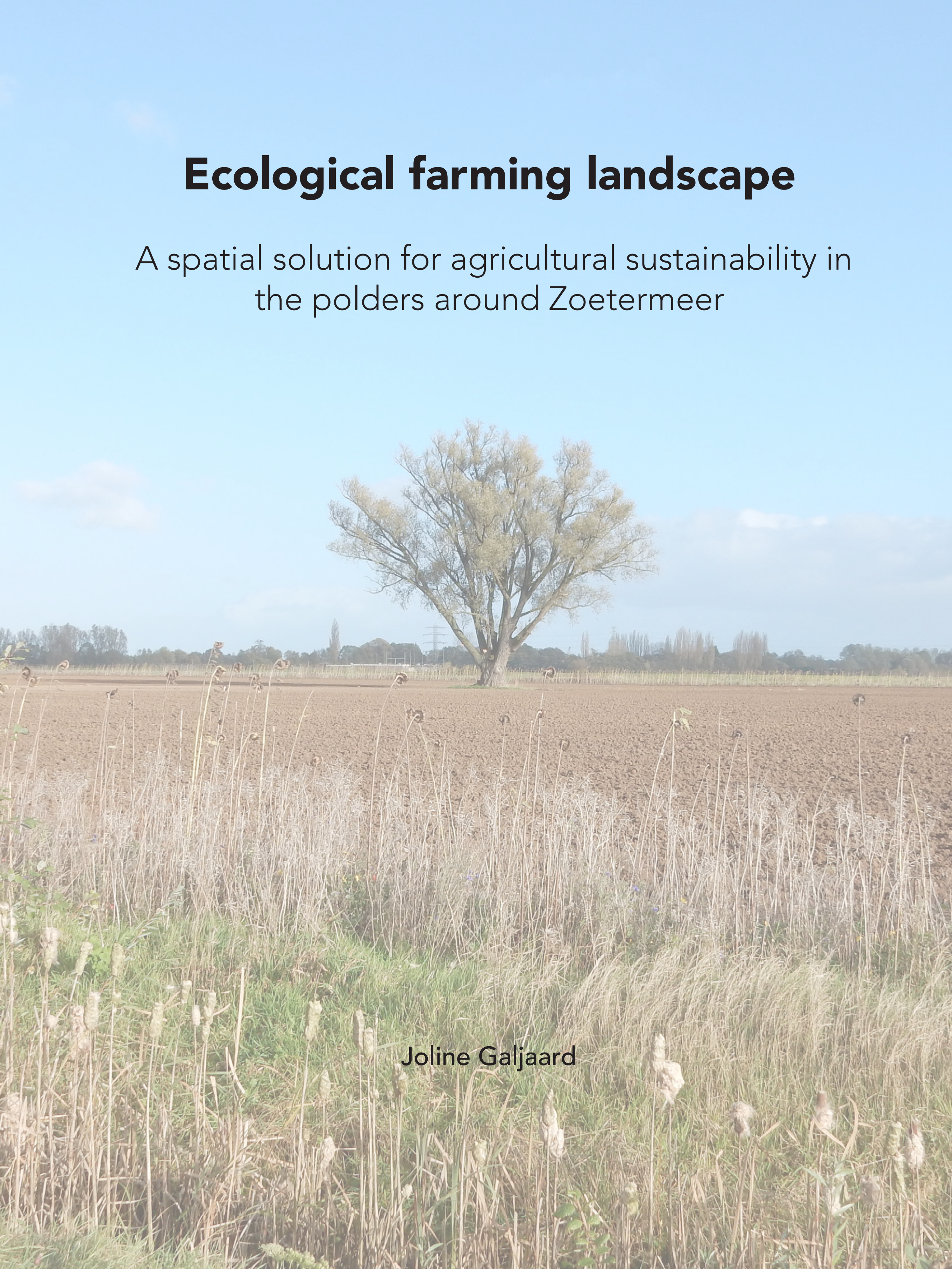
Ecological farming landscape

A spatial solution for agricultural sustainability in the polders around Zoetermeer



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PREFACE

The graduation studio at Landscape Architecture gives you the freedom to choose your own subject. That enables you to find a topic that really sparks your interest, which is important as you need to work on it for at least ten months. For me this topic was sustainable agriculture. I have always seen the current agriculture as a (large) contributor to climate change, which I find a very urgent issue. Seeing articles about the problems with factory farms, declining biodiversity and soil degradation strengthened my feeling of urgency.

These are subjects I already engage with for a longer time, linked to personal interests as permaculture, food forests and regenerative agriculture. During an internship I was involved in a project about the Flevopolder, where I learned more about the famers' side of the story. This made me realise the problem is bigger and more complex than just the contribution to climate change, but also has a large social and economic aspect.

Of course I wondered whether I could do something with sustainable agriculture as a landscape architect. Doing some research, I soon discovered it might be even necessary to look at the issues from a landscape perspective as well. The spatial impact the agriculture has on the landscape (and a bit the other way around), asks for a spatial view on the subject. It formed the starting point of my project.

This Master thesis was made possible with the helpful guidance of my two mentors. Therefore I would like to thank Gerdy Verschuure for her personal mentoring and critical view on the project and Ulf Hackauf for his enthusiasm and inspirational input. Furthermore I would like to thank my friends and family who have been a great support in the last year.

ABSTRACT

A large part of the Dutch landscape is used by agriculture, and the two are strongly related. However, the current agricultural system has problems with sustainability, leading for example to the loss of biodiversity, soil degradation, water pollution and high emissions of greenhouse gases. Besides ecological issues, economic and social problems are present as well. The current way of farming has turned the landscape in an industrial, monotone area, losing characteristic landscape elements.

The project explores in what way agroecology and ecological principles can provide a sustainable solution to agriculture on the landscape level. The polders around Zoetermeer serve as a case study, showing how the existing landscape can be used as a starting point for the spatial implementation of sustainable farming solutions. Linking ecological principles, problems of sustainability and different areas together, a toolbox for the design of the area is formed. The end result offers a perspective on the functioning and appearance of an ecological farming landscape, using the concept of diversity, connectivity and circularity.

Keywords: Agricultural landscape, ecological landscape design, sustainable agriculture, agroecology

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1. INTRODUCTION

1.1 Subject of choice

More than half of the Dutch land is used for agriculture (CBS, 2016), but it is a part that is often not at the focus of landscape design. Agricultural land is the land of the farmer after all, where production and efficiency are central. Like other industries it has negative consequences. You cannot follow the news for a week without hearing something (negative) related to agriculture (see figure 1.1).

Figure 1.1: Some recent newspaper headlines about agriculture
(NOS, NRC & Trouw)

Especially livestock farming got a lot of attention in 2017. The fipronil case and the high amount of barn fires killed thousands of animals. Farmers in the south of the Netherlands were meanwhile involved in the 'manure fraud', highlighting the problems with the surplus of manure in the country. The amount of manure and chemical fertilizer put on the land is restricted, as it leads to problems of eutrophication and acidification in water and nature areas. However, these restrictions result for the farmer in more work and costs. Furthermore, a new research revealed that the amount of insects heavily declined over the last years. The use of pesticides in agriculture is named as one of the main causes. Also the declining habitat due to the increased scale and monoculture in farming contributes to the problem. These prevailing issues only show a part of the ecological problem, which covers large problems like climate change and land degradation as well. Apart from ecological problems, the agriculture also has to deal with social and economical issues. Farmers that aren't able to make ends meet, a lack of new farmers, CAP (Common Agricultural Policy) reformation and critical consumers are all occurring issues.

A transition in the farming sector is needed, to move to a more sustainable agricultural system. How can landscape architecture contribute to this goal? Agriculture is presumed to be strongly related to the landscape. It does not only use a large part of the Dutch land, it also has a lot of impact on the landscape. Think about the straight open landscape of Flevoland (see figure 1.2), or the greenhouses in the Westland (see figure 1.3). The landscape itself had its impact on the agriculture as well. The soil type and location often determined the sector, like the grassland in the peat areas (see figure 1.4).

Figure 1.2: Crop farming in Flevoland (Swart, 2013)

Figure 1.3: Greenhouse horticulture in the Westland (de Jong, 2012.)

Figure 1.4: Cow farming in the peat area (STOWA, n.d.)

Considering their link, changing the agricultural system will also lead to changes in the landscape. The landscape can even facilitate the change. The 'College van Rijksadviseurs' states sustainable agriculture (duurzame landbouw, divers cultuurlandschap) as one of their nine themes, saying:

*"Wij willen bijdragen aan het verkennen van de ruimtelijke impact hiervan. Ook willen wij het debat over de mogelijkheden van de verduurzaming van de landbouw stimuleren, onder meer door met ontwerpend onderzoek de mogelijkheden van nieuwe arrangementen in het agrarisch landschap te laten zien." (College van Rijksadviseurs, 2017, p.27)**

They are not the only ones seeing landscape architects contributing to solve the problem:

It is remarkable that despite landscape architecture's historical involvement and the value which agriculture represents in a rapidly changing world, that landscape architects have not done more to shape a solution to one of the most fundamental environmental questions facing our world today—How do we design ecologically and culturally sound agricultural systems? (Patterson, 2004, p.86)

The agricultural assignment is inseparable from the Dutch landscape. Intensive farming and overfertilization have led to monotone landscapes, loosing site-specific details and biodiversity. It is as much a spatial assignment as an agricultural one, requiring an integral solution. Designers can translate the sustainable principles invented by others to spatial solutions. Where most of these principles are small-scale and focus on the size of the farm, it is specific the larger scale that can be interesting to look at to integrate both landscape and sustainable agriculture.

*EN: "We want to contribute to the exploring of its spatial impact. We also want to stimulate the debate on the possibilities of sustainable agriculture, among other things by showing, through research-by-design, the possibilities of new arrangements in the agricultural landscape."

1.2 Problem statement

This has led to the following problem statement:

A large part of the Dutch landscape is used and formed by agriculture. The current agricultural system has to deal with problems on ecological as well as on social and economical levels. The intensification and increase in scale have led to soil degradation, a decline in biodiversity and pollution of the environment. This is resulting in a landscape of production, consisting of large-scale and monotone fields without characteristic landscape elements. Additionally, the farmer has problems with coping economically, while the consumer gets more critical about animal welfare and health issues. The current system and its landscape is not sustainable and therefore a transition in the farming sector is needed. Considering the strong link between farming and the landscape, an integral spatial solution for the agricultural landscape on all scale levels is desired.

1.3 Main goal

The project shows a way to translate ideas of sustainable agriculture to a spatial landscape for a regional scale. It connects the large and small scale, using a toolbox of ecological farming principles and ecological landscape concepts.

1.4 Research questions

To come to an integral spatial solution, the following research question and sub-questions should be answered:

How to translate ecological agricultural principles into spatial solutions for the regional landscape to create a more sustainable farming landscape, using the area around Zoetermeer as a case study?

Sub-questions

1. *How is the Dutch landscape related to agriculture?*

2. *What is the problem with the current agriculture and how are these problems related to the landscape?*

3. *What is sustainable agriculture?*

4. *Which elements of sustainable agriculture can be implemented in the landscape?*

5. *How can you apply sustainable agriculture principles using the landscape characteristics of the area around Zoetermeer?*

1.5 Methodology

The study consists of two parts. The first part is a general analysis and research on the theory of landscape and sustainable agriculture. It looks for a spatial link between sustainable agriculture and the landscape, eventually leading to a list of concrete principles that can be used as input for the design. This part can therefore be named as research-for-design. The second part is a case study on the area of Zoetermeer (research-by-design). This case study is a design assignment that uses the general analysis on landscape and agriculture together with the specific site analysis to come up with a sustainable agricultural landscape.

1.6 Choice of area

For the case study and design, the agricultural area around Zoetermeer is chosen (see figure 1.5), a regional area of approximately 15 by 18 kilometres. This is the scale level that turns out to have the most influence on ecological sustainability (further explained in paragraph 5.3). The location is focused on the area around a city, because regional production near cities will be a relevant aspect of future sustainability (paragraph 5.2). Apart from the scale and peri-urban location, this area was specifically chosen because of its diversity, both in landscape, agricultural land use and problems. Therefore it makes a good test location. On top of that, the space between the cities in the Randstad is often not considered as one whole area, but more as residual space. Changing that perspective for the project might give interesting insights.

1.7 Relevance

The graduation project has both scientific and societal relevance. Scientifically, it shows a way to integrate landscape design with agriculture by linking problems, sectors, soil and ecological principles all together. The project tries to combine not only one, but several points of view on sustainability and sets it in the bigger context of the landscape-scale. For society, it is an example on how to create a more socially, ecologically and economically sustainable agricultural landscape. Right now, the emphasis of sustainable agriculture is at farm-level scale, or mainly focussed on one aspect of sustainability. This projects shows how the landscape can contribute to sustainability problems in agriculture.

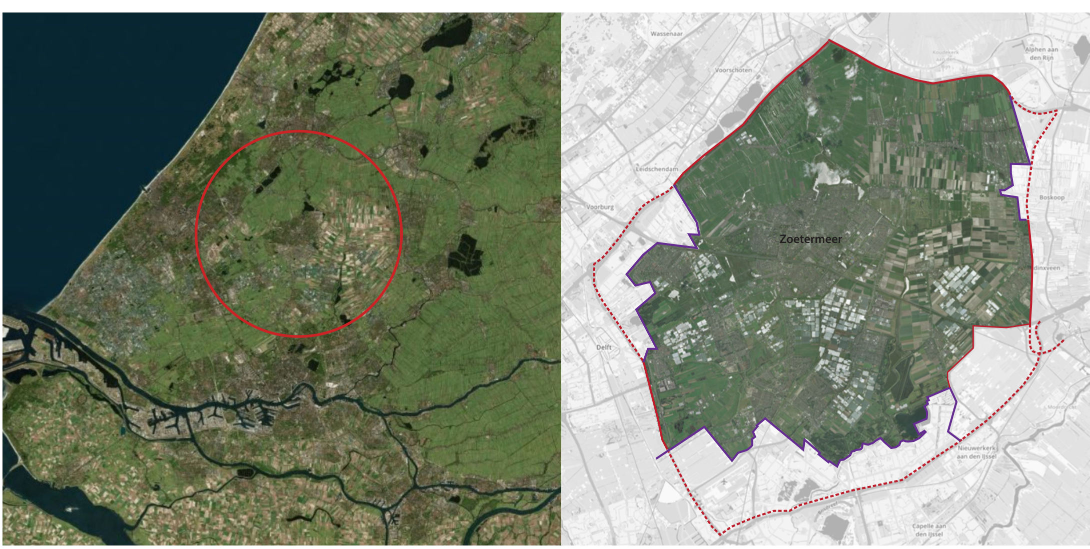


Figure 1.5: Location of the case study area. The polders around Zoetermeer.

2. METHODOLOGICAL FRAMEWORK

2.1 Theory

At the start of this report we need to elaborate on some definitions and statements which form the starting point for the research in the project. These include the relationship between landscape and farming, the definition of sustainable agriculture and the selection of five agricultural sectors.

Landscape and agriculture are related

According to Hendriks & Stobbelaar (2003), agriculture forms landscape and vice versa. Farmers used to use the characteristic landscape features to improve their farming, while after modernization the roles were reversed and agriculture changed the cultural landscape drastically.

However, the definition of 'landscape' is not always clear, as the concept of landscape has several perspectives. It can be seen as a region, as a visual image or as a system. This report will use the definition of the Council of Europe (2000, p.2), describing it as "*an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors.*"

From this definition it becomes clear that the relationship between agriculture and landscape is not as simple as 'landscape forms the agriculture' or 'agriculture forms landscape'. Since the landscape is also the result of the agriculture, both happen at the same time. More beautiful described by Vejre et al, writing:

"Agriculture and landscapes share many characteristics. The actions of agriculture produce cultural landscapes, and landscapes are the theatre of agricultural activities." (Vejre et al, 2007, p.94)

Elaboration on the interaction and the way how agriculture and landscape relate, is part of chapter 3.

Sustainable agriculture

Sustainable agriculture is the focus of the project. The RLI (Raad voor de leefomgeving en infrastructuur, 2013) describes sustainable agriculture using the People-Planet-Profit definition: it should be both socially, ecologically and economically sustainable. This is the approach towards sustainable agriculture of this project as well. A more elaborate definition by the EU defines it as:

"an integrated system of plant and animal production that will last over the long time, satisfy human food needs, enhance natural resources, use efficiently of non-renewable resources, sustain economic viability of farms and enhance the quality of life for farmers and society as a whole. It is the practice of farming using principles which respect ecology and save natural resources." (European Parliamentary Research Service, 2012)

When the description is ordered by aspect of people, planet and profit, it results in a short list on the goals of sustainable agriculture:

People (social sustainability):

- Satisfy human food needs
- Enhance the quality of life for farmers and society as a whole

Planet (ecological sustainability):

- Enhance natural resources
- Use efficiently of non-renewable resources
- Using principles which respect ecology and save natural resources

Profit (economic sustainability):

- Sustain economic viability of farms

These aspects are still very abstract and hard to work with. Therefore, in chapter 5, more concrete ways to approach sustainable agriculture are investigated.

Although the final design will address all aspects of sustainability, the main focus will be on ecological sustainability, since these problems have the strongest connection with the landscape and are (in my opinion) also the most extensive and relevant issues in the Dutch agriculture.

Agricultural sectors

The agriculture in the Netherlands is very diverse, making the problem of sustainability complex. Therefore this project will use a division in agricultural sectors. A lot of different ways of dividing the sectors are made in practice. Some take all the cow dairy farms together, while others make a division between barn animals and grazing animals. Especially the diverse horticulture sector knows many categories, like permanent cultivation, bulb flowers, fruit trees and greenhouse horticulture (Rienks & Meulenkamp, 2009).

Five types of agriculture will be distinguished: crop farming (***akkerbouw***), land-based live-stock farming (***grondgebonden veehouderij***), intensive live-stock farming (***intensieve veehouderij***), outdoor horticulture (***vollegrondstuinbouw***) and greenhouse horticulture (***glastuinbouw***) (see figure 2.1).

Figure 2.1: Icons of the five agricultural sectors that will be used in the project

2.2 Research design

The method follows the structure of the research questions. It can be divided in three phases: the theory research (research-for-design), the case study (research-by-design) and the reflection (research-on-design). Chapters 3 till 6 cover the theory on the subject. This serves as input for the case study which is covered in chapter 7 and 8. Figure 2.2 shows a scheme of the connections between the different chapters. The brown elements are headings that link two elements of the story together, like the problems and the principles. Two intermediate steps that were part of the practical research, but not relevant for the main line of the story, are placed in the appendixes (A2 & A3). Not part of the scheme is chapter 9 with the reflection.

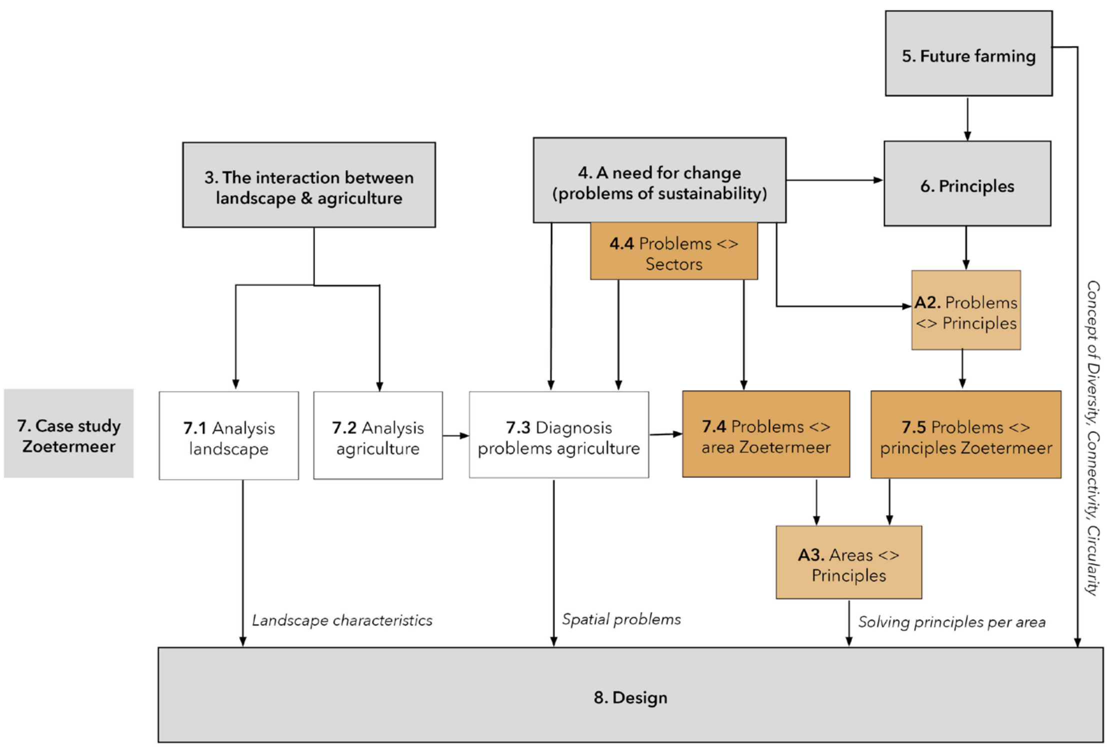


Figure 2.2: Scheme of the connections between the different chapters and sub-headings.

2.2.1 Research

<u>Chapter 3 - How is the Dutch landscape related to agriculture?</u>
The main goal of this chapter is to make clear what the link between agriculture and landscape is, to be able to work with farming for landscape design. Theory is used to define the connections, and also the most important links are being described. A short theoretical research on the current agriculture and its history in the Netherlands is being done and linked to the most important developments with effect on the landscape.

Chapter 4 - What is the problem with the current agriculture and which of these are related to the landscape?
To be able to address the sustainability problems in agriculture, this chapter aims to find and understand the occurring issues regarding agricultural sustainability. A diverse group of sources offers input to generate a list of the problems. Newspapers serve here as a valuable starting point, as they often point out relevant ongoing issues. These problems are structured into categories, further investigated and supported with data. Furthermore, the connections between themselves, the landscape and the different agricultural sectors are explored.

Chapter 5 - What is sustainable agriculture?
This chapter will investigate the meaning of sustainable farming from an abstract definition to concrete solutions. After stating a definition and sustainability goals, theoretical research on how to achieve sustainable agriculture is being done. This theory will start with showing several general strategies, and then focuses on the ecological vision.

Chapter 6 - Which elements of sustainable agriculture can be implemented in the landscape?
From these sustainable systems (chapter 5), sustainable principles are extracted to generate a range of concrete solutions that can directly be linked with the landscape. Solutions resulting from case-studies (theory) and the problems (chapter 4) will be added. Next to ecological principles, circular, economic and social principles are described.

2.2.2 Case study

Chapter 7 and 8 - How can you apply sustainable agriculture using the landscape characteristics of the site?
The location of Zoetermeer is used as a case-study for the application of the research. This case study consists more or less of the same steps from the first phase of the project, only now from the viewpoint of a specific location. Chapter 3 serves as input for the analysis of the landscape and agriculture in the area. Next, a problem diagnosis of the agricultural sustainability problems of Zoetermeer is made, with help of chapter 4. The earlier stated link between the problems and sectors (paragraph 4.4) is used to make assumptions about issues on which no data was found. The found problems are then connected to the specific areas in Zoetermeer and linked to solving ecological principles.

The analysis and synthesis of the case study then serve as input for the design in chapter 8, as can be seen in figure 2.2 as well.

2.2.3 Reflection

Chapter 9
Finally, the results will be evaluated, to see how it answers the main research question, how it solves the problems found on this location and how the research can be used for other locations.

3. THE INTERACTION BETWEEN LANDSCAPE & AGRICULTURE

This chapter covers the interaction between landscape and agriculture to answer the first research question: *How is the Dutch landscape related to agriculture?*
It is already stated that a link between the two exist and this assumption forms the basis of the project. However, to be able to work with this relationship for a design, it is necessary to know what this link means in concrete, how the two are related.

The chapter starts with the aspects where the indicated relationship between agriculture and landscape becomes clear. Next, it elaborates on what happens to the landscape when changes in agriculture occur. This is interesting since it is presumed that changes in the agricultural system needs to take place. The chapter ends with current changes in agriculture, to have an idea where the future is currently going.

3.1 Landscape & agriculture in the Netherlands

About 54% of the total surface area (and 67% of the land surface area) in the Netherlands was used for farming in 2012. Although the amount of agricultural land is slowly decreasing (in 2000 it was still 56%), it nevertheless covers large part of the Dutch land (CBS, 2016). This landscape can be perceived as a cultural landscape, since almost every part of it is man-made, cultivated for agriculture. The relationship between agriculture and landscape is two-sided: landscape forms agriculture, and agriculture forms landscape. Aspects where this becomes clear are soil type, cultivation, land pattern, agricultural sector, visual perception and landscape elements. Three connections are explored; the link between soil, cultivation and land pattern, between soil and sector, and between sector and visual perception.

Soil, cultivation and land patterns
To be able to farm in the Netherlands, the land was cultivated. How (and when in history) this happened depended on the soil of the area. Centuries ago the sandy soils and river clay soils were cultivated (kamptonginningen, stroomrug- en komontginningen). From the 9th century people started to cultivate the wet peat soils in the western part of the Netherlands. In the 16th century the technology made it even possible to turn lakes into suitable agricultural areas – the lake bed polders (droogmakerijen) (Barends, 2010). These different types of cultivation, on different soil types and with different technologies, resulted in a differentiation in land patterns (verkavelingspatronen). In the Netherlands we can speak of four main types of land patterns (see figure 3.1): the block pattern, the open field pattern (esverkaveling/kampontginning), the strip pattern and the modern rational pattern (Rienks & Meulenkamp, 2009). Each of these types can be linked to certain soils or cultivation types.

Block pattern
This pattern consists of irregular, polygonal parcels that are bordered by ditches or hedges. They occur mostly on the sea clay soils of Friesland, Groningen and Zeeland.

Open field pattern
This pattern contains the smallest scale parcels. They form strips within a field, without a bordering element in between them. They are most common on the sandy soils, around the villages.

Strip pattern
Small, elongated parcels, separated by ditches. This type is mainly found on wet clay- and peat soils, where the high amount of ditches is necessary to keep the land dry.

Modern rational pattern
This is the largest pattern type, consisting of geometrical and rectangular parcels. They are mainly found in the newest polders, especially the lake-bed polders.

Figure 3.1: The different types of land patterns with description
(images from Google Maps)

Soil and sector

Although both peat and sandy soils were in the end cultivated for agriculture, it didn't make them all very suitable for the same type of agriculture. This becomes clear if you look at the way the different agricultural sectors are spread over the country. Figure 3.3 shows the Netherlands divided in 66 agricultural areas (*Landbouwgebieden*). Each of these areas is coloured after its most occurring sector. The reason these sectors are clusters in this way has mainly to do with the soil (see figure 3.2).

If we compare the two maps we see that crop farming is mostly located on the fertile sea clay areas, where the soil is not too wet. This is visible in Zeeland, the north side of Friesland and Groningen, and in the reclamation polders (Flevoland, Wieringermeerpolder, Haarlemmermeerpolder). Land-based livestock farming is located on the places where the soil is too wet for crop farming, but where grass can still grow, like the peat soils. The sandy soils aren't very fertile, which led to a specialization in intensive, not land-based, livestock farming. Around the rivers you'll find orchards, and the bulb flowers are located on the sandy 'geestgronden'. The greenhouse horticulture is strongly concentrated in the west of the Netherlands. This has to do with the fertile soil, but also because of the suitable climate, hours of sunshine and close proximity of the city (Rienks & Meulenkamp, 2009).

So instead of being evenly spread over the country, the sectors in the Netherlands are linked to certain areas, for a large part based on soil type.

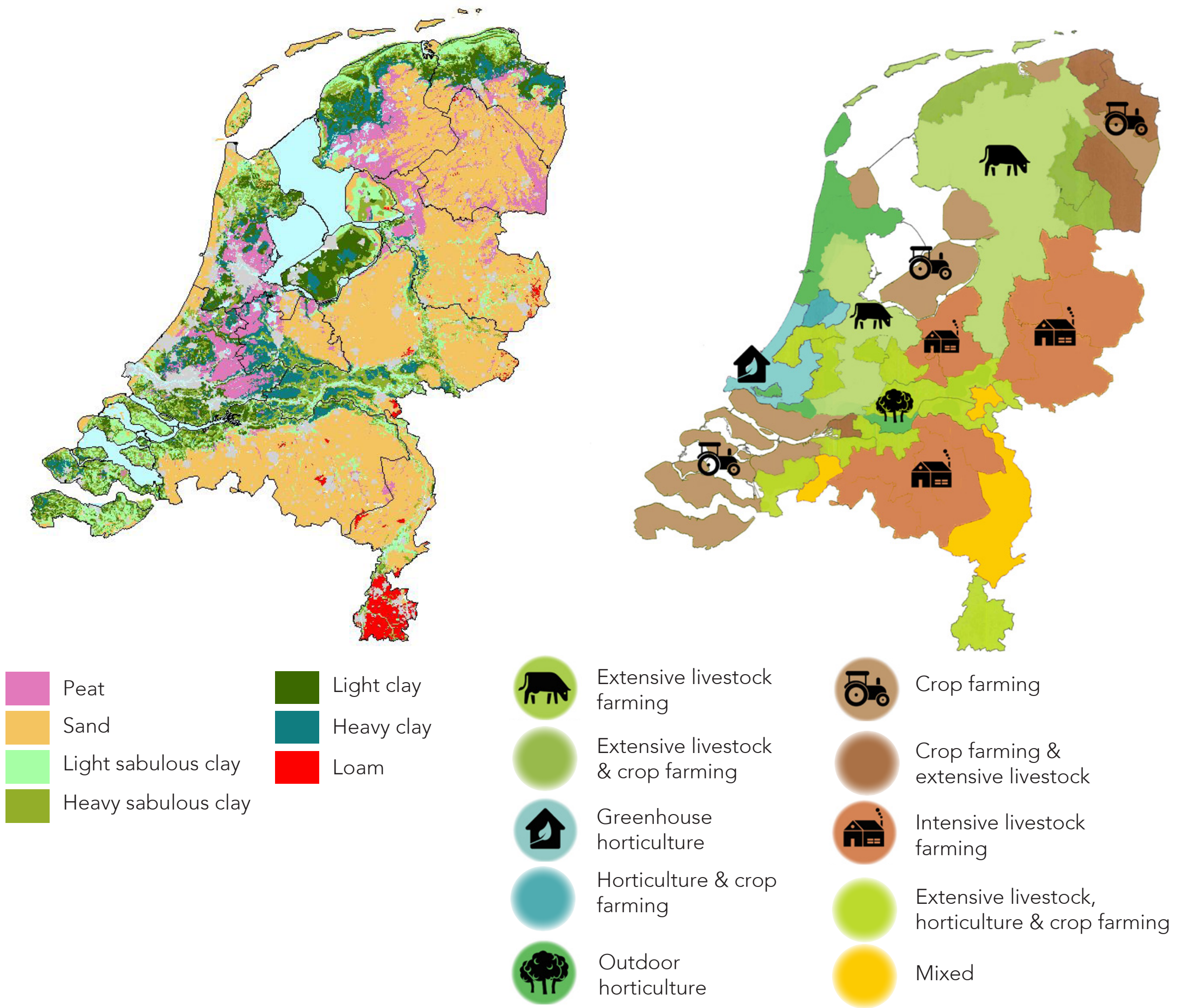


Figure 3.2 (left) and 3.3 (right): Soil map and corresponding sector
(Alterra Wageningen, 2006) RIght map edited from (Rienks & Meulenkamp, 2009)

Sector & visual perception

Each sector uses the land in its own way, and consequently defines the agricultural landscape. This can be due to scale, land patterns or landscape elements. Landscape elements are often linked to a specific region as well. Examples are tree rows, small groves, vegetation on land corners (oeverhoekvegetatie), hedgerows (houtwallen) and vegetated water edges.

In crop farming (see figure 3.4), farmers use large machines to work the land, often leading to an open large scale landscape. Another reason for the size of the landscape is because crop farming is mainly located in the lake-bed polders, with rational parcellation, leading to a wide space with straight lines. Land-based livestock farming (see figure 3.5) has an open image, with meadows, cows, ditches, wooden fences and frequently, pollarded willows. The perception of the outdoor horticulture shows more differentiation per area and type of horticulture. In the Betuwe (see figure 3.6), the area is dominated by fruit trees, showing curved lines and a more diverse and closed landscape.

Although intensive farming has nowadays the least connection with the landscape, not being land-based, it has on the other hand a large influence on the landscape itself. Especially in the Westland, the large greenhouse area, the whole landscape is dominated by the greenhouses (see figure 3.7). In the intensive livestock farming the barns are on the horizon (see figure 3.8). The landscape is small-scale, because of the intensive farming less land is needed. Also corn fields are an often seen element in these areas, closing the landscape.

Figure 3.4: Crop farming
(Google Maps)

Figure 3.5: Land-based livestock farming
("Veenweide, Koe", n.d.)

Figure 3.6: Outdoor horticulture (fruit trees)
(van Broekhoven, 2013)

Figure 3.7: Greenhouse horticulture
(de Jong, 2012)

Figure 3.8: Intensive livestock farming
(Oude Keizer Makelaardij, n.d.)

3.2 Changing agriculture, changing landscape

Both agriculture and landscape are continuously changing. Changes in the agriculture often have (large) consequences for the landscape. Especially because of modernisation, farmers became less independent on the existing features of the landscapes. Their influence on the landscape became bigger than the influence of the landscape on their farming.
Figure 3.10 shows a timeline of the main developments in agriculture, starting around 1900. Linked to the timeline are important events and developments. You can see that especially in the period after 1950, after the Second World War, many things changed. Several agricultural developments changed the agricultural landscape drastically: chemical fertilizer, scale enlargement, mechanization, intensification, reallotment and some years later nature awareness. (Bieleman, 2008)

Around 1850, chemical fertilizer was invented. This development especially had a lot of influence on the farmers in the sandy areas of the Netherlands. They used to rely on the manure from the stables to heighten up and manure the fields. With the use of fertilizer they now could make the soil enough fertile to produce for example corn.

After the World War the main focus was to prevent future hunger, so: increased food production. The agriculture had to grow bigger and become more efficient. To meet these demands, mechanization was necessary, which led to scale enlargement and intensification of farming. The use of pesticides, fertilizer and other technologies was strongly increasing as well.

Linked to this process of scale enlargement is the reallotment. This was a government's plan to exchange small parcels between the farmers, so farmers could get a large continuous piece of land. This naturally made it easier to work with machinery, thus making the work more efficient. Although the first reallotment plans were already initiated in 1924, most of the projects happened between 1960 and 1980. Because of the reallotment plans, the Dutch landscape changed radically. Hedges and ditches were removed, leading to a large scale, more open landscape (see figure 3.9).

Starting in the 60's and 70's, there was a growing concern with the intensification of the agriculture and the negative effects it had on nature and the landscape. The new reallotment plans therefore had to plan in space for nature as well. Also rules limiting the use of pesticides and fertilizer were implemented. (Bieleman, 2008)

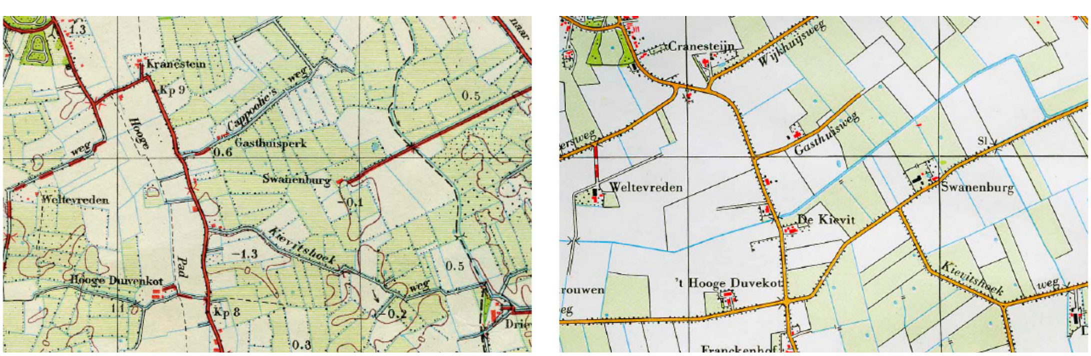


Figure 3.9: The effects of reallotment in Walcheren
(Rijksdienst voor het Cultureel Erfgoed, n.d.)

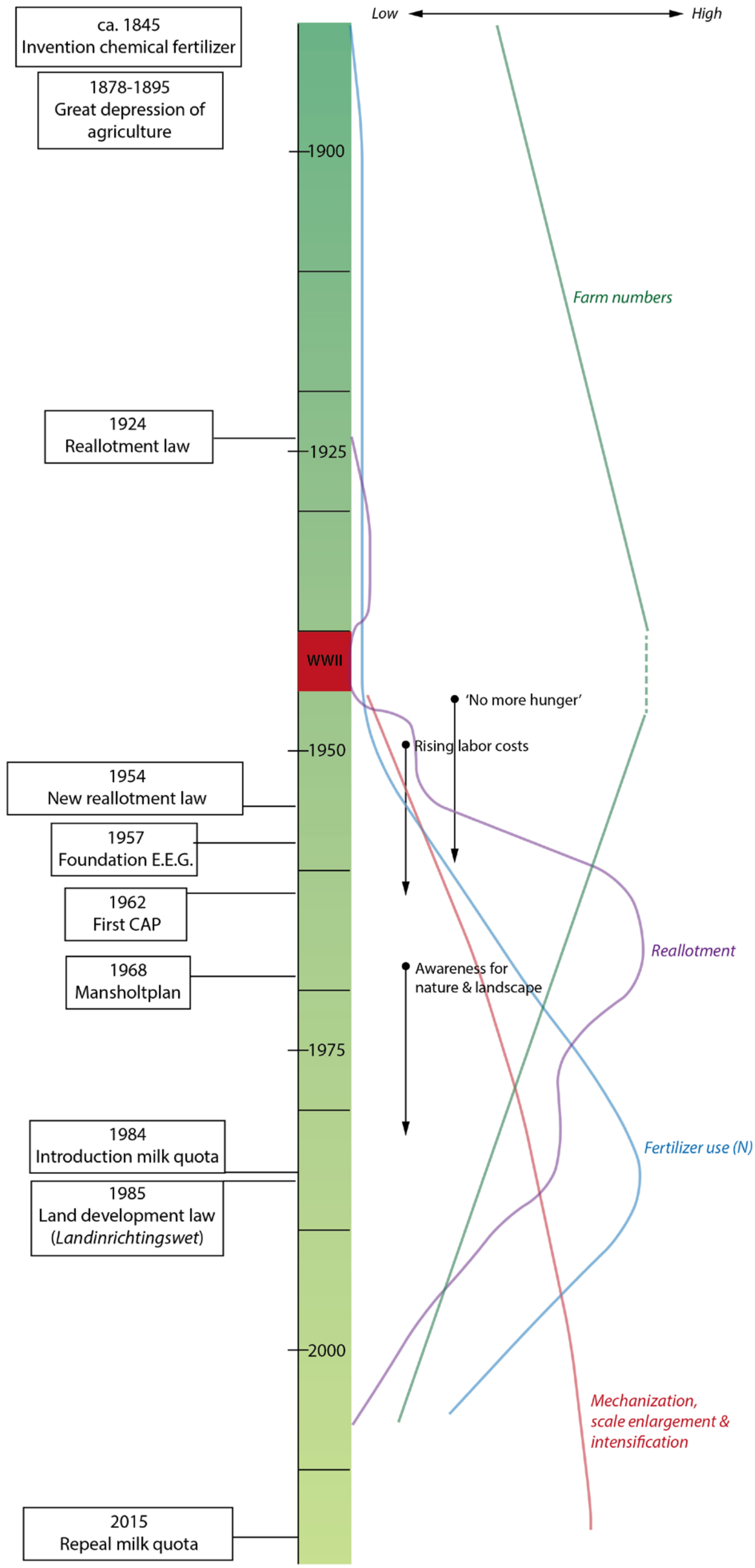


Figure 3.10: Timeline main developments in agriculture from 1850 till now
(based on Bieleman, 2008)

3.3 Current trends in agriculture

Trends that started the last century are currently developed further. Six important trends in farming at the moment are described here.

Technology and robotization

Technology is developing further. Machines are taking over more tasks, like monitoring and harvesting the crops (figure 3.11). The amount of people working on a farm is declining. Technology is also focussing on ways to produce more efficiently and sustainably, the so called precision agriculture (precisielandbouw). Drones for example can now measure exactly which plants need to be treated with pesticides, avoiding the need to spray the whole field. (Nieuwenhuizen, Gies, Goossen, van Och & de Rooij, 2015).

Scale enlargement

The farms continue on growing, by expanding their land or livestock. Technological developments make it possible to farm larger fields of land with less work, but often scale enlargement is also used to compensate the large investments made in expensive technology. It is a way to increase the income of the farmers, sometimes necessary to sustain the farmer's business. The scale increase leads to larger barns and farmyards, impacting the landscape. Furthermore, large farms have such a high production that it becomes impossible for smaller farms to compete. (Nieuwenhuizen et al., 2015; CBS, 2017)

Less farmers, empty farmyards

The amount of farms is declining heavily. In 2000, there were still 97.390 farms, compared to 55.680 in 2016 (CBS, 2017). Some farmers quit because they can't make ends meet, others don't have a successor. The land is often sold to large farmers, leaving the farmyard empty behind (see figure 3.12). (Nieuwenhuizen et al., 2015)

Figure 3.11: The feed robot at Hoeve Biesland automatically picks and mixes the fodder
(Author)

Figure 3.12: Sale of agricultural land
(Author)

Specialization & side activities
Farmers who don’t increase in scale, search for extra income in side activities or specialization. They are the farmers selling their own cheese, ice-cream or managing a camping on their farm. They connect to the consumer more directly. Specializations like organic-dynamic farming can also help increase income. (Nieuwenhuizen et al., 2015)

Sustainability awareness
It becomes clear that the current agriculture is polluting water and soil and is contributing a lot to climate change as well. The farming system is dependent on fossil fuels to work the land and to produce fertilizers and pesticides, plus emits large amounts of methane through the livestock farming. Some agricultural areas are removed to make space for nature, while there is also more attention for making the remaining farming areas more sustainable itself. The main focus is on innovation and technology as a way to improve sustainability, using renewable energy sources and precision agriculture (figure 3.13). (Nieuwenhuizen et al., 2015)

Urban Agriculture & Agroparks
Another growing trend is the rise of urban agriculture: farming in the city. Starting with small plots managed by locals, the trend is getting more professional: there is an official education focussed on urban farming and in the Hague recently opened a large new commercial urban farm ‘Stadsboerderij UF002 De Schilde’ (figure 3.14). Besides urban farming, agroparks are rising as well. These are large areas where all kind of agricultural firms are clustered together, making it possible to enforce their collaboration and linking flows. (van Cooten, 2017; Nieuwenhuizen et al., 2015)

Figure 3.13: Farmers turn to windturbines and solar panels as source of sustainable energy and extra income
("Boerderij, Windmolens", n.d.)

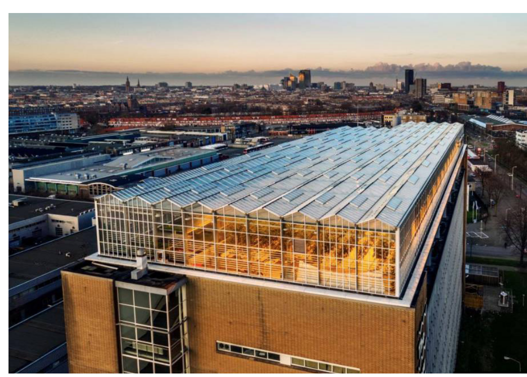


Figure 3.14: Urban Farm 'de Schilde' in the Hague
(Urban Farmers, n.d.)

3.4 Conclusion

The relation between agriculture and landscape is reflected in the link between soil and land patterns, between soil and sector and between sectors and visual perception. The soil often determines the sector and together they impact the land pattern and the visual perception. These aspects will be used as input for the case study analysis in chapter 7.

After the Second World War, agriculture was changed by several large developments. The small-scale farming turned into large-scale industrialized production, with an increased use of fertilizer, pesticides and technologies. Agriculture became larger and more intensive, which was supported by the reallotment plans. The landscape was impacted by these changes, losing site-specific landscape elements, land patterns and characteristic vegetation.

Many of these developments are carried on at the moment. More technology is being used and the scale is increased even further, leading to a monotone production landscape. However, the attention for sustainability has also grown. Past developments show that the landscape is impacted by developments in agriculture. So when the agricultural system will change to a sustainable form of farming, the landscape will change as well. Why and how agriculture should become more sustainable will be explained in the next two chapters.

4. A NEED FOR CHANGE

In the last 50 years, the agriculture has changed from small-scale family farming to heavy-industry food production, leading to problems of sustainability. The problem of the current agriculture doesn't just cover one aspect, it involves a complex web of ecological, economical and social issues. This chapter will investigate these problems to answer the question: "*What is the problem with the current agriculture? Why isn't it sustainable?*" The issues are structured in 12 topics, of which six are ecological problems (greenhouse gases, nutrients, soil, water, climate change & biodiversity) and five cover social-economic problems (the dependent farmer, feeding the world, the critical consumer, animal welfare and public health). Ending with the spatial problems for the landscape. Next, the most important problems are listed and related to each other. The chapter ends with showing where the problems occur in the Netherlands by linking them to the different agricultural sectors.

4.1 Ecological problems

Greenhouse gas - climate change mitigation

Agriculture is one of the largest contributors to the emission of greenhouse gases. These are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The sector most responsible is the livestock farming, producing mostly methane. In crop farming it is mainly nitrous oxide and in greenhouse agriculture CO_2 is the biggest problem (see figure 4.1 and table 4.1). (Rijksdienst voor Ondernemend Nederland, 2016)

The emissions are also indirect, since products and materials are transported all around the world. A large part of the cattle feed is imported from countries like the US, Brazil and Argentina. Cattle feed can be divided into crops (mainly wheat, corn and barley) and coproducts. The coproducts are being used because of their high level of proteins. Most used are soy, rapeseed and sunflower. Especially soy is almost completely imported from other countries (Bron, 2017). The plantation of soy beans in South-America is often at the expense of nature areas, like the rainforest. Deforestation is also one of the leading causes of climate change.

The Netherlands does not only import food, they are one of the largest exporters of agricultural products as well. In 2015 almost half of the Dutch food production was being exported (Compendium voor de Leefomgeving [CLO], 2017a). All the transport requires high amounts of fossil fuels. Fossil fuels are also used for farming machinery and the production of fertilizer and pesticides, making the sector very much dependent on them.

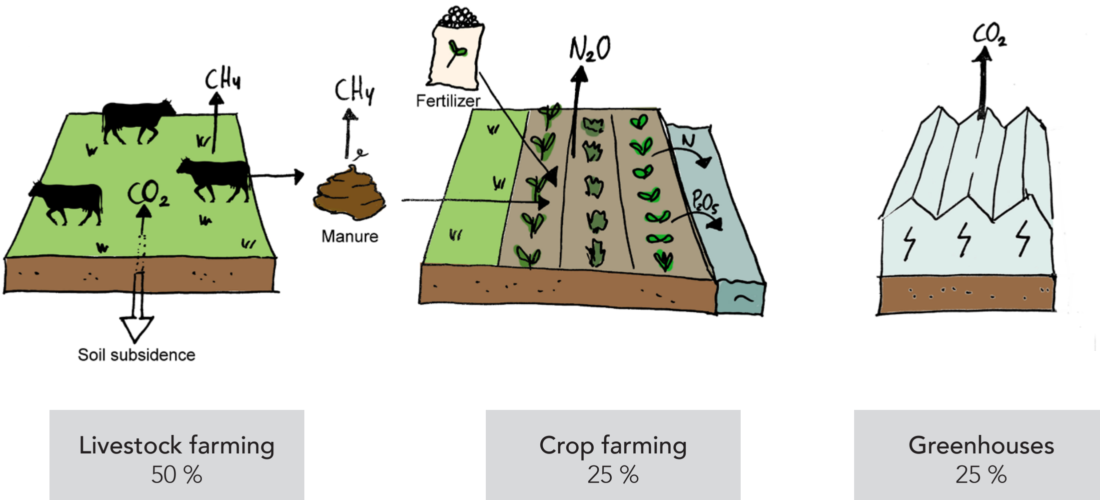


Figure 4.1: The main contributions to greenhouse gas emissions in the agriculture.

Substances in the air	Problem	Causes
Carbon dioxide (CO_2)	Greenhouse gas	Use fossil fuels (transport, production fertilizer, heating greenhouses), soil subsidence, deforestation
Methane (CH_4)	Greenhouse gas	Rumen fermentation, manure storage
Nitrous oxide (N_2O)	Greenhouse gas	Stable and manure storage, fertilizing the land (both manure & chemical fertilizer), indirectly through leaching
Nitric oxide (NO)	Eutrophication & acidification	Stable and manure storage, fertilizing the land (both manure & chemical fertilizer)
Ammonia (NH_3)	Eutrophication & acidification	Stable and manure storage, fertilizing the land (mainly manure & a bit by chemical fertilizer)
Particulate matter	Air quality	Stable emissions, reaction with (bit of NO_x) and mainly NH_3 (secundair particulair matter)

Table 4.1: Harmful substances in the air caused by agriculture
(Rijksdienst voor ondernemend Nederland, 2017)

Organic manure	Fertilizer
+ Waste product	- Production requires a lot of energy
+ Contains organic material	- Depletion of nutrients
- Inconsistent composition of nutrients	+ Right composition can be dosed and regulated
- Take in of nitrogen is less efficient	+ Efficient nitrogen intake
- CH_4 emissions	
- More ammonia emissions when used on land	

Table 4.2: The benefits and disadvantages of the use of organic manure or chemical fertilizer

Nutrients

The high numbers of import and export have led to a manure surplus in our own country. Manure can be used to increase crop productivity, but a surplus is not taken up by the soil anymore. Instead, the manure nutrients (especially nitrogen (N) and phosphate (P_2O_5)) end up in the water, polluting both ground and surface water bodies. There are other ways as well how manure can pollute the environment, for example through the emissions of greenhouse gases (see the previous heading). Furthermore, it is responsible for the emission of ammonia (NH_3) and nitric oxide (NO). Ammonia causes the eutrophication of soil and water and is responsible for acidification in nature areas. In addition, it can be converted to the strong greenhouse gas N_2O (see figure 4.2).

Because of these negative impacts of manure, there are rules on the amount of manure that may be used on the land. It is also not allowed to spread manure along the water edges, and in the winter only solid manure can be used (Rijksoverheid, n.d.). Despite the surplus of manure in the Netherlands, a lot of chemical fertilizer is used as well. This is because manure has a variable composition of nutrients, while for fertilizer this is determined. Therefore, the use of fertilizer can be adjusted exact to the needs of the crop. Also it is said the nitrogen in fertilizer is taken up more efficient in the soil. However, the use of fertilizer is not only positive. The production requires a lot of energy, leading to more greenhouse gases. Furthermore, the nutrients being used for fertilizer come from mines, and will eventually be depleted if we go on like this. Animal manure also adds valuable organic material to the soil, although it causes more ammonia emissions (OCI Nitrogen, n.d; see table 4.2.).

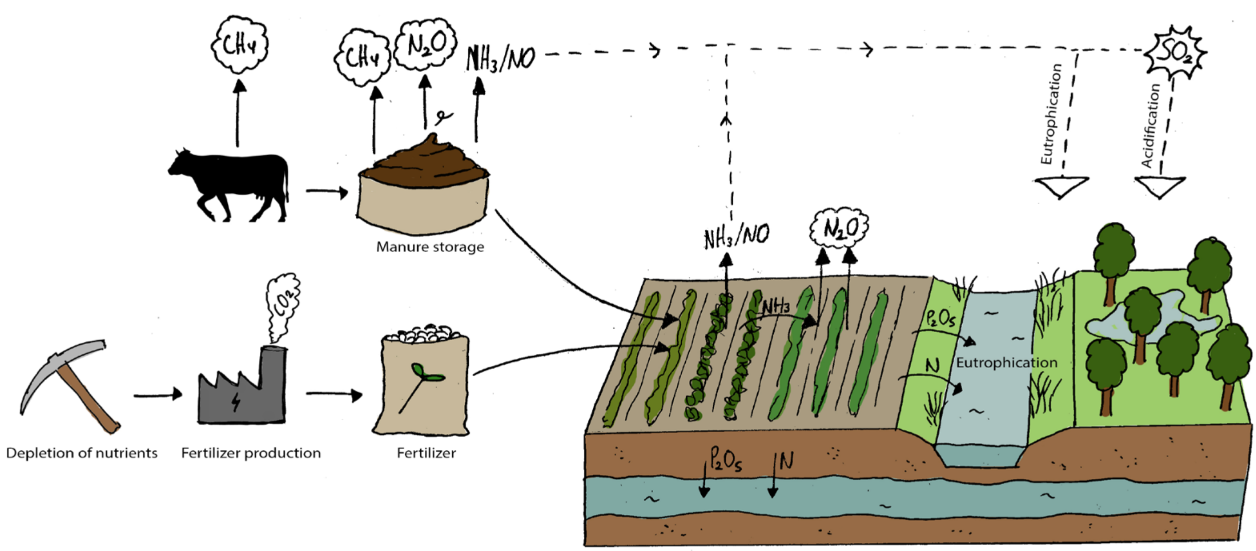
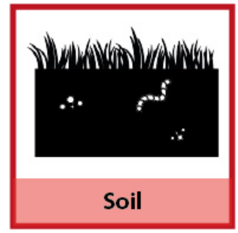


Figure 4.2: The negative effects of the use of fertilizer and/or manure in agriculture

Soil



The soil is possibly the most important aspect in agriculture, it forms the basis of farming. Currently, because of the intensive land use with fertilizers, pesticides, monocultures and heavy machinery, the soil is degrading. Soil degradation is the loss of soil fertility, which depends on nutrients (chemical fertility), the structure (physical fertility) and soil life (organic fertility). Soil life is for example affected by pesticide and herbicide use, while tillage and the use of heavy machinery is responsible for soil compaction. Soil degradation is a world wide problem, so also here in the Netherlands. It is very urgent, since wasted soil can take up 100 to 1000 years to regenerate. Therefore it is almost a non-renewable resource (Steenbruggen & van Loenen, 2015). The degradation leads to a downward spiral, since soil with less quality is less able to fight pests and diseases, consequently needing more pesticides and intensive cultivation to keep the food production on the same level (Mommers & Vanheste, 2017).

Soil erosion is world wide a large problem, although not as much in the Netherlands. It is the process where a layer of topsoil is washed away (by water) or blown away (by wind or tillage). This also ends up in less fertile soil (Bodemacademie, n.d.).

A soil problem that on the other hand is very urgent in the Netherlands, especially in the peat areas, is soil subsidence. Because of the continuously lowering of the water tables, the peat in the soil is oxidizing, causing the soil to subsidize. This leads to large amounts of CO_2 emissions. A lower land level also makes the land wetter and more vulnerable to flooding.

Water

There is no agriculture without water. However, too much water also causes problems. High water levels can prevent crops from growing, therefore on most agricultural fields the water level is artificially lowered. Most farming land is focused on fast draining, containing many ditches. The increased amount of paved surface, the low water level and the use of ground water causes problem with land that is too dry for nature. Especially in the peat areas it leads to the discussed soil subsidence. In some areas the water levels are raised again to repair nature areas. However, this often introduces problems for nearby agricultural fields.

Agriculture is a large user of sweet water with almost 124 million m^3 per year (124 billion liters). The largest percentage is used for livestock drinking (see figure 4.3). Additionally, water is used for irrigation of crops (depending on the amount of rain), cleaning and crop washing. The types of water used are tap water, surface water, ground water and rain water. 34% of the water used is tap water, mainly used for livestock drinking and cleaning. To irrigate the crops, surface or groundwater is used. (CLO, 2016; Agrimatie, 2017a)

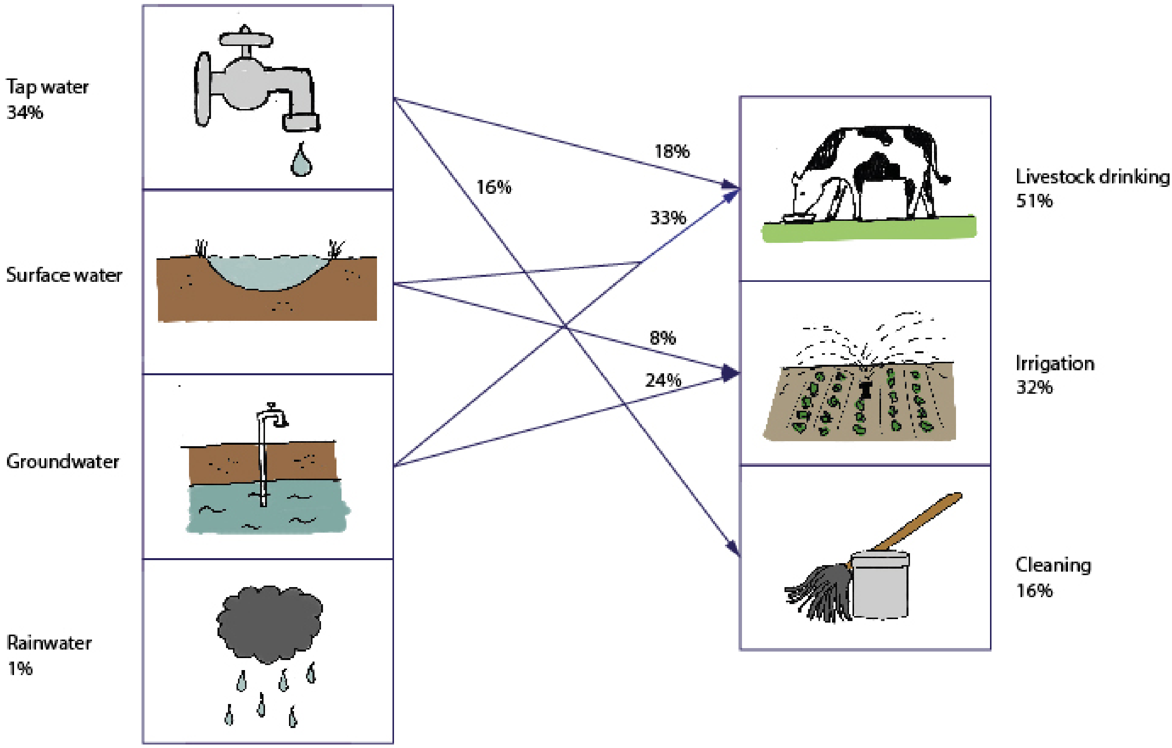
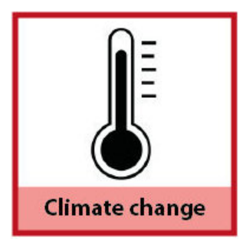


Figure 4.3: The sources and uses of water in agriculture
(based on Wageningen Economic Research)

Climate change (adaptation)



If there were not already enough problems with water, because of climate change farmers will suffer more from extreme periods of drought and rain. A lack or a surplus of water will negatively impact the yield. In summer, a lack of sweet water becomes more probable. Furthermore, a rising sea level causes saltification of the ground water (CLO, 2016). In some areas, like the clay- and peat areas, the soil can become wetter. As a positive side note: climate change can also lead to a longer growing season and might make it possible to grow new type of crops, like grapes (Agriholland, 2015).

Biodiversity

Biodiversity can be defined as the total diversity of life on earth, in form and function (Vet, 2017). In the past 100 years, unfortunately this biodiversity strongly declined in the Netherlands. Especially the insects are suffering, but also the decline of meadow and field birds receives a lot of attention. One of the main causes: agriculture (Planbureau voor de Leefomgeving [PBL], 2014). Fragmentation of the landscape, monofunctional land use, intensification, ammonia pollution and the use of pesticides all hold a part of the responsibility (Vet, 2017).

Pesticides (including herbicides, insecticides and fungicides) are used in farming to protect the crops against insects, fungi, pests and weeds. These chemical remedies have risks as well, ending up in the water, killing other plants and animals and possibly affect the public health. Therefore only tested pesticides are allowed in the Netherlands (Rijksinstituut voor Volksgezondheid en Milieu [RIVM], 2017a). Despite these rules, they are still unnatural, chemical remedies with a large impact on the environment. They cause the decline of the plant's natural pest resistance, making the plant even more reliable on the pesticides being used.

4.2 Social-economic problems

The dependent farmer

The impacts on the environment of import and export were already mentioned. The farmers however, also don't profit from it. Since the Second World War, the emphasis in the agriculture is on production, there should be no more hunger. The food prices were deliberately kept low and the farmers had to increase their production. Through reallotment and scale enlargement this increased production was made possible. Using subsidies from the EU (the CAP – common agricultural policy), the farmer received a fixed price for his product, independent of the market. This led to an oversupply of production, since more products automatically meant more income. With the help of import duties and export subsidies, the overproduction was put on the world market for a very low price (Bieleman, 2008). Although the last years this system has improved, Dutch farmers still export a lot. For example, about 65% of the Dutch dairy products is exported (ZuivelNL, 2016).

The EU wants to reduce the farming subsidies, making the farmer more dependent on the market instead of receiving fixed prices. At this moment, the price he receives for his product on the market is often not covering the production costs. However, if the market price would increase, export would be made impossible. Besides, from the 120 cents we pay in the supermarket for a liter milk, only 0,35 cent goes to the farmer (FrieslandCampina, 2018). The rest ends up with the supermarket and producer, of whom the farmer is dependent (see figure 4.4). Because of the high transport costs it is practically impossible to link the farmer directly to the consumer, making them stuck in the chain. To be sure of income, farmers are forced to scale-up and turn to mechanization (and thus decreasing production costs). Farmers that don't grow are outcompeted, or they turn to specialization and side activities. Scale enlargement and mechanization will also make the farmer dependent on other companies. Often high investments need to be made to build for example a new barn, ending up in loans that need to be paid back with interest (RLI, 2013).

Many farmers therefore have to quit, their land bought by the large megafarms, contributing to less, but larger farms. The amount of farmers is already declining for years because of scale enlargement and mechanization. This decline was the last 15 years the biggest in the grazing livestock farms (-11461) and horticulture farms (-8867). The largest percentage decrease however is seen in the intensive agricultural sectors: the horticulture farms (-52%) and barn animal farms (-51%). Both have been halved in number. (CBS, 2017)

While some farmers are forced to quit, others don't have a successor. At the moment, the average age of a Dutch farmer is 50 years. Many of them will retire within a decennia, but do not have a successor for their farm (Boerenbusiness, 2013; CBS, 2016). The amount of young farmers that start a farm is limited. High investments and expensive land prices make it financially difficult to start a new farm, and existing farms are often bought by large farmers. Besides, are there still people who want to be a farmer? The job goes with heavy work, long work times and fluctuating income.

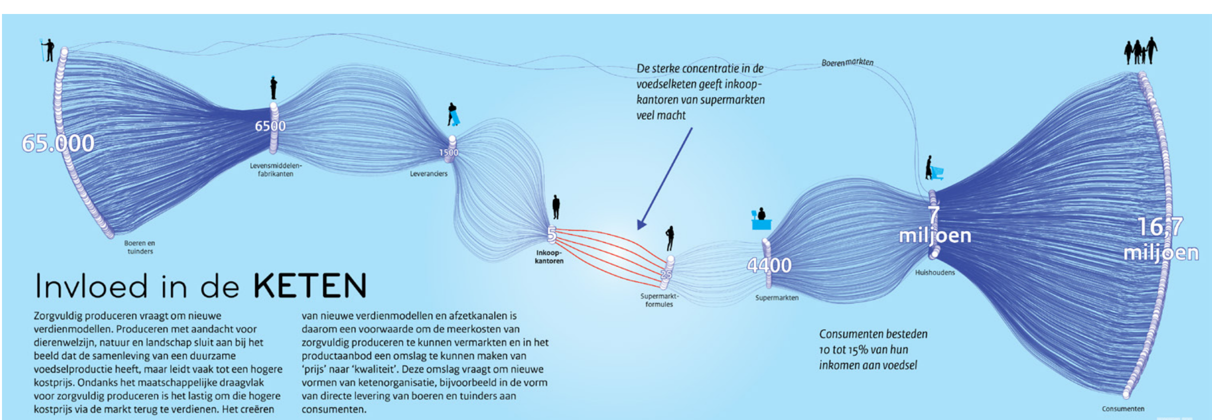


Figure 4.4: This image shows the large influence in the food chain from the small group of supermarkt purchase offices, compared to the farmers or consumers.
(Planbureau voor de Leefomgeving, 2012)

Global: feeding the world

Let's not forget the primary function of agriculture: producing enough food. Many people around the world are still underfed. Contrasting, in another part forms obesity a big problem. It seems like the distribution of food, instead of the amount, forms the problem. This issue will get more urgent with the growth of the world population, especially in the malnourished areas.

The agriculture in the western world has influence on the agriculture in other countries. Land in South-America is being used for the production of cattle feed in Europe. Not only destroying rain forests, but also taking away farming lands from the local farmers producing food for their own country. The overproduction in Europe leads to the offering of the products on the world market for very low prices. Local farmers in poorer countries can't compete with these prices (van Opheusden & Knol, 2014; see figure 4.5).

Figure 4.5: Due to the overproduction, food from the EU got put on the world market for much lower prices than local farmers could offer.

The critical consumer

Farmers are trying to increase their income, stuck in a web of large companies and subsidies they turn to intensive agriculture. Consumers are resisting against these forms of farming. They don't want mega farms and food factories, but cows in the field and free-range chickens. Naturally, they don't want to pay for that though. This shows the gap between the farmer and the consumer: the farmer is being criticized while the consumer just buys the cheapest product in the supermarket:

*"Veel boeren hebben het gevoel dat ze in de tang zitten: de markt vraagt verdergaande kostprijsreductie, rationalisatie, productie voor de wereldmarkt en schaalvergroting, maar de maatschappij vraagt dierenwelzijn, minder uitstoot, regionalisering, kleinschaligheid en een secure omgang met gezondheidskwesties." (van Gerven, Staarink & Palm, 2013, p. 55)**

It seems like two different worlds, two different view points. Consumers don't know where their food in the supermarket is coming from, and are more suspicious about it. Does this product really contains what is says it does? How animal friendly is this egg actually?

**EN: Many farmers have the feeling of being trapped: the market asks for further cost reduction, rationalization, world market production and scaling up, while society asks for animal welfare, reduced emissions, regionalization, small-scale and a secure way of handling health issues.*

Animal welfare

In a world focused on production and scale enlargement, animal welfare seems to be of secondary importance. The scaling in the intensive livestock farming has led to factory farms housing a large amount of animals on a small surface. Most of them never get outside. These factory farms form a high risk when it comes to fire and pest outbreaks, causing high death rates. Wakker Dier (2017) reported in August 2017 that that year already 250.000 animals were killed in barn fires. On top of that, the same year 2,5 million chickens were killed because of the fipronil-scandal (het Parool, 2017).

Having a large amount of animals doesn't necessarily means they get treated worse though. The modern mega barn offers often more comfort to animals than a small, outdated family barn with a lack of daylight and good ventilation (Mommers, 2011). That does not take away the fact that a lot of animals are more seen as economic product than living creature, and sometimes are even treated like that.

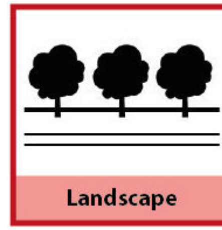
Public Health

Factory farms can have negative impacts on the public health as well. Animal diseases that are transferable to humans (like the Q-fever) and air pollution caused by ammonia and particulate matter makes living in the nearby area of a mega barn not very popular. Research from RIVM (2017b) shows that people living near a livestock farm have more respiration problems.

Particulate matter is caused by animals, the feed, stable bedding and manure. Therefore, poultry farms are the largest contributor (about 66%), followed up by pig farms (Agrimatie, 2017b). Free-range chickens that can walk around have an increased emission, because more dust is spread through the air (Nederlandse Omroep Stichting [NOS], 2016). In the air, ammonia reacts with nitrogen and sulphur oxides to particulate matter.

Another problem in the livestock farming is the excessive use of antibiotics, which can lead to the resistance of bacteria, causing new health risks.

Landscape



Back to the landscape. Considering the link between agriculture and landscape, these issues have impact on the landscape as well. Scale enlargement and intensification have changed the landscape to a large-scale, monotone production landscape (see figure 4.6 & 4.7). Hedges, ditches and other regional landscape elements are removed, making farm fields all over the country look the same. While some areas become more open, others lose their characteristic openness because of large barns and greenhouses (see figure 4.8 & 4.9). The decline of landscape elements and biodiversity has led to 'green deserts' of little natural and social value. People don't visit the countryside on their day of, they go to the more appreciated nature areas instead.

Figure 4.6: Large-scale, open, monotone landscape in Flevoland
(Swart, 2013)

Figure 4.7: Open en barren crop farming landscape
(Author)

Figure 4.8: The closed landscape of greenhouse horticulture
(Omroep West, n.d.)

Figure 4.9: Large barns dominate the landscape in the intensive livestock farming area
(Oude Keizer Makelaardij, n.d.(

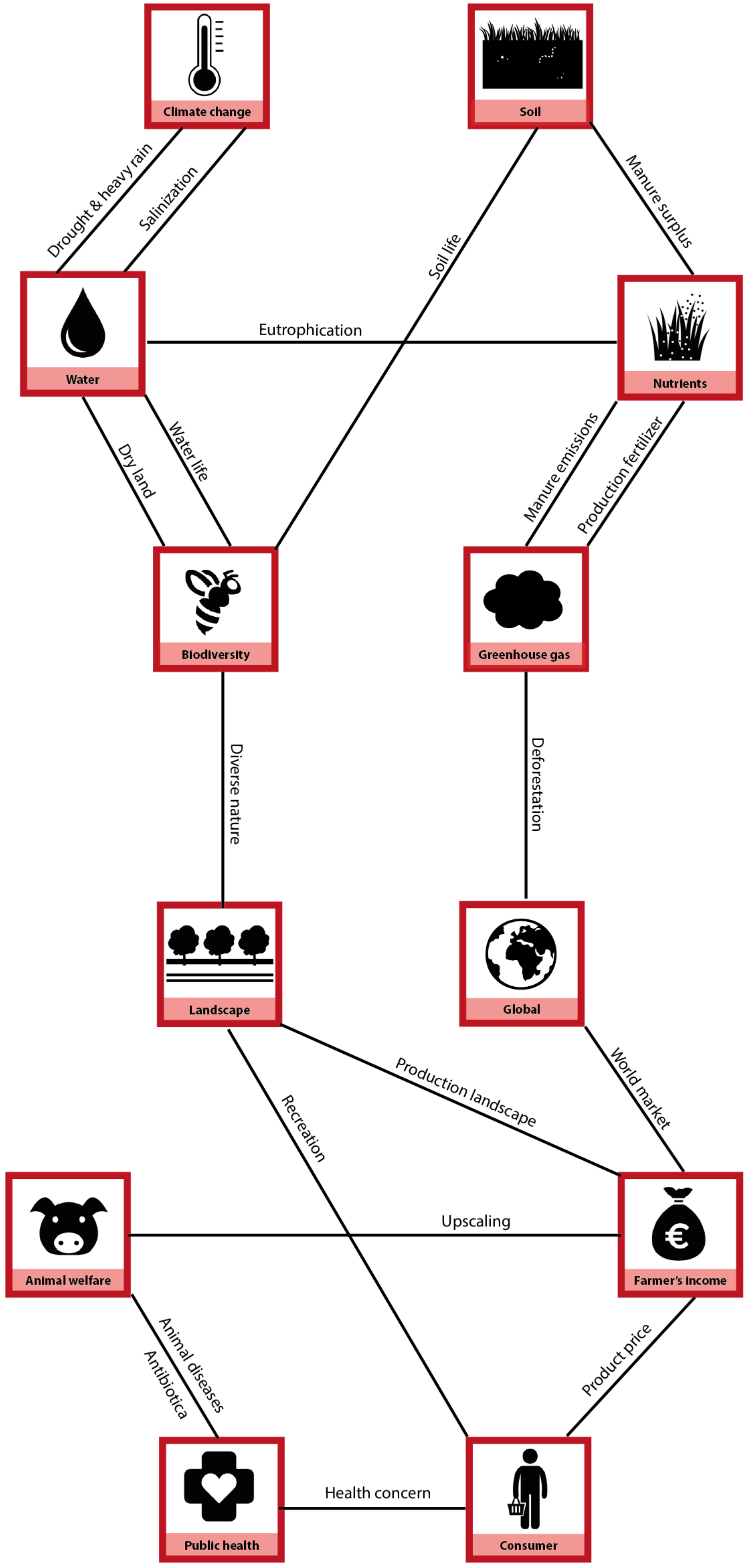


Figure 4.10: The relationships between the different problem categories

4.3 Review of issues

Below the main issues regarding agricultural sustainability are listed. Of course, these categorization is just a way of structuring. In fact, many of these aspects are related to each other, making a problem part of several categories. For example: salinization can be part of water, soil or climate change. Double listed problems are marked with *. Figure 4.10 shows the relations between the different problem categories in a scheme. Furthermore, not all aspects have direct influence on the landscape. The ones without a clear link are shown in grey.

Ecological

Greenhouse gas

- Emissions of CO_2, CH_4 & N_2O
  - Import animal feed
  - Transport, energy & heating
  - Fertilizer production*
  - Cows & manure emissions*
  - Deforestation
  - Soil subsidence*

Nutrients

- Manure surplus
- Manure emissions *
- Fertilizer production *
- Pollution of soil & water (eutrophication & acidification)
- Depletion of nutrients

Soil

- Soil degradation (quality/fertility)
  - Soil compaction
  - Soil life decline
- Soil erosion
- Soil subsidence *

Biodiversity

- Decline in biodiversity
  - Pesticides & herbicides
  - Monofunctional landuse
  - Fragmentation of landscape
  - Acidification

Water

- Ground water level: nature vs agriculture
- Soil subsidence *
- Use of sweet water
- Water pollution *
- Salinization *

Climate change

- Extreme weather events: too dry or too wet
- Salinization *
- Warmer climate

Farmer's income

- Low food prize
- Dependent on large food industry companies
- Scaling necessary to survive
- Subsidies

Global

- Hunger versus obesity
- Unfair competition world market
- Use of agricultural land elsewhere for meat & dairy production

Consumer

- Disconnection between farmer-consumer
- Shrinking amount of farmers

Animal welfare

- General animal welfare
- Factory farms
- Animal diseases *

Public health

- Air pollution (ammonia, particulate matter)
- Animal diseases *
- Antibiotics resistance

Landscape

- Monotone landscape
- Disappearing regional cultural/ historic landscape elements
- Horizon pollution (factory farms)
- Decline nature value

Social-economic

4.4 Problems linked to sector

Not all of these problems occur everywhere in the Netherlands. Soil subsidence for example occurs mainly in the peat area, in new reclamation polders (Flevoland) and in the gas winning area (Groningen). Each agricultural sector also has its own main problems, linking some issues to specific parts of the landscape. These map show where the sector is mainly located, with a list of (some of) the occuring problems.

Land-based livestock farming

Methane, manure, soil subsidence, water

Greenhouse gas:	Emissions of methane by cows and manure
Nutrients:	Water pollution by manure
Soil:	Soil subsidence in peat areas
Water:	Low water table leads to soil subsidence and decline in biodiversity
Dependent farmer:	Production surplus
Public health:	Antibiotics resistance
Landscape:	Monotone landscape. Decline amount of meadow birds.

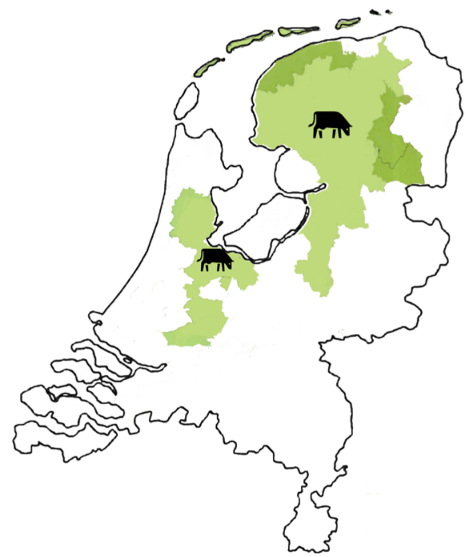


Figure 4.11: Areas where land-based livestock farming is the main sector

Crop farming

Use fertilizer and pesticides, soil degradation, monotone landuse, water

Greenhouse gas:	N_2O by using manure & fertilizer
Nutrients:	Surface water pollution
Soil:	Soil degradation, soil compaction by machinery
Water:	Salinization in coastal areas
Biodiversity:	Pesticides kill soil life, decline biodiversity Montone landuse
Climate change:	Extreme periods of drought & rain: water problems
Landscape:	Monotone landscape, decline field birds

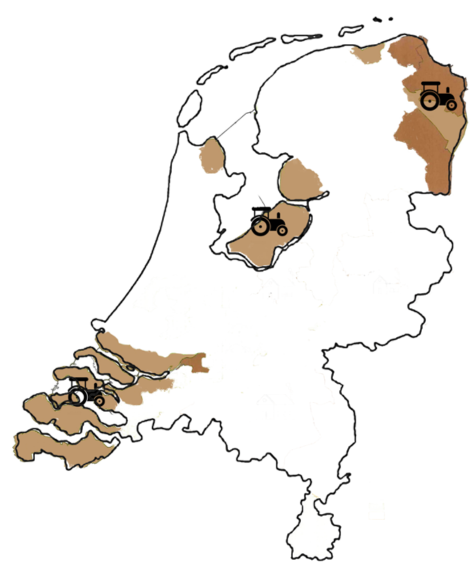


Figure 4.12: Areas where crop farming is the main sector

Figure 4.13: Areas where intensive livestock farming is the main sector

Intensive livestock farming

Manure surplus, import cattle feed, water use, animal welfare, air pollution

Greenhouse gas:	Emissions of methane by manure Import of cattle feed
Nutrients:	Manure surplus
Water:	Water pollution by manure Use of sweet water for drinking animals
Critical consumer:	Resistance vs price product
Animal welfare:	Factory farming. Risks of fire and diseases.
Public health:	Air pollution by particulate matter & ammonia Antibiotics resistance
Landscape:	Horizon pollution of barns

Figure 4.14: Areas where horticulture is the main sector

Outdoor horticulture

Use fertilizer and pesticides, water, soil

Greenhouse gases:	N_2O by using manure & fertilizer
Nutrients:	Surface water pollution
Soil:	Soil degradation
Biodiversity:	Pesticides kill soil life, decline biodiversity
Climate change:	Extreme periods of drought & rain: water problems

Greenhouse horticulture

Greenhouse gases:	Energy prodcution leads to CO_2 Fertilizer
Water:	Water use
Landscape:	Landscape pollution

4.5 Conclusion

It is clear that agriculture needs to become more sustainable. The problem is complex, consisting of many issues on both ecological as social-economic aspects, which are also influencing and linked to each other. A categorization of twelve problem categories is made. The ecological issues found are about greenhouse gas, nutrients, soil, water, climate change and biodiversity. The social-economic issues cover problems of the farmer, who has troubles with his income, is dependent on big companies and is declining in amount. The economical problems related to this affect the global situation as well. And then there is the critical consumer, who is worried about animal welfare and public health. A summary of the occurring problems per category is made. This list serves as input for the problem diagnosis of the case study area.

Most problems don't happen everywhere in the Netherlands, but are linked to a certain area and sector. By linking the problems to the agricultural sector, and using the map from chapter 3 (figure 3.3) on the general location of the sectors, an approximate location for the problems can be made. The link between problem and sectors will furthermore be used to help determine which problems occur in the area around Zoetermeer.

5. CHANGING THE AGRICULTURAL LANDSCAPE

The previous chapter has made clear that a transition in the agricultural system is needed, to move to more sustainable form of farming. This chapter will elaborate on what is meant by sustainable agriculture, how it is achieved and how it looks like, to answer the main question: *"What is sustainable agriculture?".* It will give a perspective on how the farming in the future can be.

The chapter starts by showing the goals and four different theories on how to achieve sustainable farming. Then the vision of this project is explained and investigated in the parts about ecological agriculture. First by explaining the basics of agroecology, and then more in concrete by exploring different ecological farming systems.

5.1 The future of sustainable agriculture

5.1.1 Goals of sustainable agriculture

What is the future of sustainable agriculture? We know it should be both ecological, economical and socially sustainable as was defined in chapter 2, but that is still very abstract. Therefore, twelve goals were formulated based on the previous chapter. It can be said that the ideal sustainable agriculture should have:

1. No emission of greenhouse gases, use of renewable energy
2. A closed nutrient cycle (no depletion of nutrients)
3. A healthy soil, no soil pollution
4. Closed water cycle, respecting natural water level, no water pollution
5. Resiliency to climate change
6. Improved biodiversity
7. Sustain economic viability of farms and farmers
8. Enough food for everyone & no negative impacts in other countries
9. Consumer involved in food production, appreciation for farmers
10. Good animal welfare
11. No risk for public health: healthy food & environment (no air pollution)
12. Respect for the landscape

5.2.2 Strategies for sustainable agriculture

How to achieve these goals? Opinions are divided about that. This report will distinguish four visions of strategies on how sustainable agriculture can be achieved: technological, intensification, multifunctional and ecological.

Strategy 1: Technological

Sustainability will be reached by input of new and improved technologies. Manure can be processed to a high quality fertilizer, ammonia can be filtered out of the air and with help of smart-farming technologies like gps, sensors and drones, the input of chemical fertilizers and pesticides can be reduced. Especially in the greenhouse horticulture sustainability by technology is well developed, for example in so called 'closed systems'. Scale enlargement is often linked to this perspective, making it easier and more affordable to implement the new technologies. Scale enlargement can also be accompanied by chain extension (more parts of the production process on the same location), leading to a decline in transport. (based on: Scholten (2017), Vergouw (2016), De Dagelijkse Standaard, (2013))

Strategy 2: Intensification in combination with land sparing

This is the vision of, among others, the 'ecomodernists'. They pose that through a further intensification of the agriculture less land will be used. These lands can then transform into nature areas. Monofunctional land use is a key element in this: land that is only used for agriculture or nature has a higher value (i.e. higher food production or higher biodiversity) than when they are mixed. Technology is still an important element in this perspective, because of the high production, high quality technologies can be used to make the farming more sustainable. The idea that intensifying agriculture is not only the key to solving the world food demand, but also to saving forests and other natural ecosystems from invasion by farmers is known as the Borlaug hypothesis. (Foodlog, 2012)
(based on: Dänhardt & Smith (2016), Boersma (2016), Vergouw (2016))

Strategy 3: Multifunctional and small-scale, city focused

Multifunctional agriculture is agriculture that has more functions than just food production. This can be nature management or side activities like a camping. The key element is 'land sharing'; land is scarce in the Netherlands and therefore we should use it in more than one way. Multifunctional agriculture combines both people, planet and profit: it provides extra income, connects with the consumer and values landscape and ecological aspects. The focus on the regional production and short food circuits helps contributing to sustainability. On top of that, in the Netherlands, nature management is the most common side activity in multifunctional agriculture. (Boone & Dolman, 2010)
(based on: Hendriks & Stobbelaar (2003), van der Weijden & Hees (2002)

Strategy 4: Ecological: working together with nature

In opposite of the ecomodernists, this vision poses that agriculture should work together with nature. This perspective is for example recognizable in the 'nature inclusive agriculture' (see paragraph 5.2). Here, agriculture contributes to nature and benefits from it as well. Instead of separating them, nature and farming will collaborate. Integrating ecological principles in the agriculture can help gaining sustainability because rather than chemicals and unnatural inputs, natural growing systems are used.
(based on: Greenpeace (n.d), Erisman et al (2017), Boersma (2016))

Choosing or combining?

Each of these visions has benefits and disadvantages. The future most likely contains a combination of the four perspectives, depending on the location and farming sector. In general, intensification is probably necessary to keep up with the growing food demand in the world. This is especially relevant for other countries where the agriculture is not already as intensive as in the Netherlands. However, intensification does not have to be done with more use of chemical fertilizers and pesticides. Making useful use of ecological principles can both intensify the agriculture while at the same time offering higher biodiversity. 'Ecological intensification' is the term often named, including by the United Nations. (Food and Agriculture Organization of the United Nations [FAO], n.d; Tittonell, 2014). Intercropping for example gains more yield from the same amount of land, without damaging the ecosystem. If areas suitable for agriculture get used more intensely for farming, while at the same time being more ecological, areas valuable for nature can be reserved for nature.

Technological innovations are very suitable to make farming more sustainable as well. Especially for renewable energy we rely on wind turbines and solar panels. Technology and intensification will for greenhouse horticulture be the main ways to reach sustainability. Creating a hightech closed circle with technologies, growing foods in water or on substrate and even without sunlight makes this sector very suitable for intensification. For crop farming combining technology and ecological strategies are most relevant, as these crops are grown on a large scale and outside in the soil (in contrast to greenhouse crops). In areas close to the city and the areas used for extensive livestock farming, multifunctional agriculture is suitable. Their location and function make it ideal to combine farming with public functions or nature management.

In the following chapters of this report the focus however will be on ecological agriculture, since here the connection with the landscape is the strongest.

5.2.3 The city region as location for future farming

Where lies the focus of sustainable agriculture? Urban Agriculture is a phenomenon that is occuring in more and more cities, from small outdoor plots to professional greenhouses. These projects are often small-scale and intensive. In the future, high-tech urban greenhouses, growing crops indoors with use of artificial light, might contribute fairly to the city's food supply. However, the small-scale initiatives will not replace the whole food supply. On the other end of the scale is the large-scale agricultural areas as seen in Flevoland. This production is strongly focused on export. Also here sustainability is necessary, but economically bound to import and export flows the step is more complicated.
Therefore, the switch should take place on the area in between: the borderland between the small-scale urban agriculture and the large-scale agricultural areas. This is the regional area around the cities, the place where people and food can be connected. On this level, short food flows can be established by producing regional food for the people living near.

5.2 Ecological agriculture

5.2.1 The agricultural ecosystem
To better understand the ecological vision, some basic principles of agroecology should be explained. Agroecology is about applying ecological principles to agriculture, to make it function as an ecosystem (Wojtkowski, 2004).

Figure 5.1 shows the difference between the current intensive agricultural system and an ecological system. The current system requires high energy inputs like the use of pesticides and chemical fertilizer to maintain the system. The monoculture makes it very vulnerable to pests and problems. An ecosystem on the other hand is resilient and stable, making high energy inputs (as in intensive agriculture) unnecessary. It is diverse and provides valuable ecosystem services to agriculture like water buffering, pollination and natural pest control.

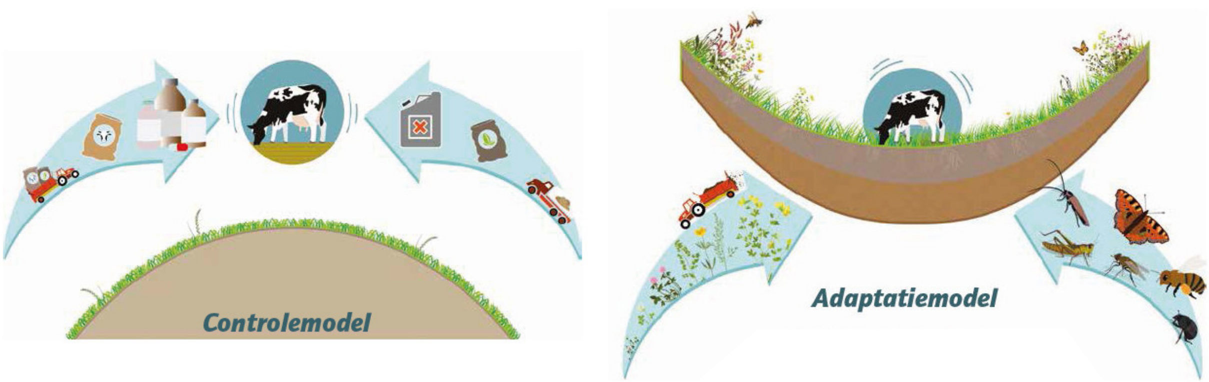


Figure 5.1: Control model of current intensive agriculture vs adaptation model of ecological agriculture
(Felixx, 2015)

An ecosystem consists of two main elements: structure and function. Structure is the spatial composition of the landscape elements. Function is about the movement and flows of animals, energy and materials through this structure (Dramstad, Olson & Forman, 1996; Lyle, 1999). Sometimes a third component of time (Dramstad et al., 1996) or location (Lyle, 1999) is added.

5.2.2 Why a landscape approach is necessary
Often, sustainable solutions are designed and implemented on the scale of a single farm. However, ecology does not work that way. You can have one very sustainable farm, but if its land is isolated, and the region around it is a green dessert, it does not help a lot. It will lead to a fragmented landscape that does not provide the contribution to sustainability that was intended.

"Because the ecological functions that underpin services of support and regulation operate at scales wider than the agricultural field or individual farm, this transition requires landscape approaches to agroecosystem design." (Tittonell, 2014, p.58)

The ecological functions and processes don’t operate on the scale of an agricultural field of a single farm, but on the scale of the landscape. Therefore a landscape approach to ecological agricultural design is necessary, taking into consideration both land use pattern and landscape structure.

“To stem the loss of function will require actions that alter landscape structure at scales larger than individual farms” – (Landis, 2016, p.4)

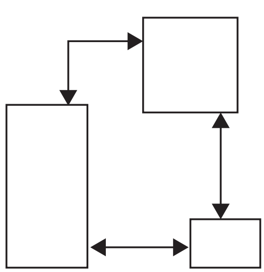
However, that doesn’t mean the smaller scales are unimportant. Better agricultural practices on field level are naturally part of the total system. A network of ecologically compensating areas should be supported on all hierarchical levels, but with the landscape level as a starting point. (Tittonell, 2014; University of Leeds, 2012; Mander, Mikk & Külvik, 1999; Landis, 2016)

5.2.3 Landscape ecology

So we are looking for ecological agriculture on landscape level. Landscape ecology is the field that covers ecology on landscape level. It has some basic spatial concepts.
Patches are areas that differ from their main surroundings, like terrestrial islands. They often represent nature areas. The edges of these patches differ significantly from the core, and are therefore often named separately. The matrix is the surrounding landscape, the type of land use that dominates the area, for example arable land. Corridors are the structures that connect different patches. The resulting pattern of the landscape is called landscape mosaic (Dramstad et al., 1996).

5.2.4 Agricultural landscape concept

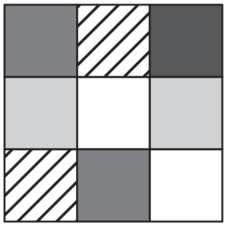
This brings us to two main concepts on how to make the agricultural landscape more sustainable, using landscape ecology: landscape connectivity and landscape diversity.



Landscape connectivity

Connectivity addresses the ecological network. This network consists of nature patches, areas with a high biodiversity (non-crop areas) and the corridors that connect them. Around the nature areas, buffer zones function as edge habitats between the high-biodiversity and low-biodiversity areas.

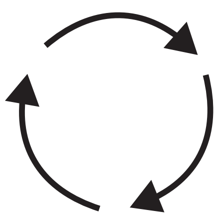
Connectivity deals with fragmentation and isolation of the agricultural landscape by creating a network of green. It is not just about connecting nature areas, but also about offering a fixed green structure in a production landscape with a low biodiversity of itself. This structure consists of three main aspects: nature areas, corridor structures and the decrease of barriers. (Tscharntke, Klein, Kruess, Steffan-Dewenter & Thies, 2005; Erisman et al., 2017)



Landscape diversity
Diversity applies to a landscape mosaic that is diverse and complex, having a variety of different land uses in a complex pattern. Landscape heterogeneity or complexity are terms closely related. A diverse landscape consists of different habitats, structures or crop types.

It is the opposite of monofunctional land use and landscape simplification, what is often seen in intensive agricultural areas. Monocultures are unstable and little resilient, therefore high inputs of energy are required to keep them in the right state (Lyle, 1999). A diverse agricultural landscape is more resilient and stable. The main aspects of diversity are land use and pattern. (Tittonell, 2014; Tscharntke et al., 2005)

Connectivity and diversity fit into the structure element of an ecosystem. However, an ecosystem also has a functional component. This component is covered by the concept of circularity:



Circularity
Circularity addresses the functioning of the landscape, the system. In current intensive agriculture, there are many extern inputs and waste flows. In an ecosystem, there is no waste. It is a circular system, where output flows are turned into input flows again. This is the aspect that is non-spatial, but systematic. However, the system or function can have spatial consequences as well.

5.3 Ecological farming systems

Sustainable by ecology: to get more concrete on how ecological farming would look like, six agricultural systems are explored, all having affinity with ecology. These are:

- Organic farming
- Permaculture
- Nature-inclusive agriculture
- Natural farming
- Agroforestry
- Regenerative agriculture

Organic farming *Biologische landbouw*

Organic farming is the most common and well known ecological farming practice. They strive to preserve environment, nature, landscape and animal welfare. Therefore, no chemical pesticides, fertilizers or genetic modificated foods are allowed. Allowed, because to be named 'organic', there are rules you have to comply with. Instead of chemicals, organic farmers make use of organic manure and natural cycles.
Within organic agriculture, there is another subgroup called biodynamic agriculture. To be a bio dynamic farmer, you have some extra requirements to meet. They have an anthroposophical perspective to farming, which involves a focus on soil fertility and often social aspects as well. (Agriholland, 2017)

Figure 5.2: Hoeve Biesland, a biodynamic farm
(Author)

Permaculture *Permacultuur*

Permaculture is a term that probably derived from combining 'permanent' and '(agri) culture'. It uses ecological design principles to create a food system that mimics the natural ecosystem. As the name says, one aspect of that is using perennial plants instead of annuals. Diversity and collaboration are other important aspects of a permaculture design: often different layers of plants are combined, all having multiple functions in the food production system. Permaculture is often associated with smaller (home)gardens instead of large scale agriculture. However, many of these principles do occur in the other ecological systems as well. (Permacultuur Nederland, n.d.; Permacultuurcentrum Nederland, n.d.)

Nature-inclusive *Natuurinclusieve landbouw*

Nature-inclusive farming is a recent term, among others used by the Dutch government. It aims for sustainability by optimizing the benefits retrieved from nature, integrating natural processes in the farming and taking care of the natural environment. The negative influence of agriculture on nature should be reduced, while at the same time the benefits from nature should be improved. Both agriculture and nature should profit from the collaboration in nature-inclusive agriculture. (Erisman et al, 2017; van Doorn et al, 2016)

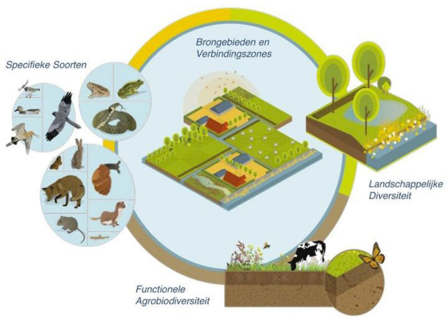


Figure 5.3: Scheme with the main elements of nature-inclusive farming
(Erisman et al,., 2014)


Figure 5.4: Natural farming in Park Lingezegen
(Author)

Natural Farming ***Natuurlijke landbouw***

Natural farming goes a step further than nature-inclusive farming. The term is originally introduced by Mr. Fukuoka and is based on letting nature do the work, going with the flow of nature instead of working against it. It seeks a balance between doing nothing and adjusting. Since it uses solely natural processes and systems, no chemicals or fertilizers are used. In the Netherlands, most areas have forest as a natural state, therefore natural farming always involves trees en bushes. Implementations of natural farming form a scale between natural and cultivated. Options are natural crop fields, alley cropping, forest meadows or (further on the scale towards 'natural') food forests. (Van Akker naar Bos, n.d.; Natuurlijke landbouw projecten & advies, n.d.)


Figure 5.5: Alley cropping in agroforestry
(Dupraz, n.d.)

Agroforestry ***Agrobosbouw***

Agroforestry is a collective name for agricultural systems that strive to introduce trees and bushes among or around farming fields used for crop or pasture. The combination with trees will lead to increased benefits because of ecological interactions. Five common ways of agroforestry practices are known: windbreaks, alley cropping, silvopasture, riparian buffers and forest farming. They fluctuate from a single row of trees next to the field to an integrate system of plants, bushes and trees. (Agroforestry Nederland, n.d.; Association for Temperate Agroforestry, n.d.)


Figure 5.6: Regenerative agriculture
(Agroforestry farm, n.d)

Regenerative agriculture ***Herstellende landbouw***

Regenerative agriculture actively strives to regenerate ecological damage by rebuilding soil organic matter, increasing biodiversity and improving the water cycle. It is a holistic way of land management, not only focused on producing food, but also on improving the ecological conditions of the site. The primarily focus is on a healthy soil, which is the basis of a healthy ecosystem, but also carbon sequestrion is involved. Practices include no-tillage, use of compost and green manures, crop rotation and managing grazing practices. (Regenerative Agriculture initiative, The Carbon Underground, 2017; Dr. Axe, n.d.)

5.4 Conclusion

Sustainable agriculture can be achieved by investing in technology and innovation, by becoming more intensive and spare land for nature, by becoming multifunctional or adapting an ecological approach. This project will focus on the ecological approach. As location, the city region is chosen, because here the best possibilities for sustainable farming are present. Agroecology is the science behind ecological agriculture. An ecological agricultural landscape should function as an ecosystem and work on the landscape scale. Therefore, the basic principles of landscape ecology are relevant. As concept for the design, the elements of diversity, connectivity and circularity will be used.

There are several agricultural systems that make use of ecological concepts. They differ in their angle of approach, but have many overlapping principles. For example, they try to mimic ecosystems and natural processes, let nature do the work and add trees and other perennial plants to the farming. The concrete principles that form part of these systems will be collected in the next chapter.

6. PRINCIPLES & SOLUTIONS

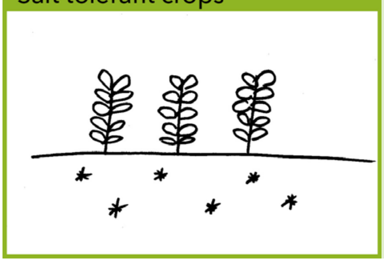
To be able to implement ecological agriculture in the design, we need to find concrete principles that can be implemented in the landscape. Therefore this chapter answers the question: "*Which elements of sustainable agriculture can be implemented in the landscape?"* First of all, it starts with the ecological principles that address ecological problems. These principles serve as input for the spatial part of the design. The system behind the ecological agriculture is covered in the heading 'circularity'. This serves as input for the circular design of the case study. Although the focus is on the ecological aspects, also social and economic principles are being discussed.

6.1 Ecological principles affecting the landscape

The ecological principles are derived from new literature or extracted from the ecological systems described in paragraph 5.3. Each of these principles addresses problems of sustainability. The problem(s) it tackles are listed at the end of each description. A list of the solutions per problem category can be found in Appendix 2.

6.1.1 Species

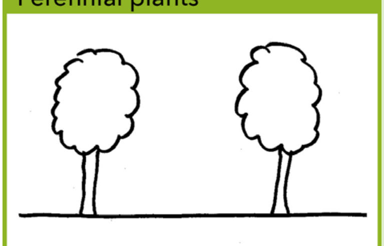
Salt tolerant crops



An easy way of climate change adaptation is to switch to crops that can handle the consequences, like drought (e.g. sorghum), warmer temperatures (e.g. grapes) or salinization (e.g. glasswort).

Tackles: Climate change consequences, extreme weather, salinization

Perennial plants



Most crops used in agriculture are annual. Switching to perennial plants offers several ecological benefits. Perennial plants have more extensive root systems and therefore are more efficiently in using water and nutrients. They make tillage unnecessary, benefitting the soil quality. Furthermore, perennials are more suitable for capturing and storing carbon. Trees and perennial grassland are well-known examples, but also other crops like grains can be perennial.

Tackles: Soil degradation, soil erosion (soil never bare), CO_2 emissions (by capturing)

Paludiculture (wet crops)

'Paludi' comes from the Latin word 'Palus', meaning marsh. Paludiculture involves growing crops in a small level of water (water level above ground level). Suitable plants for example are Azolla or Bulrush (Typha, Dutch: Lisdodde). Azolla is a nitrogen fixing plant, and therefore useful as green manure. Bulrush can serve as cattle feed, barn litter, biomass or building and isolation material. On peat soils where subsidence takes place, new peat moss (Sphagnum) can be grown. Therefore the water level can be heightened, stopping the process of subsidence and eventually leading to a higher ground level through the growing peat. The peat moss can be used as planting substrate or potting soil. Other interesting wet crops are cranberries and duckweed. (Innovatie Programma Veen, n.d.; Wojtkowski, 2004)

Tackles: Soil subsidence, CO_2 emissions by soil subsidence, eutrophication/water pollution, biodiversity, extreme weather events (water buffer)

Figure 6.1: Paludiculture with bulrush
(Veenweiden Innovatiecentrum, n.d.)

6.1.2 Polyculture

Polyculture, the opposite of monoculture, is a cultivation consisting of multiple plant species. It serves many benefits, like increasing the biodiversity, enhancing soil health and being less susceptible to pests. If the plant combination is chosen carefully, they can benefit from each other. There are different ways to achieve polyculture, some specific ways are described here. (Aufiero, Becker & Dutia, 2008; Tscharntke et al., 2005)

Tackles: Biodiversity, soil degradation, use of pesticides (pest resiliency) and fertilizer, economic income (increase yield & resiliency), soil erosion

Intercropping

Intercropping is the name for growing two or more crops simultaneously next to each other in the same field. This can be done in rows or mixed. By combining crops the land is used more efficiently, with the help of ecological processes. This leads to a higher yield and other ecological benefits. (Lithourgidis, Dordas, Damalas & Vlachostergios, 2011; Tscharntke et al., 2005; Wojtkowski, 2004)

Tackles: Biodiversity, Soil degradation, soil erosion (if planted/ harvested at different times), use of pesticides (increases pest resistance), less fertilizers (plant collaboration)

Strip cropping

Strip cropping can be seen as intercropping on a larger scale. Strips of different crops, fallows or grasslands are alternated. Although the plants benefit each other less directly, it still increases the pest resiliency. (Wojtkowski, 2004)

Tackles: Soil erosion (windbreak), soil degradation, use of pesticides (increases pest resistance)

Herb-rich grassland

Use of herbal-rich, perennial grassland instead of the common used ryegrass creates a polyculture grassland itself. Combined with no-tillage and being perennial, this grassland has large benefits for the soil quality, improving organic matter, soil life and soil moisture retention. It benefits the animal's health as well. (Erisman et al., 2017)

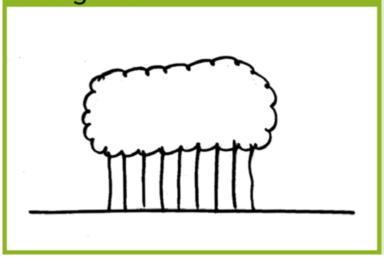
Tackles: Biodiversity, soil quality (organic matter, soil life), soil moisture retention (drought and extreme rainfall), animal health, meadow birds

6.1.3 Agroforestry

Agroforestry is the practice of trees combined with agriculture. Integrating trees in crop farming or livestock farming has several purposes. For cattle they provide shade, shelter and new food sources, but they also offer biodiversity and new habitat for birds and insects. The soil is improved by their leaf litter and the deep roots that can take up nutrients from deep soil layers. Improving the soil and preventing evaporation, the soil water retention capacity is improved as well. (Louis Bolk Instituut, n.d.)

Tackles: Animal welfare, animal feed, soil degradation (chemical/physical), CO_2 capturing (perennial), extra income (production) food/timber), biodiversity, landscape value

Tree grove



Groves are small groups of trees that can be planted on corners or useless parts of the land. The trees can provide extra income through timber production.

Tackles: CO_2 capturing

Alley cropping

Alley cropping is a combination of an agricultural crop and production trees (or hedges) planted in rows. The annual crop provides income while the tree is maturing. Trees can be planted for their wood (walnut, oak, ash), nuts (walnut, hazel) or both. They increase the soil fertility as they are able to reach for nutrients in deeper ground layers. Furthermore they can attract animals as natural pesticides. (Wojtkowski, 2004)

Tackles: Soil degradation, biodiversity

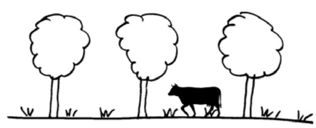
Figure 6.2: Alley cropping between two lines of hedgerows
("Agroforestry, Combinatieteelt", n.d.)

Food forest

A food forest (or forest garden) is a system that mimics forest growth patterns by combining different layers of plants, so it behaves like a forest ecosystem (i.e. a polyculture). Therefore inputs as fertilizer, pesticides and tillage are not necessary. The goal is to sustainably improve yield and biodiversity while at the same time cutting down on management.

Tackles: Soil quality, biodiversity, use of fertilizer and pesticides

Silvopasture



Silvopasture is an agroforestry practice where the livestock grazes in a meadow with trees and/or bushes. Chicken underneath fruit trees is already a common combination. The trees provide the animals with shelter and sometimes food, while the tree also can produce timber, fruits or nuts.

Tackles: Soil degradation, biodiversity, animal welfare

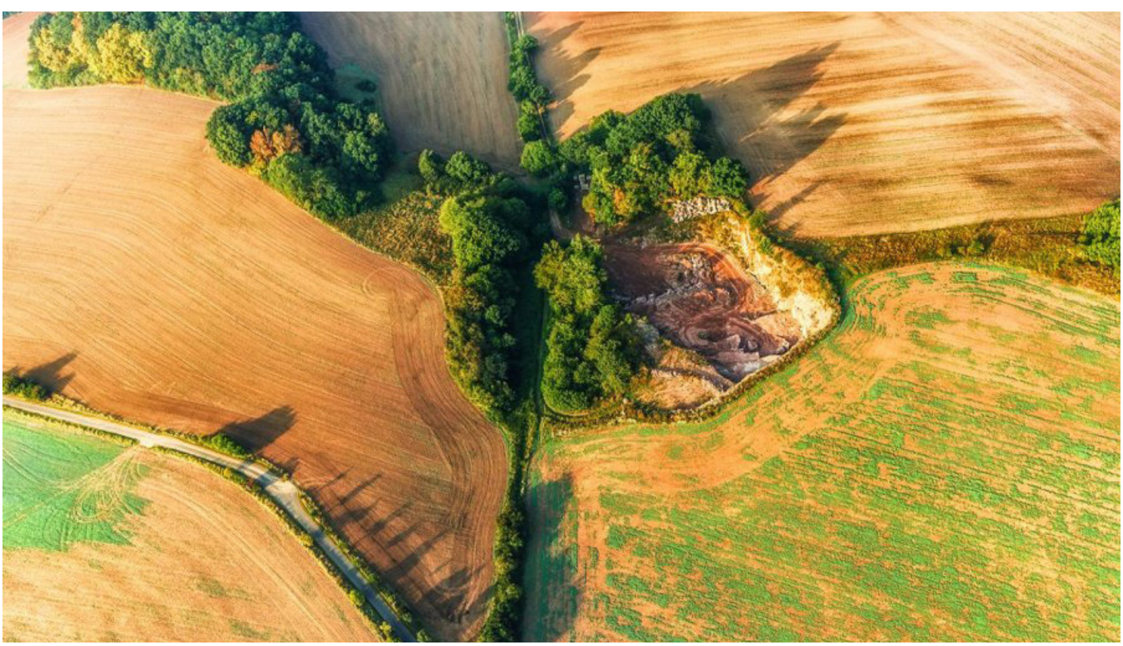
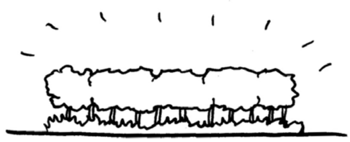


Figure 6.3: A bird-eye view of an ecological zone between agricultural fields
(Hesse, 2017)

6.1.4 Nature patches

Nature area



Nature reserves are the source areas on the large scale. They not only preserve nature, but also have positive impacts on nearby farms through pollination and natural pest control.

Tackles: Pollination, use of pesticides (habitat pest fighters), soil quality, biodiversity

Nature area buffer zone

Buffer zones around high value nature areas can take in the negative impact from e.g. intensive agriculture for the nature areas. These zones are edge habitats, having higher natural value than the common agriculture, but lower than the nature areas.

Tackles: Soil quality, water pollution, biodiversity

Refuge area

Refuge sites are nature patches on a smaller scale, like hedgerows, shelterbelts, groves, ponds, etc.

Tackles: Biodiversity, (pollination/pest control depending on species), water (retention), use of pesticides (habitat pest fighters)

6.1.5 Auxiliary structures

Field margin

Field margin is the umbrella term for edges around the field, between the crops and the field boundary. These strips can consist of grasses, (wild) flowers or kept sterile. The margins can function as edge habitats (ecotones) to stimulate biodiversity. As buffer zones they prevent the drift from pesticides or fertilizers to the environment. (Hackett & Lawrence, 2014; Erisman et al., 2017; Tscharntke et al., 2005)

Tackles: Biodiversity, eutrophication, water pollution

Insectary strips & beetle banks

Specifically focused on insects are the insectary strips or beetle banks. They attract insects that help with the pollination and to fight pests and unwanted insects.

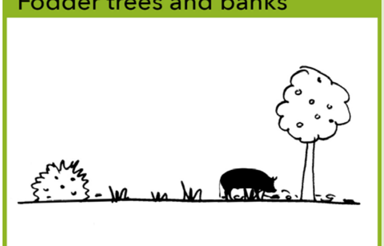
Tackles: Use of pesticides (habitat pest fighters), soil quality, pollination

Hedges and hedgerows

Hedges and hedgerows were originally used to border the field and keep the animals inside. However, even after the invention of barbed wire it is still useful for ecological functions as they improve the soil quality, water retention (especially in combination with a ditch) and offer wildlife habitat. As a windbreak or shelterbelt they shield the crops from winds, controlling soil erosion and reduce evaporation. (Tscharntke et al., 2005; Wojtkowski, 2004)

Tackles: Biodiversity, soil erosion, water retention/ drainage, soil quality, crop shelter, prevent drift & leaching (eutrophication & pollution), timber production

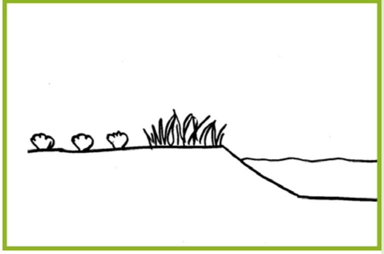
Fodder trees and banks



If trees are being used, like in an alley cropping or silvopasture system, using trees that provide fodder for the animals can be an extra benefit. Fodder banks can also be implemented as field margins, creating both a more diverse habitat as a more diverse diet for the animals.

Tackles: Soil quality, biodiversity, animal welfare

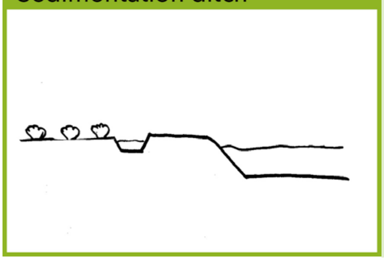
Water buffer zone



A strip between the water (channel) and the crop field, that can be free of cultivation or planted with other plants. Not being sprayed, this zone prevents run-off of manure/fertilizer nutrients from the crop field into the surface water; it acts as a buffer from nutrient loading. Planted strips are more efficient in taking up run-off water and its nutrients. Planting on the slope additionally prevents soil erosion of the water edges. (Helenius & Bäckman, 2004; Tscharntke et al., 2005)

Tackles: Water pollution (prevent leaching and run-off from fertilizers and pesticides), N2O emissions by run-off, water retention, soil erosion, potentially pest control & pollination, potentially biodiversity

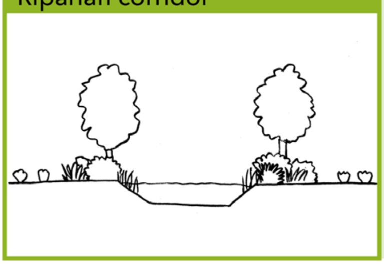
Sedimentation ditch



A ditch, parallel to the main water ditch to prevent direct (polluted) water run-off from the land in the surface water. It also increases the water retention as it allows the water more time to infiltrate in the soil.

Tackles: Water pollution (prevents run-off), water retention (infiltration time)

Riparian corridor



Riparian corridors are green zones of trees, shrubs and grasses along rivers and streams. They function both as a corridor and as a buffer zone between land and water to prevent water pollution and erosion. (Wojtkowski, 2004)

Tackles: Water pollution (prevents run-off), soil erosion, soil quality, biodiversity, (potentially) pollination & pest control

Figure 6.4: An insect flower strip in the Hoeksche Waard
(Janssen, n.d.)

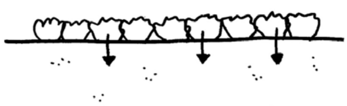
6.1.6 Auxiliary crops

Cover crop

Crops planted under the main crop or on the field after or before the growth of the main crop. By covering the soil they protect it from soil erosion, evaporation and weeds. (Erisman et al., 2017)

Tackles: Soil erosion, soil degradation, evaporation and water run-off (also by shading the surface), use of herbicides & pesticides (controls weeds and natural pest control)

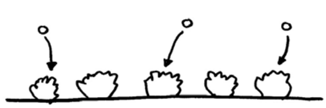
Green manure



The cultivation of crops to thereafter plow them under the soil with the aim of using them as organic amendment. The plants improve the soil in three ways: adding organic matter (organic soil quality), improving nitrogen level (chemical soil quality) and improving the soil structure (physical soil quality). Indirectly, by improving the organic & physical soil quality, the water buffering capacity of the soil will increase as well. Green manure plants are especially useful when they are so called 'nitrogen fixing plants'. These plants are able, with help of cyanobacteria, to fixate nitrogen out of the air, and store these nutrients in the ground. (Erisman et al., 2017)

Tackles: Soil degradation (organic, chemical and physical soil fertility), use of manure & fertilizer, water retention (decreases evaporation)

Catch crops



When crops are deliberately planted to catch residual nutrients from manure and prevent their run-off, they are called catch crops. These crops can be planted after the harvest of the main crop, taking up the surplus of nutrients out of the soil, or around the field to prevent the drift of pesticides. (Erisman et al., 2017; Tscharntke et al., 2005)

Tackles: Run-off nutrients (water pollution/eutrophication), drift of pesticides (biodiversity, water pollution)

6.1.7 Management principles

Highering water table

In areas where the water level is manually kept lower than its natural level, it can lead to problems with nature and soil subsidence. Therefore heightening the water tables may provide a solution. (Tscharntke et al., 2005)

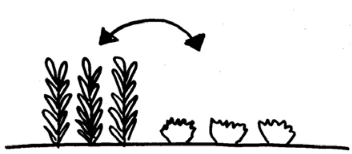
Tackles: Soil subsidence, CO_2 emissions by soil subsidence, dry-out of nature, biodiversity

Rainwater harvesting

Capturing rainwater in for example a pond or other surface water body. Lower areas can be assigned as sedimentation ponds, where water can flow to and then slowly infiltrates in the soil. The areas can be permanent filled with water, or only be used as buffer areas in times of heavy rainfall.

Tackles: Water buffering: extreme rain and drought events, use of sweet water, soil subsidence, soil water retention

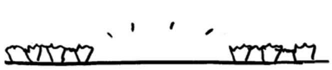
Crop rotation



Crop rotation is a system where the same field is used to plant different crops, in a particular order after each other in time. The first year one crop is cultivated, the other year another. The rotation can also be seasonal. This process contributes to the chemical soil quality, reduces soil erosion, and prevents plant diseases and pests. (Wojtkowski, 2004; Tscharntke et al., 2005)

Tackles: Soil degradation, use of pesticides (increases pest resistance)

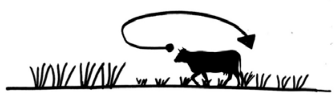
Fallows



Fallows are fields of land that are set-aside without cultivating it, to allow the soil to regenerate for future cultivation. In best practice, the field would not be left bare, but be planted with a cover crop or green manure. (Tscharntke et al., 2005; Wojtkowski, 2004)

Tackles: Soil degradation

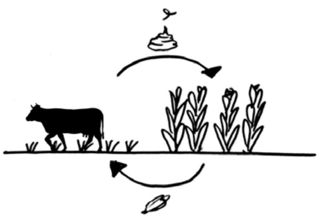
Rotational grazing



Rotational grazing involves moving livestock from one area of pasture to another, to prevent overgrazing.

Tackles: Soil quality, plant recovery, biodiversity

Land-based livestock farming



Land-based livestock farming implies that all the necessary food for the animals comes from the own land. This helps to close the nutrient cycle of cattle feed and manure, as it restricts the amount of animals.

Tackles: Import cattle feed, transport emissions, manure surplus

Conservation tillage

Conservation tillage goes from less to no tillage at all. When plowing the soil, organic material is removed and the soil becomes bare. It also causes the emission of CO_2 out of the soil, increases water evaporation and compacts the soil with heavy machinery. Therefore adapted ways of tillage (like strip tillage) are implemented, where the soil is less disturbed. Especially with grassland it is important to keep the soil intact (*Dutch: niet scheuren*), since this releases a lot of CO_2. (Erisman et al., 2017; Tscharntke et al., 2005)

Tackles: CO_2 emissions from the soil, loss of organic matter (soil quality), soil life, soil erosion & water runoff, leaching of nutrients & pesticides, lack of soil moisture retention, soil compaction, fuel fossil use for machines

Compost

Compost is the result of the composting process of vegetable and organic remains, decomposed by micro-organisms. It can be used instead of manure or fertilizer, but it also has the benefit of a natural pesticide by increasing soil life and organic matter. Another benefit of using compost is that the nutrients are released more gradually, so there is a smaller change of leaching and losing them to the water.

Tackles: Soil degradation (organic matter, physical structure), use of fertilizer and manure

6.2 Circularity

Circularity is about flows. Therefore the relevant flows are listed, and also who produces and who consumes them (see table 6.1).

	Flows	Production	Consumption
Nutrients	Food (for people)	Greenhouse horticulture Outdoor horticulture & crop farming Livestock farming	City
	Feed (for livestock/fish)	Grassland - not suitable for human food production Residual flows agriculture and food procession Algae, insects, duckweed, rapeseed	Livestock farming Aquaculture
	Nutrients (waste flows)	Manure animals (thick fraction) Manure animals (thin fraction) Green waste city Sewage silt city Organic waste agriculture Silt from the waterways	Composting Fermentation plant Biomass incineration Insect culture
	Fertilizers	Digestate (fermentation plant) Nutrient rich water aquaculture Compost	Crop farming Horticulture Garden centres
Energy	Electricity	Biogas CHP installation Biomass incineration Geothermal energy Solar panels & wind turbines	Greenhouses Crop farming Livestock farming City
	Warmth	Biogas CHP installation Residual warmth greenhouses	Greenhouses Livestock farming City
	Fuel	Biogas fermentation plant Collection methane gas	City Machinery
Water	Water	Rain Surface water Composting / fermentating Purification by helofytes	Livestock farming Crop farming Horticulture
CO_2	CO_2	Fermentation plant	Greenhouses
Materials	Materials	Willows, reed water edges	Stables livestock

Table 6.1: An overview of the relevant flows in agriculture, linked to the places of production and consumption.

6.2.1 Nutrients

Since agriculture is about food, nutrients are probably the most relevant flow concerning circularity. The most simple circular example can be found in the collaboration between livestock farming and crop farming. The livestock farming produces fertilizers for the crop farming, which on his turn provides the livestock with plants for feed. Both then produce food for human consumption (see figure 6.6). However, the current system turns out not to be so circular at all. Animal feed is imported and artificial fertilizer is being used on the crops. Waste flows lead the nutrients out of the system, without returning them. There is a surplus of manure and a huge amount of land is used for cattle.

<u>Cattle Feed</u>

*"Diervoer gaan we maken van delen van voedselgewassen die we nu niet gebruiken, zoals het eiwitrijke blad van suikerbieten. De mogelijkheden zijn enorm. Zelfs restanten die we tot nu toe als onbruikbaar beschouwden, zoals stro en loof, zijn met behulp van insecten, wormen of paddenstoelen om te zetten in voedingsrijke grondstoffen voor diervoer" * (Scholten, 2017, p.24)*

To really integrate livestock farming in the agricultural system, the amount of livestock should be adjusted to the amount of feed available and fertilizer needed. To take away the food-feed-competition, only land not suitable for human food production should be used for feed production, like wet grasslands. On top of that, residual flows from the crop farming (like the leaves of the sugar beet) or the city (grain remains) can be used for feed as well (see figure 6.7).

To create a circular system, all animal feed should come from our own lands. The most imported feed products are protein rich foods, like soy beans. Specifc protein rich crops can be grown in the Netherlands as well, replacing the need for import.

Feed producers:
- Land unsuitable for growing food (grassland)
- Residual products from crop farming and food industry (cattle feed, insect/entomo culture)
- Insects (cattle or fish feed)
- Algae, duckweed, azolla, etc

<u>Entomo culture</u>

Insects can play an important role in the future of circular agriculture. In so called 'Entemo culture' insects as mealworms, black soldier flies, crickets and locusts are feeded with organic waste flows, like grasses, duckweed or mowed water bank vegetation. The insects turn these waste products into a valuable protein-rich food source for animals (especially chicken), aquaculture and even human consumption. This type of production requires less space, feed, water and produces less greenhouse gasses than the common farm animals, making it a very sustainable protein source. (Verwer & Peters, 2017; Wageningen University and Research, n.d.)

Figure 6.5: An insect farm
(Entomo farms, n.d.)

**EN: "We will make cattle feed from parts of food crops we currently don't use, like the protein-rich leaf of the sugar beet. The possibilities are enormous. Even residues that up to now were considered as unuseble, like straw and foliage, can with the help of insects, worms or fungi be converted to nutrient-rich sources for animal feed."*

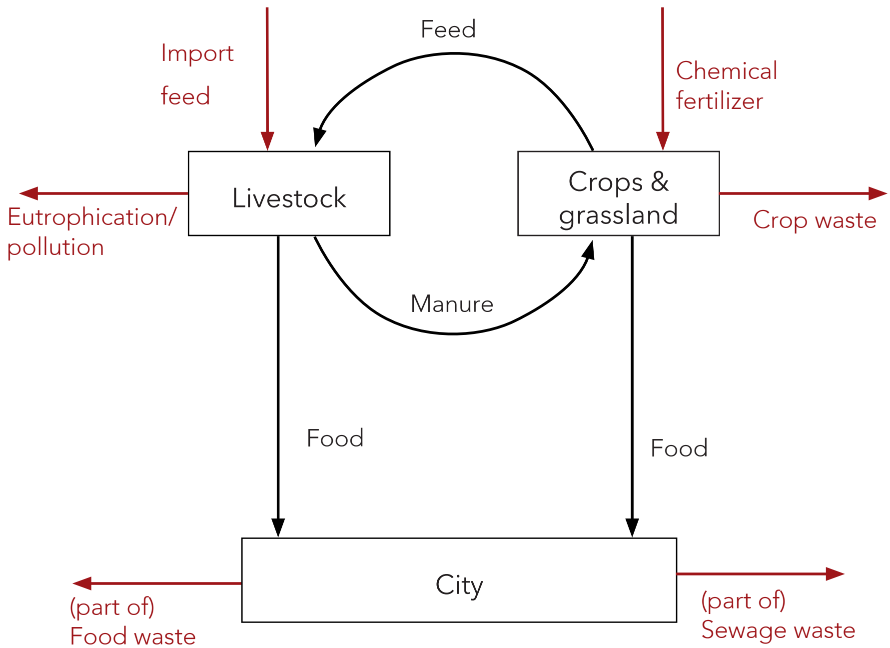


Figure 6.6: Current scheme of nutrient flows in plant-livestock collaboration

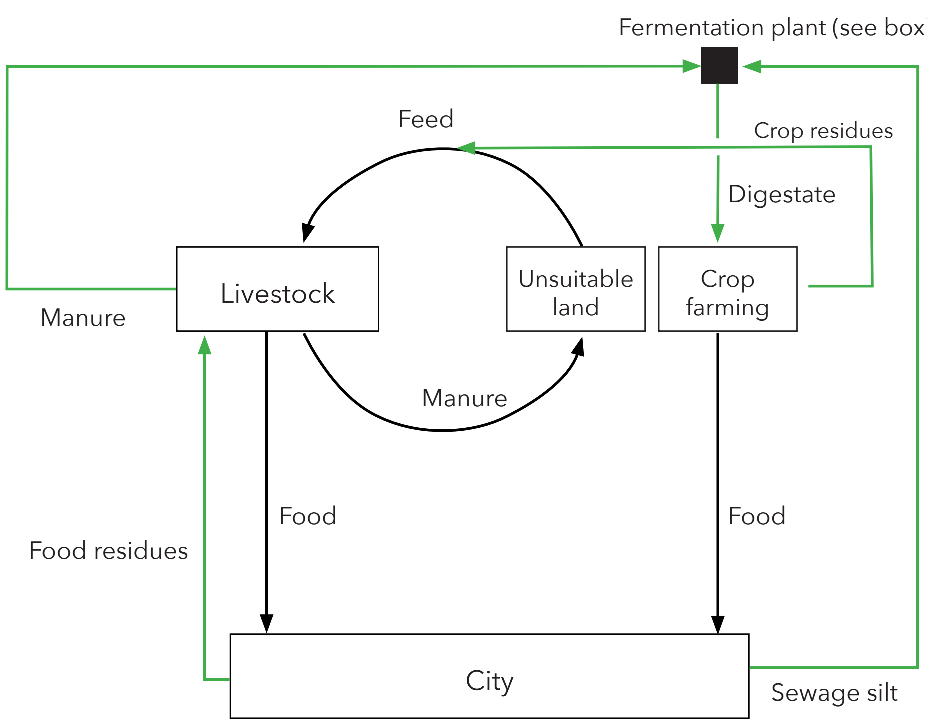


Figure 6.7: Making the existing scheme circular

Waste flows and fertilizers

Currently a lot of nutrients leave the system because of a surplus of manure, food waste and the sewage system. In a circular system, all these waste flows will function as a fertilizer for growing crops or as feed input. Some of them can be used directly, others might need to be upcycled by composting or fermenting processes.

Animal manure can be used directly as fertilizer. However, seperating the thin and thick fraction can increase the value of the product. Also water from fish tanks can be seen as a nutrient source.

- Thick fraction manure > Stalmest or fermenting input
- Thin fraction manure > Phosphate fertilizer, production algae or duckweed in bassins
- Fish manure in water > Nutrient rich water for plants

In fact, all organic waste flows can be used as fertilizer.

- Organic waste city > Composting
- Silt from sea or sewage > Fermenting
- Coffee grounds > Mushroom cultivation

The fermentation plant

Valuable processes in the nutrient system are fermentation and composting. These processes are able to recycle residual nutrient flows back to useful fertilizers. A fermentation plant can process organic waste like manure, plant residues or food residues, producing digestate (fertilizer), biogas and warmth (see figure 6.8).

Often it is combined with a cogeneration unit (CHP = combined heat and power). This unit can convert the biogas in elektricity and warmth.

The differences with composting are the anaerobic conditions and the emergence of biogas. In an incenerator where biomass is burned, nutrients are often lost.

Composting process: Organic material + O_2 → Warmth + water + CO_2 + compost
Burning process: Organic material + O_2 → Warmth + CO_2

Side note: fermentation plants are often difficult to sustain economically due to high costs.

Figure 6.8: A fermentation plant
(Host, n.d.)

6.2.2 Energy

There are several options for renewable energy inputs instead of the fossil fuels being used now. The first one is already covered by the fermentation plant, providing green gas. With help of a CHP unit (*Warmte Kracht Koppeling*) this can be transferred in elektricity, warmth and CO_2. Biomass incineration is not as desirable as fermentation. Firstly, because it reduces the nutrients to ash instead of valuable fertilizer. Furthermore, often biomass for energy is grown on land suitable for food production. A lot of land is required to produce a small amount of energy. Another option is the use of geothermal energy. Especially a lot of greenhouses turn to this for their needed warmth and elektricity.

Fermentation plant	> Biogas
CHP	> Elektricity & warmth
Solar panels	> Elektricity
Wind turbines	> Elektricity
Geothermal energy	> Elektricity & warmth
(Biomass incineration	> Elektricity)
Thermal energy storage (Dutch: *WKO)*	> Warmth

6.2.3 Water

In the perfect system, rain- and surface water would be sufficient to water all the crops and feed the animals. Currently, agriculture uses tap water, surface water and ground water as well. In periods of heavy rain, we try to get rid of the water, while in other times, there is a lack of water so we turn to inputs from other places, like tap water. The water that is returned to the system is often contaminated with nutrients and pesticides. Therefore, a circular approach to the water flows woulde be to keep the water in the system and to clear waste water.

Keep water:
- Collecting rainwater
- Composting process
- Collecting condensation water greenhouses

Cleaning water:
- Plants (especially helophytes)

6.2.4 CO_2 & materials

In the greenhouse horticulture, CO_2 can be very useful to accelerate the plants' growth. CO_2 is produced in the process of fermentation and in the WKK installation.

Apart from food, feed or energy resource, plants can also function as materials. Biobased products get more common and more possibilities turn up to use plants instead nonrenewable resources. For example, reed can be used as animal box litter and bulrush can be used as building insulation material.

Integrating animals in the system

Integrating animals in the system can add more values than just meat and manure production. A balanced integration can lead to an optimilized system where animals can furfill tasks as weed destroyers, landscape managers or to stir up the ground, mow the grass and even prevent pests. Not just cows, but also chickens and pigs can furfill such roles.

Cows /goats/sheep

- Eat: grasses, herbs, shrubs and trees
- Mowing grasses, preferably in a rotational grazing system
- Pruning shrubs and trees
- Manure

Pigs

- Eat: nuts (acorns, hazels), tubers, plant residues, food residues, fruit
- Tillage: plowing the ground by rooting with their nose. They create desirable disturbance, helping seeds to germinate. By plowing the ground, soil can be made ready for sowing (pig tractoring).
- Weed management: they eat weeds, like acorns and thistle's seed boxes. They trample the weeds and upcoming small trees.
- Pest management: by eating the falling fruit (which is most likely to be rotten), they prevent pests
- Helping the compost process: walking in a stable, they mix the straw and manure to an airy mixture, making it easier to compost.
- Manure

Chickens & ducks

- Eat: seeds, grasses, greens, grains, berries, insects and bugs
- Prepare planting beds, till up garden
- Eat pests, bugs and snails
- Spread mulch
- Manure

Figure 6.9: Piglet enjoying the sun at Boerderij 't Geertje
(Author)

6.3 Economic sustainability: how do the farmers survive?

The current farmers have problems gathering enough income from their farming practice. What are the possibilities to sustain their living with farming without needing to increase production or turn to intensive agriculture? Five ideas are described here.

- Increase product prices
- Steering with subsidies
- Specialize
- Extend activities
- Direct marketing

Increase product prices
A solution that is not as simple as it sounds. However, it should become clear that for certain products, like meat and dairy, the price really should increase. Increase to cover at least the production costs, as well as extra costs concerning sustainability. As an extra advantage, it might stimulate people to consume less animal products.

Specialize
One way to increase farming income, is to specialize in a certain (niche) product. Focussing on one product can decrease production costs, an action strongly linked to intensification. It makes the farmer very vulnerable for problems though, as it is the opposite of diversity. Therefore specializing should not be about only focussing on one product, but producing a niche product, something unique where a higher price can be asked for.
- Alternative crops: Instead of common potatoes and wheat, farmers could cultivate special, less common crops like amaranth, spelt or seaweed.
- Chain extension: Not just growing the crop, but also processing it, increases the value of the product. Take for example the potato farmer selling its own chips, or the dairy farmer producing cheese.
- Branding: Sometimes, the right way of branding a product can increase its price value as well. For example, by linking it to a location: cheese from 't Groene Hart, Zeeuwse aardappelen.

Subsidies
In the current CAP already a part of the money is linked to greening conditions. Although this turns out not to be so succesful, it is still a good idea to pay the farmers for valuable extra services they provide society in terms of nature and ecosystem services. Examples are:
- Paying for the management of nature areas (*agrarisch natuurbeheer)*
- Paying for providing 'green services', like water buffering, biodiversity, landscape management, etc.

Figure 6.10: Collecting point of local food boxes
(Boeren & Buren, n.d.)

Figure 6.11: Farm shop at Biesland Hoeve
(Hoeve Biesland, n.d.)

Extend activities: multifunctional farming and side activities

By extending their activities, farmers can gain extra income from other activities. Often used examples are:
- Recreation & tourism: camping, B&B, boat rental, children party, petting zoo
- Food: tea garden, café, ice cream, sell own products
- Care: care farm for elderly or disabled people, day-care
- Education: workshops and guided tours
- Room or space rental: rental for events, meetings and parties
- Management of nature areas and landscape

Direct marketing

Direct marketing is about selling the products yourself, to bypass the food industry. This can be done in two ways: sell the products yourself or ensure the income in advance.

<u>Sell the products yourself</u>

Farm shop: Selling own products through a (self-service) shop on the farm (see figure 6.11).

Local farmers market: Selling the products on a local farmers market.

Regular buyers in catering: Having a contract with certain catering services or restaurants that they will buy your product.

Local food boxes or food subscriptions: Consumers can buy a food box, consisting of local products directly from the farm. This can also be done in a subsciption form.
Example: Kistje vol smaak

Supermarket for regional products: A supermarket only selling regional products, mention the origin of the food as well. This can be done online, where you can order the products and receive them home. Or a physical collection point, where online orders can be collected or even be bought (see figure 6.10).
Examples: Food Value, streekboer.nl, boerenenburen.nl

Ensure income in advance

Consumer supported agriculture (CSA): In CSA, consumers pay yearly a fee to cover the production costs of a farm. In return, they receive part of the yield.

Herenboeren: Herenboeren is a Dutch foundation, that works with the CSA principle. A regional farm is set up, paid by a group of 200 investors. This group of investors forms the cooperation that employs a farmer to work the farm. In return they receive low-cost, regional and organic products.

Shareholders: Consumers can buy shares in advance, for example in meat. With these shares they pay for the production of the meat. In return they receive the produced meat.
Example: Vleesaandelen boerderij De Marsen

Other

Partnerships: Currently, a lot of farms are family businesses. To be better able to cope with the work pressure and the financial issues, a business partnership consisting of three or more partners could work.

6.4 Social sustainability: how to connect city and farming?

Although social sustainability is about more than just 'connecting city and farming', for my project I will focus mainly on this aspect.

*"Er is geen kloof, maar vervreemding tussen boer en burger." **
(Documentary 'De Boer Op', van Blokland & de Man, 2017)

What is meant with 'connecting city and farming'? When speaking about 'connection' between farmer and consumer, three types of connections can be distuinguished: conceptual, visual and physical.

Conceptual links focus on awareness and the perception. People should experience the agricultural land near them as the place where 'their' food comes from, as part of their living environment. This awareness can for example be realized by naming products after a region or place, linking the region and its food. Common examples are Beaujolais wine, Goudse Kaas or Texels speciaalbier.

Visual links make the area visible, to create awareness, interest and the feeling of 'being connected'. Being able to see the agricultural land from the edge of the city or the car road, makes people more conscious of the existing farming land that surrounds them.

Physical links focus on accessibility. The easier it is to access a place, the more likely people actually do. Consumers should be able to enter the agricultural area from the city without crossing any barriers. Recreative routes can lead them deliberately or by chance to the farming landscape. For the reason that if you happen to be near a farm anyway, you are more inclined to visit it. E.g. a farm stand along a busy cycle path can count on more income than the stand for where your have to cycle to the farm courtyard itself.

Spots are the physcial places people can visit. These are farms that can be visited, or that organize side activities. It can also be the farmland itself.

Generated ideas based on these principles are listed below.

Informing & creating awareness

- Connecting products to a local identity. Making the origin of the product know to consumers.
- School programs (e.g. teaching about food production, bringing kids to the farm)
- Focus on seasonal products
- Festivals celebrating harvesting season
- Creating a better image of the farmer, for example: the farmer as manager of the landscape
- Creating a local food network
- Making it easier to work on a farm as a side job (for youth)
- Supermarket with local products
- View on agricultural land from roads or city edge

** EN: There is no gap, but alienation between farmer and citizens."*

Direct marketing

Already described as part of economic sustainability, direct marketing can also contribute to social sustainability. If consumers buy local products knowing where it came from, they will be more aware of the local food production. This effect is even stronger in Consumer Supported Agriculture, where the consumers are directly involved in the food production.

A reason to go there: paths and routes (physical connectivity)

- Experience trails: routes along the farmland and farms (see figure 6.13)
- Farmland paths (klompenpaden): (often unpaved) paths on the land of the farmer
- Decreasing barriers between city and agricultural land
- Let people get their daily groceries from the farm, giving them a reason to be there.

A reason to stay there: farm activities (the spots)

- Farming days or festivals
- Recreation on the farms: camping, petting, boat rental, …(see figure 6.12)
- Food on the farms: ice cream, pick your own fruits, tea garden, …

Figure 6.12: Multifunctional farm Boerderij 't Geertje
("Boerderij 't Geertje", n.d.)

Figure 6.13: Bike path through the agricultural landscape of Zoeterwoude
(Author)

7. CASE STUDY ZOETERMEER

The agricultural area around Zoetermeer is chosen as a case study for a design that integrates sustainable agriculture and landscape to answer the question: *"How to apply sustainable agriculture principles using the landscape characteristics of the area around Zoetermeer?"*

The choice for this location is based on the present agricultural sectors (several types), landscape diversity and the relation to the city. The main focus will be on the landscape scale, since this is the scale that has the biggest influence on making the agricultural landscape more ecological sustainable. (University of Leeds, 2012; Tittonell, 2014)

This case study will exists of 4 steps:

7.1 Analysis of the landscape
7.2 Analysis of the agriculture and its relation to the landscape, using the links described in chapter 3.
7.3 Problem diagnosis, using the problem categories as defined in chapter 4.
7.4 Linking the problems to fitting sustainable principles from chapter 6.
Ch.8 Design of the area, through different scales.

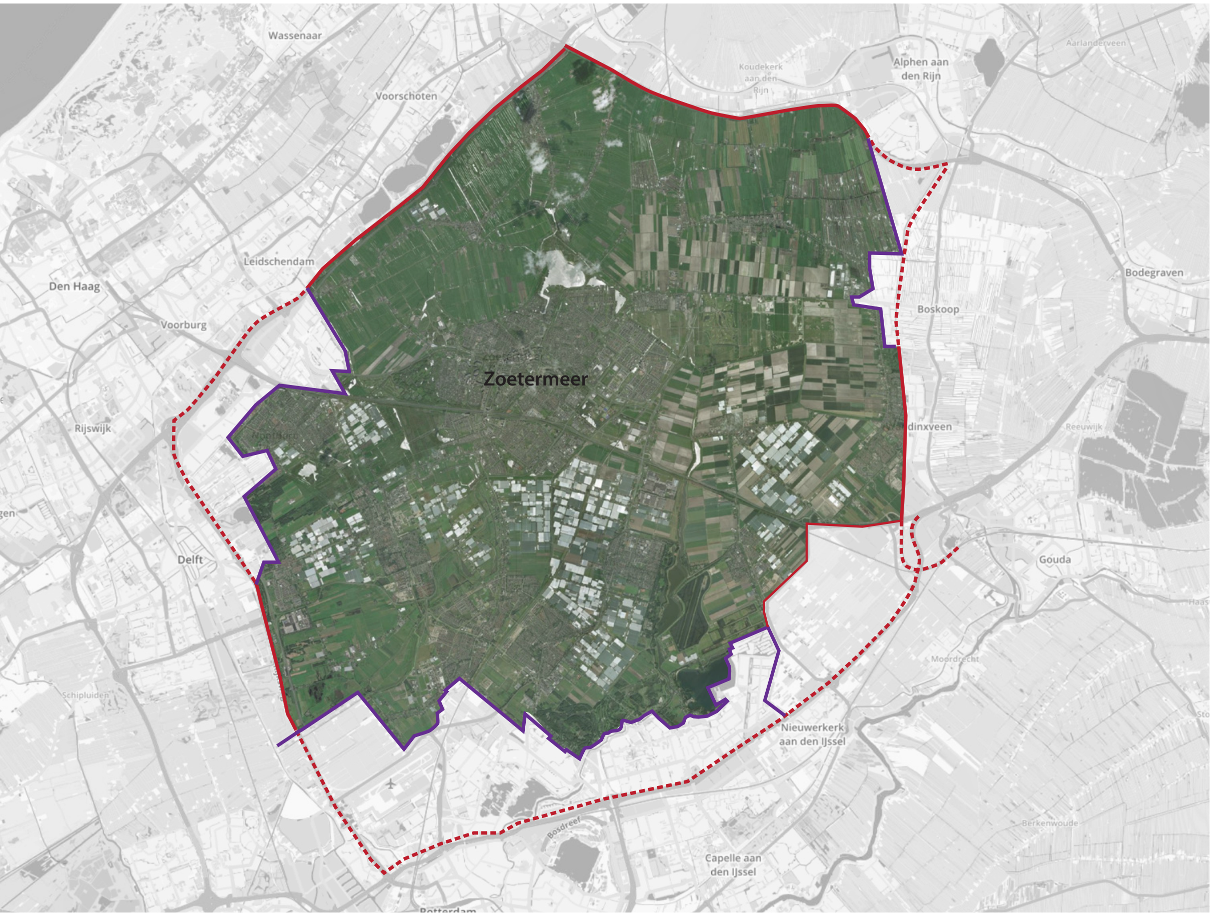


Figure 7.1: The area of focus, bordered by large infrastructure (red) and municipality borders (purple)

7.1 Landscape analysis

Bordering the area

The chosen area can't be defined by existing borders, it is real in-between area. It is part of 7 municipalities, 3 different agricultural areas, 3 water boards and part of it belongs to the nature reserve 'Het Groene Hart'. To get more grip on the study area, infrastructure and municipality borders are chosen as borders (see figure 7.1).
The region has a lot of heavy infrastructure, like highways and railways. It is in the middle of the 'Randstad', the most urbanized region of the Netherlands, bordered by big cities as the Hague, Leiden and Rotterdam. The main city in the chosen area is Zoetermeer, having about 125.000 inhabitants (Gemeente Zoetermeer, 2017). Several villages are located in the agricultural area, some quite big (like Pijnacker), some only consisting of a few houses (Bent).

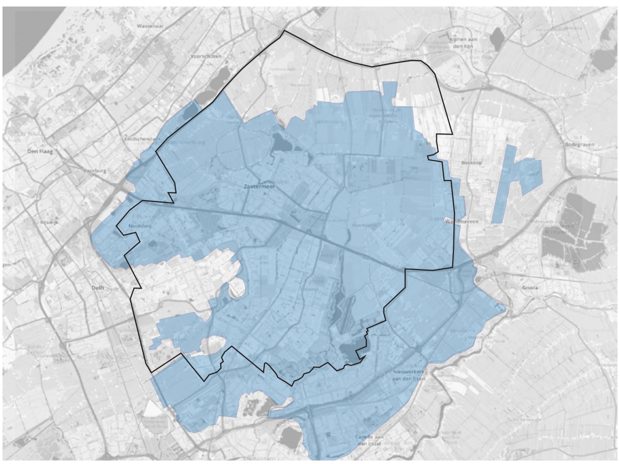


Figure 7.2: Lake-bed polder area

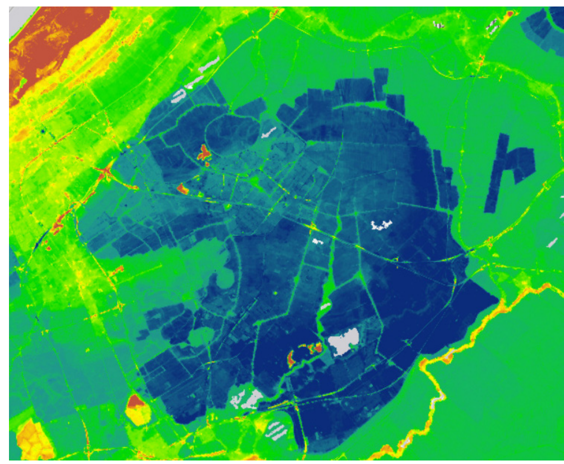


Figure 7.3: Height map
(Actueel Hoogtebestand Nederland.)

Watersystem

The area consists of two type of polders: lake-bed polders (*droogmakerijen*) and peat polders (see figure 7.2). The first lake-bed polder was the Zoetermeersche Meerpolder, drained in 1614. The last one in the bordered area was the Zuidplaspolder, finished in 1840 (Oerlemans, 1992). The difference between the two poldertypes is clear on several aspects. For example, in the groundwater levels. The peat soils are the wettest, and also around Pijnacker it is quite wet. The east side of Zoetermeer has the driest soils.
The area knows many smaller polders (see figure 7.4). The drained water goes to the rivers and canals surrounding the area: de Vliet (west), Oude Rijn (north), Hollandsche Ijssel (southeast), Rotte (South) and the Schie (southwest). During dry season, sweet water is let in from Gouda.

Height

The height in figure 7.3 clearly shows the different between the lake-bed polders and the surroundings. Also some villages are located on higher ground, like Hazerswoude and Benthuizen. These are located on soil that wasn't exevated for peat (*bovengrond*), and therefore higher than the rest of the polder. The boezemwater of the Rotte also rises above the rest.

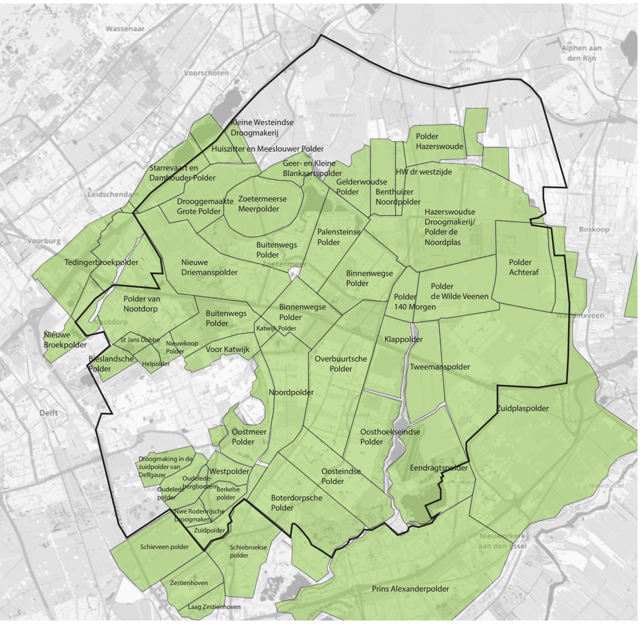


Figure 7.4: Lake-bed polders

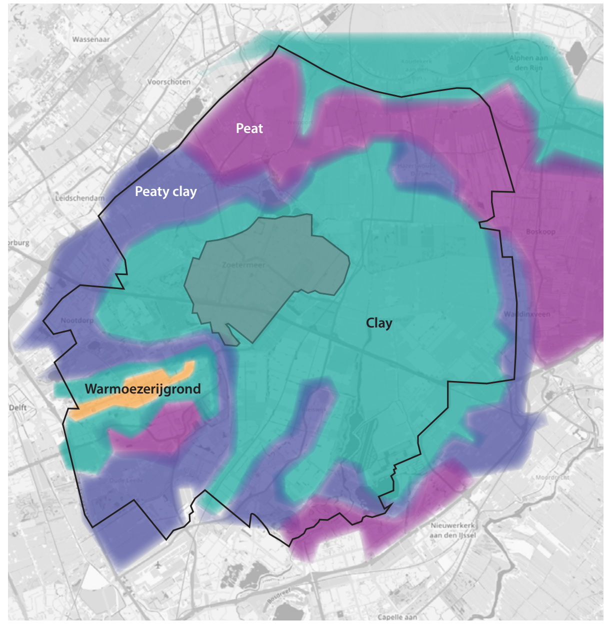


Figure 7.5: Soil map

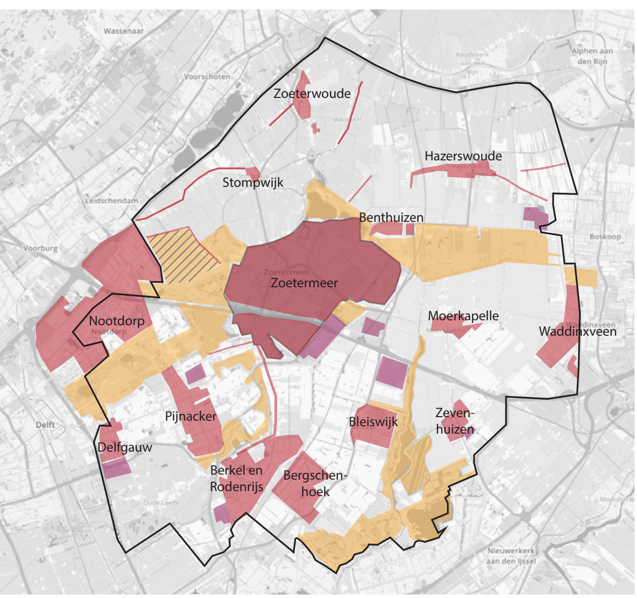


Figure 7.6: Land use


Figure 7.7: Buildings

Soil

The area consists of mainly three soil types (see figure 7.5). In the north and a little bit in the south there is the wet peat soil. The edge of the lake-bed polders consists of swampy clay with remnants of peat (*moerige klei*), while the main part of the lake-bed polders consists of normal clay. Close to Pijnacker the ground is more mixed: here they tried to improve the soil by adding dune sand and organic manure to it. The soil is called '*Warmoezerijgrond*'. (Provincie Zuid-Holland, n.d.-a)

Buildings
It is an densly urbanized area. Three types of buildings can be distinguished: clustered villages, ribbon villages (*lintdorpen*) and greenhouses (see figure 7.7).

Land use
The downside of an urbanized area is that agricultural land gets replaced for other functions, like new housing areas, industry or recreation areas (see figure 7.6). It seems like the ‘leftover areas’ are for the agriculture.

Nature value
A large part of the area belongs to ‘het Groene Hart’, about half of it. Especially the northwest grassland area is very well protected and valued. It is marked as a green buffer zone, a meadow bird area, and contains a silence area, several nature areas and one Natura 2000 zone (de Wilck) (Provincie Zuid-Holland, n.d.-c). Compared to this green space, the other parts around Zoetermeer are less appreciated and also less protected (see figure 7.8).

Cultural-historical value
In cultural-historical value the peat soils seem to score higher as well (see figure 7.9). The Weipoort forms, together with Zuidbuurt and Westeinde, a historical ribbon village, with still existing features as Kerkepaden (church paths) and a Weddepad (path where the river was crossed). Other interesting landscape elements in the region are the wind mills, a duck decoy and the land seperation dikes (*landscheidingen*) on the border between the water boards. If the lake-bed polders can be perceived as of cultural-historic value, the Meerpolder as the first one and the edge between the lake-bed and the peat polder are also of specific interest. (Provincie Zuid-Holland, n.d.-b)

Conclusion
The cultural landscape shows a contrast between the lake-bed polders and the peat polders, where the peat area (and also the wet part of the lake-bed area) gets all the attention when it comes down to natural & cultural value. The peaty part of the lake-bed polders forms the exception here: due to the wet soil, it is more perceived as part of the meadow landscape than the clay polders.

The clay area is therefore the victim of the ongoing urbanization: formerly open agricultural area gets filled up with houses, greenhouses, infrastructure and recreation areas. Degrading the quality of the area very quickly.

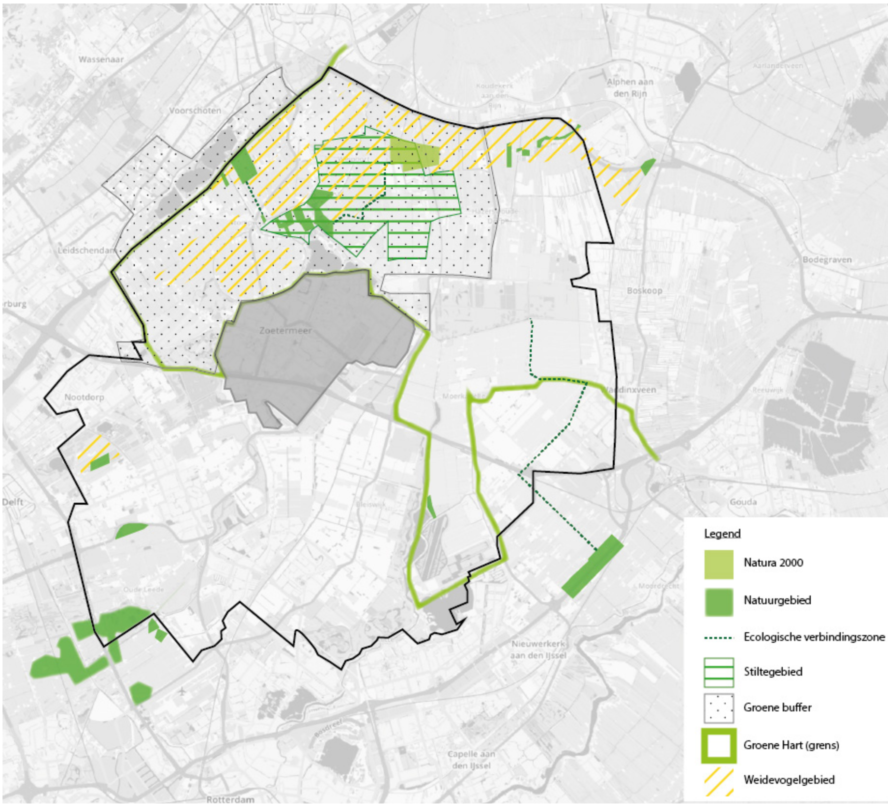


Figure 7.8: Assigned nature areas

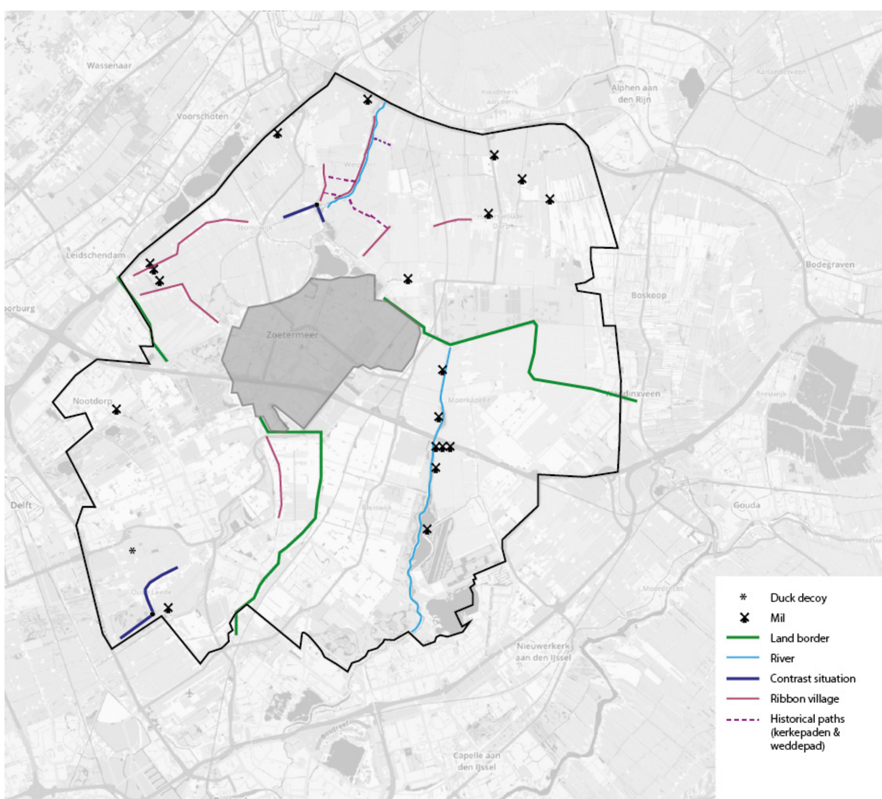


Figure 7.9: Cultural-historical value

7.2 Agricultural landscape analysis

Soil and sector

The area has three main agricultural land uses: land-based livestock farming, crop farming and greenhouses horticulture (see figure 7.10). In general determines the soil the type of agriculture (see figure 7.11). The peat areas (including the peaty clay) is dominated by grassland and land-based livestock farming. Also in the southwest this type is found. The clay of the lake-bed polders is very suitable for crop farming. This sector is concentrated on the east side of Zoetermeer.
The greenhouse sector is less soil-dependent. It is mainly located in the south on the clay soils, and on the adapted mixed soils (*Warmoezerijgronden*). In the northeast of the region, some outdoor horticulture is found, although the large area of this sector (in Boskoop) is just outside the chosen borders. Here, the soil was adapted as well to make the land suitable for the horticulture. It was raised with a mixture of manure, sand and dredger (*Toemaak*) (Oerlemans, 1992).

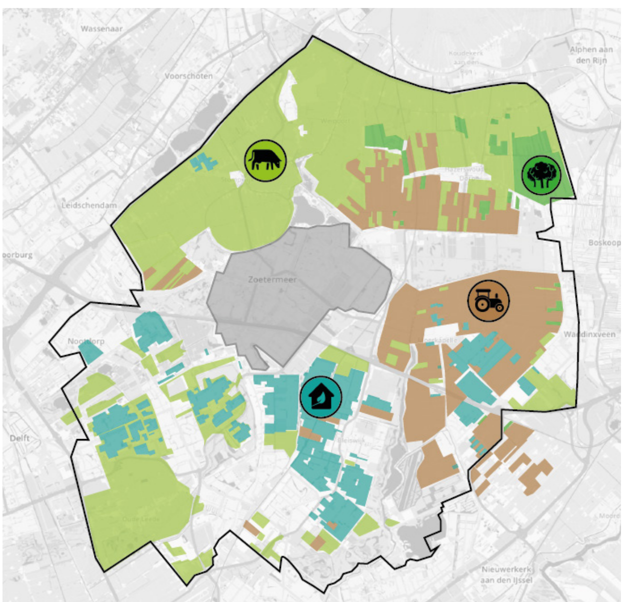


Figure 7.10: The different sectors in the area

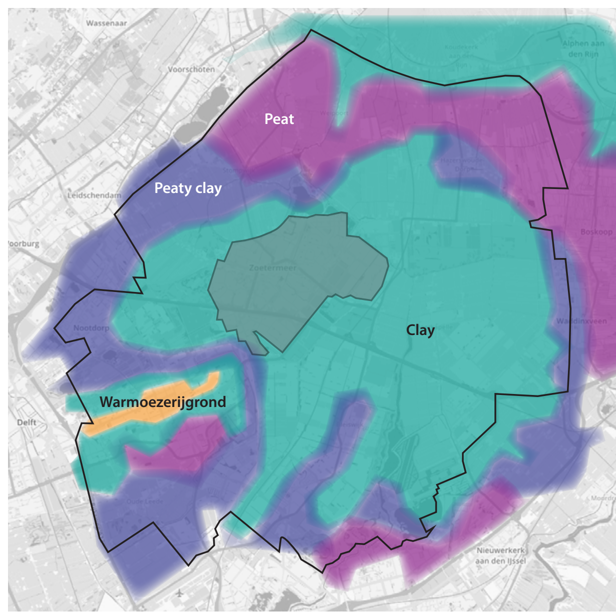


Figure 7.11: Soil types

Soil, cultivation and land patterns

Two types of land patterns are present: the strip pattern (the peat soils) and the modern rational pattern (the clay soils in the lake-bed polders). In the wet parts of the lake-bed polders, with the peaty clay, the difference is not that clear. They have a rational pattern of strips, much smaller than other parcels of the lake-bed polder. Each polder has its own pattern, with own direction. The clay areas have large parcels, the peat areas small. In the southeast, near Pijnacker, the patterns are quite small and irregular.

Visual perception & landscape elements

The visual perception and landscape elements of the three most important sectors are being explored: the crop farming area, the extensive livestock farming and the greenhouse horticulture (see figure 7.12 till 7.20).

Crop farming

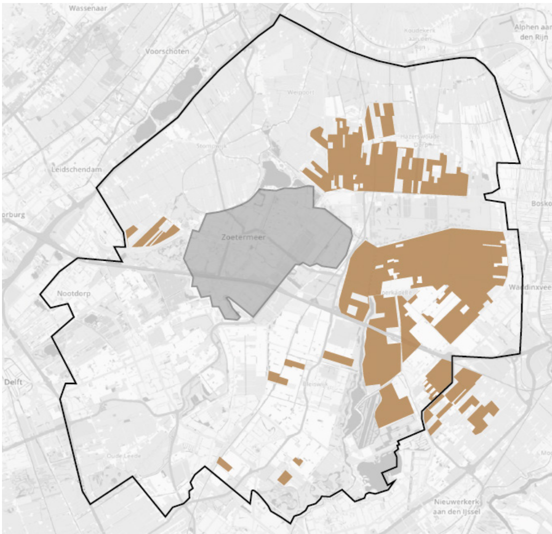


Figure 7.12: Location of crop farming in the area

Perception: Open, large scale, empty, bare land, straight, strict, simple. More diverse land use than grassland.

Land pattern: Modern rational, large parcels

Landscape elements: Windmill stairs (Molengang), pumps, straight and deep ditches, elektricity masts.

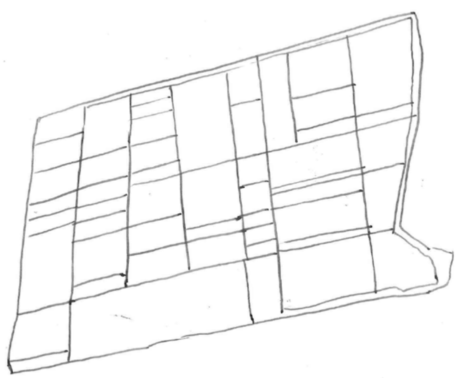


Figure 7.13: Land pattern of a crop farming polder

Figure 7.14: Visual perception of the crop farming area

Extensive livestock farming

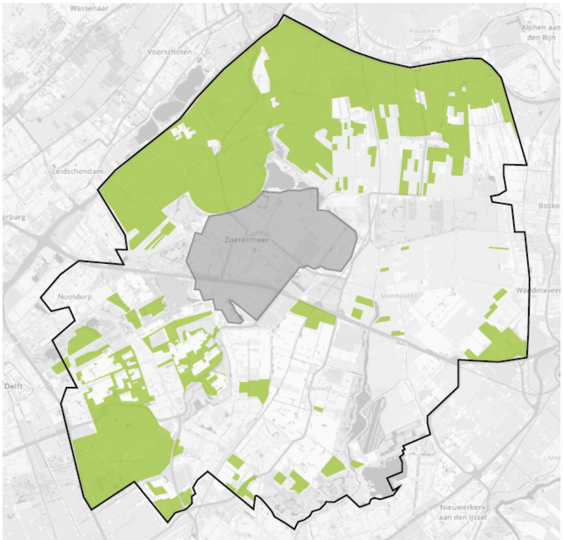


Figure 7.15: Location of extensive livestock farming

Perception: Open, straight lines (ditches), green, more elements than crop farming.

Land pattern: Strip pattern

Landscape elements: Dam gate (damhekjes), ribbon villages, shallow ditches with more bank planting, drawbridges (Stompwijk), windmills

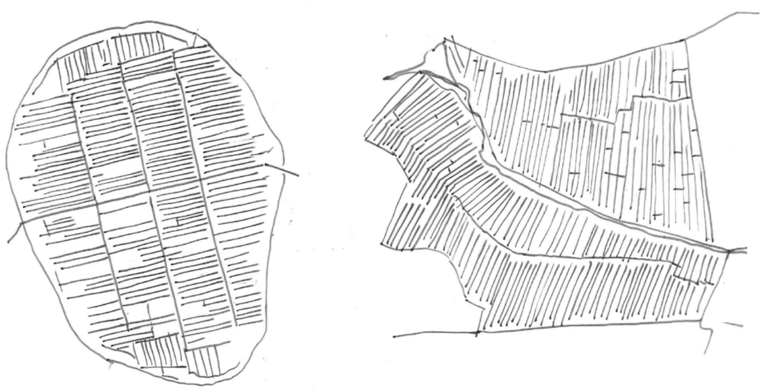


Figure 7.16: Land pattern in a peaty clay polder (left) en peat polder (right)

Figure 7.17: Visual perception of the extensive livestock farming area
(de Wit, 2017)

Greenhouse horticulture

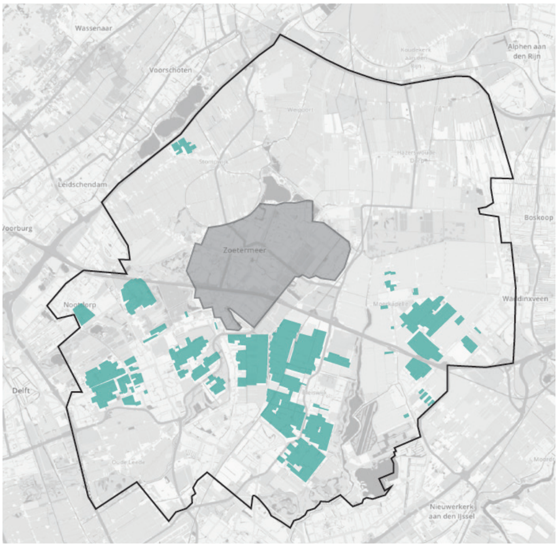


Figure 7.18: Location of greenhouse horticulture

Perception: Closed, small scale, messy, large water surfaces, view focused on end of road, less natural.

Land pattern: Modern rational

Landscape elements: Greenhouses, broad water canals, water bassins, heating installations, housing

Figure 7.19: Land pattern in a polder filled with greenhouses

Figure 7.20: Visual perception of greenhouse area

Changing agriculture, changing landscape

In the last 70 years, the area around Zoetermeer has changed from an agricultural area to an urban area. Especially the crop farming sector was the victim of this, going from the main land use in the region to a minor function. Handing land over to housing, greenhouses and quite recently to the large recreation area of Bentwoud. These developments have changed the once so large and open landscape of the lake-bed polders to the divided and closed landscape that it is now (see figure 7.21).

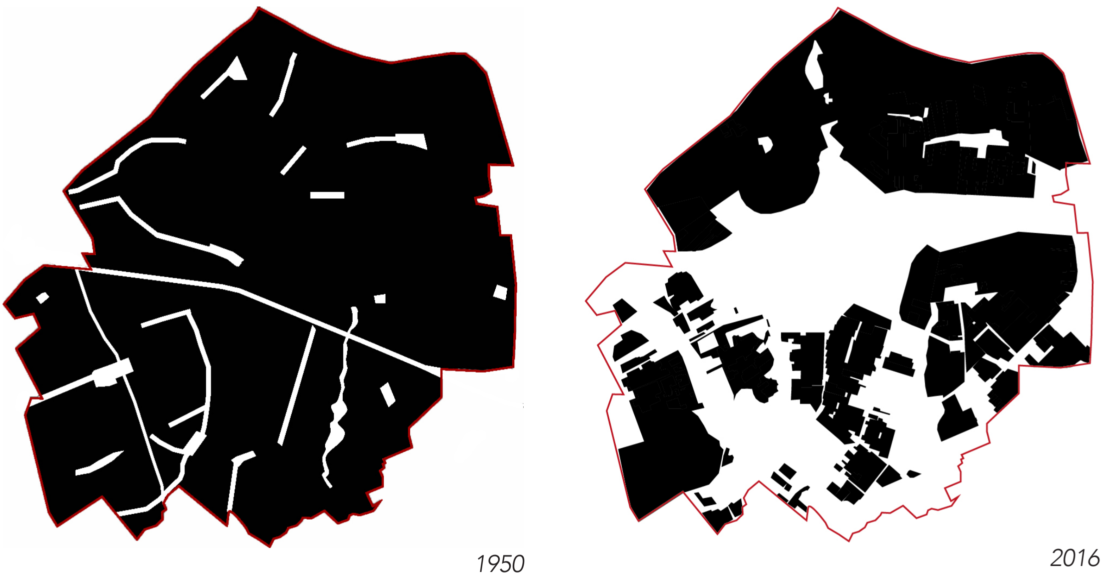


Figure 7.21: The black area is the land used for agriculture. Left the situation in 1950, where agriculture forms the main land use. Right the situation in 2016, where agriculture becomes the residual space.

Conclusion

There are three main sectors present: land-based livestock farming, crop farming and greenhouse horticulture. There are some fields of tree horticulture and some animal barns. Combining the types of agricultural landuse and the types of soil, four groups can be distinguished: the crop farming on clay, the livestock farming on peat, the livestock farming on peaty clay and the horticulture.

The livestock farming on the grassland is very much protected due to the nature value of the area. This in contrast to the crop farming, which is the most vulnerable to new land developments, handing in more and more land. The greenhouse sector is still growing, closing the orginal open crop landscape.

7.3 Sustainability problems of agriculture in Zoetermeer

As stated earlier, agriculture has a problem with sustainability. Which of these problems do occur in the region around Zoetermeer? The list below is composed based on the analysis, new sources and (if necessary) assumptions based on the sectors present.

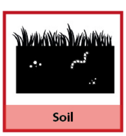
7.3.1 Ecological problems

Greenhouse gas (climate change mitigation)

- There are a lot of cows in the area, responsible for emissions of CH_4. Possibly (a small amount of) cattle feed is imported from another location.
- The peat soil is subsiding, which leads to the emission of CO_2.
- In the crop farming and horticulture, manure and fertilizer are being used. This leads to the formation of N_2O. Also the production of fertilizer requires a lot of energy.
- The greenhouses need light and warmth, causing CO_2 emissions.
- Long transport lines require a lot of fossil fuels.

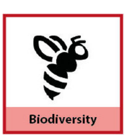
Nutrients

- Cows and other animal produce a lot of manure, leading to CH_4 emissions.
- Nitrate concentration in groundwater is quite low, however there is a posphate surplus in the peat areas. (Rienks & Meulenkamp, 2009) The water in the peat area is vulnerable for eutrophication.
- Production of fosfate & nitrate relative low compared to other parts of the Netherlands (Rienks & Meulenkamp, 2009)
- More acidification caused by city than agricultural area. (CLO, 2017b) The same goes besides for particulate matter.
- Use of fertilizer leads to depletion of nutrients elsewhere



Soil

- Soil subsidence in peat areas, and a bit in the peaty clay areas. Mainly above Stompwijk and in between Hazerswoude and Alphen a/d Rijn (Provincie Zuid-Holland, 2017)
- Soil compaction due to heavy machinery. The wet areas are more vulnerable for compaction (Provincie Zuid-Holland, 2017).
- Probably declining soil quality (organic&chemical) in crop farming area due to monofunctional land use.



Biodiversity

- Use of pesticides and herbacides in crop farming and horticulture.
- Fragmentation of the landscape
- Monofunctional landuse
- Light pollution by greenhouses

Water

- Salinization is a problem in the whole area, because of salt seepage. Especially in the low lake-bed polders. (Provincie Zuid-Holland, 2017) Horticulture is most vulnerable for salinization, followed by crop farming (LINT, 2015). It can be tackled by flushing it with sweet water or by highering the water level.
- Use of sweet water. Especially in the greenhouse horticulture.
- Water pollution because of manure (livestock farming), fertilizer and pesticides (crop farming & horticulture)

Climate change (adaptation)

- The changing climate will lead to extreme weather events. One of them is extreme rain fall, in concentrated moments. This will cause problems with getting rid of the water, worsened by soil compaction and the increase of paved surfaces.
- In dry periods a lack of sweet water can occur, also giving problems to crops.
- Extreme hail events are more likely to occur, destroying greenhouses
- Higher temperatures can lead to a lower biodiversity and speed up the eutrophication process in the surface water.
- Higher temperatures and dry periods can accelerate soil subsidence (Provincie Zuid-Holland, 2017)

7.3.2 Social-economic problems

As the focus will be on the ecological aspects, the social and economic problems will not be considered per category, but in general. Two main issues occur in the area, the difficulties in scale enlargment and the relationship between the city of Zoetermeer and the agricultural land.

Modern crop farms in general are forced to become bigger. However, this is in this area almost impossible. In the first place because a lot of crop farming land is disappearing from the area. The remaining fields are small, divided and cut through by infrastructural barriers. There is a lack of large contiguous amounts of land necessary for modern farming. Therefore the land is more useful for the extensive, hobby farmer (Agricola, 2010).

Food being produced so close to the city could be a great asset. However, it is not perceived like that. The agricultural area seems more like a residual area in the leftover pieces of the Randstad, slowly making place for recreation areas. The potential value of the local food production for the people from the city is undermined. The disconnection between the city and agricultural land has moreove also a spatial aspect (see figure 7.23)

7.3.3 Spatial problems

Considering the spatial aspects, five issues can be distinguished: hunger for land, fragmentation, messy space (verrommeling van de ruimte), compaction and pattern vulnerability.

The hunger for land is mainly applicable to the crop farming area. Here, the agricultural land is dissappearing to make room for greenhouses, industry, housing and recreation areas. Being in the middle of the Randstad, the pressure of urbanization is very high (Agricola, 2010). The space is very fragmented as well (see figure 7.22), because of infrastructure and greenhouses. Large contiguous parcels are hard to get (Agricola, 2010). As a result the space gets messy. Especially in the areas which are not protected by spatial regulations, everything is allowed, leading to a chaotic perception. The building of greenhouses and other large barns additionally contributes to the compaction of the landscape, that used to be very open. The amount and size of the open areas are declining.
Finally, scale enlargement can have large impact on small scale landscape patterns like the strip pattern in the peat area. To preserve the historical strip pattern, regulation is necessary (Agricola, 2010).

Figure 7.22: Landscape fragmentation by greenhouses, industry areas and large infrastructure

Figure 7.23: (Dis)connection between agricultural land and city

7.4 Sustainability problems of agriculture per area

As in the Netherlands (see 4.3), the problems are often linked to certain locations or sectors. Therefore the problems are here grouped by area. For the Zoetermeer region, two areas are based on their location (peat polders and lake-bed polders), and three on the based sectors (extensive livestock farming, crop farming and greenhouse horticulture). The maps show which part of the region is part of these areas. The link between the areas and the problems are sometimes based on data maps (e.g. the map shows that the problems certainly occurs there), or concluded based on the type of soil and sector (it is likely this problem occurs there). The problems based on soil or sector are marked with an asterisk.

<u>All areas</u>

- Transport emissions*
- Monofunctional land use (low biodiversity)
- Dry land (low water level)*
- Lack of sweet water/drought stress

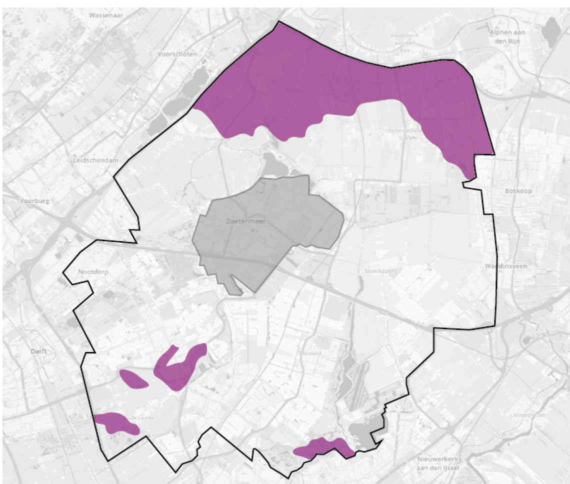


Figure 7.24: The peat area

<u>Peat soil</u>

- Soil subsidence
- Phosphate saturation

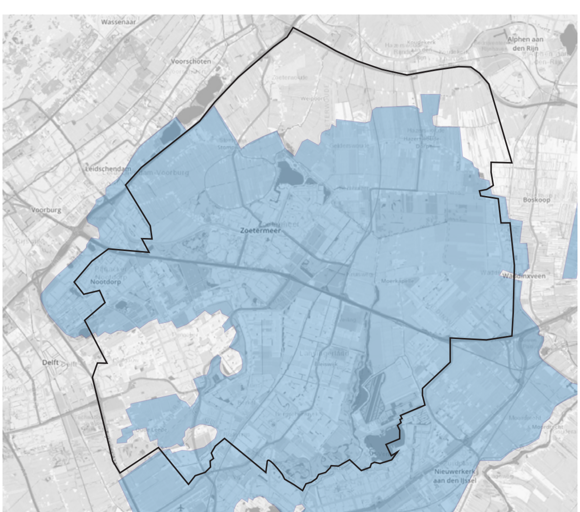


Figure 7.25: The lake-bed polders

<u>Lake-bed polders</u>

- Salt seepage
- Use of sweet water
- Extreme rainfall

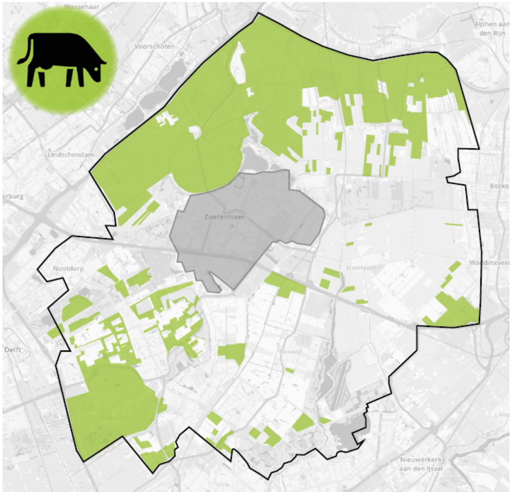


Figure 7.26: The extensive livestock farming area

Extensive livestock farming

- Cows & manure
- Import cattle feed *

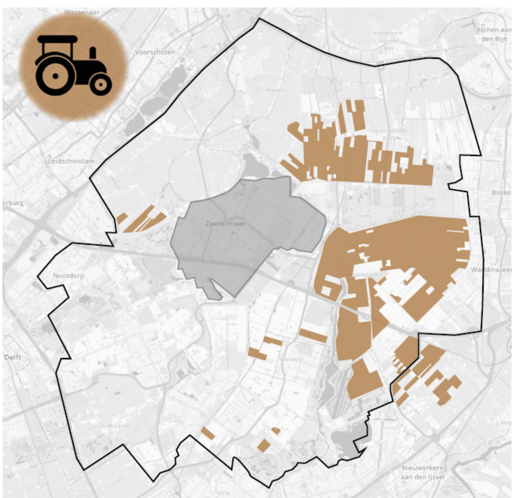


Figure 7.27: The crop farming area

Crop farming

- Use of manure (N_2O) *
- Use of fertilizer (N_2O, CO_2) *
- Use of pesticides *
- Soil compaction *
- Soil degredation *
- Use of sweet water *
- Surface water pollution *

- Fragmentation landscape
- Land hunger

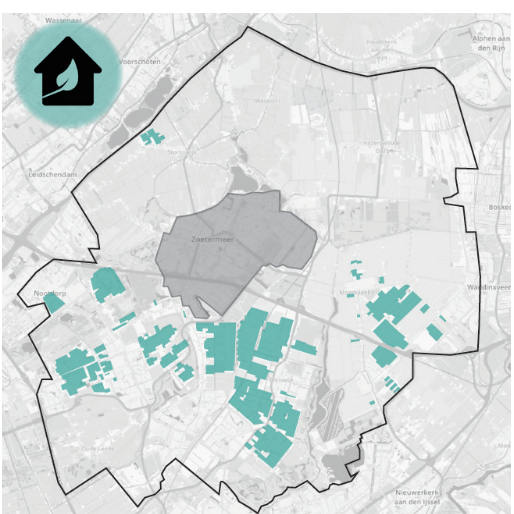


Figure 7.28: The greenhouse area

Greenhouse horticulture

- Energy & warmth (CO_2) *
- Use of fertilizer (N_2O, CO_2) *
- Use of pesticides *
- Fragmentation landscape
- Use of sweet water *
- Extreme weather events *

- Light pollution *
- Landscape compaction

7.5 Linking problems and principles

This table gives a summary of the sustainability problems in the area, linking them to (ecological) principles from 6.1 and 6.2 that address them. Annex 3 shows the problems and solving principles per area. The problems based on soil or sector are marked with an asterisk, important issues with an exclamation mark and the less relevant ones with a tilde.

Problem category	Problem		Place of occurence	Solving principle
Greenhouse gas, nutrients	Cows and manure production (CH4)		Extensive livestock farming	Less cows, manure processing (or for other uses)
Greenhouse gas	Import cattle feed	~ *	Extensive livestock farming	Land-based livestock farming, production own feed
Greenhouse gas, soil, water	Soil subsidence	!	Peat area	Highering water tables, Paludicultuur, Carr (Broekbos), water buffering, other cow species on wet grassland
Greenhouse gas, nutrients	Use of manure & fertilizer (N2O, depletion nutrients)	*	Crop farming and horticulture	Use organic manure, compost, green manure, buffer zones along water, catch crops
Greenhouse gas	CO2 emissions greenhouses	*	Greenhouses	Solar-, wind- or geothermal energy, use methane or manure as energy source, use residual warmth.
Greenhouse gas	Transport emissions (CO2)	~ *	All areas	Shorter transport links (regional network), bio fuel, electric machinery
Nutrients, soil	Phosphate satura-tion		Peat area	Less cows
Soil	Soil compaction	! *	Crop farming	Less heavy machinery, conservation tillage
Soil	Soil degradation (chemical & orga-nic)	! *	Crop farming	Stop use of pesticides and fertilizer, green manure, compost, polyculture, perennials, agroforestry, intercropping, strip cropping, cover crop, fallows, crop rotation
Soil, water, biodiversity	Use of pesticides and fertilizer	*	Crop farming and horticulture	Catch crops, Integrated pest management (intercropping, strip cropping, crop rotation, cover crop, nature reserves, refuge sites, insect strips), use (green) manure, compost, nitrogen fixing plants
Biodiversity	Fragmentation landscape	!	Crop farming and horticulture	Landscape connectivity (through hedges, buffer zones and strips)

Problem category	Problem		Place of occurence	Solving principle
Biodiversity	Monofunctional land use (low bio-diversity)	*	All areas	Landscape diversity, polyculture, agroforestry (alley cropping, silvopasture, food forest), herbal-rich grassland, field margins, riparian corridors, hedges
Water	Salt seepage (low water level)	!	Lake-bed polders	Heighten water level, flushing with sweet water, salt (tolerant) crops
Water, biodiversity	Dry land (verdroging) - low water level impacts nature		All areas	Heighten water level
Water	Use of sweet water	! *	Crop farming and horticulture	Improve soil water retention (soil quality), prevent evapo-ration (cover crop), delay run-off (water buffer zone, riparian corridor, sedimentation ditch), rainwater harvesting, use surface water for drinking cattle
Water, nutrients	Surface water pollution	*	Crop farming	Water buffer zone, riparian corridor, sedimentation ditch, catch crops, paludicultuur (purifying)
Climate change	Draining extreme rainfall	!	Lake-bed polders, paved surface	Rainwater harvesting, more surface water, improve soil structure, delay run-off (water buffer zone, riparian corridor, sedimentation ditch)
Climate change	Extreme hail events		Greenhouses	-
Climate change	Lack of sweet water/ drought		All areas	Improve soil water retention (soil quality), prevent evaporation (cover crop), delay run-off (water buffer zone, riparian corridor, sedimentation ditch), rainwater harvesting, drought tolerant plants

8. THE DESIGN

8.1 Landscape concept

With this analysis, for each area we can point out the principles that help to make it more sustainable. However, a lot of these principles (like flower strips) work on a scale much smaller than the total region. As we stated the main focus will be on the landscape level, so how can the large scale be designed and contribute to sustainability?

For this, the concepts of connectivity, diversity and circularity will be used (see paragraph 5.2). The ecological landscape should be diverse, connected and function as a circular system (see figure 8.1). These (abstract) concepts will guide the design from above, while the concrete ecological principles on the small scale form the toolbox to meet these goals.

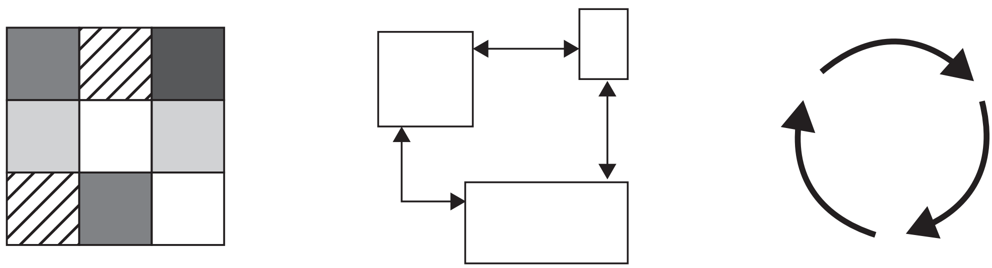


FIgure 8.1: Concept of the landscape. From left to right: diversity, connectivity and circularity

Scale levels

As a general ecological concept, these aspects not only function on regional scale level, but work best if applied on ALL scale levels (see figure 8.2). So not only some nature areas on regional level, but also (smaller) nature spots in every polder or small groves in every field. Different types of land use in the whole area, but also mixed farms on the small scale. The scale is a continuum that extends in both directions, but for this project three scale levels were determined: the region, the polder and the farm.

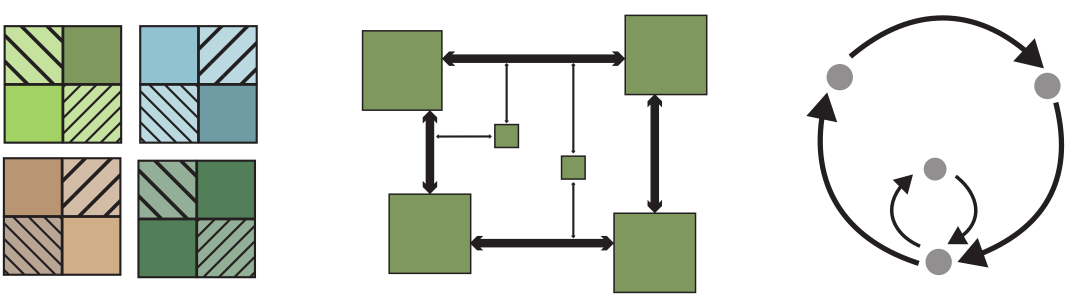


FIgure 8.2: Concept of the landscape on different scale levels

Since on all three levels the concept aspects are present, you can schematize it like this:

	Diversity	Connectivity	Circularity
Region	Regional diversity	Regional connectivity	Regional circularity
Polder	Polder diversity	Polder connectivity	Polder circularity
Farm	Farm diversity	Farm connectivity	Farm circularity

The area of the regional scale was already shown in the analysis. For the polder scale, the polder 'de Wilde Veenen' will be used (see figure 8.3-8.6). This is a crop farming polder of about 590 hectares on the east side of Zoetermeer. The polder was reclaimed in 1647 and contains the small village of Moerkapelle. The crop farming area was chosen, because it is most vulnerable to the problems in the area and very suitable for ecological solutions. One specific farm and its fields (approximately 14 hectares) are elaborated as well. This farm is not located in polder de Wilde Veenen, but closer to Zoetermeer (see figure 8.4). The reason for this location will be clarified later.

The design will be explained using the structure of diversity, connectivity and circularity. For each concept, the application will be described through the scales, starting with the region.

Figure 8.3: The location of the polder in the region

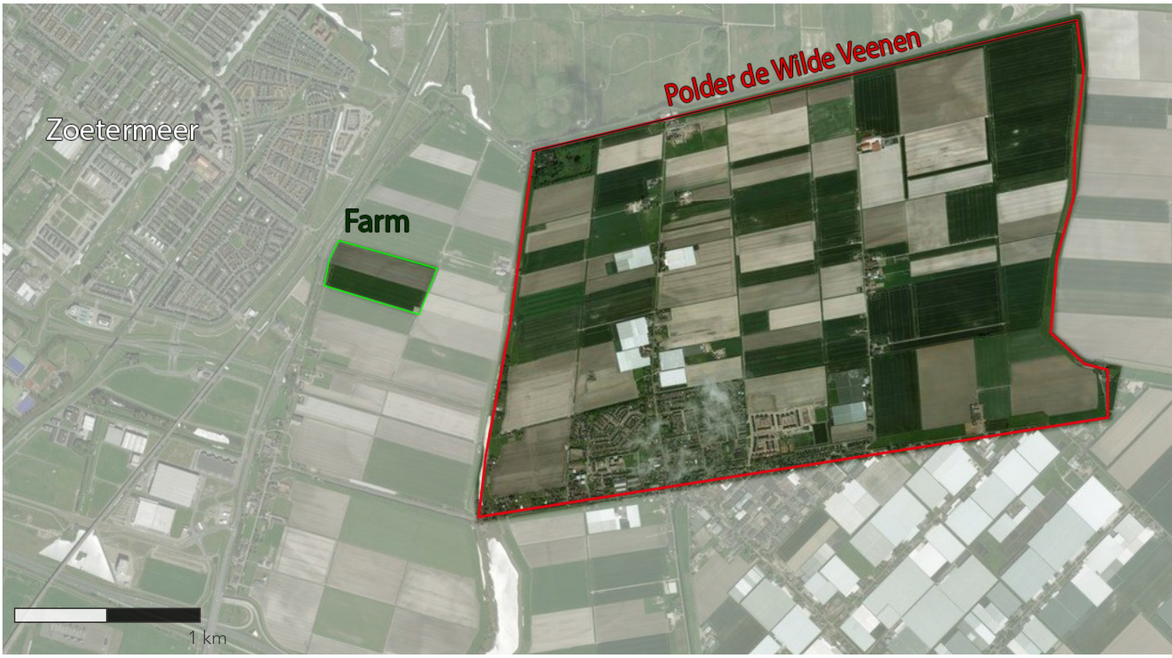


Figure 8.4: The location of the farm related to the polder and Zoetermeer

Figure 8.5: The polder in december 2017
(Author)

Figure 8.6: The polder in april 2018
(Author)

8.2 Diversity

Region

In the Zoetermeer region there are several different areas with their own land use and character, like the extensive livestock area, crop farming and greenhouse area. Part of the variation exists because of differences in the soil and water management. Since the areas are quite different both in land use as in site conditions, they have their own (ecological) problems and own fitting solutions as well. In the total regional plan, the individual characters will remain and even strengthened. Partly because of the different solutions, but mostly to keep and reinforce the legibility and awareness of the landscape. This way, people will be easily aware they are in the Peat area, or notice it when they enter the Greenhouse area.

Six characters are assigned to the region (see figure 8.7). These are Peat, Meadow, Crop Farming, Greenhouse, Outdoor horticulture and Water (buffer) areas. The Peat area is naturally located in the areas with peat soil. The location of the Crop Farming area is based on the soil suitability, so mainly the area with a clay soil. In the peaty clay areas, where the land is not suitable for crop farming, grassland is situated. There is no strict border between those areas, so on the edge often both grassland and crops are mixed. The Greenhouse areas are still present in the area, but are more strictly clustered to prevent fragmentation and compaction of the landscape.

Each of the characters has their own atmosphere, formed by the type of land use and parcellation. Additionally, in every area there is also diversity, by different types of land uses. All the areas together form the diversity map in figure 8.16.

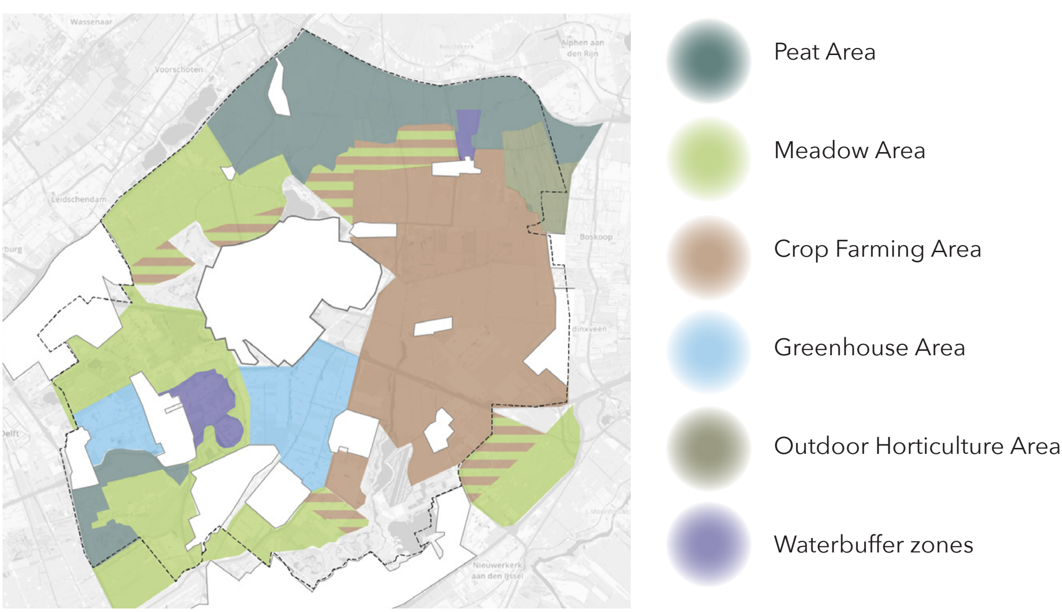
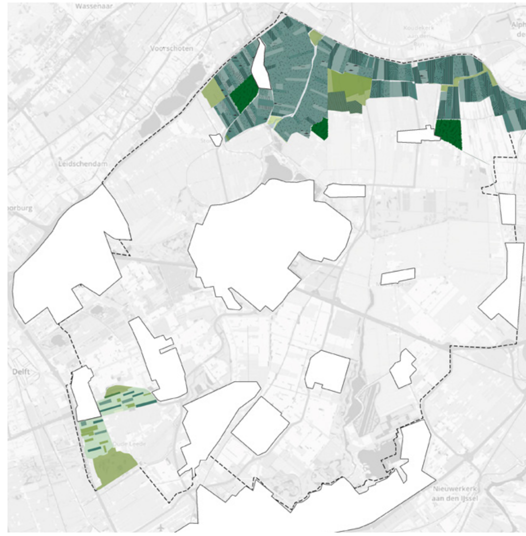


Figure 8.7: Map with characterization of the areas

Peat area



To cope with the water problems in the area, the water tables will be raised enough to stop the soil subsidence. This will have consequences for the landscape. The current grassland will get too wet for the cows. Removing the cows out of the area also stops the main cause of the phosphate saturation of the surface water. Consequently, new types of production need to occur, with paludiculture as the most promising solution. Keeping the small, narrow fields, there will be more variation in crop types such as bulrush, peat moss, willow and micanthus (see figure 8.8). Crops will be produced for cattle feed, biomass or materials. Where openness is an important feature of the landscape, fields of peat moss will maintain this character. In other places, the crops will make the view more closed. Besides wet crop types there are other optional land uses like wet grasslands (as nature) and carr forests. These new patches of carr (*Dutch: broekbos*) are placed close to the villages, referring to the original wooded lands the villages are named after (Zoeterwoude, Hazerswoude, Gelderswoude).

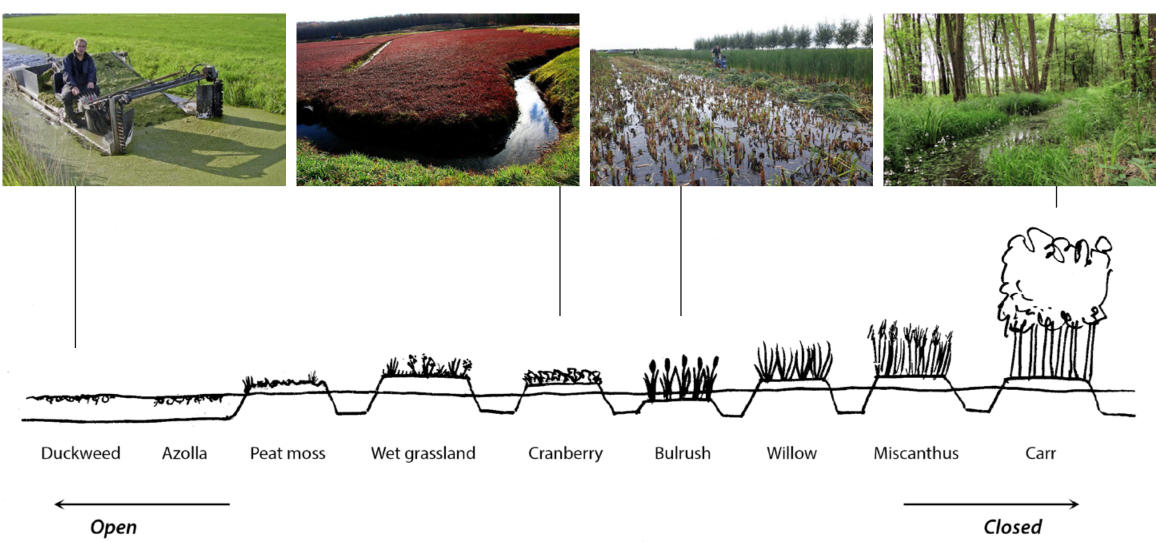


FIgure 8.8: Types of crops and land uses suitable for the new peat area

Figure 8.9: A possible crop layout for the northern peat polders with open peat moss fields near the ribbon village of Weipoort and closed fields of bulrush, reed and miscanthus near Rietveld in the east.

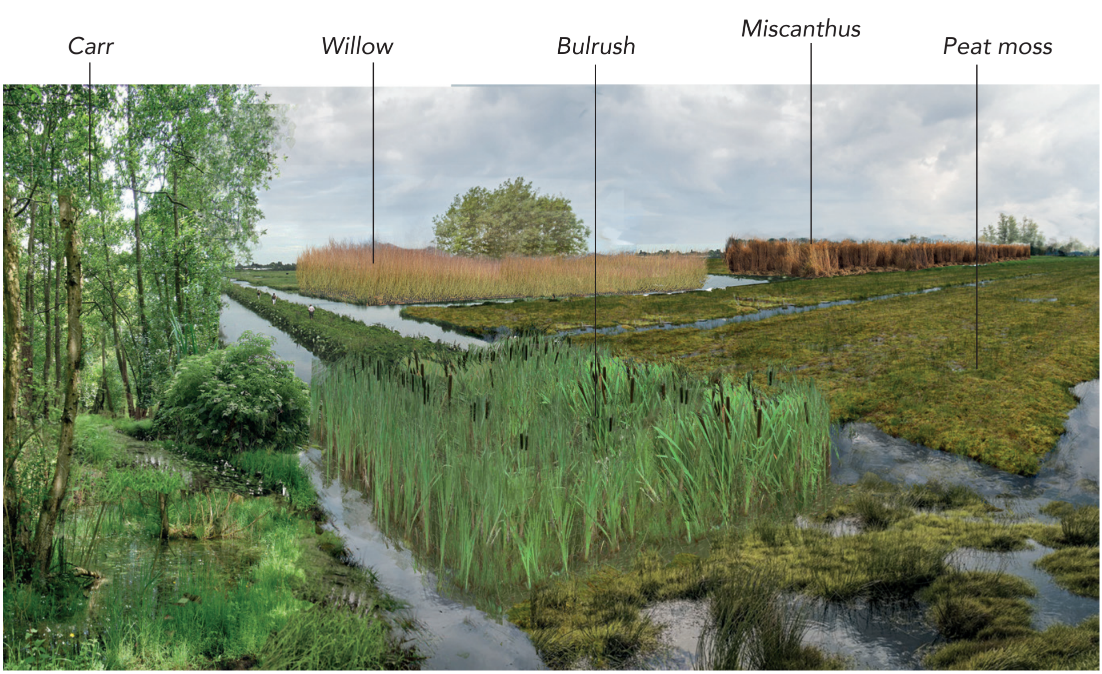
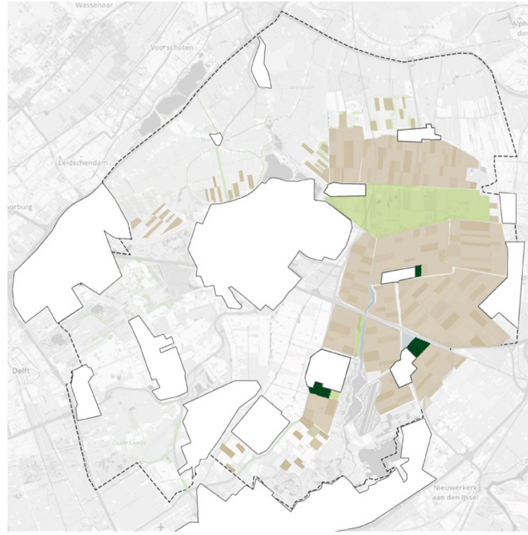


Figure 8.10: Impression of the peat area

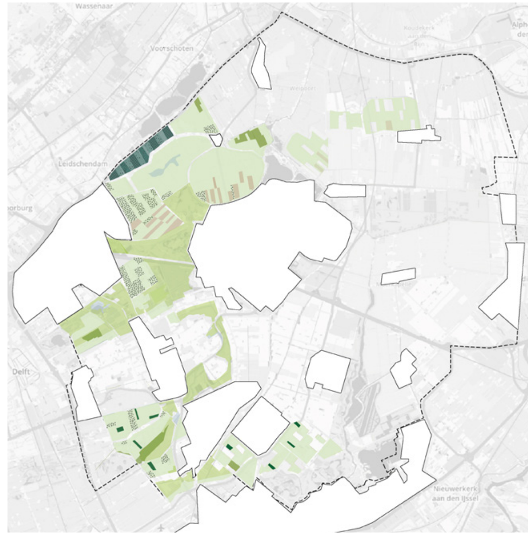
Crop farming area



The current crop farming area is very open, large-scale and has little to no landscape elements. Landscape elements such as hedges, trees and field margins can play an important role in addressing issues related to crop farming, like the use of pesticides, lack of biodiversity and water problems. Providing the area with new habitat patches will not only increase the biodiversity, but also attracts beneficial insects and improves the soil quality. A better soil quality improves the soil water retention, natural pest resistance and soil fertility, decreasing the need for fertilizer, pesticides and irrigation. Although the main land use will still be crop farming, the new elements will transform the landscape to a more closed one. The large fields turn into lineair plots as green structures divide them into strips. Every now and then, the view will be interrupted by a dense patch of trees or a food forest. Those food forest will be concentrated near the villages, as they require intensive work inputs. Water is a major aspect as well. Not only will the soil water retention capactiy be enhanced, broadening ditches and creating water buffer areas should increase the amount of water that can be stored in the area too.

Figure 8.11: Impression of the crop farming area

Meadow area

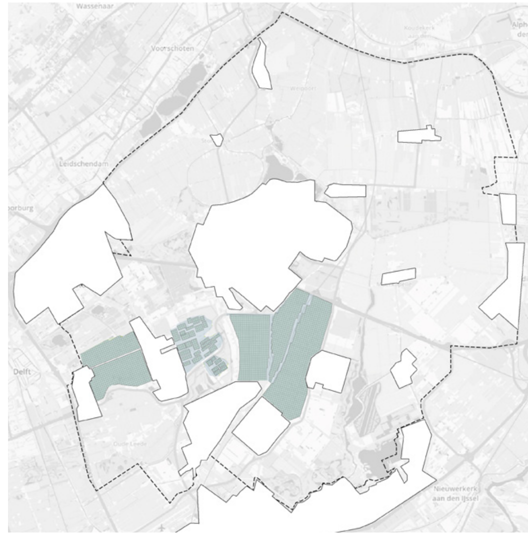


The current pasture land will have a decline in the amount of cattle, which causes the problems with methane and ammonia emissions. However, as the soil here is unsuitable for crop farming anyway, the land will still focus on grassland and extensive livestock farming. Decreasing the amount of livestock leaves place to a more diverse land use such as silvopasture and sustainable grassland practices including herb-rich grassland and rotational grazing.

All animals are held outside and feed from the local land. On the wettest areas, paludiculture can replace grassland to provide other sources of feed. Landscape elements like hedges, tree clumps and water buffers will be reinforced to stimulate biodiversity, soil and water quality, indirectly increasing the small scale of the landscape. However, in the most important meadow bird areas, the landscape will stay open and contain wet areas (*plas-dras*) to attract the birds.

Figure 8.12: Impression of the grass area

Greenhouse area



Although the total area of the greenhouses will be reduced, its character will be stronger. As the farming is indoors, technological solutions are a better fit than the ecological ones. Water issues and lack of diversity can be solved using the many canals as the green structures of the area, with planted buffer zones that tackle the water pollution. These straight lines also form view lines out of the closed area, to show a glimpse of the landscape beyond. The current water bassins will be more integrated. The new landscape is a sustainable glass city, where high-tech greenhouses will be interspersed with green structures and an increased amount of surface water. This area also offers room for new innovations, like aquaponics and growing food with artificial light. It forms an agricultural area where sustainability is reached through technology, but combined with nature.

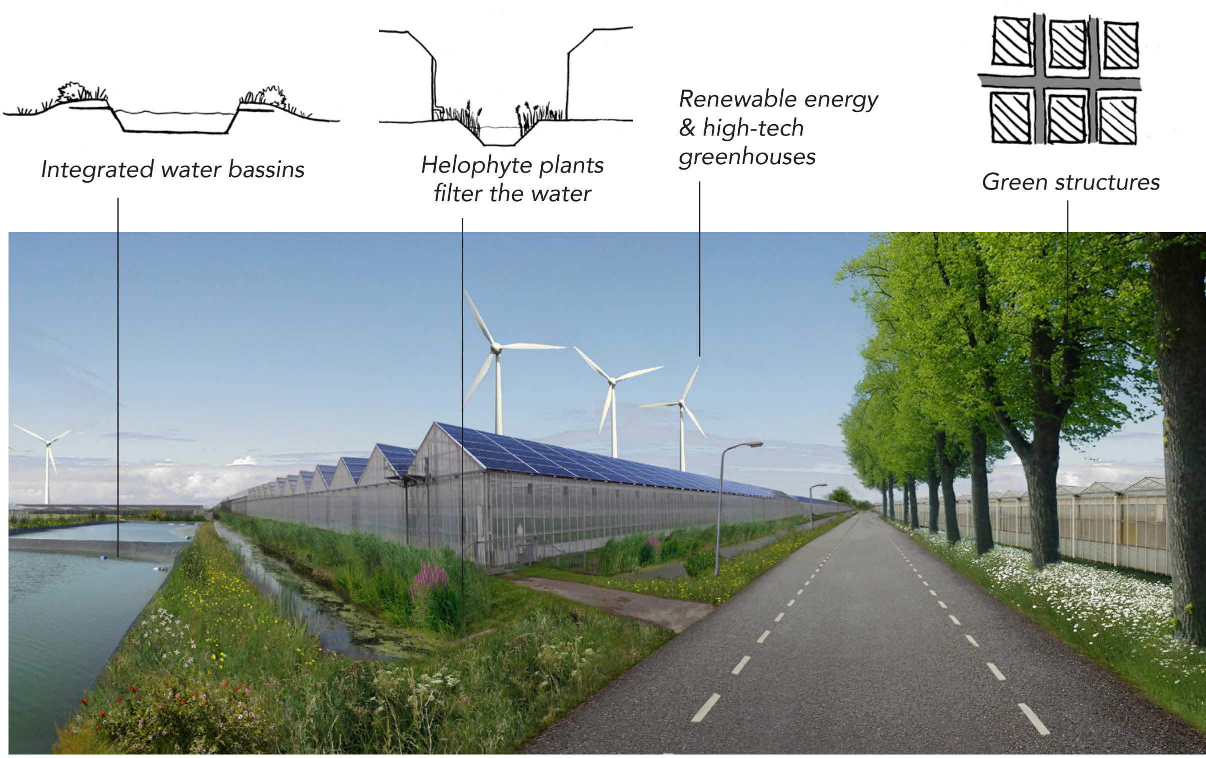


Figure 8.13: Impression of the greenhouse area

Outdoor horticulture area

The horticulture area around Boskoop already has a specific character nowadays, the pattern looking like floating crop beds in the water, like the historic chinampas from the Aztecs. Putting the focus on the waterways, keeping the landscape small-scale and closed with trees wil maintain this character.

Figure 8.14 Impressions of the Outdoor horticulture area
(Legoretta, 2015; Gebroeders van den Nieuwendijk, n.d.; Swart, 2011)

Waterbuffer zone

Considering the amount of water problems in the area, because of the soil, reclamation and climate change, special attention should be attended to water. The water buffer zones are places where water can be stored in the region, instead of working it out the polders as quickly as possible. They collect water in times of heavy rainfall and provide it to agriculture when needed. The Eendragtspolder is an example of an existing one, double functioning as recreation area. The new buffer zone above Hazerswoude consists of wet grassland, being flooded when necessary. The area between Pijnacker and Zoetermeer always contains water and is covered with floating greenhouses. As these greenhouses don't require soil, but do have a water problem, it is an ideal combination. The assignment of specific water zones remind people of the huge importance of water in these polders.

Figure 8.15: Impressions of the Waterbuffer zone
(Except, n.d.; Platform Mooi Zuidplas, n.d.)

Figure 8.16 shows all these areas together in the regional plan with different characters as well as diversity in landuse. The borders from the peat and greenhouse area are pretty clear, while at the meadow and crop farming area, this isn't that strict.

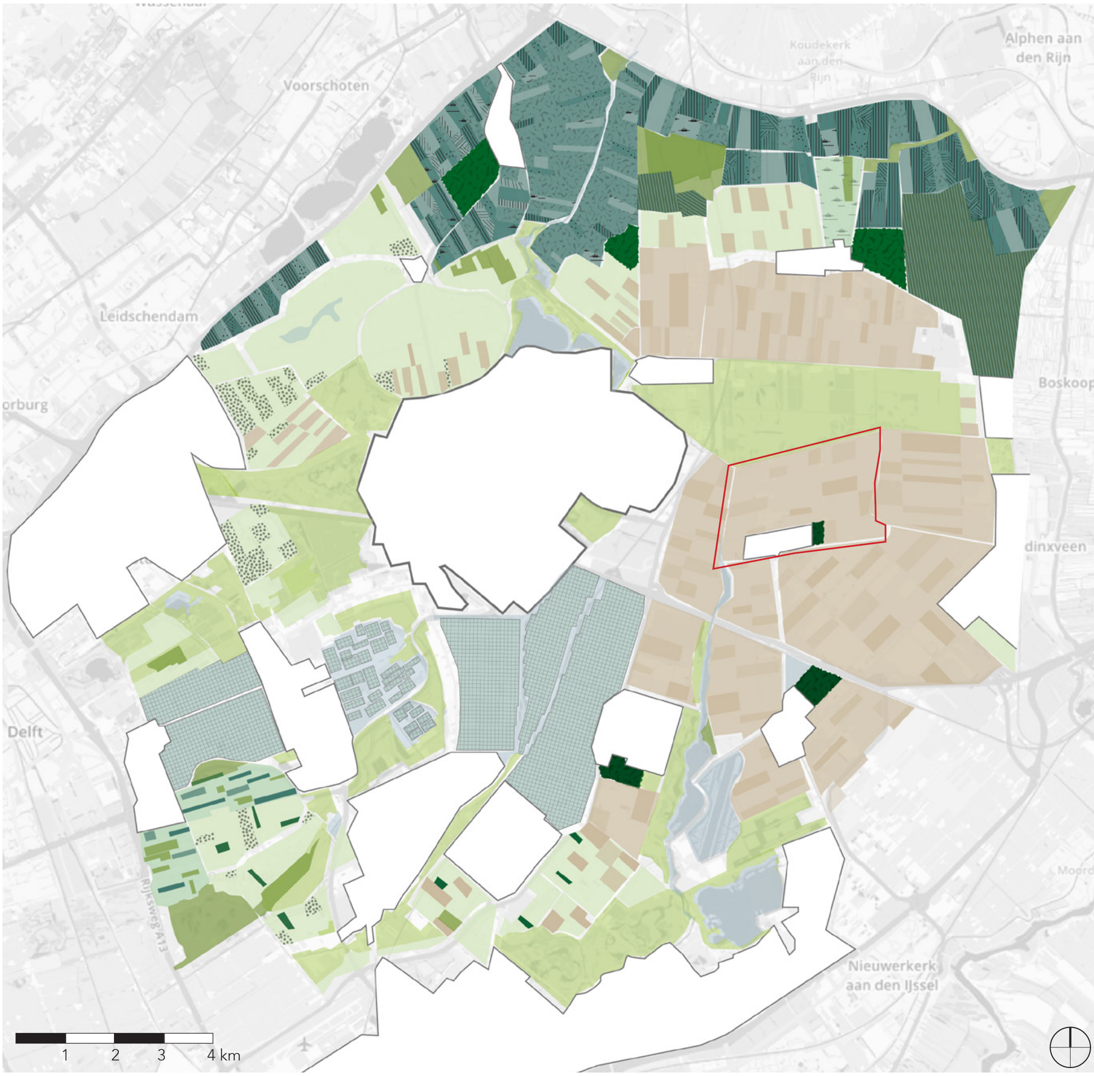


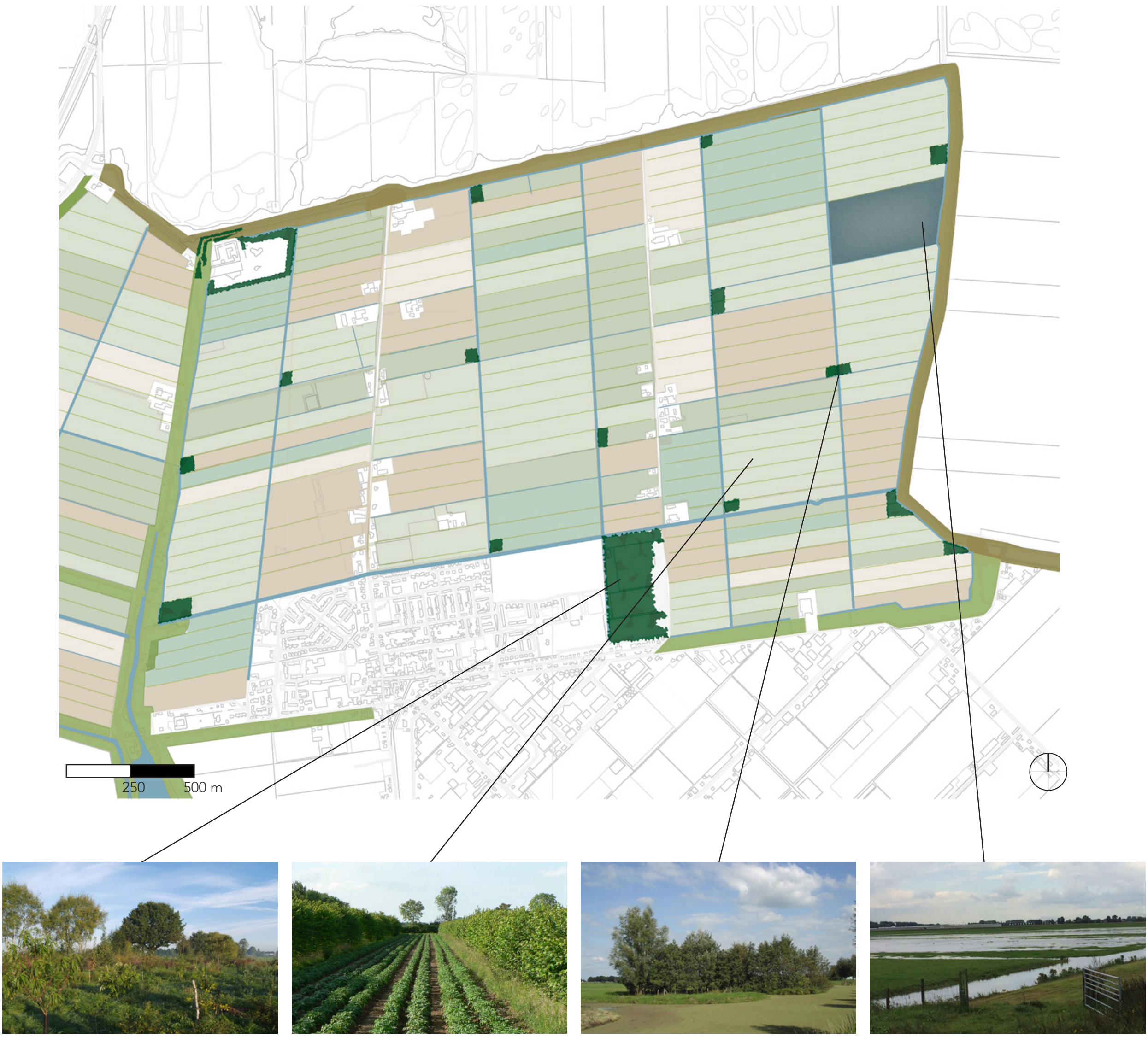
Figure 8.16: The different types of land uses in the region

- Nature area
- Recreation area
- Water
- Forest
- Tree horticulture
- Crop farming
- Pasture
- Silvopasture
- Wet grassland
- Paludicultuur
- Greenhouse area

Polder & farm

The land of the polder will only be used for crop farming, as the few greenhouses that were present are removed. The diversity is visible in different land uses and landscape elements, like the water buffering area, refuge areas, alley cropping and the food forest (see figure 8.17). These will turn the open landscape in a more closed one. However, the main diversity is found in the use of different crop types, which is stimulated by the alley cropping system (see figure 8.18).

On the farm level, diversity is reflected in the mixed farm. A farm where both crops are cultivated and animals are held. There is also a small food forest and orchard present (see figure 8.19). Systems as intercropping and crop rotations stimulate the crop diversity.



Food forest

Alley cropping

Refuge area

Water buffering

Figure 8.17: The different types of land uses in the polder
(IVN Natuureducatie, n.d.; "Agroforestry, Combinatieteelt", n.d.; Leestekens van het landschap, n.d.; Waterberging Woudse Polder, n.d.)

Figure 8.18: Crop diversity and its visual perception in crop farming

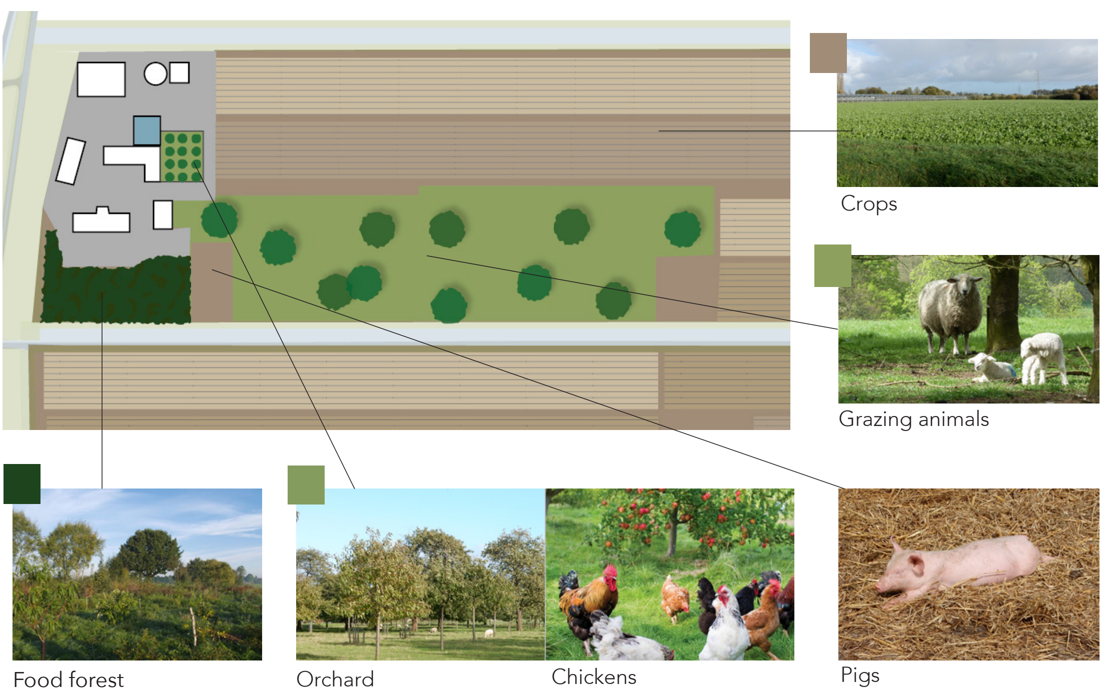
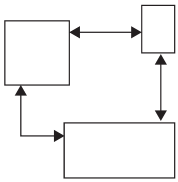


Figure 8.19: The different activities on the mixed farm
(Ketelbroek, n.d.; Abacuscards, n.d.; Palace Farm, n.d; Author)



8.2 Connectivity

Region

The region already has a lot of nature areas, both for preservation and recreation, for example the newly realised Bentwoud (see figure 8.20 & 8.21). Also, large connection zones have been assigned, like the 'Groenblauwe slinger' (see figure 8.22). However, the current strategy is to replace agriculture by (recreative) nature, not solving the problems in the agricultural area itself, that still has a lack of green structures and a low biodiversity. Therefore, to ensure the biodiversity in the area, a fixed network of green structures is needed on all scale levels. Not primarily to connect nature areas, but to form the ecological structure of the agricultural land.

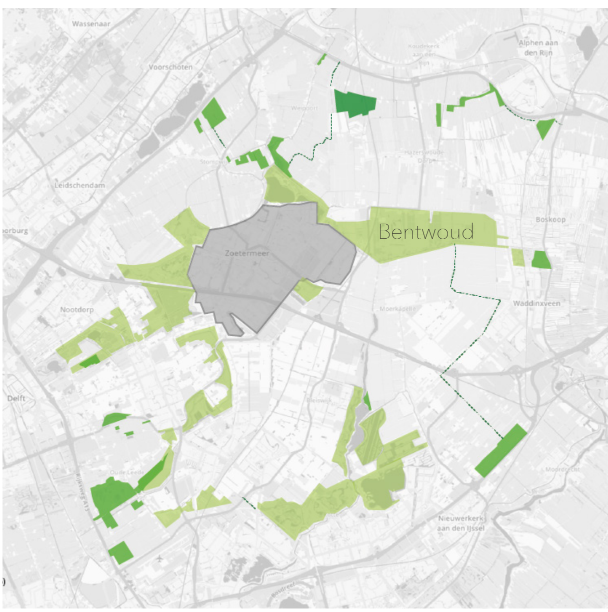


Figure 8.20: Nature and green recreation areas

Figure 8.21: Highland cows in the Bentwoud
(Author)

Where should this be located on the scale of the landscape? Using existing structures would make it easier to establish an ecological network. The main structure in the landscape is formed by the polder dikes (see figure 8.23). These dikes, lying as elevated leaf veins between the polders, can be used as a green corridor, offering biodiversity and connection through the area. Some of them are already accented in green, like at Noordeinde (see figure 8.24). However, most dike's are not, (see figure 8.25). Often dikes are used for ribbon villages or car roads, so there is simply no space for green except for a few trees (see figure 8.26 and 8.27).

Figure 8.22: 'de Groenblauwe Slinger'
(Provinciaal adviseur ruimtelijke kwaliteit Zuid-Holland, n.d.)

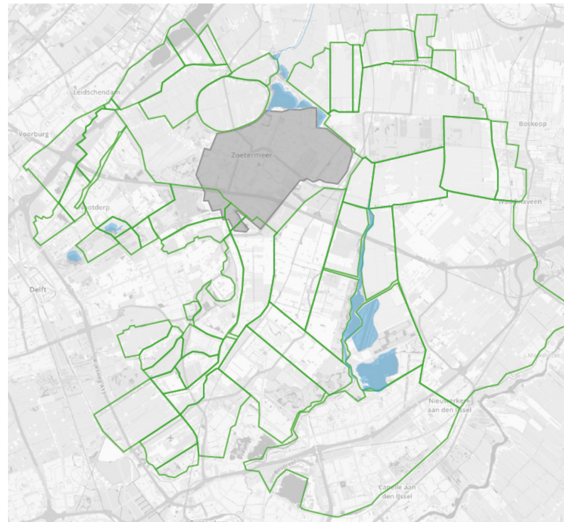


Figure 8.23: The polder dikes

Figure 8.24: Noordeinde
(Google maps)

Figure 8.25: Westzijdeweg
(Google maps)

Figure 8.26: Noordeindseweg
(Google maps)

Figure 8.27: N209
(Google maps)

Figures 8.28 and 8.29 shows a map of different groups of dikes. And figure 8.30 which of these dikes are suited for a green connection.

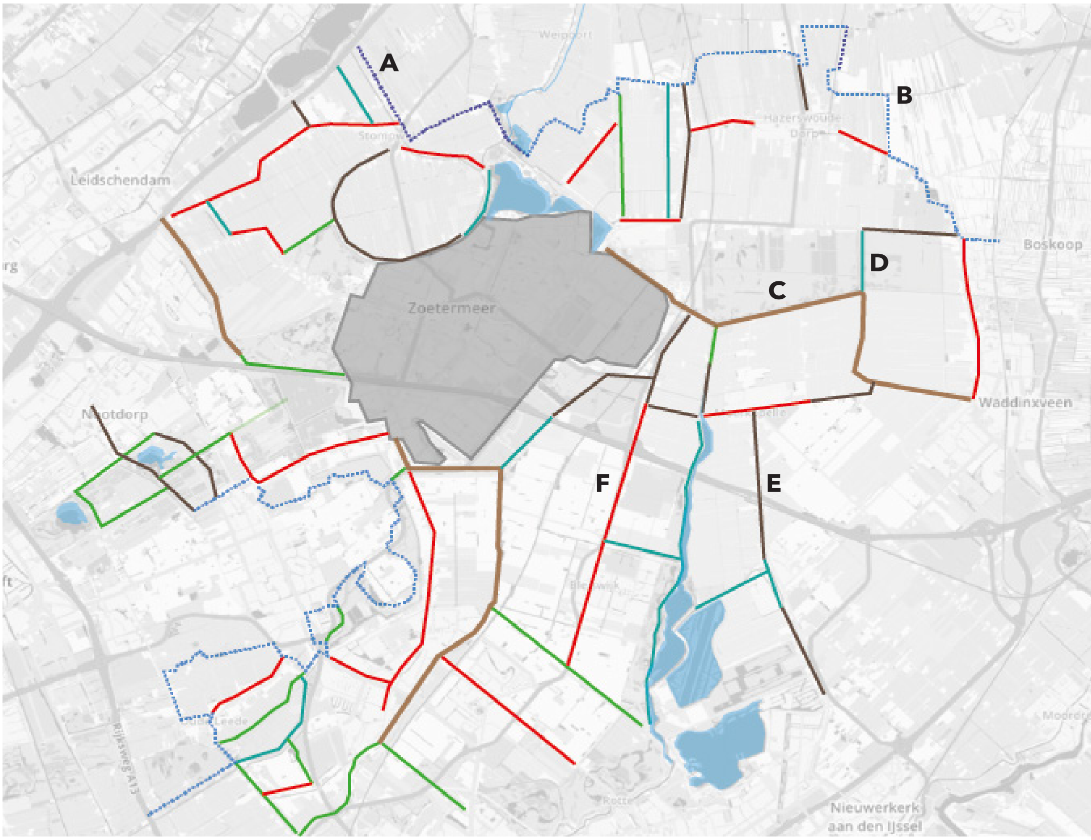
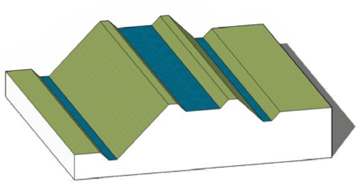
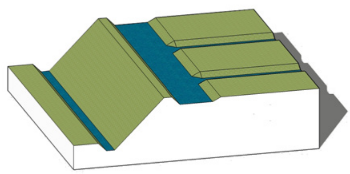


Figure 8.28: Different groups of dikes



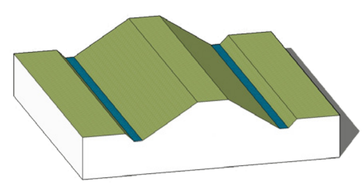
A

Boezem dike between peat and lake-bed polder



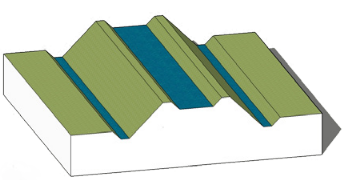
B

Border between peat and lake-bed polder



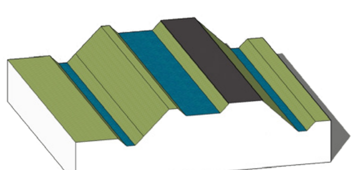
C

Dike without road or water



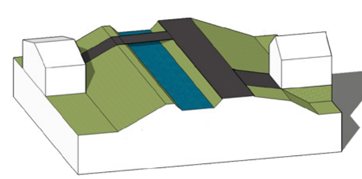
D

Dike with waterway



E

Dike with road and waterway



F

Dike with housing on both sides

Figure 8.29: Appearance of different groups of dikes

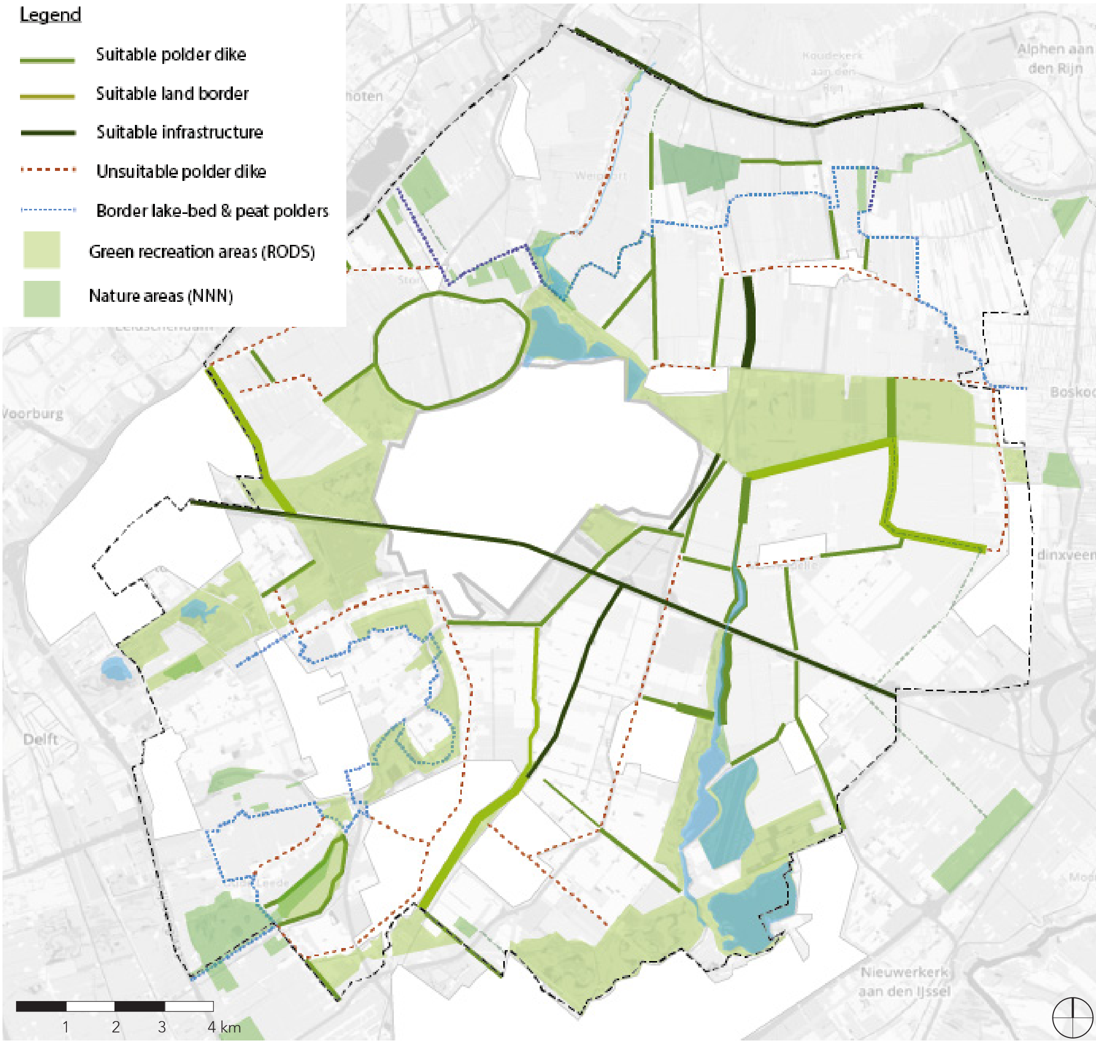


Figure 8.30 The suitability of the polder dikes for functioning as green structure

To make the dike function as a green structure, four types of vegetation can be added: wetland plants, herbal grassland, thicket/shrubs, trees/woodland, or a combination of those (see figure 8.32). Most often the vegetation is placed on the talud of the dike. However, if possible, on top or along the dike are options as well. (see figure 8.31). The choice for the location and the sort of vegetation will impact the spatial perception of the dike and the view on the (agricultural) landscape. To ensure this view, closed vegetation should only appear on one side of the dike.

Figure 8.31: Different options for the location of the planting: along (a), on the talud (b) or on top (c).

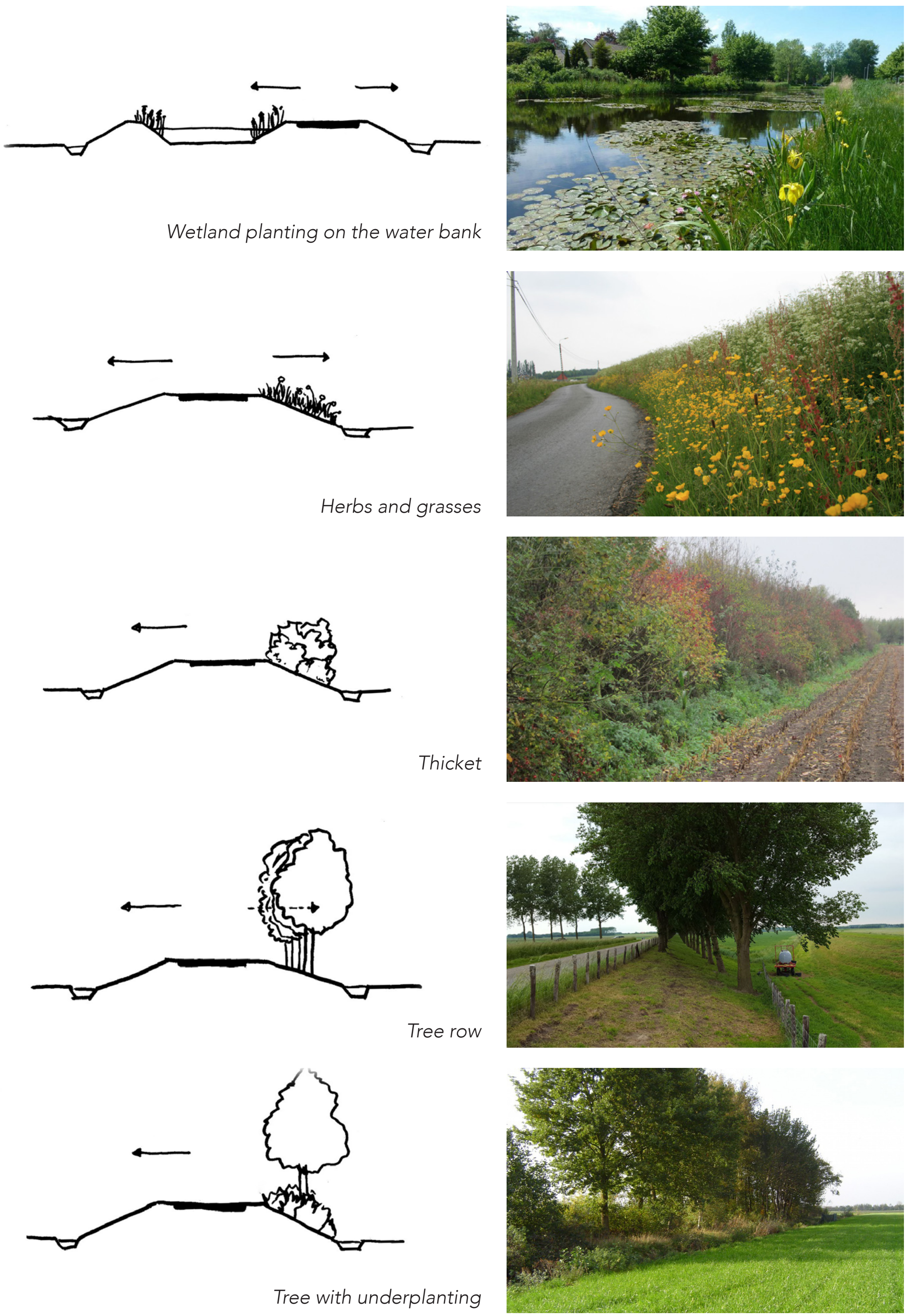


Figure 8.32: The possible vegetation types that form part of an ecological structure in sketch and picture.
(Waternet, n.d.; Anzegem, n.d., Kromme Rijnlandschap, n.d.; Zwarthans, n.d.;Brabants Landschap, n.d.)

Trees and planting on the dike – is that possible and allowed?

To answer that question, first a difference has to be made between different dike types. Primary dikes are the ones that protect the land from outside water. Vegetation here is strongly discouraged. However, in the area around Zoetermeer, mainly secundary or regional dikes are located, like boezem dikes, polder dikes and land borders. The last two are specifically meant to form the border between two different water levels. They don't protect the land from flooding, like the boezem dike does by preventing the boezem water flowing into the polder.

Some regulations give an insight in the possibilities of planting. The waterboard from Rijnland (Hoogheemraadschap van Rijnland, n.d.) states that if a tree or hedge is lower than 5 meters and not placed on top of the dike, it is fine. Otherwise, a permit is required. Trees higher than 5 meters have a higher risk of falling, resulting in a gap in the dike (*ontgrondingskuil*), and move the soil more by their roots. The erosion of the grass on the dike should be prevented. Especially on top of the dike only low vegetation is desired. STOWA (Stichting Toegepast Onderzoek Waterbeheer, 2000) furthermore adds to this information that deep rooting trees are more favorable than shallow rooted trees.

These recommendations will be taken into consideration for the project, especially for the boezemdikes. As the polder dikes and land borders don't have a water protecting function, all vegetation will be acceptable there.

Besides normal polder dikes, there are also some special dike structures: the border between the lake-bed and the peat polder, and the land border (*landscheiding*) between the different water boards (figure 8.33)

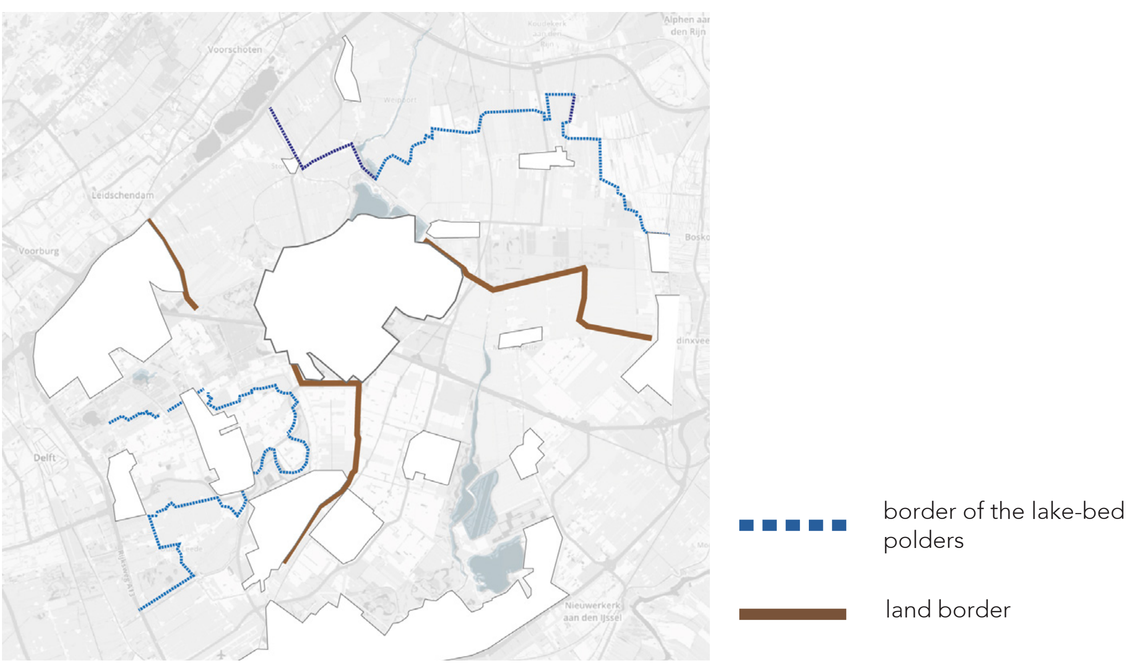


Figure 8.33: Location of the special dike types on the map

The lake-bed border is a dike between two contrasted areas: the higher peat land with the small narrow parcelation and the low fields of the large-scale crop farming area (see figure 8.34-8.36). The two areas on the side of the land border do not show any difference (figure 8.37-8.38). These dikes can serve as a green corridor, but can also be highlighted to create awareness of their special function. The land border can be accentuated by a row of trees along its line (see figure 8.39). On the lake-bed-peat-border the contrast between the two different sides is emphasized by two contrasting tree rows (see figure 8.40). The chosen species stay below the 5 meter, as the dike holds the boezemwater. The continuous tree line makes it also clear that when the dike is crossed, a border is passed as well.

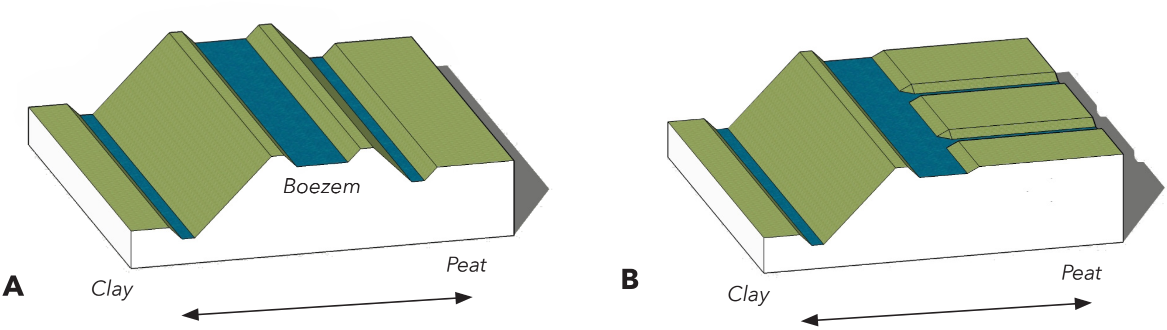


Figure 8.34: The two types of borders between the lake-bed and peat polder

Figure 8.35: Aerial view of the border
(Bing maps)

Figure 8.36: Bird eye view of the border
(Bing maps)

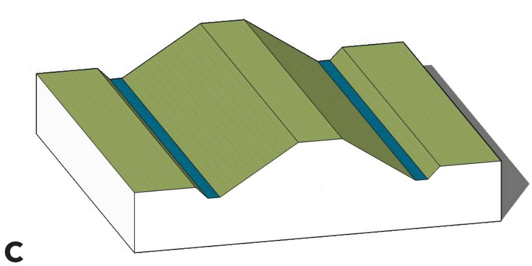


Figure 8.37: The land border schematized

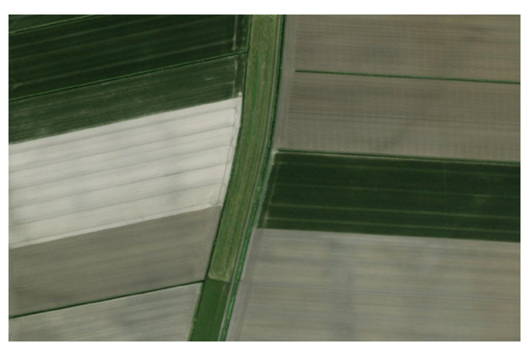


Figure 8.38 Aerial of the land border
(Bing maps)

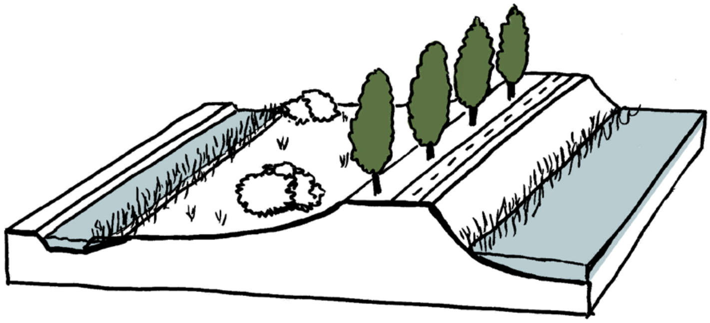


Figure 8.39: Possible intervention land border

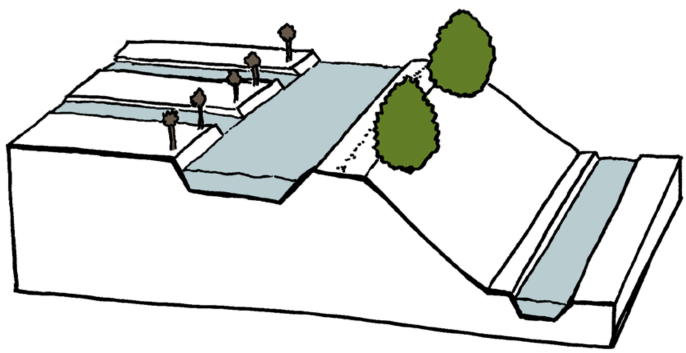


Figure 8.40: Possible intervention lake-bed border

Salix alba

Sycoparrotia semidecidua

Ulmus ´Columella´

Figure 8.41: Suggestions for tree types for the lake-bed border (Salix & Sycoparrotia) and the land border (Ulmus)
(Zalix, n.d.; vd Berk Boomkwekerijen, n.d.)

Other existing structures in the region are infrastructure lines. Roads, highways, railways; they not only provide physical connection to people, but also form barriers in the landscape and cause fragmentation. Along these structures, often a green zone is already present, like between the highway and the railway. This can be reinforced. However, there is often little connection that crosses the infrastructure. To make this connection, water or pedestrian tunnels can be combined with a planted ecostrip, that allows smaller animals to cross as well. (see figure 8.42 and 8.43).

In case of the elevated railway track in the Overbuurtsche Polder, it is even easier to use it as a green structure, as the space underneath can be used as well (see figure 8.44).

Figure 8.42: Culvert that only allows water to pass
("Duiker", n.d.)

Figure 8.43: Culvert that also allows small animals to cross
(Petero_dk, n.d.)

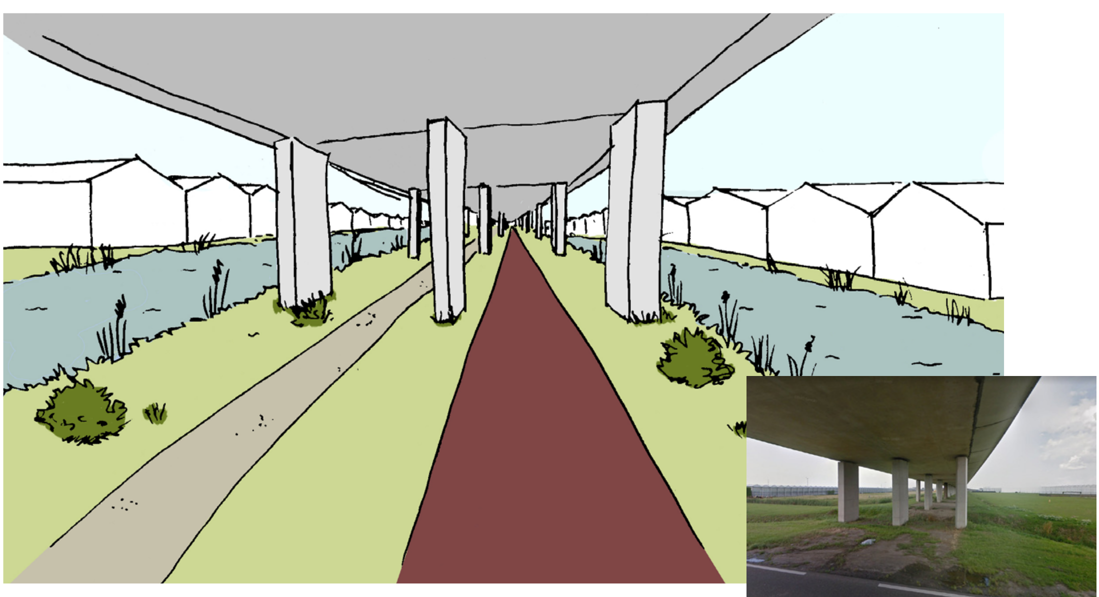


Figure 8.44: The viaduct as green, blue & recreative corridor
(picture from Google Maps)

Polder

Polder de Wilde Veenen is surrounded by three different dike types (see figure 8.45). The Noorddijk and Oostdijk are part of the land border between Rijnland and Schieland & Krimpenerwaard (figure 8.46 & 8.47). The Rottedijk is where the boezem of the Rotte begins (figure 8.49). The Julianastraat is the only dike with a car road on it, but its profile is still suitable to be used as green structure (figure 8.48). The sections (figure 8.50-8.54) show the different dikes before and after the design.

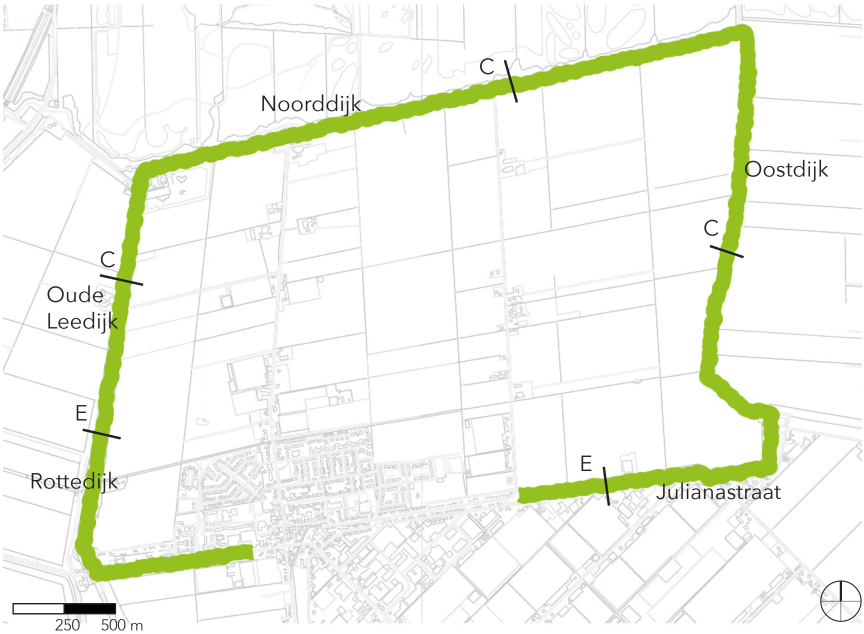


Figure 8.45: Map with the dikes around Polder de Wide Veenen

Figure 8.46: Noorddijk

Figure 8.47: Oostdijk

Figure 8.48: Julianastraat
(Google maps)

Figure 8.49: Rottedijk
(Google maps)

Noorddijk

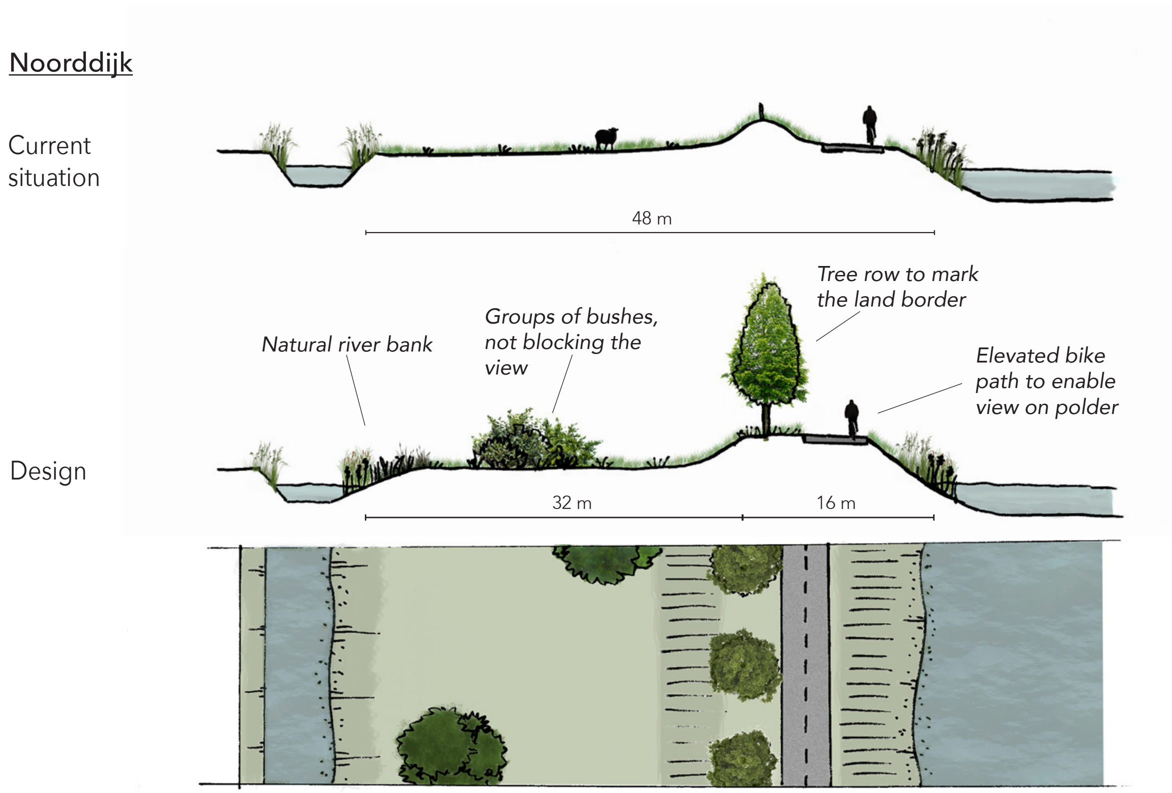


Figure 8.50: Design of the Noorddijk

The Noorddijk and Oostdijk are both landborders. They will be marked with a distinctive upright tree row. Furthermore, the slope that is now just grass will increase in biodiversity by adding different kind of plant types, like grasses, herbs, bushes and wetland plants at the water banks. On the Noorddijk, the bike path is elevated to enable view into the polder. To not block this view, scattered green areas are used instead of lineair structures.

Figure 8.51: Impression Noorddijk

Oostdijk

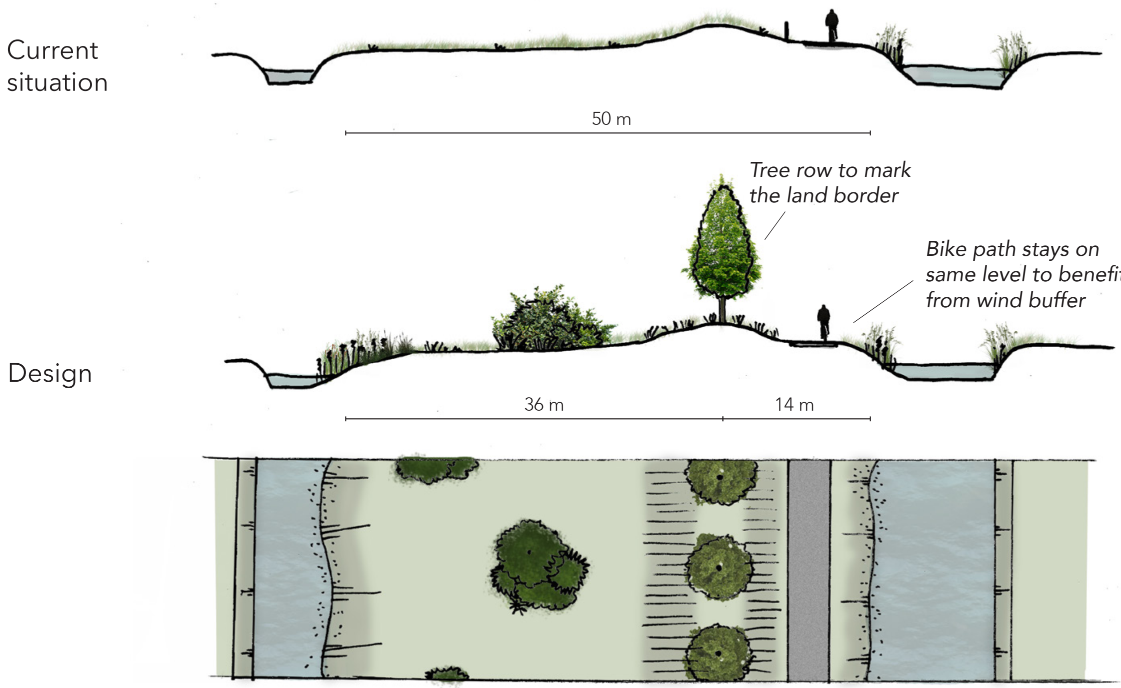


Figure 8.52: Design of the Oostdijk

Julianastraat

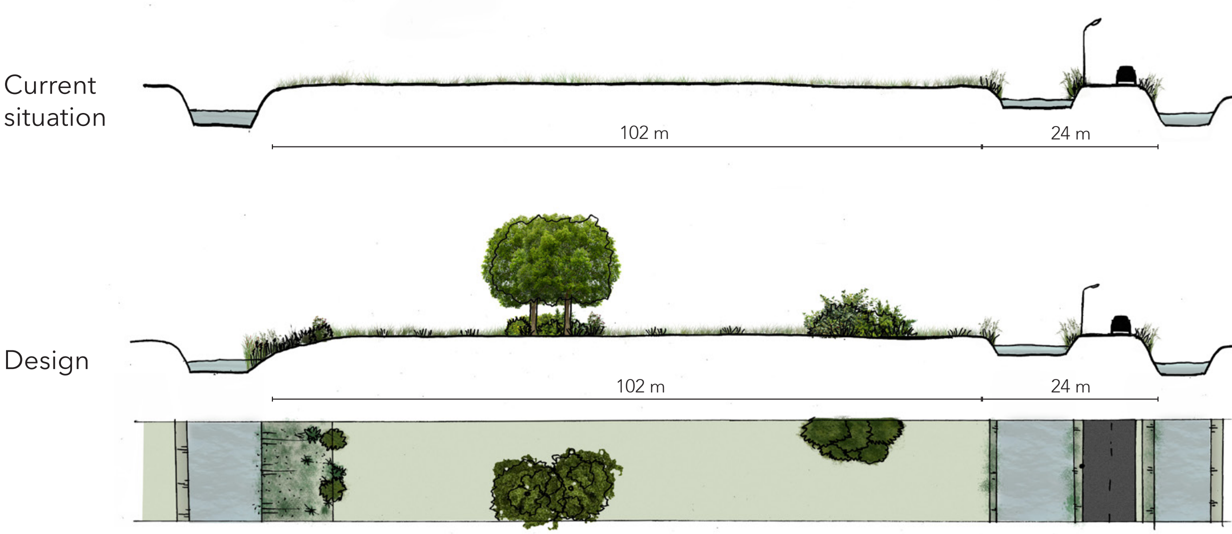


Figure 8.53 Design of the Julianastraat

The same principles are being used for the Julianastraat and the Oude Leedijk. The Julianastraat (see figure 8.53) has a large strip of land next to the car road that forms part of the dike. Most of this land is now being used as grazing land and a small part for crops. In the proposal this land will be used as green structure by adding different plant types. A walking route along this strip can be added as well, since there is no pedestrian path along the car road. The same method is applied to the Oude Leedijk (see figure 8.54). The path that is now on top of the dike is currently not all the way connected to the Noorddijk. By making this connection, the road will form part of a green walking and cycling route.

<u>Oude Leedijk</u>

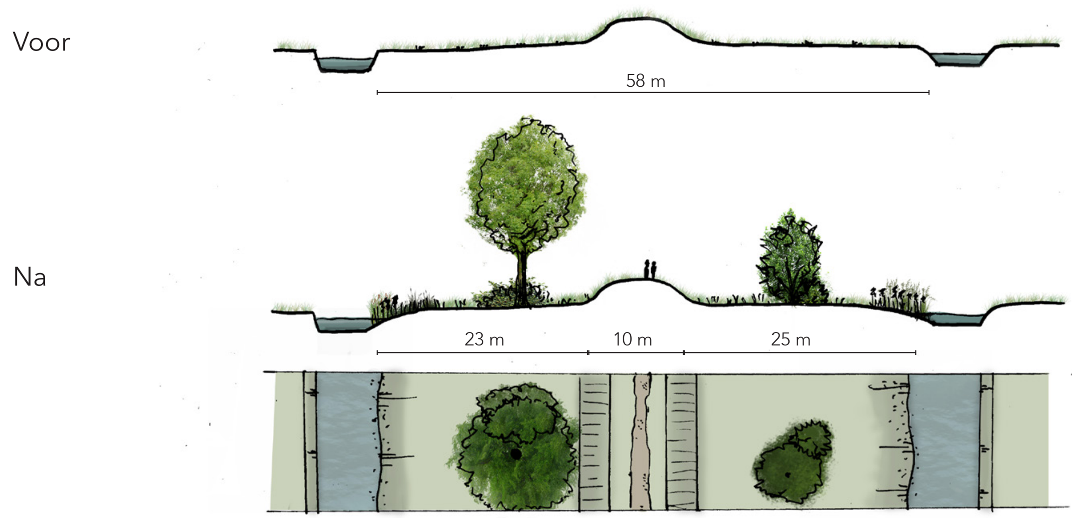
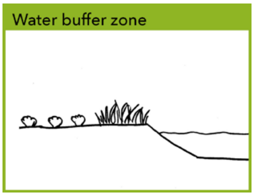
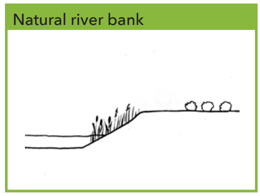


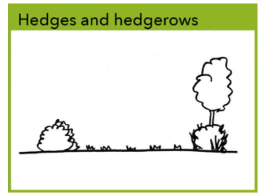
Figure 8.54: Design of the Oude Leedijk

A finer part of the network is formed by the water system (see figure 8.55). In the polder three different ditches are present, named primary, secondary and tertiary. The main primary ditch is called the Groote Duikertocht and brings all the water from the polder to the Rotte (figure 8.56). Perpendicular to this ditch are the more narrow ditches named Dwarstochten (figure 8.57). The smallest ditches are the ones ending up on the Dwarstochten, parallel to the Groote Duikertocht (figure 8.58).

The current sections of the ditches show they have a steep talud and the crop starts directly next to the ditch. To prevent pollution and drift from pesticides and fertilizer into the water, a buffer zone is desirable. This buffer zone can also provide biodiversity and serve as a habitat for useful insects – increasing pollination and preventing pests. A more gentle slope offers more diversity in water levels and marsh plants like reed and bulrush. These plants have a purifying effect on the water (see figure 8.59-8.62).







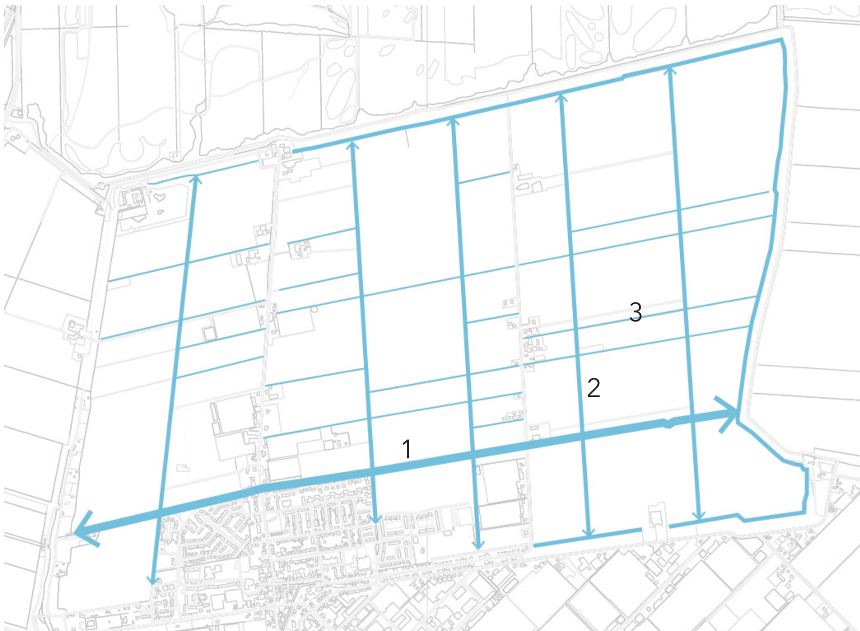


Figure 8.55: The water system in the polder

1

Figure 8.56 Groote Duikertocht

2

Figure 8.57: Secondary ditch

3

Figure 8.58: Tertiair ditch

1

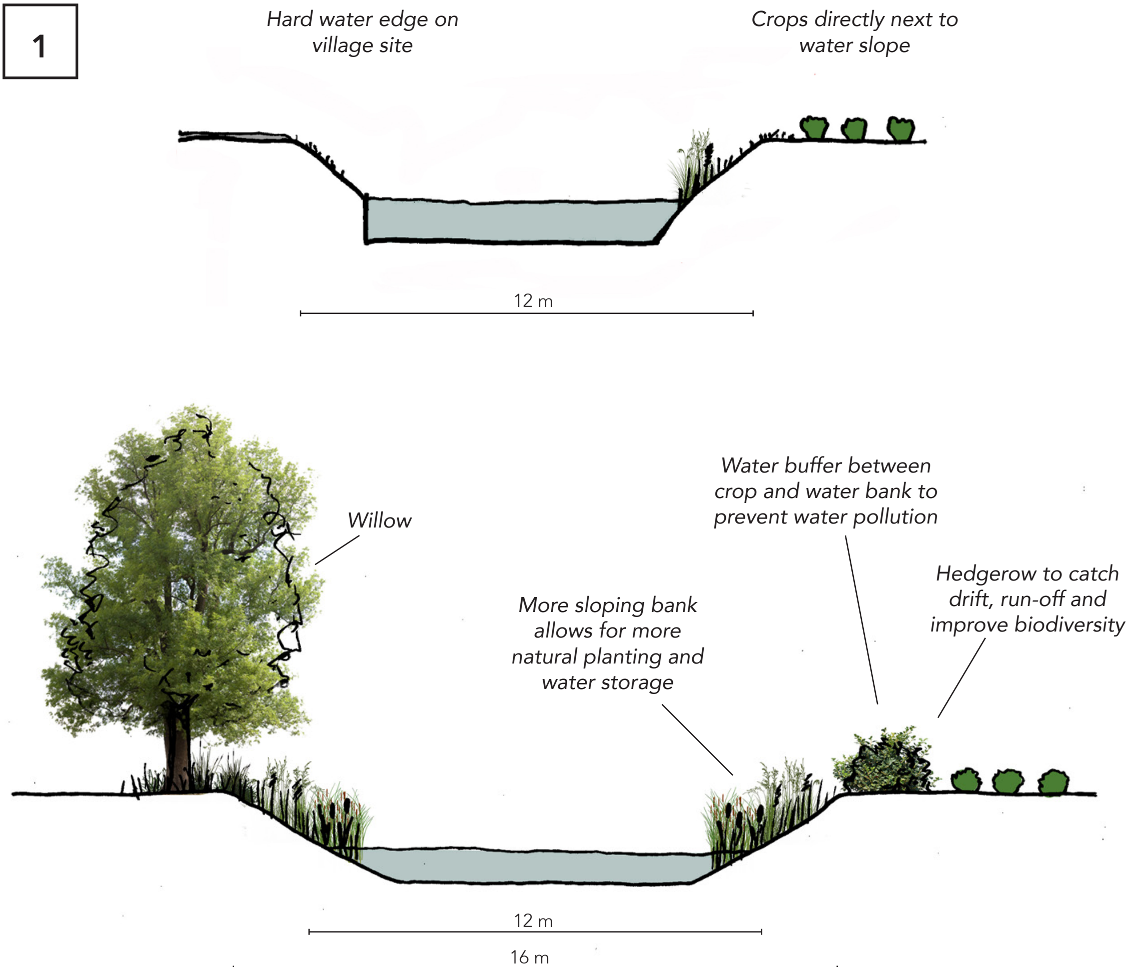


Figure 8.59: Section of the before and after situation of the Groote Duikertocht

Figure 8.60: Impression of the polder after adjustments

2

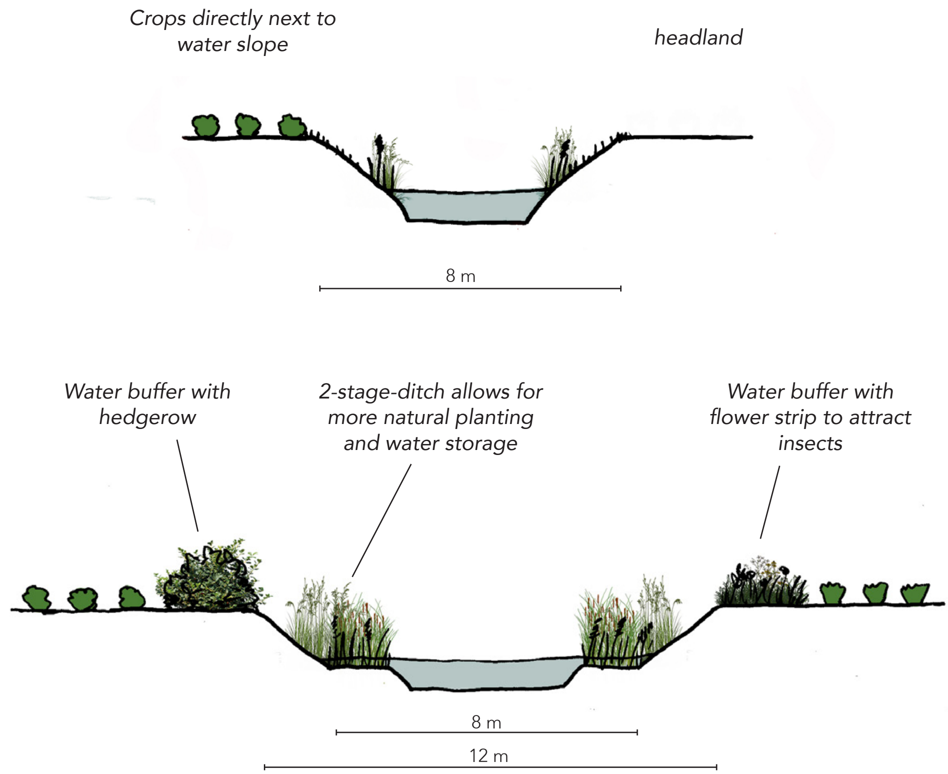


Figure 8.61: Section of before and after situation of a secondary ditch

3

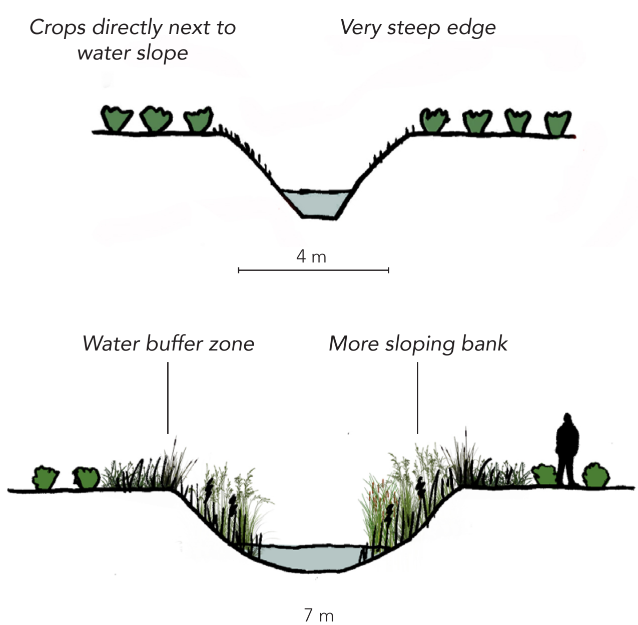


Figure 8.62: Section of before and after situation of a tertiary ditch

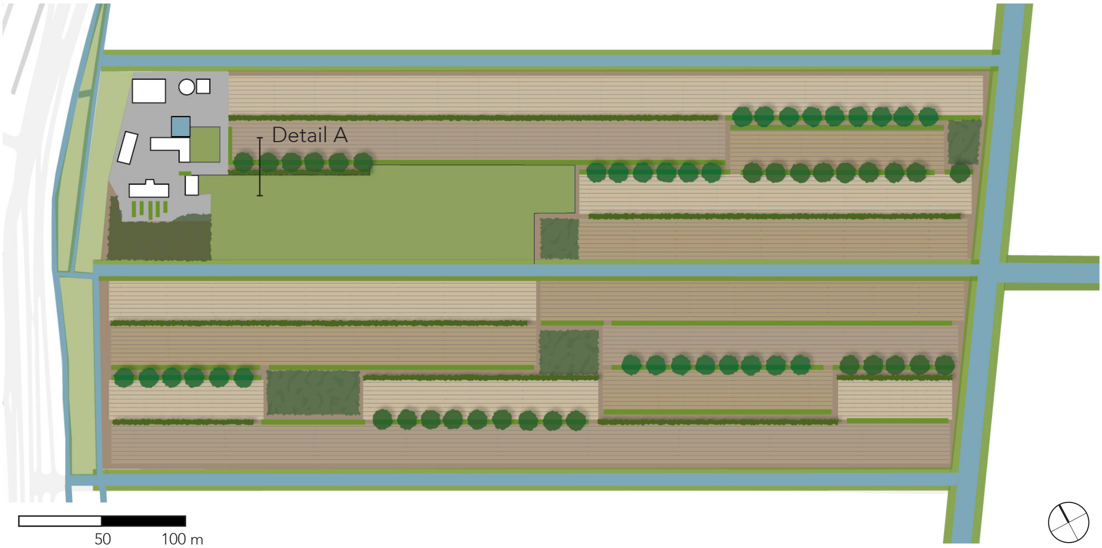
The smallest level of structure is formed by an alley cropping system (see figure 8.63). Every few meters, the production field is interrupted by a strip of trees, hedges or flowers. To keep the arable land workable for machines, the distance between the strips conforms to a plurality of 3 meters. Refering to the original distance of the parcels before the reallotment, this will be around 60-72 meters (depending on the location in the polder).

Figure 8.63: Alley cropping in the polder

<u>Alley cropping – hedge orientation</u>

The current orientation of most parcels is about east-west. The cultivation of the field therefore happens in this direction as well. The most logical choice thus whould be to place the hedges in the same direction. However, if you look at the function as a windbreak, a north-south orientation would be more helpful because of the dominant wind direction (southwest). Regarding sunlight, different sources say different things. After a small research it was determined that the north-south orientation provides more sunlight during winter, while east-west is better during summer. In general, in the east-west orientation especially the strip north of the hedge suffers from shadow, while in the north-sourth orientation there is less sunlight in total, but it is more evenly distributed among the crops (which often is preferred as the crops grow more equally).

Overall, it seems a north-south orientation is slightly better. However, as the differences are not that great, there is a large distance between the hedges and the strips are alternated with low flower strips, I chose to stick to the east-west orientation in the design. Farmers can decide themselves if they want to change orientation. However, it is advised never to place a hedgerow south of a ditch, as this leads to algae forming.



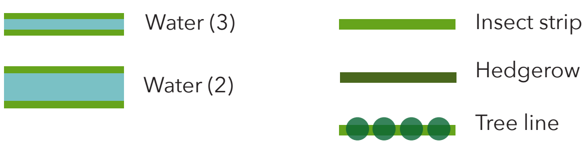


Figure 8.64: Plan of the farm

Farm
On the ideal farm, this distance can even be shorter, so here it is 24 meters (see figure 8.64). It is a balance between productivity (how easy it is to plow-seed-harvest the crops) and ecological value. The strips in between are about 3 meters broad, and preferably alternated between tree rows, flower strips or hedges (creating another level of diversity). For the flower strips a mixture of flowering seeds can be used, preferably one suited for bees.

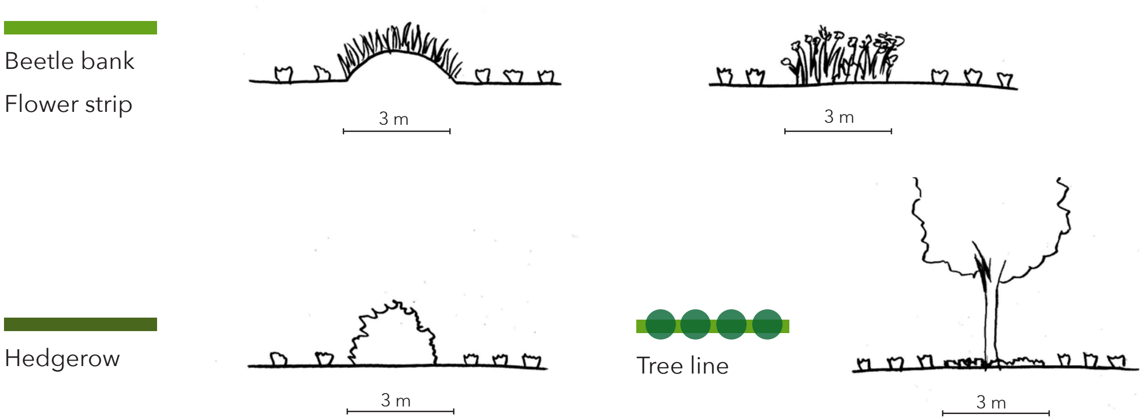


Figure 8.65: Types of possible vegetation strips

Suitable hedge species for the fields are ***crataegus monogyna*** (see figure 8.66)***, prunus spinoza*** (see figure 8.67)***, rosa canina*** (see figure 8.68)***, cornus sanguinea, corylus avellana, sorbus aucuparia, prunus padus, sambucus nigra, euonymus europaeus and viburnus opulus***. These are all native or old species with a high biodiversity as they provide food for birds and insects. Pruning is for most of them necessary to stay at a lower height. Often used tree species for alley cropping are ***populus, quercus, juglans, acer, corylus or carya*** as these trees provide extra income through timber, nuts or fruit and can be good combined with the crops (see figure 8.69 & 8.70).

Figure 8.66: Crataegus monogyna
(Jacobs Budgetplant, n.d.)

Figure 8.67: Prunus spinoza
(Olsson, 2005)

Figure 8.68: Rosa canina
(Hedges Direct, n.d.)

Figure 8.72 shows a detail of the farm path (see figure 8.64 for location). On one side of the path a line of trees is present, and on the other side a hedgerow seperates the path from the meadow. On the meadow side a fence is placed to keep the livestock out till the hedge is fully grown. Both hawthorn (***Crataegus monogyna)*** and Blackthorn (***Prunus spinoza***) are good in keeping the livestock out as they are dense hedges with thorns. The half-hard path is 4 meters broad so it can be used for the farming machinery as well. As materialization the use of Graustabiel is suggested, which has a natural appearance (see figure 8.71).

Figure 8.69: Poplars in an alley cropping system with wheat
(Dupraz, n.d)

Figure 8.70: A young juglans regia
(van den Berk, n.d.)

Figure 8.71: Half-hard path of Graustabiel ®
(Graustabiel, 2012)

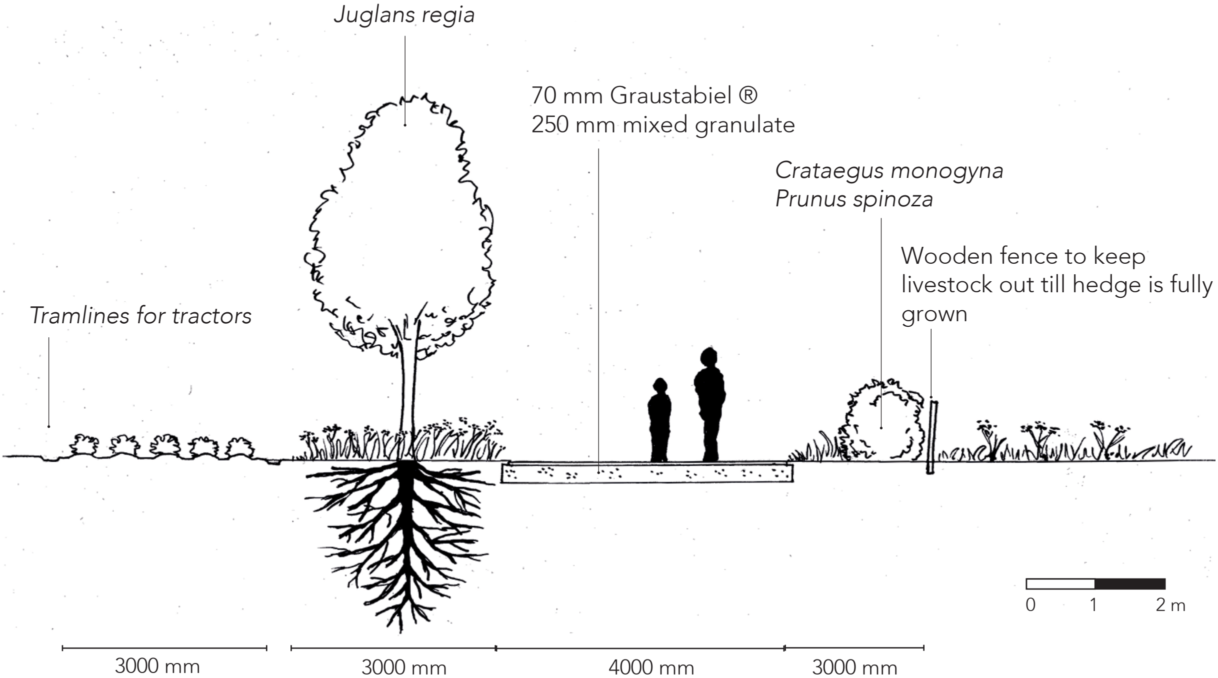


Figure 8.72: Detail A of the farm path

8.3 Circularity

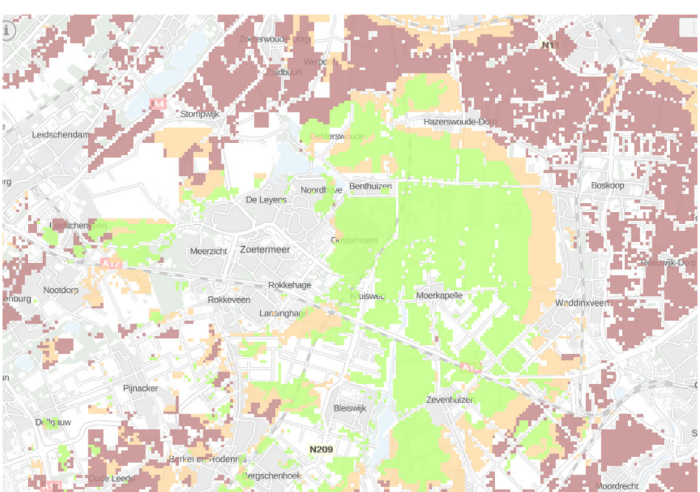
Having covered how the new agricultural land will look like, the next question is how it will work.

8.3.1 Nutrients

Figure 8.73 shows which of the land in the Zoetermeer region is not suitable for crop production. These are the peat and the peaty clay areas. As a starting point, these are the areas where feed for animals can grow in the form of grass or wet crops. However, it can also be suitable for other functions, like the production of materials, biomass, or non-landbased production like intensive greenhouse horticulture.

The right collaboration between the livestock farming and crop farming makes the import of chemical fertilizer unnecessary. Currently, a lot of cows are being held in the region. Raising the water tables in the peat area makes less land for them suitable to live, restricting them to the meadow area (see figure 8.74). Their amount will decrease, also because of sustainability reasons. Other livestock such as pigs will partly replace them in the system, but in total the amount of livestock will decrease. In the meadow area cows, sheep and chickens will be the main animals, and in the crop farming pigs and chickens will dominate. The manure of the livestock that is not directly placed on the field (e.g. during winter), can be composted or fermented in fermentation plants. Two of these plants are located in the region, on small industry areas between the 'livestock' area and the crop areas (see figure 8.74). Sewage silt from the city can also be a valuable input for the fermentation process.

Food residues and other organic waste from crop farming and the city on the other hand, offer more value as feed for the livestock (see figure 8.75). The residues that are not suitable for the livestock anymore, can go to the insect farms. There it is again transformed to a protein-rich food source for the livestock (mainly chickens) and aquaculture nearby Pijnacker. In the future, the insects might serve as food for people as well.



Cattle feed
- *Herb-rich grassland*
- *Duckweed, Azolla, Bulrush*

Materials
- *Stable litter (reed)*
- *Buidling material (wood, bulrush)*
- *Substrate (peat moss)*

Biomass (not as primary goal)
- *Willow, poplar, alder, miscanthus*
- *Miscanthus*

(Food)
- *Cranberries, wild rice*
- *Aquaculture*
- *Intensive (not land-based)*

Figure 8.73: Suitability for land-based crop farming (red = not suitable)
(Bodematlas Zuid-Holland, n.d.)

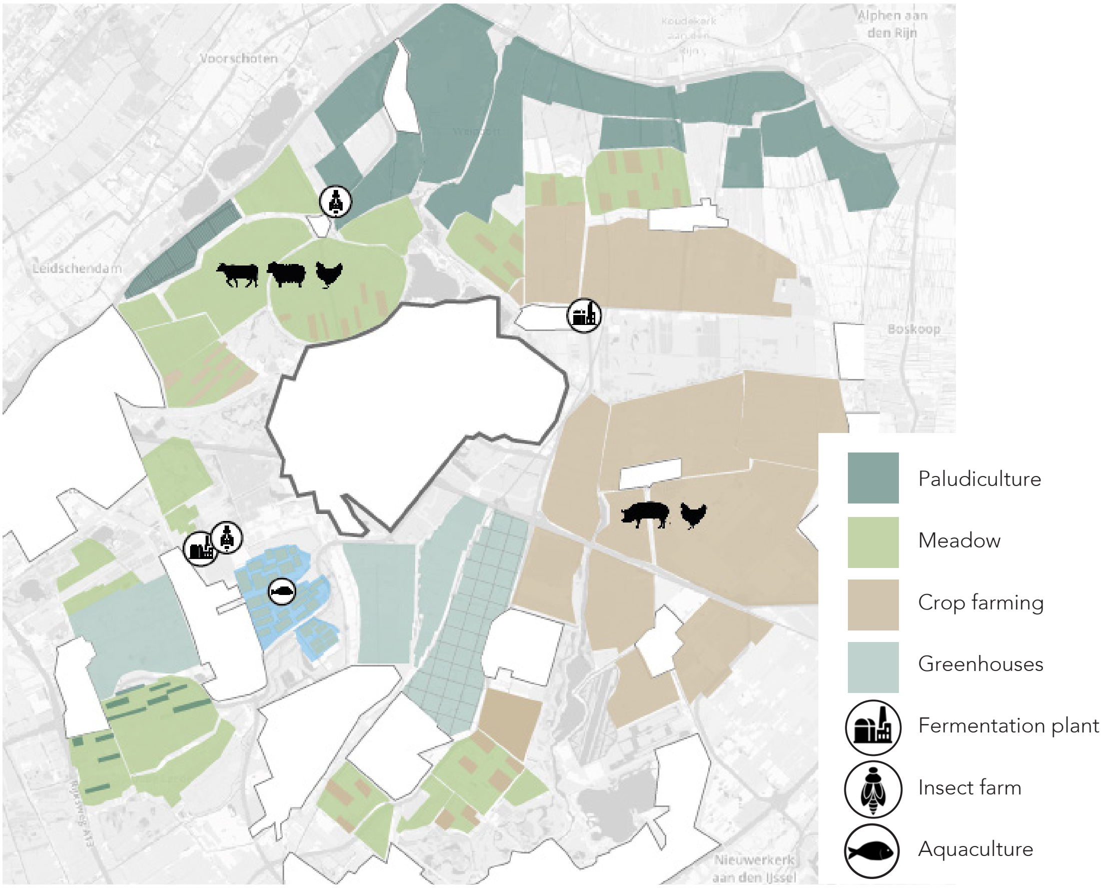


Figure 8.74: Nutrient map of the region with main production and consumption areas

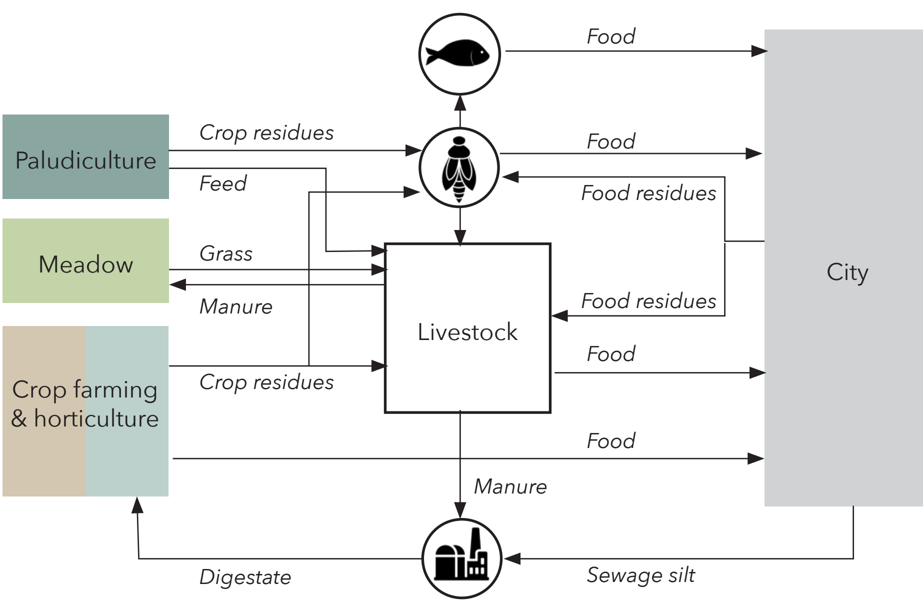


Figure 8.75: Main nutrient flows in the region

Food production in numbers

The new plan for the agriculture in the polders has its impacts on the food production as well. The table below shows the food need of Zoetermeer (125.000 inhabitants (Gemeente Zoetermeer, 2017)), based on the average food consumption in the Netherlands (Rienks & Meulenkamp, 2009). The column next to it shows the current food production in the polders, based on the total of eight municipalities*. The far right column shows a rough estimation of the food production in the new plan.

Food consumption per 1000 inhabitants	Food need Zoetermeer (125.000 inhabitants)	Current food production	New food production (indication)
16 ha plantbased products (sugarbeet, corn, wheat, oil, potato)	**2000 ha** crop farming	**2.730 ha** crop farming	*4000 ha*
9 ha fruit & vegetables	**1125 ha** horticulture	**659 ha** outdoor horticulture / of which **322 ha** fruit & vegetables	*659 ha/ 322 ha*
		1.288 ha greenhouse horticulture / of which **608 ha** fruit & vegetables	*1000 ha / 700 ha*
-	-	**8.651 ha** grassland/feed production	*5000 ha*
83 dairy cows, 69 meat bulls	8708 cows	19.174 cows	*5000*
-	-	15.699 sheep	*10.000*
250 meat pigs	31.250 pigs	9.605 pigs	*5000*
4000 meat broilers	500.000 broilers	101.300 broilers	*20.000*
1100 egg laying hens	137.500 laying hens	84.545 laying hens	*50.000*

Table 8.1: Numbers on the food consumption and production of Zoetermeer

Generally it shows that the current agricultural land furfills most food needs, but has a surplus of cows and a lack of pigs and chickens. There is a small lack of fruit and vegetables from horticulture as a large part of this area is used for growing plants, trees and flowers. The future food production will focus more on vegetable production, while dairy and meat production will decrease. So all the livestock numbers decline, especially the amount of cattle. Linked to this is the decrease of grassland and feed production. The amount of crop farming will increase, just as the focus on fruit & vegetable production in the horticulture.

* Approximation based on CBS numbers from the municipalities of Lansingerland (2017), Leidschendam-Voorburg (2017), Pijnacker-Nootdorp (2017), Rijnwoude (2013), Waddinxveen (2017), Zoetermeer (2017), Zoeterwoude (2017) and Zuidplas (2017). Therefore the total area is slightly larger than the bordered area of the project.

These numbers naturally only serve as a guideline for the amount of food production. First of all, Zoetermeer is not the only place that needs to eat in this region. Furthermore, a completely regional diet is nor feasible or desirable. In other parts of the Netherlands, the land might be more suitable for wheat production, while here more cows are being held. And currently bananas don't grow in the Netherlands yet. However, a more regional food production is a good aspiration.

Farm

The animal-plant-collaboration can be implemented on the regional level, but of course also on the level of the farm. In fact it returns us to the mixed farms, that were very common in history. To be able to have a complete closed system on a simple farm, animals are necessary. On the farm, a compost heap transforms the manure, organic resiudes and woody remains from the trees and hedges into compost that can be applied on the land. The manure being used comes from the stable, where it gets mixed with the stable litter. The pigs in the stable ensure the straw mixture gets enough oxygen for composting by rooting up the material.

A possible surplus of nutrients doesn’t run off in the water, but is taken up by the plants in the water buffer zone. When these plants are being mowed, they can be put on the compost heap or used as stable litter, closing the nutrient circle.

If it is possible to seperate the thin fraction from the manure, it can serve as a fertilizer for the production of duckweed. The production of duckweed can be combined with the collection of rainwater and functions as a valuable feed source for animals (especially the chickens).

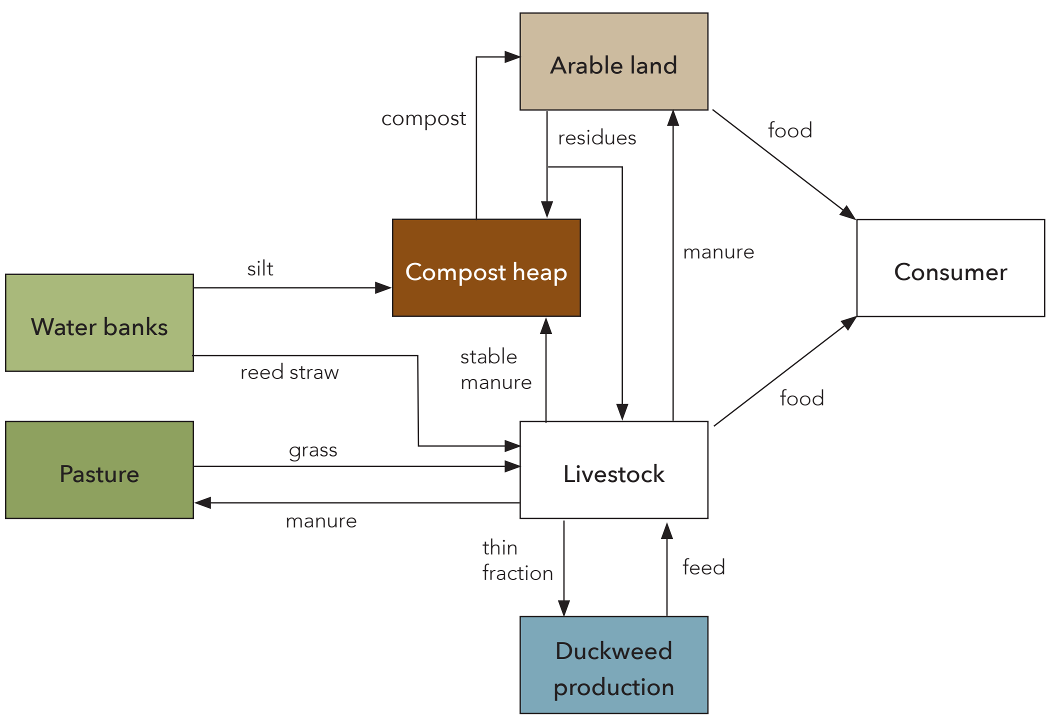


Figure 8.76: Scheme of nutrient flows on the farm level

8.3.2 Energy

Energy is needed both in the city and villages as on the farms itself. A circular energy system means turning to renewable sources. For the city, the fermentation plants in combination with CHP installation can provide energy. Furthermore, solar panels and windturbines contribute to the energy need of Zoetermeer (see 'Energy in numbers').

Each individual sector has its own sustainable options too. For example, in livestock farming, high-tech stables are able to catch methane gas. The greenhouse sector is probably best on its way to be self sustainable. Geothermal energy, CHP and thermal energy installations provide them with warmth and energy. Surplus of warmth in summer can be used for city heating as well, turning the greenhouse in an energy source.

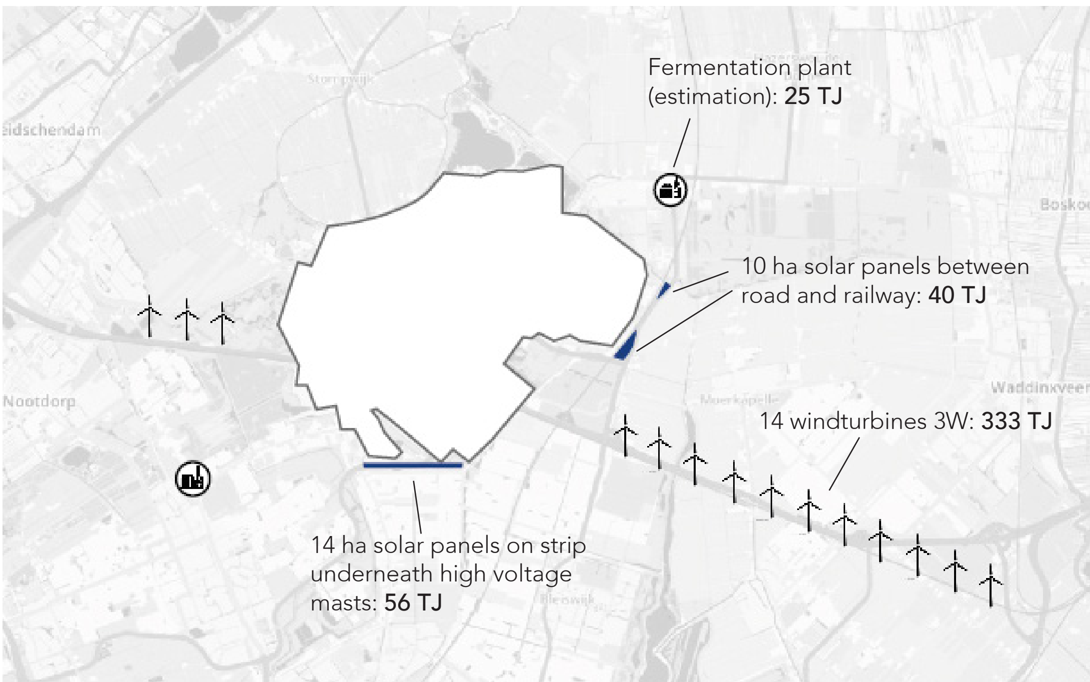


Figure 8.77: Map of energy in the region

<u>Energy in numbers</u>

What is the wcurrent energy need of the city of Zoetermeer? Looking at electricity, the average household consumes 3500 kWh per year (van Leeuwen & Pols, 2017). Zoetermeer has about 55.000 households (Gemeente Zoetermeer, 2017), leading to a demand of approximately 192.500.00 kWh = **693 TJ** per year.

The energy production of a fermentation plant is very dependent on different factors, including the ratio between manure and coproducts. Fermentation of only manure has a very low energy value. The more coproducts (e.g. maize or roadside planting) are added, the higher the energy value gets. However, growing biomass for fermentation requires land as well, which might be undesirable. Furthermore, cows are outside during summer, restricting the main manure collection to winter times. Based on existing numbers, an estimation of 5000 cows in the area, together with a 75-25% manure-coproduct ratio, the placed fermentation plants will probably generate about 50 TJ per year.

In the energy plan the energy need of Zoetermeer is adressed by the following resources (calculations based on guidelines from van Leeuwen & Pols (2017)):

- Solar panels on suitable roofs in Zoetermeer:	300 TJ
- Fermentation plants:	50 TJ
- 14 wind turbines (3W, approx. 150 m):	333 TJ
- Fields of solar panels on city edge (24 ha)	96 TJ
- Total:	**779 TJ**

This amount is larger than the estimated need of 693 TJ. However, this need didn't take in account the villages and industry areas around Zoetermeer. It also might not be possible to place solar panels on all the suitable roofs in Zoetermeer, leading to less supply. Therefore an estimated surplus is a good starting point.

<u>Farm</u>

Energy on the farm is mainly needed for machinery to work the land: to plow, sow, weed, fertilize, spray and harvest the plants. Working with ecological principles, some of this work will become unnecessary, thus reducing the energy input. To keep the soil healthy, a no-tillage system is used, removing the plowing task. After the harvest of a crop, the pigs are let on the bordered field to clear the fields as they root up the soil and eat crop remains (see figure 8.79). Growing a good cover crop removes the need for weeding. Naturally, no pesticides are used on the land. The pest resiliency is increased by the soil quality, intercropping and crop rotation practices. Each year the crop types are grown on different fields. In between the crop periods, the field is covered with a cover crop like clover, which is used as green manure for the soil besides the compost. Furthermore, the hedges and insects strips attract the right pest fighters. Animals can take over tasks as well, besides the plowing pigs, chickens serve as pest control in the orchard and cows or sheep mow the pasture land (see figure 8.78).

The remaining work of sowing and harvesting won't be done with large tractors fuelled by petrol, but with small, light-weight robot machines. These unmanned machines work on electricity instead of fuel (see figure 8.80). Driving on a GPS system, the robot tractors have as extra advantage that they cause less land compaction. The needed electricity can be generated by solar panels on the roofs of the farm buildings, and possibly a windturbine.

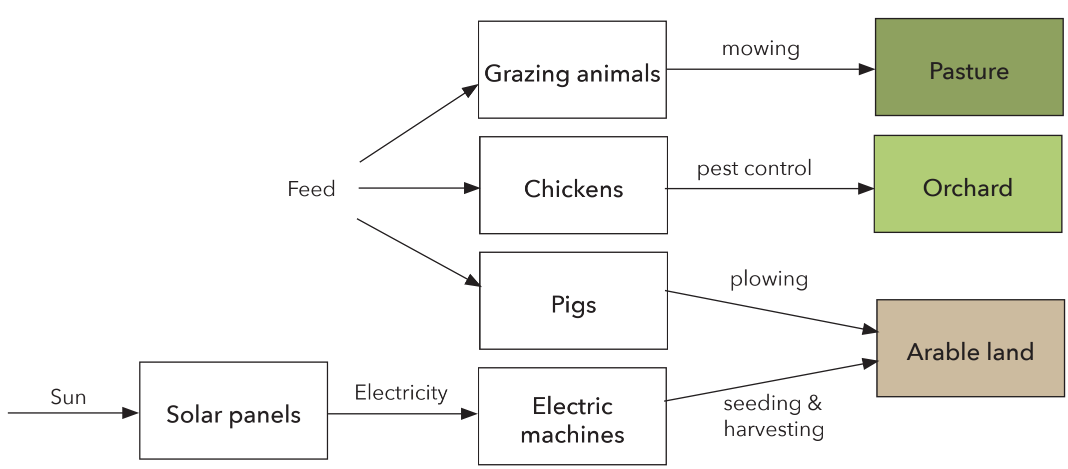


Figure 8.78: Scheme of energy flows on the farm level

Figure 8.79: Pigs plowing and clearing a forest field
(Cox, n.d.)

Figure 8.80: Robot tractor in horticulture
(Agriland, n.d.)

8.3.3 Water

The area has water problems because of its low surface level. To cope with the increased water stress, also because of climate change, better water retention is needed. This is done by adding two new water areas for rainwater collection (next to the existing Eendragtspolder).

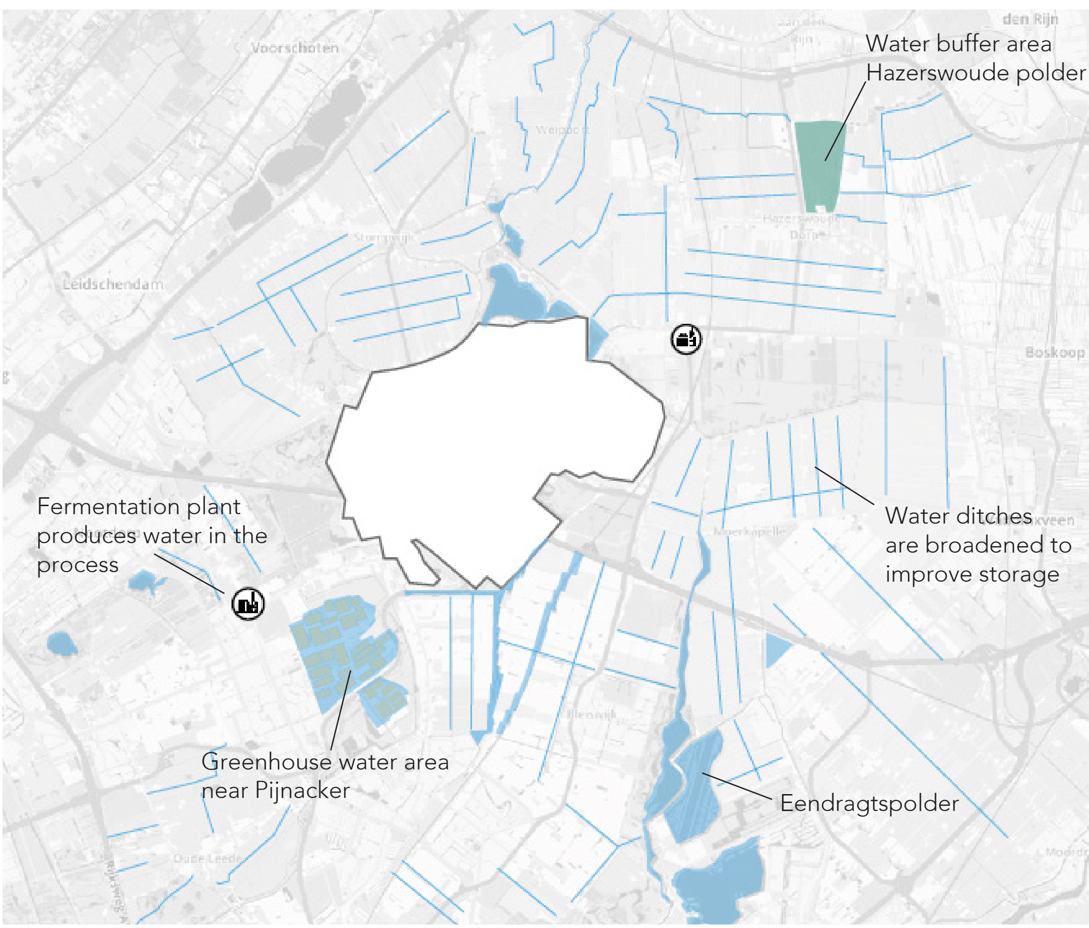


Figure 8.81: Map of water buffers in the region

One of them (area between Pijnacker & Zoetermeer) is flooded all year and provides place for floating greenhouses and aquaponics. The other, in the Hazerswoude polder, is a buffer area where water is only collected in periods of high rain fall. Besides these large water areas, the main water structures in the polders are broadened to improve the storage in the polders itself. These measures not only address water stress, but also provide more surface water that can be used as water for livestock, irrigation and cleaning, instead of the use of tap- or groundwater.

Another providing source for clean water comes from the fermentation plant. The water that is released during this process, can be used as input in the greenhouses. Greenhouses do not profit from normal rainfall, so they depend on irrigation. Most greenhouses collect rainwater in large bassins, charachterizing the area. However, still a lot of groundwater is used as well. Surface water is often not clean enough to be used. Water bassins should be more integrated in the surroundings and if possible with the surface water, instead of the elevated black bassins (although this will cost more).

<u>Farm</u>

As a start, the amount of water being used on the farm should be reduced. By improving the soil (increasing the sponge function) and increasing the amount of shadow (reducing evaporation), less water for irrigation is necessary. This is for example done by making use of green manure, cover crops, trees, compost, no-tillage, intercropping and crop rotation. Furthermore, rainwater can be reused by collecting it in a waterbassin. The water collection can be combined with the cultivation of duckweed. The collected water is used for irrigation and livestock drinking. The water that is lost due to run off, can be recycled by cleaning it with the purifying plants on the water edge before it ends up in the Boezem system.

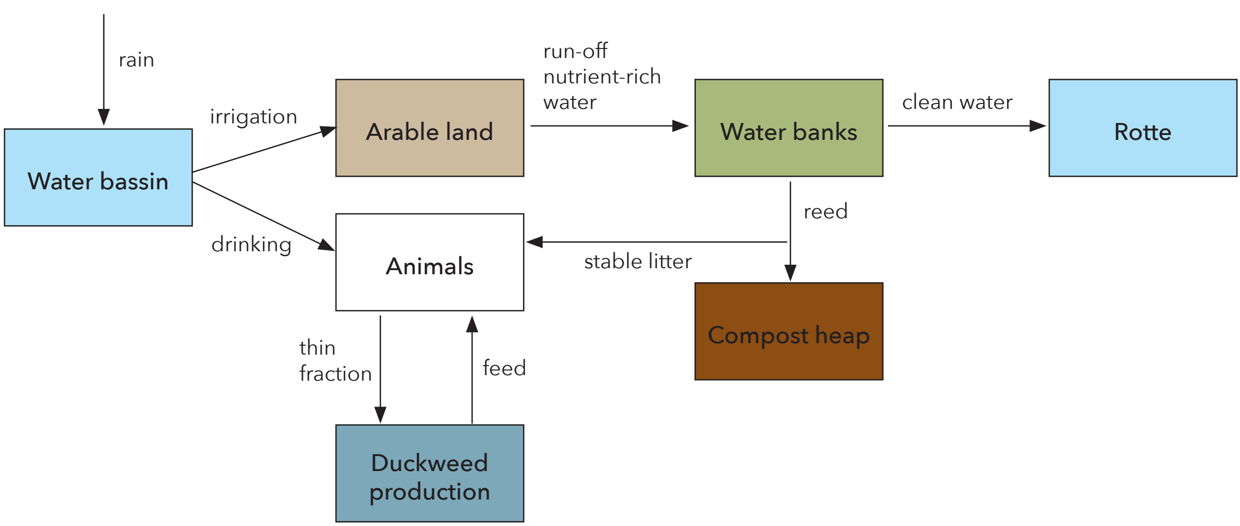


Figure 8.82: Scheme of water flows on farm level

8.4 Social sustainability

How to connect the city of Zoetermeer with its surrounding agricultural land? These principles show spatial concepts that correspond to that question.

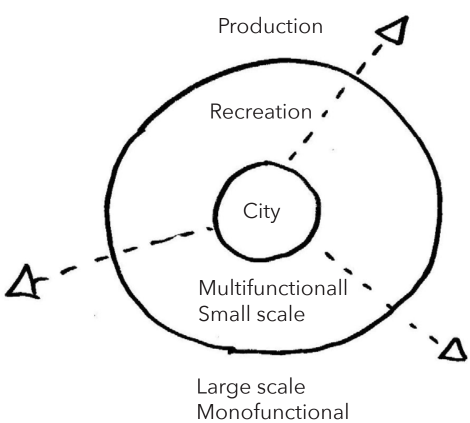


Figure 8.83: The multifunctional, small-scale farming should be close to the city, while the more large-scale, productive farm can be further away.

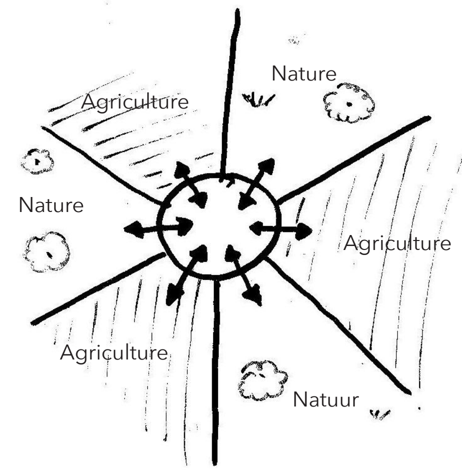


Figure 8.84: Currently, most lands next to the city are recreative areas, making the agricultural land physically and emotionally further away from the city. Although it is nice for people to have green recreation close to their house, in an optimum form this can be alternated between recreative agriculture and recreative nature.

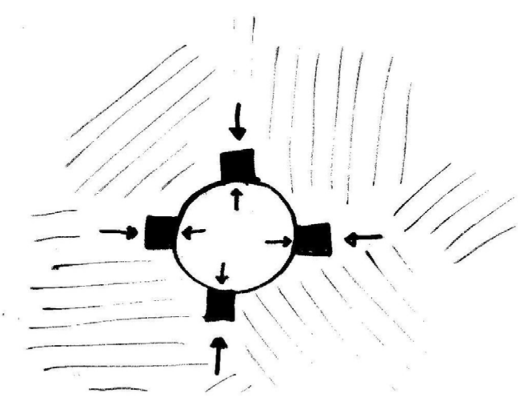


Figure 8.85: Certain places can serve as a connection center between agriculture and the city, located on their edge. Food produced on the land can be brought here, where the people from the city come to collect it.

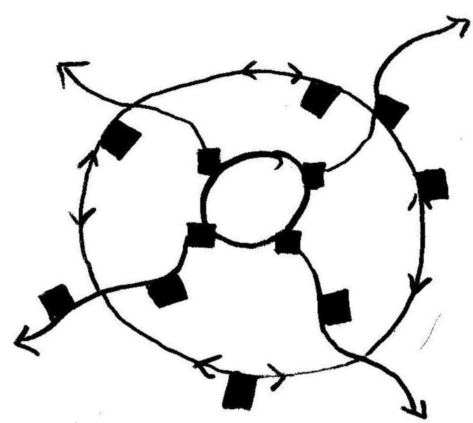
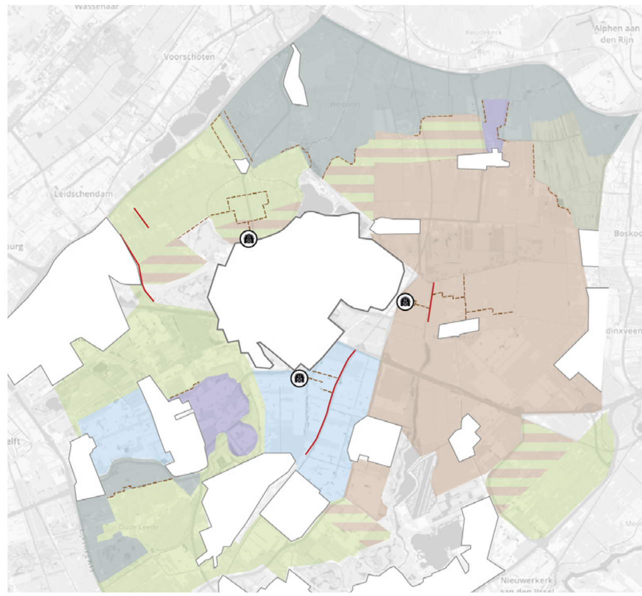


Figure 8.86: These Farm Centers can also function as the start of recreative routes from the city out into the agricultural land, making the people connect to the farming.

Region

These concepts are applied on the regional plan. Zoetermeer is adjacent to three agricultural zones: the meadow landscape, the crop farming landscape and the greenhouse landscape. In each of these zones a Farm Center is located, relating to the character of these specific landscapes and sectors. From here, walking paths explore this specific type of agricultural landscape. The new added walking routes and bike paths are also shown in figure 8.87a. Figure 8.87b shows the total plan including the nature areas and all the other separated bike paths and walking paths through the region. Most of them are located in the northern peat area.



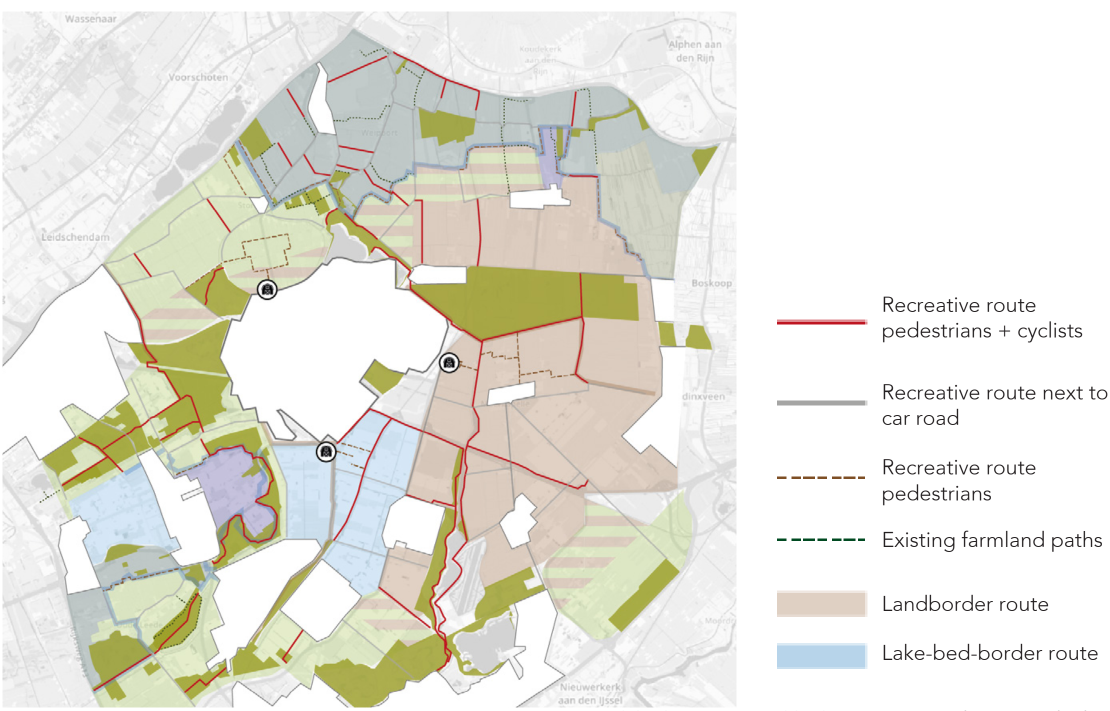


Figure 8.87a (top): new added routes and b (bottom): total regional plan

Polder

The polder de Wilde Veenen addresses social sustainbility by adding recreative routes (see figure 8.88). The polder dikes used as green structures, will function as recreative structure for cyclists and pedestrians as well. Also, a polder path along the agricultural fields is created. This path additionally provides a better pedestrian route from the village of Moerkappelle to the Bentwoud in the north.

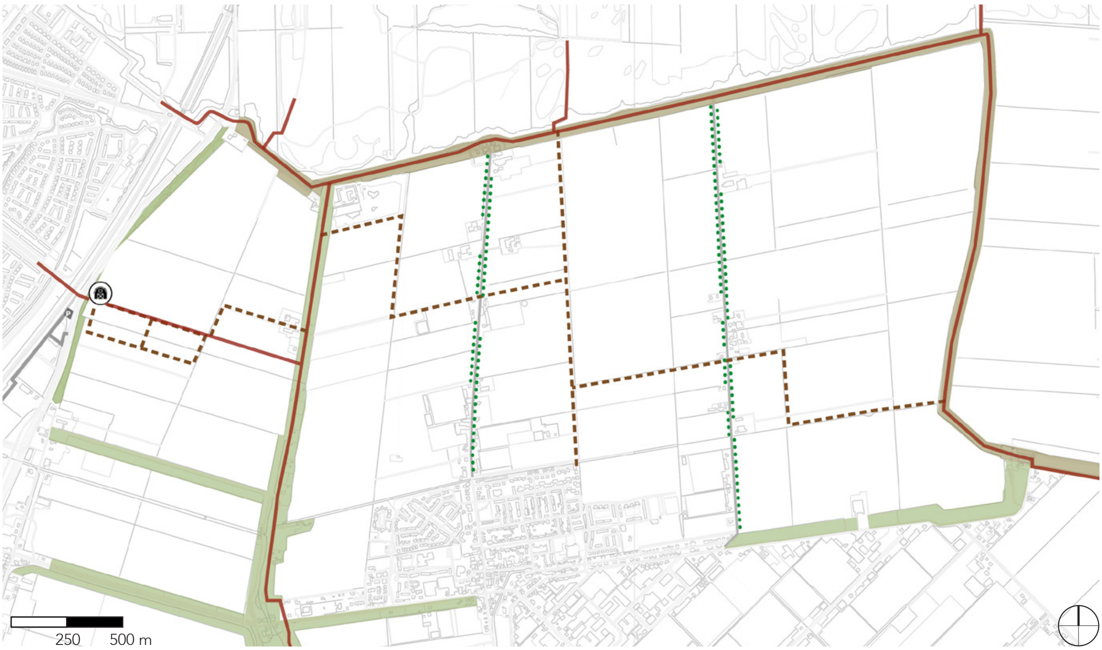


Figure 8.88: Pedestrian paths in the polder

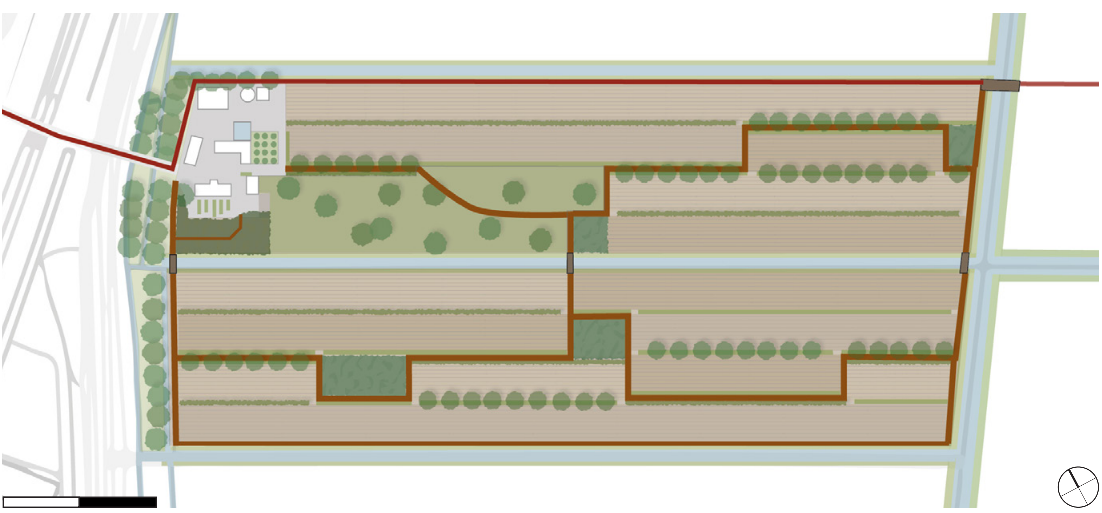


Figure 8.89: Walking route on the farm

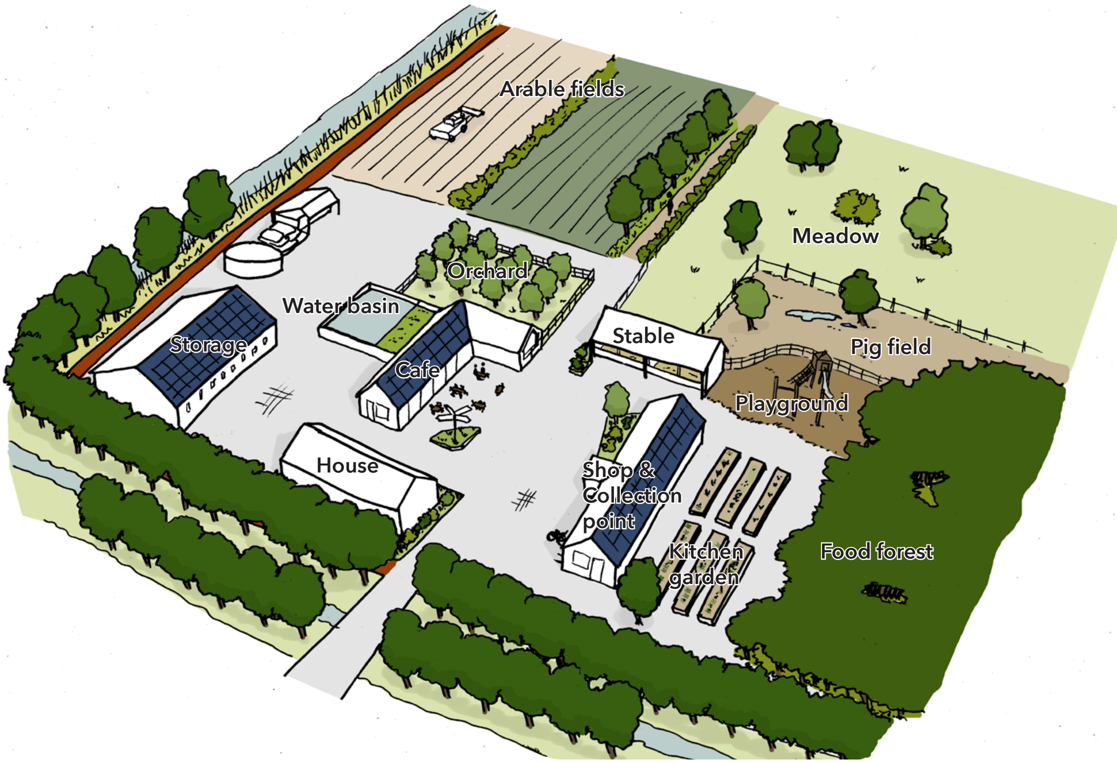


Figure 8.90: Overview of the farm courtyard and its functions

Farm
The farm elaborated on is the Farm Center of the crop farming landscape. Therefore it is located on the direct edge of Zoetermeer, to be easier accessible for consumers. Just in the agricultural land though, to invite people into the farming landscape.

The food center is paid for by a cooperation. A farmer works as their employee on the small farm, consisting of a courtyard and about 12 ha of arable land.

The farm courtyard functions as a collection place for citizens and their local produced food (see figure 8.90). There is a collection point, where people can pick up their ordered products. These products are ordered online, and on the farm center they are packed in boxes. The offered products are all produced locally, from the farmers in the whole region around Zoetermeer. With every product is noted which farm it comes from.

On the farm, it is also possible to buy some single products, or to pick vegetables yourself in the kitchen garden or food forest. A cafe invites people to stay for a little longer, before they might start their tour of the farming landscape that starts at the end of the farmyard. The farm mainly serves as a gateway, to invite people to explore the agricultural landscape. It is possible to walk a short route of 1,5 km over the farmers field (see figure 8.89), to see how ecological agriculture looks like. Because of the different field margins and strategically placed groves, the view is constantly changing (see figure 8.91). Hopefully it encourages people to explore the farming area more.

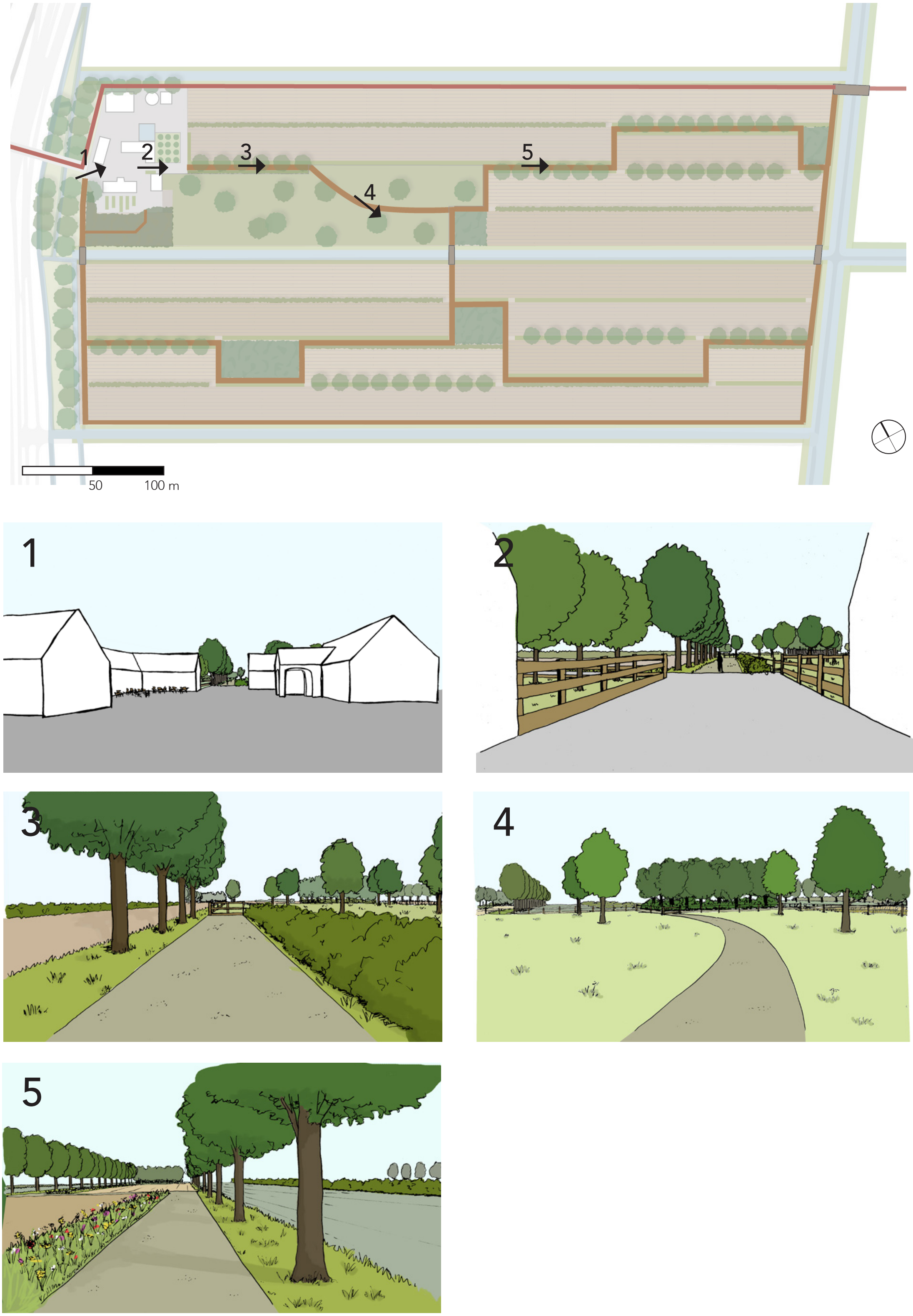


Figure 8.91: Impressions of the farm path with corresponding plan

8.6 Process

To transform the current landscape to the proposed plan, a lot needs to be changed. Considering the size of the area, different approaches are necessary. Some changes are applied to a certain area or sector, while others are implemented in the whole region. Some adjustments have to be made top-down, while other elements can be implemented by the farmers (bottom-up). Furthermore, some aspects take a very long term vision against the ones that can be applied right away.

In the peat area the water tables need to be heightened and the cows removed to make space for the cultivation of wet crops. To stop the emissions from soil subsidence, the water levels can slowly be raised in the whole area. The actual flooding of the land (i.e. bringing the water levels to the level necessary to stop the peat oxidation) can be done by starting with certain pilot areas in the zones where the subsidence is the strongest. These pilots can than serve as an example for the rest of the area. This large operation should be done in a collaboration between the province, water board and the farmers. The policy on the water levels should be decided for the whole area. Farmers who want to participate in a pilot project receive financial compensation. Farmland from a retiring farmer can be used as well. Furthermore, all the peat farmers should receive support and guidance on the transition and their possibilities as it is a difficult process that requires a long term vision.
Near the villages, new carr forests will be planted by a nature organization or the municipality. The land has to be bought from the dairy farmers. The planting can be done in sections if not all land is available yet.

In the meadow area the dairy farmers stay, but the total amount of cows has to decrease. This is a process that will take a long period, as you don't want to directly kill half of the livestock. Clear guidelines for the future should be communicated to the farmers, so they can work towards it. The best way to restrict the amount of livestock, by farmer, area, available land or feed, has to be researched. Farmers are stimulated to create a silvopasture system by planting trees and hedges, switch to herbal-rich grassland and create more habitat areas. They receive financial support for the investments made in biodiversity.

In the crop farming area farmers will also plant hedges, trees, insect strips and nature patches themselves, in return for financial compensation. The larger water ways will be adjusted by the water boards (broadening, natural river banks), while the farmers improve the small ones and implement buffer zones. The planting of the food forests near the village will be done by the municipality or by enthusiastic community members. The removal of the greenhouses has to be made top-down. Leaving horticulturists make space for new crop farmers, preferably starting farmers.

In the greenhouse area investments are made in technological innovations concerning sustainability, with the final goal to create a closed greenhouse system. These innovations are carried out by the farmers or as a corporation of greenhouse farmers. They also integrate their water basins in the landscape, in return for a small compensation. The green and blue structures, with buffer zones and helophytes along the water, are realized by the municipality.

A more extreme plan covers the area between Pijnacker and Zoetermeer, where the greenhouse area gets flooded. It can serve as a high-tech example how to create high food production in the wet and densely populated Netherlands. Innovations as floating greenhouses and aquaponics are shown. The amount of water in the area can be slowly decreased by increasing the amount of service water or by heightening the water tables. Land that is now used for greenhouses and housing can be spared in the beginning. In the further future more focus and space can be given to floating houses.

Besides the adjustments in the different areas, changes need to be made on the scale of the region. For example, the transformation of the dikes to green structures. First, per dike should be decided what and how the biodiversity is increased. Then a party like the province, water board or municipality can start planting. Building the fermentation plants can be done by Zoetermeer or a corporation of farmers. A pilot for an insect farm can be stimulated by the province, but should be carried out by enthusiastic entrepreneurs.

The authorities should also invest in the construction of new recreational routes in the polder, for example on the lake-bed border. However, farmer's can contribute to this network by creating pedestrian routes on their own fields as well. The smart ones will combine it with direct sales and advertisement of their farm. One central website for the area will show a map with the available routes through the polder and a map with all the farms in the network, together with the products they produce. Via this website, people can directly order their local products. In the meanwhile, three large groups of consumers are attracted who invest in the building of the Farm Centers. From their money, the land rent, building of the farm and the farmer will be paid. After the Farm Center is build, it will function as the collection point for the ordered products.

The actions that are applied by the farmers, bottom-up, are the elements of the plan that can be done right away. However, financial motivation and good information on the possibilities and ecological benefits might be necessary to stimulate the start of the movement. The connection between the city and farmland by the creation of Farm Centers, a local online market and recreational routes stands also at the beginning of the transition. Additionally, the authorities can directly start with the creation of a green network on the regional scale. Starting with these relative small changes, large operations as the moving of the greenhouses, transforming the peat area and reducing the amount of cattle will follow in time.

8.7 The farmer

The changes in the landscape ask for adjustments from the farmer. But why would the farmer contribute to this?

The changes that have to be made differ per area, so let's start with the crop farmer. He is asked to divide his land by planting strips of hedges, trees and flowers. Furthermore, he needs to broaden the ditches and plant water buffer strips and natural river banks. This costs him both money and work, for the realisation as well as for maintenance. On top of that, it also results in less land available for cultivation, which is less efficient to work with. Therefore it is necessary the changes come from an inner motivation from the farmer to make his land more sustainable. Recently it was published that more than 80% of the Dutch farmers actually wants to become more sustainable and nature-friendly (Trouw, 2018). However, changing to ecological farming offers many other benefits for the farmers as well:

Every farmer benefits from a healthy soil. The listed ecological measures contribute directly to a more fertile soil with more organic matter, a healthier soil life and better soil structure. This positively affects the crops. Additionally, these methods enrich the soil each year, ensuring a fertile soil and good yield for the farmer even after 10 or 50 years. The measures contribute to a sustainable yield for the long term instead of depleting the soil. Through a healthy soil and natural pest management, less input from pesticides and fertilizers is needed. This has ecological benefits, but also takes away work and costs for the farmer.

The agroecology focuses on diversity on the farm. By cultivating trees, different crop types and keeping livestock, the farmer generates extra income and is more resilient to failing yields and fluctuating prices. In other fields the resiliency is increased as well. The current intensive agriculture is very susceptible to extreme weather events and pests. By improving the water management, the water buffering capacity of the soil and the pest resiliency, the farmer is less vulnerable and better able to cope with setbacks. Especially with the climate change this gets more important.

Income is strengthened by a more direct connection to the consumer. Farmers in this specific region have the advantage of being so close to the consumer in the city. Using direct sale initiatives, the farmer is able to ask a higher price for its product. In return, the consumer asks for a healthy, sustainable product. Being so close to the farm, this can even be directly visible for them. For the farmer, the higher price and better connection makes it worth the investment in sustainability.

A lot of these arguments are also relevant for the dairy farmers on the peaty clay soils. They will apply more herb-rich grassland, hedges, trees and water bank planting, leading to a healthier soil, healthier animals and more resiliency. However, they are also asked to reduce their amount of cattle. Even if the reduction is made over a long time period, the question is 'how to sustain income with less cows?'.

There are several possible answers to that, for now ignoring the investments already made in for example large high-tech stables. First of all, ecological land-based farming reduces the input costs (feed import, antibiotics), leading to less costs per cow. Additionally, income can be increased by focussing on sustainability. Sustainable dairy products and nature-friendly production should be rewarded with higher product prices and environmental subsidies.

Direct sale of their products via a website or the Farm Centers enables the farmer to ask a higher product price as well. Although it is easier for the crop farmer to directly supply their product to the consumer than for the livestock farmer. Farmers can be paid for their management work in nature areas, but also for the delivering of ecosystem services and the management of the landscape. The farmer gets in fact a second function as nature manager. Another option is to combine the dairy farming with other activities like crop farming or social activities for people from the city (camping, event location, etc.). Last but not least, farmers can combine their companies in corporations or partnerships. This way, large investments and financial risks are shared with more farms, together reaching the necessary threshold amount of cows.

The main and possibly only argument for the dairy farmers on the peat areas to move or switch to wet crops is that the current situation is untenable in the long term. The soil will subside further, become wetter and will ask more costs to pump it dry. Although there are technological measures that slow down the process, it is a dead end road. In the end wet crops will prove to be more lucrative.

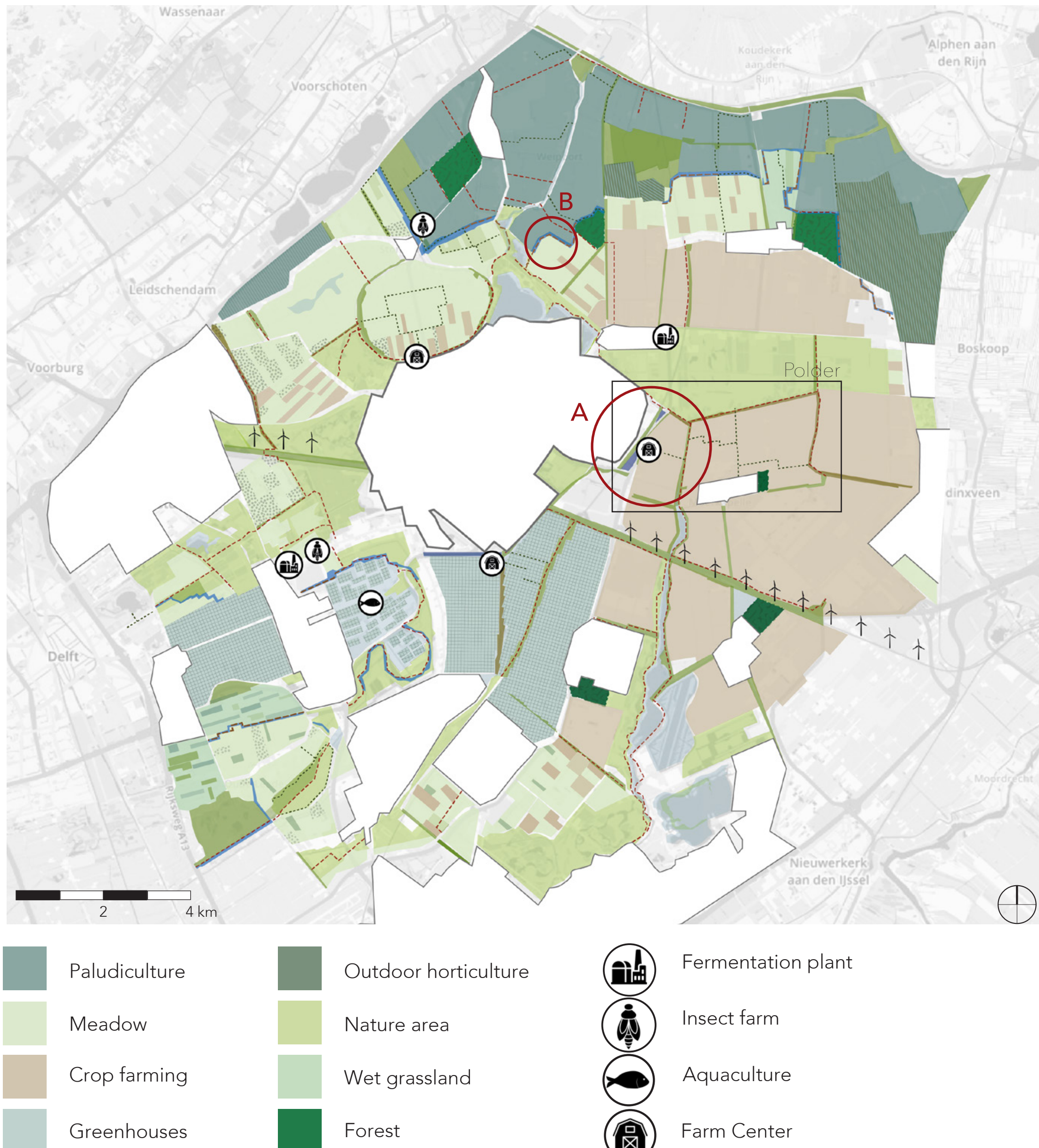
The greenhouse horticulturists are asked to invest in technological sustainability, which is already being done. Financial compensation can help them become a completely circular sector, which will eventually reduce their input costs and makes them less dependent on for example rainfall.

Besides the necessary financial support, the government needs to look at the agricultural regulations to make sure ecological adjustments and sustainable innovations are stimulated instead of hindered.

8.8 Total plan

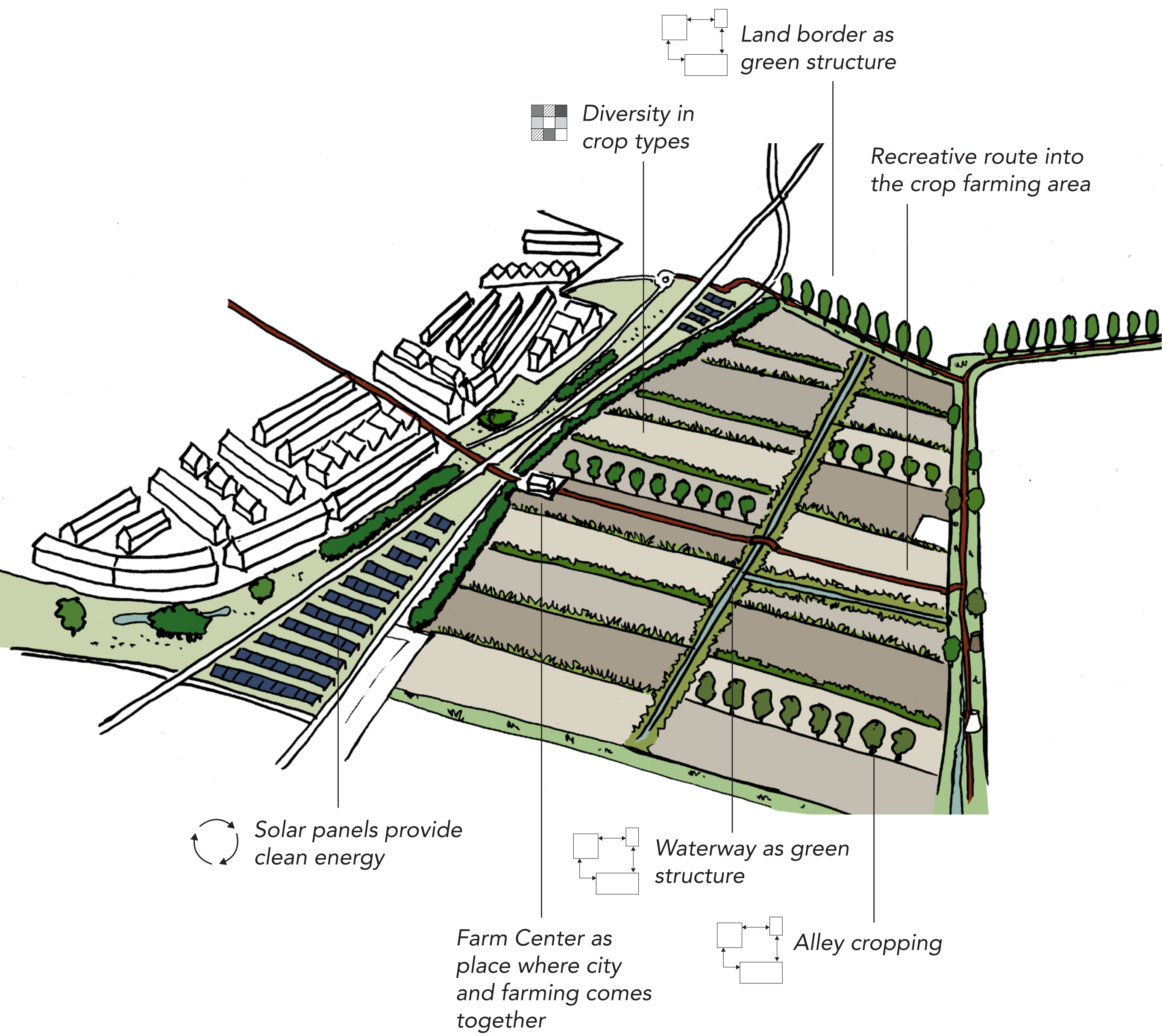
All the different elements; diversity, connectivity, circularity and social sustainability come together in the total plan on three different scales. Here, the three plans of the region, polder and farm are shown. To give a better idea of the coherence between the different layers, three elements of the plan are zoomed in on (location indicated with the red circles A, B & C).

The region



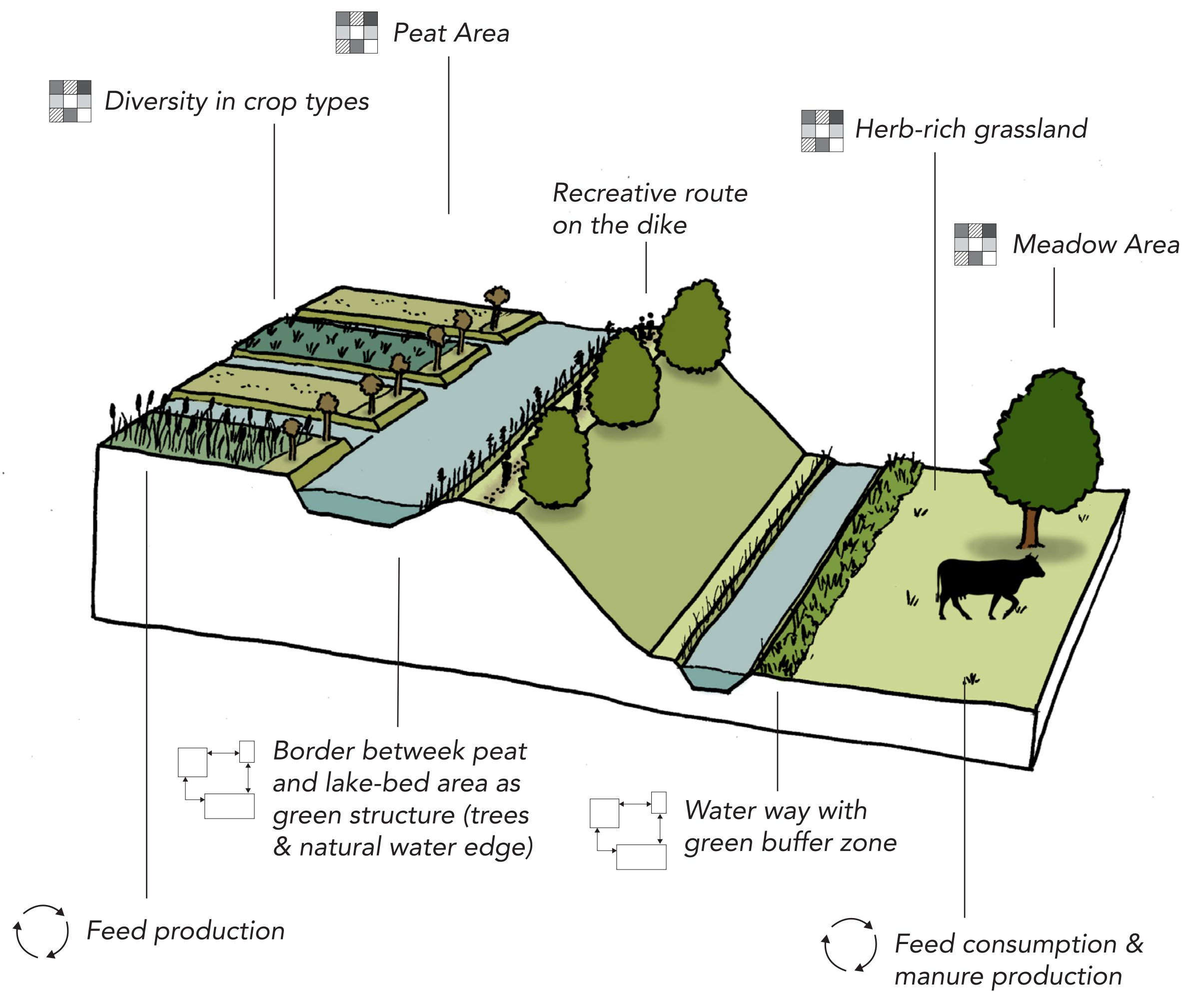
Element A: The city edge

This bird's eye view shows the east edge of Zoetermeer with the Farm Center as place of interaction between the city and the farming. This is the location where farmers bring their food and where citizens pick it up. It also forms the start for a recreative route into the polder, crossing the multiple new green structures.



Element B: The lake-bed border

The axonometry below shows the border between the peat polder on the left and the lake-bed polder on the right. The peat polder is used for paludiculture, the peaty clay on the other side of the dike for extensive livestock farming. The dike in between is not just a green structure, but also is part of a recreative route through the polders.



The polder

Crop farming

Dike as green structure

Land border

Food forest/grove

Water buffer area

Water

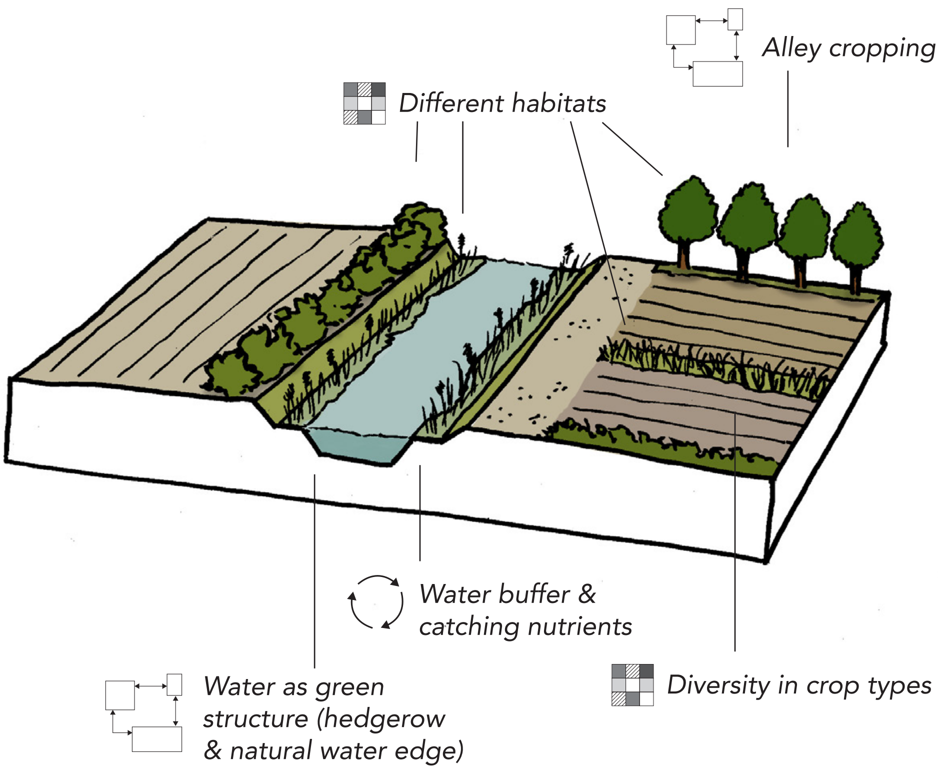
Farm Center

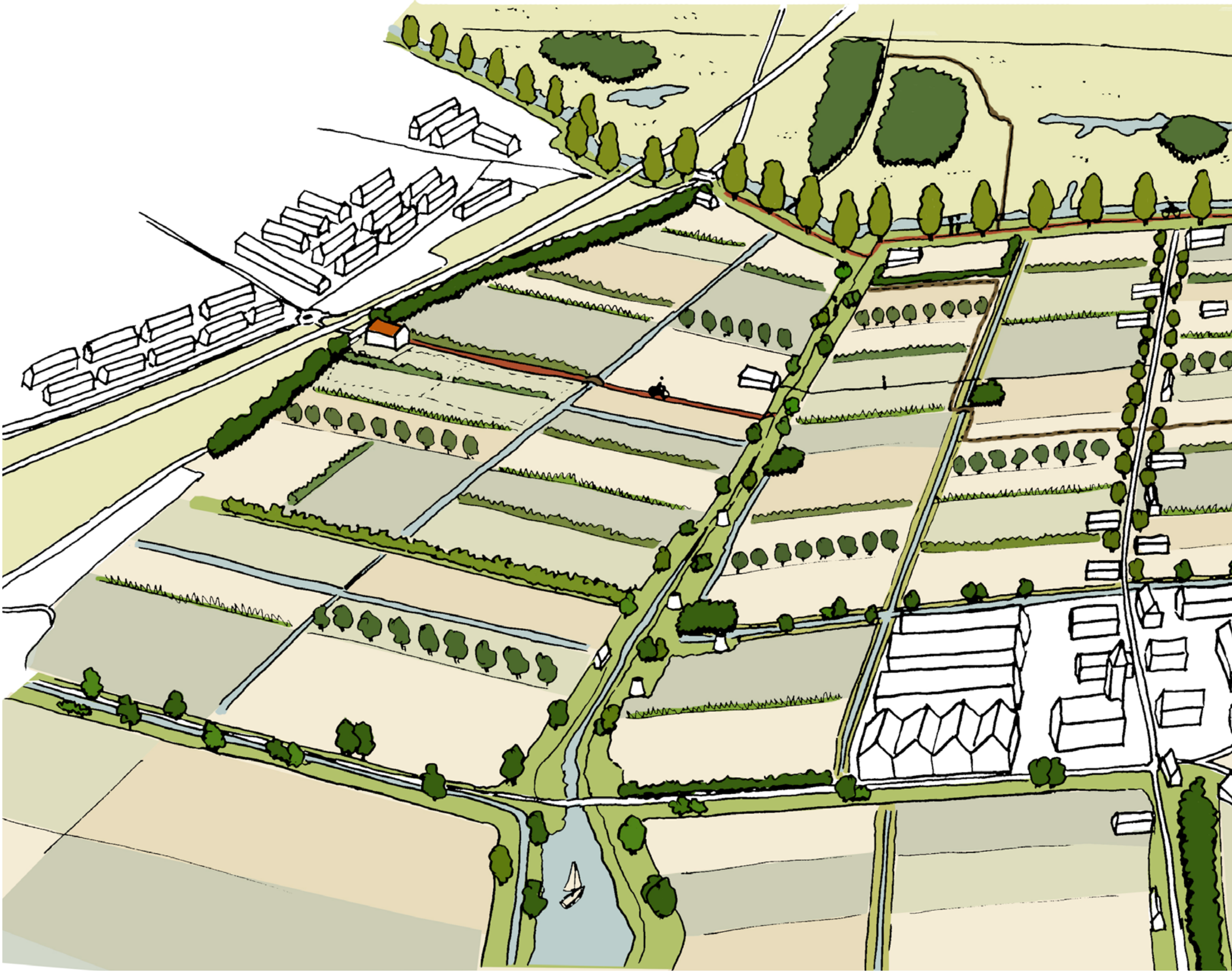
Cycle path

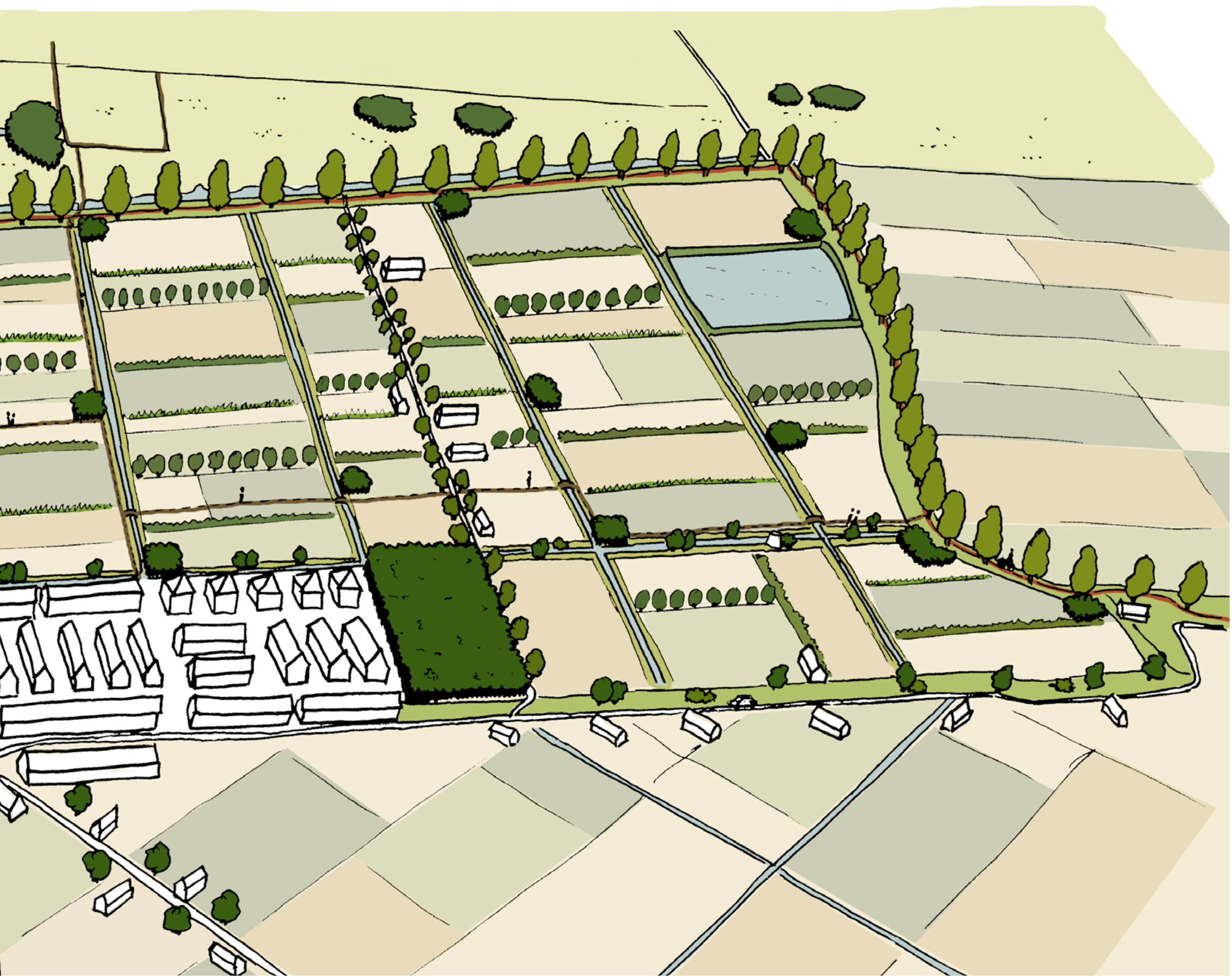
Pedestrian path

Element C: Water in the polder

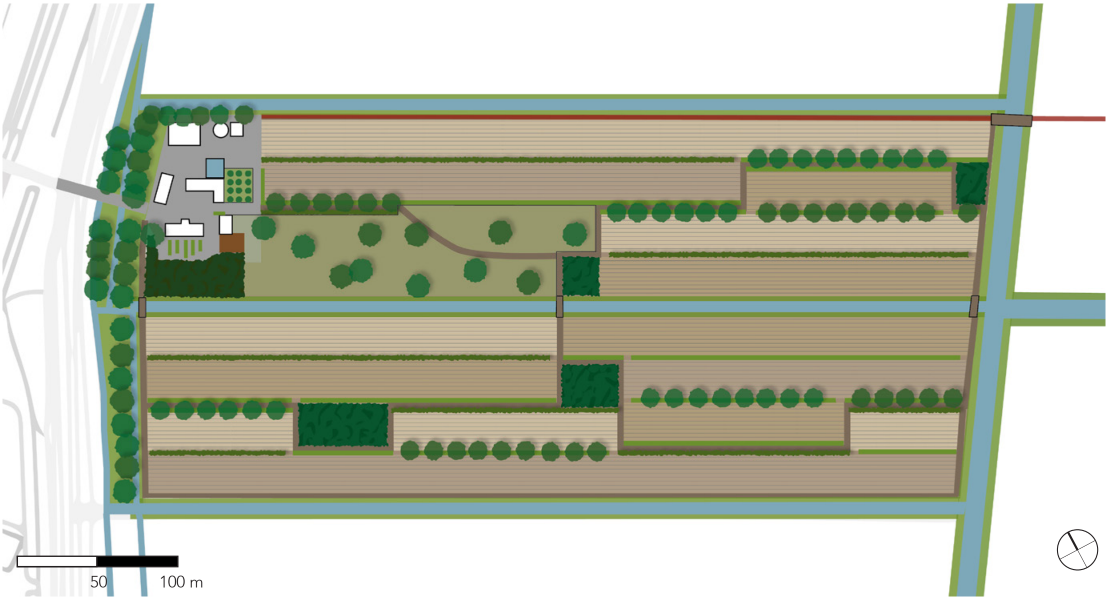
The figure shows a ditch in the middle of crop farming land. On this small scale, several elements come together. Connective green structures such as water edges and hedgerows contribute to diversity as well by creating new habitat types. The water edge itself supports a closed nutrient and water cycle in the polder.



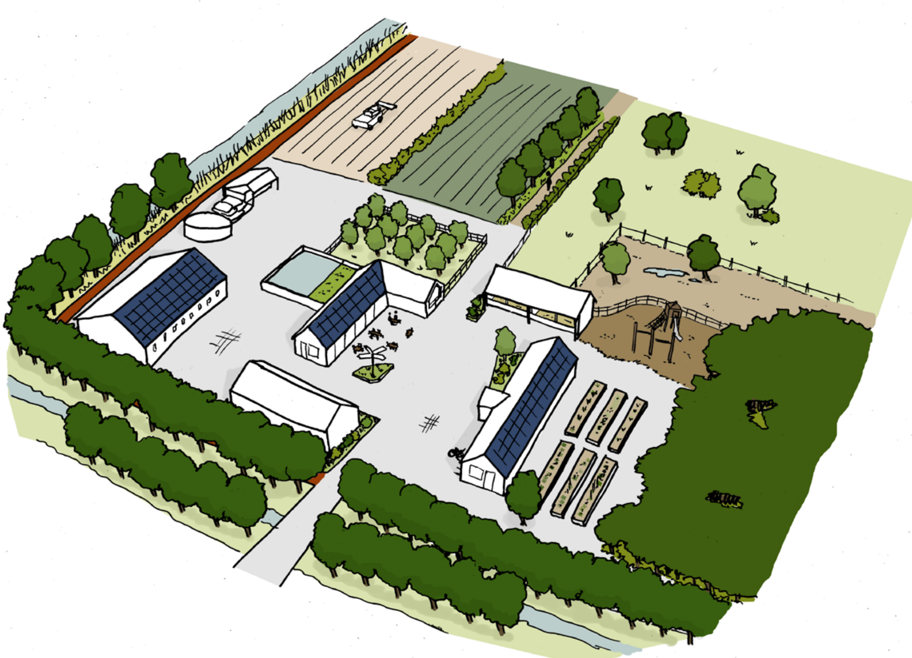




The farm



Arable land
Meadow
Grove
Food forest
Water (3)
Water (2)
Insect strip
Hedgerow
Tree line
Farm path
Cycle path



9. CONCLUSION & REFLECTION

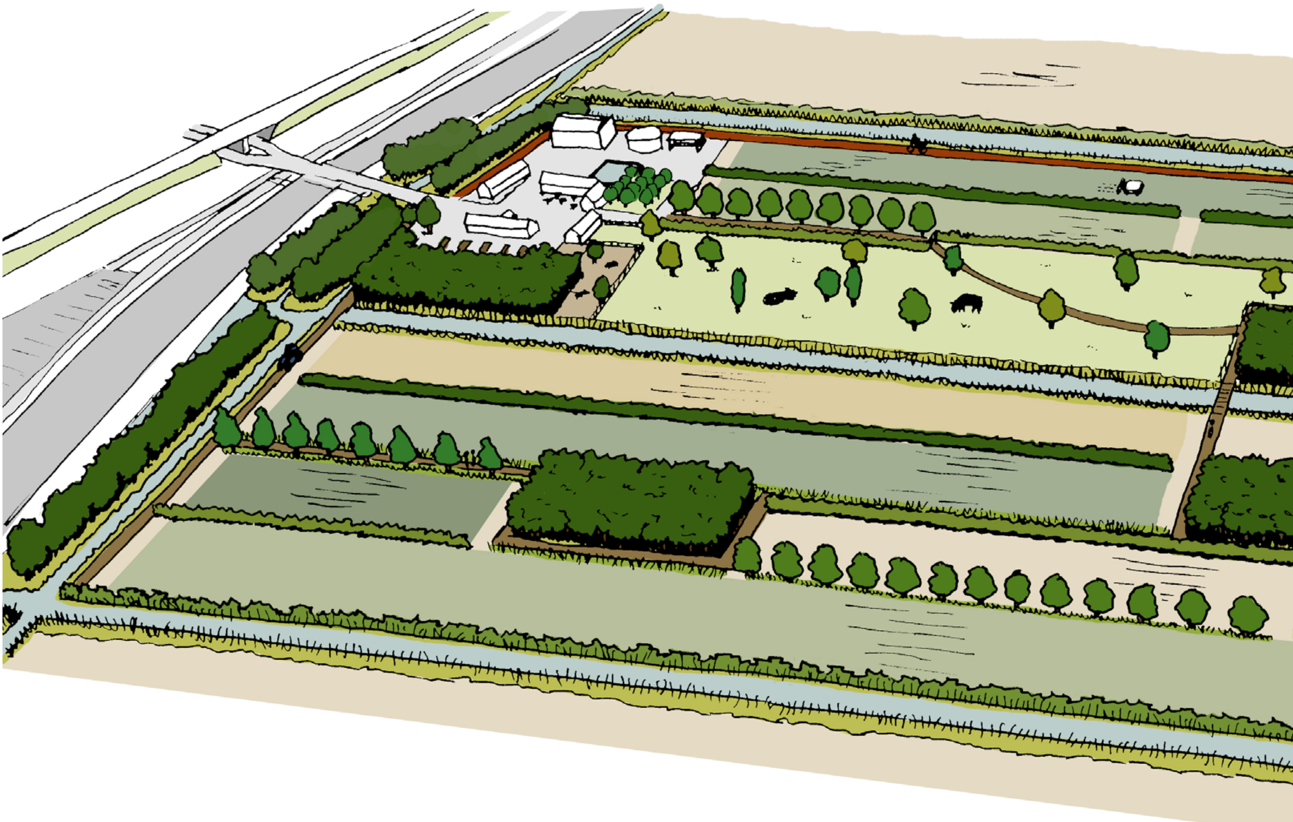
9.1 Conclusion

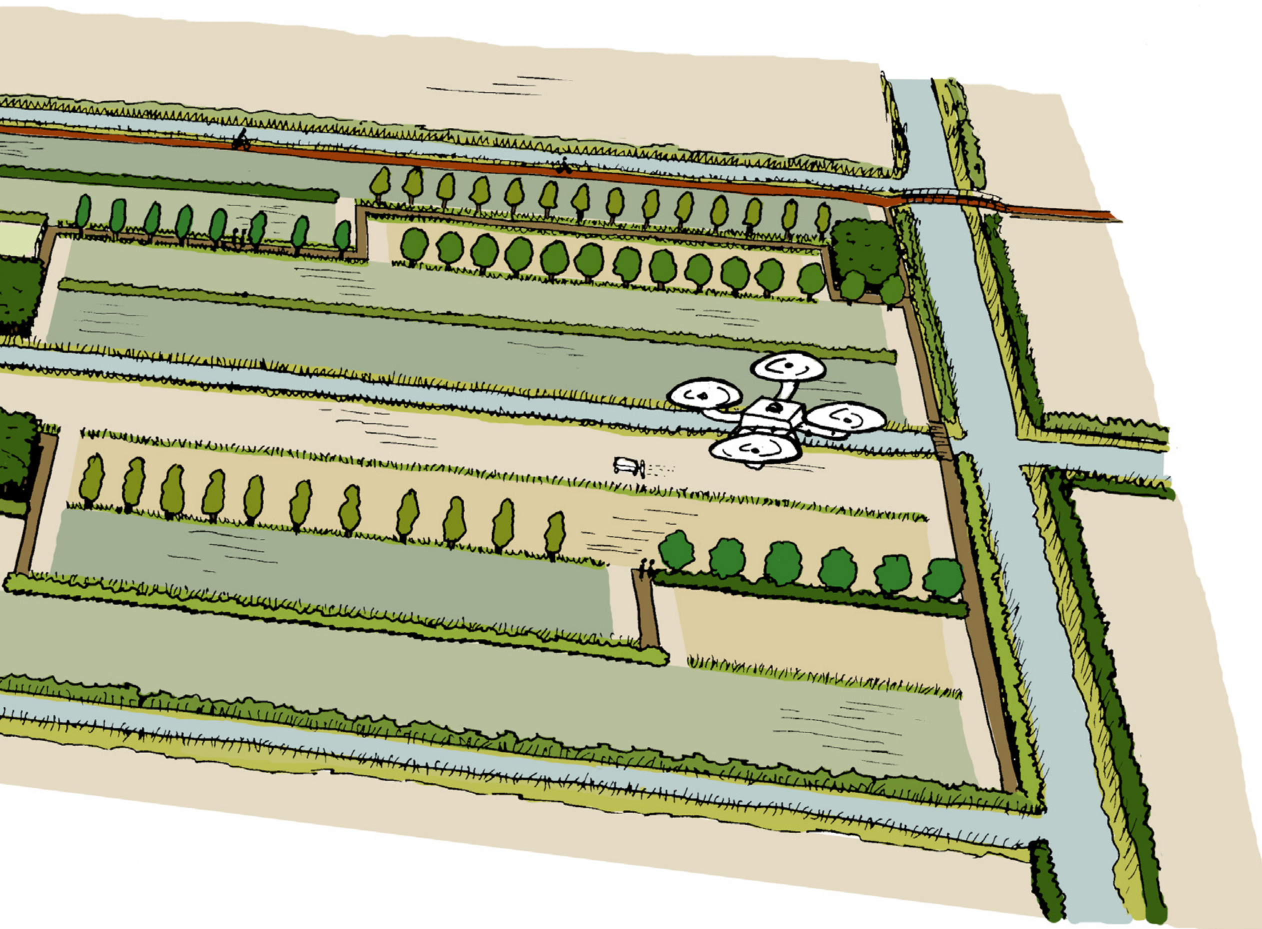
The main research question of the project was:
How to translate ecological agricultural principles into spatial solutions for the regional landscape to create a more sustainable farming landscape, using the area around Zoetermeer as a case study?

In the theoretical part of the report is shown that the relationship between agriculture and landscape is found between soil, sectors, land patterns and visual perception. If agriculture changes, the landscape changes as well. At the moment, a change to a more sustainable form of farming is needed. Agriculture has to do with ecological problems concerning greenhouse gas, nutrients, soil, water, climate change and biodiversity. Social-economic issues include the dependent farmer, feeding the world, the critical consumer, animal welfare and public health. The landscape is affected as well. Most of the ecological problems can be linked to certain areas and/or sectors.

One promising strategy to make agriculture more sustainable, is agroecology. To use this strategy for a spatial design, a list of concrete principles was generated as link between sustainable farming theory and concrete landscape applications. These principles all tackle certain ecological problems. The link between the two can be used to compile a toolbox of solving principles based on the specific problems of an area. On a higher conceptual level, an ecological landscape contains diversity, connectivity and circularity, of which the first two are found in the spatial design, and circularity in the working of the system.

Diversity on different scale levels is visible in area characters, different land uses or crop variety. Landscape structures that are suitable to form part of connectivity are dikes, water structures, and land patterns for alley cropping. These structures can be very well combined with social sustainability, to connect people to farming. The most important flows to look at in the circular farming system are nutrients, water and energy. All the aspects should be applied on different scale levels, like region, polder and farm level.





9.2 Reflection

The project in the context of Flowscapes studio and Landscape Architecture

The Flowscapes theme is being described as "exploring infrastructure as a type of landscape and landscape as a type of infrastructure." This relationship is reflected by the link between agriculture and the landscape in the project. Agriculture can be seen as a system, a space of flows. Flows of food, but also of water, nutrients and energy. Efficiency and productivity are central. However, it is connected to the landscape. This spatial-visual place consisting of fields, hedges, polders has a spatial appearance, but is intertwined with the flows of the agriculture.

In the project both these aspects are addressed. For example, in the analysis of the agricultural problems, both spatial and system aspects are shown in the used axonometries. The focus on the aspects diversity, connectivity and circularity also demonstrates the division in spatial design (diversity and connectivity – the scape) and system design (circularity – the flows).

Another description of 'Flowscapes' is as "operative landscape structures". The design of this project is two-sided. On the one hand, it can be seen as the resulted landscape, after the implementation of sustainable agriculture. However, more interesting, it can also be an operative structure, as not just the passive (spatial) result of agriculture, but having a positive effect on the agriculture as well. A landscape that supports and facilitates the processes of sustainable agriculture.

In the Master Guide of Landscape Architecture, four perspectives on the landscape are described: landscape as spatial-visual structure, landscape as palimpsest, landscape as scale-continuum and landscape as (ecological, economic and social) process. Although some perspectives might be more relevant than others, they are all included in the project. For example, in the analysis, the historical relationship between the landscape and agriculture is investigated, to understand the current agricultural landscape (landscape as palimpsest). The aspect of circularity elaborated in the project fits into the perspective of 'landscape as process'. It is about the flows of nutrients, energy and water in the agricultural system. The spatial design on the other hand, especially the aspect of visual perception is part of the spatial-visual structure. Finally, the link between the scales plays an important role in the project. Starting from the scale of the Netherlands, the projects ends up focussing on the main scales of the region, polder and farm, and their interrelationships.

Research and Design

The relationship between research and design is an interaction, consisting of "research-for-design" and "research-by-design". The research-for design part in this project investigates the relation between landscape and agriculture, the range of problems concerning agricultural sustainability and theory on sustainable agriculture. This served as input for the design phase, the case study of Zoetermeer. The ecological principles form the link between the theory and the design, as they are concrete elements that can be directly applied to the landscape. They derive from the theory on sustainable agriculture and are linked to the problem research. Together with the stated link between agriculture and landscape, these are used to generate the regional design. The design is a research in itself as well, since it is a way to investigate hów to design a sustainable agricultural landscape.

Reflection of the methodology

The method of the project can be split in two parts. The first part consists of general theory, that eventually leads to a toolbox of ecological principles. The second part is the case study of Zoetermeer, where the research and the toolbox is being used to design a sustainable agricultural landscape. The method connects the agriculture and landscape by showing a way to translate the sustainable solutions for agriculture to a spatial landscape. Together with the guiding principles of diversity, connectivity and circularity, a landscape on all scale levels can be created. Although here Zoetermeer is used as a test case, the same steps can be applied to any other location. A disadvantage of the method is that it provides a lot of input for the design, but how and where to apply the principles can still be a challenge, especially in large regions. Therefore in this project the whole region of Zoetermeer was firstly divided in different areas.

Another issue that occurred during data collection was the difficulty in obtaining data about the agricultural problems in the area. Information on pesticide use or water pollution in the region was unfindable, so for these problem categories assumptions were made based on the sector. The method focuses on the ecological problems and the ecological principles. However, it also included aspects as social sustainability and circularity. It adopts a holistic approach, and uses landscape architecture as a way to combine different layers and inputs from different fields. The strength of the project lies therefore in its generalism instead of specialism. The downside of this approach is that some elements might not be elaborated in depth.

Relevance

The project offers a perspective on how a landscape approach can help to make agriculture more sustainable. This is done by a toolbox of methods that translates agricultural problems of sustainability to spatial solutions for the landscape. As currently the emphasis of sustainable agriculture is at farm-level scale, or mainly focussed on one aspect of sustainability, this can be of societal relevance. This projects shows how the landscape can contribute to sustainability problems in agriculture on several aspects (both ecological and social-economic) and multiple scale levels (region, polder and farm).
Scientifically, agriculture is a topic not often researched in landscape architecture, even though the topics are strongly connected in the cultural landscape. The project shows a way to integrate landscape design and agriculture by linking problems, sectors, soil and ecological principles all together. It combines not only one, but several points of view on sustainability and sets it in the bigger context of the landscape-scale.

Ethical issues and dilemmas

Choosing ‘sustainable farming’ as a topic makes that some aspects needs to be considered because they counteract. One contrast is found in the world food demand and ecological sustainability. The world food demand is rising, it is said we need to feed 10 billion people in 2050. Therefore, we need to increase production and intensify our agriculture. Pesticides and chemical fertilizer might be necessary to ensure the food supply. This is often in contradiction with ecological farming, where a reduction of intensive agriculture is promoted, without any fertilizers or pesticides. As already mentioned in the report, ‘ecological intensification’ can be the middle ground between the two. Preferably without pesticides and chemical fertilizers, as in the end they will decrease the food production instead of ensuring it.

Animal welfare is another ethical dilemma when it comes to sustainability. Keeping animals inside a high-tech barn can actually be more sustainable and healthier for the people living around than outdoor livestock as it makes it possible to filter particulate matter, ammonia and methane out of the air, and separate manure flows. However, we do think the animals prefer it to be outside in their ‘natural environment’. In this dilemma, the choice for animal welfare was made because it fits best in an ecological vision. Reducing the emissions should be done by reducing the amount of livestock, instead of keeping the animals inside. When it comes to the particulate matter production of free-range chickens, it turns out chickens on grassland don’t contribute to the problem. A bit more effort and a large livestock reduction can therefore serve both sustainability and animal welfare.

Furthermore, food production is naturally connected to people. If you design a new agricultural landscape and make changes to the amount and type of food production, it involves both farmers and consumers. In the plan, the amount of livestock will heavily decrease. In practice, it is not possible to (directly) remove half of the cattle from the farmers. Farmers invested in large barns, and they need the high amount of livestock to gain enough income. To change from livestock farming to for example paludiculture is something that requires time and money. It also implies the change of people's diet to a more plant-based menu. However, can you force people to change their food habits? Or, if you don’t produce the meat yourself, will it be imported from abroad – not solving anything at all? The plan offers a viewpoint on how the future system can be, with more expensive but less meat and dairy products available. This will not have direct consequences for people’s dinner, but might stimulate them to slowly move to a more plant-based and regional diet.

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APPENDIX 1: GLOSSARY

A1.1 Landscape Architecture

Landscape
“Het uiterlijk beeld van een gebied op de schaal van enkele vierkante kilometers, dat zijn karakteristiek ontleent aan een unieke combinatie van elementen en patronen.” (Bobbink, 2004)

Landscape is defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000).

Landscapes are a human appreciation of landforms together with their assosciated ecology and cultural history. One crucial aspect of this socio-economic and ecological interaction is the agro-ecosystem. (Conway)

Urban landscape: The landscape of the city
Cultural landscape: Cultivated landscape, agriculture, farms, dikes
Natural landscape: The natural features of the landscape, before cultivation: geomorphology, soil, water and planting.

Urbanized landscape
A part of a city of housing area where the original (cultivated) landscape was used as a structure.

Ecology
The study of interactions between organisms and their environment.

Ecosystem
An community of living organisms in combination with the non-living, abiotic components of their environment, interacting as a system.

Genius Loci
The character, or soul of a place. Can be linked to many aspects, like cultural-historical, natural, spatial perception, etc.

Tabula rasa
Blank page, starting (with a design) from nothing, without considering the existing context and landscape.

Polder
An area where the water is managed. Types:
- **Reclamation polder (droogmakerij)**
  - **Lake-bed polder –** a former lake was turned into land
  - **Sea-bed polder** – a former part of the sea was turned into land
- **Peat polder (ontginning)** – a cultivated peat area, where ditches regulate the water
- **Indijking** – A part of new diked land that used to be water along the older land.

Palimpsest
Reused manuscript, meaning that it is 'layered'. The landscape has a long history of many functions and representations, which still exist as old layers.

Scale-continuum
The landscapes doesn't exist of different seperated scale-levels. Instead it is a scale-continuum: it goes gradually from small scale to large scale, the large scale including the small scales, and the small scale influenced by the large scale.

3 types of nature representations
If nature is made by humans, is it able to be 'natural'? Often it is a representation of nature. Three types of nature representation are distinguished:
- 1st nature: Wilderness
- 2nd nature: Lawn/meadow
- 3rd nature: Garden

A1.2 Agriculture (Dutch)

Agrarisch natuurbeheer / beheerlandbouw
Natuurbeheer op landbouwgronden uitgevoerd door boeren gecombineerd met de agrarische bedrijfsvoering. Dit is voor boeren vaak administratief voordelig, omdat het subsidies en voordelen in de mestboekhouding oplevert.

Beregening
Het sproeien van het land met water.

Bodemvruchtbaarheid
Het vermogen van de bodem om een plant van water en voedingsstoffen te voorzien.
Chemisch: Aanwezige minerale voedingsstoffen, zuurgraagd (pH) en kationenomwisselingscapaciteit (CEC)
Fysisch: Dichtheid bodem, grondwaterstand, luchthuishouding (voldoende zuurstof)
Biologisch: Gezond bodemleven (regenwormen, micro-organismen), goede vruchtwisseling

Bokashi
Een vorm van composten waarbij het organische afval wordt gefermenteerd.

Bouwvoor
De bovenste laag grond waarin wordt geteeld.

Brijn
Zout water dat ontstaat nadat aan opgepompt brak/zout water zoet water wordt onttrokken. Het zoute water (brijn) wordt terug de bodem in gebracht. Het zoete water wordt gebruikt voor glastuinbouw.

Coulisselandschap
Een coulisselandschap is een halfopen landschap dat door de beplanting en bebouwing het karakter van een toneel met coulissen heeft. Deze beplantingen bestaan vooral uit houtwallen en heggen.

Essen
Essen zijn grote aaneengesloten akkers die deels gemeenschappelijk gebruikt werden door boeren vanaf de Middeleeuwen. De benaming essen komt vooral voor op de Nederlandse zandgronden.

Gemeenschappelijk landbouw beleid (GLB)
De landen van de Europese Unie (EU) maken samen een Gemeenschappelijk landbouwbeleid (GLB). De EU-landen mogen hun eigen landbouwbeleid bepalen, binnen de grenzen van het GLB. Het GLB heeft 2 onderdelen: landbouwsubsidies en subsidies voor plattelandsontwikkeling.

Gemengde landbouw
Een bedrijf waar akkerbouw met veeteelt wordt gecombineerd. Oorspronkelijk kwam dit vooral voor op de zandgronden, waar veeteelt de akkerbouw ondersteunde. Met de komst van kunstmest ondersteunde akkerbouw de veeteelt. De opkomst van de intensieve veeteelt betekende de stop van het gemengde bedrijf.

Gewasbeschermingsmiddelen
Pesticide = Insect and pest killer
Herbacide = Weed killer

Grondgebonden landbouw
Bedrijf dat afhankelijk is van de aanwezige grond, dit kan zijn voor mestverwerking, productie van veevoer of grond voor plantenteelt.

Groenbemesting
Het telen van planten op een stuk grond om deze vervolgens onder te ploegen of te mulchen. Doelen:

- Percentage organische stof (humus) en stikstofgehalte in bodem te verhogen
- Als vanggewas voor opvang van meststoffen
- Helpen bodemstructuur te verbeteren

Intensieve en extensieve landbouw
Landbouw waarbij de boer een zo groot mogelijke opbrengst van zijn land wil halen door in verhouding tot de oppervlakte grond veel arbeid en kapitaal te gebruiken. Bij intensivering neemt het aantal productiemiddelen (arbeid, kapitaal) per hectare grond toe.

Gewoonlijk spreekt men van een 'extensieve landbouw' wanneer, in verhouding tot het volume arbeid en kapitaal dat wordt ingezet, een groot areaal wordt gebruikt. Andersom is van een intensieve landbouw sprake wanneer in verhouding tot de oppervlakte grond veel arbeid en kapitaal wordt aangewend. Beide begrippen 'intensief' en 'extensief' hebben bovendien geen absolute betekenis, maar slechts een relatieve, namelijk ten op zichte van elkaar. (Bieleman, 2008)

Intensiteitstheorie van Boserup:
Is grond in overvloed aanwezig, terwijl arbeid schaars (en dus duur) is, dan zal schaalvergroting en daarmee extensivering het dominante patroon in de landbouw worden. Is het omgekeerde het geval (veel arbeid, weinig grond), dan zal intensivering de meest voor de hand liggende strategie vormen. (Bieleman, 2008)

Kipper = Wagen met grote bak waarin oogst wordt gespoten. Rijdt vaak naast oogstwagen.

Landbouwgebied (LB)
Lokalisering van gemeenten per landbouwgebied. Groepering van gemeenten met (zoveel mogelijk) gelijksoortige typen van landbouwbedrijven. De indeling in landbouwgebieden is in 1991 door de Adviescommissie Landbouwstatistieken vastgesteld en valt binnen de provinciegrenzen. Nederland telt 66 landbouwgebieden.

Landbouwontwikkelingsgebieden (LOG)
Een gebied wat is toegeweven voor voornamelijk een agrarische functie. De intensieve veehouderij mag hier uitbreiden, hervestigen en nieuwvestigen.

Mest
Gier (Beer) = Vloeibare mest. Vooral urine
Drijfmest = Mengsel van vaste mest en gier.
Stalmest = Mengsel van vaste mest, urine en stro.

Poten = in de grond stoppen
Rooien = uit de grond halen

Reconstructiewet 2002
Op 1 april 2002 is de Reconstructiewet concentratiegebieden in werking getreden. Daardoor komen instrumenten beschikbaar voor een voortvarende herinrichting van het landelijk gebied in vijf provincies: Limburg, Brabant, Utrecht, Gelderland en Overijssel. De wet voorziet in een integrale en planmatige aanpak van de problemen in de concentratiegebieden van de Intensieve veehouderij. (Rijksoverheid) Onderdeel hiervan is de toekenning van landbouwontwikkelingsgebieden.

Schaalvergroting
Groei van het bedrijf door toename in hoeveelheid grond of hoeveelheid dieren om de productie te vergroten.

Scheuren grasland
Bij het scheuren van grasland wordt het gras machinaal kapot gereden, waarbij de bodem open komt te liggen. Dit wordt gedaan om beschadigde graszoden te herstellen door opnieuw in te zaaien.

'Sitopia'
Food place

Stallen
Potstal: Stal waarin de mest wordt opgepot. De stalvloer wordt steeds opgehoogd met een nieuwe laag stro.
Ligboxstal (loopstal): Koeienstal waar koeien vrij kunnen lopen, en de mogelijkheid tot eigen lixbox hebben. De mest valt door roosters.

Tiendwegen
Tiendwegen zijn polderwegen als verbinding tussen bouw- en weilanden en de boerderijen. Tiendwegen zijn ontstaan als karrenpaden en lopen evenwijdig aan de ontginningsbasis van een polder. Ze staan haaks op de langgerekte kavels. Tiendwegen volgen, niet als bijvoorbeeld houtkaden, precies de loop van de ontginningsbasis. Ze lopen zo recht mogelijk. Aan weerszijden van een tiendweg ligt de tiendwetering, waardoor de polder ontwaterd wordt. De oevers van de tiendwetering werden verstevigd met houtig gewas dat regelmatig wordtt afgezet. We zien els, wilg en knotessen. (Landschap in Nederland)

Vanggewassen
Vanggewassen worden geteeld om de uitspoeling van meststoffen tegen te gaan. Deze planten worden gezaaid na de oogst van het hoofdgewas. Ook kunnen vanggewassen worden ingezet om de verwaaien van gewasbeschermingsmiddelen tegen te gaan, zoals een windscherm rondom een akker.

A1.3 List English – Dutch

Cogeneration plant / CHP	WKK-installatie
Cultivate	Ontginnen
Fertilizer	Kunstmest
Lake-bed polder	Droogmakerij
Land pattern	Verkavelingspatroon
Leaching	Uitspoeling
Manure	Dierlijke mest
Overfertilization	Overbemesting
Parcel	Kavel
Reallotment	Ruilverkaveling
Rumen fermentation	Pensfermentatie
Scale enlargment	Schaalvergroting
Thermal energy storage	WKO-installatie
Yield	Oogst
Eutrophication	Vermesting/eutrofiëring
Acidification	Verzuring
Salinization	Verzilting

Intensive livestock farming	Intensieve veehouderij
Land-based livestock farming	Grondgebonden veehouderij
Crop farming	Akkerbouw
Outdoor horticulture	Vollegrondstuinbouw
Greenhouse horticulture	Glastuinbouw

APPENDIX 2: LINKING PROBLEMS & PRINCIPLES

Greenhouse gas

Subproblem	Solution	Type*	Extra explanation
Import animal feed, transport	Produce animal feed in own country	S	
Import animal feed, transport, manure emissions	Land-based livestock farming	S	
Transport	Shortening transport lines, local/regional network	S	
Cow & manure emissions	Decreasing amount of livestock (esp. cows)	S	
Fertilizer production	Use (processed) organic manure instead of chemical fertilizer	S	
Manure emissions	Water buffer zones (prevent leaching)	P	Prevents indirect formation of N_2O by leaching of N in the water
Manure emissions	Methane collection, manure processing	T	
Energy & heating	Use renewable energy: solar, wind, biomass or geothermal.	T	
Energy & heating	Use methane from manure as city heating source	T	
Energy & heating	Greenhouse as energy source	T	
Soil subsidence	Heighten water tables	S	
CO_2 soil emissions	Conservation tillage	S/P	
Compensation	CO_2 emissions compensation with planting of trees and perennials	S/P	

* A solution can be a general or system solution (S), an ecological principle (P) or technological solution (T)

Nutrients

Subproblem	Solution	Type*	Extra explanation
Manure surplus, emissions	Decrease amount of livestock	S	
Manure emissions	Cover manure storage, adapted ways of applying manure on the land, adapted stables (NH3)	T	
Manure emissions	Collecting methane at manure storage	T	
Manure surplus, emissions	Manure processing/using it for other functions	T	
Use of manure & fertilizer	Green manure, nitrogen fixing plants, compost	P	
Fertilizer production, depletion of nutrients	Use (processed) organic manure instead of chemical fertilizer	S	
Depletion of nutrients	Recycling P & N out of drainage/waste water	T	
Pollution of soil & water	Measures in manure spreading (solid manure, not along water sides)	S	
Pollution of soil & water	Water buffer zones	P	Prevent leaching into surface water
Pollution of soil & water	Catch crops	P	Take up suplus of nutrients, catching pesticide drift
Pollution of soil & water	Paludiculture	P	Filtering water

Soil

Subproblem	Solution	Type*	Extra explanation
Organic soil quality (soil life)	Stop of decrease use pesticides	S	
Physical soil quality	Conservation tillage	S	
Physical soil quality	Less heavy agromachinery/pressure distribution	S	
Soil quality	Polyculture, more diverse landuse	S/P	More pest-resiliency
Soil quality	Perennial crops	P	
Soil quality	Agroforestry: Alley cropping, Silvopasture, Food forests	P	
Soil quality, soil erosion	Intercropping & Strip cropping	P	
Soil quality	Less chemical fertilizer, more compost and green manure	S/P	Compost improves soil structure & water retention capacity, improves soil life, chemical quality
Soil quality	Cover crop, green manure, compost	P	
Soil quality	Fallows	S	
Soil quality, soil erosion	Crop rotation	S	
Soil erosion	Cover crop, terraces (with slope), perennial crops	P	
Soil erosion	Windbreaks, hedgerows	P	
Soil erosion	Conservation tillage, contour tillage	S	
Soil subsidence	Paludicultuur	P	
Soil subsidence	Highering water tables	S	

Water

Subproblem	Solution	Type*	Extra explanation
Water level: nature vs agriculture	Function follows water table (instead of the other way around), finding balance between nature and farming.	S	
Soil subsidence	Keeping the water tables in peat areas high enough to prevent further soil subsidence	S	
Use of sweet water	Circular water use: own rainwater collection	S	
Use of sweet water	Use surface water for livestock drinking	S	
Use of sweet water	Increase the water buffer capacity of the soil by improving the organic soil quality (organic manure, green manure, cover crops) and physical soil quality (no heavy machinery, no-tillage).	P/S	
Use of sweet water	Drip irrigation instead of sprinklers (water saving, less evaporation)	T	
Use of sweet water	Rainwater harvesting	S	
Water retention / Drought-resistence	Herbal-rich grassland, trees (agroforestry)	P	
Water retention capacity	Water buffer zone, riparian corridor, sedimentation ditch	P	
Water retention capacity	Cover crop, green manure	P	
Water retention capacity	Conservation tillage	S/P	
Water pollution	Water buffer zone, riparian corridor, sedimentation ditch	P	
Water pollution	Catch crops	P	

Climate change

Subproblem	Solution	Type*	Extra explanation
Extreme weather events, salinization, warmer climate	Adjusted crop types (warm, wet, dry, salt tolerant)	S/P	
Extreme weather events	Rainwater harvesting and buffering	S	
Extreme weather events	Keeping / buffering water	S	

Biodiversity

Subproblem	Solution	Type*	Extra explanation
Monofunctional landuse	More diverse land use (prevent monofunctionality)	S/P	
Habitat aantasting	Mowing management for meadow birds (specific for meadow birds)	S	
Diversity increase	Herbal rich perennial grassland	P	Increasing species diversity
Diversity increase, pest resiliency	Alley cropping	P	Trees function as habitat, can habit natural pest fighters
Diversity increase	Silvopasture, food forest	P	
Diversity, habitat providing	Refuge sites	P	
Diversity, habitat providing	Field margins (in general. Hedgerows, insect strips, etc)	P	
Diversity, habitat providing	Riparian corridors	P	
Fragmentation of landscape	Connecting nature areas (prevent fragmentation)	S/P	
Pesticides & herbacides	Catch crops	P	
Pesticides & herbacides	Stop of decrease use pesticides	S	
Pest resiliency	Integrated pest management: increase pest resiliency & provide habitat pest fighters	S	
Pest resiliency	Intercropping & strip cropping	P	
Pest resiliency	Cover crop, crop rotation	P	Controls weeds
Habitat pest fighters	Nature reserves, refuge sites, field margins, esp. Insect strips	P	Habitat for pest fighters

The 'how' behind the problem-principle link
This text is an addition to the table where the solving principles from chapter 6 are linked to the (sub) problems of chapter 5. However, what misses is the 'how' of the story. How does the use of cover crops tackles the water problem? How do insect strips improve biodiversity? As all these ecological problems are very much related to each other, this isn't always as straightforward. For example:

- Improving organic and physical soil quality leads to improved soil moisture retention
- Healthier soil leads to better biodiversity, better pest resiliency
- Improved soil moisture retention leads to decrease water-run off, so decrease of the water pollution.
- Improved soil moisture retention leads to less water use
- Less use of manure and fertilizer leads to less water pollution
- Decrease water pollution leads to better biodiversity

Problems are <u>underlined,</u> principles are in *cursive*, and the linking strategies to solve the problem are shown in **bold**.

Greenhouse gases & nutrients
Decreasing the emission of greenhouse gases can be done in many ways, as there are many different causes for the emissions. First of all, the use of fossil fuels should be reduced, for example by shortening transport lines or making them unnecessary:

Produce cattle feed in own country, land-based livestock farming, regional/local food network

Furthermore, fossil fuels can often be replaced by renewable energy sources:

Solar-, wind-, geothermal energy, biomass, fermentation, methane for city heating, greenhouse as energy source

Many of the problems are linked to the livestock farming and the use of manure. *Reducing the amount of livestock (especially cows)* contributes both directly (rumen fermentation) and indirectly (manure emissions) to less emissions. *Replacing chemical fertilizer* saves the energy from this production process. It can be replaced by processing organic manure, or even better:

Use alternatives as green manure (especially nitrogen fixing plants), compost, bokashi

The manure emissions are mostly tackled by technological solutions, like:

Covering manure storages, collecting methane at storage, manure processing, water buffer zones

Replacing chemical fertilizer by manure also prevents the depletion of nutrients. Other ways are:

Recycling nutrients out of waste water, processing organic manure

Greenhouse gases from the soil can be prevented by:

Heigtening water tables (soil subsidence) + Paludiculture, conservation tillage

Finally, it is also possible to compensate the emissions by *planting perennial plants*, like trees.

Soil degradation
Tackling soil degredation works at three aspects: organical (decrease soil life), physical (soil compaction) and chemical (decline amount of nutrients).

<u>Soil compaction:</u>	*Conservation tillage, use of lighter machinery*
<u>Soil life:</u>	*Stop use pesticides & herbacides*
<u>Other general:</u>	*Polyculture, Intercropping, Strip cropping, Perennial crops, Agroforestry: Alley cropping/Silvopasture/Food forests, Herbal-rich grassland, Green manure, Compost, Crop rotation, Fallows, Cover crop*
<u>Soil erosion:</u>	*Cover crop, terraces, perennial crops, windbreaks, hedgerows, conservation & contour tillage*

Water

The water retention capacity is the amount of water that can be hold in an area until it needs to be put away. This can be done by **increasing the soil moisture retention**, the ability of the soil to take up water. Measures that increase the organic & physical soil quality, automatically help to improve the soil moisture retention. Water can furthermore be encouraged to be infiltrated in the soil (instead of running of to the surface water) with measures **preventing or delaying run-off and evaporation**, like:

> *Cover crop (evaporation), Green manure (evaporation), Water buffer zone, Riparian corridor, Sedimentation ditch.*

<u>Water pollution</u>

Preventing runoff and **improving soil moisture retention** also helps to prevent nutrient loading in the surface water, and therefore surface water pollution. All the measures that reduce the amount of manure used contribute to this as well:

> *Water buffer zone, Riparian corridor, Sedimentation ditch, Measures spreading the manure, Catch crops, (paludicultuur)*

<u>Water use</u>

If more water is taken up by the soil, less water is needed for irrigation. The water use can be further declined by:

> *Rainwater harvesting, Using surface water for drenking, (Drip irrigation)*

A better soil water retention and harvesting rainwater makes the field less susceptible for extreme weather events in climate change.

Biodiversity

Biodiversity can be adressed directly, by **increasing the diversity** in agriculture (e.g. by adding more trees and hedges) and by **providing habitats** for plants and animals. (these two often work together: providing habitat increases the diversity and increasing the diversity provides new habitat.)

> *Divers landuse, Herbal-rich grassland, Alley cropping, Silvopasture, Food forest, Nature areas, Refuge sites, Field margins, Riparian corridors*

Indirectly, the biodiversity can be addressed by **tackling its causes.**

Fragmentation:	*Landscape connectivity*
Acidification:	*Nitrogen fixing plants (?), decrease manure*
Use of pesticides:	*Catch crops (adaptation), decrease or stop use of pesticides (mitigation)*

However, to be able to decrease the use of pesticdes, herbacides and insecticides, we should make sure their are other ways to fight the pests and unwanted insects. This is called **Integrated Pest Management**. It exists of providing habitat for natural pest fighters (like birds) and by improving the resiliency of the plant.

Habitat pest fighters:	*Nature reserves, Refuge sites, Field margins, especially Insect strips*
Pest resiliency:	*Intercropping, Strip cropping, Cover crop, crop rotation*

APPENDIX 3: PROBLEMS AND PRINCIPLES SORTED BY THE 5 AREAS

Peat polders

Problem	Relevance	Solution
Soil subsidence	High	Function follows water level, Highering water tables, Paludicultuur, Carr (Broekbos), water buffering, other cow species on wet grassland, Aquacultuur
Phosphate saturation		Less cows

Lake-bed polders

Problem	Relevance	Solution
Salt seepage	High	Heighten water level, flushing with sweet water, salt (tolerant) crops
Use of sweet water		Improve soil water retention (soil quality), prevent evaporation (cover crop), delay run-off (water buffer zone, riparian corridor, sedimentation ditch), rainwater harvesting, use surface water for drinking cattle
(draining) Extreme rainfall	High	Rainwater harvesting, water buffer areas, more surface water, improve soil structure, delay run-off (water buffer zone, riparian corridor, sedimentation ditch)

Crop farming

Problem	Relevance	Solution
Manure & fertilzer use, N2O emissions		Compost, green manure, catch crops, bufferzones along water
Use of pesticides and fertilizer		Catch crops, Integrated pest management (intercropping, strip cropping, crop rotation, cover crop, nature reserves, refuge sites, insect strips), use (green) manure, compost, nitrogen fixing plants
Surface water pollution		Water buffer zone, riparian corridor, sedimentation ditch, catch crops, paludicultuur (purifying)
Landscape fragmentation	High	Clustering. Landscape connectivity, structure, zoning.
Land hunger	High	(Spatially) reserve areas for agriculture, integrate agriculture

Extensive livestock farming

Problem	Relevance	Solution
Cows and manure production (CH4)		Less cows. Manure processing
Import veevoer	Low	Eigen veevoer produceren, grasgevoerd

Greenhouse horticulture

Problem	Relevance	Solution
CO2 emissions		Solar-, wind- or geothermal energy, use methane or manure as energy source, use residual warmth, exchange with Snowworld, circular system.
Fertilzer use, N2O emissions		Compost, bufferzones along surface water where run-off goes through
Use of pesticides		Decrease use pesticides by integrated pest management. Diversity in crops. Insect plants around greenhouses? Closed system.
Landscape fragmentation		Clustering greenhouses.
Use of sweet water		Creating more usable surface water. Circular system with collection, filtration & reuse of run-off and evaporation water. Rainwater harvesting.
Extreme rainfall		More surface water, less paved surface. Rainwater buffer zones. Floating greenhouses? Aquaponics?
Extreme hail events		-
Light pollution		Shutting down light at night, use of screens
Landscape compaction	High	Concentration of greenhouses, view lines through greenhouse area (visual connection with landscape), using landscape as ecological structure.

All areas

Problem	Relevance	Solution
Transport emissions		Shorter transport links (regional network), bio fuel, electric machinery
Monofunctional land use (low biodiversity)	High	Landscape diversity, polyculture, agroforestry (alley cropping, silvopasture, food forest), herbal-rich grassland, field margins, riparian corridors, hedges
Dry land (low water level)		Heighten water level. Wet nature areas.
Lack of sweet water/drought stress	High	Improve soil water retention (soil quality), prevent evaporation (cover crop), delay run-off (water buffer zone, riparian corridor, sedimentation ditch), rainwater harvesting, drought tolerant plants