Animal Farming in Flourishing Foodscapes and Thoughtscapes

--- Sustainable, nature-inclusive animal farming with attractive recreational qualities in Den Bosch region, Noord Brabant

Author: (Jessica) Xulingyun Ji

COLOPHON

Animal Farming in Flourishing Foodscapes and Thoughtscapes
Sustainable, nature-inclusive animal farming with attractive recreational qualities in Den Bosch region, Noord Brabant

Xulingyun Ji
5344050

Delft University of Technology
Faculty of Architecture and the Built Environment
Landscape architecture track
Studio Urban Ecology and Ecocities

First mentor: Dr.ir. Nico Tillie- Landscape architecture
Second mentor: Dr.ir. Remon Rooij- Spatial planning and strategy

29/08/2022
Delft, Netherlands

All images, graphics, diagrams are by the authours unless otherwise mentioned.
Source for all maps: Google map, Open street map
Sources for additional data are mentioned aside the maps

PREFACE

This report explores the topic of ‘Animal Farming in Flourishing Foodscapes and Thoughtscapes’. Having always been fascinated by knowing more about animals, this report puts the focus on the food animals which are the most familiar but also most unfamiliar for human beings. Food animals are very important to humans because of the high-protein products they provide for humans. However, the current intensive animal farming is making people disconnected from the live food animals, most animal products are already accessed by the food factories before they are exposed to humans. Therefore, the reestablishment of the connection between consumers and live food animals is necessary.

This project roots in creating sustainable, nature-inclusive animal farming with attractive recreational qualities in Den Bosch region, Noord Brabant in order to deal with the problems of current intensive animal farming from 4 main aspects: increase ecological value, improve animal welfare, create recreational foodscapes and thoughtscapes and create climate-adaptive animal farming landscapes. Through site analysis, site visit, literature review, design explorations… a proposal for creating flourishing animal farming foodscapes and thoughtscapes is achieved which aims to provide stepping stones for animal farming related landscape architecture globally.

In addition, I have the opportunity to review and conduct what I have learned at Tu Delft and I enjoyed doing this graduation project a lot. I would like to thank my mentors, Nico and Remon, for helping me find and adjust my directions and thesis setup for the graduation project. I would say this report is an effort of three people. I also want to thank the girls from the Urban Ecology Lab, without their company, this year won’t have so many wonderful memories. Finally, I want to thank my family and friends for their support throughout the whole year.

August, 2022

CONTENTS

ABSTRACT

Animal farming is increasingly getting more attention and debate nowadays because of a lot of environmental issues it caused. Apart from that, the intensive animal factories have made consumers quite separated from food animals. What's more, the animal welfare in current animal farming is not ensured, especially in those intensive animal factories which are always capital-dominated.

As the world's second-biggest agricultural exporter, the Netherlands is characterized by its intensive farming. Noord Brabant is one of the most important agricultural provinces in the Netherlands with a huge number of animals. The study area Den Bosch region in Noord Brabant has a lot of intensive animal farmlands and factories. These existing intensive animal farms have a high demand to be improved in order to reduce the environmental issues in Den Bosch region. Together with the natural, historical and cultural resources of Den Bosch, there is great potential to create flourishing animal farming landscapes and thoughtscapes in Den Bosch region.

Therefore, the main research question of this report is exploring 'How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in Den Bosch region?'

Four objectives of building up sustainable, nature-inclusive animal farming landscapes are promoted in this report which include: Improving the ecological value of animal farming; Improving animal welfare; Creating recreational foodscapes of animal farming; Creating climate-adaptive animal farming landscapes. Design principles have been researched and concluded based on these four objectives. While the design principles are adjusted when applied on the design sites to be more suitable for the specific local context. Three sites are selected in different contexts of the city locate respectively in a natural area, suburban area, and urban area to explore the roles of different city contexts played in animal farming. The relationship between animal farming and nature also has been explored through design exploration in three selected sites.

The outcome of this report aims to provide people with a set of possibilities for improving current animal farming spatially, environmentally, and socially by creating flourishing animal farming foodscapes and thoughtscapes.

Keywords: *Animal farming, Husbandry, Agriculture, Foodscapes, Animal welfare, Landscape architecture*

CHAPTER 1: INTRODUCTION

This chapter starts with reasons for exploring the topic field 'Animal Farming' for this project from personal, scientific and social perspectives. It then introduces the study area: Den Bosch region in Noord Brabant. The chapter elaborates more on the problems of current intensive animal farming in Den Bosch region environmentally, socially and spatially. At the end of this chapter, the main design assignments and research questions are achieved as the starting point of the project.

Personal fascination

Personally, animals always intrigue me a lot as different creatures from human beings but still have similar spirits, emotions, individualities and even social structures as human society. There is a type of animal that is very tight related to our daily life but we do not even pay any attention to their lives and living conditions. Nowadays intensive animal farming has made food animals quite alienated from us, the little contact we have with food animals is the processed animal products in the market (Figure 1.1). What are the real living conditions of food animals? This question always bothers me a lot. Therefore, that's why I want to explore the field of animal farming.

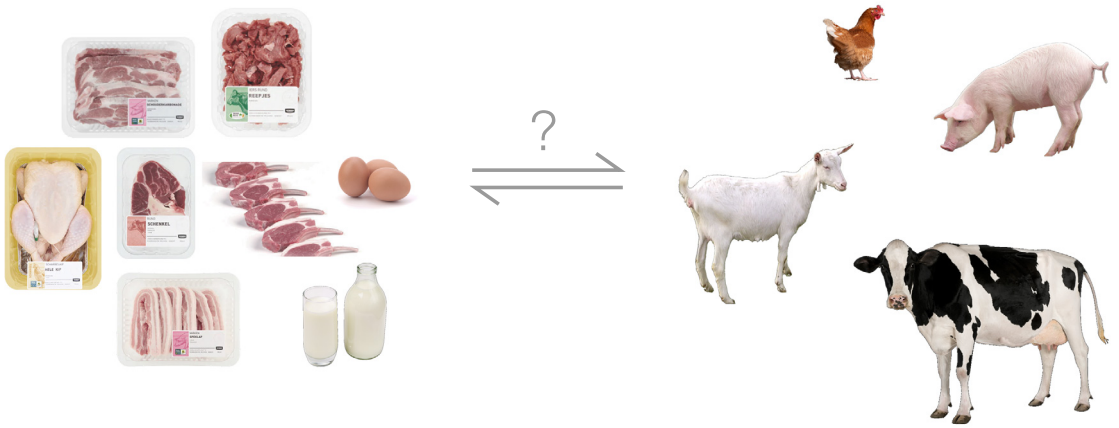


Figure 1.1 *Alienated food animals (adapted from Jumbo.com & pngimg.com)*

Scientific field

Foodscapes are drawing a lot of attention and interest because of the urgent food issues globally. However, current foodscapes are more concerned about plant-based production than animal-product-based production. Plant-based urban farms and community gardens have experienced significant growth within developed nations in recent years, in both scholarship and practice, however, the design and implementation of integrated grazing lands within the urban zone have been largely left out. (Davis, 2021) The animal-product-based production is also causing a lot of serious problems. Therefore, I want to explore more about animal-product-based foodscapes to try to expand the current scope of foodscapes (Figure 1.2).

Societal field

From societal perspective, current intensive animal farming has already caused a lot of problems, my graduation work tries to improve current animal farming to create a better environment for animals and people.

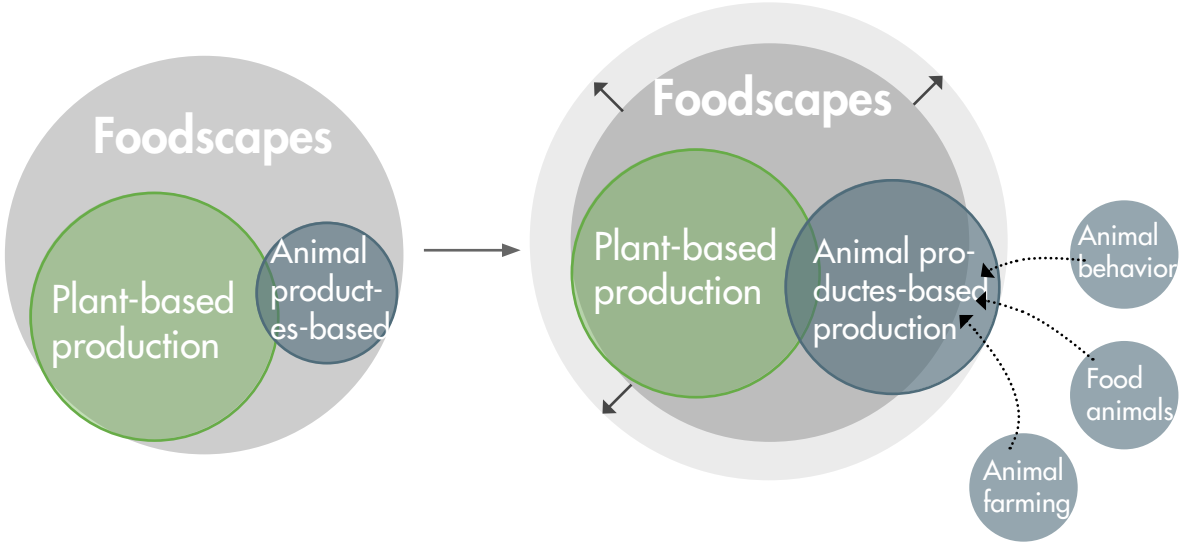


Figure 1.2 *Expansion on scientific field (made by author)*

Study Area: Den Bosch Region in Noord Brabant

Under 'The Nitrogen Approach Programme' (PAS), which is a policy framework of the Dutch government concerning the protection of nature reserves of the European Natura 2000 program. In the period up to 1 January 2022, Noord Brabant wants to guide 40 traditional agricultural companies in land-based livestock farming in the further development toward nature-inclusive agriculture outside the nature network. The province encourages that land within the NNB, where this can be combined with nature objectives, also become part of nature-inclusive management. (Province Noord Brabant, 2022)

Noord Brabant has a huge amount of food animals (Figure 1.3), it is the province with the most chickens (25.6 million), pigs (5.9 million) and goats (172,000), and the most cattle (631,600 after Gelderland). (Brabantse milieufederatie, 2014). When comparing the average stock density of Noord Brabant with Netherland, the stock density in Noord Brabant is higher than the average level of the Netherlands, especially the density of chickens and pigs (Figure 1.4).

Den Bosch is the capital city of Noord Brabant, which sits in the south of 'Maas River' in the transition zone between river clay soil and sandy soil (Figure 1.5). It is also one of the 14 cities that has the highest priority under the assignment of Staatsbosbeheer to improve the quality of life for people.

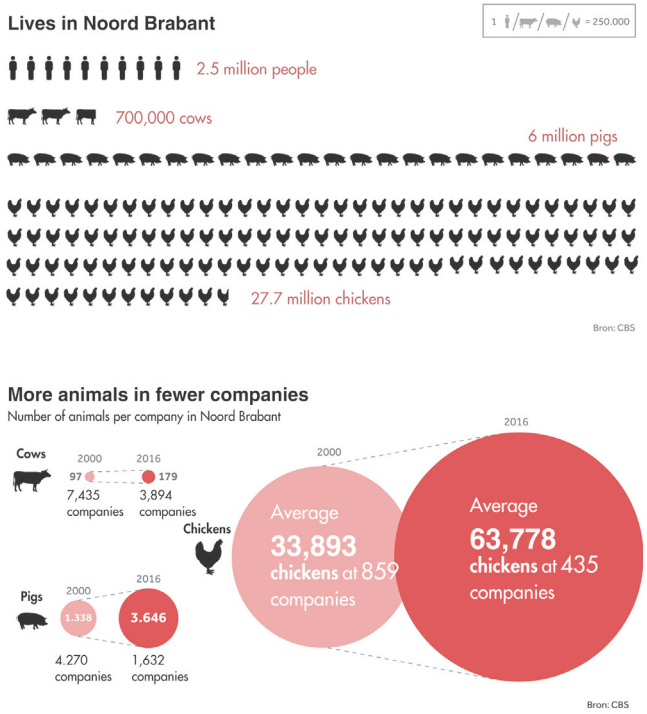


Figure 1.3 Food animals in Noord Brabant (source: Bas de Vries, 2017)

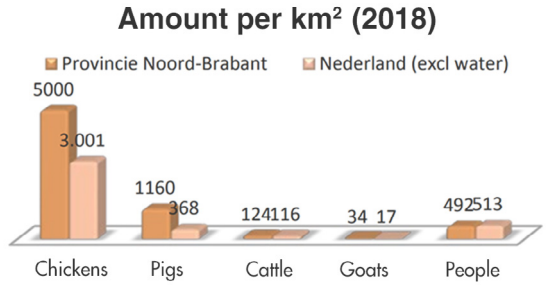


Figure 1.4 Animal density in Noord Brabant (source: Brabantse Milieufederatie, 2019)

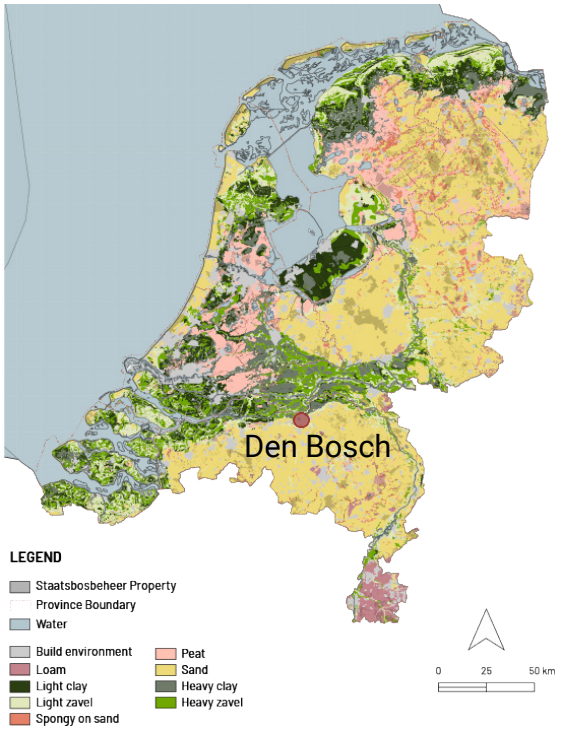


Figure 1.5 Soil types of Netherlands (source: Nicolle Cobben, 2022)

Problem Statement

1. Environmental issues caused by current animal farming in Den Bosch region.

The first problem is the environmental issues caused by animal farming in Den Bosch region. The protein-rich soy meal is an important raw material for animal feeds for pigs, chickens, and cattle. Soy cultivation can have negative consequences, especially in Argentina and Brazil, such as damage to valuable nature, violation of land rights of the local population, and excessive use of plant protection products. (Figure 1.6) The Dutch animal feed industry mainly imports soy from Brazil, Argentina, and the United States (Figure 1.7). (Nevedi, 2018) According to the data from CBS of Netherlands, 2.4 million tons of soybean meal (including soybean hulls) were used for compound feed production in 2020. (CBS, 2020)

Feed production and utilization of feed (Figure 1.8) have the largest impact on greenhouse gas (GHG) emissions and land use (De Vries and De Boer, 2010; Gerber et al., 2013 in Zanten, 2016). About half (47%) of all GHG emissions produced globally by the livestock sector are related to feeding production (Gerber et al., 2013 in Zanten, 2016).

Because of a lot of intensive animal farmlands and factories in Den Bosch region, in order to feed those animals, feed production and utilization have caused harm to the ecological environments globally.

Figure 1.6 *Destroy of rainforests (source: phytoalchemy, 2020)*

Figure 1.7 *Dutch animal feed imports (data source: Nevedi & CBS. Image made by author)*

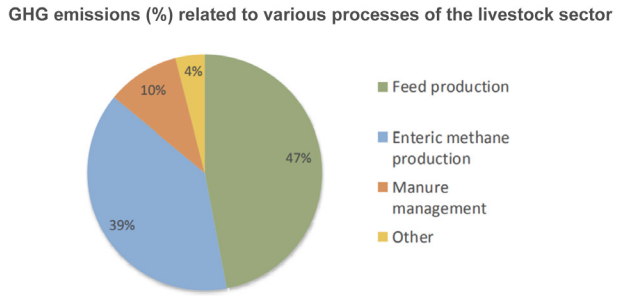


Figure 1.8 *GHG emissions (%) related to various processes of the livestock sector. (source: Hannah van Zanten, 2016)*

Problem Statement

Due to a large number of animals, Noord Brabant produces a large amount of animal manure, no less than 15 billion kg per year. 2.5 times more nitrogen and phosphate are produced than what can be excreted legally. (Brabantse milieufederatie, 2014) As Figure 1.9 shows that Noord Brabant is the province that has the most Nitrogen and Phosphate excretion compared to other provinces in the Netherlands. Cattle, pig and poultry farming take the most responsibility for the nitrogen excretion in animal manure (Figure 1.10).

Nitrogen in the form of nitrate leaches mainly from arable land and partly from grassland to the groundwater. Compared to the rest of the Netherlands, the southern sandy soils are significantly exceeding the standard (the Maximum Permissible Risk) of 50 mg/l for drinking water. The target value for drinking water is even 25 mg/liter. (Brabantse milieufederatie, 2014). As Figure 1.11 shows, the water quality in Den Bosch is not at a good level because of the Nitrogen and Phosphate excretion.

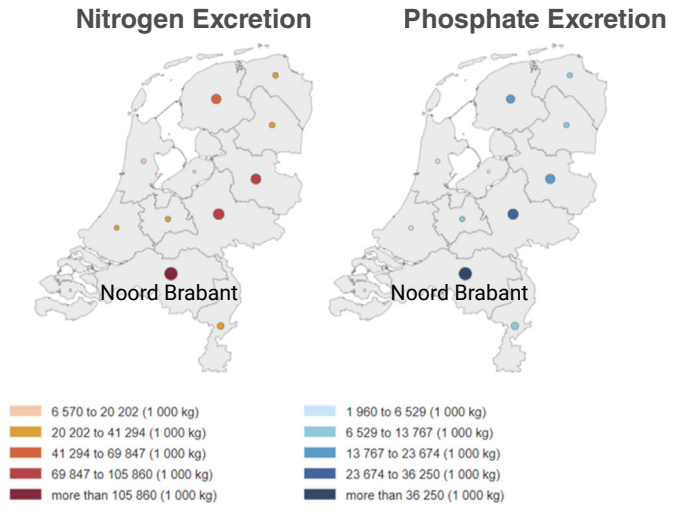


Figure 1.9 *Nitrogen and phosphate excretion of Netherlands (source: CBS, 2022)*

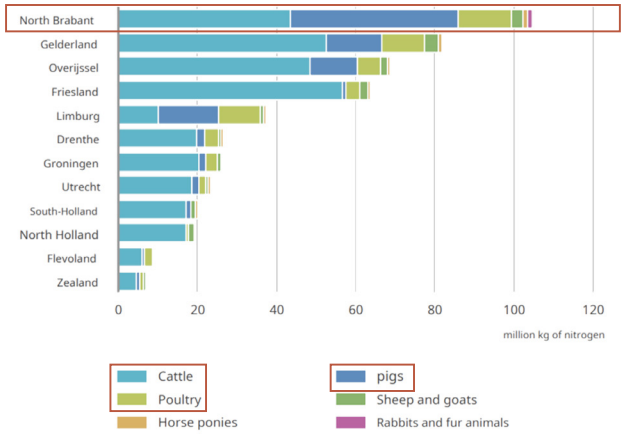


Figure 1.10 *Nitrogen excretion in animal manure by province and animal species in 2019 (source: CBS, 2019)*

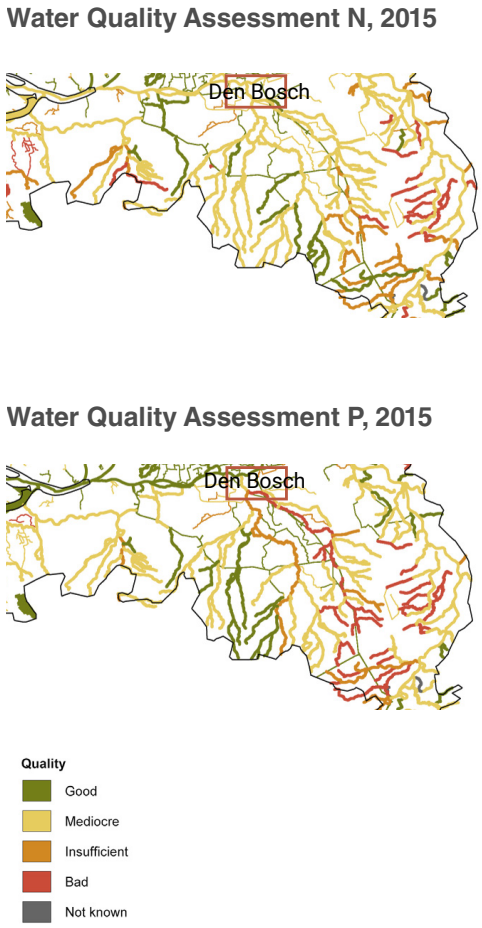


Figure 1.11 *Water quality assessment (source: Brabantse Milieufederatie, 2019)*

Problem Statement

Besides, the over excretion of animal manures has caused phosphate and nitrogen overload, which will further harm the water (Figure 1.12), air, and soil quality. The terrible outcomes of this are the disappearance of local vegetation, especially the Nitrogen sensitive vegetation such as the heathlands which is typical vegetation on sandy soil in Den Bosch (Figure 1.13 & Figure 1.14). According to the area analysis from 2017 in the context of the Nitrogen Approach Program (PAS), in 2030 the old oak forests, raised bogs and weakly buffered fens will still be 100% overloaded with nitrogen in the Kampina, the Peel, Brabantse Wal and Loonse Drunense Dunes. (Brabantse milieufederatie, 2014)

The large monofunctional grasslands for livestock farming also decrease biodiversity. Many wildlife lost their habitats because of the occupation of natural areas for agricultural usage.

Figure 1.13 *Degradation of heathlands (source: image a from Dream the World, 2019. Image b from EenVandaag, 2019)*

Figure 1.12 *Polluted ditches (source: Sem Wijnhoven/DCI Media, 2020)*

Figure 1.14 *Death of local oak trees (source: EenVandaag, 2019)*

Problem Statement

2. Animal welfare is not good in current intensive animal factories.

Animal welfare is also a big issue in those intensive animal factories in Den Bosch region. (Figure 1.15) Welfare is the state of the individual as regards its attempts to cope with its environment (Broom, 1986). Poor welfare is associated with immunosuppression and hence linked to disease and anti-microbial use and some widely-used animal housing systems are unsustainable (Broom, 2017). The living spaces of food animals are quite limited and crowded. Under such high stock density raising, animals are not easy to keep healthy, so a lot of chemicals or antibiotics are used to avoid or deal with the diseases of food animals, which means the poor welfare within current unsustainable intensive animal farming in Den Bosch region.

Apart from that, production always ranks the highest under current capital-dominated animal factories, which means food animals are not given the natural speed to grow up. In addition to health issues, the lack of natural environment, and no access to outdoor or different climatic areas in barns form part of the critiques. (Busch et al. 2018) Animals are not provided opportunities to behave naturally, although some of their natural behaviors can help to improve the environment if guided in the right way.

Figure 1.15 *Animal welfare in current intensive animal factories (source: image a from ANP, 2021. Image b from Varkens in Nood, 2022. Image c from Avrotros, 2019)*

Currently, there are many intensive animal farms in Den Bosch region, especially surrounding the city region (Figure 1.16). The cattle farms spread out through the whole city region, while pig farms mainly concentrate in the eastern part of Den Bosch. Some of the animal farms are quite close to natural or eco-sensitive areas, which will cause harm to the ecology of those natural areas. The animal welfare in those intensive animal farms, especially in those cattle, pigs and poultry farms is not guaranteed in Den Bosch region.

Problem Statement

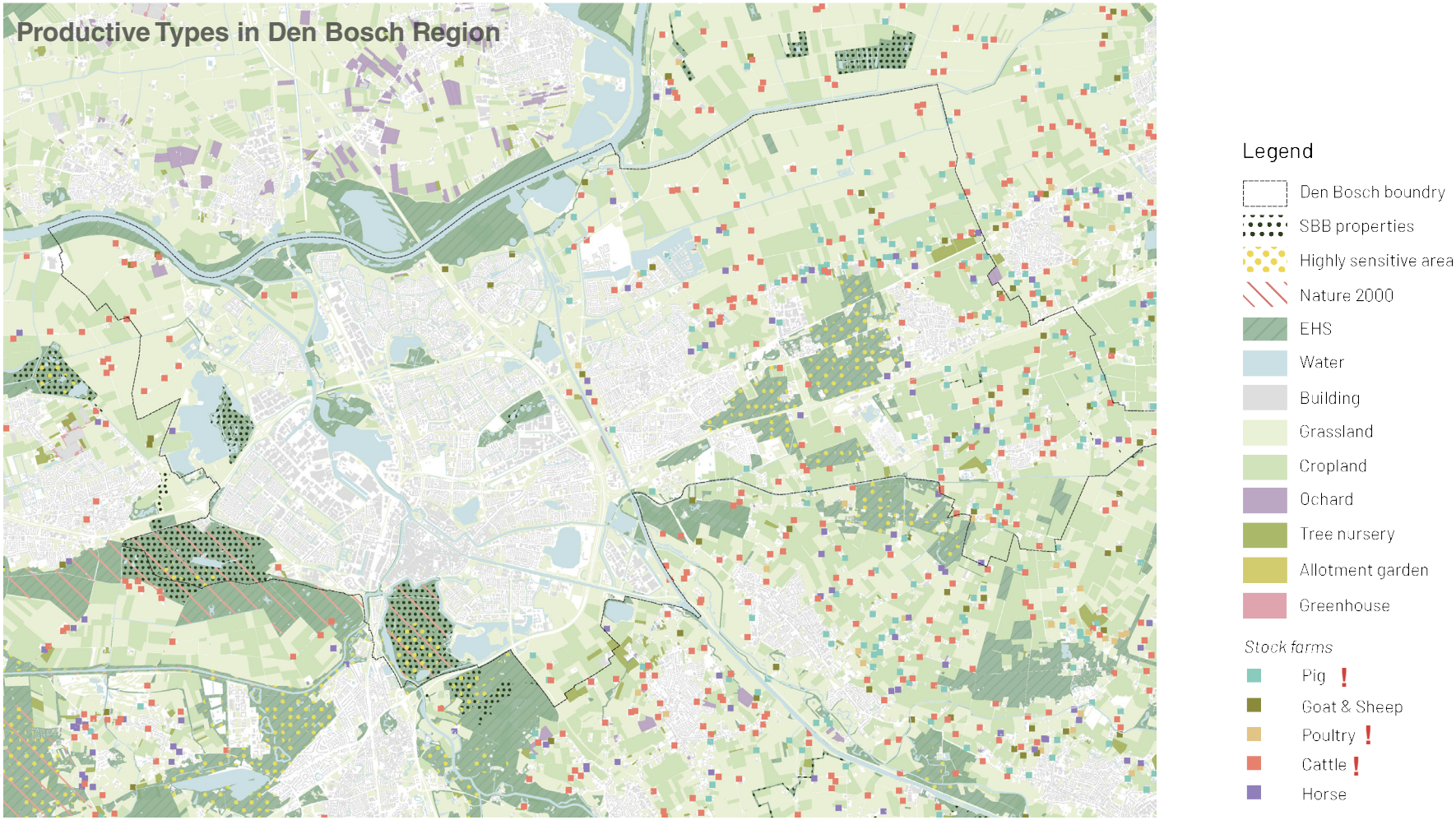


Figure 1.16 *Productive Types in Den Bosch region (data source: PDOK NL & Georegister provincie Noord-Brabant, 2021. Map made by author)*

Problem Statement

3. Insufficient recreational landscapes work as foodscapes and thoughtscapes in Den Bosch region.

Thirdly, consumers are quite unfamiliar with food animals nowadays. With most of the butchering of animals now being concealed or abstracted, the post-domestic and urbanized public are left in a state of disconnect and quasi-denial (Rothgerber, 2019 in Leroy et al. 2020). The little contact that consumers have in real daily life with the food animals is the already-processed animal products in the market. Since Den Bosch region is lack sufficient recreational landscapes to work as animal farming landscapes, livestock may have the potential to start playing a role at the forefront of healthy and sustainable foodscapes, thoughtscapes, landscapes, and ultimately social scapes (Leroy et al. 2020), therefore to establish the connection between consumers and food animals.

Besides, there is one Nature 2000 area '*Vlijmens Ven, Moerputten & Bossche Broek*' in Den Bosch region which is facing high recreational pressure (Figure 1.17) because a lot of tourists and cars flow in. This will harm the ecology of this natural area. Building up the flourishing animal farming foodscapes and thoughtscapes will provide more recreational landscapes to attract tourists and reduce the pressure on the current Nature 2000 area.

Figure 1.17 *Pressure of recreational areas in Den Bosch (data source: PDOK NL & Staatsbosbeheer NL, 2021. Map made by author)*

Problem Statement

4. Other climate-related issues in Den Bosch region

Last but not least, the Den Bosch region itself is facing many climate-related issues such as high flooding risks (Figure 1.18) because of the sea level rise and its location near '*Maas River*' (Figure 1.19); High urban heat effects (Figure 1.20) in some urban areas for lacking enough green spaces to absorb the heat; Low livability in some areas (Figure 1.21). Those issues can be solved or mitigated through creating flourishing animal farming foodscapes and thoughtscapes.

Figure 1.18 *Flooding in Den Bosch (source: Omroep Brabant, 2018)*

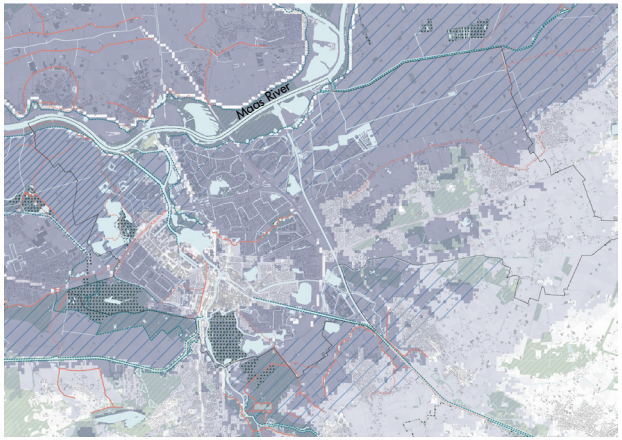


Figure 1.19 *Flooding risks in Den Bosch region (data source: PDOK NL& Klimaateffectatlas NL, 2021. Made by author)*

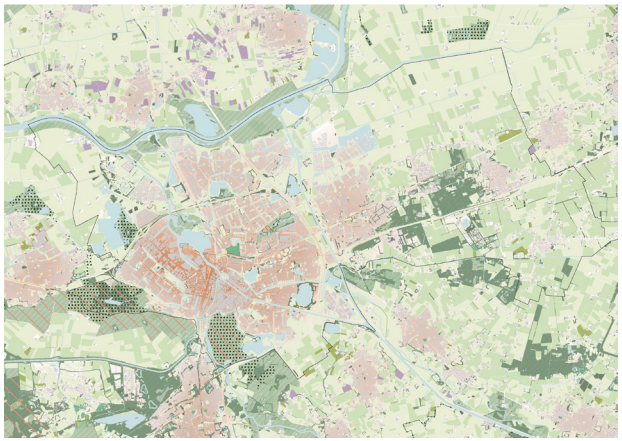


Figure 1.20 *Urban heat effect in Den Bosch (data source: PDOK NL& Klimaateffectatlas NL, 2021. Made by author)*

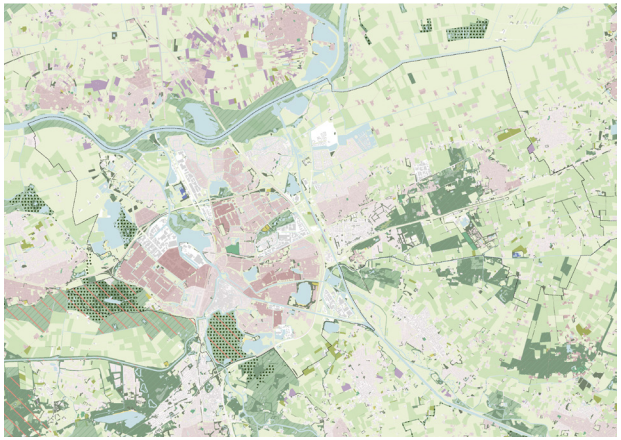


Figure 1.21 *Livability in Den Bosch (data source: CBS& PDOK NL, 2021. Made by author)*

Based on the problems mentioned above, my main design objectives mainly include four main aspects (Figure 1.22): Increasing ecological value of animal farming to reduce or solve the environmental issues caused by the current animal farming; Improving animal welfare of current intensive animal farming; Creating recreational foodscapes of animal farming to establish the connection between consumers and food animals; Creating climate-adaptive animal farming landscapes to adapt the environmental issues such as flooding, urban heat effect, low livability in some areas of Den Bosch region.

My main research question is: How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in Den Bosch region?

The main research question relates to the problem statement, while the sub-research questions explore further the various aspects of answering the main research question.

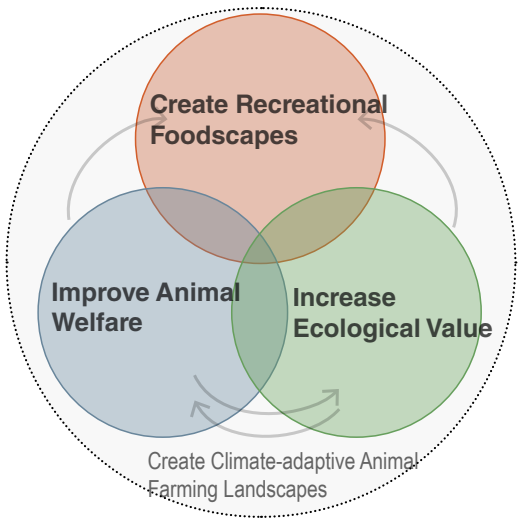


Figure 1.22 *Main design objectives (Made by author)*

Main Research Question

How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in Den Bosch region?

1. Increase ecological value of animal farming

Sub-RQ 1: - How to realize the nutrient cycle and reduce pollution within the areas through landscape design?
Sub-RQ 2: - What kind of local vegetation could be brought back to improve the ecology and biodiversity of animal farms?
Sub-RQ 3: - What is the good assemblage of multi-species food animals in the landscape that can maximize the land?
Sub-RQ 4: - How to transform current intensive animal farming to a more eco-friendly level through landscape design?

2. Improve animal welfare of animal farming

Sub-RQ 5: - What kind of environment can be the baseline for food animals to be able to behave naturally and create living environments by themselves?
Sub-RQ 6: - What types of vegetation in landscape design can be the desirable natural diets for food animals at different seasons?
Sub-RQ 7: - What landscape architecture design principles can keep food animals healthy and improve production in a natural way?

3. Create recreational foodscapes of animal farming

Sub-RQ 8: - What landscape architecture design principles can establish the connection between consumers and food animals?
Sub-RQ 9: - How could the animal farming landscapes help to mitigate the recreational pressure of De Moerputten?
Sub-RQ 10: - How to bring back/reshow some characteristics of historical farmlands through landscape design?

4. Create climate-adaptive animal farming landscapes

Sub-RQ 11: - What are the climate-related problems in Den Bosch region currently and how animal farming landscapes can react to them?
Sub-RQ 12: - Which areas have the high demand for improving animal farming there in order to improve the green structure of Den Bosch region?

CHAPTER 2: METHODOLOGICAL FRAMEWORK

Based on the previous problem statement, design objectives and research questions achieved in the previous chapter, this chapter further elaborates on the methodological framework of this project which includes methodology and research approach. The methodology for this project includes Multilayers analysis; Multiscale research & design; Multiphase design; Interdisciplinary research and expanded scope of landscape architecture. The methodological framework for this project is a looping and cyclical process which contains eight main steps: introduction, research questions, site analysis, synthesis & vision, design principles, design explorations, conclusion, and reflection. Multiple research methods are explained in detail and the figure of the research approach shows how the design objectives, problem statement, research questions, research methods and outcomes are linked.

Multilayers analysis (Figure 2.1)

Based on the problem statement of the topic 'Animal farming in flourishing foodscapes and thoughtscapes', related factors such as Nitrogen deposition, recreational pressure, heritage resources, flooding risks, green plan of the municipality… are analyzed. With the group of related analyses, relationships between different layers have been studied and synthesis is then conducted. Arranging the analyses with hierarchy, less important factors give way to main related factors in order to solve the core issues of the project. A vision scenario is achieved through synthesizing, which will be the basis of further design explorations.

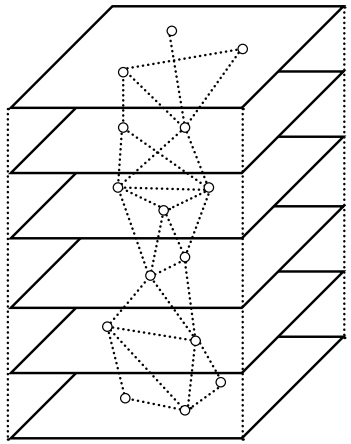


Figure 2.1 *Multilayers analysis (Made by author)*

Multiscale research & design (Figure 2.2)

The research and design are conducted through multiple scales: local scale, mesoscale and regional scale. The multiscale research gives a good direction to the design intervenings. The design is a bidirectional way that combines the directions of 'Top-Down' and 'Down-Top' together, which not only includes the impacts of regional planning but also the influences of local design intervenings towards the larger scale.

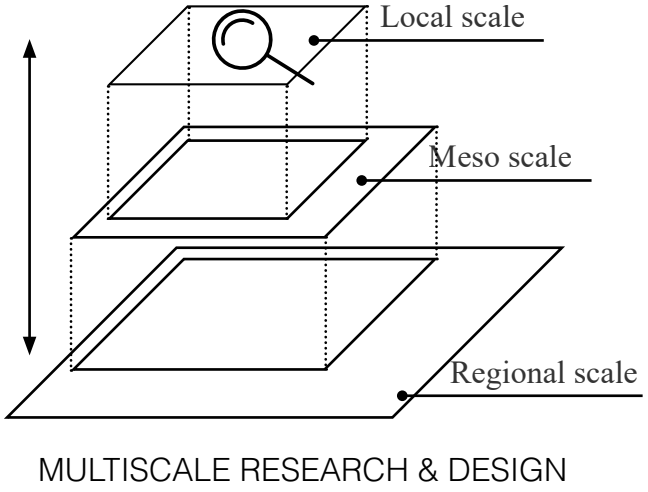


Figure 2.2 *Multiscale research & design (Made by author)*

Multiphase design (Figure 2.3)

With the increasing human modification towards the nature and especially agriculture, the historical development process of agriculture was transformed from semi-natural agriculture which had high numbers of species and grassland habitats to the intensification of agriculture which a had decline of species and grassland habitats, then into the stage of intensive agriculture which has high chemical nutrient input and significant decline of species and grassland habitats. In order to recover the ecology of current intensive animal farming agriculture, multiple phases are conducted to reestablish sustainable, nature-inclusive animal farming agriculture step by step rather than recovering the ecology drastically of a sudden.

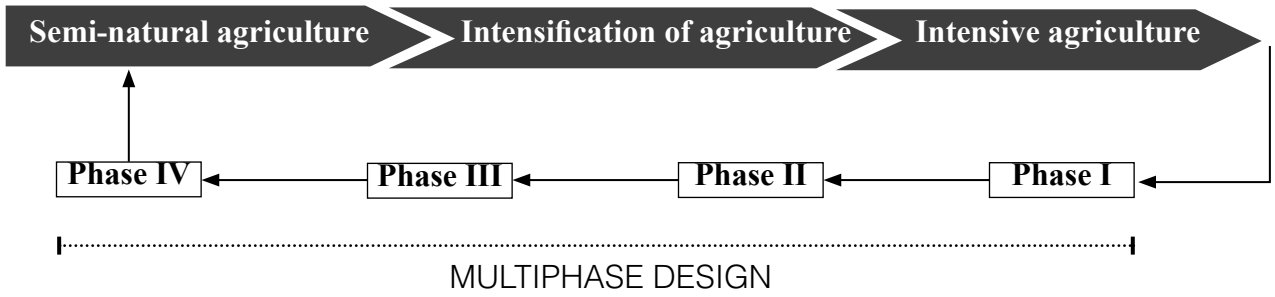


Figure 2.3 *Multiphase design (Made by author)*

Multidisciplinary research and Expanded scope of landscape architecture (Figure 2.4)

Diverse related disciplines such as Agriculture, Husbandry, Food, Ecology, Urbanism … are integrated to expand the research scope of landscape architecture. More comprehensive design principles will then be achieved by multidisciplinary research which can answer the research questions from various perspectives. In this way, landscape architecture design is not limited within the single architectural faculty, knowledge of other disciplines assists to achieve better solutions for the research questions.

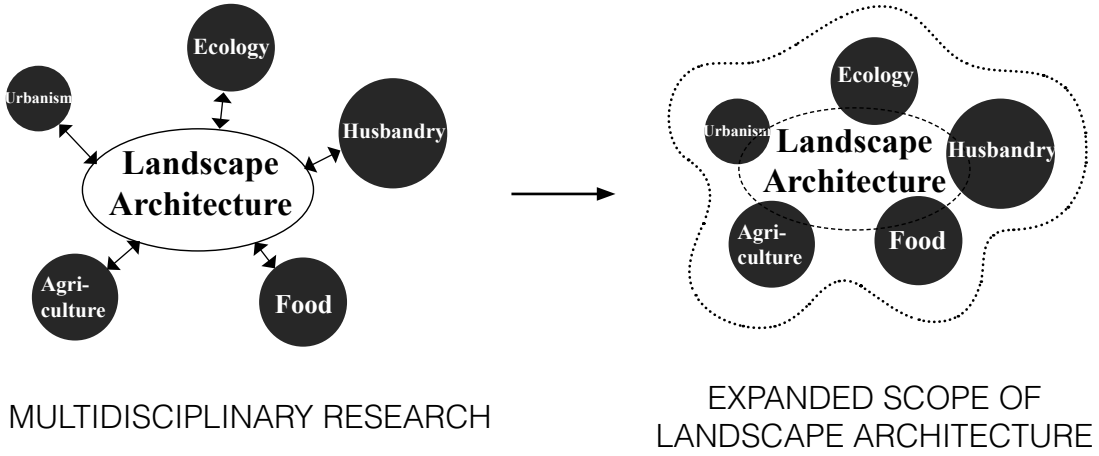


Figure 2.4 *Multidisciplinary research and expanded scope of landscape architecture (Made by author)*

Methodological Framework

The design process is also looping and cyclical in this project. ‘Knowledge of a later phase influences conduct of an earlier one, and early decisions are later reworked. Site design is a process of learning in which a coherent system of form, client, program, and site gradually emerges.’ (Kevin Lynch and Gary Hack, 1984) A modeling of the design process should include a number of feedback loops indicating that information acquired at each stage alters subsequent procedures. Decisions made at one stage necessarily limit the range of possible actions and decisions at any other point in the process. (Low, 1980) Based on this looping process, the methodological framework of this project contains eight main actions (Figure 2.5):

Action 1: Introduction

The first step starts with fascination from three perspectives: personal fascination, scientific field and societal field. Analysis of the study area followed by the problem statement, which contains four problems related to current intensive animal farming in Den Bosch region: 1) Environmental issues caused by current animal farming. 2) Animal welfare is not good in current intensive animal factories. 3) Insufficient recreational landscapes work as foodscapes and thoughtscapes in Den Bosch region. 4) Other climate-related issues in Den Bosch such as flooding risks, urban heat effects and low livability in some areas. Then the main design objectives which include increasing ecological value, improving animal welfare, creating recreational foodscapes and creating climate-adaptive animal farming landscapes are proposed. The research questions then followed.

Action 2: Figure out Research Questions

In this step, the main research question is ‘How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in Den Bosch region?’ The sub-research questions are grouped based on each specific design objective.

Action 3: Site Analysis

Good examples of regional animal farming in Noord Brabant and natural behavior and benefits of food animals are studied firstly in this step. Then problems of current animal farming in Den Bosch such as Nitrogen deposition, recreational pressure… together with other linked analyses such as flooding risks, urban heat effect… are analyzed to get out a set of design assignments regarding to the four main design objectives.

Action 4: Vision Exploration

The set of analyses is grouped and synthesized. Based on the synthesis of mapping and analysis, a vision map for the city region was achieved, which finds out the areas where animal farming there needs to be more sustainable and nature-inclusive, therefore improving the green structure of Den Bosch region.

Action 5: Design Principles Formation

Design principles related to each specific design objective and assignment are achieved based on literature review, site visit, mapping, case study… Besides the four main design objectives, the average stock density and size of current intensive animal

farms in Noord Brabant are studied and more eco-friendly stock density is studied through the literature review and case study.

Action 6: Design Explorations

Design explorations are conducted on the three sites which are selected separately in a natural, suburban and urban context to explore what roles different contexts can play in animal farming as well as the relationship between animal farming and nature. The first site 'Animal farming in Nature' locates in a natural area. Animal farming in this site is more nature-oriented and stock density is low to correspond with the natural context. The second site 'Animal farming with Nature' is in a suburban area with several animal factories and a natural eco-sensitive area, animal farming in this site tries to seek a balance between ecology and production. The third site 'Animal farming through Nature' in the industrial area explores how urban areas can help to improve animal farming and how animal farming landscapes can benefit the urban areas.

Action 7: Conclusions Making

In this step, the main research questions and design objectives are reviewed first and the main findings regarding each sub-research question which related to the main objectives are answered before proposing final solutions to the main research question. Then main findings are synthesized and the final conclusions and answers towards the main research question are provided at the end of this part.

Action 8: Discussion, Recommendations & Reflection

In the discussion part, the design explorations of three sites are explained, the possible expanded scope of this project is discussed and the limitations of this project are reflected in different aspects including the accuracy of data, the interests of farmers and the professional restrictions of the author's capacity. Recommendations are proposed to different parties and people to dedicate to improving animal farming together. In the end, the reflection is written through these aspects: the relationship between research and design which includes research on design, research for design and research through design; The relationship of Graduation Topic to Studio Topic, MLA and Msc AUBS; Elaboration on research method and approach; Transferability of the project results and Ethical issues and dilemmas.

Methodological Framework

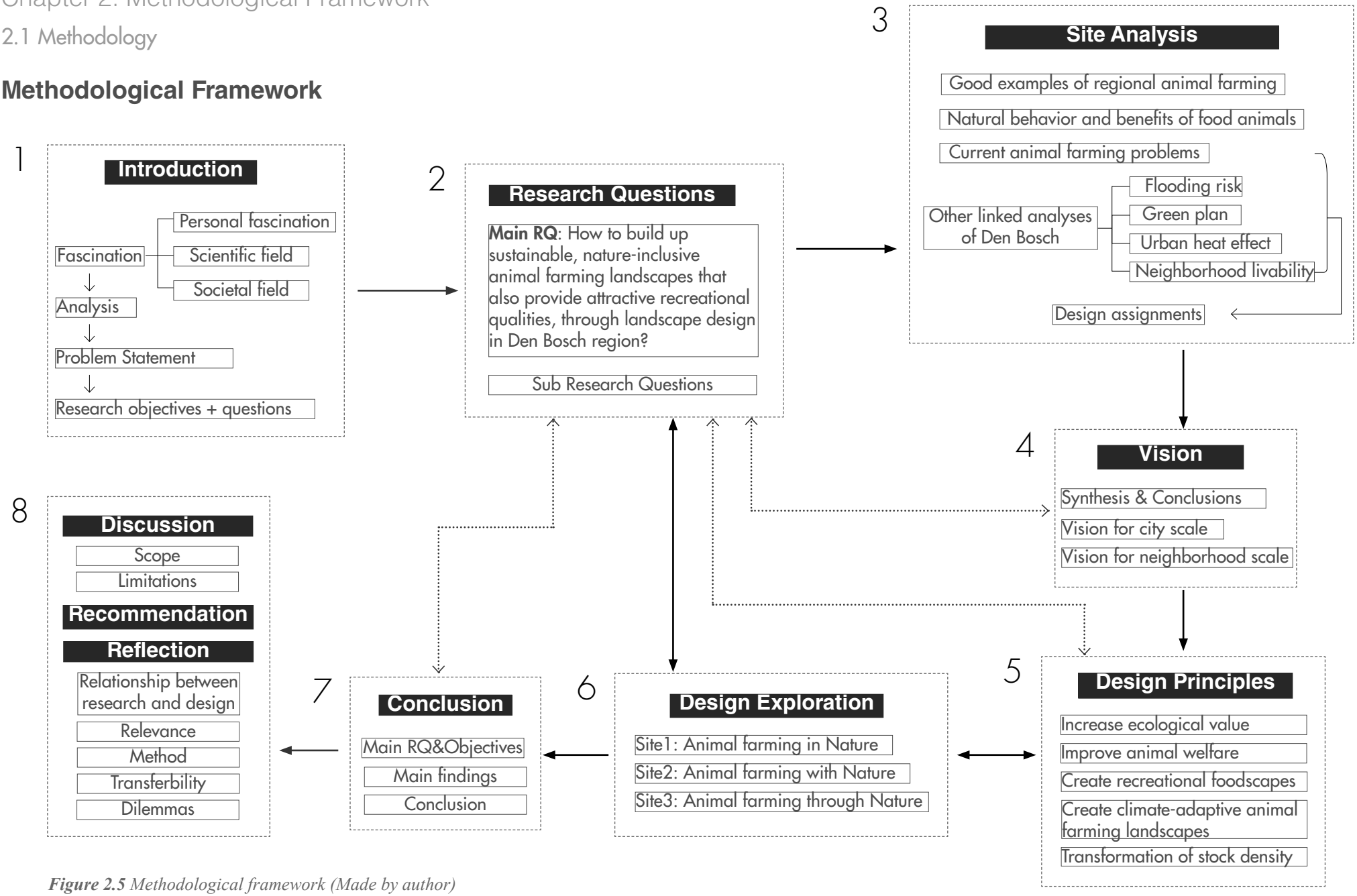


Figure 2.5 *Methodological framework (Made by author)*

Research Methods

Research is conducted based on the 4 main design objectives (Figure 2.6): 1. Increase ecological value. 2. Improve animal welfare. 3. Create recreational foodscapes. 4. Create climate-adaptive animal farming landscapes. The research methods used include Literature review; Case study; Stakeholder analysis; Policy analysis; Mapping; Workshops; Site visits; Interviews; Scenario exploration; Design principles formation; Video watching. The research is conducted literally, visually and experimentally in this project.

Literature review

Literature review here refers to reading papers, books, reports and articles related to animal farming landscapes topic. It is not limited to the field of landscape architecture or urban design, interdisciplinary research is implemented which involves agriculture, livestock farming, animal behavior, biology, ecology… Findings of design strategies or principles are concluded in order to assist the design of this project.

Case study

Study the exemplary projects from academic papers, books related to foodscapes, landscape architecture & urban design offices, good attempts of farmers… Figure out the problems, objectives and strategies used in those cases, make the summaries and selected out the suitable design strategies or principles which could also be applied in this project and make some adjustments to fits the topic and design sites if necessary.

Stakeholders analysis

The interests and responsibilities of different stakeholders are analyzed and included in different design phases. The stakeholders of this project mainly include farmers (crop growers, fruit growers, food animal breeders...); Ecologists who can assist with renewing the farmlands and improving the ecological quality and the Staatsbosbeheer board is also included to work together with ecologists; Governments from the Den Bosch municipality and Noord Brabant province; Residents; Tourists who mainly have the recreational and educational purposes. The analysis of stakeholders is conducted in one of the design explorations 'Animal Farming in Nature' to show the responsibilities and interests of different stakeholders in different design phases in detail.

Policy analysis

Key policy documents and decisions from the Den Bosch Municipality, Noord Brabant Province and National Government such as Den Bosch regional green plan, *Nature 2000* areas, and *National Ecological Network* (EHS)… are studied in order to find out urgencies, planning of the green structure, and countermeasures of current animal farming in the study area. Critical thinking is implemented when studying the plans of policies and governments, and alternative solutions are proposed in some disagreement areas in the site analysis and vision formulation.

Mapping

Data from 'Statistics Netherlands (CBS)' 'Nationaal georegister' 'Georegister provincie Noord-Brabant' 'Hét platform voor hoogwaardige geodata (PDOK)' are collected and visualized in QGIS. Mapping helps to get a spatial view of the problems and potentials in the study area. Through synthesizing the maps, the

vision for the Den Bosch city region related to the animal farming landscapes can be achieved.

Workshops

During the workshop '*Thinking with Maps*' various methods of visualizing the data and design are attempted such as QGIS, Modeling, and 3D printings, these help the author learn how to analyze the study area with GIS data and also how to visualize the design intervenings through making 3D models in the design explorations. The workshop '*Drawing Time*' explores different drawing ways to express the changes of different time scales, this workshop teaches the author to have a time-scale thinking when expressing and exploring the design intervenings. The workshop '*Designing Knowledge Ecologies*' helps the author develop a multi-layered approach of thinking through the transformation of the Dutch Innovation Hub in Zoetermeer, which can be applied in site analysis and design explorations.

Site visit

'Visual research consists of activities of a passive nature--- namely, looking at photographs, sketches, and work executed in the field.' (Hideo Sasaki, 1950) In this type of research, site visits to Den Bosch and specific design sites have been done by several times, photographing and video recording of local conditions are recorded. Perceptions of the design sites are achieved through walking and feeling within the sites.

Interviews

Interviews with the Staatsbosbeheer board of Noord Brabant are conducted to find out the urgencies of Staatsbosbeheer properties in Den Bosch. A meeting with staff from the Noord Brabant government has also been conducted to understand the green plans and animal farming policies of Noord Brabant more deeply.

Scenario exploration

Various scenarios for different city contexts and scales are explored to investigate the potential futures of animal farming landscapes in the study area. 'Experimental research is the manipulative activity used to discover new aesthetic possibilities of materials, construction methods, and spatial relationships' (Hideo Sasaki, 1950) This experimental scenario exploration gives the robust direction for the design principles and design explorations in the natural context, suburban context and urban context.

Design principles formation

Sets of design principles related to four design objectives are achieved to provide directions and solutions for further design explorations. The design principles are common to be applied to the Noord Brabant region, but the specific intervenings need to be adjusted flexibly when applying the design principles on specific design sites.

Video watching

Documentaries related to animal farming such as '*Citizen of the Earth*' are watched to have a better understanding of the problems in current intensive animal farming. Documentaries such as '*The Private Life of Pigs, Cows and Chickens*' show the meaning and benefits of food animals' natural behaviors which could give some inspiration when doing the design exploration to improve the animal welfare. Other documentaries such as '*The Biggest Little Farm*' provides some good attempts and experiences of establishing a sustainable cycling animal farm.

Research Approach

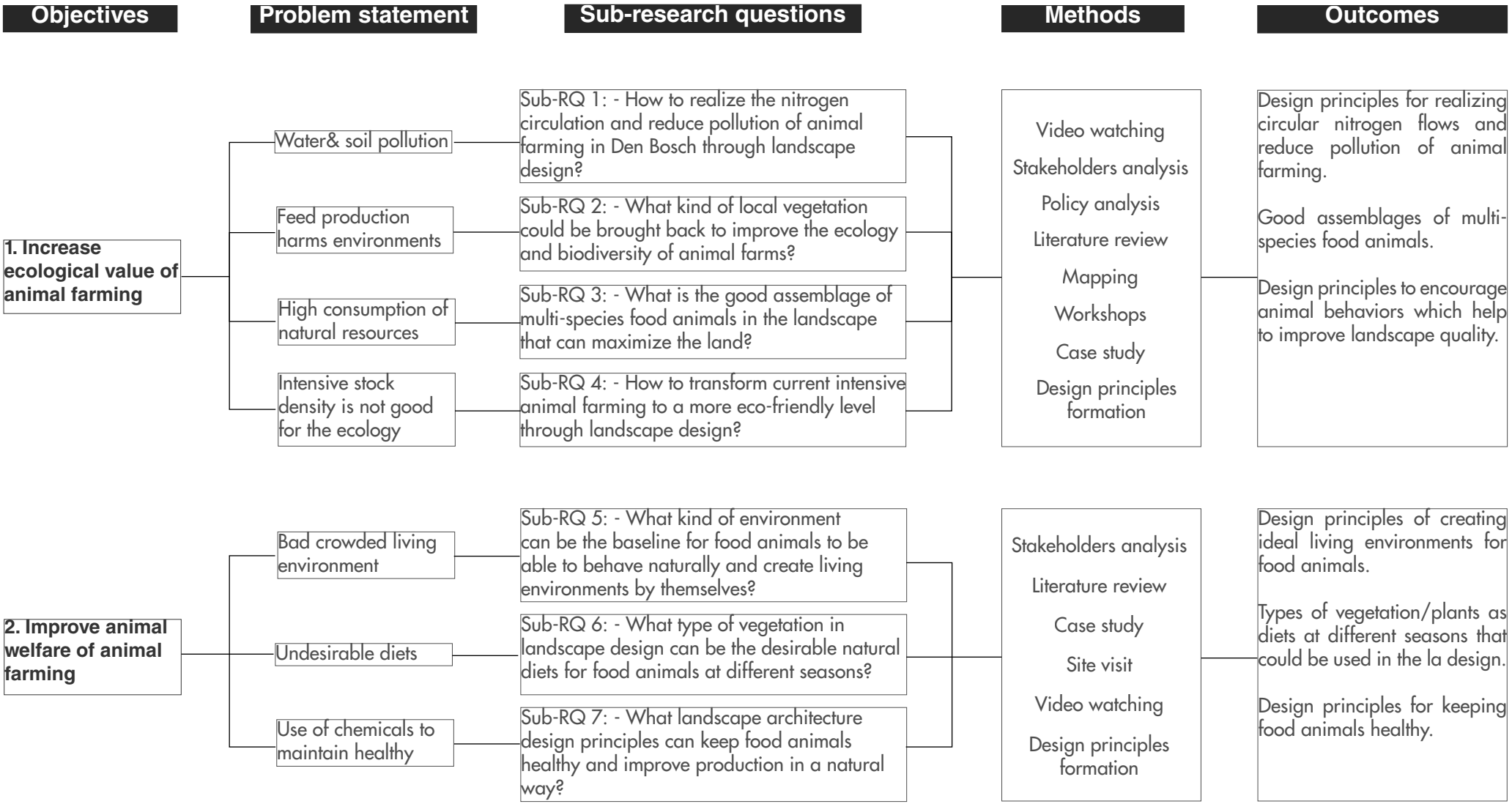


Figure 2.6 *Research approach-a (Made by author)*

Research Approach

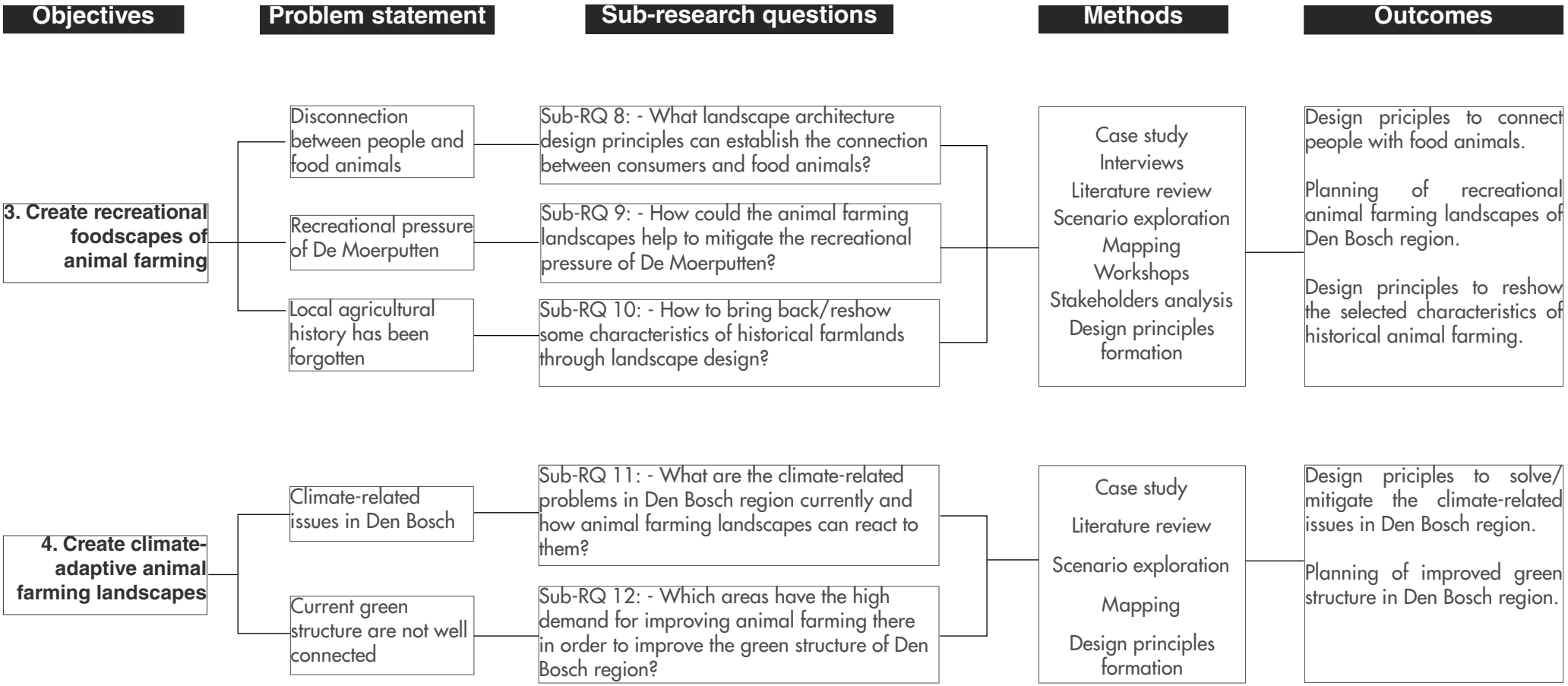


Figure 2.6 *Research approach-b (Made by author)*

Following the 'Methodological Framework' which is a basic guideline for the whole project, this chapter studies the problems and potentials of Den Bosch in-depth through mapping and analyzing. Before diving into the specific site analysis, this chapter firstly shows some good examples of animal farming in Noord Brabant and studies the natural behaviors and benefits of food animals. Then a detailed analysis of the study area is conducted in order to get out the specific design assignments based on the four main design objectives: increase ecological value, improve animal welfare, create recreational foodscapes, and create climate-adaptive animal farming landscapes.

The leading sub-research questions in this chapter include:
Sub-RQ 11*: - What are the climate-related problems in Den Bosch region currently and how animal farming landscapes can react to them?*
Sub-RQ 12*: - Which areas have the high demand for improving animal farming there in order to improve the green structure of Den Bosch region?*

CHAPTER 3: SITE ANALYSIS

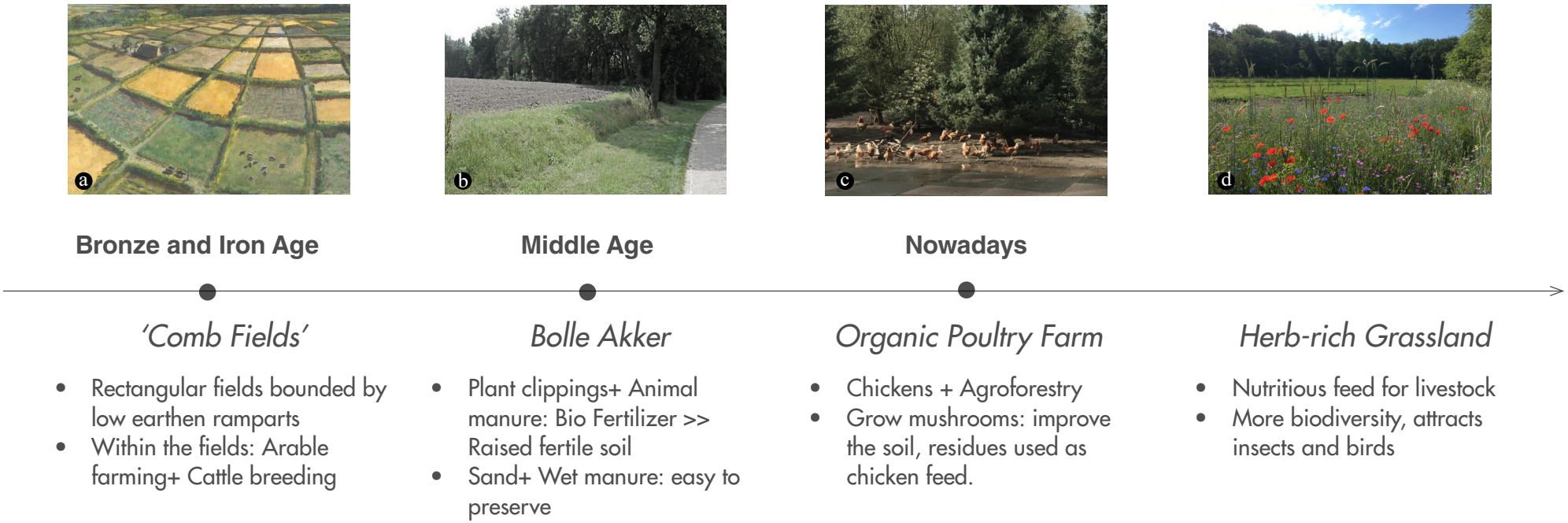


Figure 3.1 *Good examples of animal farming in Noord Brabant (source: image a from Rob Beentjes, 2021. Image b from Jan Timmers, 2016. Image c&d from Landbouw met natuur, 2022)*

First of all, taking a look at some good examples of animal farming in Noord Brabant can provide us better understanding of what characteristics the organic farmlands in Noord Brabant should have. Historically, in the very ancient Bronze and iron age, there is a type of 'comb fields' characterized with rectangular fields bounded by low earthen ramparts. Within the fields, arable farming and cattle breeding are combined. Then in the middle age, there is a special farmland called 'Bolle Akker', plant clippings and animal manure are mixed to create a fertilizer, which also raised the soil layer. (Brabants erfgoed, 2021) Nowadays, in the organic poultry farm, chickens and agroforestry are combined. In some livestock farms, herb-rich grasslands are created to provide the nutritious diverse food for livestock (Landbouw met natuur, 2022).

Natural behaviors of food animals

Dust bath of chicken

Wet mud bath of pig

Water bath of cattle

Benefits of animal behaviors towards the environment

Chicken eats insects

Pig rooting

Manure fertilizer

Figure 3.2 *Natural behaviors and benefits of food animals (source: image a from Betsy Russon, 2021. Image b from Lauralee Blanchard, 2017. Image c from Clara Bastian, 2020. Image d from Landbouw met natuur, 2022. Image e from John Harvey, 2002. Image f from Pxhere, licensed under CC0, 2019)*

The food animals have some natural behaviors such as dust bath of chickens to kill lice and mites (Betsy Russon, 2021), wet mud bath of pigs to keep cool, prevent sunburn and stay free of parasites (Lauralee Blanchard, 2017). Water bath of cattle to keep cool and healthy. Some of their natural behaviors could also benefit the environment. (Figure 3.2) For example, chickens eat the insects so this could reduce the use of pesticides. Pig rooting helps to loosen the soil and animal manure could be used to form the bio fertilizer (European Commission, 2019). Therefore, animal natural behaviors should be allowed and can be guided in the right way to improve the ecology of the environments.

Monofunctional Grassland

Cattle, sheep, horse...

- Lack biodiversity
- Very one-sided diet for livestock
- Lack landscape elements

Intensive Animal Factories

Pigs, chickens...

- Bad animal welfare
- Huge pollution
- Disconnection between people and food animals

Figure 3.3 *Current animal farming in Den Bosch (data source: Google map, PDOK NL & Georegister provincie Noord-Brabant, 2021. Map made by author)*

What is happening in animal farming of current Den Bosch are mainly two types of animal farming (Figure 3.3). One is the monofunctional grasslands for grazing livestock. This type of grassland is lack of biodiversity and provides very one-sided diets for livestock. The landscape elements are also missing in these grasslands, making the spatial quality not very attractive. Another type of animal farming is intensive animal factories, mainly for pigs and poultries. As mentioned before, the animal welfare is not good in these factories. They also produce huge amount of pollution. Besides, people are also unfamiliar with these food animals because these food animals are always locked in the factories, what people can contact with them are the processed animal products in the supermarket.

Nitrogen Deposition in Den Bosch Region

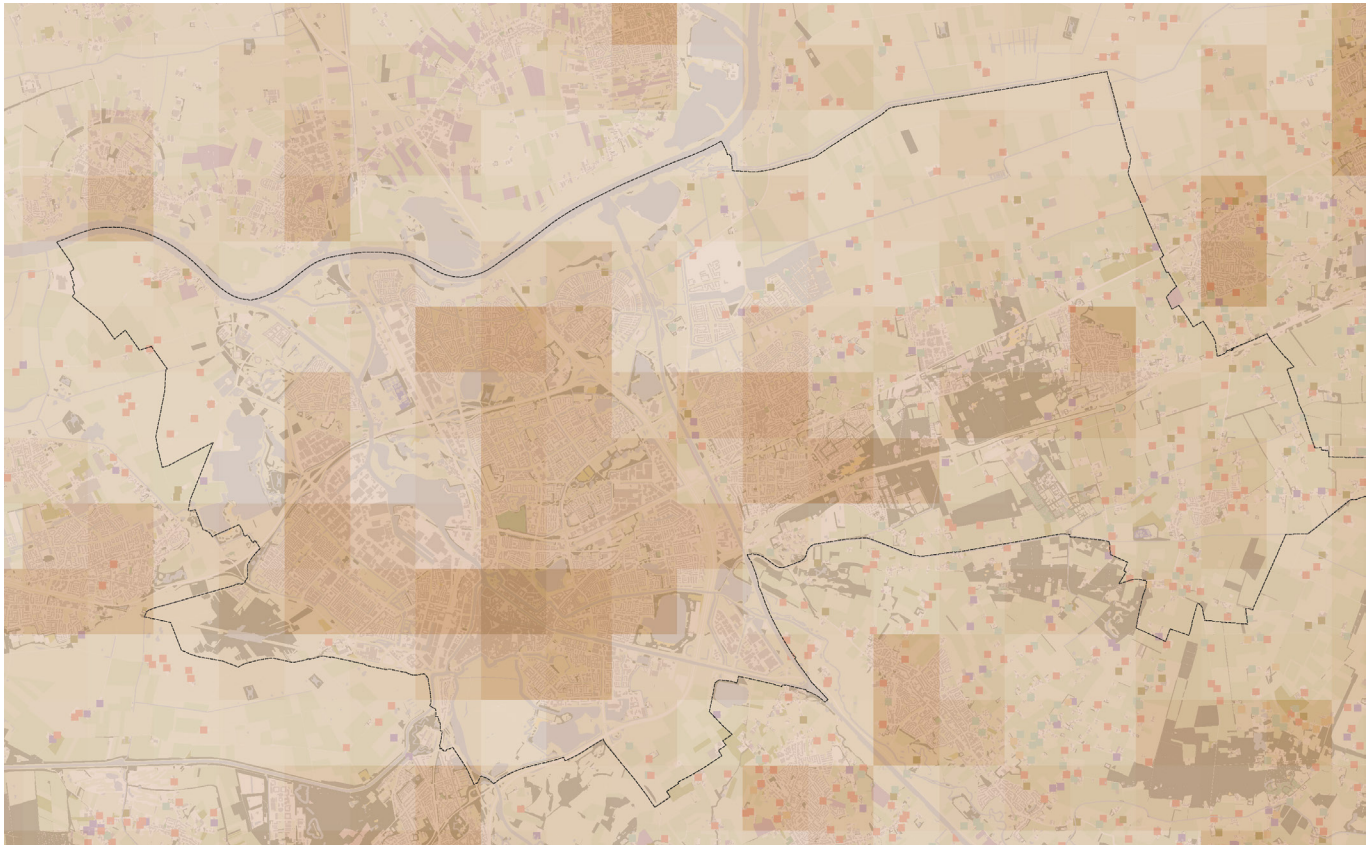
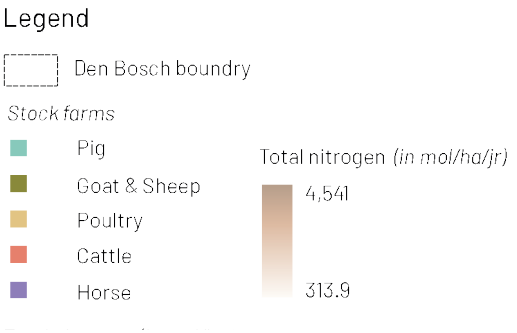


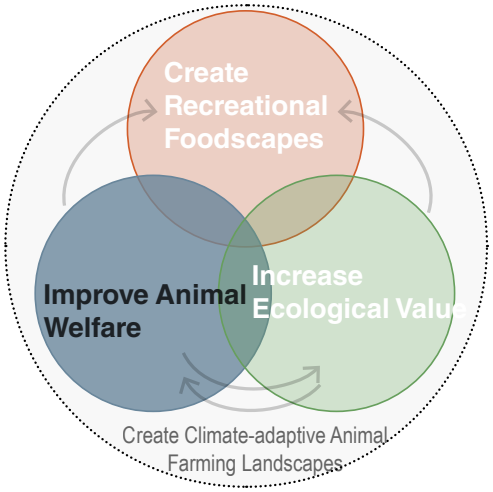
Figure 3.4 *Nitrogen deposition in Den Bosch region(data source: Nationaalgeoregister, 2022. Map made by author)*

Figure 3.5 *Threats from nitrogen pollution (source: Sutton and Billen, 2010)*



The Nitrogen Deposition (Figure 3.4) is quite severe in Den Bosch region. Animal farming takes a large part of responsibility for this issue. The excessive Nitrogen hurts the water quality, soil quality and air quality of the city. (Figure 3.5) 'Excess reactive nitrogen represents a major environmental threat that is only now beginning to be fully appreciated. At a global level, humans have more than doubled the production and cycling of reactive nitrogen, leading to a plethora of impacts that interact across all global spheres: atmosphere, biosphere, hydrosphere and geosphere.' (Sutton et al., 2009) Urban ecology is harmed furthermore.

Design Assignments

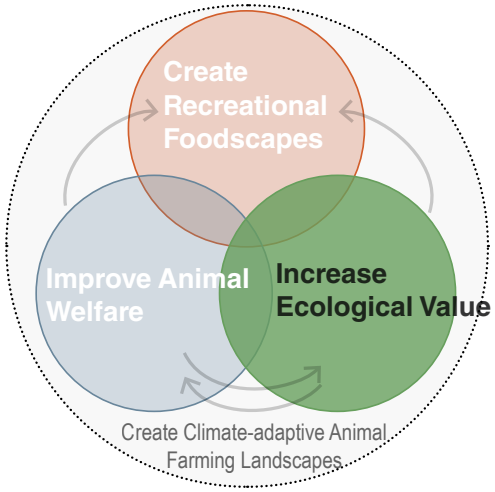


Improve Animal Welfare

Improve living environment
Allow natural animal behaviors

Supplementary diverse diets

Figure 3.6 *Specific design assignments for 'improve animal welfare' (made by author)*



Increase Ecological Value

Nitrogen circulation

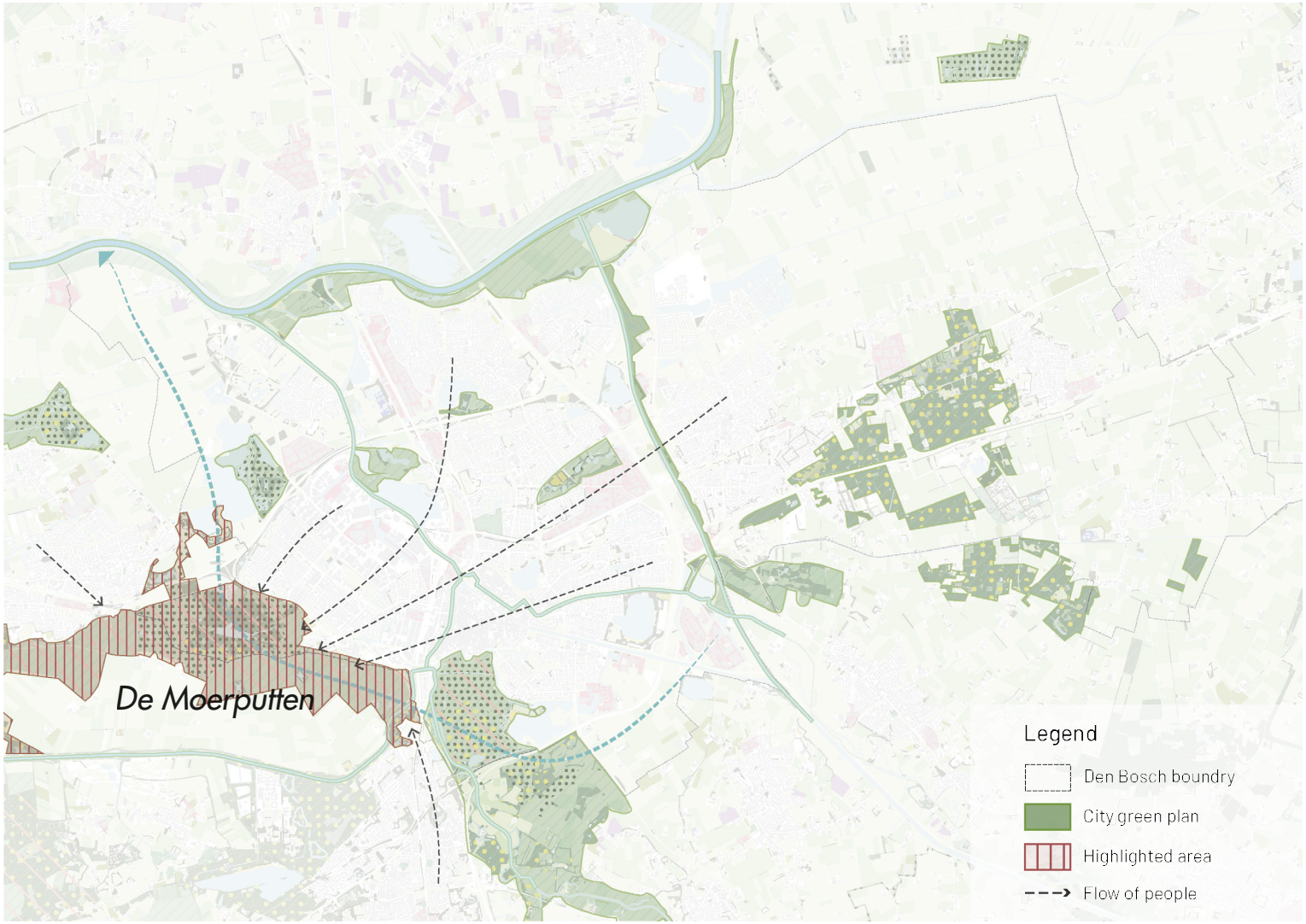
Sustainable animal farming

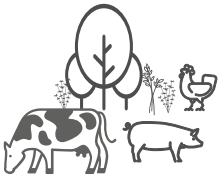
Increase biodiversity

Figure 3.7 *Specific design assignments for 'increase ecological value' (made by author)*

Based on the analysis mentioned before, in order to improve animal welfare (Figure 3.6), the living environment of food animals should be improved and their natural behaviors should be allowed. Instead of artificial animal fodders, supplementary diverse diets should be provided for food animals. As for reducing pollution of animal farming (Figure 3.7), Nitrogen circulation should be considered and sustainable animal farming should be established. Besides, the biodiversity could be increased to attract more wildlife and build up a more resilient and stable eco farming system.

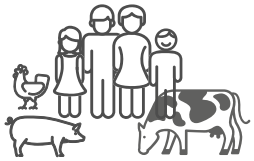
Pressure of Recreational areas





Need for new attractive landscapes to reduce current recreational pressure of De Moerputten.

+



Need for animal farming foodscapes and thoughscapes to make people reconnect with food animals!

As mentioned before, the recreational pressure of De Moerputten causes a demand for new attractive recreational areas (Figure 3.8). Since there is also a need for recreational foodscapes of animal farming to make people and food animals more connected, these two requirements could be combined.

Figure 3.8 *Pressure of recreational areas in Den Bosch (data source: PDOK NL & Staatsbosbeheer NL, 2021. Map made by author)*

Heritage resources with recreational potential

Some heritage resources are not obvious in Den Bosch nowadays, especially inundation areas which played an important role in Dutch history (Figure 3.9). Since these heritages have the great recreational potentials, they can be combined with the requirements mentioned before to create recreational foodscapes of animal farming.

Figure 3.9 *Heritage resources with recreational potential (data source: PDOK NL & Nationaal Georegister NL, 2021. Map made by author)*

Design Assignments

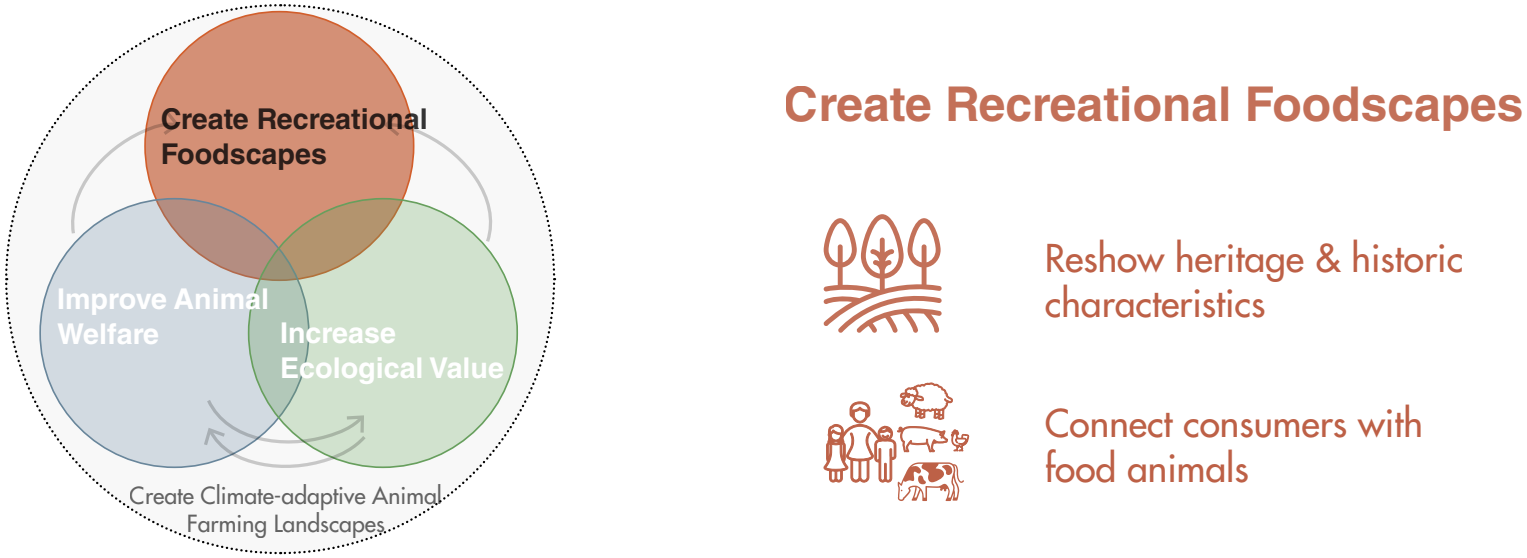
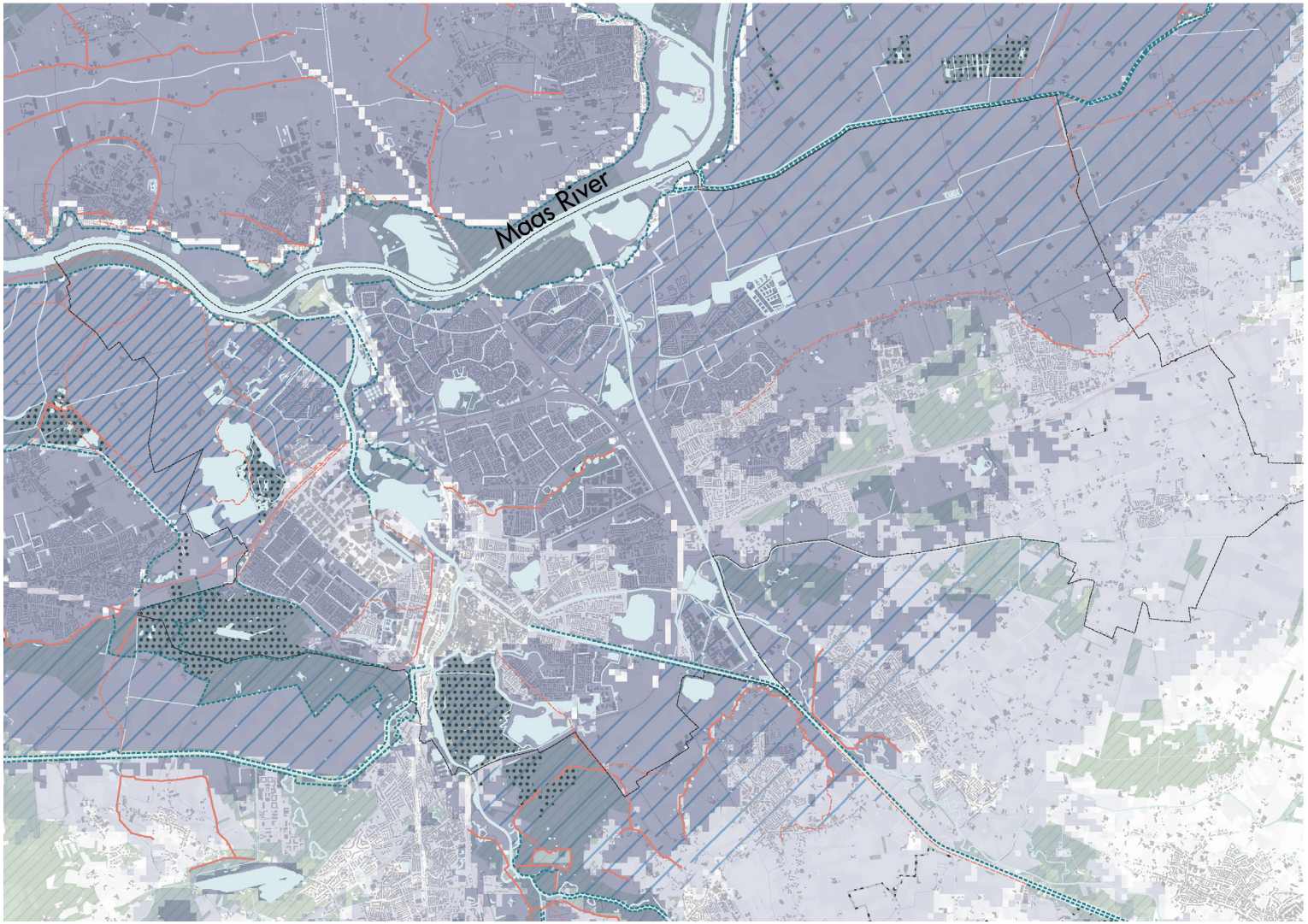


Figure 3.10 *Specific design assignments for 'Create recreational foodscapes' (made by author)*

Therefore, in order to create recreational foodscapes of animal farming (Figure 3.10), historical heritage could be combined with animal farmlands and some characteristics of ancient farmlands could be reshowed. People should be provided some opportunities to get know more about food animals in the recreational foodscapes of animal farming.

Flooding risk of Den Bosch Region



Besides the issues of animal farming in Den Bosch, some other linked analysis of climate risks is also taken into account in order to create climate-adaptive animal farming landscapes. Currently, Den Bosch is facing flooding risks, especially in the northern area close to the Maas River.

Figure 3.11 *Flooding risks in Den Bosch region (data source: PDOK NL& Klimaateffectatlas NL, 2021. Made by author)*

Green plan of Den Bosch region

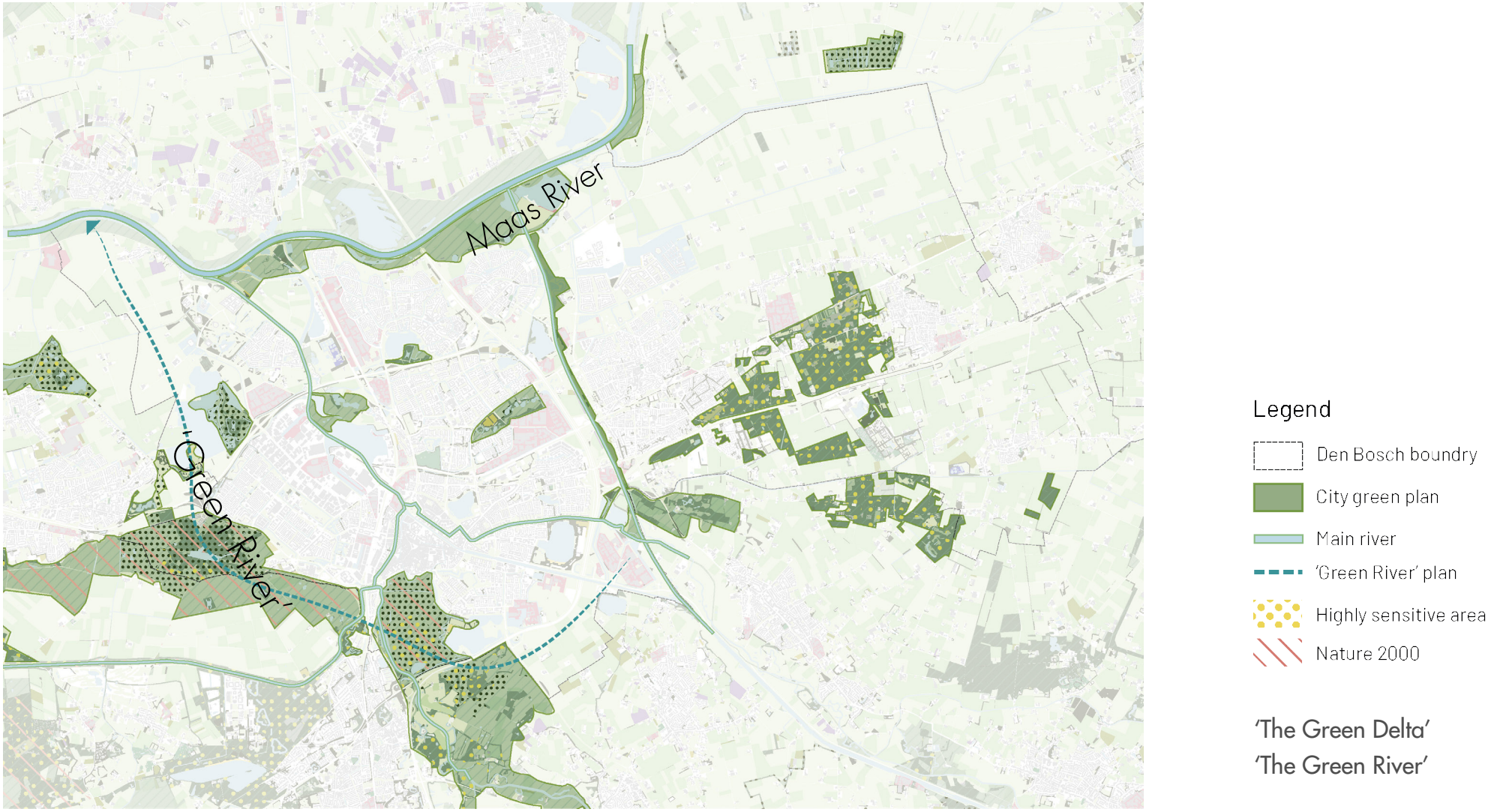


Figure 3.12 *Green plan of Den Bosch region (data source: PDOK NL,2021& GEMEENTE 'S-HERTOGENBOSCH, 2014. Made by author)*

Green plan of Den Bosch region

The green plan from Den Bosch municipality explicate that they want to make Den Bosch become a ‘Green Delta’ to make the city more resilient. The Green Delta is made up of ‘green areas’ and ‘connections’:

- The green areas have been given different accents. These are ‘consolidation’, ‘transformation’ and ‘landscape valuable areas’. On this, discussed under the headings “Green Consolidation Areas”, “Green Transformation Areas”, ‘Small-scale valuable landscape’, ‘Open valuable landscape’ with the Kloosterstraat and ‘recreational lakes’. (Den Bosch municipality, 2014)

- It is desirable to connect green areas with each other. It makes exchange of plants and animals between one area and another. In many cases there are simultaneously opportunities for a combination with, for example, recreational routes. This also gives these connections meaning for people. Within the connections, a distinction is made between ‘Robust ecological connections’ and ‘Green-blue connections’. City-Aa, Stads-Dommel and Dieze are the most important green-blue connections within the city and are the bearers of the ‘green-blue garlands’. (Den Bosch municipality, 2014)

There is a ‘Green River’ (Figure 3.12) planned along ‘Gement’ ‘De Moerputten’ ‘Engelermeer’ to help charge the excessive water from Dommel and Aa River towards the Maas River. This means that at high water in the Aa and Dommel streams, the water can be temporarily diverted to two polder areas, the Gement with the Moerputten and the Engelermeer. At a later stage this can be extended via the Hedikhuizense Maas to the Maasdal. These water storage areas will be combined with the realization of a robust ecological connection from Het Groene Woud and the Loonse en Drunense Duinen via the Gement, the Zooislagen and the Hedikhuizense Maas to the Maas, creating a ‘green river’. (Den Bosch municipality, 2014)

Urban heat effect in Den Bosch

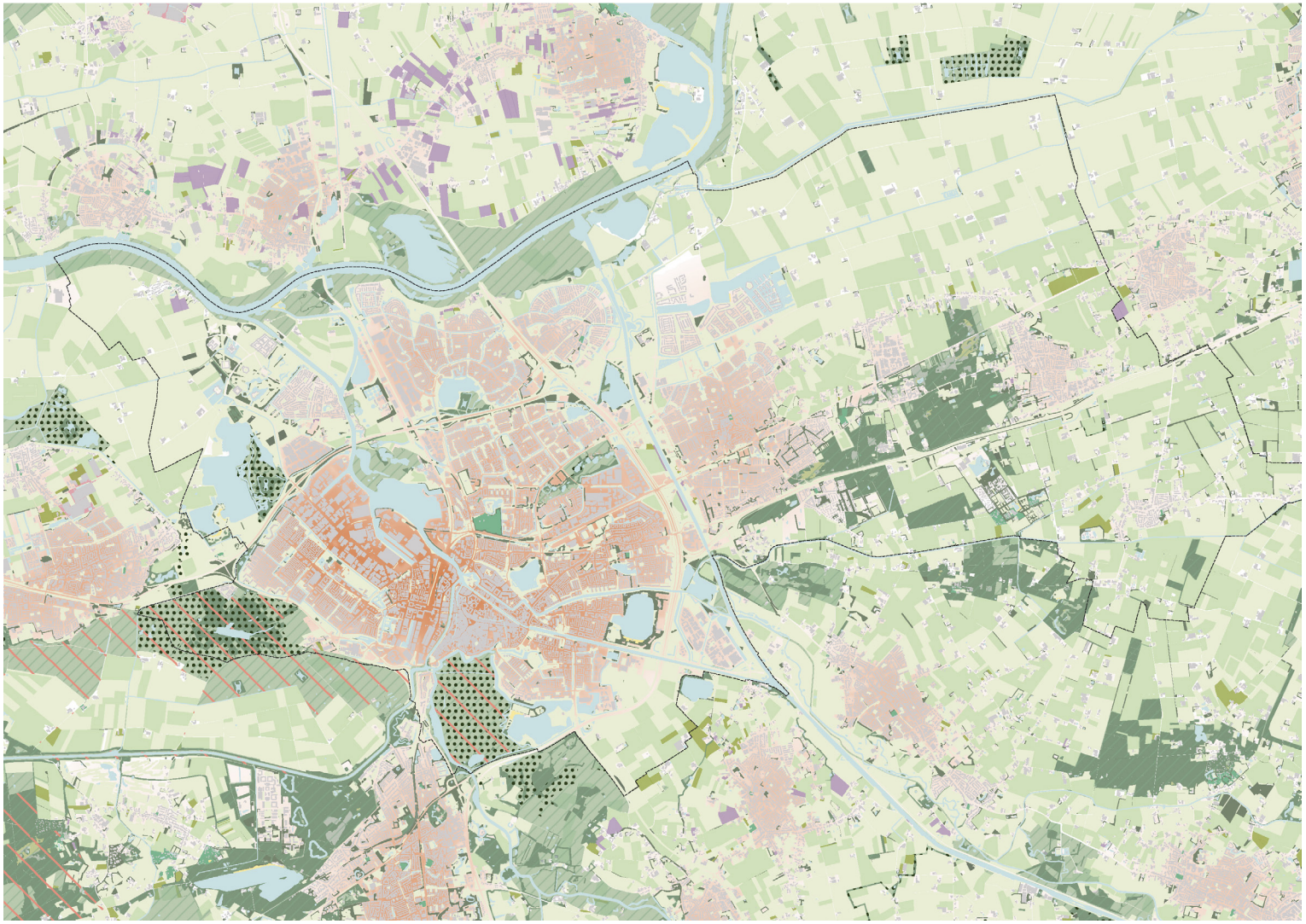


Figure 3.13 *Urban heat effect in Den Bosch (data source: PDOK NL& Klimaateffectatlas NL, 2021. Made by author)*

The city area is also facing the problem of urban heat effect, especially in the old city center and the neighborhoods surround it (Figure 3.13). This is due to the lack of green spaces in the city to help absorb the heat and provide sheltering areas.

Livability of neighborhood

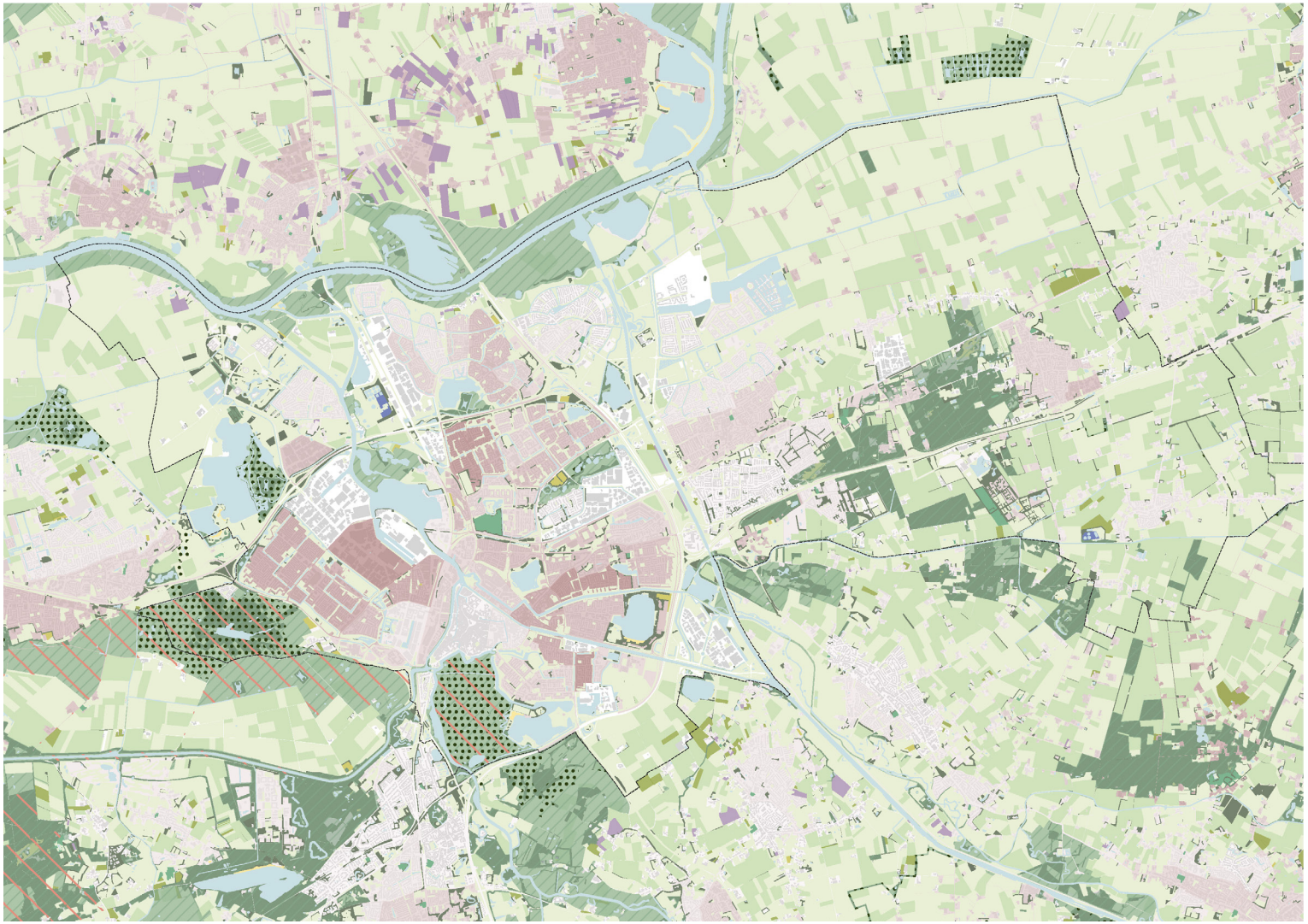


Figure 3.14 *Livability of neighborhood in Den Bosch (data source: CBS, 2021& PDOK NL, 2021. Made by author)*

Some neighborhoods in Den Bosch do not have a good livability, especially in the darker red areas (Figure 3.14). Factors that affect livability include many social and economic aspects, but spatial quality is also an important factor that influence the livability. Better spatial quality with more recreational green spaces can help to improve the livability.

Design Assignments

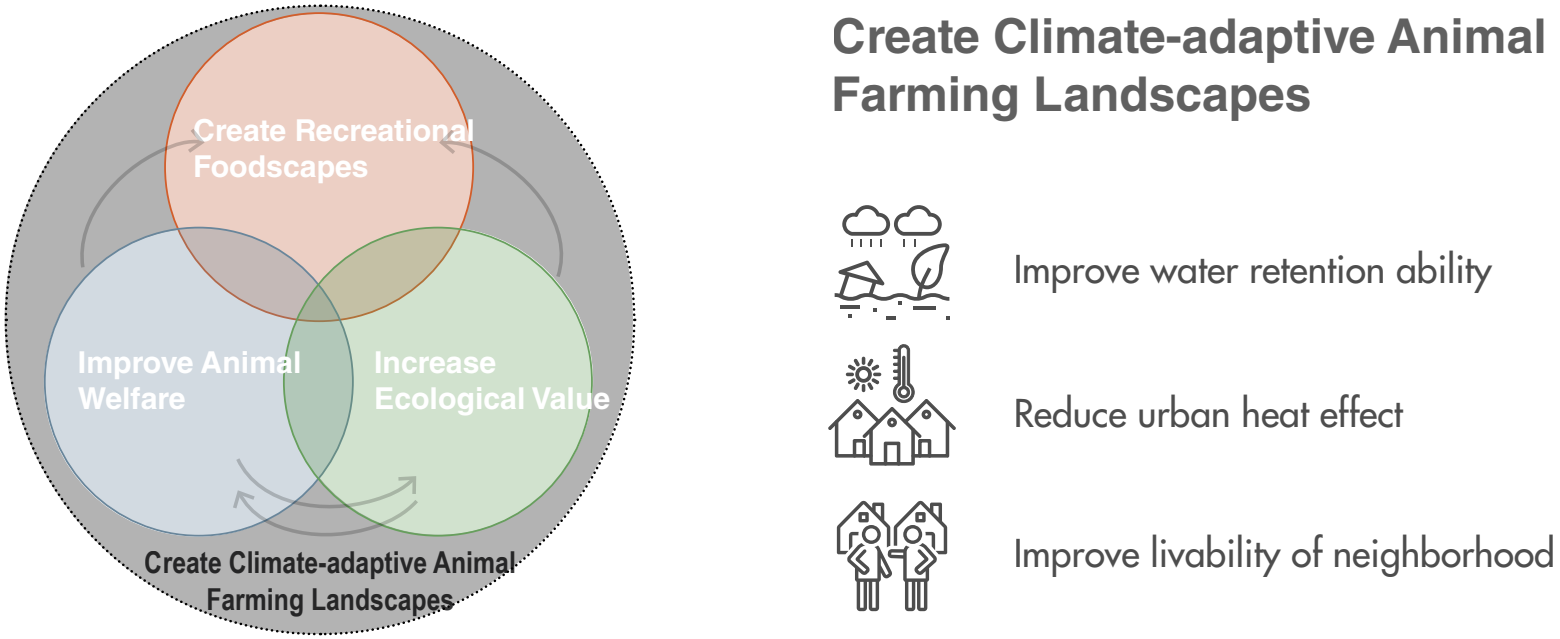


Figure 3.15 *Specific design assignments for 'Create climate-adaptive animal farming landscapes' (made by author)*

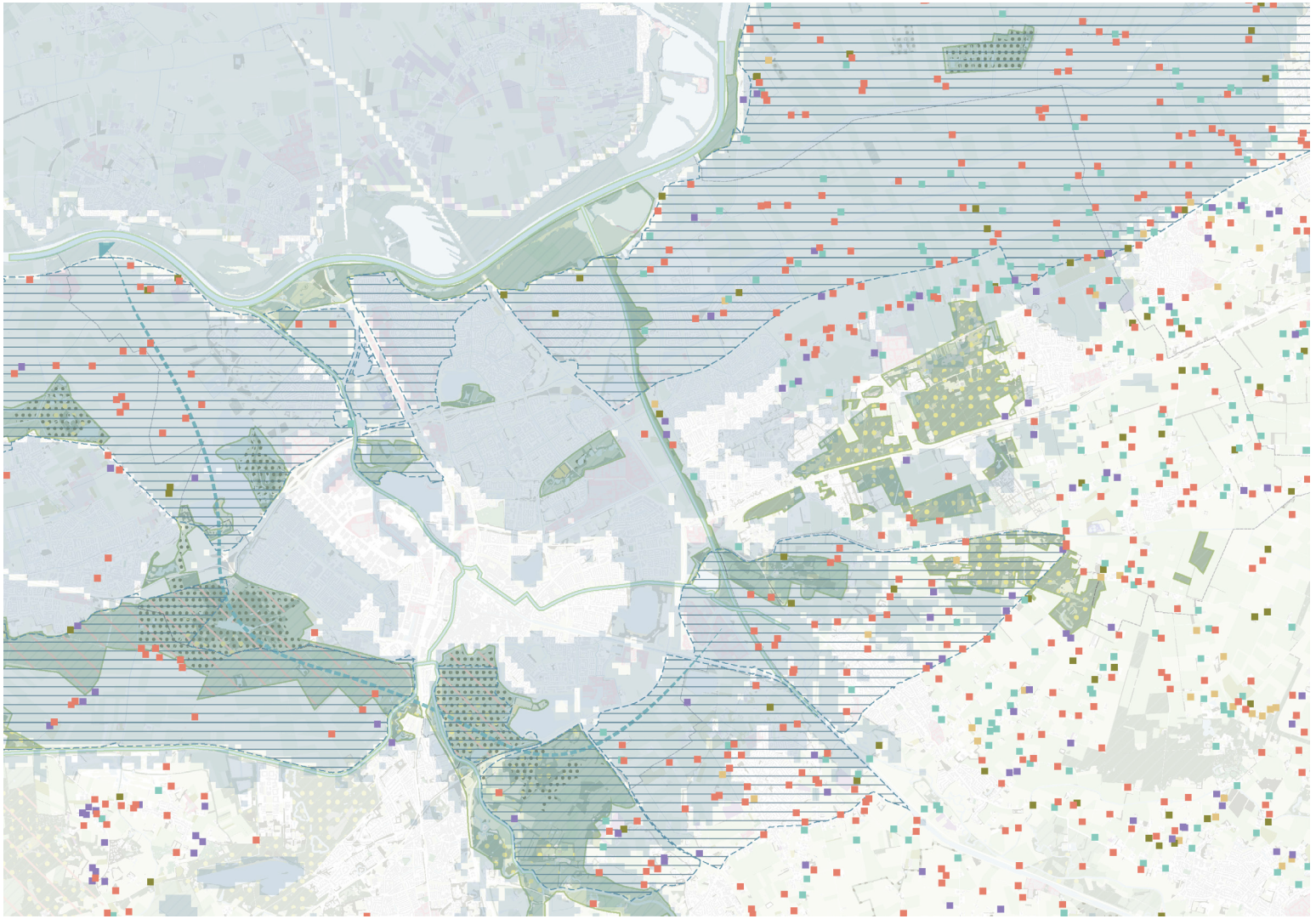
Based on what have been analyzed above, in order to create climate-adaptive animal farming landscapes (Figure 3.15), the water retention ability of animal farmlands should be improved to resist with the flooding risks. More green foodscapes could be added in the neighborhood to reduce urban heat effect and improve the livability of neighborhood.

CHAPTER 4: VISION

Based on a set of site analyses in the previous chapter, a synthesis of related analyses is made in order to provide a basis for visions of city-scale and neighborhood scale. The vision for the city scale mainly has two directions, one is to create sustainable animal farmlands with improved water retention ability and another is to create recreational animal farming foodscapes and thoughtscapes. The potential productive areas in the neighborhood are found out to improve the green structure of the neighborhoods.

The leading research questions in this chapter include:
Sub-RQ 9*: - How could the animal farming landscapes help to mitigate the recreational pressure of De Moerputten?*
Sub-RQ 12*: - Which areas have the high demand for improving animal farming there in order to improve the green structure of Den Bosch region?*

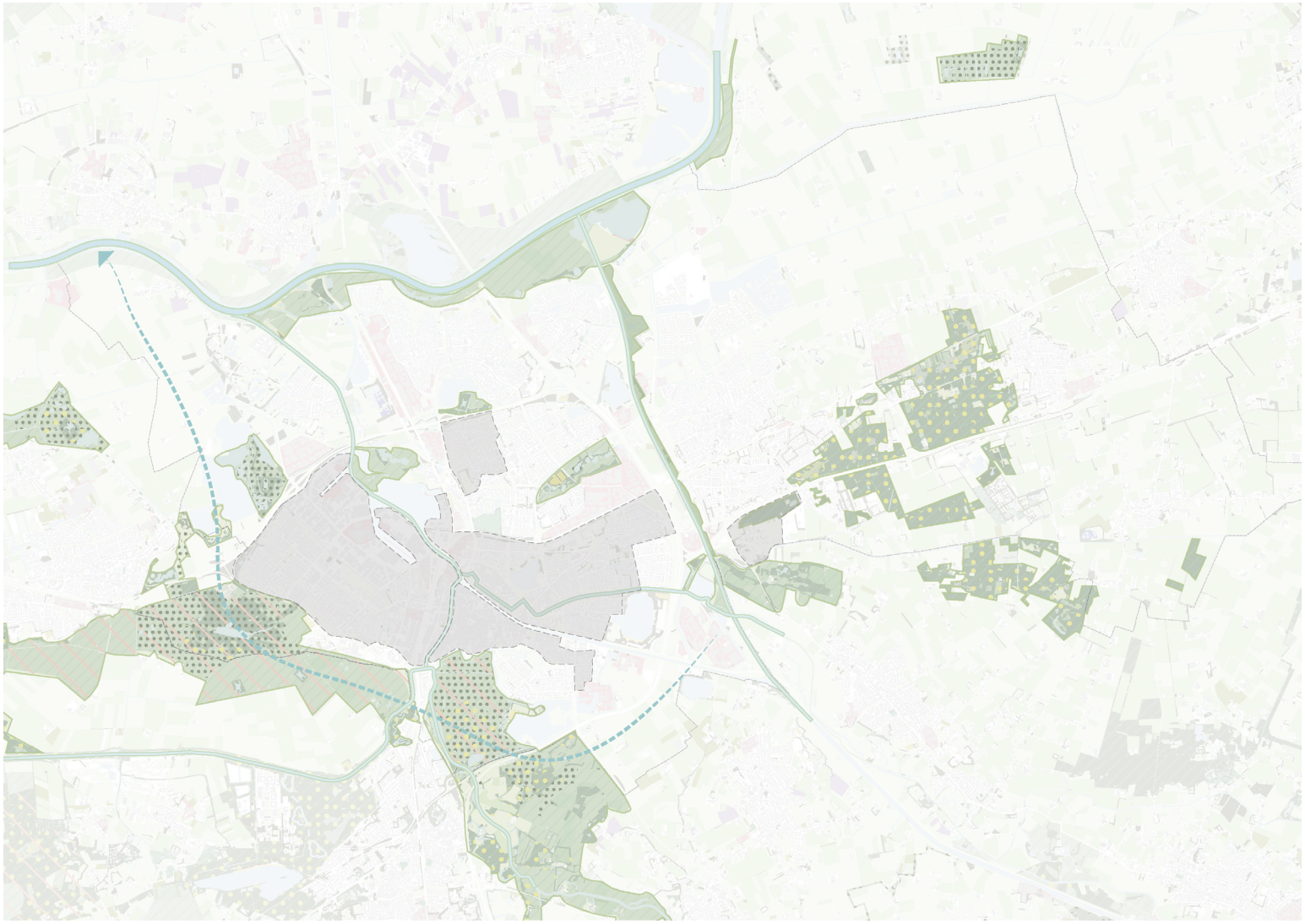
Synthesis Flooding Risk + Heritage + Stock Farms + Green Plan



Firstly, the flooding risk map, the inundation heritage map, the current stock farm map and the green plan from the municipality are synthesized in order to find out the possible areas which could become sustainable animal farmland landscapes with high water retention ability.

Figure 4.1 *Synthesis Flooding risk + Heritage + Stock farms + Green plan. (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. Klimaateffectatlas NL, 2021. Georegister provincie Noord-Brabant, 2021. Made by author)*

Synthesis of Neighborhood Livability + Urban Heat Effect + Green Plan



Then the neighborhood livability map, the urban heat effect map and green plan are synthesized in order to find out the neighborhood areas which have high demand for green foodscapes (Figure 4.2).

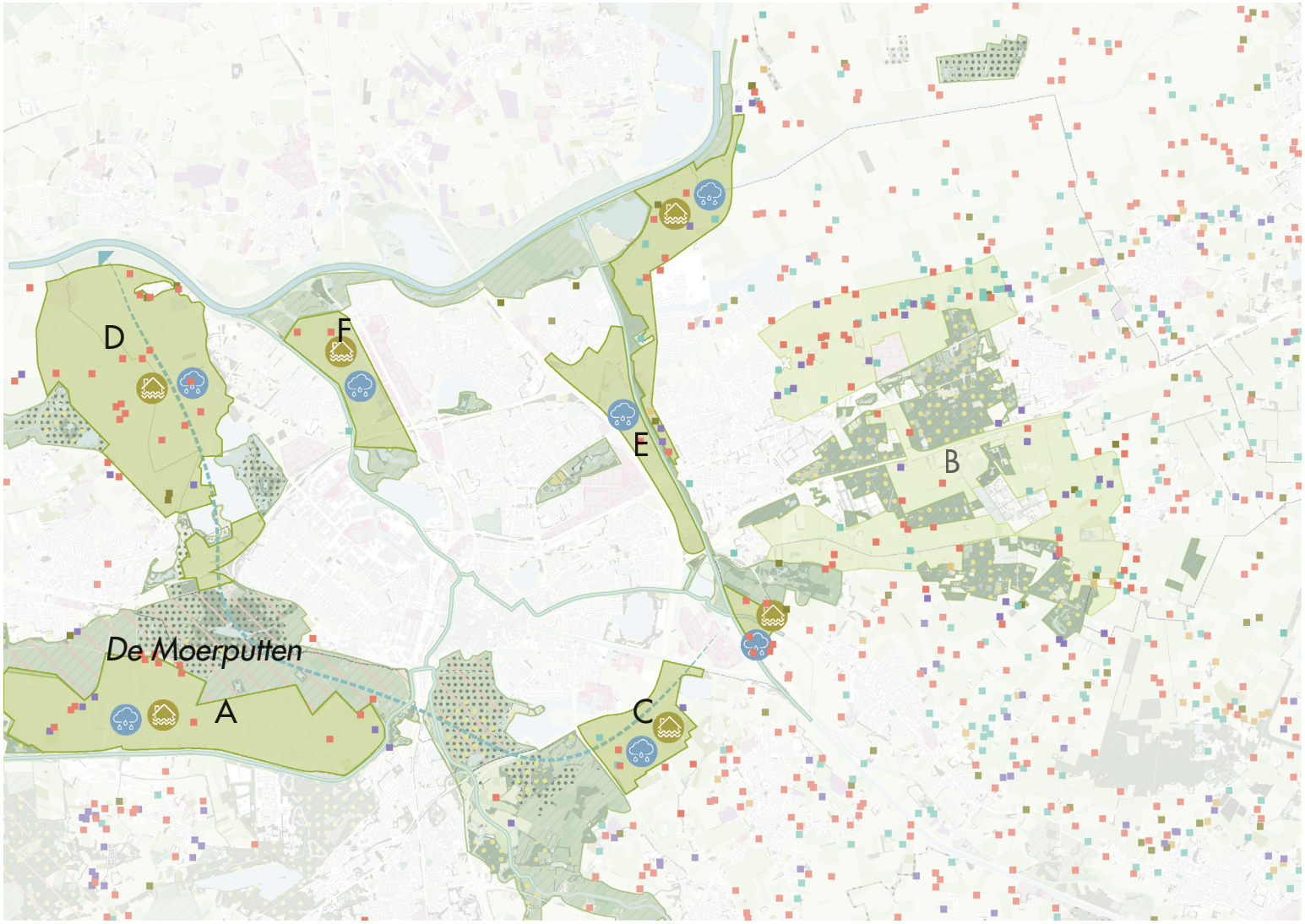
Figure 4.2 *Synthesis of Neighborhood Livability + Urban Heat Effect + Green Plan. (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. CBS, 2021. Made by author)*

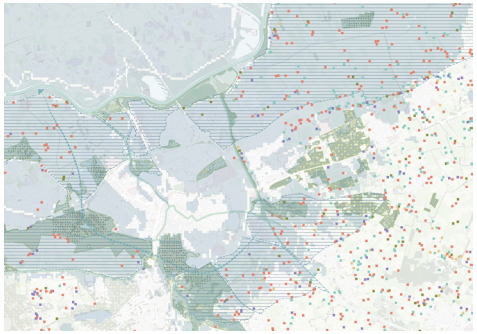
Sustainable, Nature-inclusive Animal Farmlands --- Regional Scale Vision

Based on the previous synthesis maps, the light green areas are the animal farmlands that need to be more sustainable and nature-inclusive (Figure 4.3). The animal farms in Area A near the current Nature 2000 area need to be more sustainable and nature-inclusive in order to reduce the damage of N towards De Moerputten. The animal farmlands in Area C, A, D need to be improved in order to conform with the 'Green River' plan from the municipality. The Area B is near the current natural forest area, this natural forestry has a high ecological sensitive, so the animal farms in the Area B need to be more sustainable and nature-inclusive. Besides, the animal farms in the Area E and F also should be improved to make current green structure more connected.

Figure 4.3 *Sustainable, Nature-inclusive Animal Farmlands --- City Scale Vision (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. Georegister provincie Noord-Brabant, 2021. Made by author)*

Sustainable Animal Farmlands with Water Retention Ability --- Regional Scale Vision





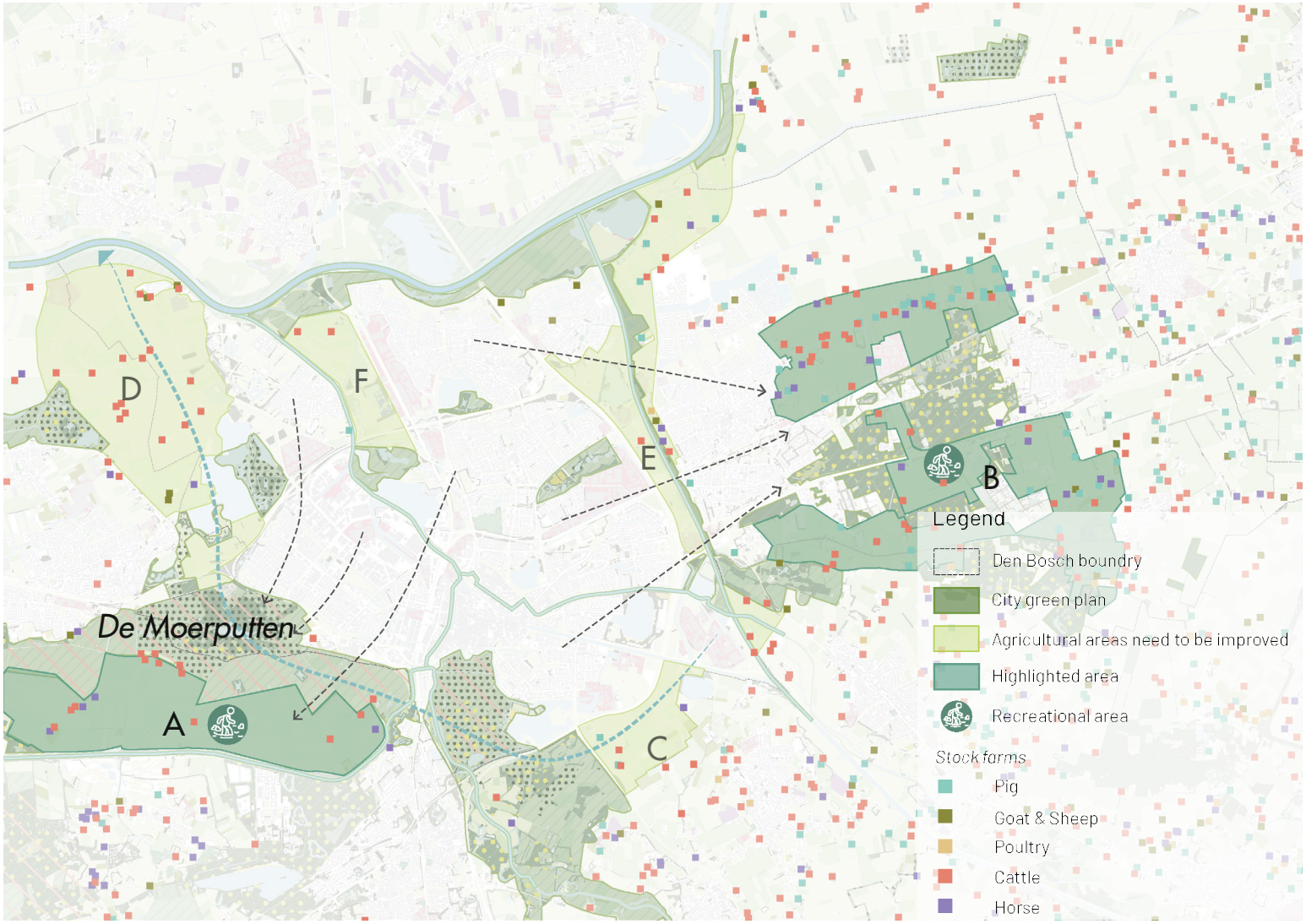
The animal farms in the highlighted green areas (Figure 4.4) are required to improve their water retention ability combined with inundation heritage.

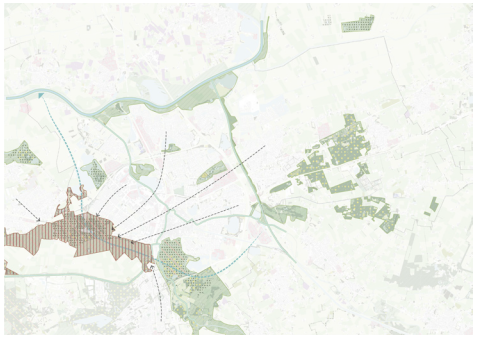
Legend
- Den Bosch boundry
- City green plan
- Agricultural areas need to be improved
- Highlighted area
- Inundation area
- Flooding area

Stock farms
- Pig
- Goat & Sheep
- Poultry
- Cattle
- Horse

Figure 4.4 *Sustainable Animal Farmlands with Water Retention Ability --- City Scale Vision (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. Klimaateffectatlas NL, 2021. Georegister provincie Noord-Brabant, 2021. Made by author)*

Recreational Animal Farming Foodscapes and Thoughtscapes --- Regional Scale Vision

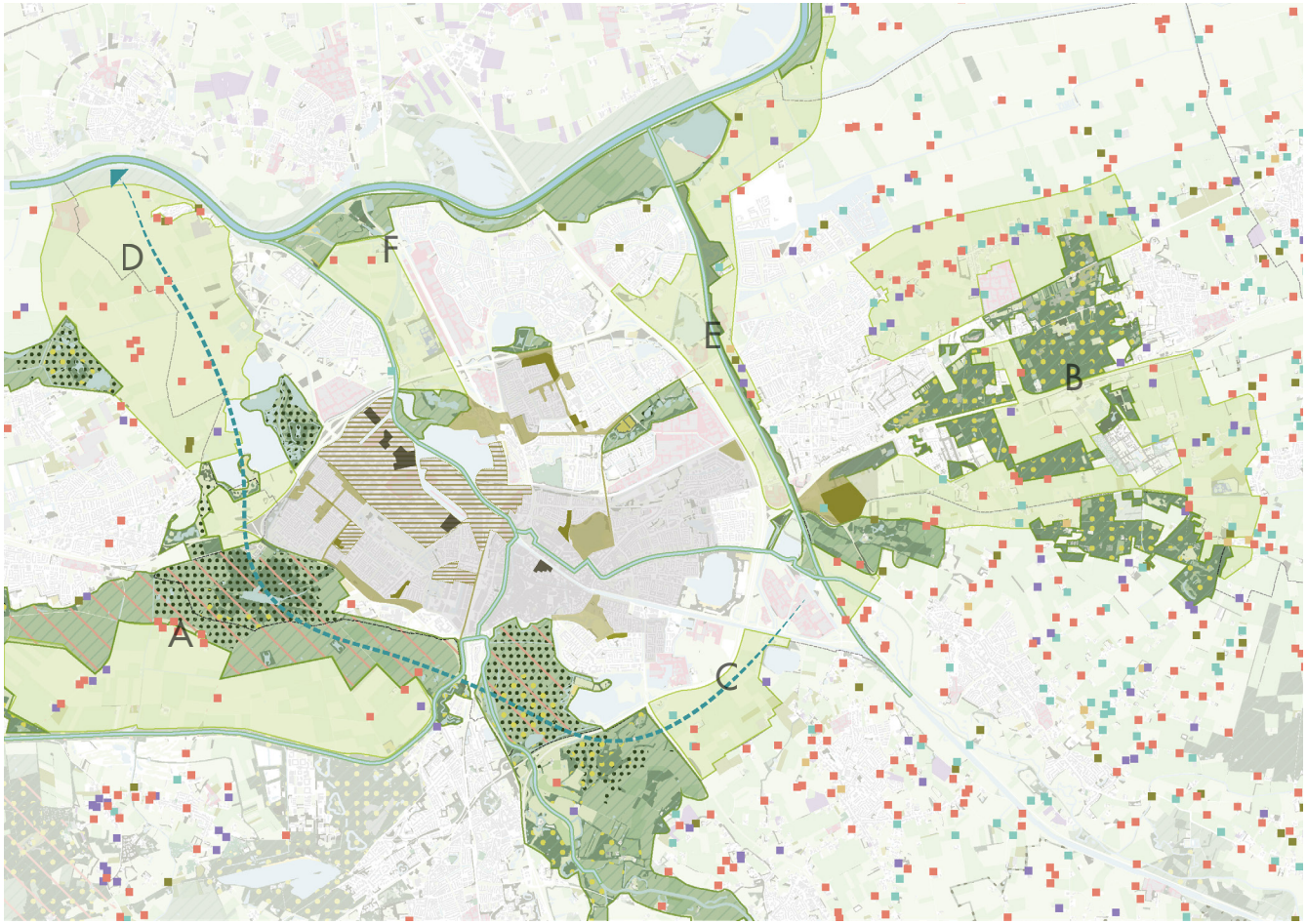




Since the high recreational pressure in De Moerputten, the building up of sustainable, nature-inclusive animal farming landscapes in Area A could help to reduce the recreational pressure of De Moerputten. Besides, since there are already some natural resources in the eastern forestry areas, it has a great potential of developing attractive animal farming landscapes in Area B to help to divide the flows of people towards De Moerputten (Figure 4.5).

Figure 4.5 *Recreational Animal Farming Foodscapes and Thoughtscapes --- City Scale Vision (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. Georegister provincie Noord-Brabant, 2021. Staatsbosbeheer NL,2021. Made by author)*

Potential Productive Areas --- Neighborhood Scale



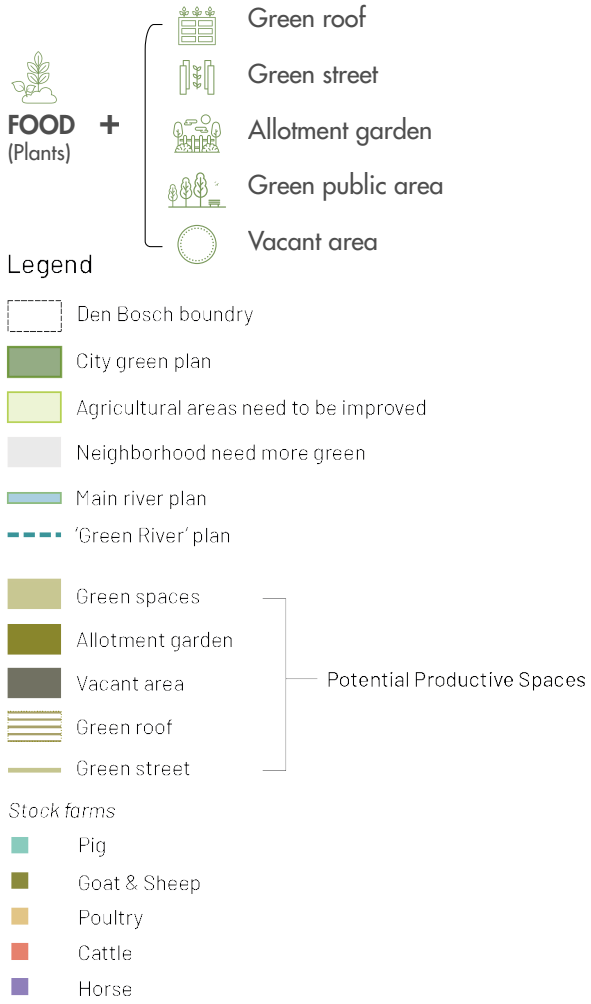


Figure 4.6 *Potential Productive Areas --- Neighborhood Scale (data source: PDOK NL 2021, GEMEENTE 'S-HERTOGENBOSCH, 2014. Georegister provincie Noord-Brabant, 2021. Made by author)*

As for the vision in neighborhood scale (Figure 4.6), since it's hard to raise food animals in the neighborhoods. In order to make people more connected and involved in the animal farming, the neighborhoods could help to provide raw materials for making the animal feeds or the bio fertilizers. Combining 'Food' with green roof, green street, allotment gardens, green public areas and vacant areas in the city, these potential productive areas could function as green foodscapes to improve the livability and reduce the urban heat effect of the neighborhoods.

Figure 4.7 *Scenarios of Potential Productive Areas in Neighborhood (source: image a from Brie Arthur, 2020. Image b from Mariska, 2012. Image c from Foodplaces, 2018. Image d from HERE COMES THE SUN, 2022)*

- Raw materials for animal feeds
- Green wastes for bio fertilizer

Scenarios of Potential Productive Areas in Neighborhood

Here are some images (Figure 4.7) that show the different types of potential productive areas in the neighborhoods. The plant wastes from these local foodscapes could be the raw materials for animal feeds. When these green wastes are mixed with animal manure, a bio fertilizer could be created thus make the animal farming more sustainable. Small food animals such as chickens can also be raised in the urban context.

The green foodscapes can help to make the neighborhood more active and improve livability of neighborhoods. Besides, they can also reduce urban heat effect in the city and increase more permeable surfaces in the urban context.

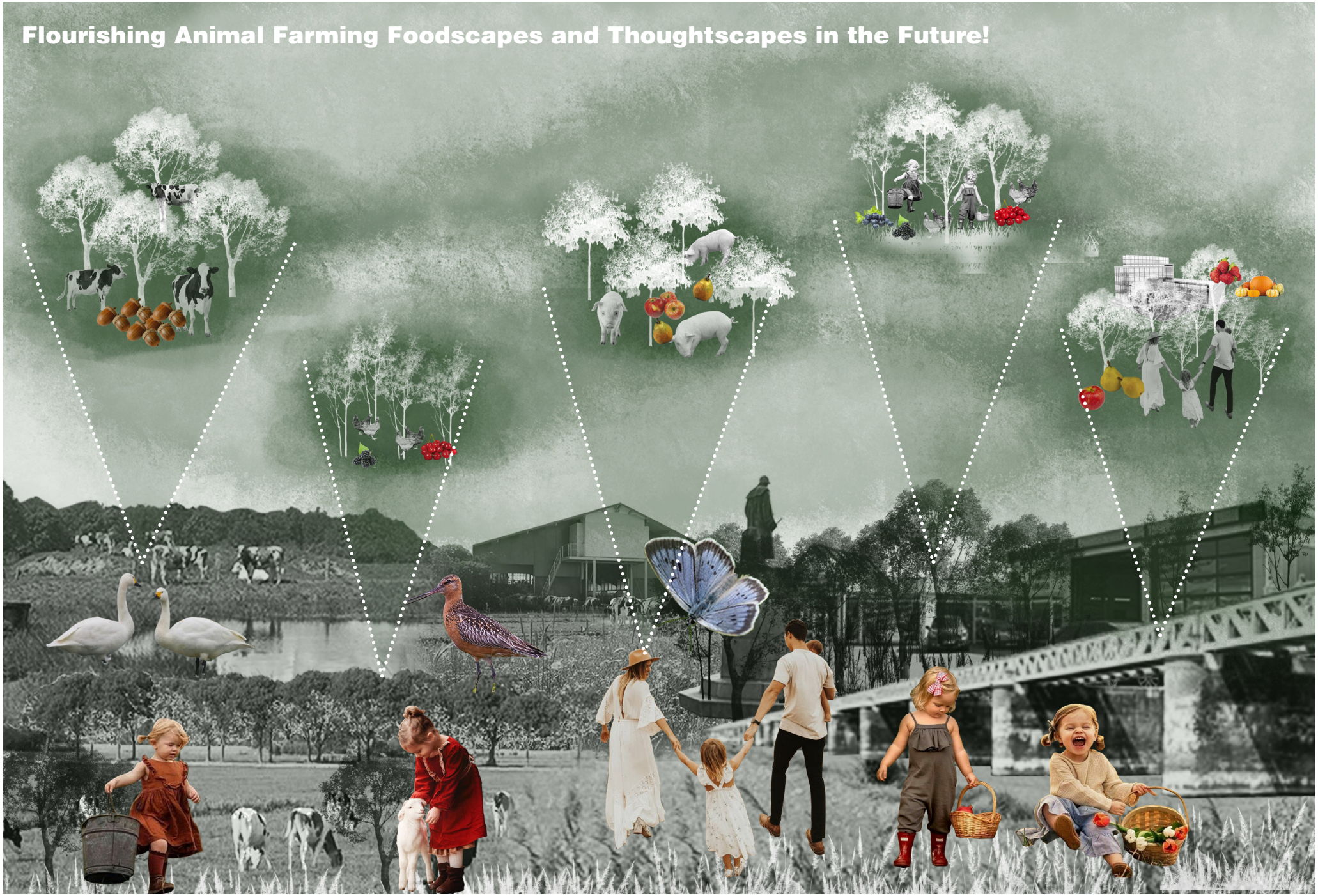


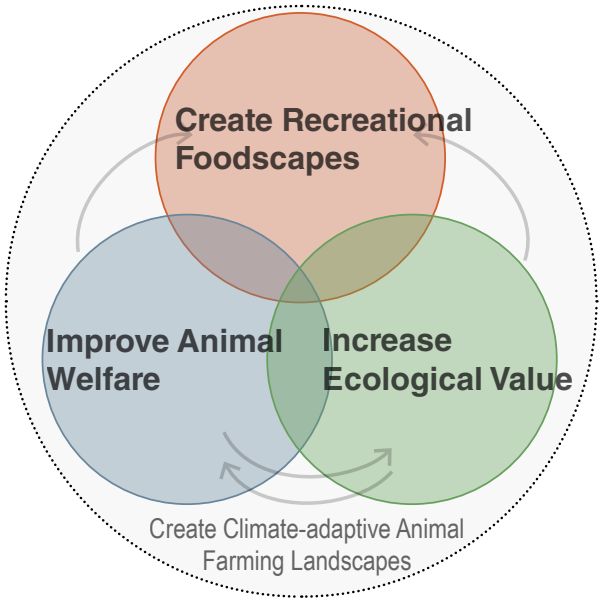
Figure 4.8 *Visions for future scenarios (made by author)*

CHAPTER 5: DESIGN PRINCIPLES

With the visions achieved in the previous chapter, detailed design principles are proposed and linked with each detailed specific design assignment in this chapter, to correspond and be consistent with the visions. These design principles also assist the further design explorations on specific design sites. The transformation strategies of current intensive animal farming density to a more eco-friendly level of stock density are studied and presented as well in this chapter.

This chapter dedicates to answering the following research questions:
Sub-RQ 1*: - How to realize the nutrient cycle and reduce pollution within the areas through landscape design?*
Sub-RQ 3*: - What is the good assemblage of multi-species food animals in the landscape that can maximize the land?*
Sub-RQ 4*: - How to transform current intensive animal farming to a more eco-friendly level through landscape design?*
Sub-RQ 5*: - What kind of environment can be the baseline for food animals to be able to behave naturally and create living environments by themselves?*
Sub-RQ 6*: - What types of vegetation in landscape design can be the desirable natural diets for food animals at different seasons?*
Sub-RQ 8*: - What landscape architecture design principles can establish the connection between consumers and food animals?*
Sub-RQ 10*: - How to bring back/reshow some characteristics of historical farmlands through landscape design?*
Sub-RQ 11*: - What are the climate-related problems in Den Bosch region currently and how animal farming landscapes can react to them?*

Aims & Design Assignments



Increase Ecological Value

- Nitrogen circulation
- Sustainable animal farming
- Increase biodiversity

Improve Animal Welfare

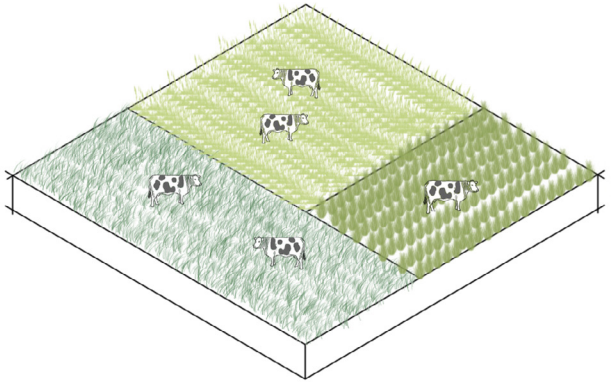
- Improve living environment
  Allow natural animal behaviors
- Supplementary diverse diets

Create Recreational Foodscapes

- Reshow heritage & historic characteristics
- Connect consumers with food animals

Create Climate-adaptive Animal Farming Landscapes

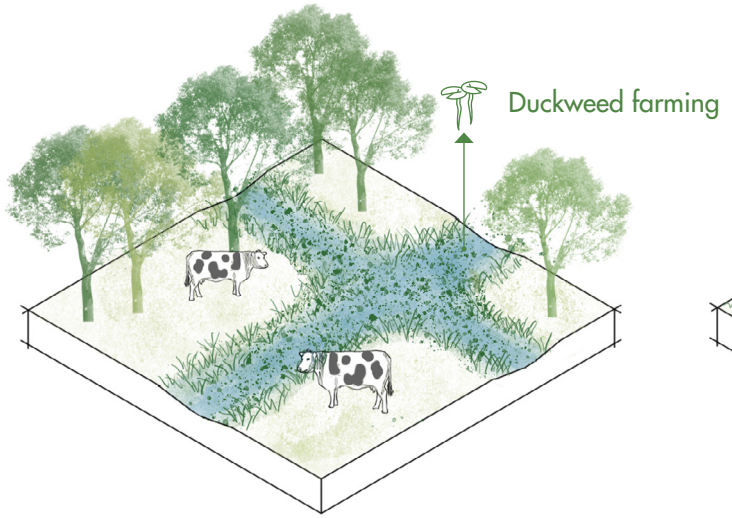
- Improve water retention ability
- Reduce urban heat effect
- Improve livability of neighborhood



Green Cover with Green Manure

After harvesting the crops, grow nitrogen-fixing crops such as clovers, alfalfa and legumes can contribute to nutrient build-up in the soil. Combining it with grazing animals to spread manures on the soil will help to recover and improve the soil quality. (Landbouw met natuur, 2022)

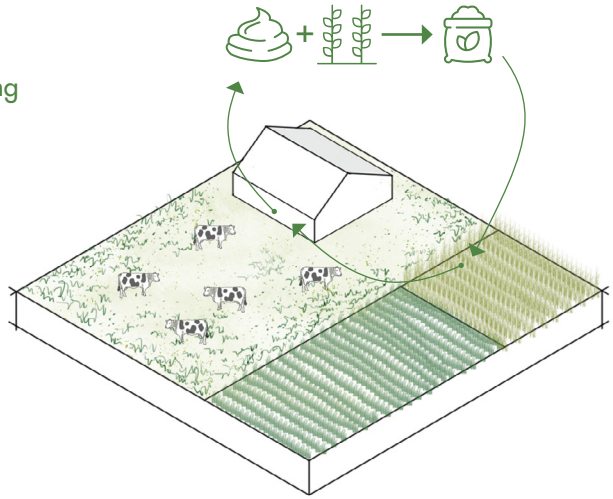
Stakeholders related: Farmer; Ecologist; Agronomist



Diverse Supplementary Diets

Animal feed and fodder can grow in wet places, such as duckweed on the water surface, which is a good natural animal protein. Plants can take up nitrogen. When digested by the animals, animals will return the manures to fertilize the soil. In this way, the Nitrogen is recycled. (Cloarec, 2018)

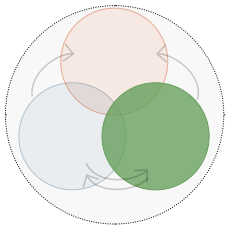
Stakeholders related: Farmer; Ecologist; Agronomist



Manure Management with Cropland

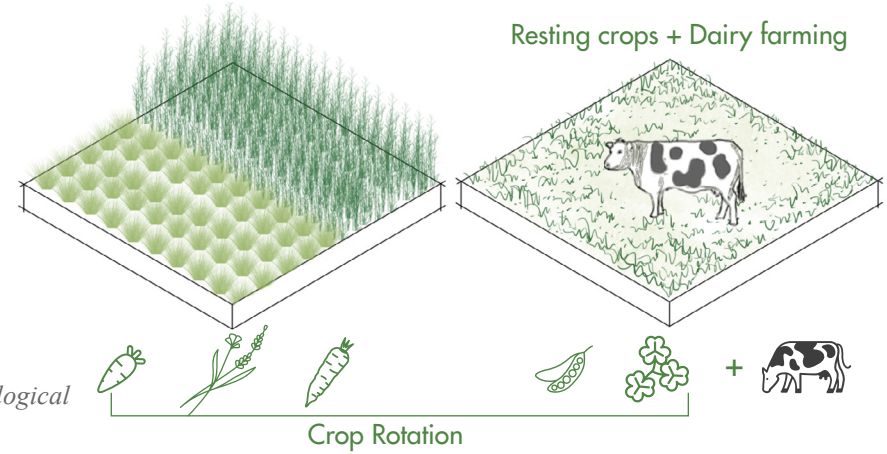
The Manures from the barns can be collected. When combined with the green waste from the croplands, a bio-fertilizer could be created. This bio-fertilizer could be reused on the croplands. This way helps to realize the circulation of Nitrogen and helps farmers to save the money for buying the fertilizer.
(Landbouw met natuur, 2022)

Stakeholders related: Farmer; Agronomist



Increase Ecological Value

Nitrogen Circulation

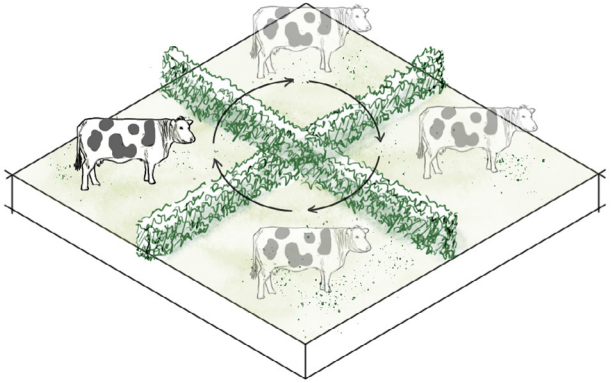


Wide Crop Rotation

Growing different kinds of crops sequentially on the same plot. Plant crops like carrots, parsnips, and cereals, as well as resting crops like clover and legumes that fix nitrogen in the soil. When growing resting crops, dairy farming could be included to help improve the health of soil together. (PSCI, 2020)

Stakeholders related: Farmer; Agronomist

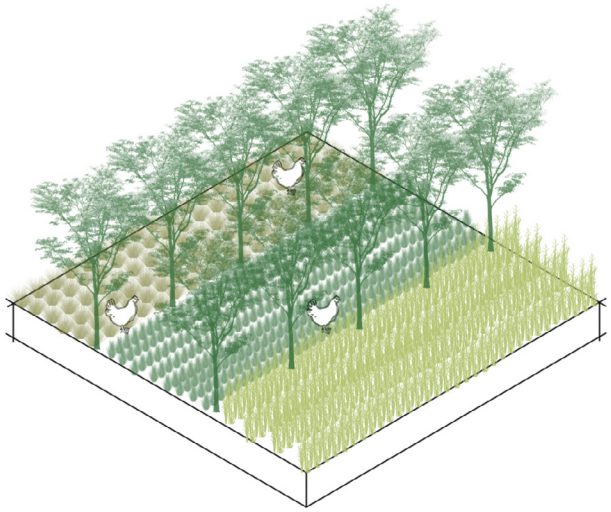
Figure 5.1 *Design principles for 'Increase Ecological Value- Nitrogen circulation' (made by author)*



Rotational Grazing

The whole pasture is divided into several smaller areas, which used to be referred as 'paddocks'. Livestock graze on one of the paddocks at a time while the remainder paddocks 'rest'. In this way, the soil and pastures will not be overburdened and have time to recover. (Smith et al., 2011)

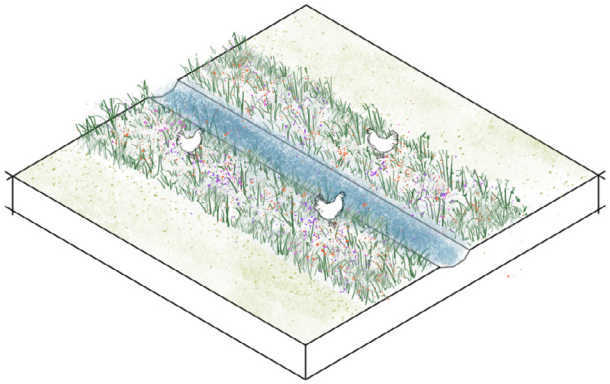
Stakeholders related: Farmer; Agronomist



Strip Farming with Chickens

Chickens are natural pest controllers on farmland and orchards. Therefore, the use of additional artificial fertilizers can be reduced to protect the environment. These insects are very good protein for chickens, which will then be converted into eggs for people. (Landbouw met natuur, 2022)

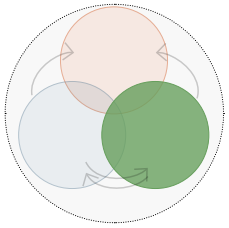
Stakeholders related: Farmer; Agronomist



Flower Strips with Poultry Farming

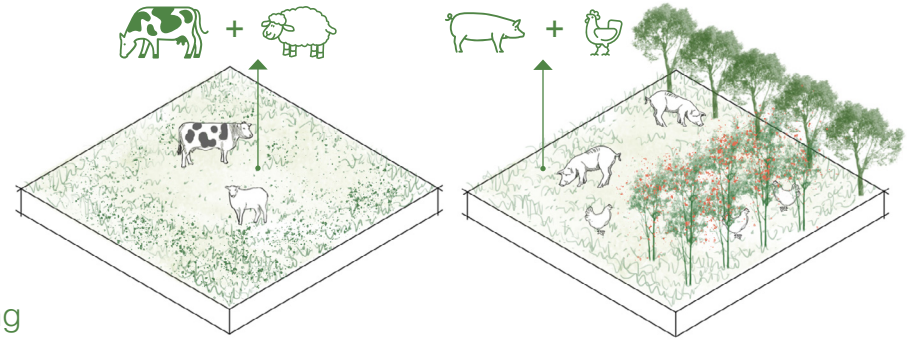
Herb-rich fields and strips can be added along the ditch. They will increase biodiversity and attract natural pollinators. They also create buffer zones between plots and ditches, which will improve water quality. Poultry can be included because of the abundant insects in these flowery strips. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Ecologist



Increase Ecological Value

Sustainable Animal Farming



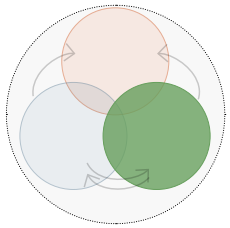
Multi-species Animal Farming

Cattle and sheep make a great group because they like to eat different parts of plants and maximize the use of grass if they are raised together. Simultaneous grazing of sheep and cattle also provide suitable habitats for butterflies. (Martin et al., 2020)

Pigs and chickens are also a good group with fruit trees. They provide symbiotic benefits to each other. For example, chickens are natural pest controllers for pigs and fruit trees. Pigs can provide food for chickens by rooting insects out of the soil and also protection for chickens. (Abel, 2022)

Stakeholders related: Farmer; Agronomist

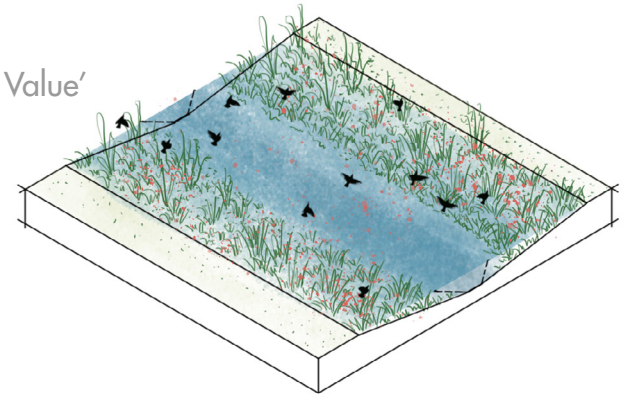
Figure 5.2 *Design principles for 'Increase Ecological Value- Sustainable animal farming' (made by author)*



Increase Ecological Value

Improve Biodiversity

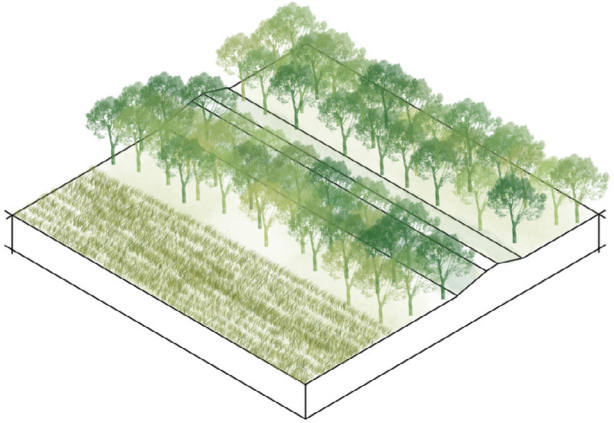
Figure 5.3 Design principles for 'Increase Ecological Value- improve biodiversity' (made by author)



Nature-friendly Water Bank

Widen the ditches with enlarged banks. A variety of plants grown along the banks help to increase biodiversity. Plants can also absorb nitrogen from the water, thus improving water quality. (Hollands Noorderkwartier, 2022)

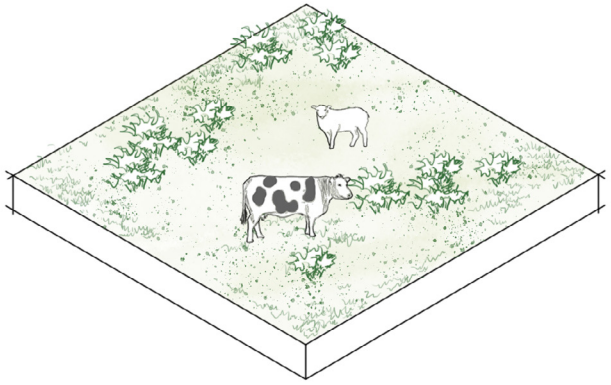
Stakeholders related: Farmer; Ecologist; Waterboard



Local Nature as Green Connection

Local nature has a great potential to increase local biodiversity. The local nature can be brought back to connect the site with surrounding natural resources. Together with main ditches, the green-blue network can be established. (WUR E-depot,1975)

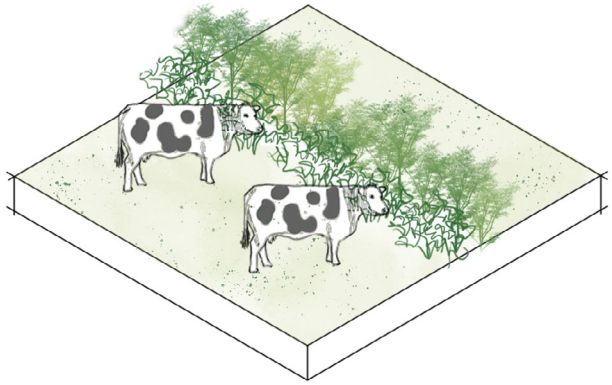
Stakeholders related: Farmer; Ecologist; Staatsbosbeheer



Nature-oriented Mowing with Grazing

Heavy duty mowers can endanger life in soil and vegetation. Instead, livestock can help mow grass through their natural "grazing" behavior, while they also spread natural fertilizers across the grasslands. (Ecopedia, 2022)

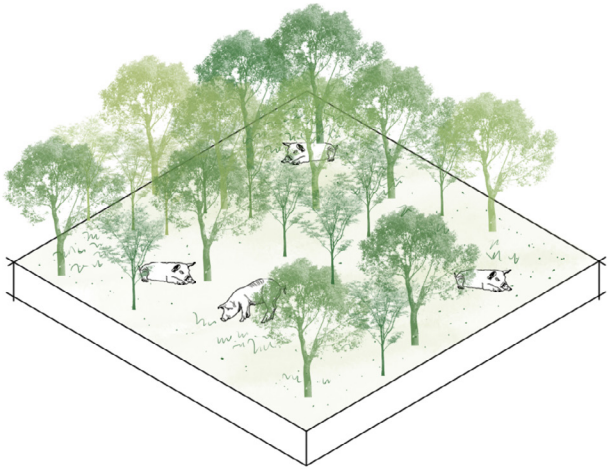
Stakeholders related: Farmer; Ecologist



Natural Fences

Instead of using artificial iron or wooden fences, the hedgerow with some forestry edges can be used to help increase the biodiversity. The hedgerows are also one of the characteristics of historical farmland, forming a beautiful agricultural landscape. (The USDA National Agroforestry Center, 2013)

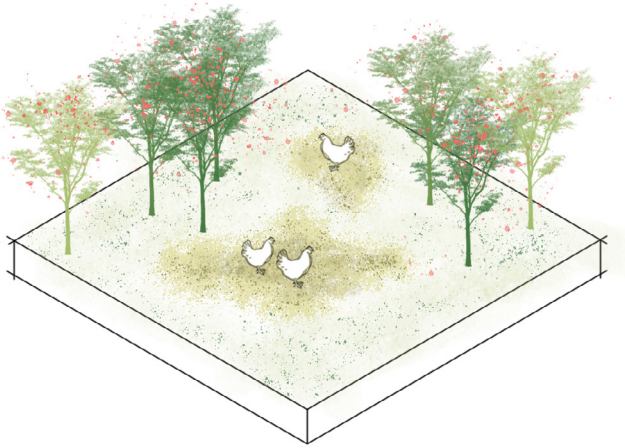
Stakeholders related: Farmer; Ecologist



Trees for Sheltering

Shade from trees can provide shelter for animals, especially during the hot summer months. A cool environment is very important for pigs as they do not have functional sweat glands. This inability to self-cool can quickly lead to heat stress, which can be dangerous for pigs. (Landbouw met natuur, 2022)

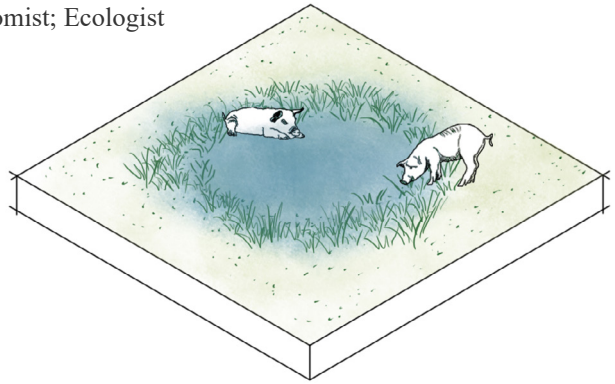
Stakeholders related: Farmer; Agronomist; Ecologist



Sand Pits for Chicken Bathing

Chickens like sand bathing just like any other bird. Sand baths are a chicken's way of keeping clean. The fine sand or dust in their bathing area keeps their feathers in pristine condition and helps them stay free of mites, lice and other parasites. (Russon, 2022)

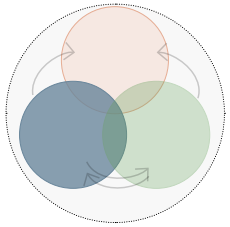
Stakeholders related: Farmer; Agronomist; Ecologist



Ponds for Drinking and Bathing

Animals need to keep themselves cool through bathing, especially in the hot summer. For instance, pigs love wallowing in the cooling mud. This way prevents them getting sunburn and keep the files and parasites off. (Blanchard, 2017)

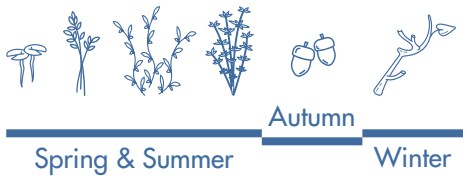
Stakeholders related: Farmer; Agronomist; Ecologist

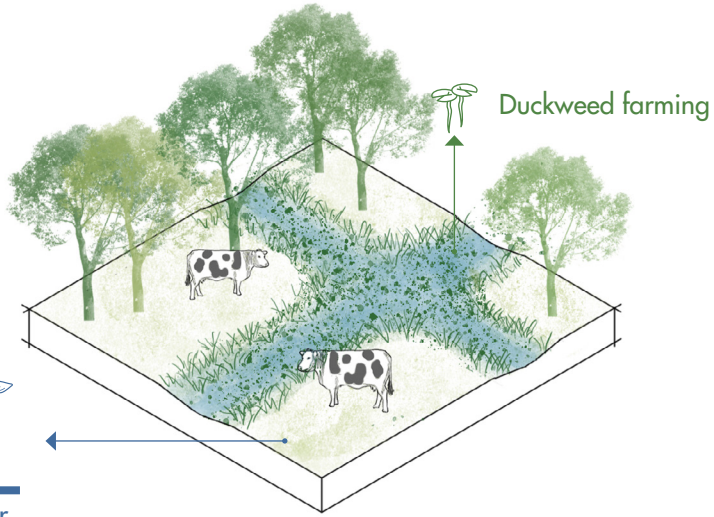


Improve Animal Welfare

Improve living environment
Allow natural animal behaviors

Figure 5.4 *Design principles for 'Improve Animal Welfare- Improve living environment& Allow natural animal behaviors' (made by author)*

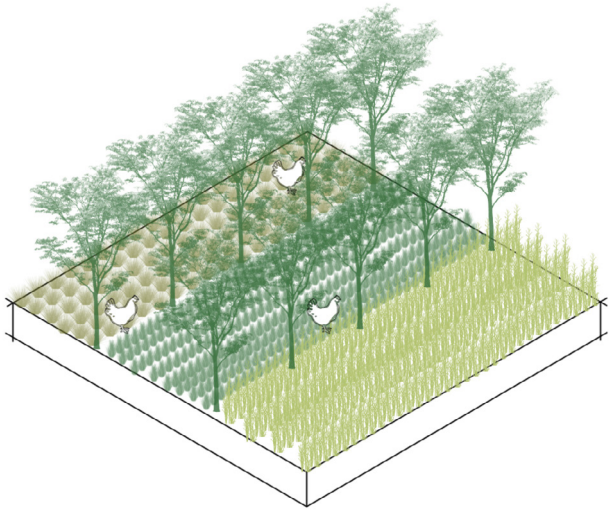




Diverse Natural Diets

Plants and duckweeds that grow in wet areas and provide natural fodder for animals mainly in spring and summer. In the fall, nut trees bring high-quality protein to the animals. The twigs of the shrub can feed livestock in winter. Therefore, a natural diet can be supplemented throughout the year. (Paridon et al., 2018)

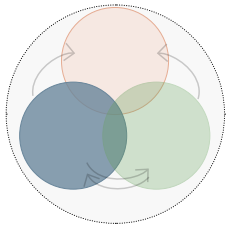
Stakeholders related: Farmer; Agronomist; Ecologist



Strip Farming with Chickens

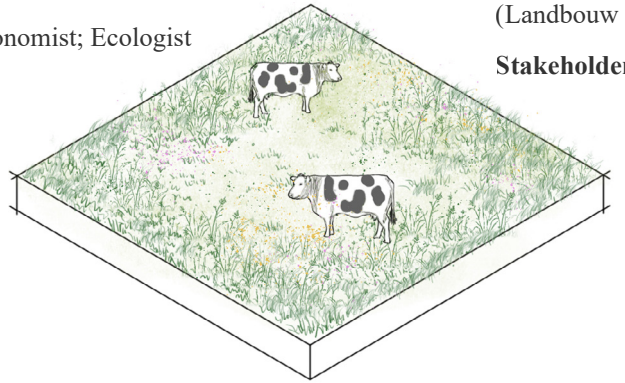
Various crops and grasses are grown on the strip plots. Between these strips, the fruit trees could be included to add diverse income. Chickens can be combined with fruit trees because the chickens can eat insects that can damage the fruit and keep the fruit healthy. The insects themselves are very good proteins for chickens. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Agronomist; Ecologist



Improve Animal Welfare

Supplementary Diverse Diets

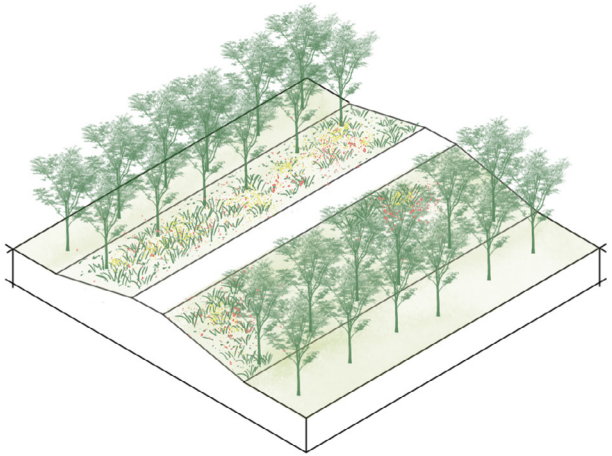


Herb-rich Grassland

Monotonous meadows form deserts for biodiversity and form a very one-sided diet for livestock. Instead, herb-rich grasslands can not only help boost biodiversity, but also ensures that the livestock get a better composition of nutrients during outdoor grazing. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Agronomist; Ecologist

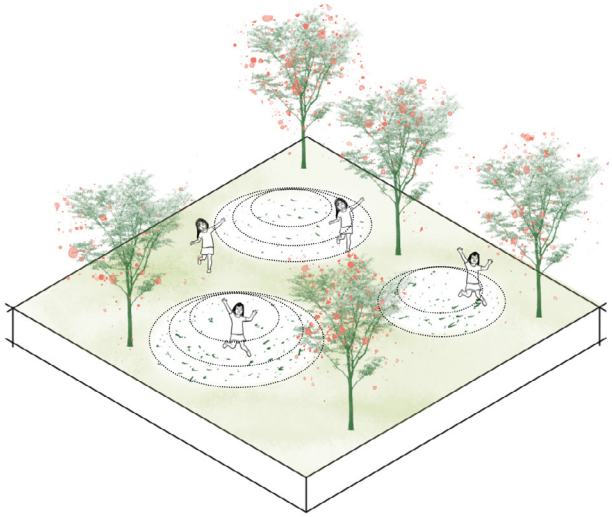
__Figure 5.5__ Design principles for 'Improve Animal Welfare-Supplementary diverse diets' (made by author)



Historical Flowery Dike

Bring back the historical dike which has the important cultural meaning behind. In order to make this kind of dike more attractive and recreational, various flowery plants can be grown along the dike, in the lower parts of the dike fruit trees can be planted.

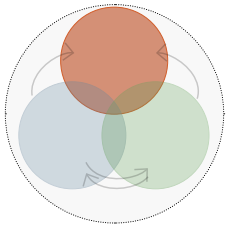
Stakeholders related: Farmer; Tourist; Ecologist



Raised 'Bolle Akker'

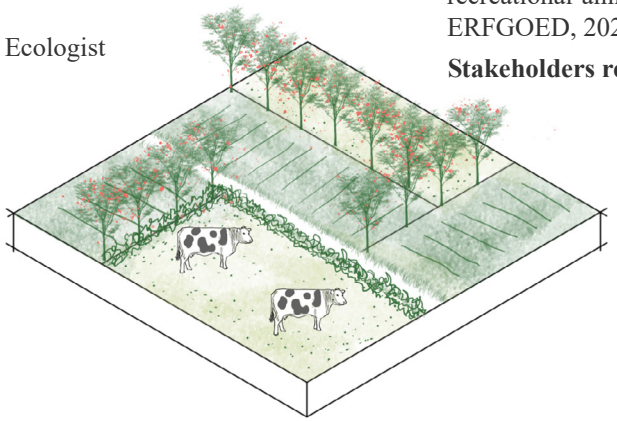
'Bolle Akker' is an ancient characteristic of historical agriculture in sandy areas. Animal manures and plant clippings are combined to fertilize the soil and raise the land. This characteristic can be reshowed in the recreational animal farming foodscapes. (BRABANTS ERFGOED, 2021)

Stakeholders related: Farmer; Tourist



Create Recreational Foodscapes

Reshow Heritage & Historic Characteristics

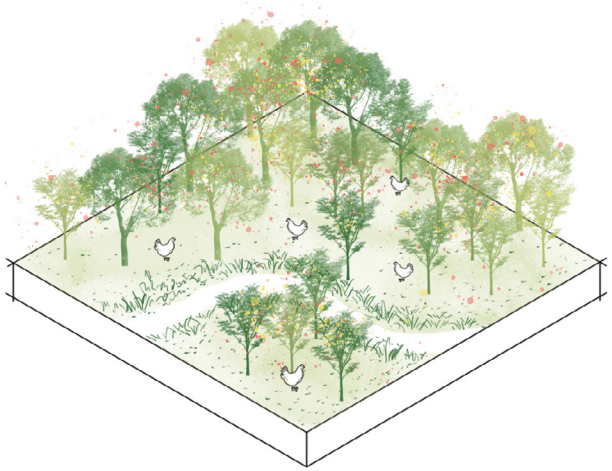


Historical Farmland Landscape

Hedges, willows, windbreaks, grass edges, etc. used to be features of historical farmland, but they have been gradually eliminated in intensive modern agriculture. These elements can be brought back to enhance and recall the local agricultural culture. (BRABANTS ERFGOED, 2021)

Stakeholders related: Farmer; Tourist; Ecologist

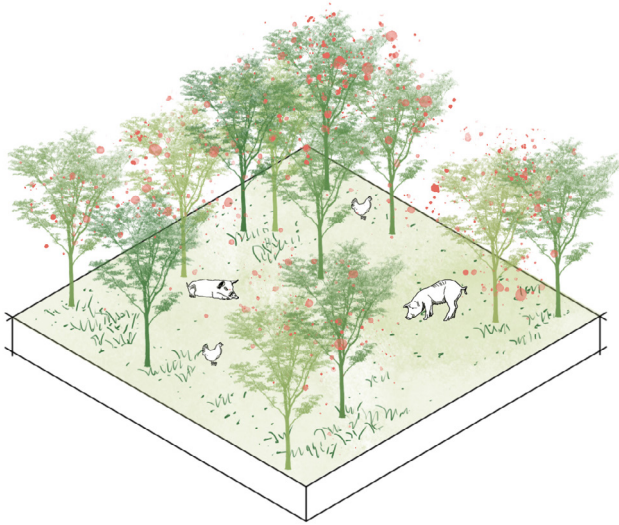
Figure 5.6 *Design principles for 'Create Recreational Foodscapes- Reshow heritage & Historic characteristics' (made by author)*



Picking Garden with Chickens

Edible species such as blueberries, hawthorn and other fruit trees can be planted in the picking garden. Chickens can be raised at the same time to control the pest naturally and keep the fruits healthy. People will see how the animals and plants work together and benefit each other.

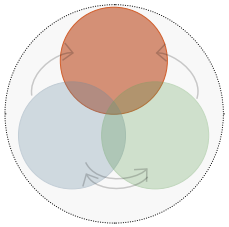
Stakeholders related: Farmer; Tourist; Ecologist



Local Traditional Breeds

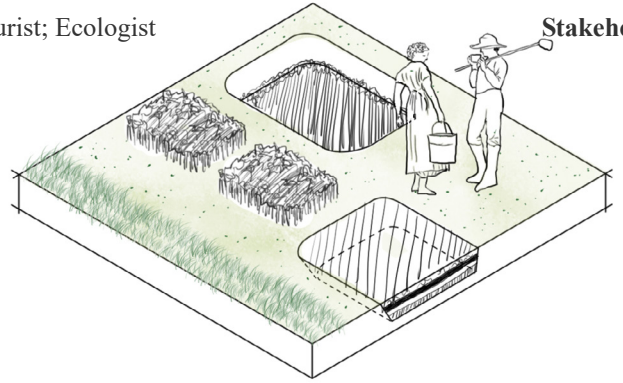
The recreational animal farming foodscapes can work as a gene pool for local traditional breeds. For example, the Dutch land pig is now endangered because of the industrial animal farming. This species can be raised and their features can be point out to let people know more about it. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Tourist; Agronomist



Create Recreational Foodscapes

Connect Consumers with Food Animals

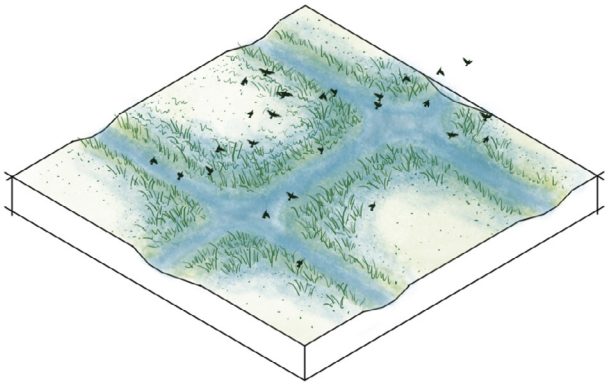


Bio-fertilizer Making

People can be involved in the making of bio-fertilizer. Through collecting different materials and spread them layer by layer, people will raise the awareness of how the Nitrogen circulate in the practical way. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Tourist; Agronomist

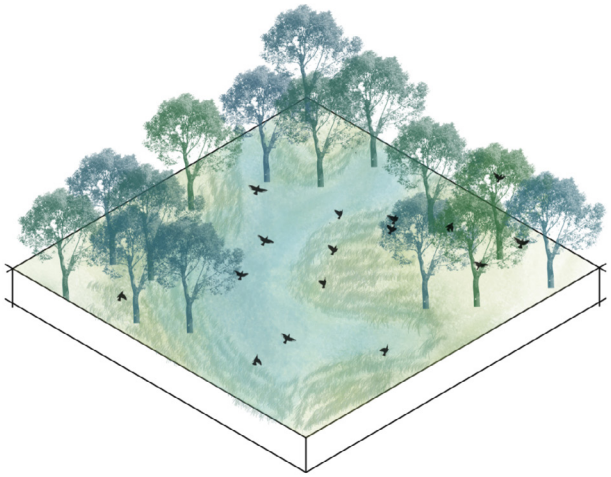
Figure 5.7 Design principles for 'Create Recreational Foodscapes- Connect consumers with food animals' (made by author)



Wide Ditch Marshes

The main ditches can be widened, the water banks can be more environmentally friendly, and various plants can be planted. Widened ditches can store more water after heavy rains, reducing the flooding pressure of Maas River. (Landbouw met natuur, 2022)

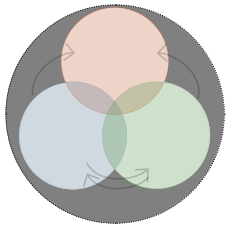
Stakeholders related: Farmer; Ecologist; Waterboard



Fen Wetlands

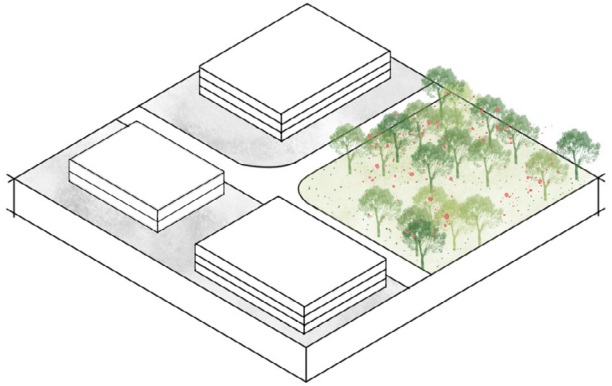
Fen wetlands are typical type of nature on the loamy/ sandy soil. They have the vegetation types such as the blue grasslands, birch-alder marsh forests etc. They are not only resilient for the high flooding risk, but also help to increase the biodiversity. (Jansen, 2022)

Stakeholders related: Farmer; Ecologist; Staatsbosbeheer; Waterboard



Create Climate-adaptive Animal Farming Landscapes

Improve Water Retention Ability

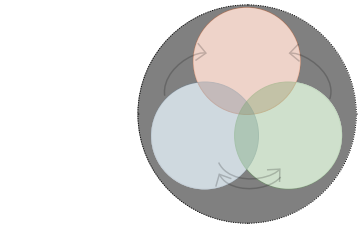


Productive Permeable Spaces

The green foodscapes can help to increase the permeable spaces in the hard urban areas. These permeable spaces will reduce the drainage pressure of the city pipes because they store and infiltrate water into the soil. (Keulen et al., 2018)

Stakeholders related: Farmer; Ecologist; Developer; Government

Figure 5.8 *Design principles for 'Climate-adaptive Animal Farming Landscapes- Improve water retention ability' (made by author)*

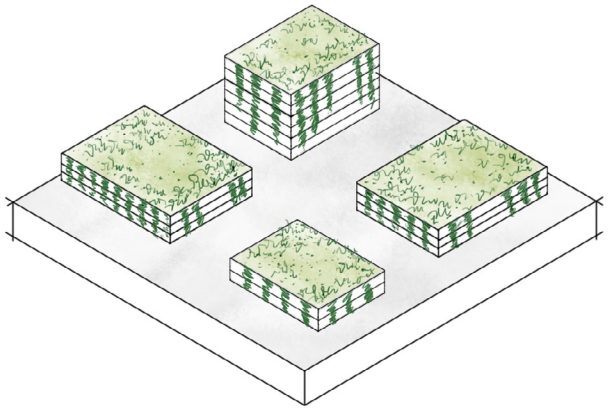


Create Climate-adaptive Animal Farming Landscapes

Reduce Urban Heat Effect

Improve Livability

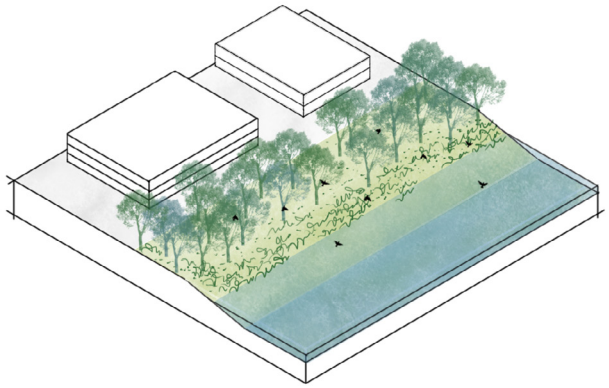
Figure 5.9 *Design principles for 'Climate-adaptive Animal Farming Landscapes- Reduce urban heat effect & Improve livability' (made by author)*



Productive Green Roofs & Vertical Greenery

The green roofs and vertical green spaces can help to absorb the heat and cool the building. The green waste from these areas can be recycled to make the biofertilizers or animal fodders. (Dubbeling, M. & Bracalenti, L. 2018)

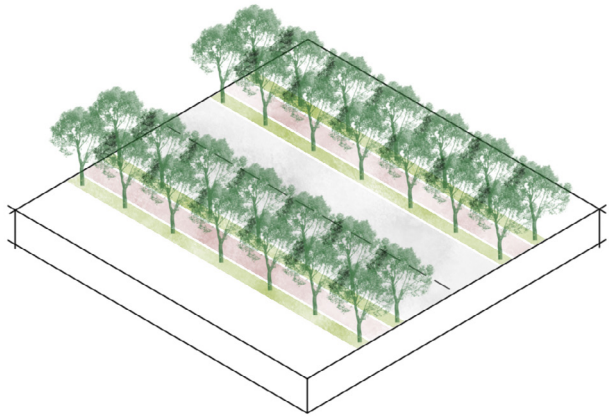
Stakeholders related: Building owner; Farmer; Ecologist



Productive Green Soft Banks

The hard water banks can be transformed into soft green slopes with diverse vegetation. This eco-friendly bank is very attractive for the birds and beneficial for the environments, the livability will then be improved.

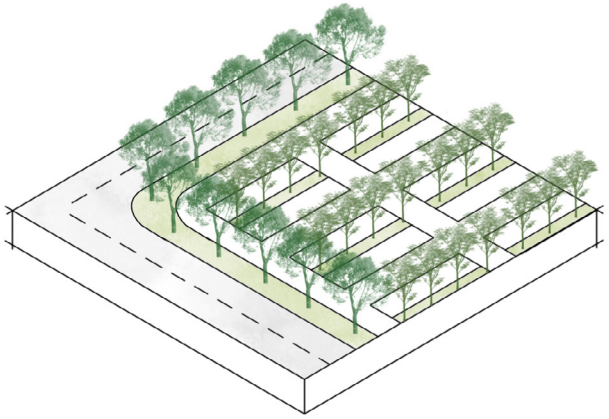
Stakeholders related: Ecologists; Government



Productive Green Streets

Some grey streets can be greenified by planting some nut trees. The nuts can be collected later to be the animal fodders. The trees also help to reduce the heat and absorb the pollution from cars. (Dubbeling, M. & Bracalenti, L. 2018)

Stakeholders related: Ecologists; Developer; Government; Urban designer



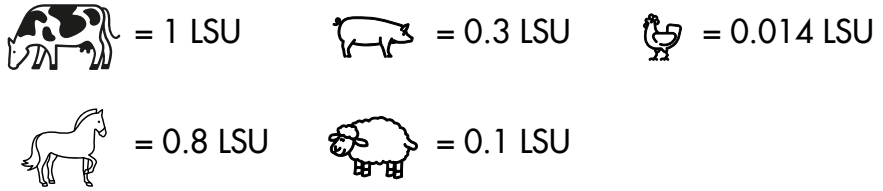
Productive Green Parking Areas

The grey parking areas can be greenified to reduce the urban heat effect. As mentioned before, the green waste from these areas can be recycled to make the biofertilizers or animal fodders. (Dubbeling, M. & Bracalenti, L. 2018)

Stakeholders related: Ecologists; Government

Livestock Unit (LSU)

The livestock unit, abbreviated as LSU (or sometimes as LU), is a reference unit on the basis of the nutritional or feed requirement of each type of animal.
The reference unit used for the calculation of livestock units (=1 LSU) is the grazing equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs. (EUROSTAT)



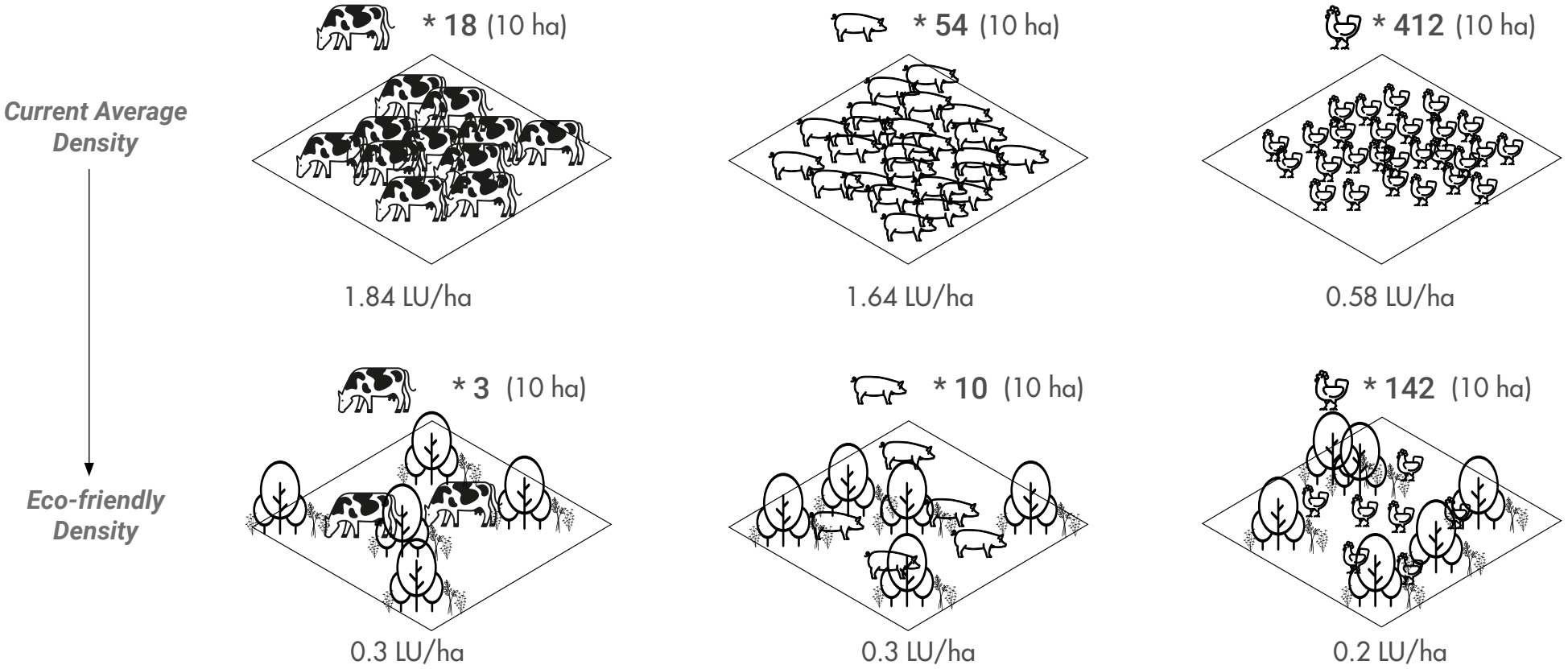


Figure 5.10 *Transformation of stock density (made by author)*

Dairy Farming as An Example

In the Sand Region, the size of the dairy farms is on average 52.2 ha per farm in 2019 (WUR), the average livestock density of dairy farming is 1.84 LU/ha in 2019 (FAOSTAT), which means there are about 96 cows in each farm. This high livestock density is harmful for the ecology and the animal welfare cannot be ensured because of limited living space.

Therefore, the livestock density should be limited to ensure the environmental quality in Netherlands. There are already some good examples in Europe. For example, in Belgium, grazing livestock density has limits of 0.35 to 0.5 LU/ha/year to allow the tree generation (Van Uytvanck 2009, Plieninger et al., 2015). For wood-pasture systems such as the 'montado', in Southern Portugal, in order to prevent 'montado' loss under current ecological conditions, grazing livestock densities are remained between 0.18 and 0.60 LU/ha (Godinho et al., 2016).

If we take the data of current dairy farming in 2019 in Netherlands as an example, if the livestock density has a limitation from 0.35 LU/ha to 0.5 LU/ha, there should be about 18 to 26 cows in each farm if we consider the average size is 52.2 ha/farm. More spaces will be left for the improvement of the ecology. Agroforestry can be introduced to provide supplementary diets for animals and also help to increase the biodiversity (Figure 5.11).

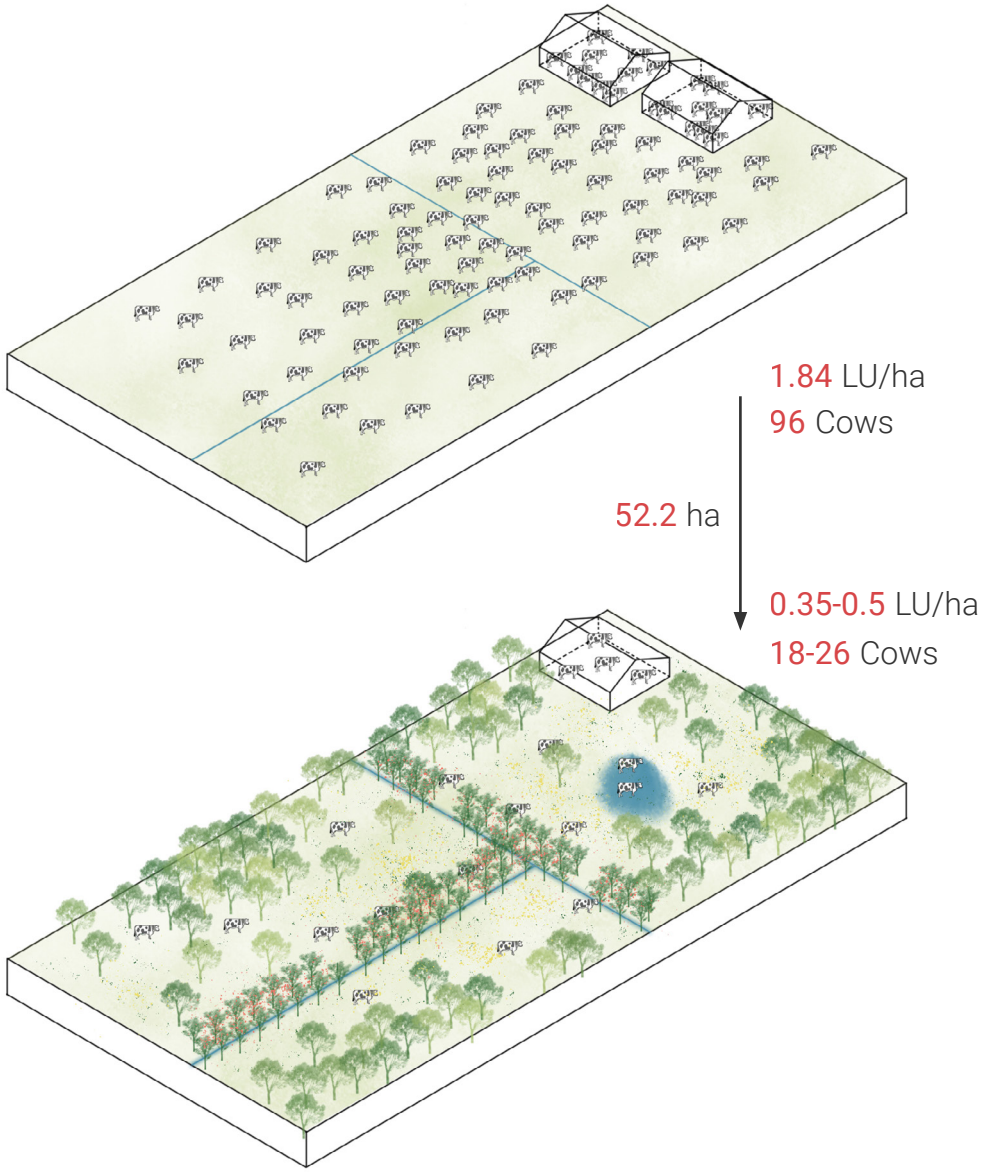


Figure 5.11 *Transformation of stock density- Dairy farming as an example (made by author)*

The selection of three design exploration sites is based on the vision maps achieved previously, and the set of design principles in the former chapter will be applied on the selected design sites. The design goals for each site are proposed firstly in this chapter. Then the detailed design explorations are conducted and presented which include the following parts: 'Animal farming in Nature', 'Animal farming with Nature', and 'Animal farming through Nature', to explore the relationship between animal farming and nature in different city contexts and the roles of different city contexts in improving the animal farming in Den Bosch.

Apart from the sub-research questions explored in the previous chapter, this chapter is additionally dedicated to exploring the sub-research question:
Sub-RQ 2*: - What kind of local vegetation could be brought back to improve the ecology and biodiversity of animal farms?*
Sub-RQ 7*: - What landscape architecture design principles can keep food animals healthy and improve production in a natural way?*

CHAPTER 6: DESIGN EXPLORATION

Design Areas + Goals

Figure 6.1 *Selection of three design sites (made by author)*

Three sites are selected separately in natural, suburban and urban context (Figure 6.1) to explore what roles animal farming could play in different contexts as well as the relationship between animal farming and nature.

The site 1 'Animal Farming in Nature' locates in a more natural area with many natural resources such Nature 2000 and EHS areas. Animal farming on this site will mainly be natura-oriented with eco-friendly stock density to correspond with the nature context.

The site 2 'Animal Farming with Nature' is in a suburban area with many intensive animal factories and a large eco-sensitive natural area nearby. Animal farming on this site will try to achieve a balance between production of animal farming and the ecological value of nature. Together with better recreational value to attracts more people.

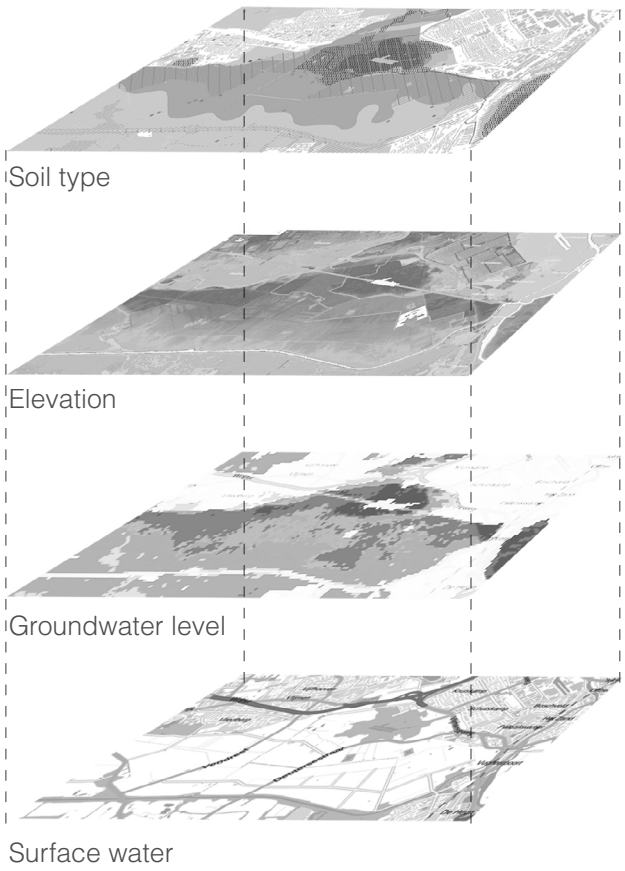
The site 3 'Animal Farming through Nature' explores how urban area could help with improving animal farming and how animal farming landscapes could help to solve the urban issues.

Site 1: Animal Farming in Nature

The design of 'Animal farming in Nature' is explored within and near the context of Nature 2000 area 'Vlijmens Ven, Moerputten & Bossche Broek', it is also surrounded by a lot of natural resources. The design exploration in this natural context shows how animal farmlands could work within the interweaved natural context and with surrounding natural resources. The stock density in this area should be kept at a low level and food animals are encouraged to benefit the environment through their natural behaviors.

Source: Google map

Analysis --- *Geo Typologies*



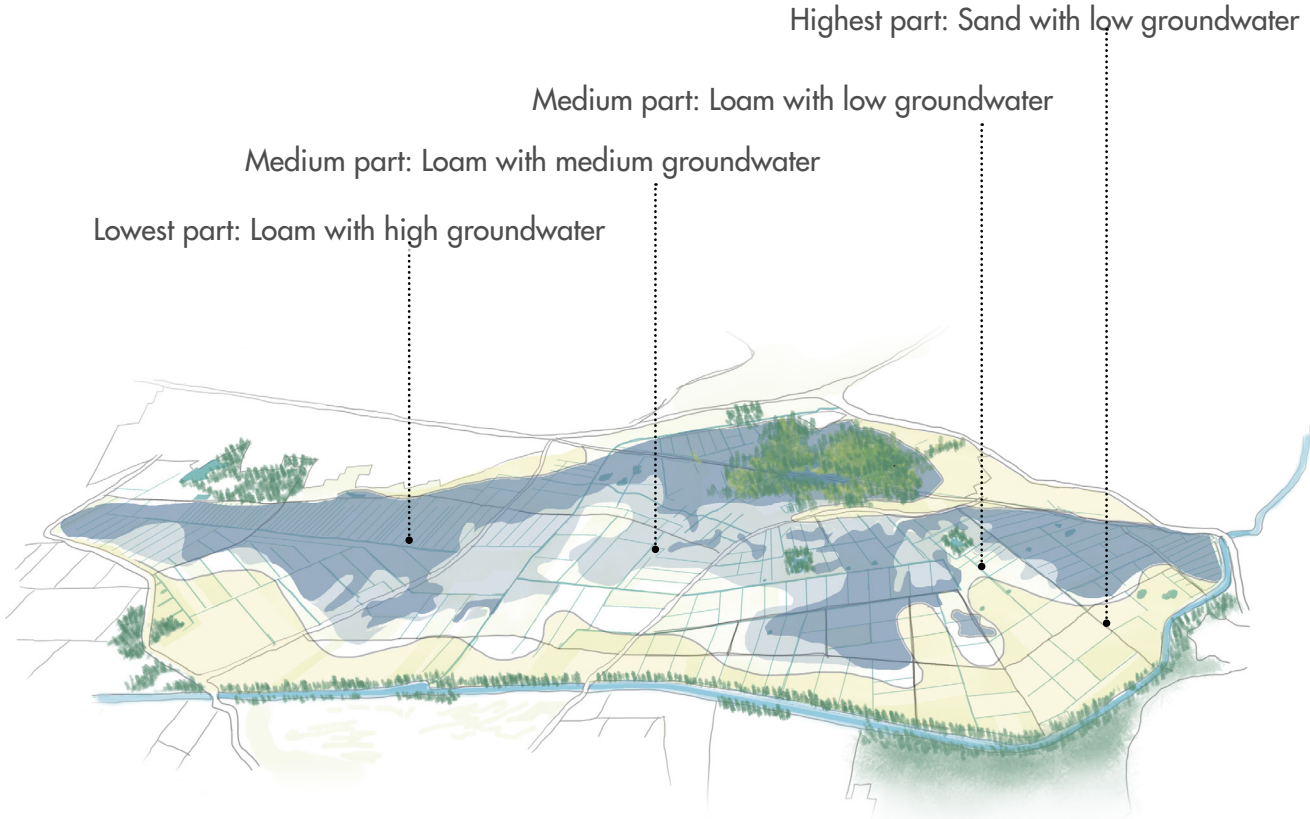


Figure 6.2 *Analysis --- Geo Typologies (data source: DINOloket & Waterschap Aa en Maas, 2022. Made by author)*

Based on the analysis of 'Soil type' 'Elevation' 'Groundwater level' and 'Surface water map' (Figure 6.2), the site is mainly divided into four main geo types: Lowest elevation--- Loam with high groundwater level; Medium elevation--- Loam with medium groundwater level; Medium elevation--- Loam with low groundwater level; Highest elevation--- Sand with low groundwater level. As the figure xx showed, the darkest blue areas which are the loamy soil with high groundwater level and lowest elevation, these areas have the most of the flooding risk compared to the whole site.

Analysis --- *Historical Resources*

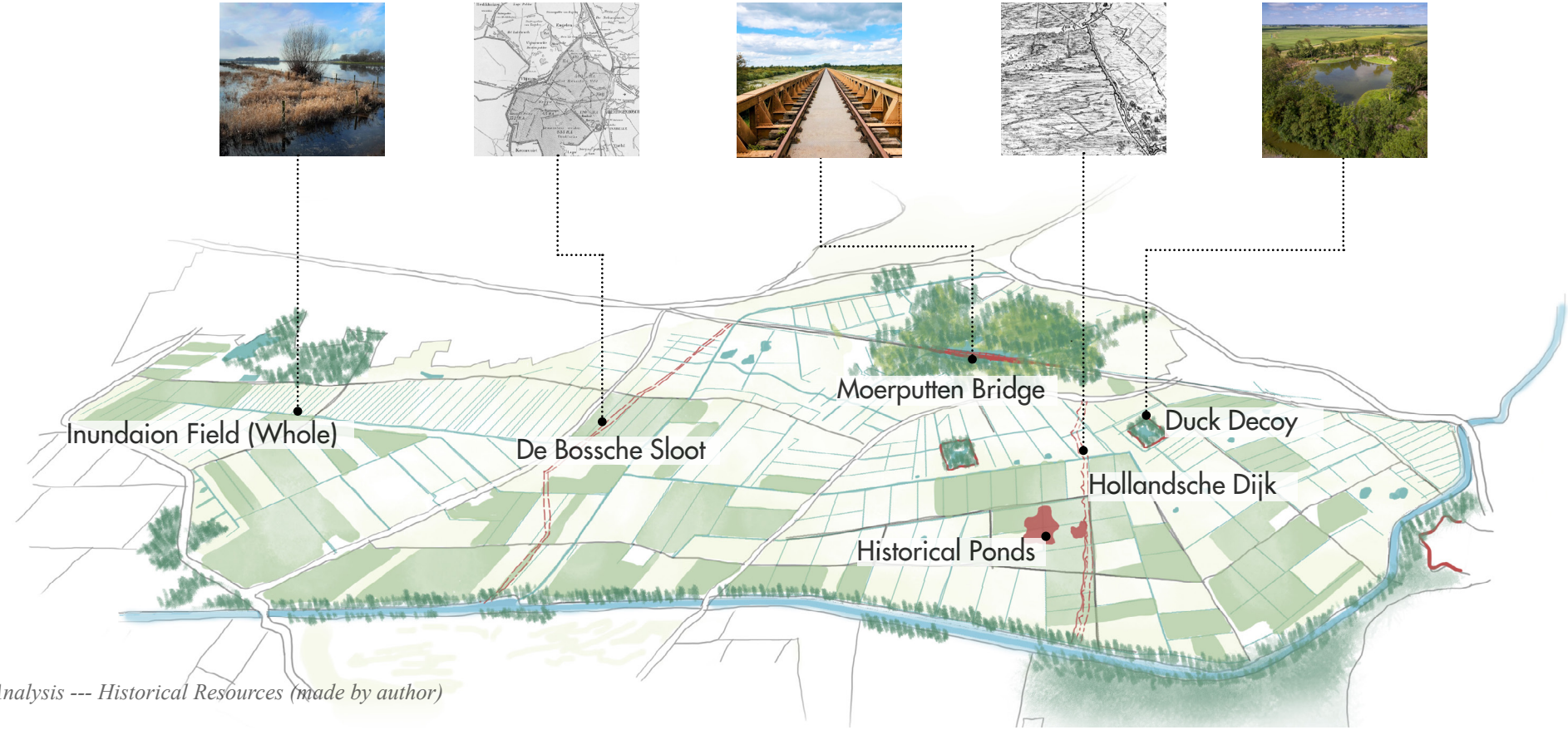


Figure 6.3 *Analysis --- Historical Resources (made by author)*

There are abundant historical resources on the site. The whole site was used be the inundation area during the wartime. There are two Duck decoys on the site which used to catch the ducks. They have stopped catching ducks nowadays but their ecological value remains. 'De Bossche Sloot' once played important role in transporting the peat from 'Loon op Zand' to Den Bosch in order to ensure the energy supply of the city. 'Hollandsche Dijk' was the final piece of the Line of Frederik Hendrik which played important role in the war (De Groene Vesting, 2022).

Another important historical element on the site is the Moerputten bridge, which was part of the Langstraat railway line until 1972. The railway was built because of the shoe industry. When the demand for train transport decreased and a different zoning plan was made, traffic over the Moerputtenbrug was abolished. The bridge was reopened to public after 2011. (Strip Away, 2022)

Analysis --- *Flora and Fauna*

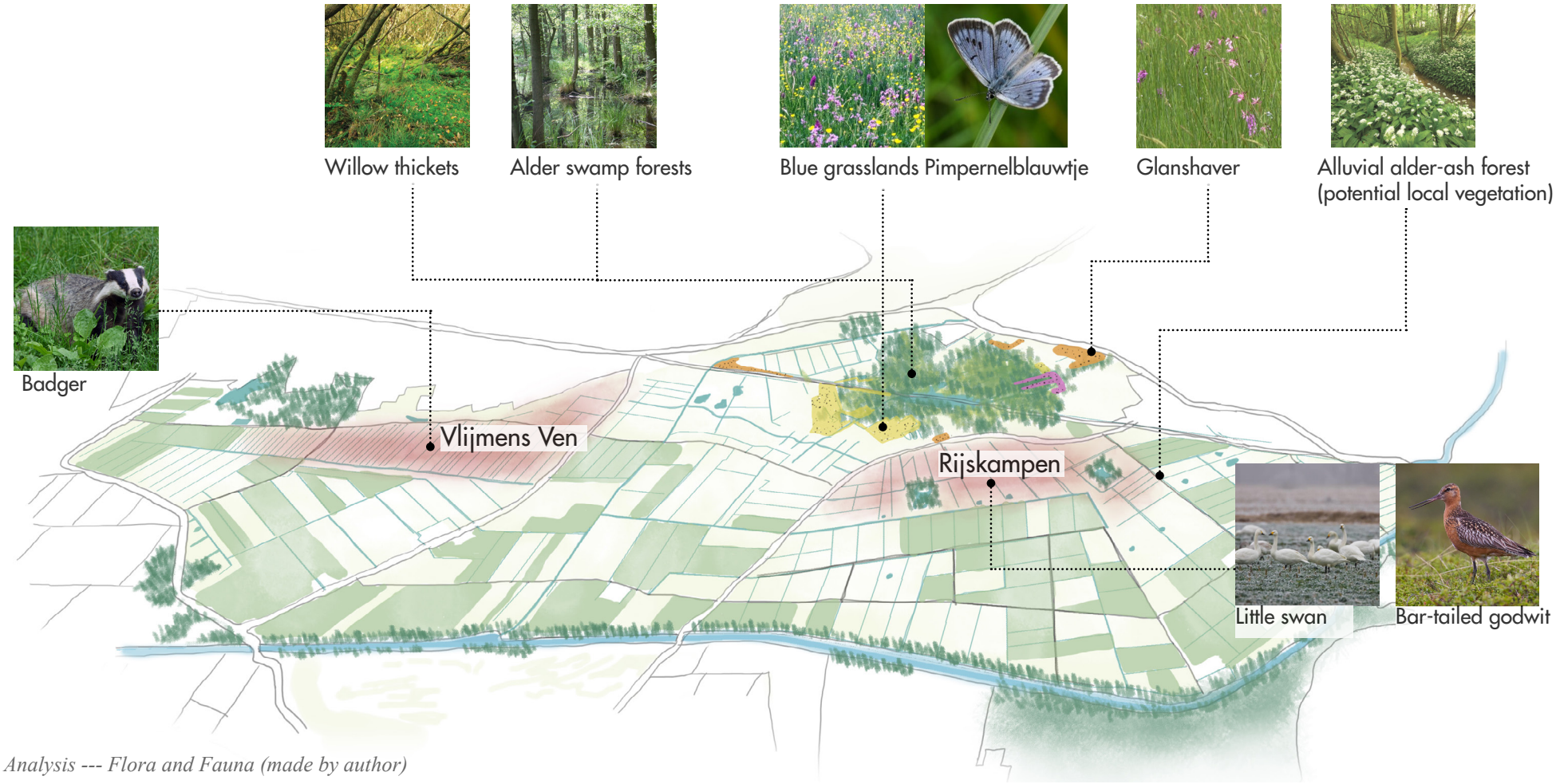


Figure 6.4 *Analysis --- Flora and Fauna (made by author)*

De Moerputten mainly consists of large sedge marshes, reed lands, marsh marigold hay lands, moist gloss oat grasslands and blue grasslands in less nutrient-poor areas. Around the peat holes of the Moerputten are among other things willow thickets and alder swamp forests. (Nature 2000, 2017) The blue grasslands are important habitats of the rare endangered butterfly 'Pimpernelblauwtje'. The Vlijmens Ven is the habitat of the badger and Rijskampen is attractive for birds such as little swan and bar-tailed godwit. (Nature 2000, 2017)

Analysis --- *Agriculture*

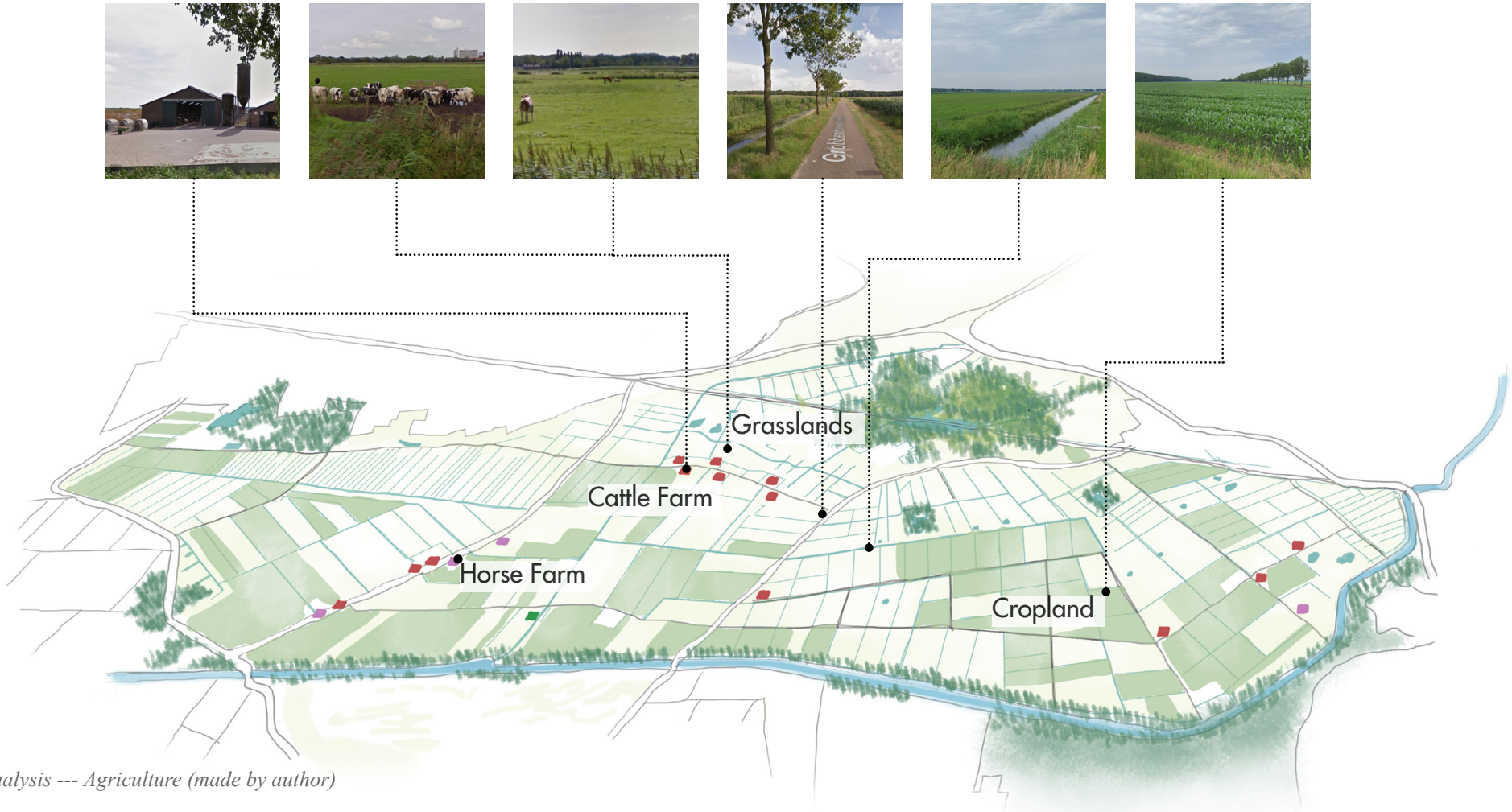


Figure 6.5 *Analysis --- Agriculture (made by author)*

Livestock farming is the dominant animal farming on this site, together with large monofunctional grasslands and intensive croplands, the ecological value here is low. There are also not enough habitats for the wildlife such as badger, butterfly 'Pimpernelblauwtje', little swan etc. as mentioned before because of the farmlands which are lack of biodiversity.

Analysis --- *Risks*

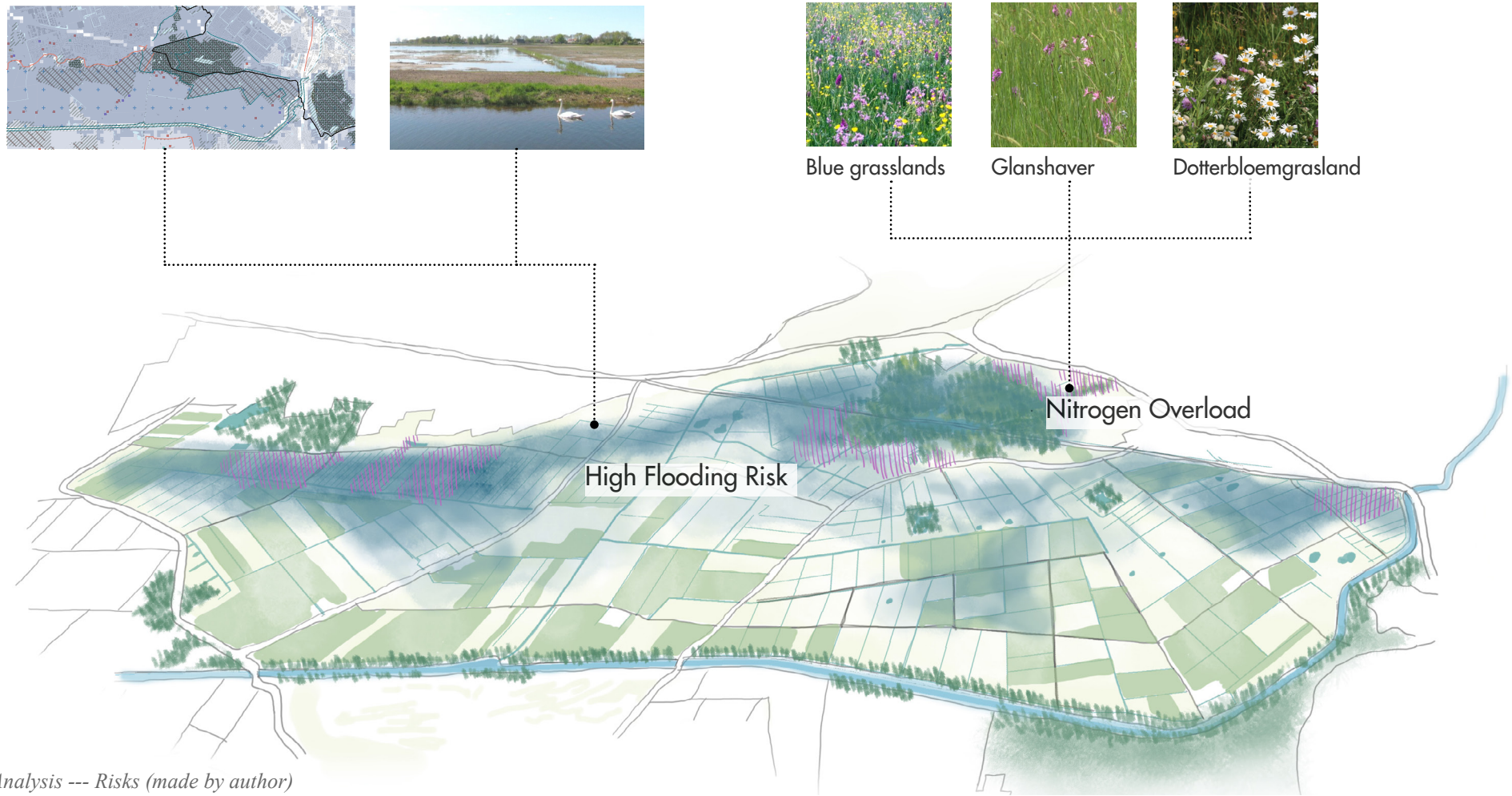


Figure 6.6 *Analysis --- Risks (made by author)*

As what the geo typologies have shown, the dark blue areas in figure xx are the zone that have high flooding risk because of their low elevation and high groundwater level. The purple line hatches are the zone within Nature 2000 that have the issue of Nitrogen overload. The local vegetation such as blue grasslands, glanshaver are sensitive to nitrogen. The over emission of Nitrogen would harm these local vegetation types.

Aims

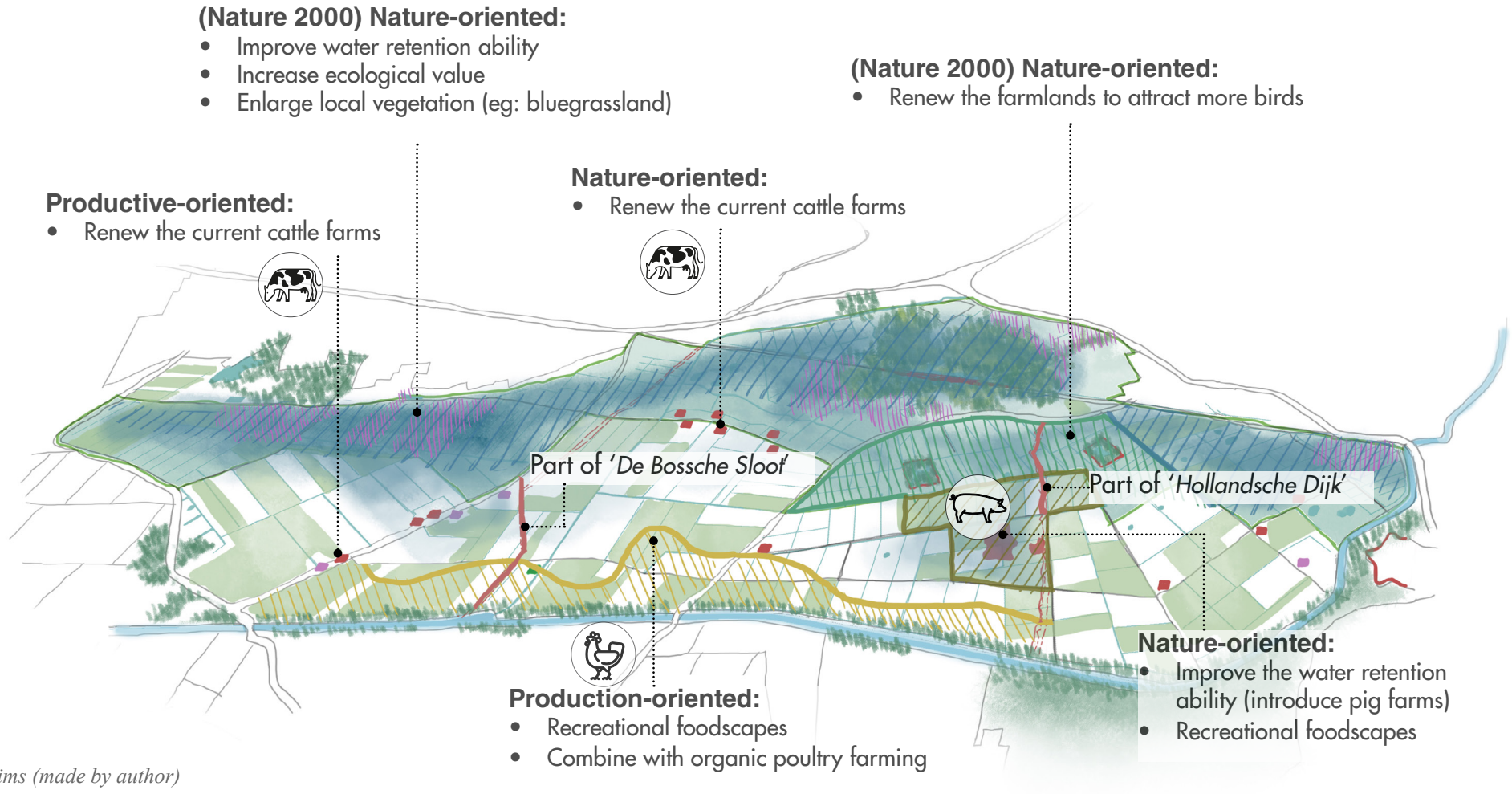


Figure 6.7 *Aims (made by author)*

Based on a series of analysis mentioned above, the animal farming in this site will mainly have two directions (Figure xx): one is more nature-oriented which is close to the Nature 2000 area and another is more production oriented which is on the farmland a bit further away from the Nature 2000 area. Extra food animals such as pigs and chickens would be introduced in the right spot to create recreational animal farming landscapes. More detailed information will be presented in the later steps. Part of 'De Bossche Sloot' and 'Hollandse Dijk' would be brought back and given recreational value to make the site more attractive.

Spatial Framework --- *Phase 1: Improve Water Retention Ability*

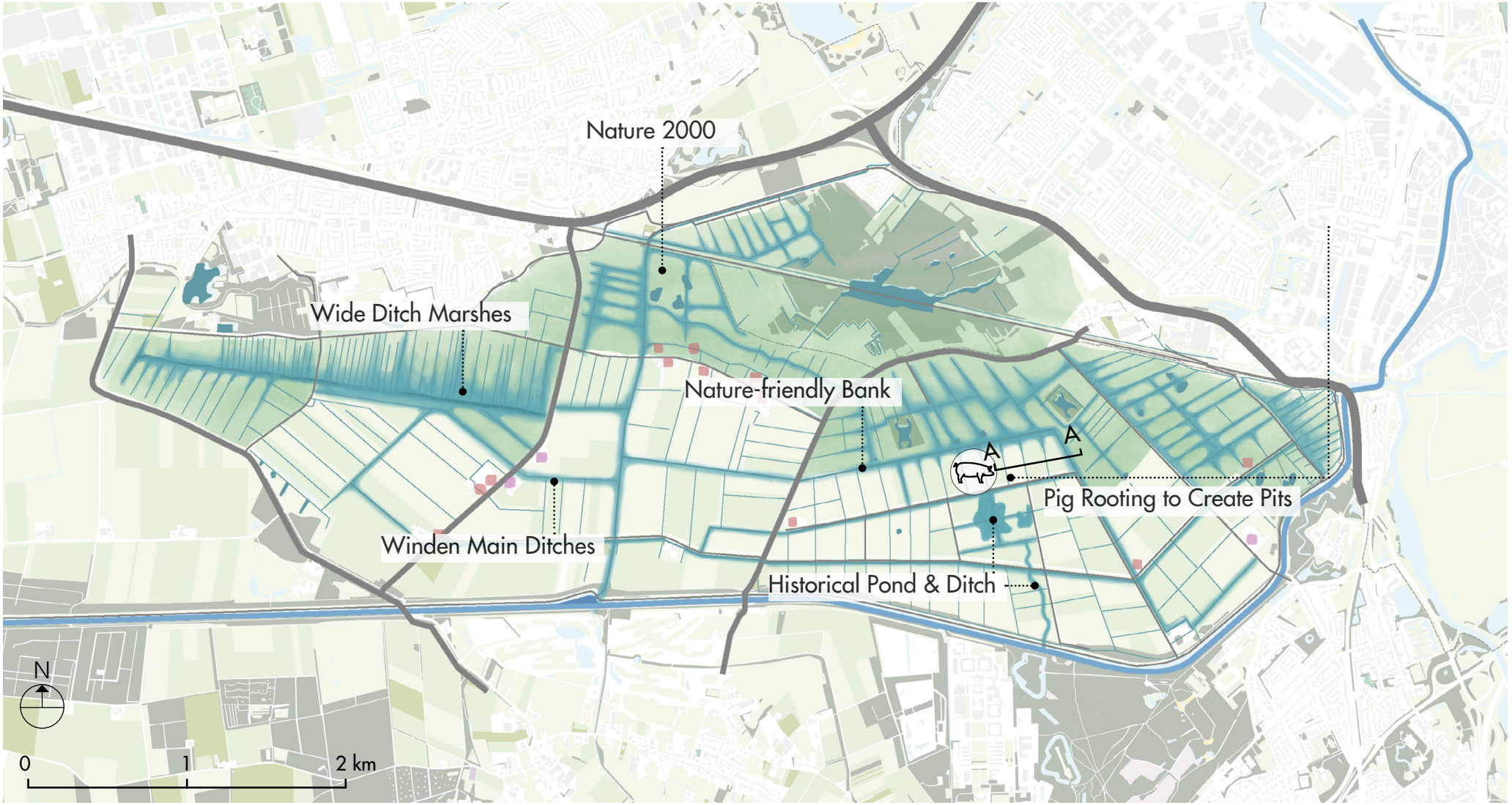
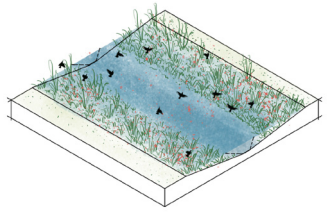
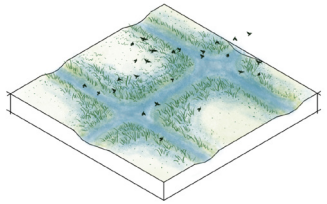


Figure 6.8 *Spatial Framework --- Phase 1: Improve Water Retention Ability (made by author)*

Spatial Framework --- *Phase 1: Improve Water Retention Ability*

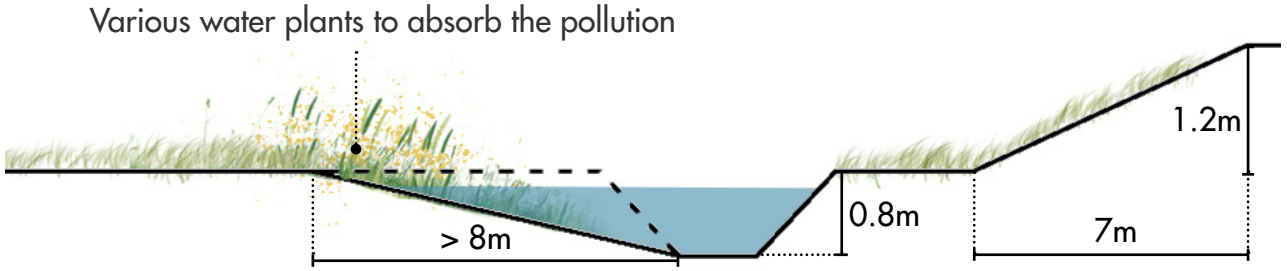


Nature-friendly Water Bank



Wide Ditch Marshes

In this phase, in order to improve water retention ability of the site, the main ditches are widened to create marshes. Various water plants are grown along the banks to make the banks be more eco-friendly. Historical ponds and ditches can also be brought back partly. Besides, pigs can be introduced in the area where has high flooding risk outside the Nature 2000 area because of the pig rooting behavior can help to improve water retention ability. The stakeholders related in this phase includes the Water Board, the ecologists and farmers.



(Height exaggerated)

Sectioin A-A

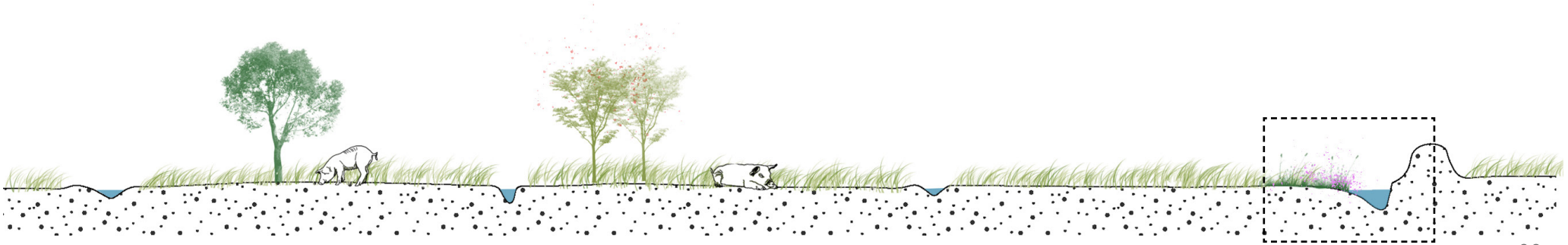


Figure 6.9 *Sections --- Phase 1: Improve Water Retention Ability (made by author)*

Spatial Framework --- *Phase 1: Improve Water Rentention Ability*

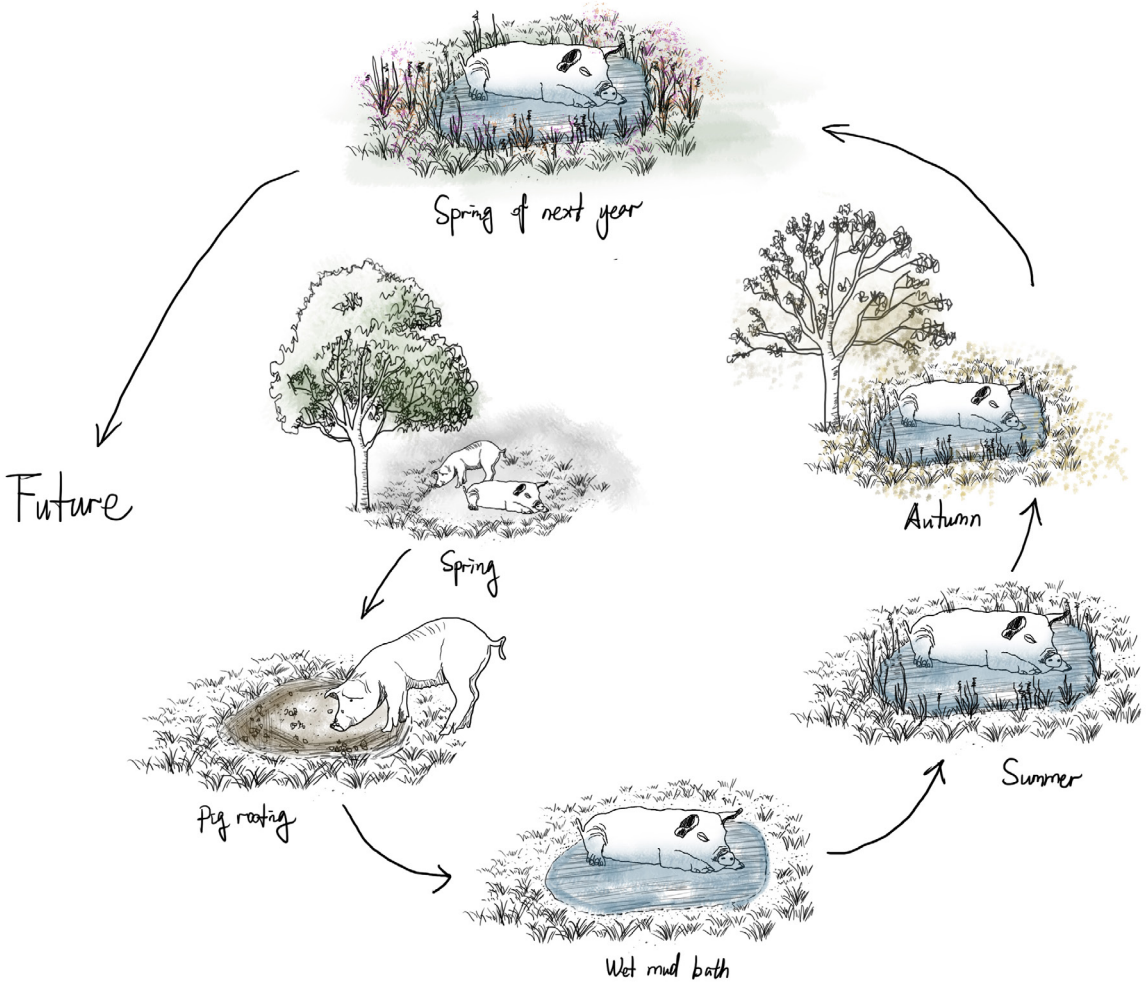


Figure 6.10 *Benefits of Pig Rooting (made by author)*

Benefits of Pig Rooting

Pigs have the natural behaviors of rooting and they like cool environments. Especially in the hot summer, they tend to gather under the trees to escape the hot sun. They will dig the small pits near the area they gather. After raining, they are able to take a mud bath in the wet pits they dug. The mud bath is beneficial towards pigs' health. This way prevents them getting sunburn and keep the files and parasites off. Gradually, there could be some grass grow near the edge of the pits because of sufficient water. In the autumn, the falling leaves of the trees will also fertilize the soil near the pits, this will make the grass even more diverse near the pits in the spring of next year.

Therefore, pigs can be introduced and trees can be added in the area with high flooding risk to let pig rooting behaviors happen.

Spatial Framework --- *Phase 2: Establish Green Connection with Local Nature*

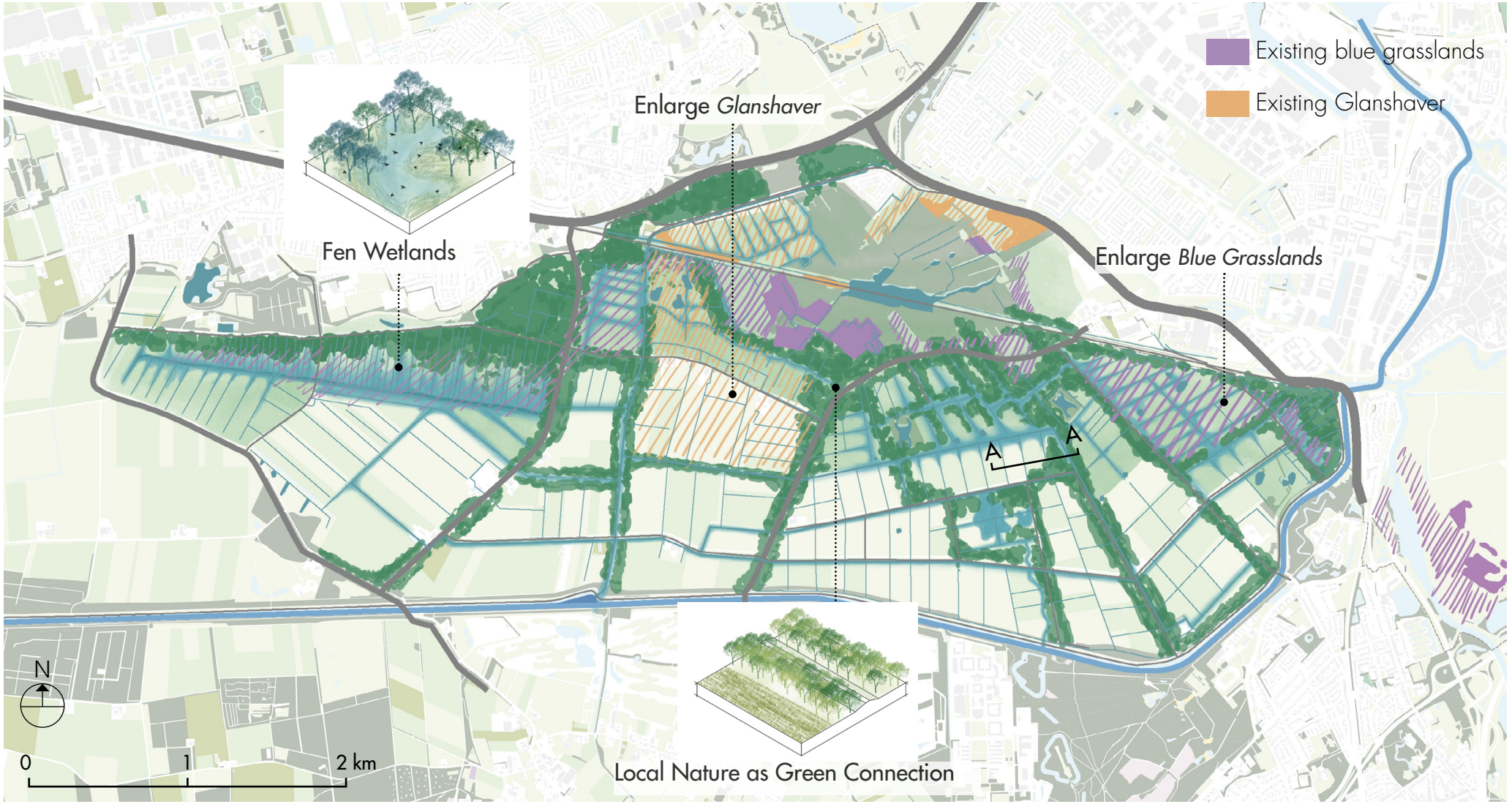


Figure 6.11 *Spatial Framework --- Phase 2: Establish Green Connection with Local Nature (made by author)*

Spatial Framework --- *Phase 2: Establish Green Connection with Local Nature*

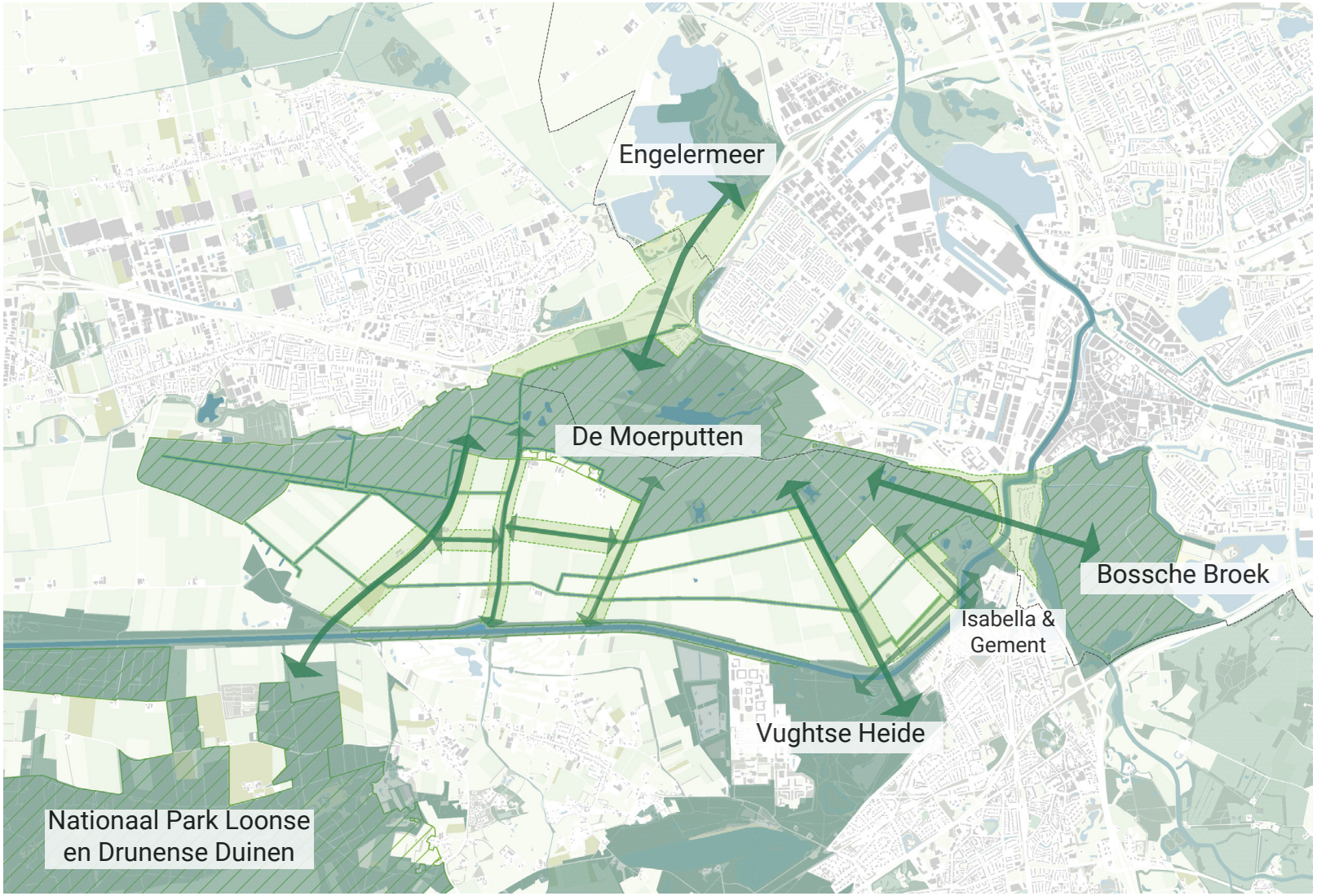


Figure 6.12 *Green connection with surrounding natural resources (made by author)*

There are abundant natural resources surrounding this site (Figure 6.12). The 'Engelermeer' in the north which has the swamp forest belongs to the alder kingdom of ash-elm forest and the dry ash-elm forest. The 'Bossche Broek' beside is an important meadow and marsh bird area with blue grasslands. The 'Vughtse Heide' in the south has forests of birches and scots pines, and oaks and beech trees on the more fertile ground. While the 'National Park Loonse en Drunense Duinen' in the south west has the forests type of Oak- Birch Forest and Beech- Oak Forest. (IVN 's-Hertogenbosch, 2015)

Spatial Framework --- *Phase 2: Establish Green Connection with Local Nature*

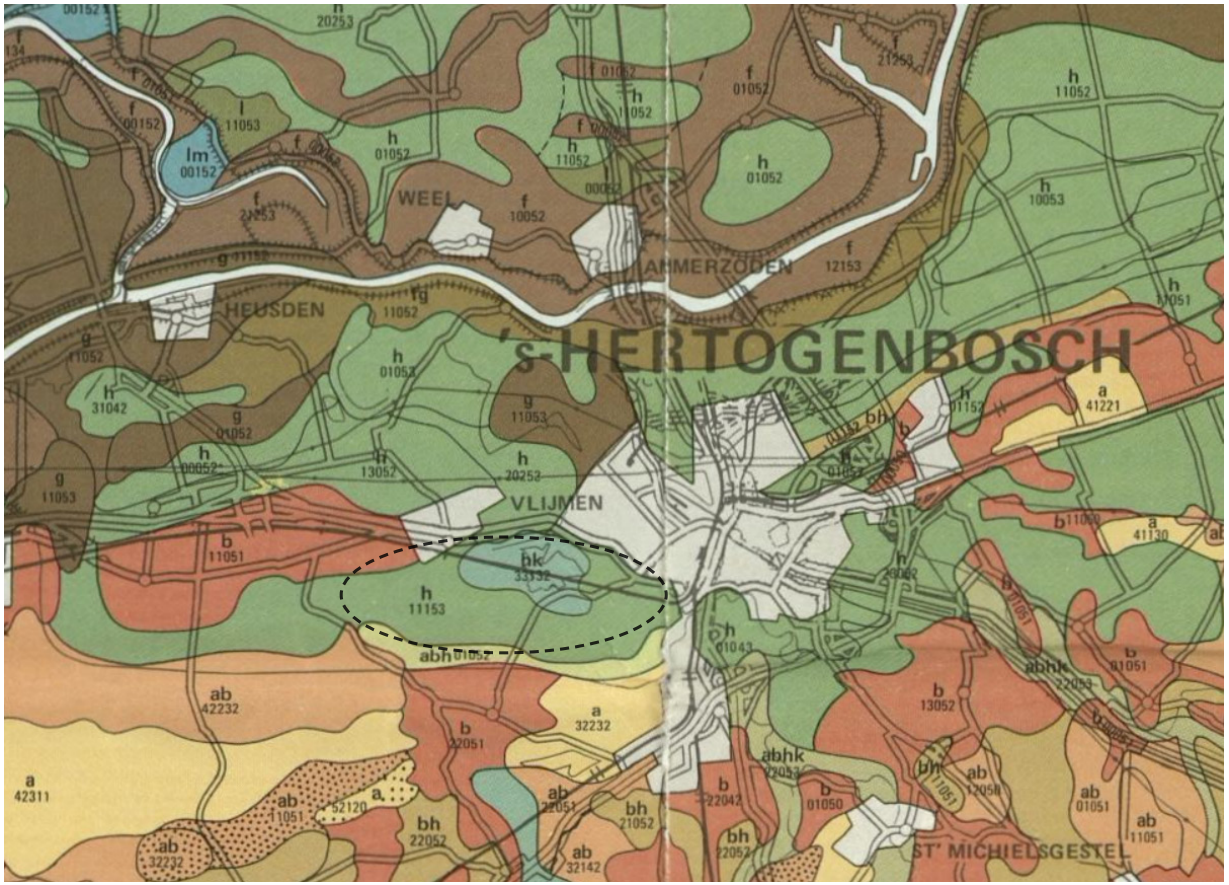


Figure 6.13 *Vegetation map of the Netherlands (source: WUR, 1975)*

For most areas of the site, 'Alluvial alder-ash forest' could be brought back to establish the green connection. Other vegetation types from the surrounding area such as 'Oak-birch Forest' in the southern part of the site which is suitable for a bit drier condition could penetrate a little into the site to strengthen the green connection between the site with the surrounding natural areas. (Figure 6.13)

Oak-birch forest

Beech-Oak Forest

Alluvial alder-ash forest

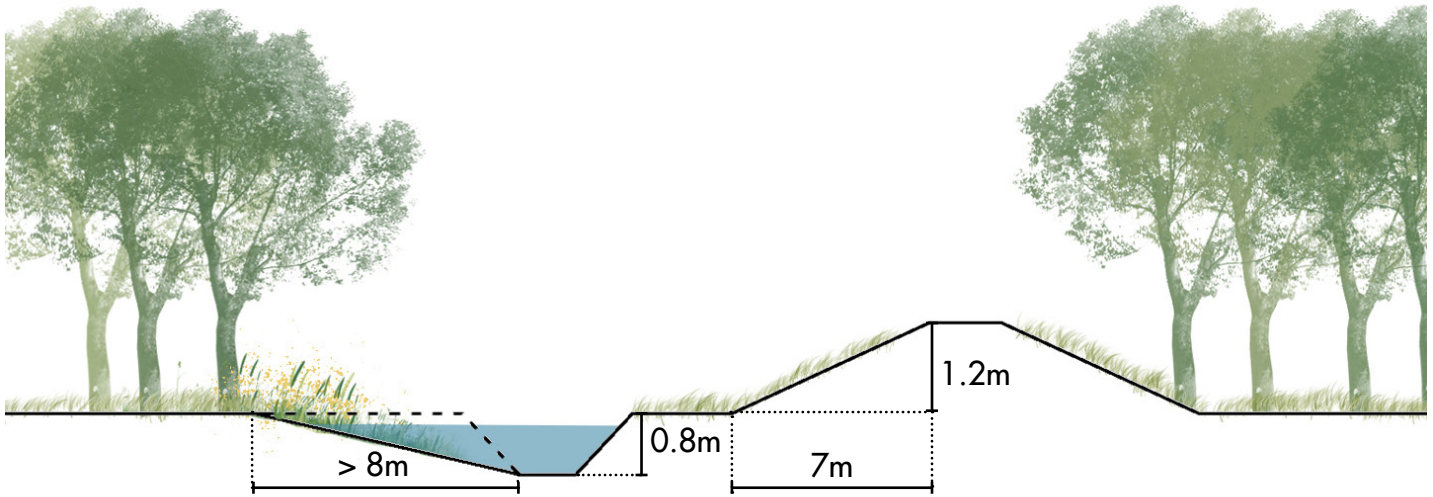
Association of the alder pants forests

h	Alluvial alder-ash forest	hk	Alluvial alder-ash forest (va) + Association of the alder pants forests
a	Oak-birch forest	ab	Complex of Oak- Birch Forest + Beech- Oak Forest
b	Beech-Oak Forest	abh	Complex of Oak- Birch Forest + Beech- Oak Forest + Alluvial alder-ash forest

Spatial Framework --- *Phase 2: Establish Green Connection with Local Nature*

In this phase, the local nature could be brought back along the main ditches and routes to establish the green connection with surrounding natural resources. Besides, the site also has a rare typical vegetation 'blue grassland', which is the habitats for the specific butterfly 'Pimpernelblauwtje'. 'Pimpernelblauwtje' is endangered nowadays. In order to bring them back, their habitats 'blue grassland' can be enlarged. The 'Bossche Broek' near the site also has the 'blue grassland'. Therefore, it is sensible to make 'blue grassland' within the site be more connected with 'Bossche Broek' to let their habitats be more connected.

The stakeholders in this phase includes the farmers, Staatsbosbeheer and ecologists. Parts of the land from farmer will be taken out for the nature purpose.



Sectioin A-A

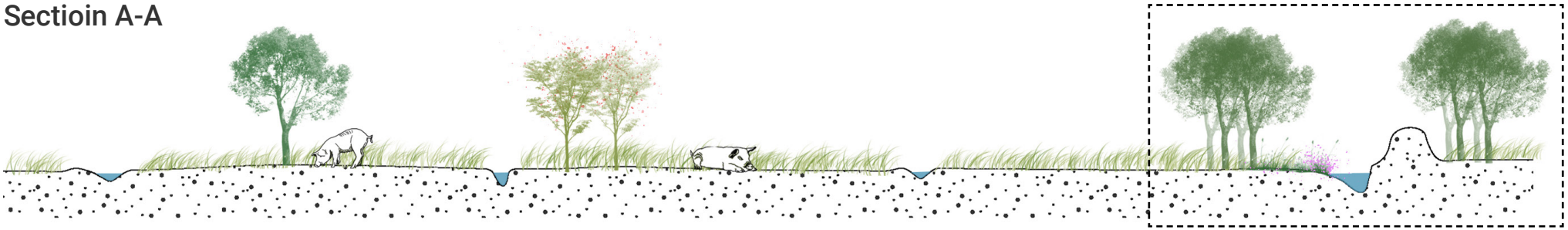


Figure 6.14 *Sections --- Phase 2: Establish Green Connection with Local Nature (made by author)*

Spatial Framework --- *Phase 3: Interweave Nature with Renewed Farmlands*

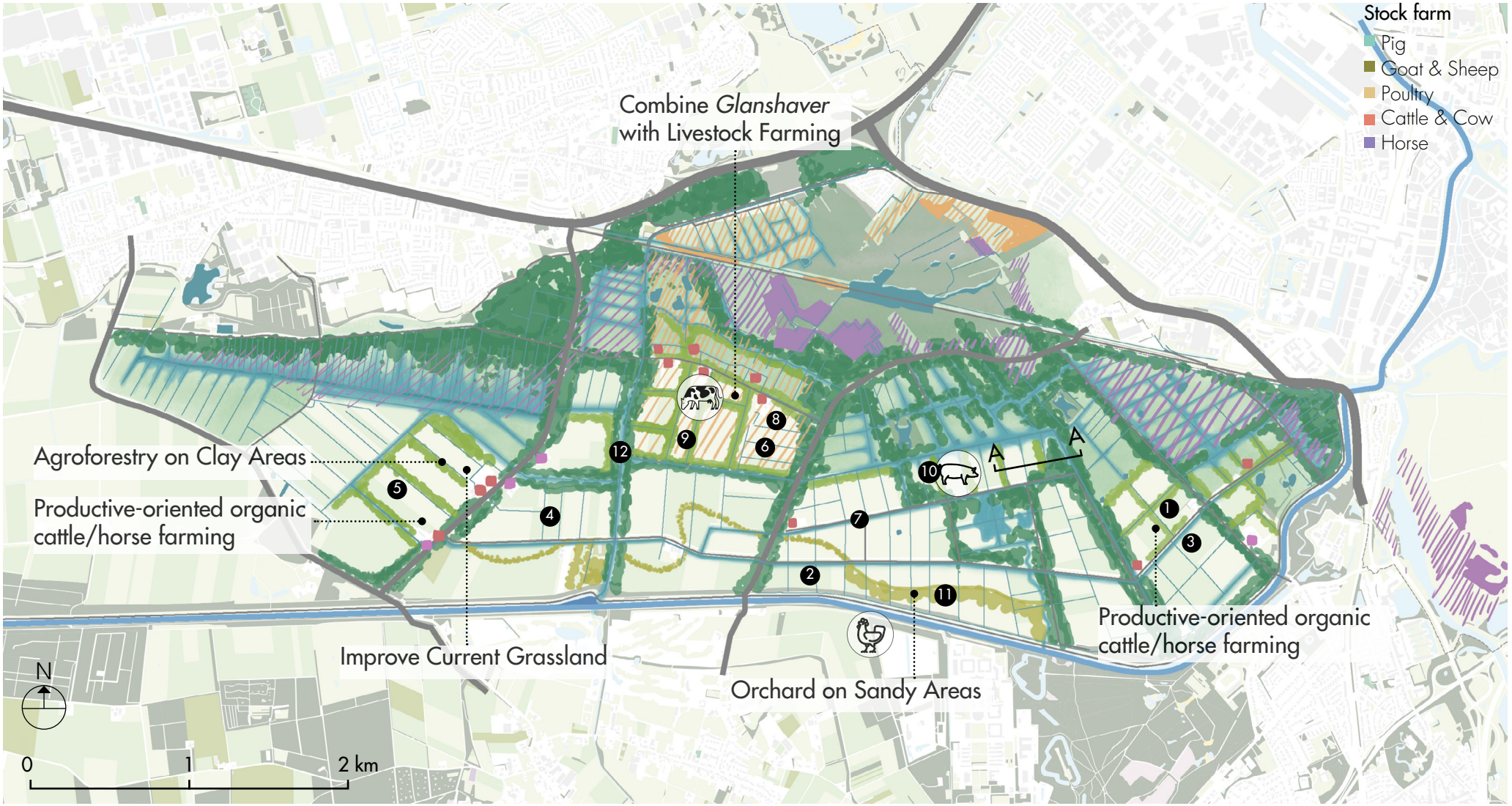


Figure 6.15 *Spatial Framework --- Phase 3: Interweave Nature with Renewed Farmlands (made by author)*

Spatial Framework --- *Phase 3: Interweave Nature with Renewed Farmlands*

Application of Design Principles

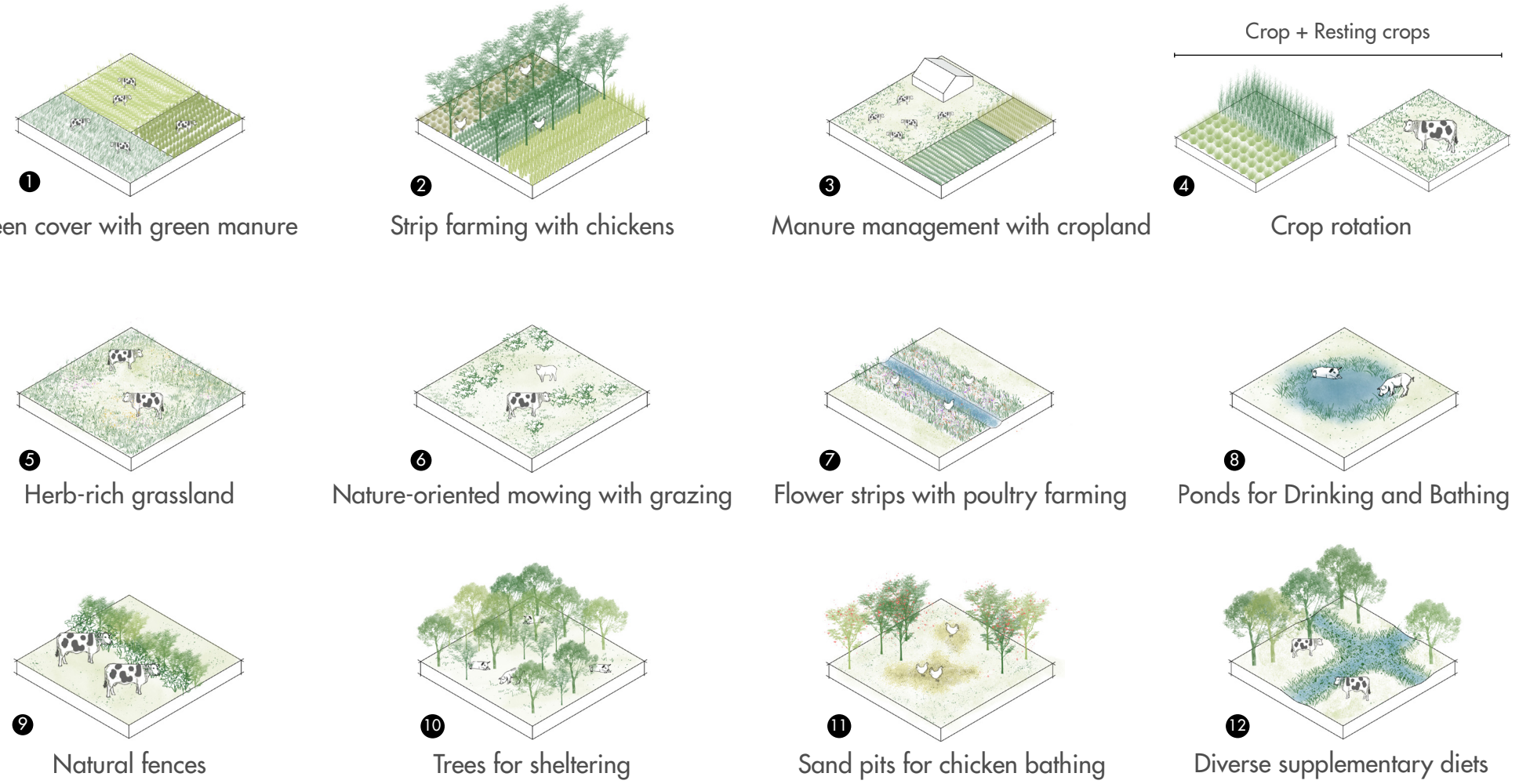
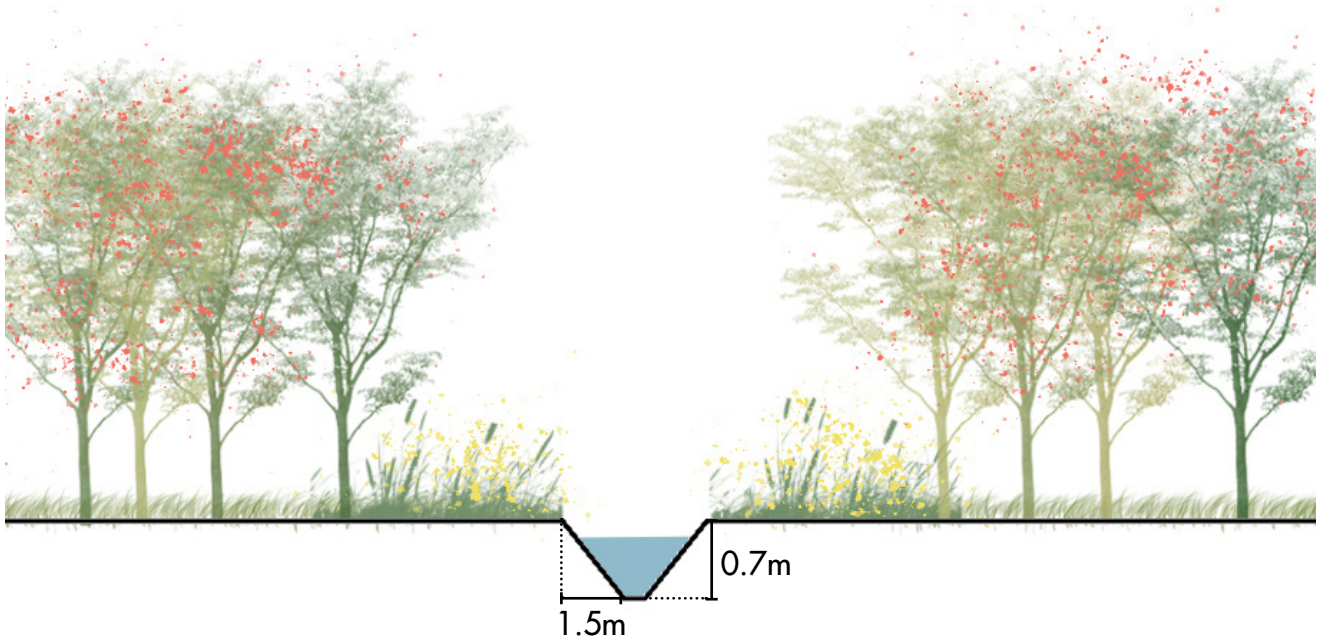


Figure 6.16 *Application of Design Principles --- Phase 3: Interweave Nature with Renewed Farmlands (made by author)*

Spatial Framework --- *Phase 3: Interweave Nature with Renewed Farmlands*

In this phase, the stakeholders are mainly farmers, Agriculture board and agronomists. The farmlands are renewed and improved through changing the monofunctional grassland into herb-rich grassland, adding flower strips along ditches to protect water quality, doing the strip farming and planting some agroforestry to increase the biodiversity, trees added to provide sheltering spaces for animals such as cows and pigs, sand pits are provided right on the sandy areas for chicken dust bathing…animals such as chickens are introduced to control the pests and reduce the use of pesticide, cows can provide natural fertilizers to the soil and work as the natural mowers... Besides, the agroforestry with chicken farming is also planted along the border between sandy soil and loamy soil to show how the animal farming landscape reacts towards the land.



Sectioin A-A

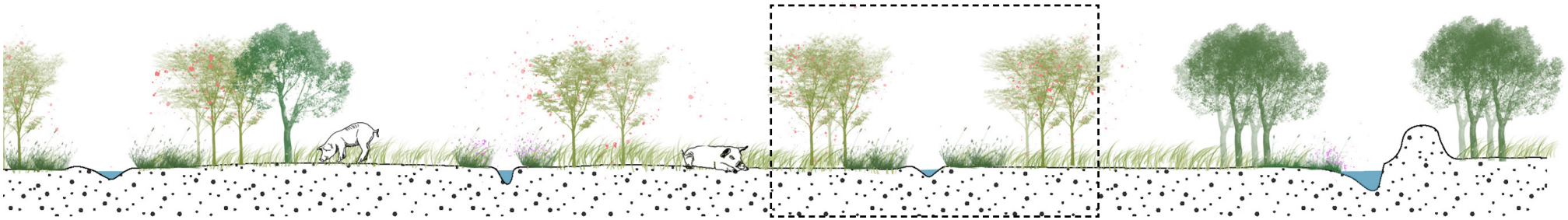


Figure 6.17 *Sections --- Phase 3: Interweave Nature with Renewed Farmlands (made by author)*

Spatial Framework --- *Phase 4: Develop Recreational Functions and Routes*

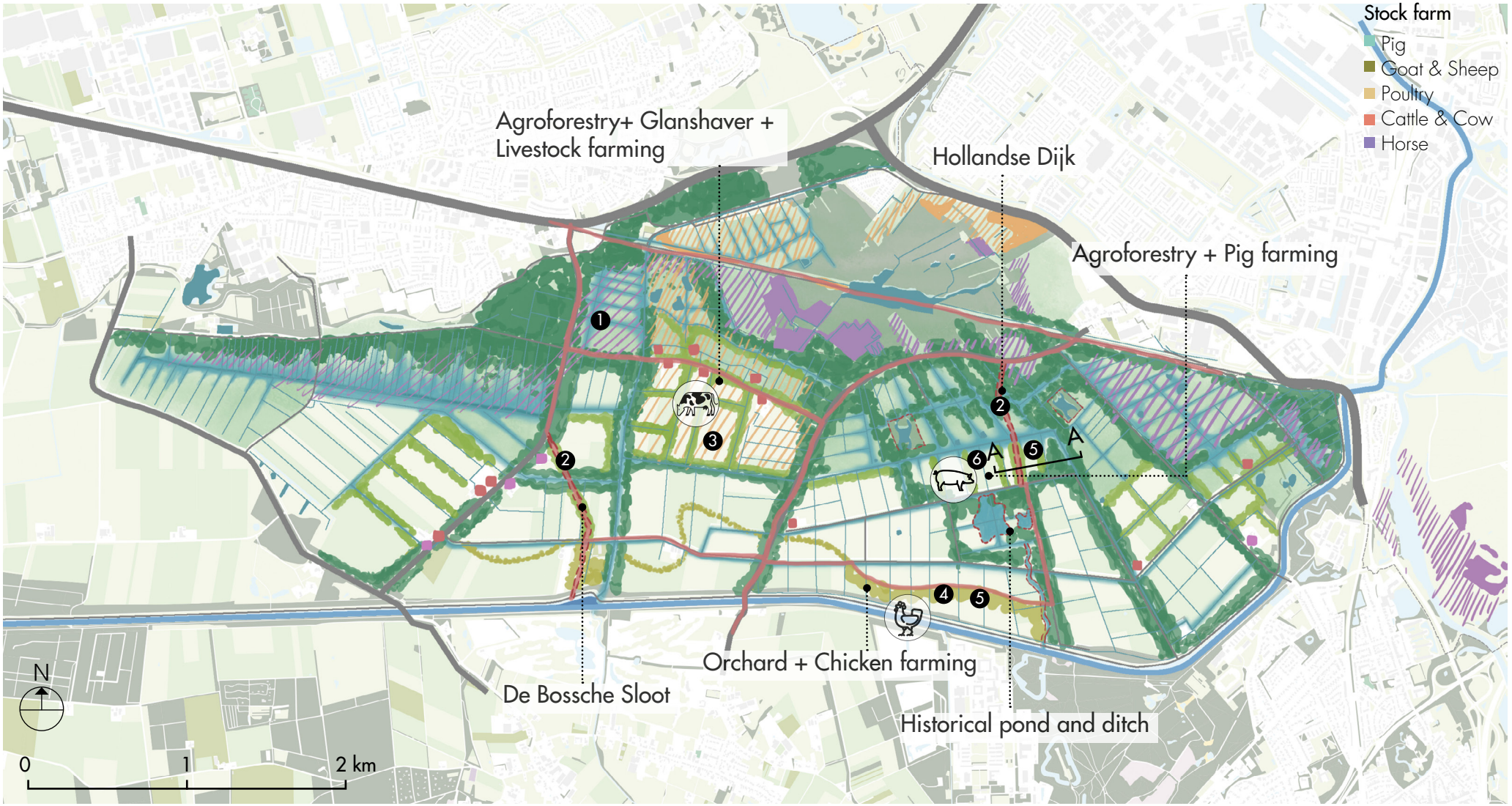
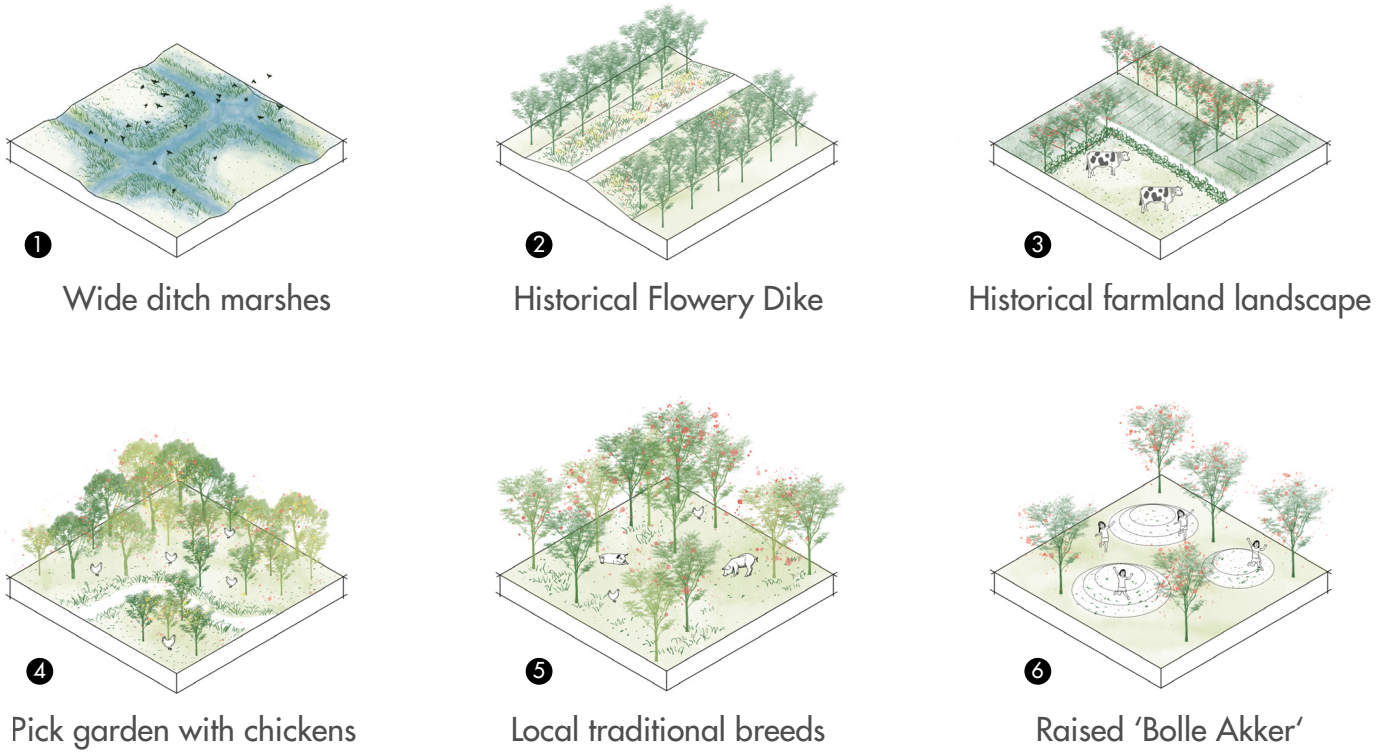


Figure 6.18 *Spatial Framework --- Phase 4: Develop Recreational Functions and Routes (made by author)*

Spatial Framework --- *Phase 4: Develop Recreational Functions and Routes*

Application of Design Principles

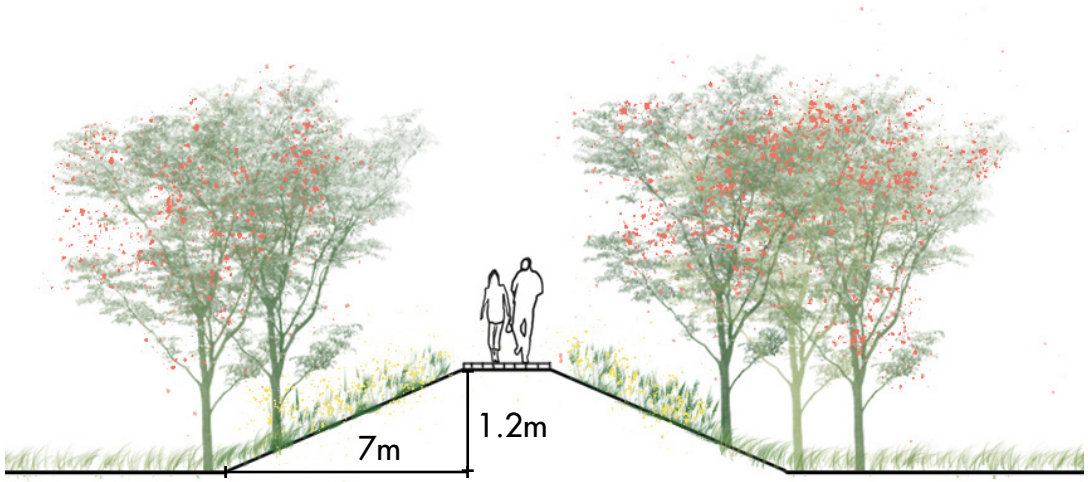


In this phase, the historical elements of the farmlands such as the hedgerows, pollard willows etc. are brought back. The inundation heritage is also enhanced by creating wide ditch marshes. The historical resources such as De Bossche Sloot and Hollandse Dijk which had played important roles in previous war are partly brought back as well and are given the recreational functions to remind people of the history. Pick gardens with chickens can make people have fun with the foodscapes, local traditional breeds such as 'Netherlands landvarken' which is now endangered can be raised in the recreational animal farming landscapes to make people know more about the local food animals. 'Raised Bolle Akker' which used to be typical features in Noord Brabant can also be brought back partly to increase recreational value in the animal farming landscapes.

Figure 6.19 *Application of Design Principles --- Phase 4: Develop Recreational Functions and Routes (made by author)*

Spatial Framework --- *Phase 4: Develop Recreational Functions and Routes*

The stakeholders related to this phase are mainly tourists and residents while farmers are also included. In order to bring back and strengthen the recreational function of the historical dikes. In the higher parts of the dike can grow flowery plants while in the lower parts the fruit trees can be planted as what the section beside has shown.



(Height exaggerated)

Sectioin A-A

Figure 6.20 *Sections --- Phase 4: Develop Recreational Functions and Routes (made by author)*

Stakeholders Involved in Each Phase

Phase 1: Improve Water Retention Ability

Phase 2: Establish Green Connection with Local Nature

Phase 3: Interweave Nature with Renewed Farmlands

Phase 4: Develop Recreational Functions and Routes

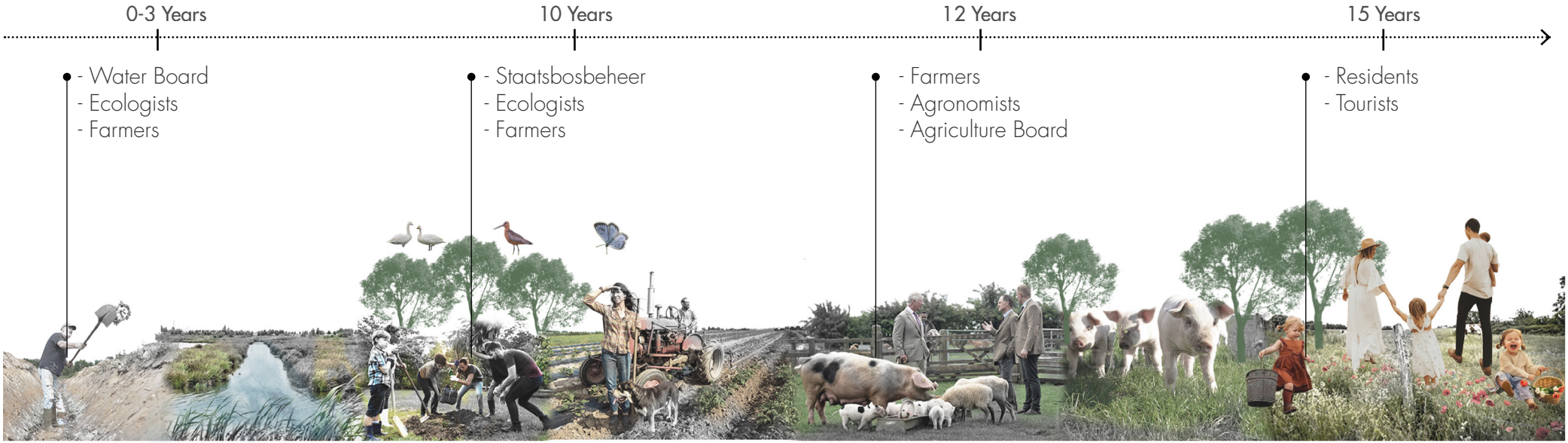


Figure 6.21 *Stakeholders involved in each phase (made by author)*

Stakeholders Involved in Each Phase

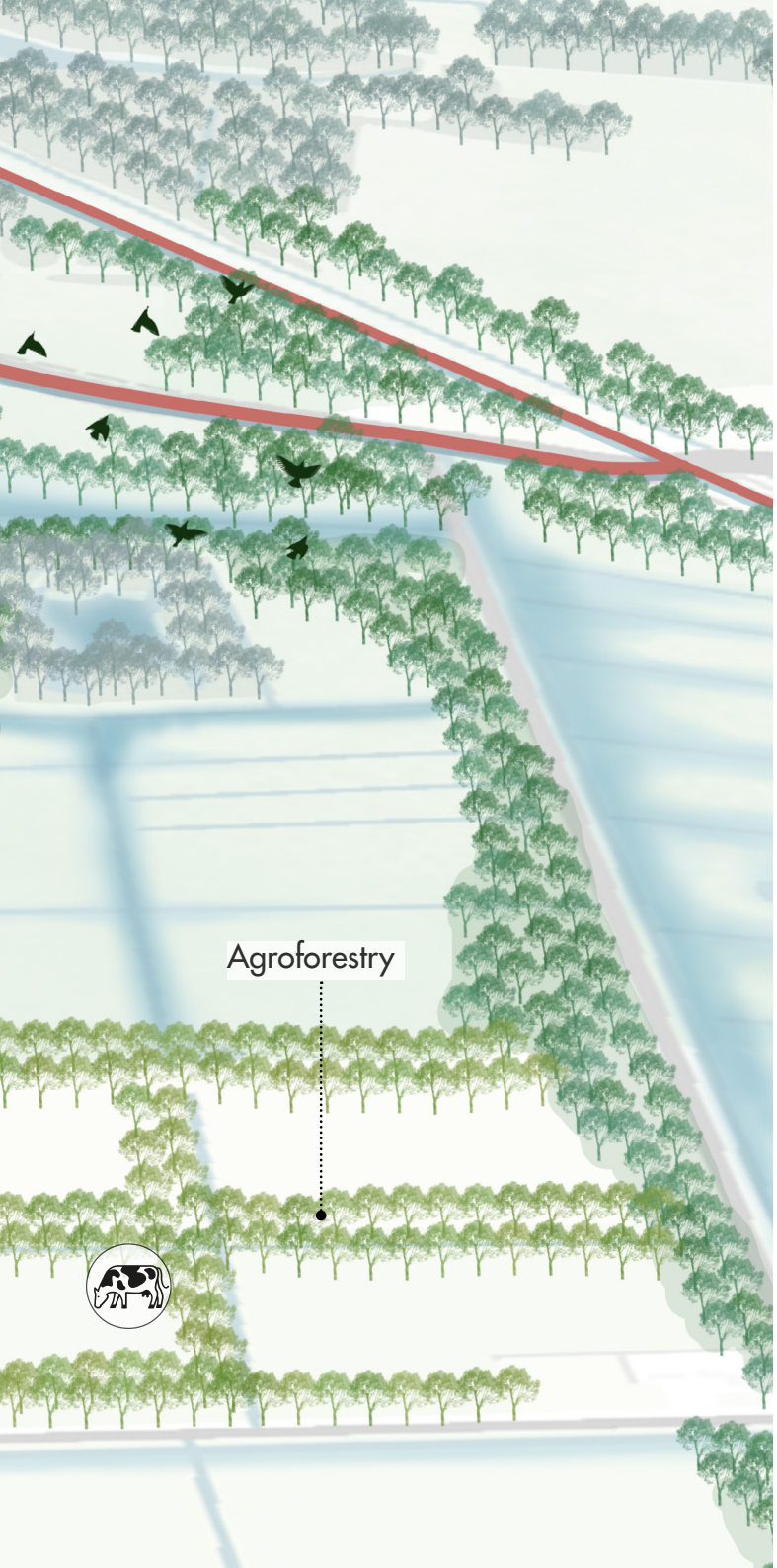
Different Stakeholders are involved in different phases (Figure 6.21). In the first phase, the main goal is to improve water retention ability, this phase can be conducted and finished within 3 years. The stakeholders involved mainly include the ecologists, the Water Board and farmers. The Water Board and ecologists need to widen the ditches and create ditch marshes, also create nature-friendly water banks. While this also needs the cooperation of farmers because some plots are taken up to create widened ditches and the ditch marshes, farmers need to be informed of the benefits of these actions and wet farming in wet areas can be encouraged by the government.

The second phase 'establish green connection with local nature' aims to bring back the local potential vegetation and make the site more connected with surrounding natural resources. This phase can be finished in around 10 years. The stakeholders involved in this phase mainly include Staatsbosbeheer, ecologists and farmers to help to plant the local forests and other plants along the green structure together. The local wildlife such as the Bar-tailed godwit, little swan, and Pimpernelblauwtje… are brought back again.

'Phase 3 --- Interweave Nature with Renewed Farmlands' aims to improve current farmlands together with farmers, agronomists and the Agriculture Board. Animal breeders, crop farmers and fruit farmers can collaborate together to make the nutrients flow in a cycle and benefit each other. Agronomists can communicate and provide some professional knowledge of renewal agriculture for farmers. The Agriculture Board needs to give subsidies to farmers when necessary to encourage them to improve the farmlands. This phase can be finished within 12 years.

The last phase 'Develop recreational functions and routes' mainly considers the interests of residents and tourists, especially the children. This phase aims to create recreational foodscapes and thoughtscapes for people to be more connected with food animals and know more about the local food animals. The whole process of four phases can be finished within about 15 years.


Flower strips
Widened ditches
Historical pond
Orchard
Recreational routes
Local vegetation



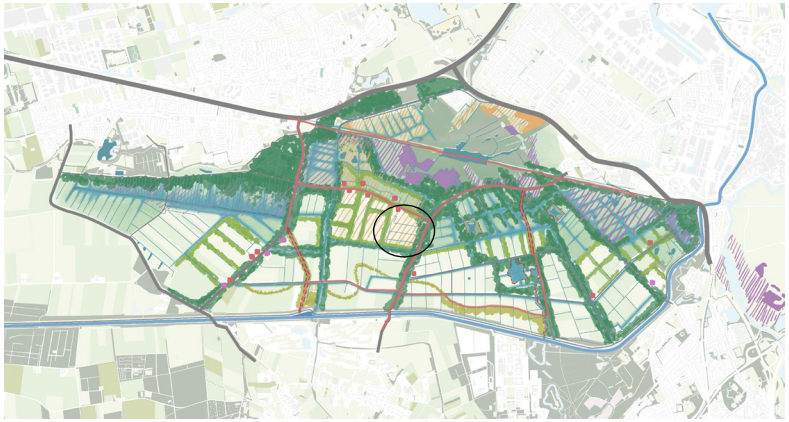
Bird View of Future Animal Farming in Nature

After developing the four phases and with the effort of different stakeholders, the water retention ability is improved with widened ditches, fen wetlands , pig rooting pits and ditch marshes... Local nature such as ‘Alluvial alder-ash forest’ is developed and functioned as green connection with surrounding natural resources. The local typical vegetation such as ‘Bluegrassland’ is developed to attract the endangered local butterfly ‘Pimpernelblauwtje’. With more local vegetation recovered, the site is an ideal habitat for other local animals such as ‘Bar-tailed godwit’ and ‘Little swan’. The farmlands are renewed by adding agroforestry, flower strips, herb-rich grasslands, natural fences... The important historical elements are brought back and involved in the recreational routing, together with the recreational animal farming landscapes, people are provided with recreational and educational spaces to get more in contact with local food animals and know more about local animal farming. Together, the flourishing animal farming foodscapes and thoughtscapes which is more sustainable and nature-inclusive is achieved!

Design Detail 1

Livestock farming + Glanshaver + Agroforestry

The typical grasslands 'Glanshaver' of De Moerputten is enlarged partly on this area. This type of grassland can be combined with extensive seasonal livestock grazing (Ecopedia). Other parts of the grassland should be more herb-rich. The dairy farming should be kept at a low stock density lower than 0.5 LU/ha, meaning that there will be no more than 9 LU in this area. Sheep can be introduced together with cows to improve the utility of the vegetation. Agroforestry such as nut trees and fruit trees are planted on this area to provide supplementary natural diets for livestock. Some bushes can be grown as well to provide twigs for livestock in winter. Instead of artificial fences, hedgerows can be used to help increase the biodiversity. Orchards planted along the ditches to enhance the pattern of this grassland.



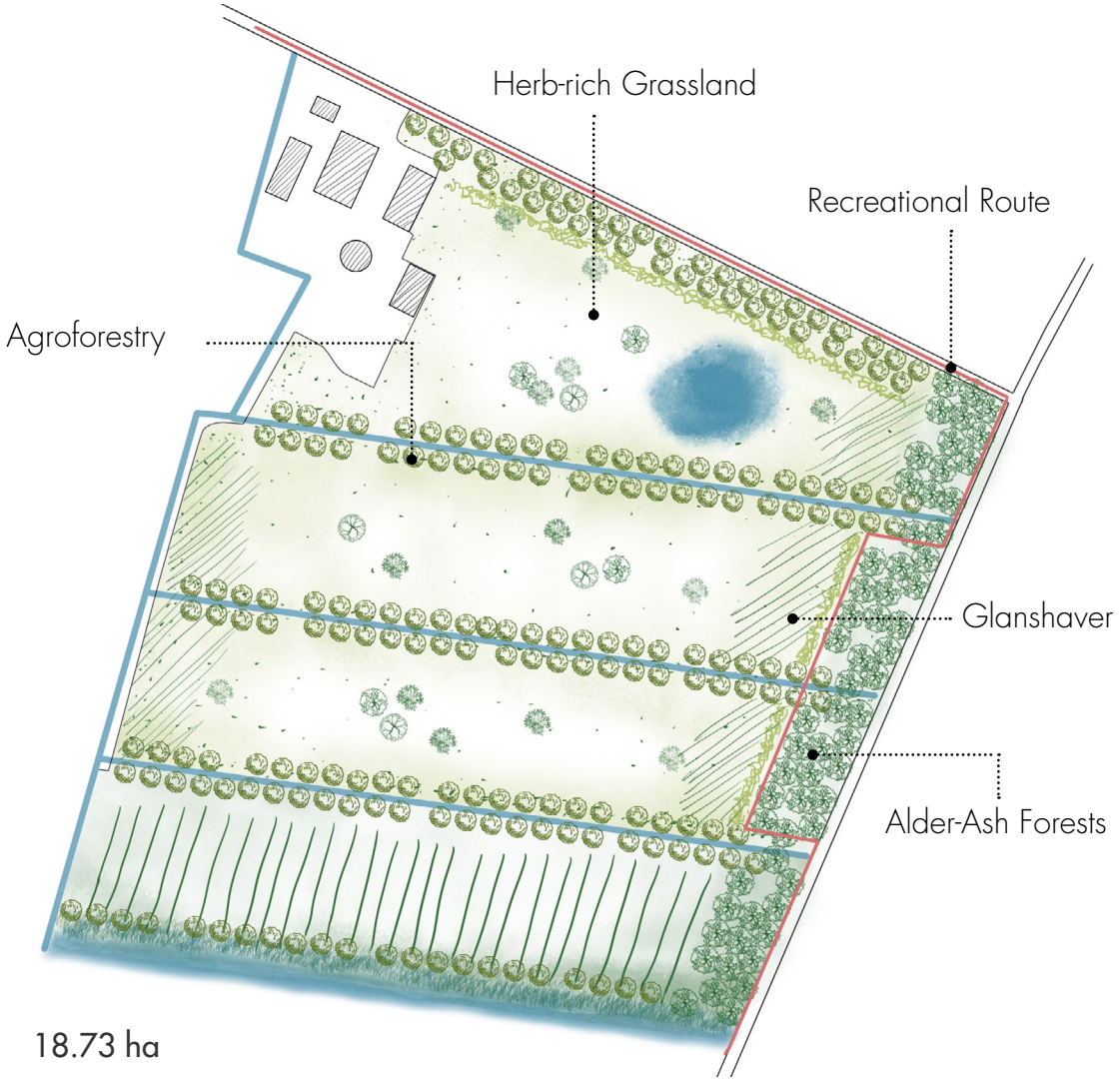


Figure 6.22 *Design Detail 1--- Plan (made by author)*

Design Detail 1

Livestock farming + Glanshaver + Agroforestry

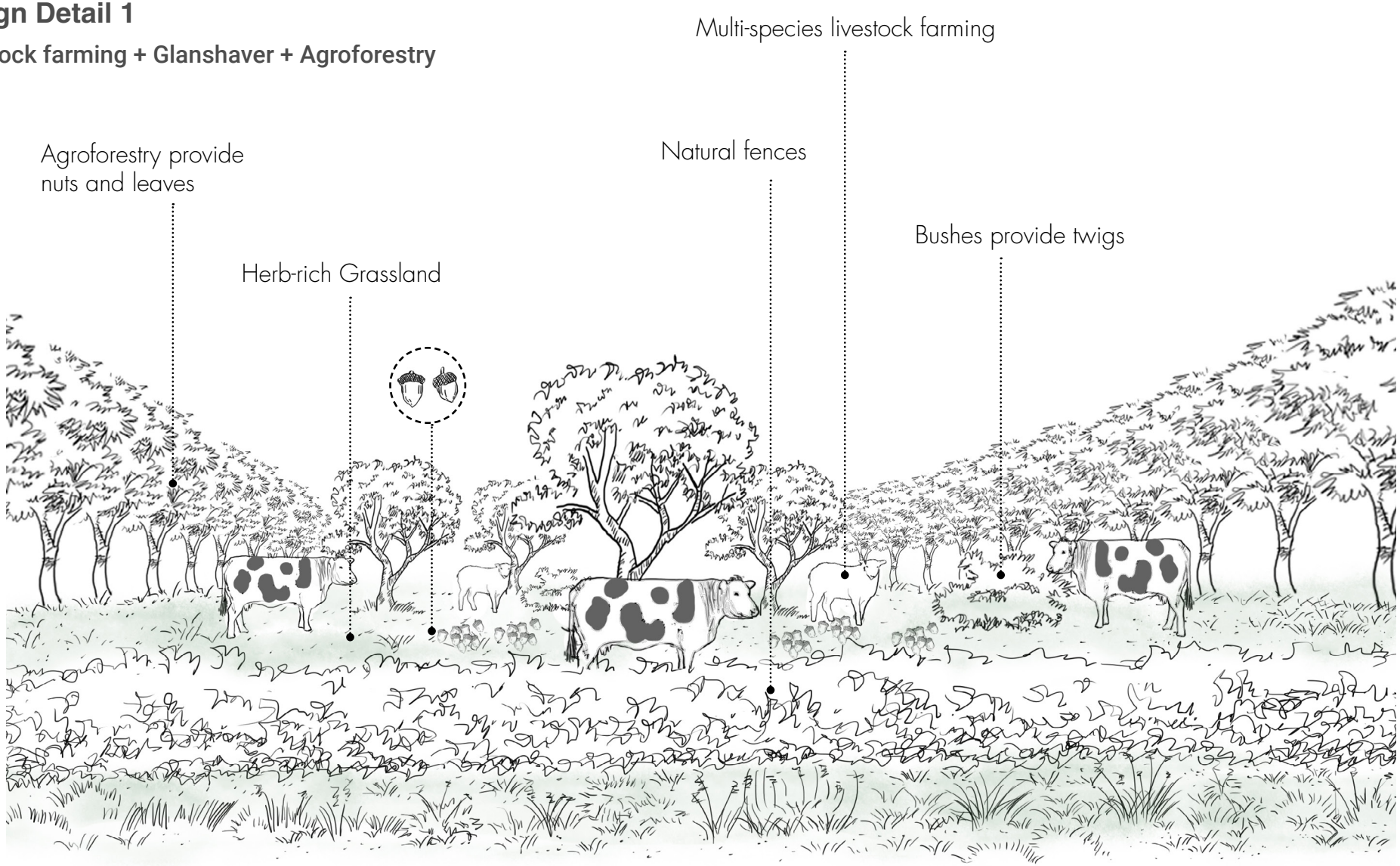
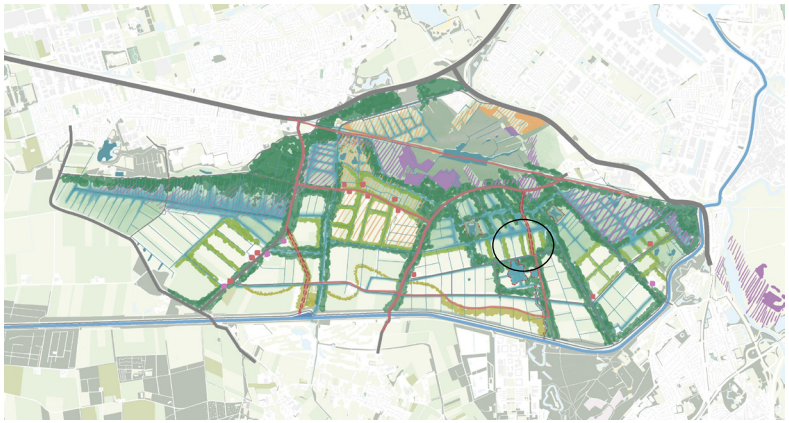


Figure 6.23 *Design Detail 1--- Perspective (made by author)*

Design Detail 2

Pig farming + Agroforestry

As mentioned before, pigs in this area are introduced to help improve the water retention ability of the land. The local traditional breeds such as 'Netherlands landvarken' are raised here. This breed of pigs can also be fondled by children. The 'raised bolle akker' landscapes can be combined with pig farming to make the animal farming landscape here be more recreational. Fruit trees are planted to provide fruits for people and also the sheltering space for pigs. The stock density in this plot should be better lower than 0.35 LU/ha, which means no more than 3 pigs are raised in one plot. Pig farming can be rotational in this area. Each pig will have pig farming for limited days to give the grassland time to recover.



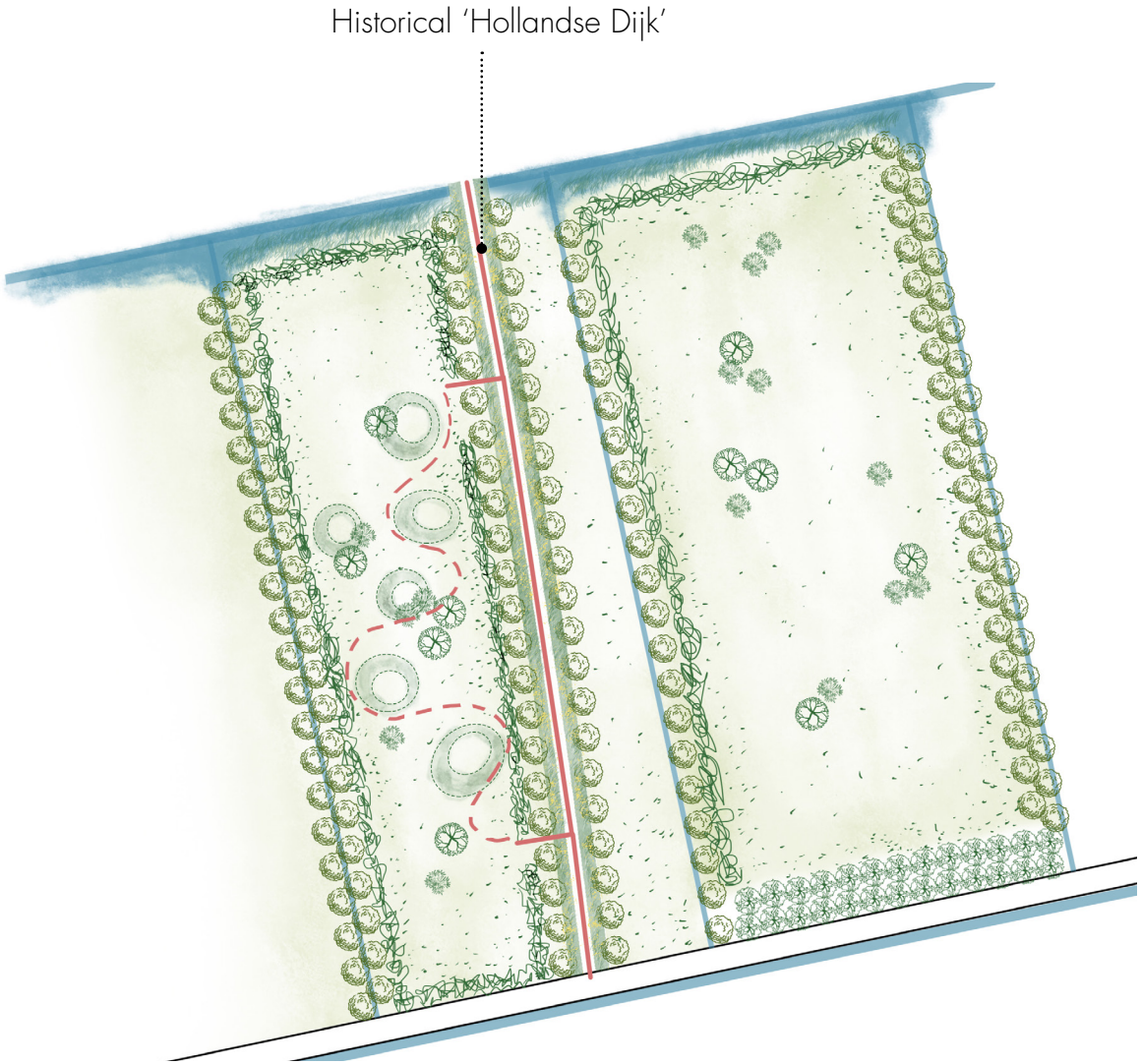


Figure 6.24 *Design Detail 2--- Plan (made by author)*

Design Detail 2

Pig farming + Agroforestry

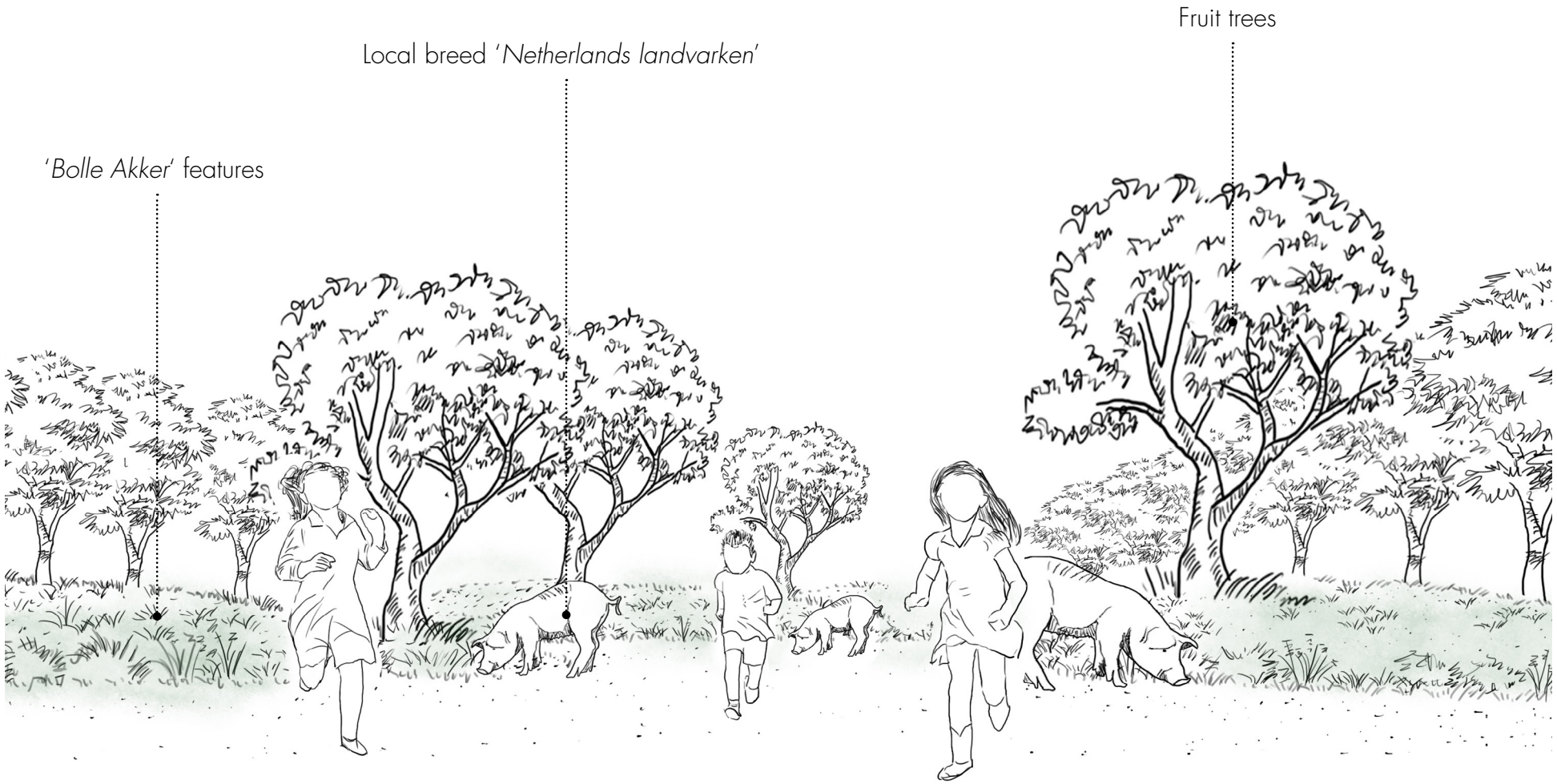
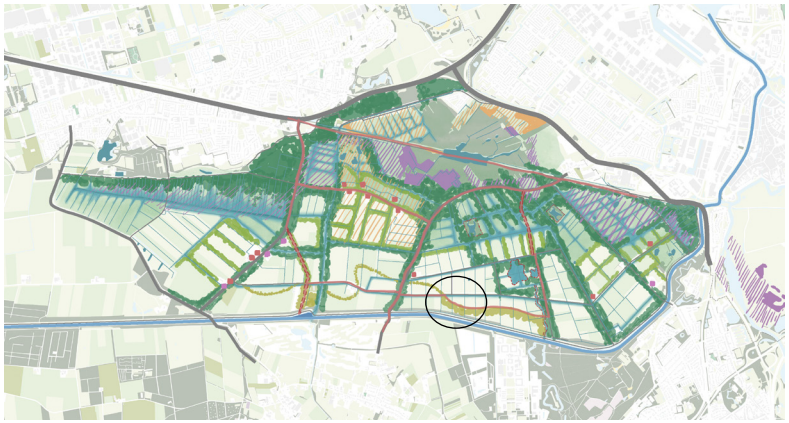


Figure 6.25 *Design Detail 2--- Perspective (made by author)*

Design Detail 3

Chicken farming + Orchards

Agroforestry with chicken farming is introduce along the border between sandy soil and loamy soil. Because chickens like dust bath which is beneficial for them to keep their feathers in pristine condition and help them stay free of mites, lice and other parasites. Therefore, sandy soil is the perfect soil to raise chickens. Chickens are also natural pest controllers because they like eating insects. This will perfectly help to keep fruits healthy. People can walk along parts of this soil borders to enjoy the animal farming foodscapes.



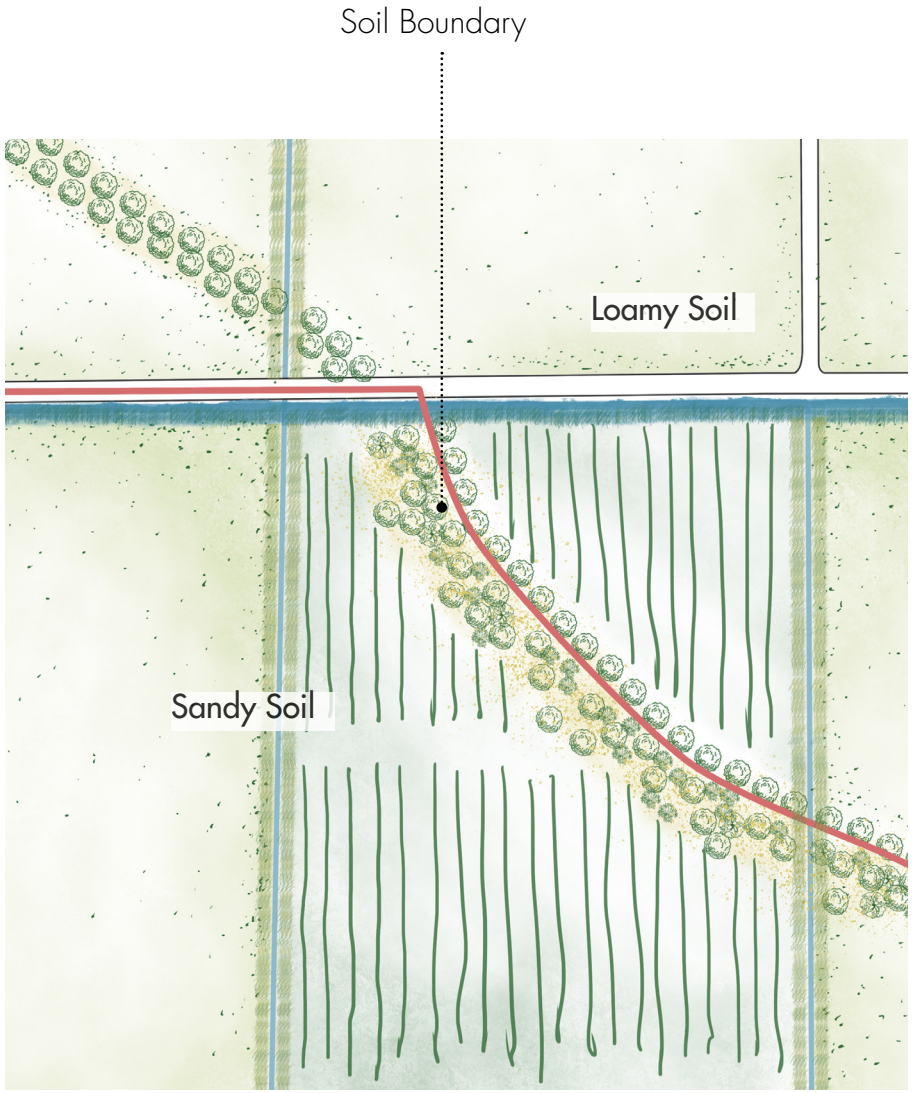


Figure 6.26 *Design Detail 3--- Plan (made by author)*

Design Detail 3

Chicken farming + Orchards

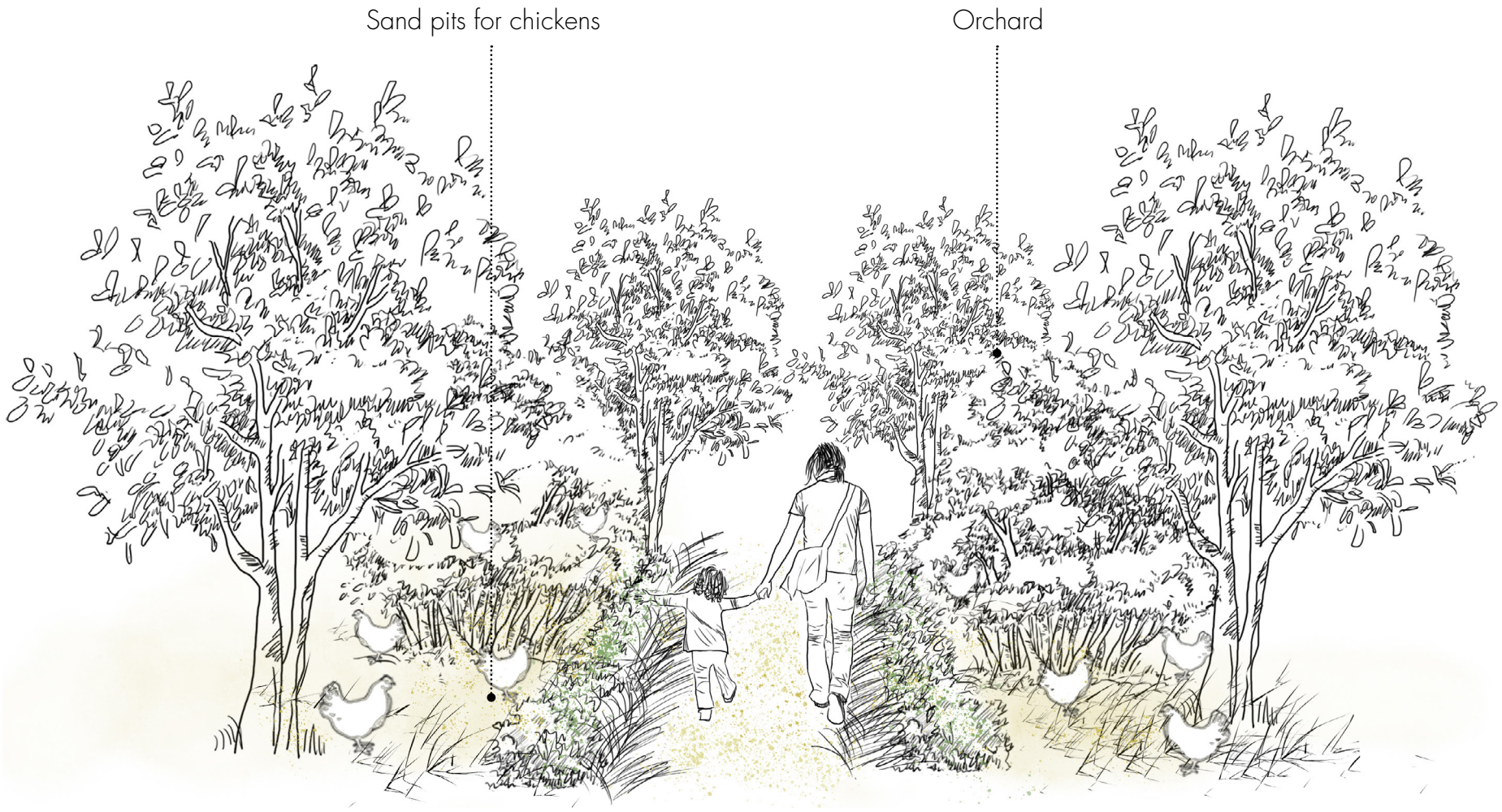
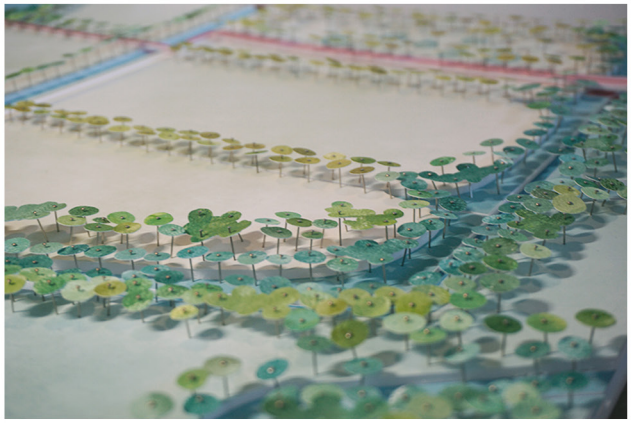
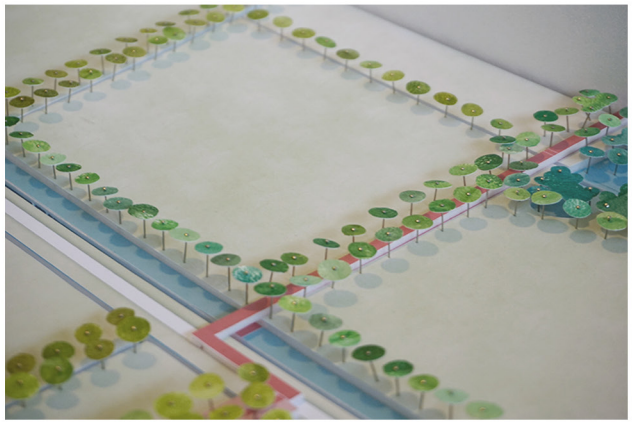


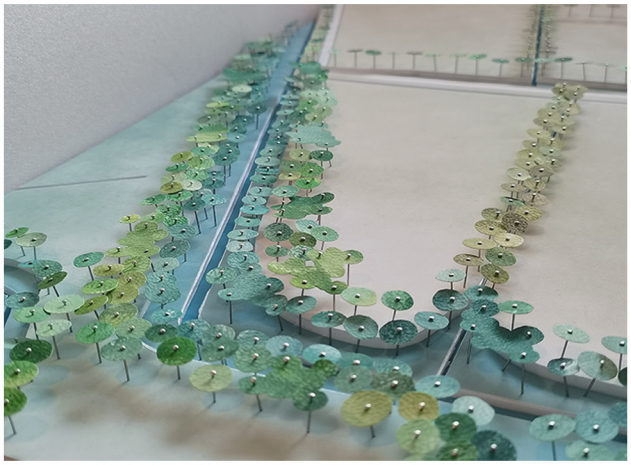
Figure 6.27 *Design Detail 3--- Perspective (made by author)*

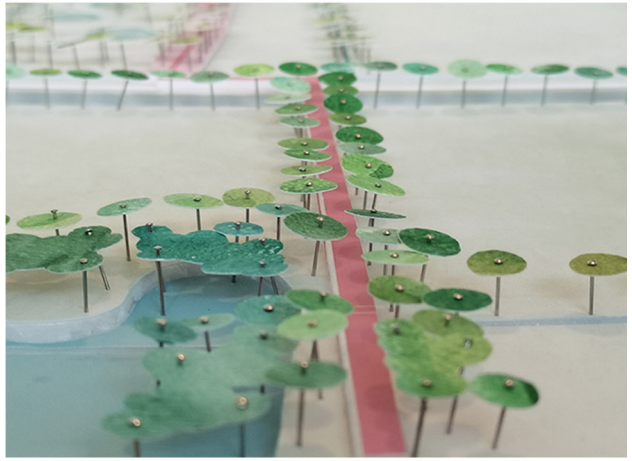
Model 1:1000

A part of site 1 'Animal farming in Nature' is made into a real model with a scale of 1:1000. The model shows how the main ditches are widened to improve the water retention ability of the site. The eco-friendly water banks are created with the local vegetation, which also helps to establish the connection with surrounding natural resources. Agroforestry is planted along the ditches to increase the biodiversity of the farmlands. The recreational route is highlighted in red color. Part of the historical dike is brought back and involved in the recreational route. It is enhanced with agroforestry planted on the lower part of the dike to attract tourists.









Site 2: Animal Farming with Nature

'Animal farming with Nature' is explored in suburban area where has several intensive animal factories near an eco-sensitive natural area. Differs from 'Animal farming in Nature' which is mainly nature-oriented animal farming, 'Animal farming with Nature' is more productive oriented. It is a balanced and compromised result of animal farming and nature work together. How to renew the animal farming with nature to reduce the damage towards the surrounding natural area and increase the recreational function is explored thorough design in this site.

Source: Google map

Analysis

Figure 6.28 *Analysis--- Site 2: 'Animal Farming with Nature' (made by author)*

Most parts of the site are sandy soil with a natural park 'Nulandse Heide' in the south. Only a small part in the north west is loamy soil with higher groundwater level. There are several animal factories on this site mainly include dairy farming and pig farming. When checking the historic map, the red line hatched area was used to be the ancient forest area, which has the potential to be brought back and involved in the establishment of green connection.

Spatial Framework --- *Connection with surrounding natural resources*

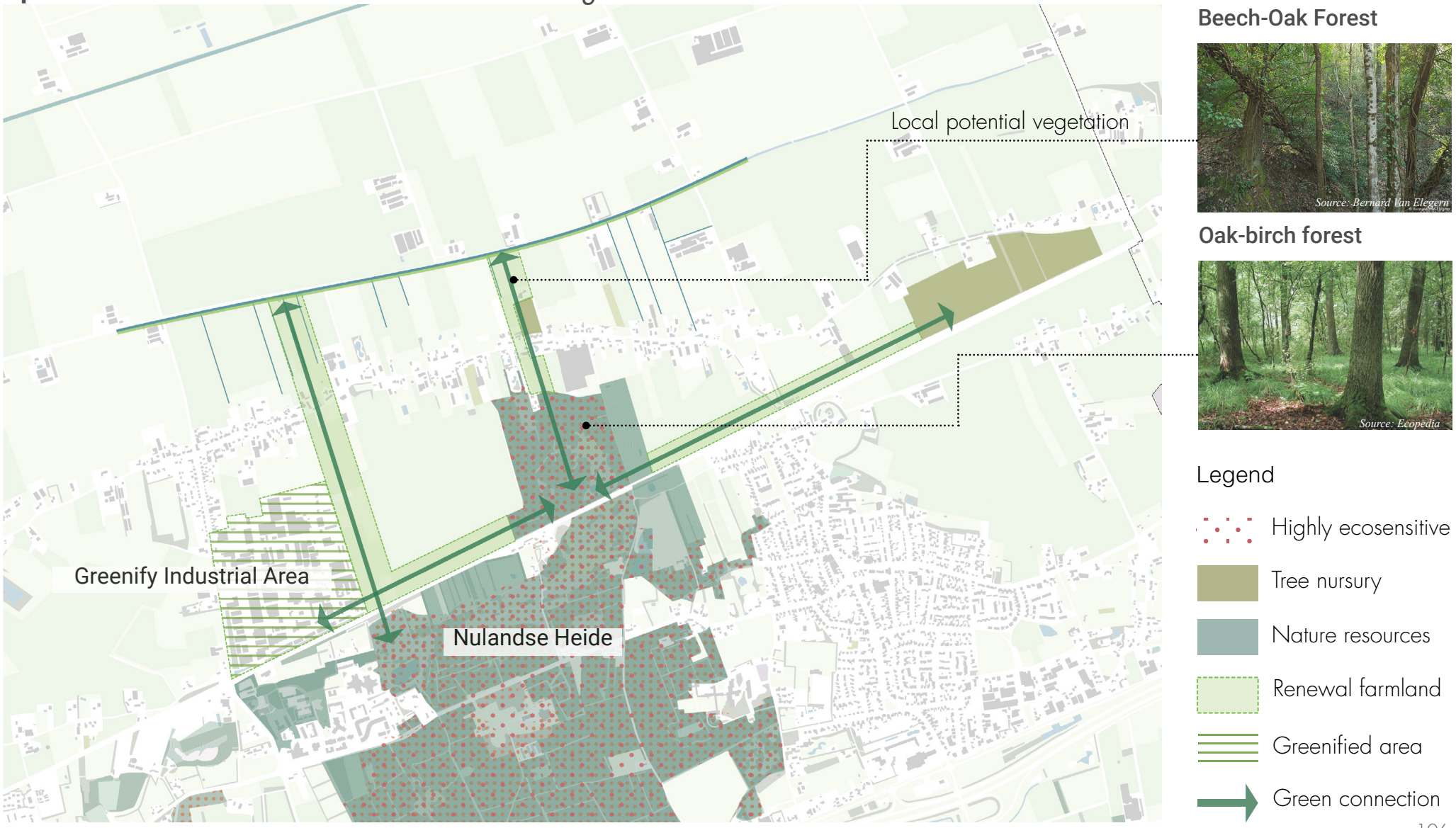


Figure 6.29 *Spatial Framework --- Connection with surrounding natural resources (made by author)*

Spatial Framework

The ditches in the north-west loamy part are widened to improve water retention ability. The green structure is established based on the previoud analysis. The orchards are planted along the pattern and ditches to strengthen the structure of the farmland. Various design principes have been applied on this site to improve the current farmlands.

Figure 6.30 *Spatial Framework (made by author)*

Spatial Framework --- *Application of Design Principles*

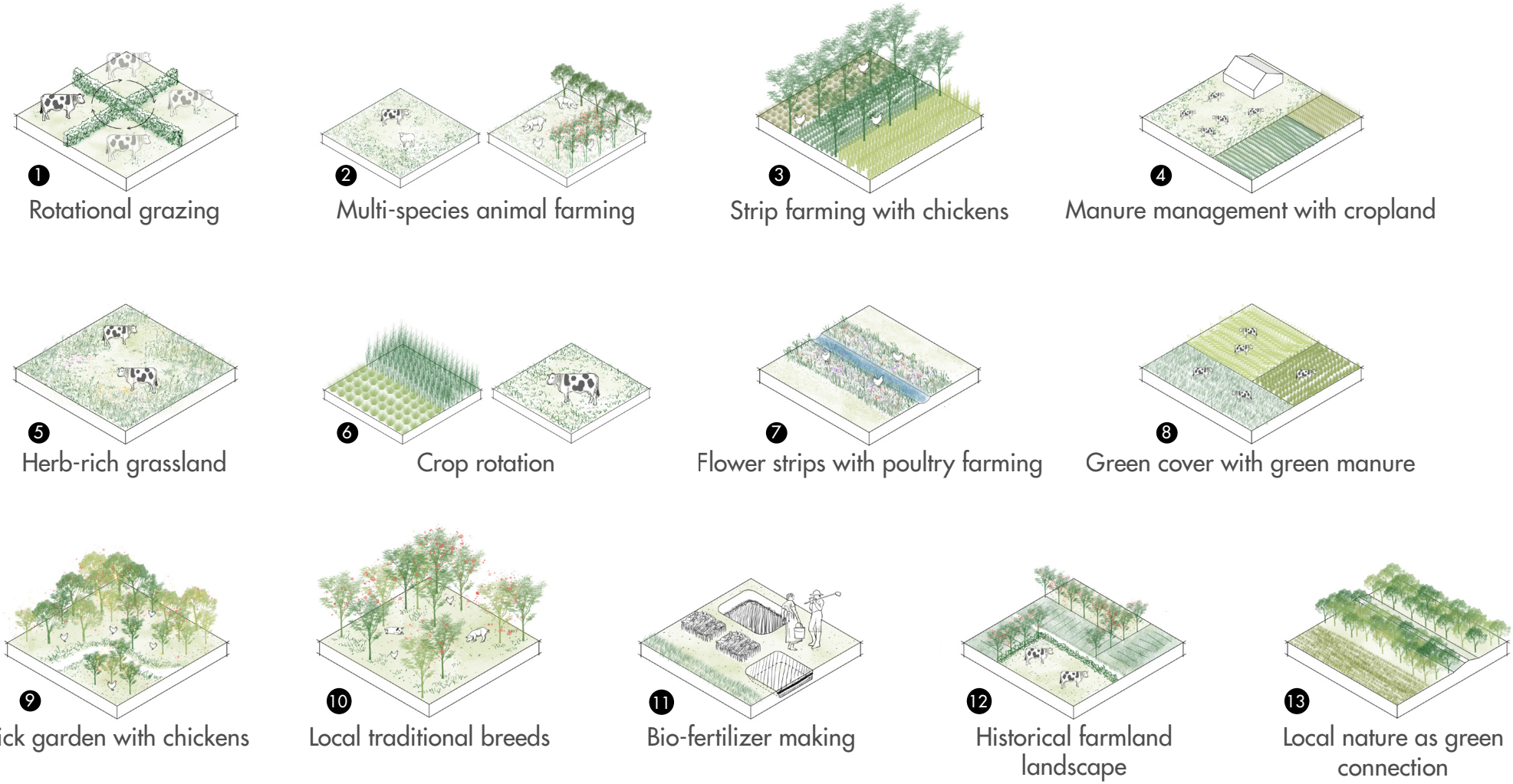
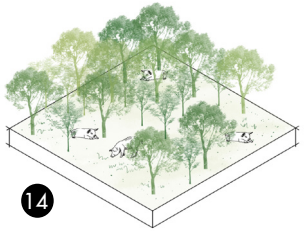


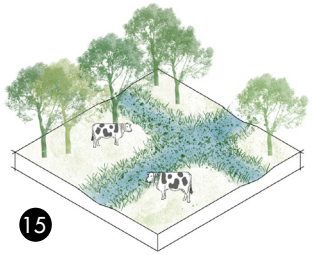
Figure 6.31 *Application of Design Principles (made by author)*

Spatial Framework --- *Application of Design Principles*

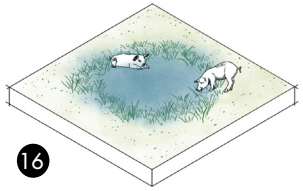
The design principles (Figure 6.31) used on this site intend to improve current intensive animal farms and assist with the achievement of balance between production and ecology in animal farming on this site. For example, 'Rotational grazing' can be conducted here when the stock density needs to be maintained at a relatively high level to give the plots more time to rest and recover. 'Multi-species animal farming' can also be conducted to help save the space of animal farms and maximize the resources of the land. 'Manure management with cropland' 'Bio-fertilizer making' dedicates to the nutrient cyclic flow of animal farming here etc.



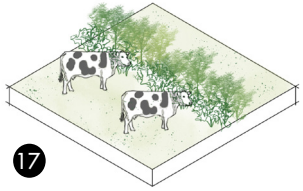
14 Trees for sheltering



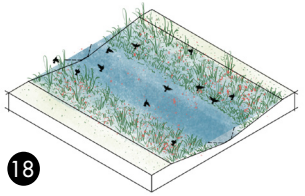
15 Diverse supplementary diets



16 Ponds for drinking& bathing



17 Natural fences



18 Nature-friendly water bank

Transformation from Current to Renewed Condition

Current situation

The area of the axonometric is in the northern-east part of the SITE 2. The cropland and the animal factories are separated and do not collaborate with each other very well. The welfare of pigs in the factories are not very good, the grasslands nearby the factories are monofunctional and lack of biodiversity.

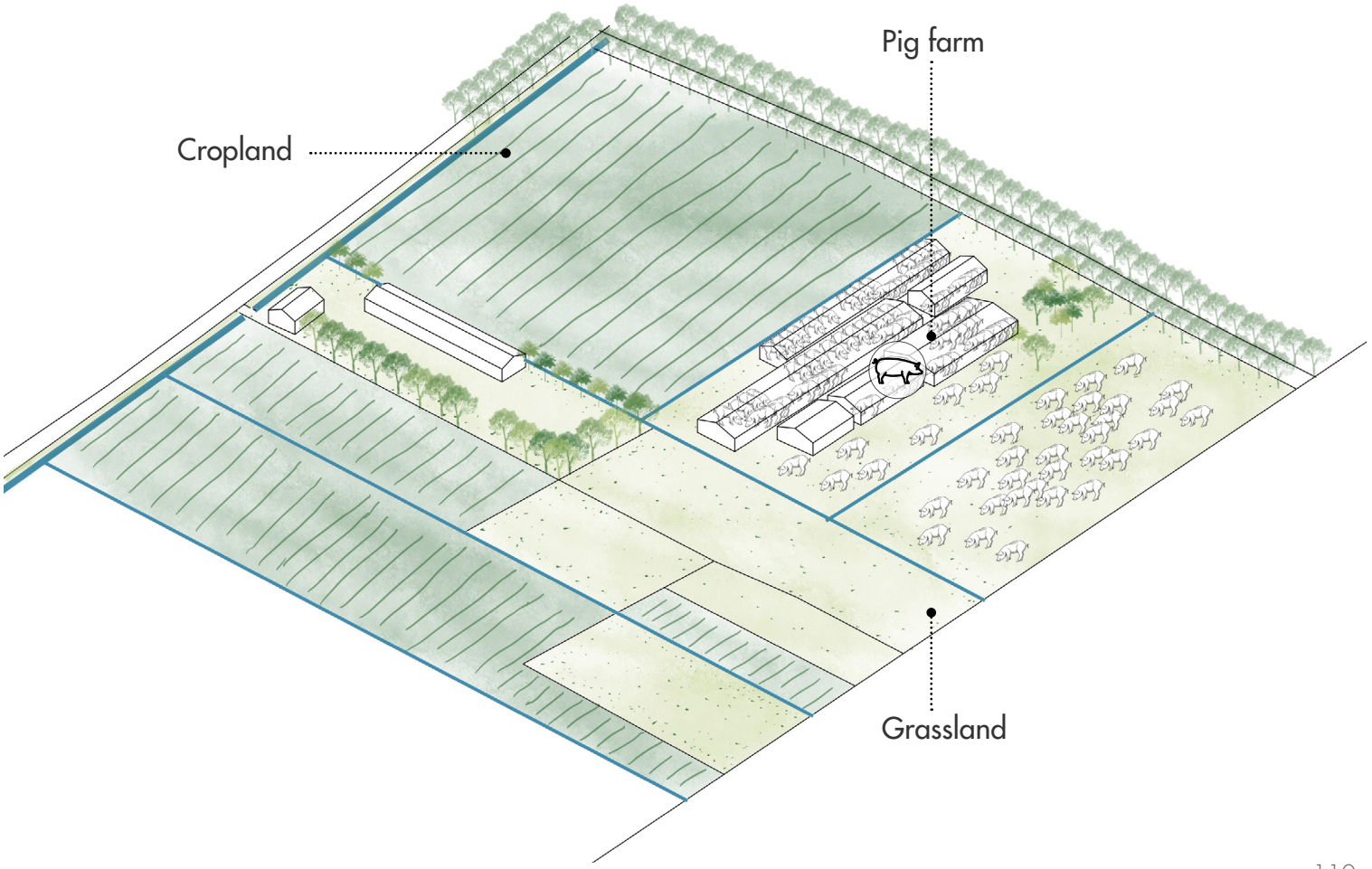


Figure 6.32 *Current situation (made by author)*

Transformation from Current to Renewed Condition

Renewed Conditioin

The croplands can operate strip farming with orchards along the pattern of the farmland to increase the biodiversity. Food animals such as pigs from the factory nearby can be introduced into the croplands at specific time after harvesting to loosen and fertilize the soil. Flowery strips can grow along the main ditches to protect the water quality from pollution of agriculture. Agroforestry such as nut trees and fruit trees can be planted to provide natural proteins for pigs. Trees can create sheltering spaces for pigs in hot summer as well. Chickens can also be raised together with pigs to help control the pests of the orchards.

A part of cropland is spared for people to collect the manure from the animal barns nearby and learn to make the biofertilizer with green waste from the croplands. This can give the animal farming landscape more recreational value through making people involved in the nutrient circulation of farmlands.

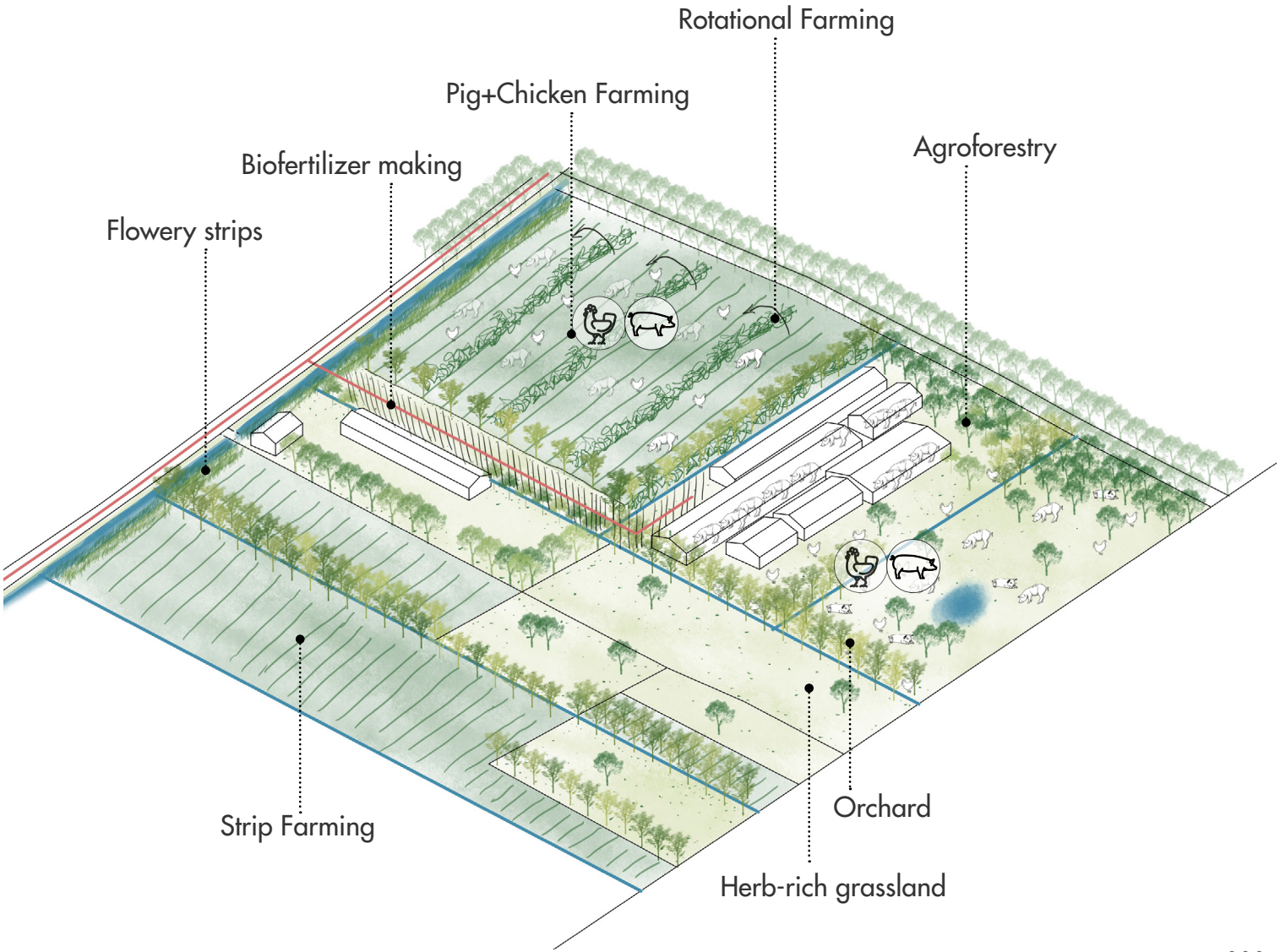


Figure 6.33 *Renewed condition (made by author)*

Perspective --- *Involve people into sustainable nutrient flow*

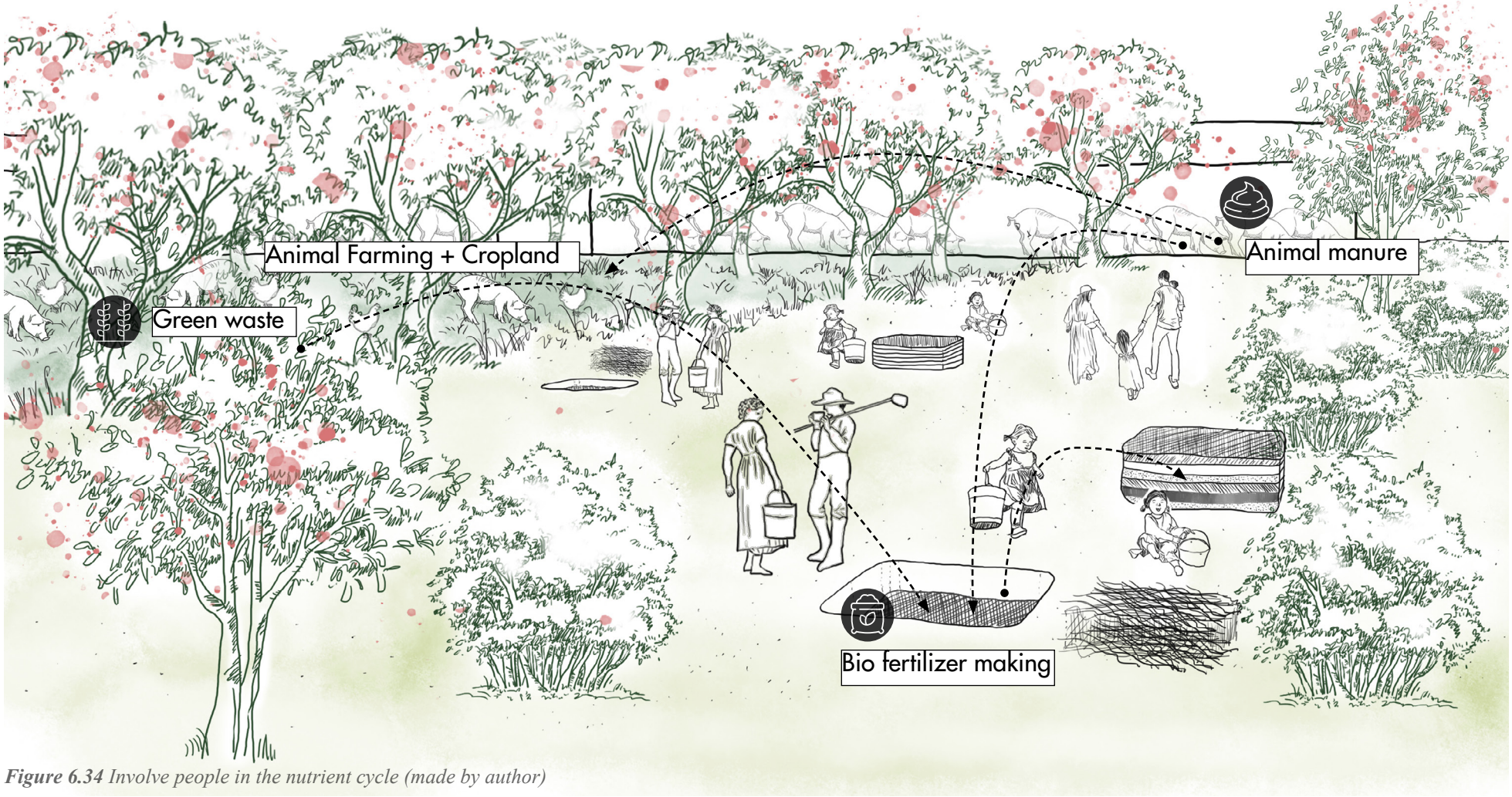


Figure 6.34 *Involve people in the nutrient cycle (made by author)*

The pig farm and the cropland nearby are combined. The manure from the pig farm can be collected and mixed with green waste from surrounding plants to make the bio-fertilizer. Then the bio-fertilizer can be used in the croplands. People are encouraged to involve in this nutrient flow of sustainable animal farming through making bio-fertilizer by themselves.

Compensation for Farmers

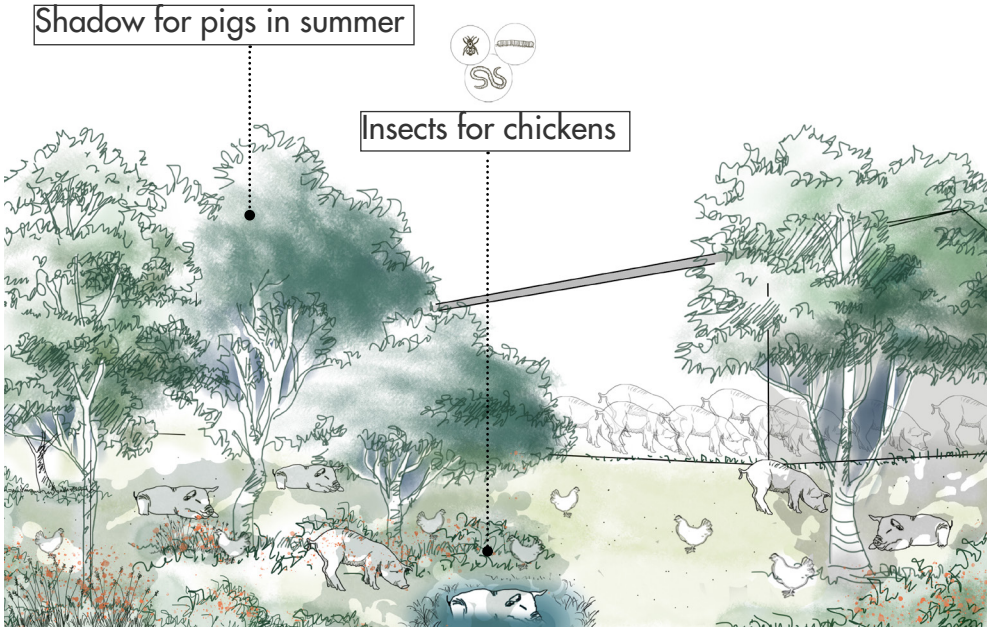


Figure 6.35 *Pig farm in summer (made by author)*

Pigs and chickens can be raised together because they can benefit each other (see design principle in Chapter 5). The agroforestry in the pig farm can provide shadow for pigs in summer, pigs are animals that have difficulty cooling themselves and maintaining their body temperature (A Greener World, 2022). Tree shadows are important for pigs to keep healthy and avoid sunburn and heat stress. The herb-rich grasslands can provide abundant insects for chickens in spring and summer. Farmers can get diverse high-quality animal products in this way.

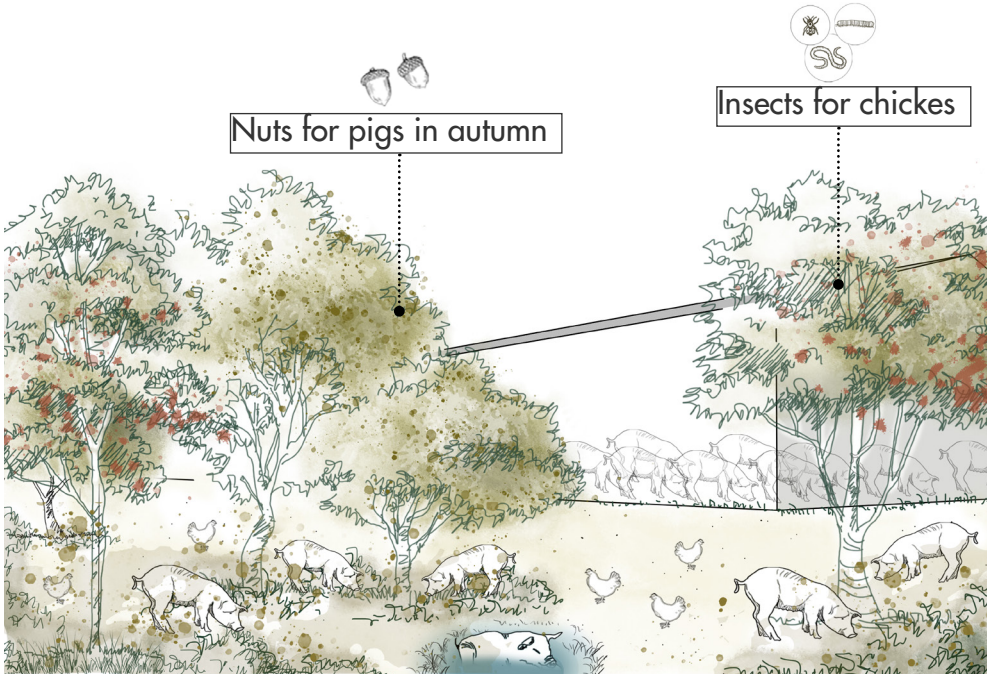
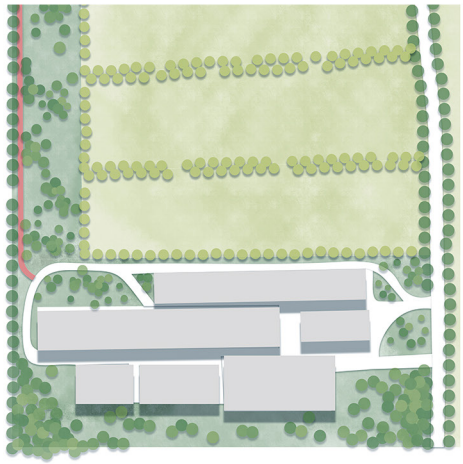


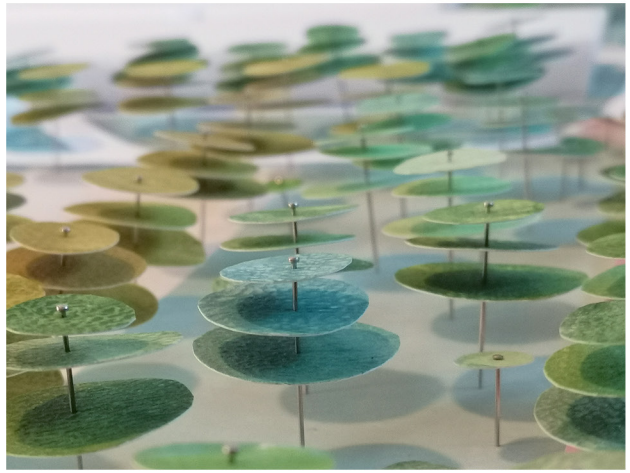
Figure 6.36 *Pig farm in autumn (made by author)*

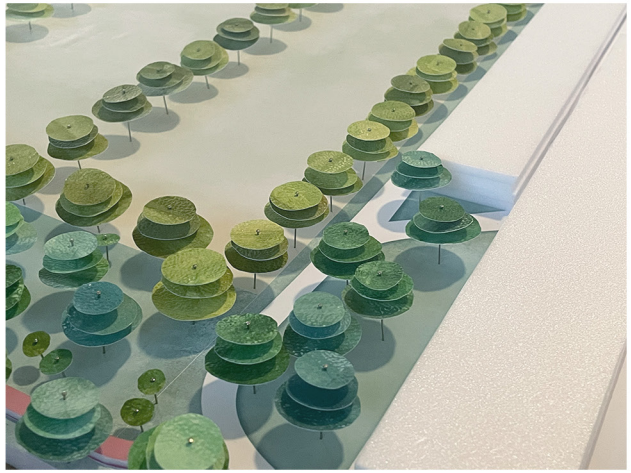
In the autumn, nuts from agroforestry can be the natural high-quality protein for pigs. Chickens can eat the pests for the fruit trees which also helps to keep the fruits healthy. In this way, farmers do not need to buy extra artificial fodders. Animal welfare is ensured and the costs for farmers are reduced. The manure of animals can also help to fertilize the soil and the agroforestry, which realize a nutrient circulation in this pig farm. Besides the high-quality animal products. Farmers can also make some profits through fruit trees.

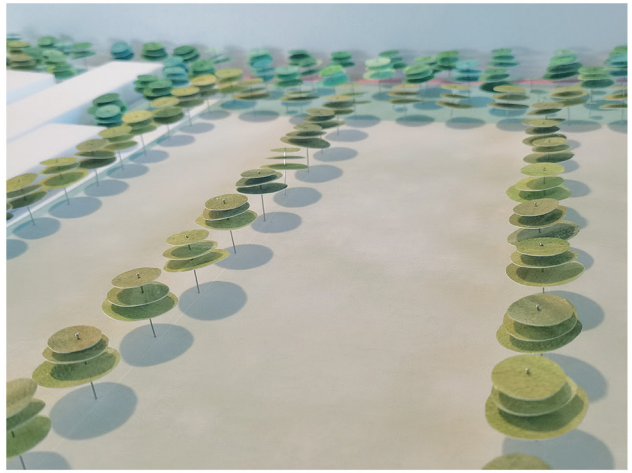
Model 1:500

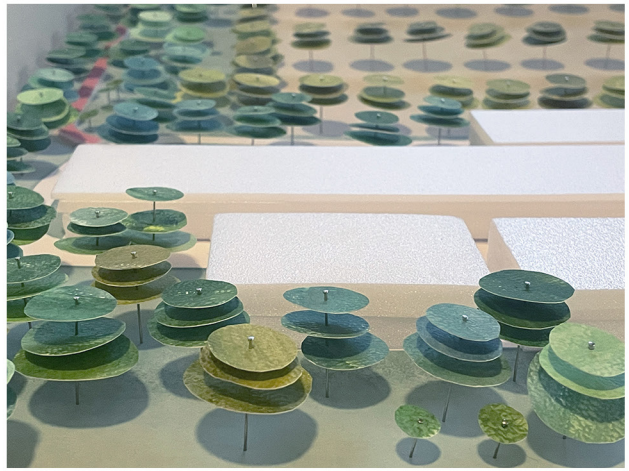


Part of site 2 'Animal farming with Nature' is made into a real model with a scale of 1:500. The model includes a pig farm and the croplands near it. It aims to show how animal farming is combined with croplands. The pig farm is forested with local vegetation 'Beech-oak forest' which could also provide natural nuts for pigs. People are also involved in the nutrient flow of sustainable animal farming. They can collect pig manure from the pig farm and mix the manure with green wastes to make the biofertilizer near the croplands. The biofertilizer can be used on the croplands to realize nutrient circulation.



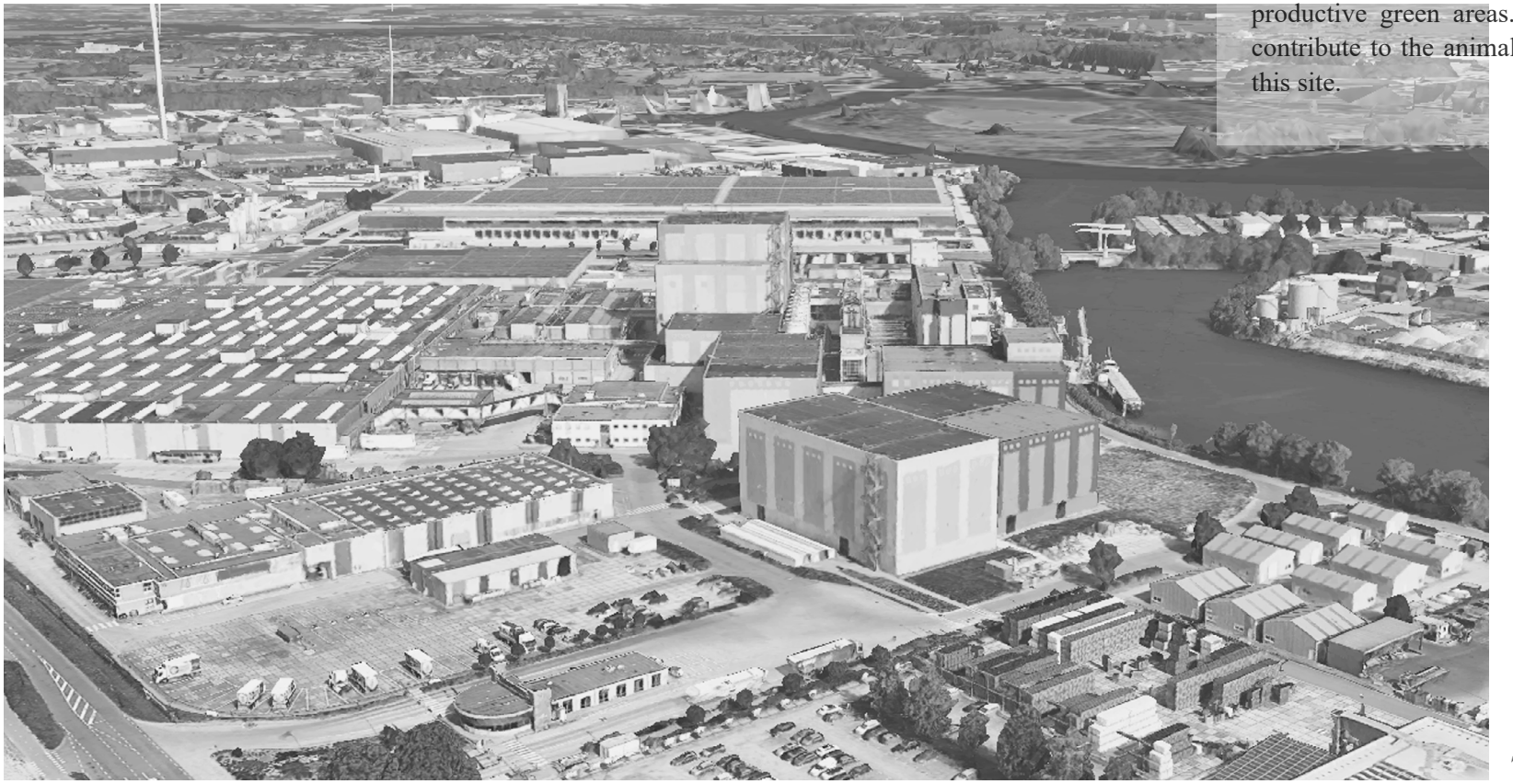






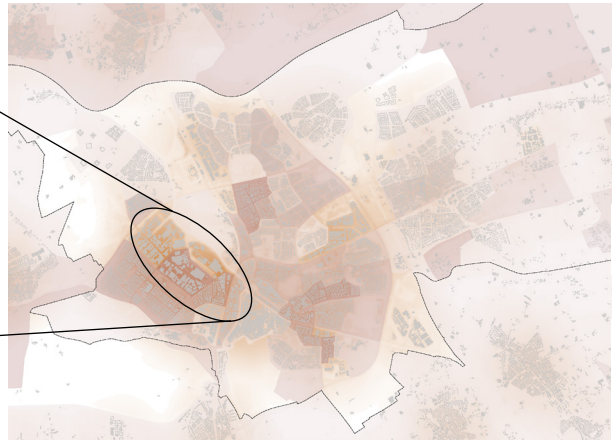
Site 3: Animal Farming through Nature

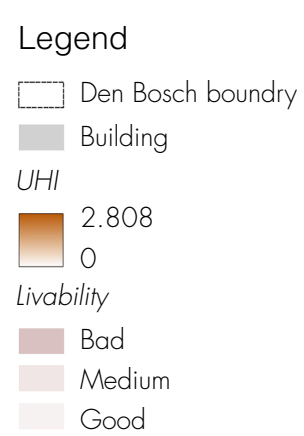
'Animal farming through Nature' is explored in the urban context which is an industrial area near 'Engelermeer'. Through establishing the green structure of the industrial area to create climate-adaptive environments. The foodscapes could also be combined with the green structure in those potential productive green areas. How the urban area could contribute to the animal farming will be explored in this site.



Source: Google map

Environmental and Spatial Problems





There are several main environmental and spatial problems in this industrial area. As what the maps have shown, the urban heat effect is quite serious on this site compared to the whole urban areas of Den Bosch. The site is lack of green spaces which leads to the low livability and vitality as well as permeable surfaces. There are also some EHS areas surrounded this industrial area but the site itself is like a boundary to isolate those EHS areas from connecting with each other.

Figure 6.37 *Environmental and Spatial Problems (data source: PDOK NL& Klimaateffectatlas NL, 2021. Google maps, 2022. Made by author)*

Spatial Framework

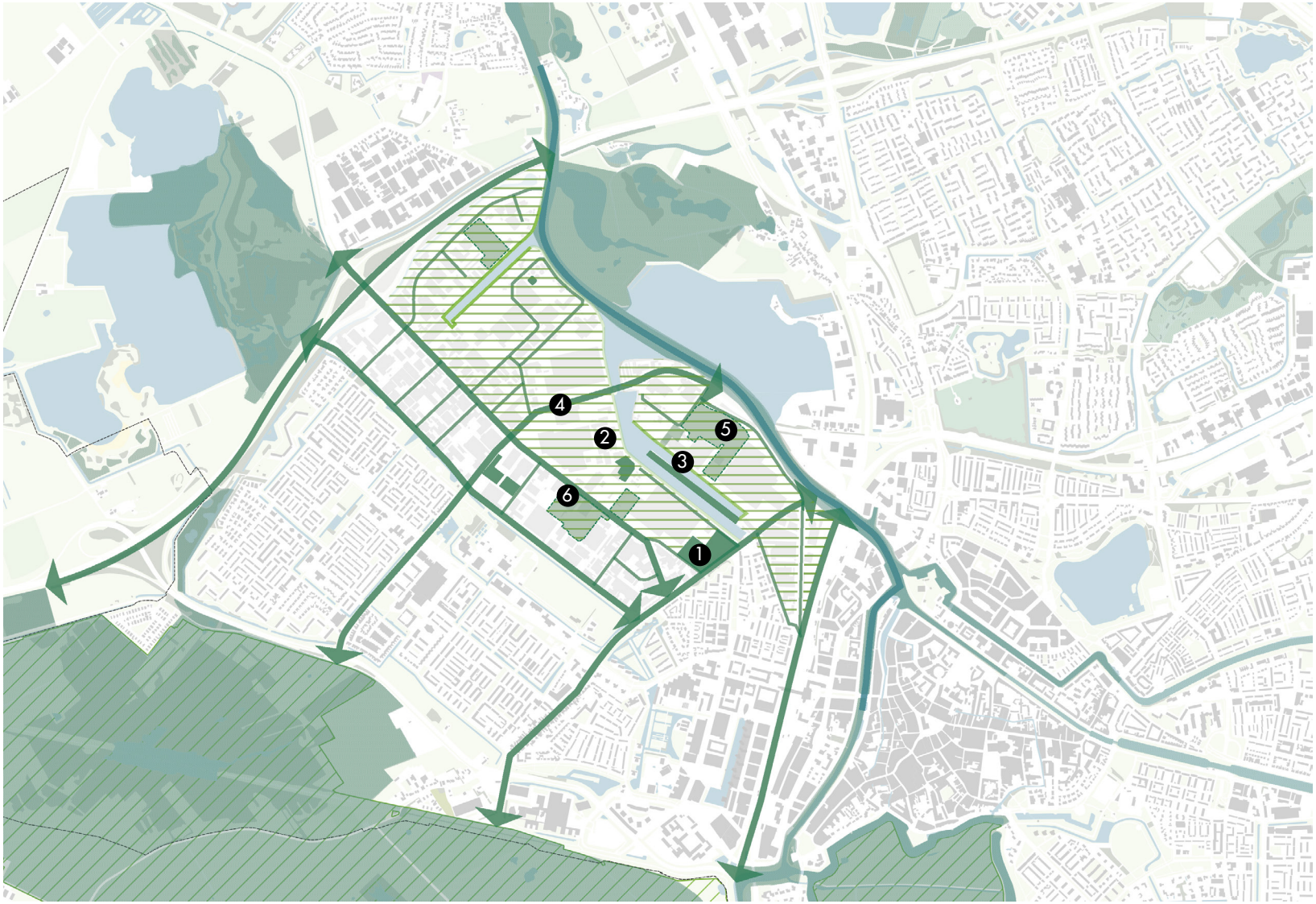
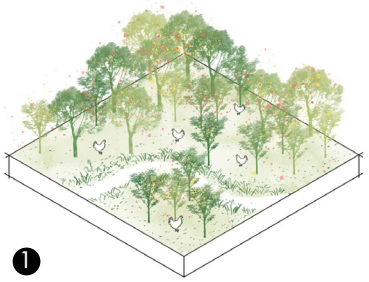


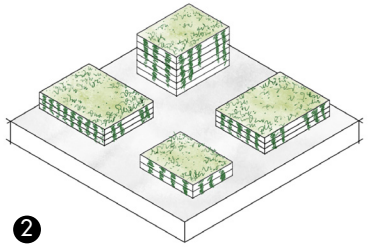
Figure 6.38 *Spatial Framework (data source: PDOK NL, 2021. Map made by author)*

However, although the site has a lot of environmental and spatial issues, it still has a lot of potentials to improve current condition. A lot of vacant roofs and facades can be utilized by greeneries. The grey street can be greenified to build up the green connection with surrounding EHS areas. Grey parking areas, hard river banks ... also have the need to be greenified. These areas have great potentials to be productive when combined with green foodscapes.

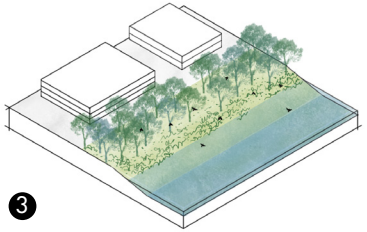
Spatial Framework --- *Application of Design Principles*



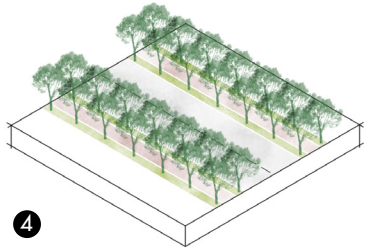
❶ Picking Garden with Chickens



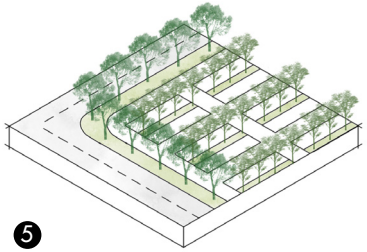
❷ Productive Green Roof & Vertical Greenery



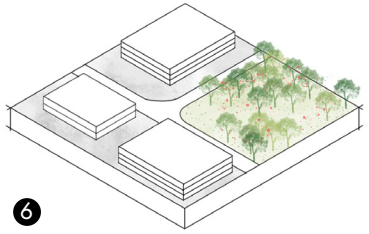
❸ Productive Green Soft Bank



❹ Productive Green Street



❺ Productive Green Parking Space



❻ Productive Permeable Space

Productive plants such as nut trees can work as street trees to greenify the current street and strengthen the green connection with surrounding natural areas. The green roof and vertical greenery can help to reduce the urban heat effect, when combined with green foodscapes, the livability can also be improved. Because Den Bosch is facing high flooding risk and there are a lot of impermeable surfaces in the urban area, add more green foodscapes can help add more permeable surfaces and reduce the flooding pressure. Picking gardens can also be created in those vacant green areas, small food animals such as chickens can be raised there to make the foodscapes recreational. The green wastes from those green areas can be collected to be the raw materials of animal fodders or biofertilizers.

Figure 6.39 *Application of Design Principles (made by author)*

Transformation from Current to Renewed Condition

Current

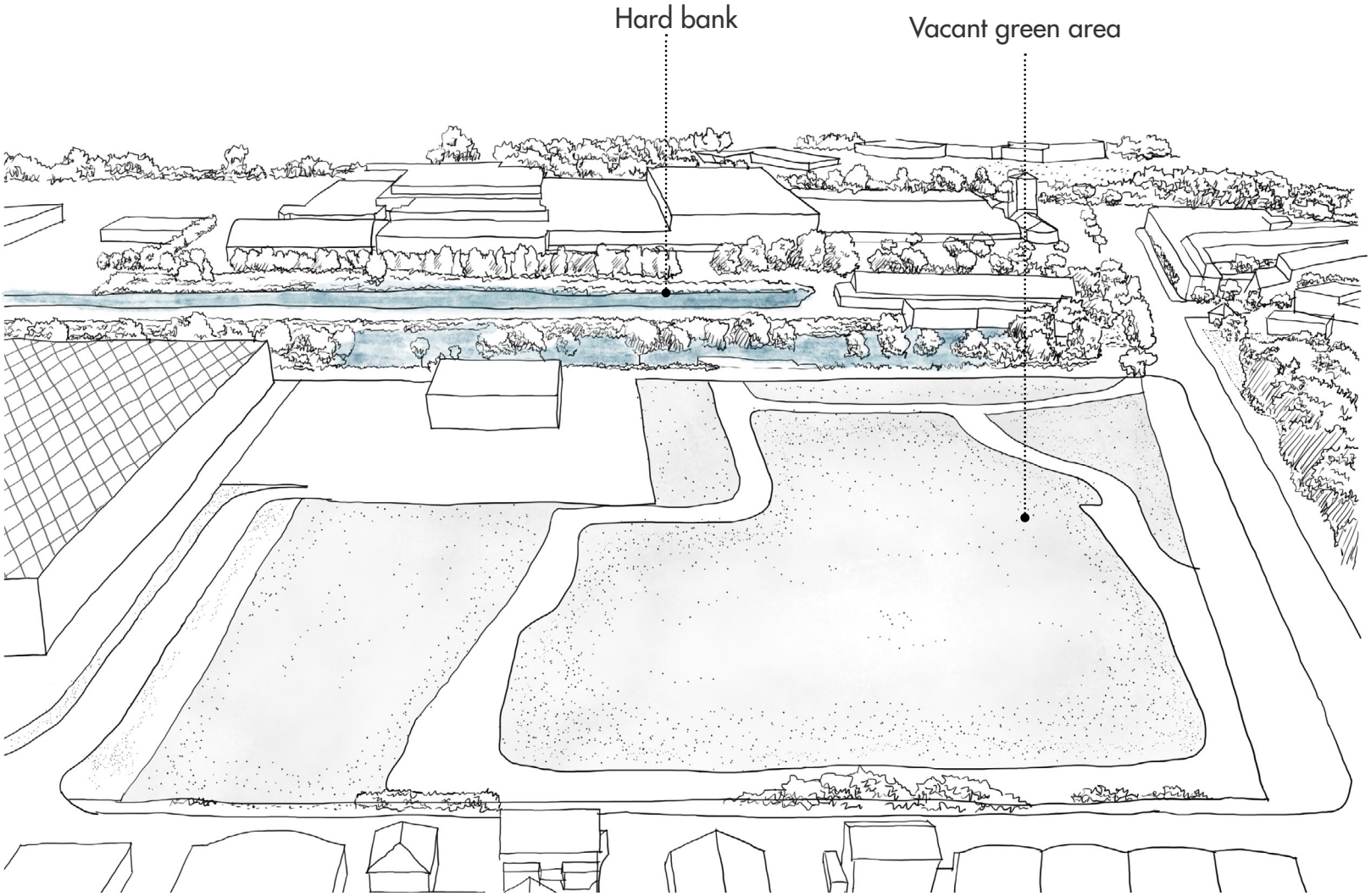


Figure 6.40 *Current situation--- spot 2 (made by author)*

There are some vacant green areas only with monofunctional grasslands in this industrial area (Figure 6.40). Picking garden with chickens can be created on these vacant green areas. Different planting layers are considered in creating picking gardens. Higher layer could be tall nut trees with low fruit trees, medium layer could be some shrubs such as black currant, blueberry, raspberry, redberry etc. In the lowest herb layer, pumpkin family, mints, strawberry etc. can be planted. (Permacultuur Nederland, 2022) Some reed plants can grow near the green banks which could be used as litter in animal barns later (Figure 6.41).

Transformation from Current to Renewed Condition

Renewed Condition

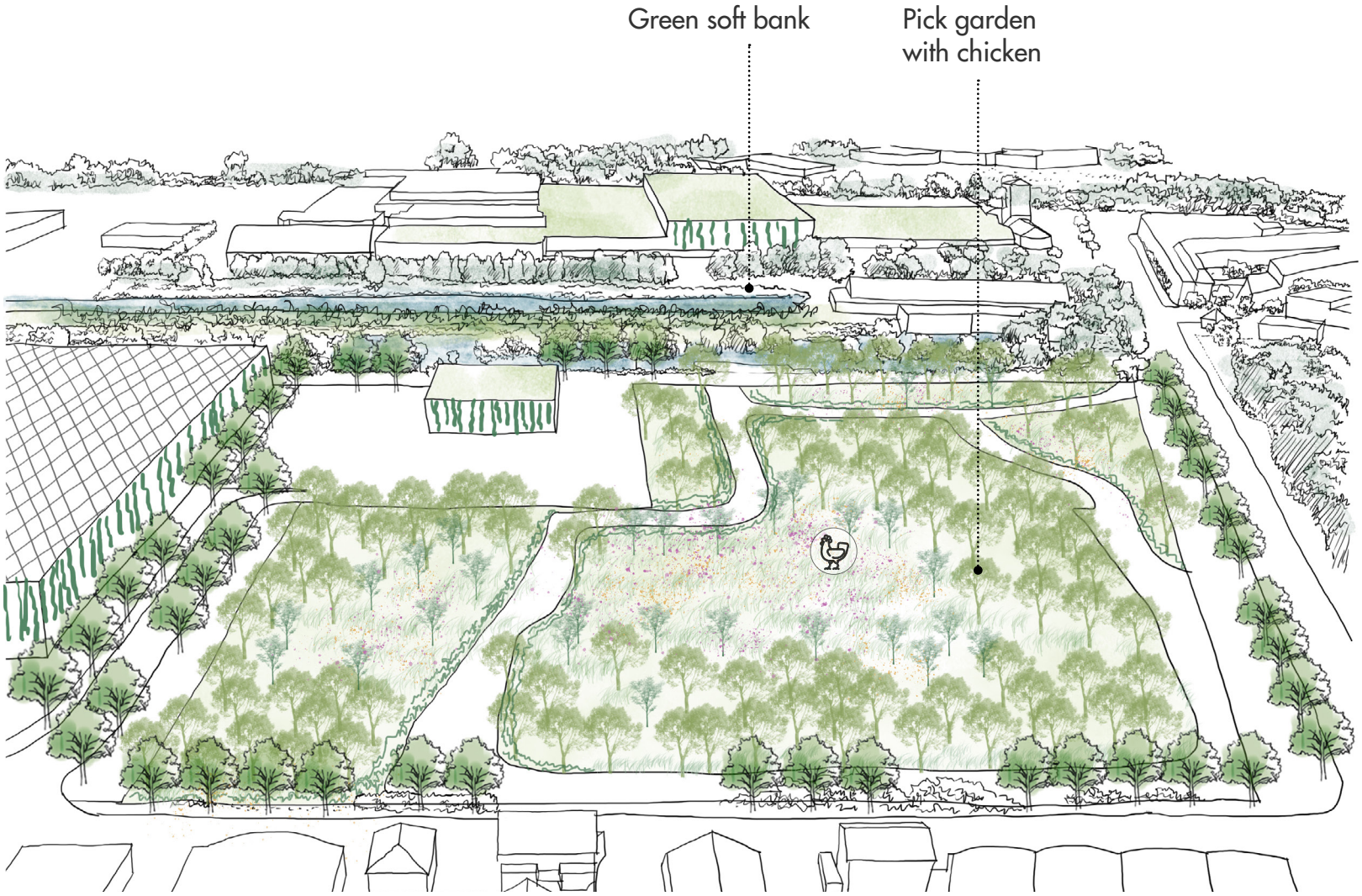


Figure 6.41 Renewed condition--- spot 2 (made by author)

Picking Garden

Tall trees:


Horse chestnut


Walnut

Low trees:


Apple


Sweet cherry

Shrubs:


Blueberry


Black currant


Redberry


Raspberry

Herb layer:


Pumpkin


Strawberry

Transformation from Current to Renewed Condition

Current

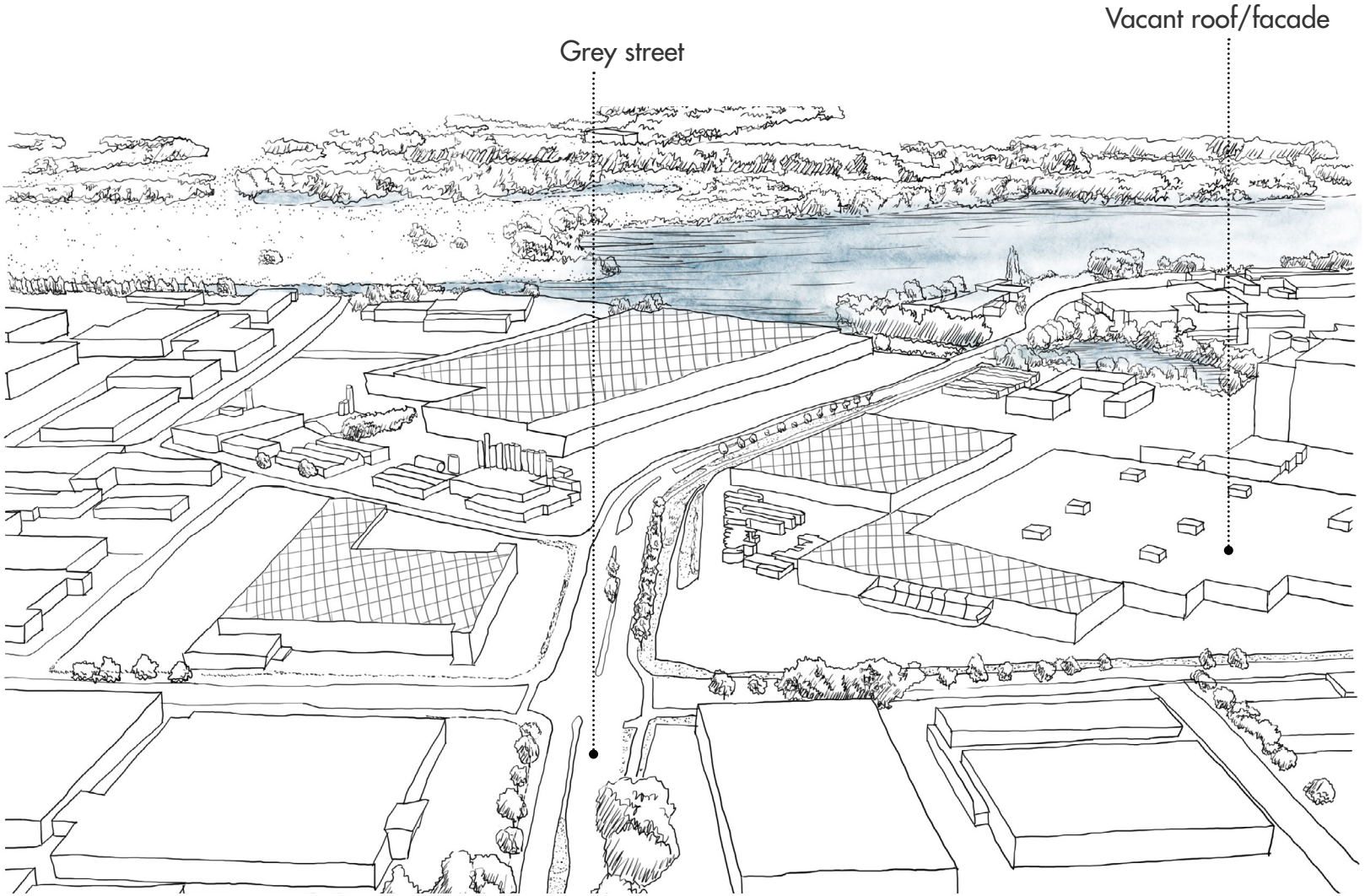


Figure 6.42 *Current situation--- spot 1 (made by author)*

There are many large vacant roofs in this industrial area. (Figure 6.42) Herbs such as strawberry, pumpkin family can be grown on the roofs because they will not need thick soil layer to grow. Climbing species such as black berry, siberische kiwi can be planted to greenify the facades.
Tall nut trees such as walnut, horse chestnut trees can be used as street trees, together with low fruit trees such as apple trees, sweet cherry trees can be added to increase the biodiversity of the streets (Figure 6.43). (Permacultuur Nederland, 2022)

Transformation from Current to Renewed Condition

Renewed Condition

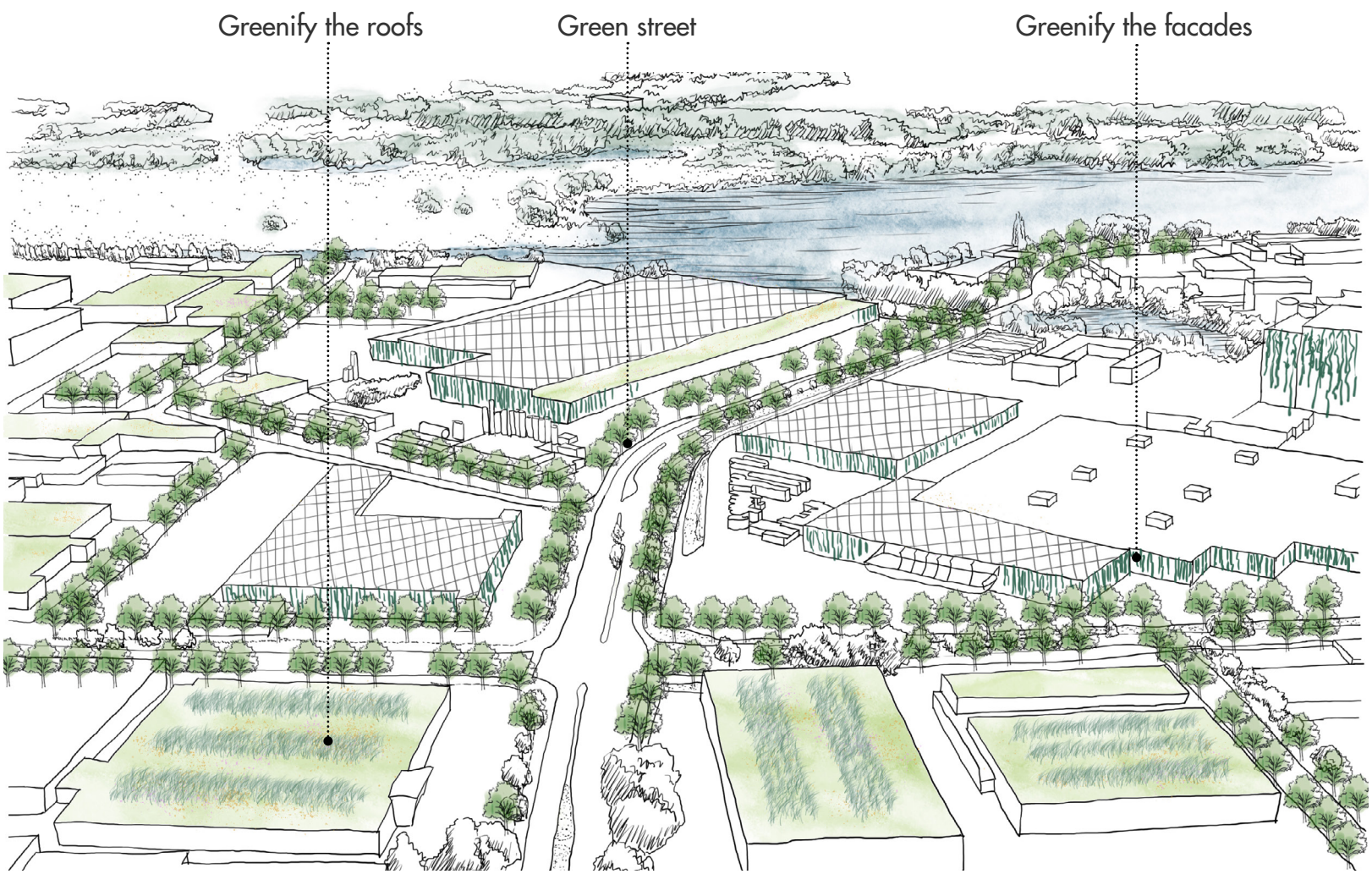


Figure 6.43 *Renewed condition--- spot 1 (made by author)*

Green Street

Tall trees:


Horse chestnut


Walnut

Low trees:


Apple


Sweet cherry

Green Facade

Climbing plants:


Black berry


Siberian Kiwi

Green Roof

Herb layer:


Pumpkin


Strawberry

Perspective

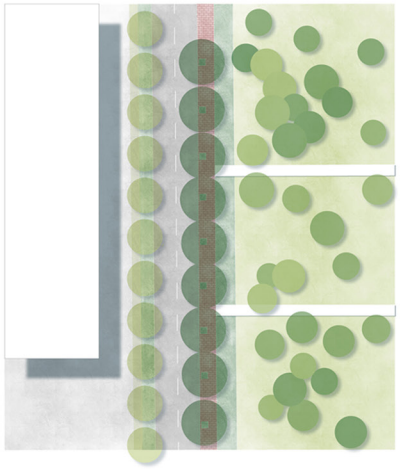
Currently (Figure 6.44) the building is fenced by iron fences, and there is a vacant grassland near the street which is lack vitality. The green area and the district are not connected. The street itself lacks greenery which is highly needed in this area to help absorb the urban heat effect.

As for renewed condition (Figure 6.45), the iron fences are replaced by natural hedges. High nut trees and medium apple trees are planted along the street to increase biodiversity. The sidewalk is added beside the green area. The agroforestry is planted on the previous grassland, which will attract people. The increased green surface also helps add a more permeable surface in this area.

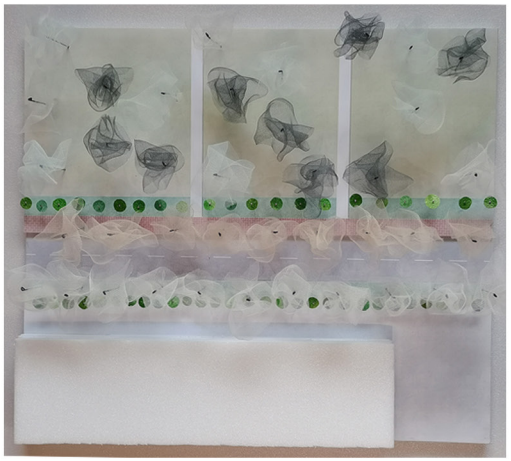
Figure 6.44 *Current condition (made by author)*

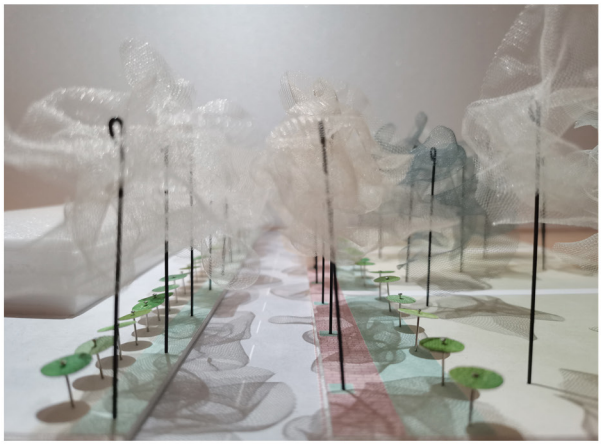
Figure 6.45 *Renewed condition (made by author)*

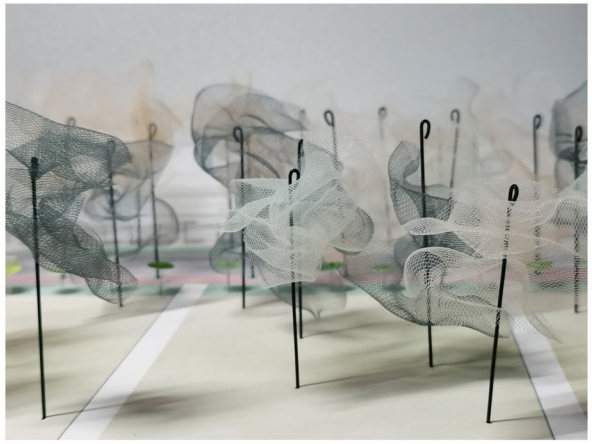
Model 1:200



Part of site 3 'Animal farming through Nature' is made into a real model with a scale of 1:200. The model shows the spatial quality of the greenified street with nuts trees and fruit trees. Those nuts and fruits can be collected for food animals. A small picking garden beside the street also provide people a recreational place to enjoy the foodscapes. The small chickens can be raised in the picking garden to help maintain the health of fruit trees. People can also be connected to small food animals.







CHAPTER 7: CONCLUSION

CONCLUSION

Currently, the problems of animal farming in the Den Bosch region mainly include:
1. Cause environmental issues such as Nitrogen overexcretion, and water&soil pollution… by animal farming in the Den Bosch region.
2. Animal welfare is not good in current intensive animal factories.
3. There are insufficient recreational landscapes that work as foodscapes and thoughtscapes in the Den Bosch region.
4. Climate-related issues such as high flooding risks, low livability in part areas, and urban heat effect… in the Den Bosch region.

In order to solve or mitigate the main problems mention above, this project endeavors to explore the topic '***Animal farming in Flourishing Foodscapes and Thoughtscapes***': a set of design principles is found out and design explorations on three pilots---**'Animal farming in Nature' 'Animal farming with Nature' 'Animal farming through Nature'** are conducted in the Den Bosch region.

The main research question for this project is **'How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in the Den Bosch region?'** This main research question can be answered by realizing four main design objectives (Figure 7.1): **Increase the ecological value of animal farming; Improve animal welfare; Create recreational foodscapes of animal farming; Create climate-adaptive animal farming landscapes**. The answers to the main design objectives can also be the reaction towards the problems of animal farming in the Den Bosch region mentioned above.

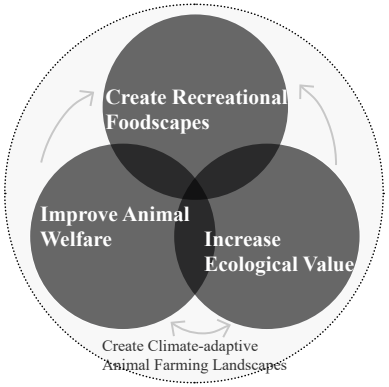


Figure 7.1 *Design objecitves (made by author)*

However, before giving and reflecting on the answers to the main question directly, we will first summarize the main findings to the set of sub-research questions, each one related to a design objective.

Main Results

1. Increase ecological value of animal farming

With regard to the problem of environmental issues caused by animal farming, the ecological value of animal farming should be increased to reduce or mitigate the negative environmental influence of current animal farming in the Den Bosch region. This objective can be achieved through exploring and answering the following sub-research questions:

Sub-RQ 1: - How to realize the nutrient cycle and reduce pollution within the areas through landscape design?

The Nitrogen circulation should be attempted to realize in the animal farms to reduce the risks of Nitrogen over excretion of animal farming. A more sustainable animal farming system can be established by combining animal farming with plant farming. Animal feeds could be addressed locally by growing some natural local plants which can also help to absorb the pollution from animal farming and increase the biodiversity of animal farmlands.

Sub-RQ 2: - What kind of local vegetation could be brought back to improve the ecology and biodiversity of animal farms?

Local potential vegetation based on the soil types and wet conditions can be brought back, for instance, *Alluvial alder-ash forest* in the wetter loamy areas, *Oak-Birch forest* and *Beech-Oak forest* in the drier sandy areas. Besides, the local grasslands such as *Blue grasslands* which is an important habitat for the rare protected butterfly *Pimpernelblauwtje* can also be redeveloped to increase the ecology and biodiversity of animal farmlands.

Sub-RQ 3: - What is the good assemblage of multi-species food animals in the landscape that can maximize the land?

For the most common food animals, sheep and cattle can be raised together to maximize the resources of the land because they eat different parts of vegetation. Pigs and chickens are also good to raise together because they can benefit each other, for example, chickens are the pest controllers for pigs, and pigs also provide food for chickens by rooting the soil and digging out the insects. Besides, pigs provide protection for chickens from predators.

Sub-RQ 4: - How to transform current intensive animal farming to a more ecofriendly level through landscape design?

The current stock density in intensive animal farming is very high in the Netherlands. However, we can transform the current stock density to a more eco-friendly density which ranges from 0.35 LU/ha to 0.5 LU/ha *(The reference unit used for the calculation of livestock units (=1 LSU) is the grazing equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs. (EUROSTAT))*. More spaces will be left out for fewer food animals to behave freely and for the improvement of the ecology by planting agroforestry or local vegetation.

2. Improve animal welfare

Animal welfare can be improved if they are allowed to have the opportunities to behave naturally. Animals also have the spirits and emotions like human beings while intensive animal farming is hard to take this into account. Some of the animals' natural behaviors are beneficial to the environment which means there is potential to cooperate with animals together to improve our environment. The following sub-research questions help to find solutions for realizing this objective in a specific detailed way.

Sub-RQ 5: - What kind of environment can be the baseline for food animals to be able to behave naturally and create living environments by themselves?

Animals need trees and shrubs for sheltering, for example, pigs need tree shadows to avoid the hot sunshine and keep cooling, chickens are tree species that like perching in the trees or shrubs for protection… Pigs like taking mud baths in the wet ponds to keep cool and keep parasites away so they can be raised on the high flooding risk area because they have great potential to help increase water retention ability through rooting. Chickens like bathing in the sand to clean their feathers so they are suitable to be raised on sandy areas. Grazing livestock like herb-rich grasslands which can provide multifaceted nutrition for the livestock.

Sub-RQ 6: - What types of vegetation in landscape design can be the desirable natural diets for food animals at different seasons?

Natural supplementary diets can be provided to animals instead of artificial animal fodders, for example, in the spring and summer, various plants or crops can be fed to animals. In the autumn, nuts and fruits can bring high-quality protein for food animals. The twigs of the shrub can feed livestock in winter.

Sub-RQ 7: - What landscape architecture design principles can keep food animals healthy and improve production in a natural way?

Various vegetation types such as herb-rich grasslands, shrubs, orchards and forests can be planted to create ideal living environments for food animals. Water ponds for bathing can also be provided for food animals. These activities can help food animals to

keep healthy. Diverse natural supplementary diets can provide high-quality multi-nutrition for food animals, therefore helping to improve the production and quality of animal products such as milk and eggs without using chemicals.

3. Create recreational foodscapes of animal farming

Recreational foodscapes and thoughtscapes of animal farming integrate food animals and landscape elements together. It aims to provide recreational and educational space for people so that people can get more in contact with food animals and know more about local animal farming. The local historical features of farmlands can be integrated into the design to make people know more about the local agricultural culture. The attractive recreational animal farming foodscapes and thoughtscapes can also help to reduce the recreational pressure of Nature 2000 in Den Bosch by dividing the large flow of tourists. This objective can be realized by exploring the following sub-research questions:

Sub-RQ 8: - What landscape architecture design principles can establish the connection between consumers and food animals?

Consumers can be involved in the nutrient circulation system of animal farming, for example, they can help to make the biofertilizer by collecting animal manure and green wastes. Picking gardens with chickens also provide opportunities for people to contact with small food animals. Local breeds such as *Netherlands Landvarken* can be raised to let people know more about local food animals.

Sub-RQ 9: - How could the animal farming landscapes help to mitigate the recreational pressure of De Moerputten?

Other areas such as the farmlands near *De Moerputten* and the areas near the natural park *Nulandse Heide* which have the great potential to develop recreational animal farming landscapes can help to mitigate the recreational pressure of *De Moerputten* by dividing the flow of tourists to these areas.

Sub-RQ 10: - How to bring back/reshow some characteristics of historical farmlands through landscape design?

The historical features of farmlands in Noord Brabant such as '*Bolle Akker*' can be utilized and combined with recreational animal farming landscapes. The hedges, pollard willows, windbreaks, and grass edges… which were the typical elements of historical farmlands can also be brought back and combined with animal farming landscapes. The historical dikes in the farmlands can also be stressed by planting fruit trees and flowery plants along the dikes to create recreational foodscapes.

4. Create climate-adaptive animal farming landscapes

Since the Den Bosch region is also facing many climate-related issues, animal farming landscapes can help to reduce these issues and also be more resilient in order to adapt to climate changes. This aim can be realized through exploring and answering the following sub-research questions:

Sub-RQ 11: - What are the climate-related problems in the Den Bosch region currently and how animal farming landscapes can react to them?

Den Bosch region is facing high flooding risks because of its location near *Maas River*. Besides, Den Bosch also faces the issue of urban heat effect and some areas are quite severe, some neighborhoods also do not have good livability. Animal farming landscapes can be made more resilient to flooding risks in the Den Bosch region, the flooding areas can be combined with dairy farming. Animal behaviors such as pig-rooting can also have the potential to help increase water retention ability by digging small pits. Green foodscapes help to increase permeable surfaces in the urban area which can resist the flooding risks of Den Bosch. Besides, the urban heat effects can be reduced through green foodscapes by planting natural feeds for food animals to absorb

the heat. The livability of the neighborhood can be improved through transforming unattractive green spaces into vibrant picking gardens in the urban areas.

Sub-RQ 12: - Which areas have the high demand for improving animal farming there in order to improve the green structure of the Den Bosch region?

Based on the current green areas, *Nature Network of Netherlands* (EHS) and the green plan from Den Bosch municipality, the areas where animal farming needs to be improved there are found out to improve the green structure of the Den Bosch region, these areas cover the range of '*Green River*' from the municipality, areas along the Maximakannal, areas surround the eco-sensitive natural area *Nulandse Heide* and also some areas near the Maas River.

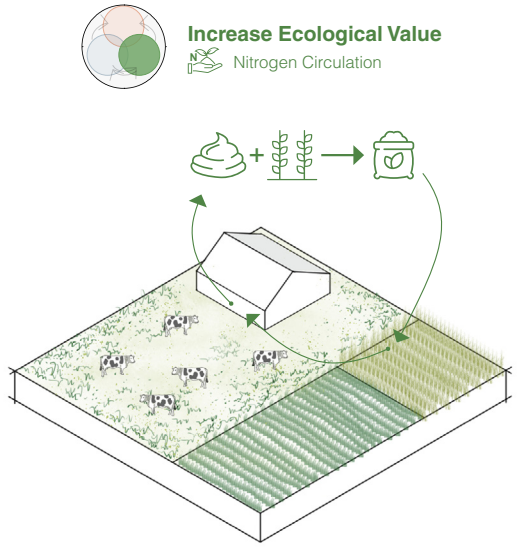
Conclusion

To sum up and give answers to the main research question of this project:
'**How to build up sustainable, nature-inclusive animal farming landscapes that also provide attractive recreational qualities, through landscape design in Den Bosch region?**'

This project purposes multiple solutions and possibilities spatially, environmentally, and socially for improving current animal farming and creating flourishing animal farming foodscapes and thoughtscapes in Den Bosch region. The vision for the regional scale (Figure 7.2) is figured out firstly based on analysis and synthesis of problems in current animal farming in the Den Bosch region, in order to find out the urgent areas that animal farming in those areas needs to be more sustainable to improve the green structure of the current Den Bosch region.

Figure 7.2 *Vision map (made by author)*

Sets of design principles (Figure 7.3) are achieved through multiple research methods such as literature review, case study, video watching…to explore the solutions for realizing the four main design objectives. Here are four examples of design principles related to four design objectives, other comprehensive design principles can be found in the chapter 5.



Manure Management with Cropland

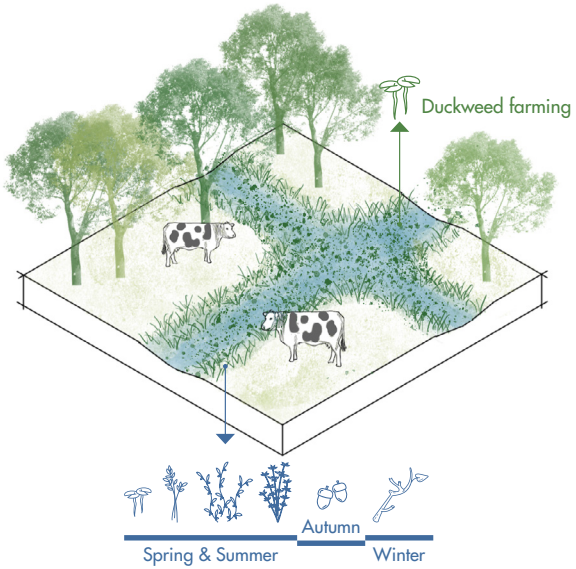
The Manures from the barns can be collected. When combined with the green waste from the croplands, a bio-fertilizer could be created. This bio-fertilizer could be reused on the croplands. This way helps to realize the circulation of Nitrogen and helps farmers to save the money for buying the fertilizer. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Agronomist

Figure 7.3 *Example 1 of design principles (made by author)*

Improve Animal Welfare

Supplementary Diverse Diets



Diverse Natural Diets

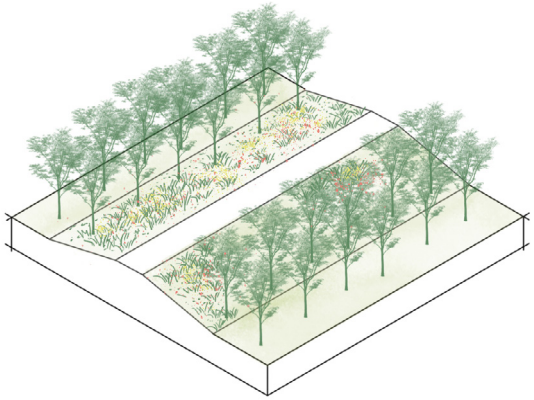
Plants and duckweeds that grow in wet areas and provide natural fodder for animals mainly in spring and summer. In the fall, nut trees bring high-quality protein to the animals. The twigs of the shrub can feed livestock in winter. Therefore, a natural diet can be supplemented throughout the year. (Paridon et al., 2018)

Stakeholders related: Farmer; Ecologist;Agronomist

Figure 7.3 *Example 2 of design principles (made by author)*

Create Recreational Foodscapes

Reshow Heritage & Historic Characteristics



Historical Flowery Dike

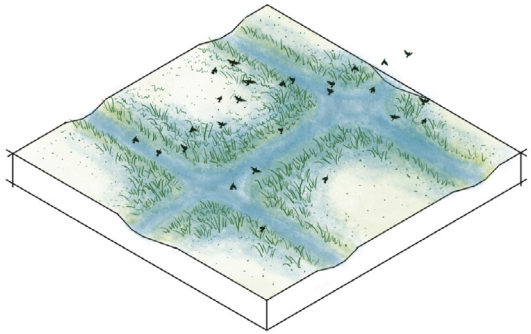
Bring back the historical dike which has the important cultural meaning behind. In order to make this kind of dike more attractive and recreational, various flowery plants can be grown along the dike, in the lower parts of the dike fruit trees can be planted.

Stakeholders related: Farmer; Tourist; Ecologist

Figure 7.3 *Example 3 of design principles (made by author)*

Create Climate-adaptive Animal Farming Landscapes

Improve Water Retention Ability



Wide Ditch Marshes

The main ditches can be widened, the water banks can be more environmentally friendly, and various plants can be planted. Widened ditches can store more water after heavy rains, reducing the flooding pressure of Maas River. (Landbouw met natuur, 2022)

Stakeholders related: Farmer; Ecologist; Waterboard

Figure 7.3 *Example 4 of design principles (made by author)*

Three design explorations ‘Animal farming in Nature’ ‘Animal farming with Nature’ and ‘Animal farming through Nature’ are conducted in different contexts of the Den Bosch region with the application of design principles. In this way, what different roles city contexts could play in improving animal farming and what animal farming could be like in different city contexts are explored.

This project aims to expand the current exploration scope of foodscapes which are mainly plant-based and provide possible directions for improving current animal farming to encourage and assist the government, landscape designers, city planners and researchers to put their efforts in this topic in the future.

CHAPTER 8: DISCUSSION, RECOMMENDATIONS & REFLECTION

DISCUSSION

This project attempts to do the design explorations related to the topic '**Animal farming in Flourishing Foodscapes and Thoughtscapes**' on three selected sites in Den Bosch region: the natural area to explore '*Animal farming in Nature*'; the suburban area to explore '*Animal farming with Nature*' and urban area to explore '*Animal farming through Nature*'. The relationships between animal farming and different contexts of the city region have also been explored in these three selected sites.

1. Animal farming in Nature

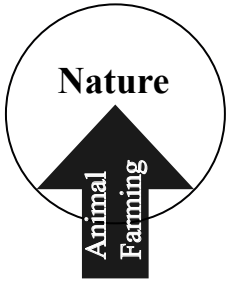


Figure 8.1 *Animal farming in Nature (made by author)*

'Animal farming in Nature' explores how animal farming would work within the natural context (Figure 8.1). With a lot of natural resources surrounded, animal farming in this exploration site needs to be nature-oriented, which means the stock density should be kept at a low level which is eco-friendly. Besides, animal farmlands here could be renewed and involved in the establishment of the green connection with other natural resources.

2. Animal farming with Nature

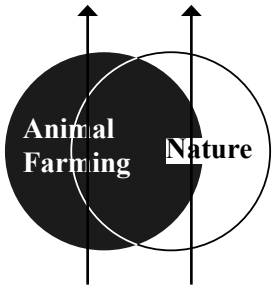


Figure 8.2 *Animal farming with Nature (made by author)*

With several intensive animal factories and a natural eco-sensitive area, the second exploration site explores the theme of 'Animal farming with Nature' (Figure 8.2). A balanced solution that takes ecology and production into account together is explored on this site. Combining animal farming with crop farming and orchards, also multi-species animal farming with renewed farmlands, etc. can help to find the balance between the production of animal farming and improving the ecological value of farmlands.

3. Animal farming through Nature

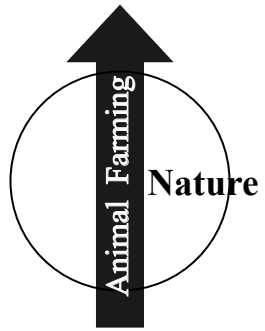


Figure 8.3 *Animal farming through Nature (made by author)*

What the role of animal farming landscapes could play in the urban context and how the urban areas could help to improve the animal farming through nature (Figure 8.3) are explored with an industrial area, which also has the environmental and spatial issues such as lack of green spaces, low livability, high urban heat effect, etc. Green foodscapes can be combined with the greeneries of this site to establish the green structure together. While the plants grown in those green foodscapes could be the raw materials for making animal feeds or the green wastes from

them could be used to make biofertilizers.

Scope

To sum up, the three design explorations provide examples for designing flourishing animal farming foodscapes and thoughtscapes in different contexts of the Den Bosch region, but other regions have different geomorphological and social conditions, the study and design principles of this project need to be reconsidered when applied on other regions. Apart from that, this project mainly focuses on the most common food animals such as cattle, sheep, pigs and chickens, there are also many other species such as rabbits, ducks and fishes… still can be discussed and explored as expanded scope from this project.

Limitations

There still exist some limitations in this report and project. The data collected from the authoritative website *Georegister provincie Noord-Brabant* for the Map- '*Productive types in the Den Bosch region*' is not the most up-to-date, the real conditions of cropland, grassland and animal farms keep changing all the time. This will cause some inaccuracies during the analysis, therefore, the design intervenings and solutions for the site are a bit delayed results because they are not the responses to the latest situations.

Part interests of farmers have to make a concession to the ecological purposes because some of their plots are taken up for adding more natural areas and widening the ditches. Besides, the lower stock density in animal farms reduces the production of animal products, although this project tries to compensate farmers by adding other types of income and reducing the costs. More collaborative works with local government should be promoted to provide subsidies for these farmers and encourage more farmers to join this team.

Since the author studies in the landscape architecture track and lacks education in other fields such as agriculture, animal farming, animal behavior… there is still a lot of more detailed professional knowledge needed from other disciplines to make the design principles and explorations more scientific and comprehensive. Therefore, more collaborations with other faculties should be conducted.

RECOMMENDATIONS

This project is a conceptual project based on research proposing sets of design principles, directions and examples of design explorations in creating flouring animal farming foodscapes and thoughtscapes. In order to put this concept into reality, there still needs a lot of effort and cooperation from different parties and people.

Water Board

Water Board should dedicate itself to helping reduce the flooding risks of the region by creating ditch marshes or wetlands to increase the water retention ability. Eco-friendly water banks should also be encouraged in the farmlands to improve the water quality and increase biodiversity.

Ecologists

Ecologists should help to increase the biodiversity of farmlands, especially by providing professional suggestions for bringing back the local vegetation or habitats for wild animals or the specific target species. More research on establishing nature-inclusive animal farmlands should also be conducted to improve the current intensive animal farming system.

Farmers

Different farmers such as animal breeders and crop/ fruit planters should cooperate with each other to help realize the nutrient cycle in the farmlands and maximize the resources of the land. Farmers should also take action actively to help increase the ecological value and improve animal welfare such as adding flower strips or other historical landscape elements in the farmlands, which also make the farmlands more attractive for tourists.

Agriculture Board

Agriculture Board should provide practical strategies for farmers in renewing their animal farmlands and show some good examples for farmers to study or imitate. knowledge base achieved by ecologists, agronomists or other scientists should be provided for the farmers to improve their animal farmlands.

Municipality/ Government

Instead of shutting down the animal farms directly in some areas, the government/ municipality should take action to encourage farmers to renew their animal farmlands and provide subsidies when necessary to those who attempt to improve the ecological value and animal welfare of their animal farms.

Agronomists

Agronomists ought to provide professional knowledge and suggestions about the renewal of agriculture and the establishment of sustainable, nature-inclusive animal farming systems for the agriculture board and farmers. More advanced and creative research in improving current animal farming should also be conducted to provide the knowledge base for the reality.

Staatsbosbeheer

Staasbosbeheer can be involved in improving the ecological value of animal farmlands by planting more local vegetation, which also helps to connect

the scattered natural areas by improving the regional green structure.

Residents/ Tourists

Residents& tourists should be involved in the animal farming system, such as helping realize the nutrient cycle through making the bio-fertilizer by combining green wastes and animal manures. Residents can also volunteer to plant the local potential vegetation to improve the green structure of the region.

Designers

Planners should propose regional spatial planning to improve current animal farming from larger perspectives and landscape architects should create more animal farming landscapes that have recreational and educational functions for people to make people more connected with food animals and gain more knowledge about the local food animals.

To sum up, multidisciplinary cooperation is very important in improving current intensive animal farming and creating sustainable, nature-inclusive animal farming with attractive recreational qualities. Landscape architects should coordinate all these forces together in order to create flourishing animal farming foodscapes and thoughtscapes.

REFLECTION

This project focuses on solving the problems of economically oriented intensive animal farming by building up sustainable and nature-inclusive animal farming system through landscape design. Animal farming could be eco-friendly and sustainable foodscapes and thoughtscapes, which can aslo connect people more with food animals and educate people to respect and appreciate other lives' sacrifice.

Relationship between Research and Design

The research and design interact each other mutually in this project. Overall, it can be concluded into 3 aspects: Research on design; Research for design; Research through design.

Research on design

Based on the literature and documentaries review of the problems of current intensive animal farming, also the database from the government of Noord Brabant and Den Bosch, four main problems of current intensive animal farming in Den Bosch were got: Environmental issues including damage of rain forests, water& soil pollution caused by nitrogen overload; Bad animal welfare; Insufficient recreational landscapes work as foodscapes and thoughtscapes in Den Bosch; Flooding risks, urban heat effects… related to climate issues in Den Bosch. Therefore, four main design assignments were concluded to help solve the problems:1. Increase ecological value which include nitrogen circulation, establish sustainable animal farming, increase biodiversity. 2. Improve animal welfare which includes improve animal behaviors of food animals, allow natural behaviors of food animals, also provide natural supplementary diets for food animals instead of artificial fodders. 3. Create recreational foodscapes which includes reshow the heritage& historical characteristics of local farmlands, connect people with food animals more. 4. Create climate-adaptive animal farming landscapes which includes improve water retention ability, reduce urban heat effect, improve livability of the neighborhood.

Then the related case studies and literature review were executed in order to get out good design principles and toolboxes to answer these four main design assignments.

Research for design

From the city scale perspective, the green planning of Den Bosch from the government has been researched, also the current green structure of Den Bosch has been analyzed in order to find out the strategies to improve current green structure through improving current animal farming and creating recreational animal farming landscapes. Then based on the vision of city scale, three areas are selected to explore how the animal farming could work in natural, suburb and urban context. The specific conditions such as geology, historical resources, flora and fauna, agriculture conditions of the selected sites are analyzed to find out the good ways of applying the design principles and toolboxes in the local context.

Research through design

Design itself is also a good way to check and supplement the implementation of the research. Three frameworks are established on three areas selected: Animal farming in Nature; Animal farming with Nature; Animal farming through Nature. In order to find out the best solution of improving animal farming in the specific context, different situations have been tested. For instance, in the site 1 'Animal farming in Nature', the local specific vegetation 'Glanshaver' is intended to be enlarged and combined with natural livestock farming. How

much area should ‘Glanshaver’ take up in a dairy farm has been tested in order to find a balance between production and ecology. If the whole dairy farm is combined with ‘Glanshaver’, the density would be kept at a very low level but has the most beneficial for the local nature. While if no ‘Glanshaver’ is brought back, the stock density could be higher but the ecological value would be lower. Therefore, in order to achieve a balance between production and ecology, ‘Glanshaver’ is brought back partly along the edges of the farm while other parts of the farm are herb-rich grassland. In this way, the ecological value can be ensured but the high-quality animal proteins can still be provided. By considering different extreme conditions, a more balanced solution can be found out.

Relationship of Graduation Topic to Studio Topic, MLA and Msc AUBS

The graduation topic ‘Animal Farming in Evolving Foodscapes and Thoughtscapes’ concerns the welfare of food animals and building up sustainable animal farming systems through landscape design. The studio topic ‘Urban Ecology and Ecocities’ intends to improve the ecology of environments and improve the life quality of people. The graduation project commits to improve the urban ecology from the perspective of animal farming. As mentioned before, a series of problems caused by current intensive animal farming in Den Bosch has damaged the urban ecology as well. Therefore, the graduation projects focus on improving current animal farming to reduce the environmental and social issues could help to improve the urban ecology.

The graduation project explores the topic ‘Animal Farming in Evolving Foodscapes and Thoughtscapes’ through landscape architecture perspective and strategies. It dedicates to solving the environmental, social, spatial issues of current animal farming in Den Bosch through spatial design, including strengthen the connection of local natural areas, increase biodiversity, bring back historical farmlands elements, create ideal living environments for food animals… to improve current animal farming and make it have recreational value to enhance the connection between people and food animals.

As for the relation between graduation topic and Msc AUBS, the graduation project explores the topic through research and design in the field of AUBS. Besides the research withing the AUBS, other fields such as ecology, husbandry, agriculture… have also been explored and a set of strategies got out from that are then transformed to fit in the AUBS context.

Methodology

The whole project includes eight main actions: Introduction; Figure out research questions; Site analysis; Vision exploration; Design principles formation; Design explorations; Conclusions making; Discussion, Recommendations & Reflection.

In the very beginning, the problem statement is explained from environmental, spatial and social aspects through literature review, data visualization, mapping, site visiting…Then the research questions and design objectives are followed: Increasing ecological value, improving animal welfare, creating recreational animal farming landscapes and creating climate-adaptive animal farming landscapes. A set of site analyses and diagnoses is conducted to get out main design assignments related to four main design objectives. A vision map is then achieved through synthesizing the analyses. A set of design principles related to four main design objectives are achieved through case study, literature review, site visit... Three pilots in the Den Bosch region are then selected to explore ‘Animal farming in Nature’ ‘Animal farming with Nature’ and ‘Animal farming through Nature’. During the application of design principles, the design principles are adjusted to make the design explorations more suitable for the local context. The design explorations are evaluated and adjusted by looking back and considering their relationship with multiple scales. In the end part of this project, the conclusion is made to provide an entrance for people

who are interested in such a topic. Also discussion, recommendations and reflection are proposed to show future possibilities of exploring this topic more broadly and deeply. These actions are not conducted in a linear way, some actions need to look back at and then be adjusted. For example, when doing the 'Site Analysis', the research questions need to be considered to make sure the analyses of the area are related to the research questions; Also the 'design principles' need to be adjusted to make sure they can really answer the research questions.

Throughout the whole project, 'Multilayers Analysis' helps a lot in understanding the site from different aspects. With the group of different related analyses, relationships between different layers can be studied and synthesized, then the vision could be formulated in this way, and the vision could then be the basis of further design explorations. 'Multiscale research and design' from local scale, mesoscale and regional scale can help understand the relationship between the site and its larger context. 'Multiphase design' integrates time thinking in the projects and it helps to realize the design objectives and vision for the region step by step. 'Multidisciplinary research' helps to integrate different disciplines into the project and also helps to expand the current scope of landscape architecture. These methodologies are recommended in other projects as well.

Beyond Den Bosch

The result of this project is a regional plan for improving animal farming and creating animal farming foodscapes and thoughtscapes in Den Bosch. The three design explorations show how sustainable, nature-inclusive animal farming landscapes could work within nature, suburban and urban context. With the increasing environmental, social and spatial issues caused by animal farming worldwide, the result of research and design principles could be applied in other areas where the environments and ecologies are damaged by the intensive animal farming. The principles are similar or can be slightly adjusted to be more suitable for the local context. The vegetation can be replaced by the local vegetation types based on the hydrology, geology, climate…… Consider improving animal farming through four different aspects: increasing ecological value, improving animal welfare, creating recreational animal farming landscapes and create climate-adaptive environments to address the environmental, social and spatial issues of animal farming systematically.

Dilemmas

Because of the current Nitrogen excretion and deposition pressure of animal farming in the Netherlands, nationally, the government proposed to halve the country's livestock in an attempt to limit agricultural pollution in the Netherlands. This proposal has caused anger from farmers. For example, from 2019 till now, there are a series of protests from Dutch livestock farmers (Figure 8.4) to resist the proposal mentioned above.

Figure 8.4 *Farmer protest in the Netherlands, 1 October 2019 (source: Vincent Jannink/ANP/ AFP/GETTY IMAGES, 2019)*

In the Den Bosch region, the local government also wants to shut down a lot of animal farmlands and factories, especially near natural areas, animal farming is forbidden and many animal factories have been removed. However, animal farming is a historical tradition and culture of Den Bosch and Noord Brabant. Farmers also rely the living on it. Rudely stopping animal farming directly will cause a lot of social issues for farmers and local history. Therefore, this project provides a suggestion that instead of shutting down animal farms directly or transforming the animal farms drastically, good proposals are figured out to improve the current animal farming step by step, make animal farming

be more eco-friendly to nature gradually, and also help reduce the recreational pressure of some natural areas by creating recreational animal farming landscapes… What is more, if animal farming is directed and utilized in the right way such as working as natural mowers by grazing, improving water retention ability by rooting, reducing the use of artificial fertilizer through utilizing animal manures, etc. They can even bring many benefits to the environment.

Besides, although parts of the farmlands or food animals are taken out from farmers for nature purposes, farmers are still benefited a lot from it. Nature will increase the biodiversity which will attract more natural pollinators which can help increase the yields. Various supplementary income from tourism can be realized through planting some agroforestry and increasing the recreational value of the farmlands. The high-quality proteins from food animals can increase the selling price. Natural supplementary diets such as nuts and fruits from agroforestry can be provided for food animals. Bio-fertilizer which are made from animal manure and green wastes can replace artificial fertilizers. Therefore, the costs of buying artificial fodders and fertilizers can also be reduced. If farmers are supported or guided to start some actions such as adding some agroforestry to their animal farms, they will have some benefits, and gradually the transformation from current intensive animal farming to nature-inclusive and eco-friendly animal farming can be realized in the future.

ACKNOWLEDGMENT

I want to thank a lot of people who companied me to pass through this graduation year, especially my two mentors Nico Tillie and Remon Rooij, and also the wonderful girls from the Urban Ecology and Ecocities Design Lab.

As my first mentor, Nico Tillie is so kind and always provides sharp and insightful instructions for my design, which always provides me a lot of inspiration to further explore the topic. My second mentor Remon always helps to revise my directions of the processes of my graduation projects in time and provides me a lot of great instructions in my academic writing to make up for my shortcomings. I have learned a lot in this short year under their help. The wonderful girls from the Urban Ecology and Ecocities Lab give me a lot of help in my academic study and personal life, I enjoyed and learned a lot during our group work for the Staatsbosbeheer.

Besides, I also want to thank my roommates in Delft who helps me to get through some tough moments and also bring me a lot of happy memories during this graduation year. They are the most sweetest girls in my heart.

I would like to send my best wishes to all of the people mentioned above for a happy life and good health!

REFERENCES

REFERENCES

Abel, C. (2022). *Can Pigs and Chickens Live Together?* Savvy Farm Life. Consulted on April 25, 2022, from https://savvyfarmlife.com/keeping-chickens-with-pigs/

Arnoldussen, S. (2021, 13 april). *Akkerbouw in de brons- en ijzertijd*. Brabants erfgoed. Consulted on January 3, 2022, from https://www.brabantserfgoed.nl/page/13030/akkerbouw-in-de-brons--en-ijzertijd

Avoiding Heat Stress in Pigs. (z.d.). A Greener World. Geraadpleegd op 4 mei 2022, van https://agreenerworld.org/a-greener-world/avoiding-heat-stress-in-pigs/

Bagchi S, Goyal SP, Sankar K (2003) Niche relationships of an ungulate assemblage in a dry tropical forest. *J Mammal* 84:981–988.

Bailey, D. W., Mosley, J. C., Estell, R. E., Cibils, A. F., Horney, M., Hendrickson, J. R., Walker, J. W., Launchbaugh, K. L., & Burritt, E. A. (2019). Synthesis Paper: Targeted Livestock Grazing: Prescription for Healthy Rangelands. *Rangeland Ecology & Management*, 72(6), 865–877. https://doi.org/10.1016/j.rama.2019.06.003

Beck MR and Gregorini P (2021) Animal Design Through Functional Dietary Diversity for Future Productive Landscapes. *Front. Sustain. Food Syst.* 5:546581. doi: 10.3389/fsufs.2021.546581

Beuken-Greben, M., Macke, F., Heeremans, E., & Kroes, J. (2013, 24 june). *Inzicht in het watersysteem leidt tot doorbraak in normdenken*. H2O/WATERNETWERK. Consulted on February 12, 2022, from https://www.h2owaternetwerk.nl/vakartikelen/martine-beuken-greben-freya-macke-gemeente-s-hertogenbosch-eugene-heeremans-waterschap-aa-en-maas-johan-kroes-rijkswaterstaat-waterdienst

Blanchard, L. (2017, 13 april). *Why Do Pigs Love Mud Baths?* Leilani Farm Sanctuary. Consulted January 4, 2022, from https://leilanifarmsanctuary.org/author/lauralee/

Born, J. (2019, 10 july). *Just emitting nitrogen is no longer allowed, but nature organizations remain concerned*. EenVandaag. Consulted on January 6, 2022, from https://eenvandaag.avrotros.nl/item/zomaar-stikstof-uits-toten-mag-niet-meer-maar-natuurorganisaties-blijven-bezorgd/

Bossche Sloot. (z.d.). De Groene Vesting. Consulted on March 12, 2022, from https://www.degroenevesting.nl/de-linie/207/14-bossche-sloot.htm

Brabantse Milieufederatie. (2019, january). *FACTSHEET verduurzamingsopgaven veehouderij Brabant* (Nr. 9). https://www.brabantsemilieufederatie.nl/wpcontent/uploads/sites/18/2019/06/FACTSHEET-verduurzamingsopgaven-landbouw-2019-1.pdf

Broom, D.M. 2018. Sustainable strategies in animal production. *Compendio de Trabajos del 7° Simposio Internacional de Bienestar Animal y 2° de Bioeticay Etologia Animal*, 58-61. Universidad Veracruzana. ISBN: 978-84-17523-41-1

Broom, D.M. 2015. New directions for sustainable animal production systems and the role of animal welfare. In: *3° Congreso Nacional de Sistemas Silvopastoriles y VII Congreso Internacional Sistemas Agroforestales*, Iguazú, ed. P. L. Peri, 385-388. Montecarlo, Argentina: INTA.

Busch, G., Gauly, M., & Spiller, A. (2018). Opinion paper: What needs to be changed for successful future livestock farming in Europe? *Animal*, *12*(10), 1999–2001. https://doi.org/10.1017/S1751731118001258.

BWK: Alluviaal elzen-essenbos (va). (z.d.). Ecopedia. Consulted on April 23, 2022, from

https://www.ecopedia.be/bwk/bwk-alluviaal-elzen-essenbos-va

BWK: Eiken-berkenbos (qb). (z.d.). Ecopedia. Consulted on April 23, 2022, from, van https://www.ecopedia.be/bwk/bwk-eiken-berkenbos-qb

BWK: Vochtig wilgenstruweel op venige of zure grond (so). (z.d.). Ecopedia. Consulted on March 15, 2022, from https://www.ecopedia.be/bwk/bwk-vochtig-wilgenstruweel-op-venige-zure-grond-so

Davis S (2021) Urban Foodscapes and Greenspace Design: Integrating Grazing Landscapes Within Multi-Use Urban Parks. *Front. Sustain. Food Syst.* 5:559025. doi:10.3389/fsufs.2021.559025

DE 7 TOT 9 LAGEN VAN EEN EETBARE BOSTUIN / VOEDSELBOS. (z.d.). Permaculture Netherlands. Consulted on May 12, 2022, from https://www.permacultuurnederland.org/wp/de-eetbare-bostuin/#.YqpRcKJBxPY

DINOloket Data en Informatie van de Nederlandse Ondergrond Hoofdnavigatie. (z.d.). DINOloket. Consulted on March 21, 2022, from https://www.dinoloket.nl/ondergrondmodellen

Farmer's protest in The Hague 1 October 2019. (2019, 1 oktober). [Jpg]. Wikipedia. https://en.wikipedia.org/wiki/Dutch_farmers%27_protests#/media/File:Boerenprotest_2.jpg

G. Busch, M. Gauly, A. Spiller, Opinion paper: What needs to be changed for successful future livestock farming in Europe?, *Animal*, Volume 12, Issue 10, 2018, Pages 1999-2001, ISSN 1751-7311, https://doi.org/10.1017/S1751731118001258.

G. Martin, K. Barth, M. Benoit, C. Brock, M. Destruel, B. Dumont, M. Grillot, S. Hübner, M. A. Magne, M. Moerman, C. Mosnier, D. Parsons, B. Ronchi, L. Schanz, L. Steinmetz, S. Werne, C. Winckler, R. Primi. Potential of multi-species livestock farming to improve the sustainability of livestock farms: a review, *Agric. Syst.*, 181 (2020), Article 102821, 10.1016/j.agsy.2020.102821

GEMEENTE 'S-HERTOGENBOSCH. (2014, january). *Ruimtelijke Structuurvisie Stad tussen Stromen* (Nr. 84). https://www.s-hertogenbosch.nl/fileadmin/Website/Inwoner/Bouwen_wonen/Bestplannen/Stad_Tussen_Stromen.pdf

Gies, E., Doorn, A., Os, J., Bos, B., & Wageningen University & Research. (2019). *Mogelijke toekomstbeelden natuurinclusieve landbouw* (Nr. 33). Wageningen Environmental Research. https://doi.org/10.18174/498926

Glossary:Livestock unit (LSU). (2022, 22 april). Eurostat. Consulted on 10 May 2022, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)

Gordon, Iain J., F. J. Pérez-Barbería, and Adrian D. Manning. 2021. "Rewilding Lite: Using Traditional Domestic Livestock to Achieve Rewilding Outcomes" *Sustainability* 13, no. 6: 3347. https://doi.org/10.3390/su13063347

Gremmen, B. (2017). A MORAL OPERATING SYSTEM OF LIVESTOCK FARMING. *Pragmatism Today*, *8*(2), 41–51.

Het pimpernelblauwtje is 25 jaar! (2015, 15 juli). De Vlinderstichting. Consulted on March 16, 2022, from https://www.vlinderstichting.nl/actueel/nieuws/nieuwsbericht/het-pimpernelblauwtje-is-25-jaar

Hofmann, R.R. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 78, 443–457 (1989). https://doi.org/10.1007/BF00378733

Hollandsche Dijk. (z.d.). De Groene Vesting. Consulted on March 13, 2022, from https://www.degroenevesting.nl/heden/97/hollandsche-dijk.htm#goto_97

Hand Painted Background Trees Trees Element Free PNG and PSD. (z.d.). pngtree. Consulted on 12 August 2022, from https://pngtree.com/freepng/hand-painted-background-trees-trees-element_281631.html

Hoogwater in Den Bosch: in 1995 was het erger! [FOTO'S]. (z.d.). Omroep Brabant. Consulted on 7 January 2018, from https://www.omroepbrabant.nl/nieuws/2624374/hoogwater-in-den-bosch-in-1995-was-het-erger-fotos

Hoving, R., Hulsegge, I., Hiemstra, S. J., Centrum voor Genetische Bronnen, Nederland, & Wageningen University & Research. (2017). *Varkensrassen in de genenbank: Beschrijving van de rassen en de ontwikkelingen in de varkensfokkerij* (Nr. 27). Centrum voor Genetische Bronnen, Nederland van Wageningen University & Research. https://doi.org/10.18174/423162

Icons and Photos For Everything. (z.d.). The None Project. Consulted on November 3, 2021, from https://thenounproject.com/

I.J. Gordon, A.D. Manning, L.M. Navarro, J. Rouet-Leduc, Domestic livestock and rewilding: are they mutually exclusive? *Front. Sustain. Food Syst.*, 5 (2021), Article 550410

I.J. Gordon, F.J. Pérez-Barbería, A.D. Manning, Rewilding lite: using traditional domestic livestock to achieve rewilding outcomes *Sustainability*, 13 (2021), p. 3347

Jannink, V., ANP, AFP, & GETTY IMAGES. (2019). *Dutch farmers have protested a ruling that curtails the expansion of livestock operations because of the nitrogen pollution they produce*. [Jpg]. AAAS. https://www.science.org/content/article/nitrogen-crisis-jam-packed-livestock-operations-has-paralyzed-dutch-economy

Jansen, S. (2022), *Flora of Dutch habitats. Table of the most common plants in the Netherlands selected by environment*. unpublished manuscript. April 2022. TU Delft

Kallerna. (2012, 28 juni). *European badger (Meles meles) in Ähtäri Zoo* [Jpg]. Wikipedia. https://en.wikipedia.org/wiki/European_badger#/media/File:M%C3%A4yr%C3%A4_%C3%84ht%C3%A4ri_4.jpg

Kennispunt Natuurinclusieve Landbouw. (z.d.). Landbouw met natuur. Consulted on April 5, 2022, from https://www.landbouwmetnatuur.nl/

Keur Waterschap Aa en Maas. (z.d.). Esri. Consulted on March 15, 2022, from https://aaenmaas.maps.arcgis.com/apps/webappviewer/index.html?id=6a38a5106b6a4a86949377c303883fa1

Klimaateffectatlas NL. (z.d.). *Kaartverhalen*. Consulted on November 24, 2021, from https://www.klimaateffectatlas.nl/nl/kaartverhalen

Leroy F, Hite AH and Gregorini P (2020) Livestock in Evolving Foodscapes and Thoughtscapes. *Front. Sustain. Food Syst.* 4:105. doi: 10.3389/fsufs.2020.00105

luchtfoto-Talmakooi. (2018, september). [Jpg]. https://www.erfgoed-onderwijs.frl/friksbeheer/wp-content/uploads/2018/09/luchtfoto-Talmakooi.jpg

Martin, G., Barth, K., Benoit, M., Brock, C., Destruel, M., Dumont, B., Grillot, M., Hübner, S., Magne, M. A., Moerman, M., Mosnier, C., Parsons, D., Ronchi, B., Schanz, L., Steinmetz, L., Werne, S., Winckler, C., & Primi, R. (2020). Potential of multi-species livestock farming to improve the sustainability of livestock farms: A review. *Agricultural Systems*, 181, 102821. https://doi.org/10.1016/j.agsy.2020.102821

MTD landschapsarchitecten. (z.d.). *Milk & Nut*. Consulted on January 2, 2022, from https://www.mtdls.nl/en/projects/project-details/q/idproject/267/titel/milk-nut

Natura 2000: Glanshaver- en Grote vossenstaartgraslanden. (z.d.). Ecopedia. Consulted on March 14, 2022, from https://www.ecopedia.be/natura2000/natura-2000-glanshaver-en-grote-vossenstaartgraslanden-6510

Natura 2000 Ministerie van Landbouw, Natuur en Voedselkwaliteit. (2017, december). *Gebiedsanalyse Vlijmens Ven, Moerputten & Bossche Broek (132)* (Nr. 71). https://www.natura2000.nl/sites/default/files/PAS/Gebiedsanalyses_vigerend/132_Vlijmens-Ven-Moerputten-en-Bossche-Broek_

gebiedsanalyse_15-12-2017_NB.pdf

Natuurtype: Dotterbloemgrasland. (z.d.). Ecopedia. Consulted on 15 March 2022, from https://www.ecopedia.be/natuurtypes/natuurtype-dotterbloemgrasland

Oak Beech forest in spring - Eiken-Beukenbos in de lente - Quercus, Fagus sylvatica. (2016, 31 march). [Jpg]. Bernard Van Elegem. http://www.bernardvanelegem.com/image/oak-beech-forest-spring

Odijk, S., Kennedy, E., Verkooijen, L., & Metabolic. (2019, februari). *CIRCULAIR VOEDSELSYSTEEM --- NOORDOOST BRABANT* (Nr. 40). https://www.metabolic.nl/wp content/uploads/2019/02/Report_Full_AgrifoodCapital_v06_CB.pdf

PDOK NL. (z.d.). *Dataset: TOP10NL*. Consulted on November 12, 2021, from https://app.pdok.nl/brt/top10nl/download-viewer/

PENN. (z.d.). Design Process. In S. Swaffield (Red.), *Theory in landscape architecture* (Vol. 3, pp. 35–38). PENN.

Project LIFE Food & Biodiversity, Instituto Superior Técnico, Teixeira, C., Sarmento, N., Proença, V., Domingos, T., & Ludes, T. (2020). *Very Good Agricultural Practice - Guideline on Livestock Production*. Food & Biodiversity. https://www.food-biodiversity.eu

Province Noord Brabant. (z.d.). *Purchase of peak loaders nitrogen*. Brabant.nl. Consulted on 6 November 2021, from https://www.brabant.nl/onderwerpen/aanpak-stikstof/vrijwillige-aankoop-piekbelasters-stikstof

Russon, B. (z.d.). *Why do Chickens use Dust Baths? (and) How to Make a Chicken Dust Bath*. What Happens on the Homestead. Consulted on April 5, 2022, from https://whathappensonthehomestead.com/why-do-chickens-use-dust-baths-and-how-to-make-a-chicken-dust-bath/

Schade, B. (2007, 20 mei). *Verbond van de elzenbroekbossen* [Jpg]. Wikipedia. https://nl.wikipedia.org/wiki/Verbond_van_de_elzenbroekbossen#/media/Bestand:Briesetal_bei_Briese.JPG

Science Communication Unit, University of the West of England (UWE). (2013, september). *Nitrogen Pollution and the European Environment - Implications for Air Quality Policy*. European Commission. https://ec.europa.eu/environment/integration/research/newsalert/pdf/IR6_en.pdf

Sloten rond Uden en Veghel vervuild met mest. (2020, 23 juli). Brabants Dagblad. Consulted on 23 April 2022, from https://www.bd.nl/uden-veghel-e-o/sloten-rond-uden-en-veghel-vervuild-met-mest~afd5439f/

Smith, R., Lacefield, G., Burris, R., Ditsch, D., Coleman, B., Lehmkuhler, J., & Henning, J. (2011, oktober). *Rotational Grazing*. UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE. http://www2.ca.uky.edu/agcomm/pubs/id/id143/id143.pdf

Stokstad, E. (2019, 4 december). *Nitrogen crisis from jam-packed livestock operations has 'paralyzed' Dutch economy*. AAAS. Geraadpleegd op 22 augustus 2022, van https://www.science.org/content/article/nitrogen-crisis-jam-packed-livestock-operations-has-paralyzed-dutch-economy

Timmers, J. (2021, 3 july). *Over de Brabantse oude akkers*. Brabants erfgoed. Consulted on January 2, 2022, from https://www.brabantserfgoed.nl/page/13173/over-de-brabantse-oude-akkers

Topographic and military map of the Kingdom of the Netherlands (1861). (z.d.). Arcanum. Consulted on March 20, 2022, from https://maps.arcanum.com/en/map/netherlands-1861/?bbox=575908.7037038633%2C6739961.39620665%2C604935.6651951589%2C6750758.126451931&map-list=1&layers=here-aerial%2C19

Trepte, A. (2011, 4 july). *Bar-tailed Godwit in breeding plumage* [Jpg]. Wikipedia. https://en.wikipedia.org/wiki/Bar-tailed_godwit#/media/File:Bar-tailed_Godwit.jpg

Van Zanten, H. & Wageningen University. (2016, june). *Feed sources for livestock: recycling towards a green planet*. Wageningen University. https://research.wur.nl/en/publications/feed-sources-for-livestock-recycling-towards-a-green-planet

Verhoeven, S., & Wiskerke, J. C.(2018). *Flourishing Foodscapes: Design for City-Region Food Systems*. Valiz.

Vermeulen, R., Widstrand, S., Helmer, J., Linnartz, E., & Jung, K. (2015, july). *NATURAL GRAZING --- practices in the rewilding of cattle and horses* (Nr. 40). Rewilding Europe. https://www.rewildingeurope.com/wp-content/uploads/2015/07/Natural-grazing-%E2%80%93-Practices-in-the-rewilding-of-cattle-and-horses.pdf

Verwoerd, S. (2012, 12 oktober). *Blauwgrasland uitgerold over Honderdmorgen. Natuurmonumenten*. Consulted on February 9, 2022, from https://www.natuurmonumenten.nl/natuurgebieden/vlijmens-ven/nieuws/blauwgrasland-uitgerold-over-honderdmorgen

Vries, B. (2017, 10 june). *Noord-Brabant: een provincie met twee keer zoveel varkens als mensen*. NOS. Consulted on January 8, 2022, from https://nos.nl/artikel/2177520-noord-brabant-een-provincie-met-twee-keer-zoveel-varkens-als-mensen

Wandelen over de Moerputtenbrug in de Moerputten. (z.d.). Stripe Away. Consulted on March 12, 2022, from https://stripeaway.nl/wandelen-moerputten-moerputtenbrug/

waterlozing-bossche-sloot-kaart-groot. (z.d.). [Jpg]. Brabants Historisch Informatie Centrum (bhic). https://www.bhic.nl/media/document/file/waterlozing-bossche-sloot-kaart-groot.jpg

Waterschapsgrenzen. (z.d.). Keur Waterschap Aa en Maas. Consulted on January 3, 2022, from https://aaenmaas.maps.arcgis.com/apps/webappviewer/index.html?id=6a38a5106b6a4a86949377c303883fa1

WUR. (1975). *Vegetatiekaart van Nederland* [Jpg]. WUR E-depot. https://edepot.wur.nl/388525

Yayota M and Doi K (2020) Goat Grazing for Restoring, Managing, and Conserving "Satoyama", a Unique Socio-Ecological Production Landscape. *Front. Sustain. Food Syst.* 4:541721. doi: 10.3389/fsufs.2020.541721

Yugov, L. (2020, 21 march). *Crop Rotation*. PSCI. Consulted on April 6, 2022, from https://psci.princeton.edu/tips/2020/3/21/agriculture-101

Zwanen in het Vlijmens Ven. (z.d.). [Jpg]. HVDOL NL. http://hvdol.nl/database/product_info.php?cPath=335_341_446&products_id=18661&osCsid=hf86ts94lil6st5fnik-012acj4

APPENDIX

Appendix

Plant community of local vegetation

Alluvial alder-ash forest

- Forest anemone (Anemone nemorosa)
- Muskwort (Adoxa moschatellina)
- Yellow dovenetel (Lamium galeobdolon)
- Slender primrose (Primula elatior)
- Teatweed (Ranunculus ficaria)
- Spotted arum (Arum maculatum)
- Duckberry (Paris quadrifolia)
- Currant (Ribes rubrum), Blueberry (Mercurialis pear niche)
- Boszegge (Carex sylvatica)
- Boswederik (Lysimachia nemorum)
- Badger garlic (Allium ursinum)
- Yellow nailwort (Geum urbanum)
- Small periwinkle (Vinca minor)

BWK: Alluvial alder-ash forest (va). (z.d.). ecopedia. Consulted on 15 August 2022, from https://www.ecopedia.be/bwk/bwk-alluviaal-elzen-essenbos-va

Blue grasslands

Herb layer

- Spanish rider (Cirsium dissectum)
- Blue sedge (Carex panicea)
- Blonde sedge (Carex hostiana)
- Vlozegge (Carex pulicaris)
- Cirsium ×forsteri (hybride spanish rider × bald jonker)
- Small skullcap (Scutellaria minor)
- Blue button (Succisa pratensis)
- Piping buttons (Juncus conglomeratus)
- Milk violet (Viola persicifolia)
- Bald Jonker (Cirsium palustre)
- Small valerian (Valeriana dioica)
- Raw walstro (Galium uliginosum)
- Multiflorous field bees (Luzula multiflora)
- Wild bertram (Achillea ptarmica)
- Lidrus Hotels (Equisetum palustre)
- Common angelica (Angelica sylvestris)
- Striped white ball (Holcus lanatus)
- Sharp buttercup (Ranunculus acris)
- Buttonwort (Centaurea jacea)
- Ordinary brunel (Prunella vulgaris)
- Cuckooflower (Cardamine pratensis)
- Sorrel (Rumex acetosa)
- Large pimpernel (Sanguisorba officinalis)
- Bird vetch (vicia cracca)
- Red clover (Trifolium pratense)
- Meadow snake flower (Festuca pratensis)
- Common hornflower (Cerastium fontanum)

Moss layer

- Tree moss (Climacium dendroides)
- Just hook moss (Rhytidiadelphus squarrosus)

Blauwgrasland. (2022, 9 augustus). Wikipedia. Consulted on 15 August 2022, from https://nl.wikipedia.org/wiki/Blauwgrasland

Appendix

Plant community of local vegetation

Association of the alder pants forests

Tree layer

- Black alder (Alnus glutinosa)

Shrub layer

- Grey willow (Salix cinerea)
- Wild mountain ash (Sorbus aucuparia)
- Ordered × grey willow (Salix ×multinervis)
- Black currant (Ribes nigrum)

Herb layer

- Marsh fern (Thelypteris palustris)
- Hennegras (Calamagrostis canescens)
- Bittersweet (Solanum dulcamara)
- Yellow lis (Iris pseudacorus)
- Real reed (Phragmites australis)
- Melkeppe Hotels (Peucedanum palustre)
- Kudos (Carex paniculata)
- Big cat tail (Lythrum salicaria)
- Great reciprocity (Lysimachia vulgaris)
- Narrow spiny fern (Dryopteris carthusiana)
- Swamp wedge (Lysimachia thyrsiflora)
- Oeverzegge (Carex riparia)
- Swamp victory (Carex acutiformis)
- Broad spiny fern (Dryopteris dilatate)
- Common blackberry (Rubus fruticosus)
- Bald Jonker (Cirsium palustre)
- Haagwinde (Convolvulus sepium)
- Marsh straw (Galium palustre)
- Queen's herb (Eupatorium cannabinum)
- Wolf's paw (Lycopus europaeus)
- Water mint (Mentha aquatica)

Moss layer

- Just star moss (Mnium hornum)
- Fine beak moss (Eurhynchium praelongum)
- Ordinary fat-headed moss (Brachythecium rutabulum)
- Ordinary pointed moss (Calliergonella cuspidate)
- Haakveenmos (Sphagnum squarrosum)
- Ordinary lace moss (Lophocolea bidentata)
- Lashed peat moss (Sphagnum fimbriatum)
- Shiny flat moss (Plagiothecium denticulatum)
- Stocky lace moss (Lophocolea heterophylla)
- Swamp possum (Calypogeia fissa)
- Lip moss (Chiloscyphus polyanthos)

Association of the alder pants forests. (2022, 12 augustus). Wikipedia. Consulted on 15 August 2022, from https://nl.wikipedia.org/wiki/Verbond_van_de_elzenbroekbossen#Vegetatiestructuur

Appendix

Plant community of local vegetation

Fen wetlands

Birch alder marshforest

Tree layer
- Downy birch (Zachte berk - Betula pubescens)
- Pedunculate oak (Zomereik - Quercus robur)
- Common alder (Zwarte els - Alnus glutinosa)

Shrub layer
- Eared willow (Geoorde wilg - Salix aurita)
- Alder Buckthorn (Sporkehout - Frangula alnus)
- Bog myrtle (Wilde gagel - Myrica gale)
- Purple chokeberry (Zwarte appelbes - Aronia x prunifolia)

Herb layer
- Cross-leaved heath (Gewone dophei - Erica tetralix)
- Marsh violet (Moerasviooltje - Viola palustris)
- Purple moor-grass (Pijpenstrootje - Molinia caerulea)
- Tormentil (Tormentil - Potentilla erecta)

Wet flowery roughs

- Woody nightshade (Bitterzoet - Solanum dulcamara)
- Common skullcap (Blauw glidkruid - Scutellaria galericulata)
- Bluewater speedwell (Blauwe waterereprijs - Veronica anagallis-aquatica)
- Valerian (Echte valeriaan - Valeriana officinalis)
- Great fen-sedge (Galigaan - Cladium mariscus)
- Yellow iris (Gele lis - Iris pseudacorus)
- Great yellow-cress (Gele waterkers - Rorippa amphibia)
- Square-stalked St. John's-wort (Gevleugeld hertshooi - Hypericum tetrapterum)
- Marsh marigold (Gewone dotterbloem - Caltha palustris subsp. palustris)
- Wild angelica (Gewone engelwortel - Angelica sylvestris)
- Common comfrey (Gewone smeerwortel - Symphitum officinale)
- Common spike-rus (Gewone waterbies - Eleocharis palustris)
- Butterbur (Groot hoefblad - Petasites hybridus)
- Greater spearwort (Grote boterbloem - Ranunculus lingua)
- Branched bur-reed (Grote egelskop - Sparganium erectum)
- Purple loosestrife (Grote kattenstaart - Lythrum salicaria)
- Bulrush (Grote lisdodde - Typha latifolia)
- Great water-parsnip (Grote watereppe - Sium latifolium)
- Common water-plantain (Grote waterweegbree - Alisma plantago-aquatica)
- Yellow loosestrife (Grote wederik - Lysimachia vulgaris)
- Hedge bindweed (Haagwinde - Convolvulus sepium)
- Great willowherb (Harig wilgenroosje - Epilobium hirsutum)
- Common fleabane (Heelblaadjes - Pulicaria dysenterica)
- Marsh thistle (Kale jonker- Cirsium palustre)
- Sweetflag (Kalmoes - Acorus calamus)
- Branched bur-reed (Kleine egelskop - Sparganium emersum)
- Lesser bulrush (Kleine lisdodde - Typha angustifolia)
- Lesser water-parsnip (Kleine watereppe -

Appendix

Plant community of local vegetation

Berula erecta)
- Hemp agrimony (Koninginnekruid - Eupatorium cannabinum)
- Long-leaf speedwell (Lange ereprijs - Veronica longifolia)
- Floating sweetgrass (Mannagras - Glyceria fluitans)
- Common club-rush (Mattenbies - Schoenoplectus lacustris)
- Marsh Woundwort (Moerasandoorn - Stachys palustris)
- Marsh pea (Moeraslathyrus - Lathyrus palustris)
- Marsh sow-thistle (Moerasmelkdistel - Sonchus palustris)
- Meadowsweet (Moerasspirea - Filipendula ulmaria)
- Water forget-me-not (Moerasvergeet-mij-nietje - Myosotis scorpioides subsp. scorpioides)
- Tufted loosestrife (Moeraswederik - Lysimachia thyrsiflora)
- Marsh spurge (Moeraswolfsmelk - Euphorbia palustris)
- Lesser pond-sedge (Moeraszegge - Carex acutiformis)
- Great pond-sedge (Oeverzegge - Carex riparia)
- Soft rush (Pitrus - Juncus effusus)
- Greater tussock sedge (Pluimzegge - Carex paniculata subsp. paniculata)
- Common meadow-rue (Poelruit - Thalictrum flavum)
- Arrowhead (Pijlkruid - Sagittaria sagittifolia)
- Common reed (Riet - Phragmites australis)
- Reed Canary-grass (Rietgras - Phalaris arundinacea)
- Bog arum (Slangenwortel - Calla palustris)
- Narrow-fruited water-cress (Slanke waterkers - Nasturtium microphyllum)
- Tufted sedge (Stijve zegge - Carex elata)
- Hoary willowherb (Viltige basterdwederik - Epilobium parviflorum)
- Fine-leaved water-dropwort (Watertorkruid - Oenanthe aquatica)
- Water dock (Waterzuring - Rumex hydrolapathum)
- Gipsywort (Wolfspoot - Lycopus europaeus)
- Flowering rush (Zwanenbloem - Butomus umbellatus)

Fen meadow

- Few-flowered spike-rush (Armbloemige waterbies - Eleocharis quinqueflora)
- Quaking grass (Bevertjes - Briza media)
- Broad-leaved marsh orchid (Brede orchis - Dactylorhiza majalis)
- Northern green rush (Duinrus - Juncus anceps)
- Common centaury (Echt duizendguldenkruid - Centaurium erythraea)
- Fairy flax (Geelhartje - Linum catharticum)
- Purple loosestrife (Grote kattenstaart - Lythrum salicaria)
- Greater yellow rattle (Grote ratelaar - Rhinanthus angustifolius)
- Little yellowrattle (Kleine ratelaar - Rhinanthus minor)
- Marsh valerian (Kleine valeriaan - Valeriana dioica)
- Black bog-rush (Knopbies - Schoenus nigricans)
- Creeping willow (Kruipwilg - Salix repens)
- Marsh bedstraw (Moeraswalstro - Galium palustre)
- Marsh helleborine (Moeraswespenorchis -

Appendix

Plant community of local vegetation

Epipactis palustris)
- Blunt-flowered rush (Paddenrus - Juncus subnodulosus)
- Grass of parnassus (Parnassia - Parnassia palustris)
- Spotted orchid (Rietorchis - Dactylorhiza praetermissa)
- Fen bedstraw (Ruw walstro - Galium uliginosum)
- Knotted pearlwort (Sierlijke vetmuur - Sagina nodosa)
- Autumn gentian (Slanke gentiaan - Gentianella amarella)
- Rigid eyebright (Stijve ogentroost - Euphrasia stricta)
- Seaside centaury (Strandduizendguldenkruid - Centaurium littorale)
- Bog pimpernel (Teer guichelheil - Anagallis tenella)
- Early marsh-orchid (Vleeskleurige orchis - Dactylorhiza incarnata)
- Watermint (Watermunt - Mentha aquatica)
- Glaucous sedge (Zeegroene zegge - Carex flacca)
- Jointed rush (Zomprus - Juncus articulatus)

Jansen, S. (2022), *Flora of Dutch habitats. Table of the most common plants in the Netherlands selected by environment.* unpublished manuscript. april 2022. TU Delft

Beech-oak forest

Tree layer

- Sugar maple (Acer saccharum)
- Paper birch (Betula papyrifera)
- Flowering dogwood (Cornus florida)
- American beech (Fagus grandifolia)
- Hop hornbeam, ironwood (Ostrya virginiana)
- Wild black cherry (Prunus serotina var. serotina)
- White oak (Quercus alba)
- Scarlet oak (Quercus coccinea)
- Chestnut oak (Quercus montana)
- Northern red oak (Quercus rubra)
- Black oak (Quercus velutina)
- Sassafras (Sassafras albidum)
- Eastern hemlock (Tsuga canadensis)

Shrub layer

- American beech (Fagus grandifolia)
- Wild black cherry (Prunus serotina var. serotina)
- Sassafras (Sassafras albidum)
- Southern arrowwood (Viburnum dentatum var. venosum)

Appendix

Plant community of local vegetation

- Common red maple (Acer rubrum var. rubrum)
- Japanese barberry (Berberis thunbergii)
- Glossy buckthorn (Frangula alnus)
- Japanese honeysuckle (Lonicera japonica)
- Hop hornbeam, ironwood (Ostrya virginiana)
- Common greenbrier (Smilax rotundifolia)
- Highbush blueberry (Vaccinium corymbosum)
- Hillside blueberry (Vaccinium pallidum)

Herb layer

- Swan's sedge (Carex swanii)
- Beech-drops (Epifagus virginiana)
- White wood-aster (Eurybia divaricata)
- Canada mayflower (Maianthemum canadense)
- Smilacina racemosa (Maianthemum racemosum)

New York Natural Heritage Program. 2022. Online Conservation Guide for *Coastal oak-beech forest*. Available from: https://guides.nynhp.org/coastal-oak-beech-forest/. Accessed August 26, 2022.

Glanshaver

- Common daisy (Leucanthemum vulgare)
- Buttonwort (Centaurea jacea)
- Field lathyrus (Lathyrus pratensis)
- Rapunzel bell (Campanula rapunculus)
- Smooth walstro (Galium mollugo)
- Large beavernel (Pimpinella major)
- Large stripe seed (Crepis biennis)
- Meadow crown (Knautia arvensis)
- Tuberous crush (Saxifraga granulata)
- Golden oat (Trisetum flavescens)
- Golden primrose (Primula veris)
- Shaggy lion's tooth (Leontodon hispidus)
- Small rattle (Rhinanthus minor)
- Beavers (Briza media)
- Graslathyrus (Lathyrus nissolia)
- Meadow chervil-tor herb (Oenanthe silaifolia)
- Large pimpernel (Sanguisorba officinalis)

Natura 2000: Glossy oat and Great foxtail grasslands (6510). (z.d.). Ecopedia. Consulted on 22 August 2022, from https://www.ecopedia.be/natura2000/natura-2000-glanshaver-en-grote-vossenstaartgraslanden-6510

Oak-birch forest

Tree layer

- Big-toothed aspen (Populus grandidentata)
- Blue birch (Betula caeruleo-grandis)
- Paper birch (Betula papyrifera)
- Red maple (Acer rubrum)
- Red oak (Quercus rubra)
- Striped maple (Acer pensylvanicum)
- Yellow birch (Betula alleghaniensis)

Shrub layer

- Mountain maple (Acer spicatum)
- Striped maple (Acer pensylvanicum)
- Yellow birch (Betula alleghaniensis)
- Lowbush blueberry (Vaccinium angustifolium)
- Poison-ivy (Toxicodendron radicans)

Herb layer

- Big-leaved aster (Eurybia macrophylla)
- Common hairgrass (Deschampsia flexuosa)
- Marginal woodfern (Dryopteris marginalis)
- Rock polypody (Polypodium virginianum)
- Wild sarsaparilla (Aralia nudicaulis)

Appendix

Plant community of local vegetation

Moss layer

- Dicranum moss (Dicranum)
- Large hair-cap moss (Polytrichum commune)
- Pincushion moss (Leucobryum glaucum)

Maine Department of Agriculture, Conservation & Forestry. (z.d.). *Birch - Oak Rocky Woodland*. Maine.gov. Consulted on 21 August 2022, from https://www.maine.gov/dacf/mnap/features/communities/birchoakwdld.htm