crop (in tonnes).

For the two farms whose production was unknown, we constructed two different production scenarios to estimate a range of values for this area. For the lower-bound estimate of the range, we assumed that production in the area (23ha) would exist entirely of grass silage for livestock, which is a low-effort crop. For the upper-bound estimate of the range, we assumed production according to a conventional rotational cropping system similar to that of the other farm in the Lutkemeerpolder that produces corn, wheat and sugar beets. This range therefore represents the possible values this part of the polder could take on.

When we calculated the total yearly production, we produced the monetary value from multiplying each yield with current market prices for each crop, as can be seen in table 7. This resulted in a range of values from €130.600 to €176.800 per year (rounded up). The elaborate computation of the total value of the yearly yield with the sources for the market prices and average yield, can be found in appendix 9.4.

Table 7 Value of crops produced in the Lutkemeerpolder. Crops marked with (O) are organically grown

Crop type	Market price (€/t)	S1: Yearly yield (t)	S1: Yearly Value (€)	S2: Yearly yield (t)	S2: Yearly Value (€)
Grass	57,00	161	9.177,00	0	0
Wheat	195,00	125	24.375,00	205	39.975,00
Potato	140,00	405	56.700,00	405	56.700,00
Sugar beet	36,00	332	11.952,00	913	32.868,00
Corn	50,00	188	9.400,00	564	28.200,00
Barley (O)	340,00	9	3.060,00	9	3.060,00
Capuchins (O)	1960,00	6	11.760,00	6	11.760,00
Mustard seed (O)	2100,00	2	4.200,00	2	4.200,00
Total			**€130.624,00**		**€176.763,00**

Since the value of agricultural production is highly dependent on climatic circumstances, such as droughts or heavy rainfall, we extend the range to account for these events. We do so by taking a 10% discount of the lower bound and adding a 10% premium to the upper bound. This final value range for the provision of agricultural goods amounts to €117.600 - €194.400 per year (rounded up).

Biopolder scenario

In the *Biopolder* scenario, the value of the crop yield is expected to remain the same. Organic farming practices could entail less intensive land tillage. Furthermore, the plan dedicates more space to recreational routes through the agricultural fields, which could decrease land available for cultivation. However, prices of organically grown crops are often higher to reflect this lower production. Since these aspects likely cancel out each other, we expect that the agricultural value will remain comparable to the status quo.

Business park sccenario

Since the business park will be constructed on the larger part of the agricultural area, the agricultural value of the area is expected to strongly decrease. 3 hectares will remain available for 'de Boterbloem' to continue its agricultural practices. We therefore assume that 27% (3/11) of the farm's yearly production value will remain in this scenario.

Part of the land that is now agricultural land, is destined to become a nature area, as can be seen in Figure 14. However, since very little is known about how this nature area will be designed and the construction of this area is of little interest to this report, we will assume that this area remains agricultural land in the business park scenario.

Therefore, in the business park scenario, the value of agricultural production amounts to the sum of 27% of the value of 'de Boterbloem' and the value of the agricultural production in the area that is not affected by the business park. This range is then adjusted for the climatic circumstances (as done before), with the final range amounting to €13.000 - €66.500 per year (rounded up). A computation of this value can be found in Appendix 9.4.

Water provisioning

Water provisioning for irrigation is an important service provided by ecosystems in order to prevent crops losses by drought. The ecosystem provides water which therefore does not need to be introduced by farmers themselves, therefore providing a provisioning ecosystem service. The availability of ground- or surface water depends on many factors, such as; the type of soil, climate zone and vegetation coverage, e.d. (see also the water regulation paragraph in the regulation services chapter). Furthermore, digging wells and machinal irrigation to counterbalance the lack of natural irrigation can be very costly.

The irrigation situation of the Lutkemeerpolder is ideal. Because of the characteristics of the clay soil and the lower surface level of the area compared to the surrounding lands and waters, the Lutkemeerpolder needs no machinal irrigation (p.c. Alies Fernhout, see appendix 9.1).

Valuation

To estimate the value of the water provisioning services provided by the Lutkemeerpolder, we used the replacement cost method. This method determines how much money it would cost to obtain the same service, as provided by the ecosystem, elsewhere. We calculated the average irrigation cost of crop farms, which do not apply to the crop farmers in the Lutkemeer (as machinal irrigation is not used) and can therefore be used as an indication of the value of the water provisioning services of the Lutkemeerpolder.

Firstly, we collected data on the amount of water an average crop farmer in the same drainage basin of the Lutkemeerpolder, the Rijn-West drainage basin, uses per year and from which source this water originated (drinking water, ground- or surface water) (van der Meer, 2020). 2017 and 2018 are reference years, where 2017 represents the need for water in average years and 2018 represents the need for water in very dry years, which will probably happen more often due to climate change (see figure 15). Then, we collected general information about the number of crop farms and the area of crop farmland. (Smit and Jager, 2018) For a more detailed description of the calculations, please look at appendix 9.4: irrigation calculations.

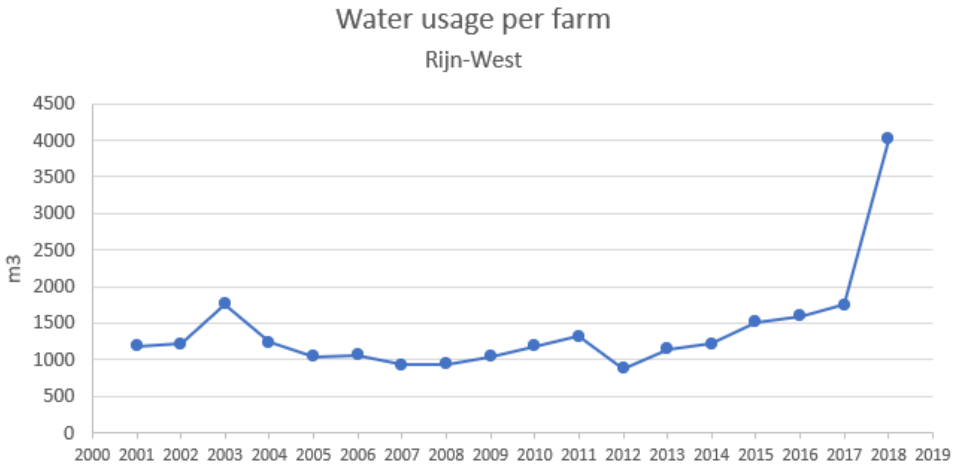


Figure 15 overview of water usage per farm in the Rijn-West drainage basin for the years 2001-2018. (van der Meer, 2020)

Yearly, an average crop farm uses almost 48 m3, or 48.000 litres of water, per hectare. When split into the different water sources, 5,5 m3 originated from drinking water, 21,1 m3 originated from groundwater, 19,9 m3 originated from surface water and a small portion for flood irrigation ('drenking') of 1,4 m3 originated from both ground- and surface water.

In dry years the average water usage can increase to almost 219 m3, or 219.000 litres per hectare of cropland (4,5 times increase). When split into the different water sources, 6,1 m3 originated from drinking water, 85,5 m3 originated from groundwater, 126 m3 originated from surface water and a small portion for flood irrigation ('drenking') of 0,9 m3 originated from both ground- and surface water. The total amount of water used per hectare is not the only factor that increases in dry years, also the total amount of surface that is irrigated increases and the total times one surface is irrigated (respectively, 70 times and 1,3 times more).

We estimate the value of the water provisioning services in the Lutkemeerpolder at a range of €1.700 - €7.200 for the 62 hectares of agricultural land. However, some caution is needed when interpreting these results as some parameters on which this range relied were determined with some uncertainty; especially the price for ground- and surface water (for more details see the extended calculation in appendix 9.4).

Biopolder

Because of the unique irrigation capacity of the polder, changing the polder into a *biopolder* or business park would probably not result in large changes to the water provisioning service of the polder.

The planting of more trees and digging of more canals in the *biopolder*, could lead to an improved retention and provisioning of water. However, these services are already sufficient in the polder and therefore will not contribute to a higher value for the water provisioning services. Therefore, the overall value of the irrigation to the polder will not change and remain €1.700 - €7.200.

Business park

In the scenario of the business park, the value of the water provisioning services for irrigation will mostly be lost, as a large part of the agricultural activities will disappear from the Lutkemeerpolder. Only 23 hectares of agricultural land will remain. Therefore, the overall value of the irrigation for the polder will drop to €700 - €3.000.

Raw materials

Ecosystems can provide many different raw materials for extraction by humans. This service can be divided into multiple categories; building materials (clay, stone, timber), uels (oils, wood, peat) or fibres (cotton, jute, sisal). (Elmqvist et al., 2010)

The main raw materials provided by the Lutkemeerpolder are;

- Different kinds of wood from the forests area or the cemetery, which could be used as building material or for wood burners.
- Withies from the pollarding of willow trees in the wetlands and grasslands, which could be used as a building material as well.
- Thatch from the wetlands and channels of the agricultural fields, which could be used for roof thatching.

Currently, raw materials are not actively extracted from the Lutkemeerpolder but rather taken as part of the maintenance of nature and waterways. As the raw materials do not have a value in the current state of the polder, as they are thrown away or are not fully grown yet (trees in the forest areas), the service could not be evaluated. Below, the steps are described that could be followed in a future evaluation of the raw materials, once they are used.

Valuation

The value of the raw materials in the polder can be determined by using the direct market valuation approach. A calculation can be used to show the value of the raw materials: the standardised price of materials times the average amount of those materials that is extracted every year from the polder. The following prices could be used for the raw materials in the calculation: the wood of the forest area and cemetery a price

of €25 per m3, the cost price of withies is €0,06 per kilo and thatch costs €2 per bundle and 250 bundles could be harvested per hectare per year. (Ruijgrok & De Groot, 2006)

Biopolder scenario

In the *biopolder* scenario the availability of raw materials will remain, the amount of raw materials may even increase depending on the management and detailed plan of the *biopolder*. In the case that more trees are planted, wood could be harvested, or other types of vegetation can be planted, which could increase the provision of raw materials.

Business park scenario

In the business park scenario, the availability of raw materials will probably decrease as a consequence of changes in the landscape. It is likely that, for example, some willow trees may be lost to make room for buildings, also the water system will be changed drastically influencing the suitability of the polder for the extracting of thatch.
However, the forest area will remain, therefore the business park does not influence the extraction of wood from the Lutkemeerpolder.

4.4 Supporting ecosystem services

Supporting ecosystem services are services that are based around biodiversity and wildlife. As their name suggests they are supporting services which means they have influence on most of the other services. For example: without the habitat for species there is no pollination or biological control. Due to this supporting nature they are also difficult to value as they do not have a direct use to people but rather increase other ecosystem services.

Habitat services

The Lutkemeerpolder provides a habitat for a multitude of different species. All species contribute to the ecosystem services provided by the Lutkemeerpolder. Examples are that trees provide timber as a raw material or that bees pollinate plants. Many services depend on the presence of certain species of organisms. Removing even one species can cause a collapse in the ecosystems that are in place. It is therefore of great importance to preserve wild habitats as much as possible and also incorporate habitats into the buildings we make.

Valuation

Habitats for species do not have a tangible value you can assign to it. It can however be valued through the services provided by species such as pollination or biological control. Those values represent the habitat value as well because if the habitat is not there then the species won't be there either and the ecosystem service would also not be present.

Social services of the Boterbloem

In the Lutkemeerpolder, several social benefits that exist in the status quo, can be identified alongside ecosystem services described earlier in this report. In this section, we will go into more detail on the social services provided by the organic farm 'de Boterbloem', located in the polder. The organic farm is an important contributor to the recreational value of the polder (Bos et al., 2019). Furthermore, the farm also organises educational activities, and presents opportunities for occupational therapy for psychiatric patients. In this report, we distinguish three main social benefits of the organic farm: the recreational function, the educational function, and the 'care farm' function.

Recreational function

Relevance

'De Boterbloem' constitutes a part of the recreational value of the polder. This is especially the case if we take a look at the recreational value of the piece of land that is now being used for agricultural purposes. Since this recreational value is captured in the calculation of the polder ecosystem service 'recreation' earlier in this report, we will not calculate it separately here to avoid double counting of the same service.

Biopolder

Plans for the *biopolder* involve increasing the recreational value of the polder by constructing bike lanes and walking paths throughout the agricultural fields. This in turn increases the recreational value of the Boterbloem. The activities proposed in the plan, such as harvest festivals, also increase the recreational value of the farm.

Business park

In the scenario that a business park is built, the recreational value of de Boterbloem will decrease. The wide, open view that is appreciated by visitors of de Boterbloem will no longer be available. In addition, possible noise nuisance disturbs the recreational experience. Recreation will only be possible on the 3 hectares of land still devoted to the farm.

Educational function

Organic farming presents opportunities for education on food production, for both children and adults. By organising activities that illustrate under what circumstances food is produced, people that are not directly involved in agriculture can learn more about the food production system. Learning about the food production system enables participants to make better informed choices about their consumption practices and causes people to become more conscious about topics like food waste (Travaline & Hunold, 2010). Organising educational farm activities thus provides a social service to the participants.

Relevance

The educational activities of 'de Boterbloem' entail educating (mainly) children about the way that crops are grown and 'where their food comes from'. In the past, the farm has organised activities like 'potato day', in which families from Amsterdam can experience how potatoes are harvested. In recent years, educational activities on the farm have been in decline due to the pressure on the farm management regarding the plans for the business park. Because of the ambiguous situation in the polder, educational

companies have become hesitant to organise activities at the farm (see Appendix 9.1). The current value of educational activities is thus low if not non-existent.

Biopolder scenario

In the *Biopolder* plan, developed by the management of 'de Boterbloem', a great emphasis is placed on the possibility of increasing the educational function of the farm. There are two main sources of educational value in the *Biopolder* plan. The first one relates to the construction of walking and cycling paths within the polder to create an educational 'route' through the polder. The second one relates to educational activities with the goal of creating awareness about food, in the form of harvest festivals and educational programs. There are ideas of cooperation with schools in Amsterdam to create a joint educational program on (locally sourced) food (*Behoud lutkemeer*, 2018).

Business park scenario

Although the construction of the business park will greatly decrease the land available for agricultural production, educational activities might still be organised on the remaining land of the farm. It is thus to be expected that the educational function of the farm will drop. However, there will still exist opportunities for educational activities.

Care function

Care farms are an alternative form of psychiatric care, organised around farm work. In care farms, clients can get used to performing a simple daily routine outside the institutional environment, as a form of occupational therapy (Elings & Hassink, 2006). The care that such farms provide thus has social value, for both clients, for society and farmers, for example by reducing the pressure on the conventional health care system.

Relevance

The organic farm 'de Boterbloem' is part of the 'Landzijde' network of care farms in the Dutch province of North-Holland. In this care farm program, 'de Boterbloem' enables people with psychiatric problems, burn-outs or rehabilitation programs to work on the farm under supervision (from here on called clients). The farm provides activities in the form of gardening, housekeeping tasks or just unwinding in nature. There is room for three to five clients per day on the farm, and the farm is open for clients four days a week.

'De Boterbloem' thus provides value by providing clients with day care activities: it presents clients with a daily routine outside the formal environment of a healthcare institution and offers them the opportunity to develop new skills and competencies (Eweg & Hassink, 2011).

Method

To value the service that 'de Boterbloem' provides to the clients that visit the farm, we use the direct market valuation approach. Care farms receive a fixed amount of money per client per day to compensate them for their activities. We believe this to be an accurate representation of the care function of the farm.

Valuation

As stated above, we use the income received by the farm for the clients as a representative estimate of the value of the care activities. 'de Boterbloem' receives a compensation of €50 to €80 per patient per day (van Doorninck, 2018). The farm provides care to five patients on average, four days a week. This produces a range of values for the care function of 'de Boterbloem' from €52.000 - 83.200 per year.

Biopolder scenario

In the *Biopolder* scenario, the care function of 'de Boterbloem' might remain at the same level or potentially increase. However, the greatest potential lies in the expansion of the care function throughout the entire polder. Given the plans for high cooperation levels among farmers in the *Biopolder*, other farms in the polder could also join the Landzijde care farm network. Given that other farms in the area will engage in similar practices like 'de Boterbloem', the care function of the entire polder could greatly increase. If, for example, 3 additional farms would start engaging in care farming practices, the care function of the entire polder increases to a value of €208.000 - 332.800 at a conservative estimate. Given a high level of cooperation between farms, this value could be increased even more by increasing the number of patients due to collaborative activities and better coordination between farms.

Business park scenario

When a business park is built, 3 hectares of land will most likely be reserved for 'de Boterbloem' to continue its care farm activities. However, clients have expressed to the management of the care farm that they mostly enjoy being at the farm because of the wide and open natural surroundings and the tranquillity of polder. When a business park is built, these characteristics will disappear, and thus the major appeal of 'de Boterbloem' for its clients. It is thus to be expected that the quality of the care that the farm provides will decrease. We expect a decrease of quality of 40% for the business park scenario, estimating the value of the service at €30.000 - €40.000 in the business park scenario.

5. Consulting recommendations

Based on the valuation of the present situation of the ecosystem services of the Lutkemeerpolder and the indicated possible changes in value for the *biopolder* or business park scenario we have a number of insights and recommendations for the commissioner. These are (1) the most important ecosystem services, (2) how our results can be used, and (3) possible next steps we have identified.

5.1 Services with highest value

Based on two criteria, monetary value of an ecosystem service and potential of the ecosystem service, we identified that the most important ecosystem services are:

I. Recreation

The Lutkemeerpolder is an urban green area that provides recreational opportunities for visitors and has the highest monetary value. While the plans for the business park do not involve building directly on the areas that are currently used for recreation, its presence might affect the overall desire of the people to go there for recreation. The business park will be built right next to the cemetery, which might potentially make it less attractive to visit for walks. The added noise might also make it a less suitable place for dog walkers to walk their dogs.

II. Air quality

The polder, as an urban green space, provides air purification. This service, although already significant, has large potential in the *biopolder* scenario, especially when more trees or shrubs are planted, aesthetic-wise the openness of the polder should remain which makes the east border of the area suitable and the north border of the agricultural fields the least suitable.

III. Agriculture

The Lutkemeerpolder has significant agricultural value due to the fertility of the ground, pollination services etc. This value would be largely lost if the agricultural area is transformed into a business park

IV. Aesthetics

Plans for the business park involve building on the agricultural area which will reduce the aesthetic value of the park by directly reducing the housing premium related to an open view of the Lutkemeerpolder. This is in addition to the increased noise pollution that will come with the business park reducing the attractiveness of the Lutkemeerpolder even further.

These are the most important services that should be considered in the quest to change the zoning plan of the area and all parties should be made aware of them. Overall, the ecosystem service valuation of the Lutkemeerpolder shows that it provides value as an urban green space.

5.2 General recommendations: How can our results be put to practice

For cultural ecosystem services on the one hand, and for provisioning and regulating services on the other, we have identified two overarching areas that could be improved based on the valuation results to increase the ecosystem service values and thus helps to tap into their potential in the Lutkemeerpolder.

I. Increase attractiveness and accessibility for higher cultural service values

To gain more value from the ecosystem services we recommend keeping the Lutkemeerpolder as a green space accessible for visitors and inhabitants, as cultural ecosystem service values will decrease if the plans for a business park are realised. We further recommend improving the attractiveness and accessibility of the Lutkemeerpolder to increase the value of cultural ecosystem services by increasing:

- **attractiveness:** to create walking paths in agricultural fields, especially applicable for *biopolder* scenario with more biodiversity: attractive for dog walkers, bikers, runners, nature enthusiasts, budding urban gardeners etc.
- **accessibility:** turn the Lutkemeerpolder into a more well-known destination; accessibility preceded by knowledge about what Lutkemeerpolder has to offer but is currently not very accessible: birdwatching walks, biodiversity walks, potato harvesting day are all already happening. Consider taking this up into *biopolder* strategy and planning.
- **attractiveness:** refrain from planting tall trees or buildings at the north site of the polder as it will block the open view from that area important for house

premiums. Beware that housing premiums based on open view will change especially at the north side with the construction of a business park. Planting trees in other areas will constitute no problems.

- **accessibility:** the memorial park can increase in spiritual value if people have access to information that it is more than just a cemetery; it is a place to recreate and commemorate, to find peace and serenity.
- **attractiveness:** beware of noise pollution from the business park and its negative effect on housing premiums and recreational benefit for visitors.

II. Develop plans for nature-inclusive agriculture for higher regulating and provisioning services

Considering the value of the agricultural production in the polder, we recommend to continue the agricultural activities in line with the *biopolder* plan. However, to increase the value from natural services, we recommend 'nature-inclusive' agricultural practices, such as the 'Farming for Nature' principle devised by scholars from Wageningen University (Gies, van Doorn & Bos, 2019). Components of nature-inclusive farming are:

- flower strips, where flower patches are placed at the borders of agricultural fields
- adapting agricultural practices to the natural landscape
- engaging in circular or closed-cycle farming

However, we stress that this plan would only be successful if this approach is adopted by all farms in the Lutkemeerpolder Adopting such practices has several benefits for the value of the ecosystem:

- Natural pollination: increasing natural habitats of pollinators, such as bees, causes increases in pollination levels, which in turn positively influences agricultural yields.
- Biological pest control: creating more habitat and introducing more biodiversity in the ecosystem increases the amount of biological pest control, which in turn lowers the need for (expenditure on) artificial pesticides.

On a similar note, we also recommend the planting of trees or other large vegetation types alongside the agricultural fields to the east and the walking and cycling paths that are advised in the section above. The openness of the landscape needs to remain intact when designing the *biopolder* to preserve the aesthetic value. Planting trees has several benefits for the value of the ecosystem:

- Air quality: increasing the number of trees in the polder increases the capacity of the polder to regulate the quality of the air. It especially enables the ecosystem to filter more nitrogen oxide and sulphur dioxide out of the air.
- Carbon sequestration: planting trees increases the amount of carbon sequestered by the Lutkemeerpolder, which increases the value of this service.
- Biological pest control: With more trees, there is increased habitat from species which provide biological control.

5.3 Next steps

In this report, we have demonstrated the current value of the Lutkemeerpolder, and have provided estimates for the change in this value in the scenarios of a *biopolder* and business park. In this section, we will provide recommendations on how to move forward from the results presented in this report, and how the results presented here relate to *Behoud lutkemeer*'s goal of conserving the Lutkemeerpolder.

In the present

The results produced in this report can already be used to prove the value of Lutkemeerpolder. Simply demonstrating the value of nature and the ecosystem services that it provides can increase awareness about the benefits provided by nature (TEEB, 2010). Furthermore, policy makers may not be fully aware of the consequences of building a business park for the provision of ecosystem services. The results of the report can be utilised to show decision makers what impact their decisions have on the ecosystem of the Lutkemeerpolder.

Additionally, the valuations expose which ecosystem services are most important and which deserve the most attention. We have also outlined above how the value of these ecosystem services can be increased, based on information we have gained on the provision of services in the polder.

For future refinement of the Ecosystem Service valuation

We also recommend to research how the values presented in this report can be refined and how the valuation ranges can be narrowed to produce a more precise estimate.

Due to government regulation concerning the coronavirus, we have not been able to collect as much data as we would have liked. Therefore, many valuations have been done using benefit transfer methods and data from other studies, which produces wide ranges

of estimates. Using these methods as a basis, we recommend conducting a larger scale research of the area to acquire local data which would be better fitted into our proposed valuation methods.

Furthermore, some ecosystem services have not been valued, for example because of incompatibility with our approach of valuing mainly the status quo. We recommend that further research employs a different approach to value these remaining services. Examples of services that are in need of further study are soil erosion, soil fertility and historical importance. We have proposed a method of valuation in the respective description of the ecosystem service and recommend to use this method to compute values for these services. Below is a summary of all the refinements that could be made to our calculations:

Aesthetics: A hedonic pricing method for the specific property area is best suited to get more accurate housing premiums. The proposed valuation method can be used as a basis to derive an annual value for the aesthetic value of the Lutkemeerpolder. A detailed description can be found on the respective section for aesthetics.

Agricultural production: To better estimate the value of agricultural production in the polder, we recommend finding more accurate production numbers for the farms in the area instead of using average yield numbers

Air quality: In our analysis we did not take the loss of air quality due to the emissions of the business park into account, we used only national data for uptake of pollutants and did not take the emissions to the atmosphere of the agricultural fields into account. Researching the emissions due to the activities in the business park, the leakage from pollutants to the air and researching local pollutant uptake rates will improve the estimate for air quality regulation.

Biological control and pollination: We recommend to find more exact numbers on yield increase for each different type of crop. Also, we advise to compare organic farms with the same crops to non-organic farms in terms of yield increase.

Carbon sequestration and air regulation: To estimate the specific carbon sequestration and air regulation potential of the Lutkemeerpolder, we advise to use data retrieved from on-site research.

Care value 'de Boterbloem': Possibly, a method could be employed that elicits the perceived value of the care provided by the 'de Boterbloem' according to the patients on the farm. We then advise using a contingent valuation method.

Education value 'de Boterbloem': To properly value the potential of 'de Boterbloem's educational value in the *biopolder* scenario, we suggest collecting more data on the types of activities and the prospected amount of (types of) visitors.

Irrigation: Accurate prices for water cost per cubic metre, depending on their source (tap water, surface water or groundwater).

Recreation: For a more accurate Travel Cost Method application, a regression should be run, for which the following data should be obtained: modes of transport to the polder; an updated figure for average distance and time spent traveling to the Lutkemeerpolder; the average wage for Amsterdam; survey questions to estimate how many visitors would alter their visiting behaviour in the *biopolder* or business park scenario; and finally and importantly, an accurate number of visitors in the polder (through representative sampling over all seasons for example)

Soil quality: Soil erosion protection is the part of soil quality that remains to be valued. We advise to gather local data on erosion prevention and compare them to data from other similar land use types. A detailed description of how to value soil erosion can be found on the section "maintenance of soil fertility".

Spirituality: To spiritually value the Lutkemeerpolder, extensive research among its visitors is required. In that manner, the emotional value of the last clay grounds in Amsterdam and the historical polder landscape can be quantified. Also, the spiritual services provided by the Westgaarde cemetery could then be considered to see if their appreciation might be influenced by neighbouring activities.

Water purification: The water quality plays no significant role in the current Lutkemeerpolder and neither in the *biopolder* scenario. These scenarios can be valued based on fish used for fishery or a slight increase in biodiversity which might lead to an increase in recreation. In the business park scenario, the costs can be more significant when purification is needed before discharging to surface water, this is only in special cases and the zoning plan assumes this is not needed.

Water regulation: We suggest quantifying the current value of water regulation by the cost of the measures that are required for the new zoning plan for water regulation. This can be estimated by researching the costs for the plans and the costs for seepage research and hydrological modelling as suggested in the zoning plan. This is likely going to result in an initial cost and higher yearly pumping costs.

Follow-up study design

Finally, we would like to make recommendations concerning the design of a study that follows up on the results of this paper. In this report, we have provided valuations that can serve as the basis of a study that examines and compares the value of the Lutkemeerpolder, the *biopolder* and the business park. We recommend using these values to run a social cost-benefit analysis (SCBA). Doing such an SCBA clearly demonstrates the (net present) total value of the polder. In this report, we have particularly focussed on the ecosystem services and shortly on the social services provided by 'de Boterbloem'. However, to make a truly thought-out decision about the purpose of the polder, all aspects have to be considered, such as the impact of the construction of a business park on people living nearby, as well as the costs and benefits associated with the business park itself. In this way, emissions of the business park can also be taken into account. This was out of scope for this report, but we highly recommend using the yearly values that we have computed in this SCBA. The results that we have produced can certainly be used to determine the costs and benefits associated with a business park or the *biopolder*. Doing this SCBA allows for a clear comparison of the value of the area in all three scenarios.

6. Discussion of valuation

This research relies heavily on the Economics of Ecosystems and Biodiversity (TEEB) framework to recognise and demonstrate the value of the Lutkemeerpolder. In this chapter, we will discuss our research and the limitations and advantages of this framework. We also consider alternative approaches here as a reflection, which we deem useful to consider for future research projects.

6.1 Limitations

The general approach

The first limitations of our approach were beyond our influence. Due to the COVID19 regulations, we were not able to gather any primary data by conducting surveys among visitors or by performing on-site research. Consequently, we were limited by the availability of secondary data. Furthermore, the lack of a detailed planning of the *biopolder* made it hard to draw conclusions about the ES would change under the new circumstances.

As a result, some values are lacking precision as it was hard to verify if the source research was carried out in a proper manner, whether the data was really applicable to our case and to find support for our assumptions. This is one of the reasons why we decided to present our values in relatively large ranges. If the certainty of our results was greater, we could have presented more precise estimates.

The TEEB framework

The TEEB framework expresses a rather anthropocentric value of nature, which means that the value of ecosystem services is mainly recognized if people directly profit from it. It provides a rough estimate of the market value of ecosystem services, but the intrinsic value of nature, for instance in biodiversity, might be overlooked.

Moreover, non-ecosystem services, like the care function of the Boterbloem, are not accounted for in the TEEB framework or up for interpretation of it. We hence we decided to integrate the Boterbloem specific values into our analysis because we think that these are relevant to take into consideration for the value of the polder. Similarly, soil fertility is not approached as a separate service in the TEEB framework, but rather as part of other services. We decided to highlight the importance of soil fertility separately as we think it has an important value for the polder.

The results

From the results table it is clear that recreation contributes significantly to the overall value of the Lutkemeerpolder. However, this inherently means that the outcome of our research is also very sensitive to the underlying assumptions that we made for the recreational services. Small alterations in the recreation calculations could thus largely influence the overall outcome.

6.2 Advantages

The general approach

A strength of our approach is that with the help of the ecosystem services valuation we could generate a value for the status quo of the polder, which can be used in a comparison, but does not only have value in comparison to different scenarios but also provides information whilst it stands alone.

The TEEB framework

The TEEB framework is an internationally known, standardised framework, therefore studies using the TEEB framework can easily be compared and results could be used in a benefit transfer. We made use of the benefit transfer method ourselves, but also the results from this study can be easily implemented in further research.

The results

The clear and structured list of ecosystem service values gives involved parties a clear overview and easy understanding of the Lutkemeerpolder's value. This list can easily be used in new research or as an argument in the debate on the value of the Lutkemeerpolder. Furthermore, these results were also converted into an infographic which makes it easier to understand the main conclusions of our research, which also contributes to easier implementation in policy making.

6.3 Alternatives

A very prominent alternative to the ecosystem service valuation can be the social cost-benefit analysis. Performing a social cost-benefit analysis on the different future plans of the Lutkemeerpolder will paint a very clear picture on the loss or the gain under the different circumstances. However, a weakness of the cost-benefit analysis is that it does not provide a current value because it is designed to measure changes, and not to provide

a complete overview of all services. This is why we did not choose this method in the current research. For further analyses of the two scenarios, businesspark or *biopolder*, a social cost-benefit analysis could have an added value.

7. Conclusion

We estimate the total monetary value of the ecosystem services provided by the current ecosystem at €1.565.000 to €8.609.800, for a *biopolder* scenario we estimate the value around €1.998.400 to €10.278.200 and for the business park our estimate ranges from €1.185.800 up to €6.927.800, hence answering our research questions with these values. The primary ecosystem services within the Lutkemeerpolder are recreation, air regulation and crop production. The care function of the Boterbloem, pollination and biological pest control are secondary services within the polder.

The previous mentioned estimates can be refined by gathering more local data such as visitor numbers, travel costs and how visitors choose to recreate. The air regulation estimates would increase and be more accurate if emission of pollutants due to agriculture and the business park are known. Uncertainty in the design of the *biopolder* and the realisation of the business park are also increasing the ranges.

The Lutkemeerpolder is known as the last clay polder with agricultural activity within the municipality of Amsterdam. At the time of publication 7.272 signatures were raised to change the business park zoning plan to one which extends local food production, education, and a place for people to take a break from the city. The plan for the business park was approved in 2013 and planned to be done in 2020 but has been stopped due to protests. Within this framework it is challenging to capture these events in monetary value even though they do show value for human well-being. We hope our estimates give some equality in information in the discussions regarding the zoning plan. We derived a perspective on logical steps to take for future studies and aimed for public awareness with the designed infographic.

"In general, however, one should not shy away from providing the best available estimates of value for a given context and purpose and seeking ways to internalise that value in decision making."

- TEEB, 2010, p.12

8. References

Aalbers, R., Renes, G., & Romijn, G. (2016). WLO-klimaatscenario's en de waardering van CO2-uitstoot in MKBA's. *CPB/PBL Achtergronddocument*, Den Haag, 23. Retrieved from https://www.cpb.nl/sites/default/files/omnidownload/CPB-PBL-Achtergronddocument-23nov2016-WLO-klimaatscenarios-en-de-waardering-van-co2-uitstoot-in-mkbas.pdf

Bartomeus, I., Potts, S. G., Steffan-Dewenter, I., Vaissiere, B. E., Woyciechowski, M., Krewenka, K. M., ... & Bommarco, R. (2014). Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. *PeerJ*, 2, e328. https://doi.org/10.7717/peerj.328

Behoud lutkemeer (2018, september). *Biopolder* Lutkemeer: lokale voedselproductie, educatie, biodiversiteit en natuurbeleving. Retrieved from: http://behoudlutkemeer.nl/wp-content/uploads/2018/11/*biopolder*DEF.pdf

Bos, E., van Ekeren, M., Fesel, K., Geerling, E.D., Pagano, G., Winarendri, J. & de Baat, M. (2019). Discovering the values of the Lutkemeerpolder (Wageningen University and Research ACT project, team number 2254). Retrieved from: http://behoudlutkemeer.nl/wp-content/uploads/2019/07/Final-Report-2254.pdf

Brady, M. V., Hedlund, K., Cong, R. G., Hemerik, L., Hotes, S., Machado, S., ... & Thomsen, I. K. (2015). Valuing supporting soil ecosystem services in agriculture: a natural capital approach. *Agronomy Journal*, 107(5), 1809-1821. https://doi.org/10.2134/agronj14.0597

Brenner Guillermo, J. (2007). *Valuation of ecosystem services in the Catalan coastal zone*. Universitat Politècnica de Catalunya. http://hdl.handle.net/2117/93710

Brookshire, D. S., Thayer, M. A., Schulze, W. D., & d'Arge, R. C. (1982). Valuing public goods: a comparison of survey and hedonic approaches. *The American Economic Review*, 72(1), 165-177. Retrieved from: https://www.jstor.org/stable/1808583?seq=1#metadata_info_tab_contents

CBS (2019, May 28th). Uurloon Grensgebieden Hoogst In België. Retrieved from: https://www.cbs.nl/nl-nl/nieuws/2019/22/uurloon-grensgebieden-hoogst-in-belgie

Cruz, A., Benedicto, J., & Gil, A. (2011). Socio-economic benefits of Natura 2000 in Azore Islands–a case study approach on ecosystem services provided by a special protected area. *Journal of Coastal Research,* 1955-1959. Retrieved from: https://www.jstor.org/stable/26482518?seq=1#metadata_info_tab_contents

De Groot, R. S., Alkemade, R., Braat, L., Hein, L., & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity*, 7(3), 260–272. https://doi.org/10.1016/j.ecocom.2009.10.006

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological economics*, 41(3), 393-408. https://doi.org/10.1016/S0921-8009(02)00089-7

De Groot, W. T., & van den Born, R. J. (2003). Visions of nature and landscape type preferences: an exploration in The Netherlands. *Landscape and urban planning*, 63(3), 127-138. https://doi.org/10.1016/S0169-2046(02)00184-6

De Lacy, P., & Shackleton, C. (2017). Aesthetic and spiritual ecosystem services

provided by urban sacred sites. *Sustainability*, 9(9), 1628. https://doi.org/10.3390/su9091628

Douglas, A., & Johnson, R. (2004). The travel cost method and the economic value of leisure time. *International Journal of Tourism Research*, 6(5), 365-374. https://doi.org/10.1002/jtr.500

Elings, M., & Hassink, J. (2006). *Farming for health in the Netherlands* (pp. 163-179). Springer, Dordrecht. https://doi.org/10.1007/1-4020-4541-7_13

Elmqvist, T., Maltby, E., Barker, T., Mortimer, M., & Perrings, C. (2010). Chapter 2: Biodiversity, ecosystems and ecosystem services. In P. Kumar (Ed.) *The economics of ecosystems and biodiversity: ecological and economic foundations.* (p.41-113). London, Washington D.C.; Earthscan.

EuroDev. (2019). MILEAGE REIMBURSEMENT IN EUROPE. Retrieved from https://www.eurodev.com/wp-content/uploads/2019/05/hea-5c-20surgic_38993149.pdf

Eweg, H. P. A., & Hassink, J. (2011). Business models of Green Care in the Netherlands. Retrieved from: https://library.wur.nl/WebQuery/wurpubs/fulltext/175712

Fischer, L. K., Honold, J., Botzat, A., Brinkmeyer, D., Cvejić, R., Delshammar, T., … Kowarik, I. (2018). Recreational ecosystem services in European cities: Sociocultural and geographical contexts matter for park use. *Ecosystem Services*, 31, 455–467. https://doi.org/10.1016/j.ecoser.2018.01.015

Freibauer, A., Rounsevell, M. D., Smith, P., & Verhagen, J. (2004). Carbon sequestration in the agricultural soils of Europe. *Geoderma*, 122(1), 1-23. https://doi.org/10.1016/j.geoderma.2004.01.021

Garrod, G. and Willis, K. G. (1999). *Economic valuation of the environment: Methods and case studies*. Cheltenham, UK: Edward Elgar Publishing.

Geiger, F., Bengtsson, J., Berendse, F., Weisser, W. W., Emmerson, M., Morales, M. B., ...& Eggers, S. (2010). Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. *Basic and Applied Ecology*, 11(2), 97-105. https://doi.org/10.1016/j.baae.2009.12.001

Gemeente Amsterdam (2010). Feiten En Cijfers Amsterdamse Bos. [online] Amsterdamse Bos. Retrieved on June 14th 2020, from https://www.amsterdamsebos.nl/organisatie/feiten-cijfers/>

Gemeente Amsterdam (2013). Bestemmingsplan Lutkemeerpolder, NL.IMRO.0363.F1003BPSTD-VG01. Chapter 5.9: Water. Retrieved from: https://www.ruimtelijkeplannen.nl/documents/NL.IMRO.0363.F1003BPSTD-VG01/t_NL.IMRO.0363.F1003BPSTD-VG01_5.9.html#_5.9.4_Watertoets

Gemeente Amsterdam (2018) Bestuurlijk reactie op motie (nr. 2018-316) van de voormalige leden Nuijens en Geenen inzake zorgfunctie boerderij de Boterbloem, Business Park Amsterdam Osdorp. Retrieved on 1-06-2020 from: https://amsterdam.groenlinks.nl/sites/groenlinks.nl/files/downloads/page/Brief%20college%2030%20oktober%202018.pdf

Gemeente Amsterdam (2019). Grote Groenonderzoek 2018 [online report]. Retrieved from: https://data.amsterdam.nl/publicaties/publicatie/grote-groenonderzoek-2018/5aac0822-3c01-49d4-8812-2f13b92520c5/

Gies, E., van Doorn, A., Bos, B. (2019). Mogelijke toekomstbeelden natuurinclusieve landbouw. *Wageningen Environmental Research Rapport 2957*. https://doi.org/10.18174/498926

Gundimeda, H., Markandya, A. and Bassi, A.M. (2018). TEEBAgriFood methodology:

an overview of evaluation and valuation methods and tools. In *TEEB for Agriculture & Food: Scientific and Economic Foundations*. Geneva: UN Environment. Chapter 7, 247-295

Hettelingh, JP., Posch, M., Slootweg, J. (2017) European critical loads: database, biodiversity and ecosystems at risk. Retrieved June 24, 2020, from https://rivm.openrepository.com/handle/10029/622367

Hogendoorn, K., Gross, C. L., Sedgley, M., & Keller, M. A. (2006). Increased tomato yield through pollination by native Australian Amegilla chlorocyanea (Hymenoptera: Anthophoridae*). Journal of Economic Entomology*, 99(3), 828-833. https://doi.org/10.1093/jee/99.3.828

Hoogheemraadschap Amstel, Gooi en Vecht (2014). Watergebiedsplan Amsterdam-West. Retrieved from: https://www.agv.nl/siteassets/werk-in-uitvoering/ruimtelijke-ordening/watergebiedsplannen/amsterdam-nieuw-west/definitief-watergebiedsplan-amsterdam-nieuw-west.pdf

Howley, P. (2011). Landscape aesthetics: Assessing the general publics' preferences towards rural landscapes*. Ecological Economics*, 72, 161-169. https://doi.org/10.1016/j.ecolecon.2011.09.026

Karp, D. S., Mendenhall, C. D., Sandí, R. F., Chaumont, N., Ehrlich, P. R., Hadly, E. A., & Daily, G. C. (2013). Forest bolsters bird abundance, pest control and coffee yield. *Ecology letters*, 16(11), 1339-1347. https://doi.org/10.1111/ele.12173

Khaddari, R. (2019, September 2nd). Actievoerders Lutkemeerpolder willen terrein niet verlaten. *Het Parool*. Retrieved from: https://www.parool.nl/amsterdam/actievoerders-lutkemeerpolder-willen-terrein-niet-verlaten~bc7cbd3e/

Looman, W., de Ruijter, T. & Vos, M. (2008). Programma van Eisen van de Tuinen van West. Gemeenteraad van Amsterdam. Retrieved from: https://assets.amsterdam.nl/publish/pages/434879/de_tuinen_van_west_-_programma_van_eisen_westrand.pdf

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and urban planning*, 48(3-4), 161-167. https://doi.org/10.1016/S0169-2046(00)00039-6

Maps Amsterdam. (n.d.). Property value- Sale price per m2. Retrieved on June 5th from: https://maps.amsterdam.nl/woningwaarde/?LANG=en

Melathopoulos, A. P., Cutler, G. C., & Tyedmers, P. (2015). Where is the value in valuing pollination ecosystem services to agriculture?. *Ecological Economics*, 109, 59-70. https://doi.org/10.1016/j.ecolecon.2014.11.007

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. Retrieved from: https://www.millenniumassessment.org/documents/document.356.aspx.pdf

Östman, Ö., Ekbom, B., & Bengtsson, J. (2003). Yield increase attributable to aphid predation by ground-living polyphagous natural enemies in spring barley in Sweden. *Ecological economics*, 45(1), 149-158. https://doi.org/10.1016/S0921-8009(03)00007-7

Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical transactions of the royal society B: biological sciences*, 365(1554), 2959-2971. https://doi.org/10.1098/rstb.2010.0143

Quinton, J. M., & Duinker, P. N. (2019). Beyond burial: Researching and managing cemeteries as urban green spaces, with examples from Canada. *Environmental Reviews*, 27(2), 252–262. https://doi.org/10.1139/er-2018-0060

Ruijgrok, E. C. M., & De Groot, R. S. (2006). *Kentallen Waardering Natuur, Water,*

Bodemen Landschap: hulpmiddel bij MKBA's. Retrieved from: http://www.omgevingseconomie.nl/wp-content/uploads/2012/03/Kentallenboek-waardering-natuur-water-bodem.pdf

SADC (2017) Start ontwikkeling fase 2 van Business Park Amsterdam Osdorp. Retrieved on June 6th 2020 from: https://www.sadc.nl/start-ontwikkeling-fase-2-business-park-amsterdam-osdorp/

Smit, B., & Jager, J. (2018). Schets van de akkerbouw in Nederland: structuur-, landschapsen milieukenmerken die een relatie hebben tot biodiversiteit (No. 2018-074). *Wageningen Economic Research.* Retrieved from: https://library.wur.nl/WebQuery/wurpubs/fulltext/463816

Sutter, L., & Albrecht, M. (2016). Synergistic interactions of ecosystem services: florivorous pest control boosts crop yield increase through insect pollination. *Proceedings of the Royal Society B: Biological Sciences*, 283(1824), 20152529. https://doi.org/10.1098/rspb.2015.2529

TEEB (2010). *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.* Retrieved from: http://www.teebweb.org/publication/mainstreaming-the-economics-of-nature-a-synthesis-of-the-approach-conclusions-and-recommendations-of-teeb/

Terragni, L., Torjusen, H., & Vittersø, G. (2009). The dynamics of alternative food consumption: contexts, opportunities and transformations. *Anthropology of food*, (S5). https://doi.org/10.4000/aof.6400

Travaline, K., & Hunold, C. (2010). Urban agriculture and ecological citizenship in Philadelphia. *Local Environment*, 15(6), 581-590. https://doi.org/10.1080/13549839.2010.487529

Tschumi, M., Albrecht, M., Bärtschi, C., Collatz, J., Entling, M. H., & Jacot, K. (2016). Perennial, species-rich wildflower strips enhance pest control and crop yield. *Agriculture, Ecosystems & Environment*, 220, 97-103. https://doi.org/10.1016/j.agee.2016.01.001

Van den Born, R. J., Lenders, R. H., de Groot, W. T., & Huijsman, E. (2001). The new biophilia: an exploration of visions of nature in Western countries. *Environmental conservation*, 28(1), 65-75. Retrieved from: https://doi.org/10.1017/S0376892901000066

Van der Meer, R. W. (2020). Watergebruik in de land-en tuinbouw 2017 en 2018 (No. 2020-030). *Wageningen Economic Research*. https://doi.org/10.18174/519864

Van der Zee, S.C., Helmink, H. (2019). Meetresultaten luchtkwaliteit 2018. *Leefomgeving Amsterdam: GGD Amsterdam*. Retrieved from: https://www.ggd.amsterdam.nl/publish/pages/897099/meetresultaten_luchtkwaliteit_2018.pdf

Van Doorninck, M. (2018, October 30th). Bestuurlijke reactie op motie (nr. 2018-316) van de voormalige leden Nuijens en Geenen inzake zorgfunctie boerderij de Boterbloem, Business Park Amsterdam Osdorp, Kenmerk 2018-9620. Retrieved from: https://amsterdam.groenlinks.nl/sites/groenlinks.nl/files/downloads/page/Brief%20college%2030%20oktober%202018.pdf

Van Zoelen, B. (2019, August 30th) De Lutkemeerpolder lijkt verloren. *Het Parool*. Retrieved from: https://www.parool.nl/amsterdam/de-lutkemeerpolder-lijkt-verloren~b400ee9c6/

9. Appendix

9.1 Interviews

Interview summary of Florentijn Vos[4] (urban green and ecology expert) (09-06-2020)

What is the Lutkemeer most known for? Certain bird migrations? Maybe a certain strawberry jelly, nice walks, nice smell, open, clean water, nice rollerblade roads, buttercup farm?

The sentiment of the last unaffected clay soils in Amsterdam might be of importance to some people. However, these clay soils are found at many more locations in the region (neighbouring municipalities such as Waterland and Haarlemmermeer). ("Haarlemmermeer is full of clay grounds") Main types of recreation are walking the dog, hiking and biking and enjoying nature.

What kind of protected flora and fauna does the Lutkemeerpolder have?

Fauna:

Observation: there are not many birds on the field

Skylark (protected) is a field bird so that would be lost in the case of a business park.

Eurasian water shrew (protected) lives here as well. When there would be more water in the business park situation than in the current situation, it could even be positive.

Natter jack toad, Eurasian bittern, Birds of prey.

Agricultural field: hare, mole

Bats from the cemetery might go hunting along the edges of open fields, such as the agricultural fields.

[4] Mr Vos spoke to us in personal capacity.

Some wildlife management: hunting hares and geese for damage control for agriculture.

The boterbloem has added a "paddenpoel" and some trees to the field.

How do the ecosystems in the lutkemeerpolder tie into the rest of Amsterdam? (for example: corridors, breeding habitat) Especially concerning the national ecological network and the groene as.

The agricultural fields are surrounded by nature: De Raesberg, hondenuitlaatgebied Lutkemeer, Herdenkingspark Westgaarde. The role of the agricultural field is ecologically not as significant as these parks. However, it might function as a connection between these areas. Building a business park could cause fragmentation of these ecosystems, by acting as a physical or light barrier.

What would be the effect of turning the Lutkemeerpolder into a "bio-polder"?

When a *biopolder* is realised, also then there must be a clear overall vision. So, avoid a situation where everybody makes his or her own plan without looking at the bigger picture. There should be unambiguous nature management and green design.

Would the business park influence the suitability of the area as an ecological network?

Building a business park, doesn't necessarily have to be bad but certain things should be taken care of:

- Light pollution might be a problem for bats
- Sightlines and architecture should integrate the landscape ("no shoeboxes")
- No "schaamgroen" but serious efforts to integrate green into the buildings

How does the presence of the Lutkemeerpolder tie in with the housing value of the area?

There are not many houses (35 households) in the Lutkemeerpolder, so it is quite hard to tell what the role of the green is on house prices. Especially since houses in Amsterdam are expensive anyway. There are however some houses that have a direct view on the

potential business park, so these could be affected.

Suggestions for data on recreation: Grote Groenonderzoek Amsterdam and Recreatieschap Noord-Holland, locatie Spaarnwoude.

Interview summary of Alies Fernhout of *Behoud lutkemeer*

General

Question 1: Do you have numbers for how many visitors the polder (proxy the farm) has? We are missing this data and that makes quantifying difficult.

Answer: The number of visitors certainly increased during the Corona epidemic. I guess around 300 visitors per day.

Question 2: Besides agricultural products, what does the area have to offer in your opinion? (open question about cultural services)

Answer: The area was designated for food production ('expansion of Amsterdam plan') and in 1865 the polder was made. Besides the Boterbloem is also used as a care farm. The area itself and its open landscape is valuable to people. It also serves as a green buffer between the city and the airport (Schiphol). Lastly, the opportunity to shop local and small scale produced vegetables, and pick them by yourself is unique.

De Boterbloem (11ha)

Agriculture

Question 1: What is the yearly production of crops? We read in a previous group's report that yearly production was 9 tons of barley, 6 tons of marrowfat peas and 2 tons of mustard seeds. Is this data still accurate?

Answer: we have numbers of last year, right now already ¾ of the land is converted into grass as building preparation.

Question 2: Do you know what kind of crops the other farms in the Lutkemeerpolder produce (and how much?). We would like to know this to calculate the total agricultural value of the polder.

Answer: the first farm produces mainly wheat, potatoes (grass) and the second farm produces wheat, sugar beets, maize. There is no livestock in the Lutkemeerpolder.

Question 3: Do you use irrigation for your crops/where does the water come from which you use to water the crops? How much water do you use each year or per hectare? Do you know this for the surrounding farms as well?

Answer: No/little irrigation is used in the Lutkemeerpolder. As it is a polder, the groundwater level is kept stable by the waternet. We only irrigate young crops sometimes.

Question 4: How does the Boterbloem and surrounding farms fertilise their land?

Answer: the Boterbloem uses left overs of champion production, but mainly for the ground structure (not much fertiliser use). Furthermore, we use the goat and chicken faeces as fertiliser. Other farms do use artificial fertilisers.

Question 5: Do you perform conservation tillage?

Answer: Not at the moment, but would like to do that in the future.

Care/education

Question 1: In what way do you believe the farm has 'social value': how does the farm contribute and add value to society?

Answer: It contributes by being a care farm. Furthermore, we also provide some catering. People can drink some coffee or tea in our building, we also host meetings or gatherings, we play movies in the orchard (mainly neighbouring people visit this activity).

Question 2: How many (psychiatric) clients does the farm accommodate per day as part of its care farm function? How much does the farm get paid per person per day? Do you believe this is an accurate representation of the intrinsic value of this service?

Answer: We normally help 5 people per day and they will normally stay at the farm from 10:00 - 15:00. We do this every day of the week apart from Tuesday and the weekend. No specific answer on payment, nor on the intrinsic value.

Question 3: Have you organised educational activities for children on the farm (pre-Corona)? If so, what was the content of these activities and how many children visited? + what other activities do you organise?

Answer: Not recent educational activities. Normally we organise a potato harvest day, we have a children's theatre in the orchard, in the future we would also like to make a small exhibition about (organic) farming.

Biopolder

Question 1: Are the plans for the *Biopolder* only for 'de Boterbloem', or have other farms in the Lutkemeerpolder also stated to be willing to cooperate?

Answer: The Boterbloem is an organic farm, the surrounding farms are not. In the *biopolder* plan, new farmers will come which will farm in a more cooperative way. There will also be room for part time farmers.

Question 2: In what way will the agricultural activities in the *Biopolder* scenario differ from 'business as usual' at 'de Boterbloem'? In the future bio polder plan, what crops will you grow? Will there also be more trees for the collection of timber or willow?

Answer: Partly the same crops will be farmed as we do now, partly some agroforestry or market garden style will be used for production. More small trees or rows of fruit trees will be planted to serve as a windbreaker.

Question 3: Would the 'Tuinen van West' concept be used as an inspiration source?

Answer: No, we are however part of the 'tuinen van west' but we will focus on the urban agriculture/local production of food/ educational role/ recreational role. Plus, in the *biopolder* plan, plots of land will not just be given away for any entrepreneurial activity (which is more or less the case in the 'Tuinen van West').

Business park

Question 1: Will 'de Boterbloem' be able to carry out any activity in case the business park is built, or will the farm disappear completely?

Answer: The Boterbloem will probably remain only in a slimmer size. (2 instead of 11 hectares) Plus we will have to focus more on the catering/shop/care side in order to keep ends meet.

Question 2: Do you know how the activities of the other farms will change if the business park is built?

Answer: the houses will remain, but the farms will disappear.

Question 3: What work has already been carried out for the business park?

Answer: they changed the existing water ways, put up screens to keep the 'natterjack toad' away and save (as this is a protected species). They have sown grass on the fields as preparation. All above mentioned things had to be and are reversible.

9.2 Recreation

Calculations

*we round to full numbers and for restults to the nearest hundred

Inhabitants Amsterdam:	862956	
6% of inhabitants visited de Tuinen van West/ Osdorper Binnenpolder in the past 12 months	51777	
31% of this area is the Lutkemeerpolder. So number of visitors estimated to be proportional to this fraction:	16051	# people visiting the polder with different frequency

As a representative sample:

Frequency visit to recreation areas	No. visits a year	% of visitors	No. of Lutkemeervisitors	No. of visits
daily (7)	365	0.02	321	117172
A few times a week (3)	156	0.05	803	125198
A few times a month (3)	36	0.14	2247	80897
A few times a year (10)	10	0.29	4655	46548
Less than a few times a year (5)	5	0.07	1124	5618
I don't know (0)	0	0	0	0
Never (0)	0	0.44	7062	0
			# visits per year:	**375432**
			per day	1029
			per month	7220

Calculation number of visitors and visits for point-estimate

Travel Cost Method	**Data**
T = travel time (in hours)	0.358
w = average wage rate (€/hour)	36.5
D = return distance (in km)	10.23
v = marginal vehicle operating costs	0.19
Ca = cost of Admission to asset	0
Va = average number of visits per year	375432.4596
V = value per visit	calculated
Assumption:	50% of people come by car
General formula:	V = (((T x *w*) + (D x *v*) + Ca)
Adapted formula to driving and free transportation:	V = (0.5Va*(T*w)+(D*v))+(0.5Va*(T*w))
Simplified:	V= (0.5*V1)+(0.5*V2)
V1=	7
V2=	7
V=	14
V*Va=	**5266072** €/year

Calculation of value from point-estimate

Inhabitants Amsterdam:	862956	
6% vistied de Tuinen van West/ Osdorper Binnenpolder in the past 12 months (Municipality of Amsterdam, 2018)	51777	
31% of de Tuinen van West area is Lutkemeerpolder	16051	
low-end estimate of Lutkemeerpolder being only 2/3 as popular as other areas	10594	# people visiting the polder with different frequency

As a representative sample:

Frequency visit to recreation areas	**No. of visits per year**	**Percentage of visitors**	**No. of Lutkemeervisitors**	**No. of visits**
daily (5)	260	0.02	212	55087
A few times a week (2)	104	0.05	530	55087
A few times a month (2)	24	0.14	1483	35595
A few times a year (3)	3	0.29	3072	9216
Less than a few times a year (2)	2	0.07	742	1483
I don't know (0)	0	0	0	0
Never (0)	0	0.44	4661	0
			# visits per year:	**156468**
			per day	429
			per month	3009

Calculation of lower-bound estimate for visitors and visitor numbers.

Travel Cost Method	**High with low number of visitors**	**Low with low number of visitors**
T = travel time (in hours)	0.358	0.358
w = average wage rate (€/hour)	36.5	18.25
D = return distance (in km)	10.23	10.23
v = marginal vehicle operating costs	0.19	0.19
Ca = cost of Admission to asset	0	0
Va = average number of visits per year	156468.1788	156468.1788
Assumtions low-end estimate:		80% of visitors walk/bike to Lutkemeerpolder Half of wage as lower-end opportunity cost
Adapted formula:		
V=(0.2Va*V1)+(0.8Va*V2)		
V1=(T*0.5w)+(D*v)	8.471	
V2=(T*0.5w)	6.527	
V=	7	**V=(0.2Va*(T*0.5w)+(D*v))+(0.8Va*(T*0.5w))**
V*Va	**1082158 €/year**	

Calculation of value for lower-bound estimate.

Inhabitants Amsterdam:	862956	
6% of inhabitants visited de Tuinen van West/ Osdorper Binnenpolder in the past 12 months	51777	
31% of this area is the Lutkemeerpolder, which is the most populat destination in the de Tuinen van West area	16051	# people visiting the polder with different frequency
based on landuse of the Tuinen van West, Lutkemeerpolder has most recreation areas and thememorial park. The rest of the Tuinen van West area is mostly pasture and allotment gardens. Hence deduction Lutkemeerpolder 30% more popular for recreation	20866	

As a representative sample:

Frequency visit to recreation areas	**No. visits a year**	**% of visitors**	**No. of Lutkemeervisitors**	**No. of visits**
daily (7)	365	0.02	417	152324
A few times a week (3)	156	0.05	1043	162757
A few times a month (3)	36	0.14	2921	105166
A few times a year (10)	10	0.29	6051	60512
Less than a few times a year (5)	5	0.07	1461	7303
I don't know (0)	0	0	0	0
Never (0)	0	0.44	9181	0
			# visits per year:	**488062**
			per day	1337
			per month	9386

Calculation of upper-bound estimate of visitors and visitor numbers.

Travel Cost Method	**Data**
T = travel time (in hours)	0.358
w = average wage rate (€/hour)	36.5
D = return distance (in km)	10.23
v = marginal vehicle operating costs	0.19
Ca = cost of Admission to asset	0
Va = average number of visits per year	488062

$$V = (((T \times w) + (D \times v) + Ca)$$

V=	15
V*Va	**7320217** €/year

Calculation of upper-bound value estimate

Validity tests for number of visitors to the Lutkemeerpolder

We were concerned about the internal validity of our method used to deduce visitor numbers to the Lutkemeerpolder. We therefore performed a number of validity checks you can find below to validate the calculated number of 375432 visitors a year critical to the travel cost valuation model.

Firstly, to check if our method to deduce visitor numbers yielded a just estimate for the number of visitors of the Lutkemeerpolder, this method was also applied to a different green area where visitor numbers were already available: *Amsterdamse Bos*. The yearly number of visitors of the most popular recreation area near Amsterdam was already known, so it could be compared to our own result. Our method from the Gemeente Amsterdam data resulted in 6 459 000 visitors of the Amsterdamse Bos, where the actual known number is around 6 000 000 in 2010 and has only increased since then (Gemeente Amsterdam, 2010). Since these numbers are close, this check of the validity of our method is positive. This confirmed that the used method gives a good estimate of the yearly number of visitors for the recreation area of the Lutkemeerpolder.

As a second internal validity check, we searched for a similar recreational area to the Lutkemeerpolder. In 2016, a report was published by NBIC-NIPO on the number of visitors of recreation areas in the province of North-Holland. Below, some of these numbers of recreation areas in the Amsterdam region are presented. Given the population increase in the Amsterdam region, it is likely that most of these numbers would currently be higher.

The number of visitors of recreation areas in the province of North-Holland, adapted from https://www.noord-holland.nl/Onderwerpen/Natuur/Links/Recreatiegebieden_bezoekersonderzoek_Noord_Holland_2016.pdf

Recreation area	**Unique visitors (x 1,000)**	**Number of visits (mln)**
Amstel, oever, dijk en polders	424	1.5-2
Amstelmeer	146	0.25-0.5
Amsterdamse Bos	1,119	5-6
Amsterdamse Waterleidingduinen	796	1.5-2
Diemerbos/ overdiemerpolder	141	0.5-0.75
Gaasperplas	286	1.5-2

't Twiske	510	2-3
Vondelpark	1,208	8-9

Of these recreation areas in the Amsterdam region, Het Diemerbos seems to be the best comparison to the Lutkemeerpolder, considering the distance from the city centre, proximity to the highway, type of vegetation, land use and the surface area. Also, the popularity of Tuinen van West and Diemerbos seem to be fairly similar according to the Grote Groenonderzoek (Gemeente Amsterdam, 2019).

As a third check, we looked at one of the smaller areas available from the above research. This is Venneperhout with 250,000-500,000 visitors per year and a surface area of roughly 1km2. Given that the Lutkemeerpolder is twice as large and near a big city, which is not the case at the Venneperhout, our reasonably higher visitor number estimate seems justified.

Recreation area	**Unique visitors (x 1,000)**	**Number of visits (mln)**
Lutkemeerpolder	16	0.375

If these three validity checks and corresponding visitor numbers are then compared to the outcome of our visitor calculations for the Lutkemeerpolder, then our estimations seem very reasonable. Also, the Grote Groenonderzoek (Gemeente Amsterdam, 2019), indicated that 3% of the Amsterdam citizens mention the Tuinen van West as the recreation area that they visit most often. This makes it the 7th most popular recreation area in the region among Amsterdam citizens, which would justify the results, although concern was voiced that the number of visitors is too high.

9.3 Regulating

Method valuation of air quality regulation

The conducted analysis is a benefit transfer. Based on the overview 'Kentallen Waardering Natuur, Water, Bodem en Landschap' provided by Ruijgrok & de Groot the highest priority pollutants can be valued based on categories as deciduous-, pine forest, heath and brushwood. The authors note that the estimates would be more accurate when local data is used. Another note is that not all vegetation types, such as pine trees, are measured from the vegetation itself. Some of these values are rough estimates based on other vegetation types. Finally, an overview is missing on some pollutants as ozone or PM2.5 (particulate matter < 2.5 µm). Although the interaction of ozone is mostly dependent on the supply from Europe or global interactions, PM2.5 is noted as a local pollutant and is being monitored near main roads by GGD Amsterdam (S.C. van der Zee et al., 2019).

For the current situation only the wet nature areas, the parks, public gardens and 30-70% of the area of the cemetery is used. The prices per ha are based on the guidelines provided by Ruijgrok & de Groot to estimate the local vegetation types. Here the agricultural areas are considered to not emit nor uptake NOx, SO2 and PM10.

This analysis does not include a valuation of air pollution caused by the business park but rather an overview of the expected air quality concentration changes is provided as mentioned in the zoning plan.

	NOx	**SO2**	**PM10**	**Total benefit (€/ha/yr)**
Deciduous				
Uptake (kg/ha/yr)	205	178	110-190	
Price (€/kg)	7	4	70	
Total (€/ha/yr)	1435	712	7700 - 13300	9847 - 15447
Pine				
Uptake (kg/ha/yr)	205	178	220-380	
Price (€/kg)	7	4	70	
Total (€/ha/yr)	1435	712	15400 - 26600	17550 - 28747
Heath				
Uptake (kg/ha/yr)	100	unknown	50	
Price (€/kg)	7	4	70	
Total (€/ha/yr)	700	unknown	3500	4200

Brushwood/ reed				
Uptake (kg/ha/yr)	10	unknown	10	
Price (€/kg)	7	4	70	
Total (€/ha/yr)	700	unknown	700	1400

Pollination Calculation

The yield of pollination is based on percentages from literature which is described in the method of pollination valuation.

Crop type	**Scenario 1 yearly yield (t)**	**Scenario 2 yearly yield (t)**	**Biopolder yearly yield (t)**	**Market price (€/t)**	**Yearly value**	**Yearly value high**	**Yearly value biopolder**
Grass	0	0	0	€57,00	€0,00	€0,00	€0,00
Wheat	18,75	30,75	31,25	€195,00	€3.656,25	€5.996,25	€6.093,75
Potato	60,75	60,75	101,25	€140,00	€8.505,00	€8.505,00	€14.175,00
Sugar beet	49,8	136,95	103,75	€36,00	€1.792,80	€4.930,20	€3.735,00
Mais	28,2	84,6	47	€50,00	€1.410,00	€4.230,00	€2.350,00
Barley	1,35	1,35	2,25	€340,00	€459,00	€459,00	€765,00
Capuchins	0,9	0,9	1,5	€1.960,00	€1.764,00	€1.764,00	€2.940,00
Mustard seed	0,3	0,3	0,5	€2.100,00	€630,00	€630,00	€1.050,00

The net value of the services is calculated by taking the sum of all crop yields multiplied with the market price.

Biological Control

The yield of biological control is based on percentages from literature which is described in the method of biological control valuation.

Crop type	Scenario 1 yearly yield (t)	Scenario 2 yearly yield (t)	Bio-polder yearly yield (t)	Market price (€/t)	Yearly value low	Yearly value high	Yearly bio-polder
Grass	16,1	0	0	57,00	917,70	0,00	0,00
Wheat	12,5	20,5	21,875	195,00	2.437,50	3.997,50	4.265,63
Potato	40,5	40,5	70,875	140,00	5.670,00	5.670,00	9.922,50
Sugar beet	33,2	91,3	72,625	36,00	1.195,20	3.286,80	2.614,50
Mais	18,8	56,4	32,9	50,00	940,00	2.820,00	1.645,00
Barley	0,9	0,9	1,575	340,00	306,00	306,00	535,50
Capuchins	0,6	0,6	1,05	1.960,00	1.176,00	1.176,00	2.058,00
Mustard seed	0,2	0,2	0,35	2.100,00	420,00	420,00	735,00

The net value of the services is calculated by taking the sum of all crop yields multiplied with the market price.

9.4 Provisioning

Agriculture

Computation of yield

To calculate the value of the agricultural output, the yearly yield was the first variable to be determined for all farms except for 'de Boterbloem', whose yield was known from a previous report. All farms in the Lutkemeerpolder use a rotational system for crops. To determine annual crop yield, the number of hectares a farm had available were divided over all crops it used in the rotation. For example, farm 3 grows wheat and potatoes on 15 hectares of land. Therefore, for the annual yield of that farm, we assume that 7,5 ha are dedicated to wheat and 7,5 ha are dedicated to wheat yearly.

Average annual yield per hectare was determined by finding sources of average yield numbers in the Netherlands in recent years. The sources for each average yield number is listed below the table.

	Crops	**Number of hectares**	**Yearly yield (t/h)**	**Total yearly yield (t)**
Business park area				
Boterbloem (11ha)	Capuchins	-	-	6
	Mustard seed	-	-	2
	Barley	-	-	9
Farm 2 (13ha)	Corn	4	47[i]	188
	Wheat	5	10[ii]	50
	Sugar beet	4	83[iii]	332
Farm 3 (15ha)	Wheat	7,5	10[ii]	75
	Potato	7,5	54[iv]	405
Nature area: scenario 1				
Farm 4 + 5 (23 ha)	Grass	23	11[v]	253
Nature area: scenario 2				
Farm 4 + 5 (23 ha)	Corn	8	47[i]	376
	Wheat	8	10[ii]	80
	Sugar beet	7	83[iii]	581

[i] In het zuiden dit jaar gemiddeld 34 ton mais per hectare. (2018, November 6). *Veeteelt.nl*. Retrieved from https://veeteelt.nl/nieuws/het-zuiden-dit-jaar-gemiddeld-34-ton-mais-hectare

[ii] Rijksdienst voor Ondernemend Nederland (2020). Prognose gemiddelde opbrengst per hectare 2019 versus oogst 2018 – situatie 30 januari 2020. Retrieved from: https://www.rvo.nl/sites/default/files/2019/03/Raming-oogst-2019-gemiddelde-opbrengst-per-hectare.pdf

[iii] Engwerda, J. (2019, December 31). *Boerderij.nl.* Opbrengsten suikerbieten onder het gemiddelde. Retrieved from https://www.boerderij.nl/Akkerbouw/Nieuws/2019/12/Opbrengsten-suikerbieten-onder-het-gemiddelde-521094E

[iv] Quiesen, G. (2019, October 8). Gemiddelde aardappelopbrengst circa 14,8 procent hoger dan 2018. *Akkerwijzer.nl.* Retrieved from

https://www.akkerwijzer.nl/artikel/221660-gemiddelde-aardappelopbrengst-dit-jaar-circa-14-8-procent-hoger-dan-2018/

[v] Colenbrander, E. (2018, September 15). Gemiddelde grasopbrengst blijft steken op 10,8 ton. *Nieuwe Oogst*. Retrieved from https://www.nieuweoogst.nl/nieuws/2018/09/15/gemiddelde-grasopbrengst-blijft-steken-op-108-ton

Computation of value

When final yield was determined, we calculated the yearly value per crop by multiplying the yearly yield by the market price for both scenarios. Computation is outlined below, with sources for the market prices listed below the table. Significantly higher prices for barley, capuchins and mustard seed is due to the organic production of these crops.

Scenario 1

Crop type	**Yearly yield (t)**	**Market price (€/t)**	**Yearly value**
Grass	161	€57,00[i]	€9.177,00
Wheat	125	€195,00[ii]	€24.375,00
Potato	405	€140,00[iii]	€56.700,00
Sugar beet	332	€36,00[iv]	€11.952,00
Corn	188	€50,00[v]	€9.400,00
Barley (O)	9	€340,00[vi]	€3.060,00
Capuchins (O)	6	€1.960,00[vii]	€11.760,00
Mustard seed (O)	2	€2.100,00[vii]	€4.200,00
		Total value	**€130.624,00**

[i] Kosten kuilgras: Wat is de prijs per ton? (2020, March 23). Retrieved June 23, 2020, from https://veevoer.nu/kosten-kuilgras-wat-is-de-prijs-per-ton/

[ii] Marktprijzen Granen-nederland. (n.d.). Retrieved June 23, 2020, from https://www.nieuweoogst.nl/marktprijzen/granen-nederland

[iii] Wageningen University & Research. (n.d.) Agrimatie - informatie over de agrosector. Retrieved June 23, 2020, from https://agrimatie.nl/Prijzen.aspx?ID=15125

[iv] Doddie, H. (2020, February 12). Cosun bepaalt bietenprijs op 36,05 euro per ton. *Nieuwe Oogst*. Retrieved from

https://www.nieuweoogst.nl/nieuws/2020/02/12/cosun-bepaalt-bietenprijs-op-3605-euro-per-ton

[v] Voorhorst, J. (2019, October 10). Vlotte handel snijmais met stijgende prijzen. *Nieuwe Oogst*. Retrieved from https://www.nieuweoogst.nl/nieuws/2019/10/10/vlotte-handel-snijmais-met-stijgende-prijzen

[vi] Value computed by multiplying the price of barley found at [ii] with the 100% premium for organic production (seen in the price of organic wheat, which is €380 according to Van der Boom, N. (2018, May 22). Prijzen biologisch graan fors hoger. *Boeren Business*. Retrieved from https://www.boerenbusiness.nl/granen-grondstof/artikel/10878607/prijzen-biologisch-graan-fors-hoger

[vii] Retrieved from contact with Machandel B.V., buyer of the produce of 'de Boterbloem'

Scenario 2

Crop type	Yearly yield (t)	Market price (€/t)	Yearly value
Wheat	205	€195,00	€39.975,00
Potato	405	€140,00	€56.700,00
Sugar beet	913	€36,00	€32.868,00
Corn	564	€50,00	€28.200,00
Barley (O)	9	€340,00	€3.060,00
Capuchins (O)	6	€1.960,00	€11.760,00
Mustard seed (O)	2	€2.100,00	€4.200,00
		Total value	**€176.763,00**

Lastly, to compute the value of the agricultural production in the business park scenario, we used 3/11 of 'de Boterbloem's production in addition to the part of the polder that will become a nature area (for simplicity reasons we assume it will remain agriculture.

The annual production value of 'de Boterbloem' amounts to €19.020,00. Taking 27% of this results in a value of €5.187,27. To this, we add the range of values of the production in the northen part of the polder, with as a lower bound only production of grass (€9.177,00) and as an upper bound the high-effort scenario of production of wheat, corn and sugar beet (€55.316,00). This results in a range of €14.364,27 - €60.503,27. Finally, we adjust this for climatic events by using the 10% discount and premium: €12.927,85 - €66.553,60.

Irrigation calculations

Picture of the Rijn-West drainage basin from van der Meer (2020)

Tables

Total water usage by crop land in Rijn-West (x1000 m3)				
	2017	2018	2017%	2018%
Drink water	326	369	0.115	0.028
'gietwater'	0	0	0	0
Ground water (irrigation)	1250	5149	0.440	0.391
Surface water (irrigation)	1179	7594	0.415	0.576
Ground- and surface water for flood irrigation (drenking)	86	53	0.030	0.004
Total	2841	13165	1	1

Average total water usage per crop farm (Rijn-West) in m3		
	2017	*2018*
Total average water usage	1821	8322
Of which drink water	209	233
Total-drink water	1612	8089

Total irrigated acreage in ha		
Rijn-West	*2017*	*2018*
Irrigated at least ones	599	41364
Total irrigated acreage	1248	140883
Times irrigated	2.08	3.41
NL		
Irrigated at least ones	7778	296856
Total irrigated acreage	16665	1150359

Percentage and times Irrigation (NL) in ha		
	2017	*2018*
Percentage of irrigated land (compared to total land)	0.008	0.305
How many times irrigated land was irrigated	2.142	3.875

Total acreage of agricultural land in ha			
	Total acreage	Number of farms	Hectares per farm
Total arable land	1833564	-	-
Acreage cropland*	446427	10685	41.8
'overige'	25454	976	26.1
Ijsselmeerpolders/N-Holland	69733	1229	56.7
Rivierklei gebied	11009	351	31.4
Average of the three areas	-	-	38.1

** includes crops, excludes maize for livestock and grassland*

Average total water usage per crop farm, per origin (in m3)		
	2017	2018
Drink water	209.0	233.3

'gietwater'	0	0
Ground water (irrigation)	801.2	3254.8
Surface water (irrigation)	755.7	4800.4
Ground- and surface water for flood irrigation (drenking)	55.1	33.5
Total	1821	8322

Average total water usage per crop farm, per origin and per hectare (m3/ha) + price							
	2017	2018	Price/ m3	Price/ha 2017	Price/ha 2018	Total costs 2017	Total costs 2018
Drink water	5.5	6.1	0.86	1.70	1.90	293.10	327.19
'gietwater'	0	0	-	-	-	-	-
Ground water (irrigation)	21.1	85.5	0.61*	565.00	2295.24	796.13	3234.20
Surface water (irrigation)	19.9	126.1	0.46*	401.86	2552.72	566.26	3597.01
Ground- and surface water for flood irrigation (drenking)	1.4	0.9	0.54*	34.41	20.91	48.49	29.47
Total	**47.8**	**218.6**	-	**1209.28**	**5101.07**	**1703.98**	**7187.87**

** expert chosen values.*

Total irrigation cost per scenario				
	Total costs status quo/biopolder 2017	Total costs status quo/biopolder 2018	Total costs in business park 2017	Total costs in business park 2018
Drink water	293.10	327.19	122.91	137.21
'gietwater'	-	-	-	-
Ground water (irrigation)	796.13	3234.20	333.86	1356.28
Surface water (irrigation)	566.26	3597.01	237.46	1508.43
Ground- and surface water for flood irrigation (drenking)	48.49	29.47	20.33	12.36

Total	**1703.98**	**7187.87**	**714.57**	**3014.27**

Detailed description of the calculations.

Step 1: retrieving information about the water usage of (crop)farms in the Netherlands, specifically of the Rijn-west drainage basin. (van der Meer, 2020) Retrieving information about the size of crop farms in the Netherlands, specifically in the overlapping area of the Rijn-west drainage basin (Smit and Jager, 2018).

Step 2: calculation of the percentage of the origin of the water for 2017 and 2018. As a control step all percentages were added, which gave a value of 100 percent or 1.

Step 3: calculation of the average acreage per farm by dividing the total acreage by the number of farms. Then the three overlapping areas of Smit & Jager (2018) compared to the Rijn-west drainage basin were averaged leading to an average size of 38 hectares per farm, including crops and excluding maize for livestock feed/grass land.

Step 4: calculating the average usage of water for crop farmers per origin of the water. In the literature the water usage per origin or per crop farmer was given, but not both. The percentages as calculated in step 2 were multiplied with the average water usage per crop farm, resulting in the average usage of water for crop farmers per origin of the water. As a control step the calculated use of drink water was compared with the use as provided in the literature. This control step was repeated with the total amount of water (see red numbers).

Step 5: the values obtained in step 4 were divided by the average areal size, as calculated in step 3, resulting in the average water usages (m3) per crop farm per origin of the water and per hectare.

Step 6: the values of step 5 could be multiplied by the cost price of the different sources of water, resulting in a price/hectare.

Step 7: the prices from step 6, could be multiplied by the number of hectares in the Lutkemeerpolder (62 ha) to determine the current and biopolder value. For the irrigation value in the businesspark scenario, the prices of step 6 could be multiplied by the remaining agricultural land (26 ha).

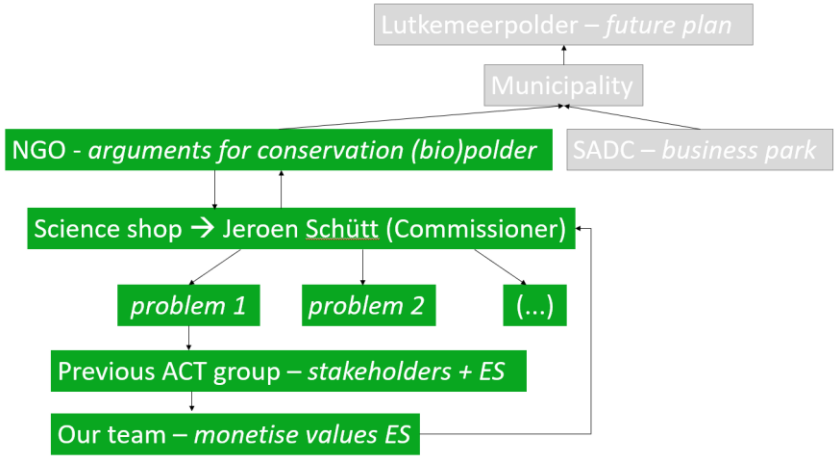
Remarks on calculations

Size of agricultural land per farm may differ. We took the number for agricultural surface per farm as mentioned in Smit & Jager (2018), this however does not include crop land

that is used for grass or maize for livestock feeders. Therefore, the real number of hectares per farm may be larger than mentioned in our calculations and therefore the price of irrigation may be overestimated.

Cost price of ground and surface water could not be obtained with certainty; therefore a rough estimate of the values was made in order to prevent an overestimation (which would have certainly happened if the drink water price was used for all water). However, and over or under estimation of the real value is still possible.

9.5 Stakeholders



Schematic overview of stakeholders involved in the problem associated with the Lutkemeerpolder

The stakeholders that relate to the broad problem are those that have an interest in the outcome of the research done by the WUR Science Shop. Although our consultancy report will mainly influence the commissioner, the aggregate output of the commissioner impacts a variety of stakeholders interested in the zoning plan of the Lutkemeerpolder. These have been schemed. The previous Academic Consultancy project of Wageningen University and Research has extensively worked on identifying and categorising further stakeholders and their interests (see report by Bos et al., 2019).

9.6 Land use map (LGN7)