Agroforestry as driver of the agricultural transition in the Utrechtse Heuvelrug

Archie Redman, Eva Droogleever, Ferry Tjeertes, Jara Coenen, Jay Loman, Jonathan Jaquet, Minou van den Doel, Namara van Bekkum, Nelleke Bekkers, Sanne Bekkering, Roos van Elk

Utrecht University Consultancy Project 2023
Supervised by Brian Dermody

Stichting Nationaal Park Utrechtse Heuvelrug - Jeroen Heemsbergen
Natuur & Milieufederatie Utrecht - Isabel Kruisheer

Word count whole report: 18472
Word count integrative chapter: 2411

Table of Contents

Integrative executive summary

The Utrechtse Heuvelrug is forested hilly area in the central part of the Netherlands. It is mostly used for recreational purposes and wildlife conversation. However, the flanks of the Utrechtse Heuvelrug have seen intensive agricultural use for a long time, with many dairy farmers calling this area their home.

With the current sustainable transition, dairy farming is an industry that is on the precipice of a major shift. Therefore, serious action needs to be undertaken to improve the sustainability of the dairy sector. A potential new approach to dairy farming is by integrating cattle and plants, also called agroforestry. This new method is something which has a lot of potential but is still in its infancy.

Currently, there are quite a few unknowns when it comes to agroforestry. There is much unknown about the financial profitability and ecological requirements of agroforestry systems, and the practical implications. Therefore, it is of interest to the client to look at the possibilities of agroforestry, to kickstart the transition and provide a clear outline for the functionality of the system.

In this report, advice has been given about what agroforestry system elements will allow dairy and cattle farmers in the flanks of the Utrechtse Heuvelrug to transition to an economically and ecologically viable agroforestry system. Firstly, relevant stakeholders should be able to access information about both silvopasture and food forest systems through knowledge exchange platforms. Additionally, subsidies and other forms of financial support should compensate farmers for the extra maintenance of the plants and the time lost in the trial-and-error process in the new system on the farm. Besides, farmers should focus on producing a small number of high-quality products. To maximize the potential products, focus on short supply chains in both the business to consumer sense and business to business. It is also important for farmers to consider the ecological conditions around their farm to determine what kind of crops they grow. For farms that are located on the Northern flank we advise to use the following crops: *Alnus ican*, *Ulmus laevis*, *Malus domestica, Fagus sylvatica* and *Sambucus nigra*. For the Southeastern flank *Ribes rubrum* and Alnus *glutinosa* would be most suitable to use. *Malus domestica, Fagus sylvatica*, and *Sambucus nigra* would also thrive in the Northeastern flank and *Alnus incana* and *Ulmus laevis* in the Western flank. Lastly, specific advice for implementing food forests includes having awareness about the spatial properties of the land and creating alternative revenue streams.

1.1 Introduction of research aim

Situation

Our clients are Natuur en Milieufederatie Utrecht (NMU) and Stichting Nationaal Park de Utrechtse Heuvelrug (NPUH) who collaborated to explore the possibilities of transitioning to agroforestry for dairy farms on the flanks of the Utrechtse Heuvelrug (UH).

The UH is the second largest woodland in the Netherlands. The areas in the UH serve several functions; historical value, recreation, nature, provision of drinking water and/or agriculture. However, the dry, nutrient-poor sandy soils make the area prone to droughts, and nitrogen deposition (van Dijk, 2021). Most of the dairy farmers on the flanks of the UH have incorporated a traditional agricultural system, in the forms of monocultural grasslands and stables with cattle (Rougoor, 2015).

Agroforestry is an umbrella term for agricultural systems (AS) that combine agriculture with forestry, through incorporating the cultivation of trees and different types of vegetation and/or cattle (FAO, 2021). AS have the potential to mitigate effects of climate change through restoring the productivity of the dehydrated soil, enhancing microbiome (Buijs, 2021). For dairy farmers, agroforestry can increase the robustness of their revenue model through the diversification of revenue streams from dairy, crops, or other activities (Wigboldus, 2022). There are many variations of AS and the design of the system depends on a multitude of conditions.

Complication

The complication is twofold. Firstly, the increasing pressures of land-use, water, and climate change on the UH have raised the vulnerability of farmers on the flanks of the UH. The effects of climate change, such as extreme weather events, droughts, water shortage, and flooding (Ruijtenberg, 2022: Appelman, 2022) and the Dutch nitrogen crisis put growing pressure on the agricultural processes of farmers (Tuenter, 2019: Rijksoverheid, 2022).

Secondly, Agroforestry can increase the resilience of agricultural systems and potentially mitigate the effects of climate change (Ruijtenberg, 2022). Nevertheless, the lack of knowledge, economic uncertainty, and practical barriers keep farmers in the flanks of the UH from transitioning to an AS (Wigboldus, 2022). Agroforestry models require adaptation to the specific microclimates and social context of farmers, it may require new market linkages, alternative business models but also radical changes in a farmers day-to-day activities. Yet, practical examples or guidelines for the transition of conventional dairy farmers to AS that integrate the environmental, social and economic aspects are missing (Pulleman, 2022).

Question

Therefore, our research question is:

" What agroforestry system elements will allow dairy and cattle farmers in the flanks of the Utrechtse Heuvelrug to transition to an economically and ecologically viable agroforestry system?"

Answering this question advises the clients on how to ensure agricultural resilience in the Utrechtse Heuvelrug. The structure of this report is divided into three sub chapters, all with a different perspective and a different sub question.

1. How can the main obstacles and concerns of farmers be bridged in order to implement a sustainable agroforestry business model?
2. "What types of vegetation and what type of agroforestry system would support or boost the surrounding natural landscape best in terms of climate adaptation?"
3. What is required for an economically viable agroforestry business model in the market context of the Utrechtse Heuvelrug?

1.2 Research Scope

Agroforestry distinguishes mainly between three distinct systems: silvoarable, silvopastoral and agrosilvopastoral agroforestry systems, the combination with woody trees and the agricultural systems are displayed in Figure 1.1. However, there is endless variation and additional forms include permaculture such as food forests (Buijs, 2021; Wigboldus, 2022)

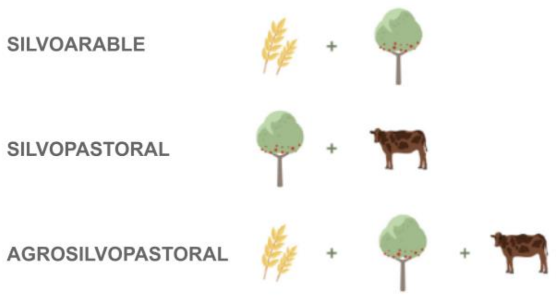

Figure 1.1. Main agroforestry types with respective combinations of trees, crops or cattle (Buijs, 2021)

A number of factors such as the micro-climate, available resources, knowledge and the incumbent business model of farmers determine the most suitable AS (Buijs, 2021). Agrosilvopastoral systems are mainly implemented in Latin-America, Africa and Asia, and the form is almost non-existent in Europe and the Netherlands (Louis Bolk Instituut, 2019). Silvoarable systems combine trees with crops, leaving out livestock. Food forests consist of different layers of trees, and vegetation. They have higher productivity, while a decreased maintenance, compared to silvopastoral and silvoarable systems (expert 1; organization 3). Therefore, we decided to focus on Silvopastoral and Food forests due to their potential and different approaches for dairy and cattle farmers in the Utrechtse Heuvelrug. This section, we will provide a general background of the systems as they are the guiding principles of our research and.

Introduction of Silvopastoral systems

Silvopastoral systems combine trees and cattle. The trees provide protection against the sun, rain, and wind for the livestock, whilst the cattle enrich the soil through their manure and by eating weeds (Buijs, 2021). The trees are applied to pastures where they can be planted using different methods such as rows, clusters, hedgerow or even randomly scattered (see Figure 1.2). Besides protection, the trees can have other functions such as providing food for the livestock, which allows up to 4 times as much livestock on the same piece of land, or the production of timber, fruits or nuts (FOA, 2019). Silvopastoral systems have various ecological benefits, and can strengthen the business model through the provision of additional income.

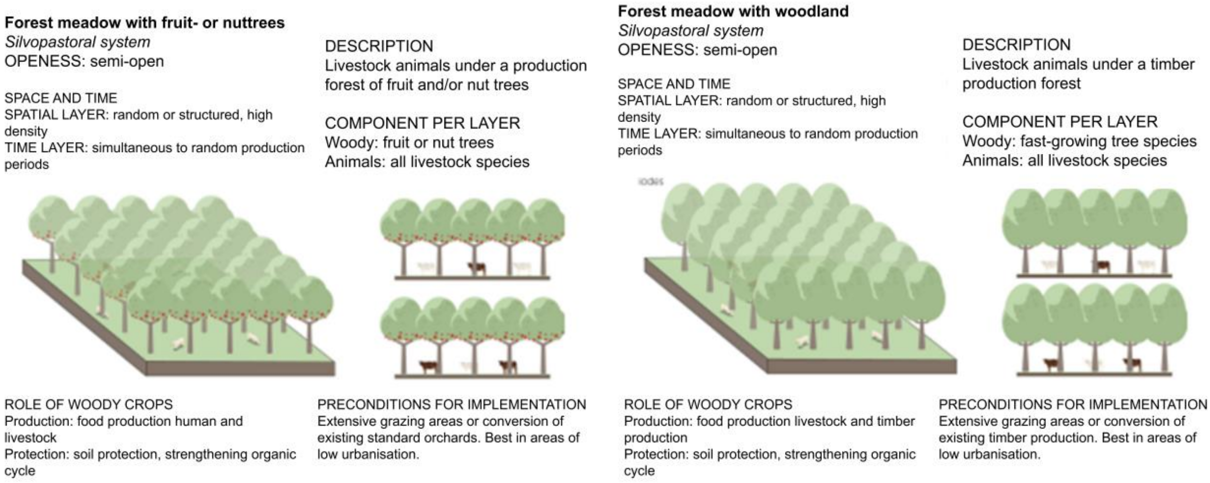

Figure 1.2. Example of Silvopastoral system (Buijs, 2021)

Introduction of food forest system

Our second system is a food forest, which can be applied to unsuitable or unproductive land or dairy farms for conventional farming. In this way the food forest forms an addition to the farmer's pre-existing business model (expert 1). Food forests emulate a natural ecosystem by including productive trees and crops in all vegetation layers. These layers interact in an ecosystem-like manner, forming a resilient system (see Figure 1.3). Benefits of this system include increased biodiversity, water storage capacity, decreased maintenance and a diversification of income streams (Buijs, 2021).

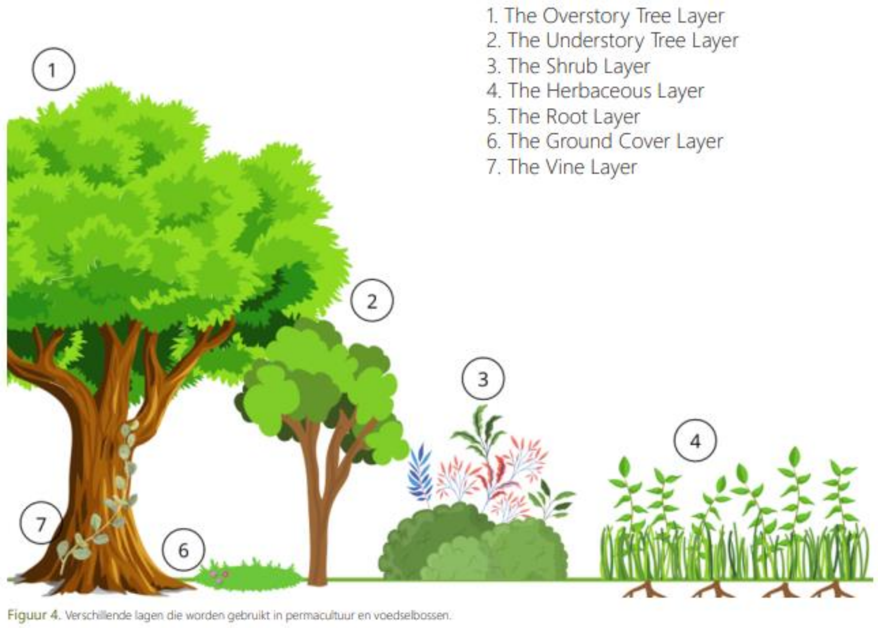

Figure 1.3. *Example of Foodforest*

In the rest of this report the interviewees will be referenced to as presented in Table 1.1.

Table 1.1. Overview of the different interviewees and the names referenced to in text

Interviewee	Name	Function	Date of the meeting
Expert 1	Wytze Walstra	Marketexpert, works for voedselbos bouw Nederland	7-3-2023
Organisation 1	René van Druenen	Chairman, foundation Agrobosbouw	9-3-2023
Organisation 2	John Vermeer	CEO Vermeer Duurzame Diensten	13-3-2023
Expert 2	Nico Wojtynia	First author paper framework	14-3-2023
Silvopasture farmer	Ron van Zandbrink	Farmer who implemented silvopastoral agroforestry	14-3-2023
Expert 3	Pieter Veen	WUR landschapsarchitect, has guided a project on Agroforestry in the Utrechtse Heuvelrug	17-3-2023
Expert 4	Maureen Schoutsen	WUR researcher on project about business models for agroforestry for dairy farmers	13-3-2023
Expert 5	Bram Wendel	Founder of BoerenBos	30-3-2023
Organisation 3	Evert Prins	Expert agroforestry Louis Bolk institute and Agroforestry Nederland	27-3-2023
Organisation 4	LTO Michaela van Leeuwen	Project leader nature-inclusive agriculture, agroforestry/nut cultivation and soil consultant at LTO Noord	22-3-2023
Expert 6	Pia Winckler	Master student writing her thesis on agroforestry in the UH	30-03-2023
Expert 7	Carel Dieperink	Member of the board of ‘Waterschap de Stichtse Rijnlanden’ and senior researcher at Utrecht University	31-03-2023

1.3 Intergrative advice

A summary of the integrative advice on both food forest and silvopasture systems can be found in Figure 1.4. The following sections provide a more thorough explanation of the advice.

Integrative advice

Provide elements for succesful:

FOOD FORESTS AND SILVOPASTURE SYSTEMS

INTEGRATIVE ADVICE 1

1.1 KNOWLEDGE AVAILABILITY

Allow the relevant stakeholders to access information about both silvopasture and food forest systems through knowledge exchange platforms. This should incorporate professional, practical, political and scientific knowledge for a hollistic knowledge exchange. This exchange should focus on the improvement of agroforestry systems.

1.2 FINANCIAL SUPPORT

The farmer has high investment costs, from purchasing and planting the plants. In addition, the time a farmer spends other than on his diary practices will lose him money. Subsidies and other forms of financial support compensate farmers also for the extra maintenance of the plants and the time lost in the trial-and error proces in the new system on the farm.

1.3 STRUCTURAL REVENUE

Focus on producing a small number of high quality products. To maximize the potential products, focus on short supply chains in both the business to consumer sense and business to business. Alternative revenue streams can also supplement the main revenue.

1.4 FITTING PLANT SPECIES

For farms that are located on the Northern flank we advise to use the following crops: Alnus icana (witte/grijze els), Ulmus laevis (Fladderiep), Malus domestica (appel), Fagus sylvatica (Beuk) and Sambucus nigra (gewone vlier).

For the South Eastern flank Ribes rubrum (Aalbes) and Alnus glutinosa (Zwarte els) would be most suitable to use.

Malus domestica, Fagus sylvatica, and Sambucus nigra would also thrive in the North Eastern flank and Alnus incana and Ulmus laevis in the Western flank.

FOOD FORESTS SYSTEMS

INTEGRATIVE ADVICE 2

2.1 SPATIAL PROPERTIES OF THE FARMLAND

Awareness about the spatial properties of the land is necessary to support the decision to transition to a food forest system. The soil properties influence the possibilities for plant species and as such, farmers should be made aware about the possibilities and limitations of their farmland.

2.2 ALTERNATIVE REVENUE STREAMS

For food forests, alternative revenue streams are an imperative addition to the core business model. These revenue streams can be divided in 3 categories: ecosystem service related, recreational and other (including hospitality) revenue streams. Due to their high aesthetic value, food forests are especially suitable for recreational and hospitality related revenue streams.

Figure 1.4. Summary of the integrative advice

1.3.1 Advice for both systems

First, we propose elements which are at the foundation for a successful implementation of both the silvopastural and food forest system.

Advice 1.1: Knowledge availability

To ensure that this knowledge reaches the farmers who are open to transitioning, an accessible knowledge exchange platform should be established where professionals, experts and policymakers are in direct contact, something that is currently lacking (chapter 1, 2.3.1.3). As such, the diffusion and production of knowledge should be geared towards the development and implementation of food forest and silvopasture as functional systems, of which currently very little data is available. Currently, the biggest and oldest food forest where most data is used from in the Netherlands is only 10 years old and there is still a lot of unknown practical knowledge (chapter 1, 2.3.1.2 Knowledge development). Until there is concrete evidence on the functioning and profitability of this system, it will be difficult to convince farmers to transition. Therefore, raising awareness through experiential learning and exchange of experiences amongst farmers and the general public is necessary (Chapter 1, 2.3.1.2 Knowledge development).

Advice 1.2: Financial support

The last key advice for the successful implementation of food forests and silvopastures is financial support for farmers, especially in the initial years. This is because these systems, particularly food forests, have high investment costs and banks are often reluctant to support the transition, see Chapter 1, 2.3.1.6 Resource Mobilisation. Related to this, is the investment in time, the farmer will lose time learning about the theory and practicalities and experimenting for the best application of the new system on their farms (see Chapter 1, 2.3.1d.5 Respects current practices). In addition, while food forests can become self-sufficient, in the first years it is important to cut and prune the plants, the silvopasture system need maintenance not only in the first years but the whole time. This maintenance can be conducted by hired labour force, which increases the costs further; but, frequently farmers do this themselves (see Chapter 3, 4.3.3) Differences between silvopastoral and food forest + conventional). The time the farmer spends other than on his diary practices will lose him money. Therefore, to remove some obstacles in the transition process, enabling farmers to have access to financial means is crucial.

As it takes several years to recover the investment, the farmer should be financially supported by, for instance, Plan Boom or the

POP3 subsidy or the agricultural collective (Chapter 1). Furthermore, for the same reason, it would be a good strategy for farmers to start with a trial field. In that way, farmers can continue with their current business model, until the new system becomes profitable (Chapter 3). Good examples of transitions should play the role model for this.

Advice 1.3: Structural revenue

An agroforestry business model can be economically viable if it is structured in the right way. Firstly, it is important to note that the silvopastoral system works in conjunction with the conventional dairy farm to diversify and supplement goods and income and is not a completely new system (Chapter 3, 4.3.4.3) whereas a food forest is a separate system that can be implemented on unproductive land (Chapter 3, 4.3.3)

As such, we advise the following actions. Focus on producing a small number of high-quality products. In order to maximize the potential products, focus on short supply chains in both the business to consumer sense and business to business, such as supplying local restaurants. Focus on direct selling of processed goods such as cheese and ice cream that is made from the dairy and the trees present in the system rather than the raw goods (Chapter 3, 2). Maximize profit potential by selling goods at a premium price based on marketing that emphasizes the value created by the production methods. (Chapter 3, 2). Furthermore, an agroforestry system has the potential to decrease the costs of the dairy farming system as there is the ability to grow feed for the livestock (Chapter 3, 4.3.2.2).

Alongside the revenue streams resulting from the produce in the system, there is the potential for alternate revenue streams elaborated in section 4.3 of Chapter 3.

Advice 1.4: Fitting plant species

Ecological conditions can determine the suitable plant species for both systems (Chapter 2, section 3.2). For farms that are located on the Northern flank we advise to use the following crops: *Alnus icana* (witte/grijze els), *Ulmus laevis* (Fladderiep), *Malus domestica* (appel), *Fagus sylvatica* (Beuk) and *Sambucus nigra* (gewone vlier). For the Southeastern flank *Ribes rubrum* (Aalbes) and *Alnus glutinosa* (Zwarte els) would be most suitable to use. *Malus domestica*, *Fagus sylvatica*, and *Sambucus nigra* would also thrive in the Northeastern flank and *Alnus incana* and *Ulmus laevis* in the Western flank.

1.3.2 Additional advice for food forest system

In addition to the points mentioned in the previous section, there are some specific elements which should be included for successful food forests.

Advice 2.1: Spatial properties of the farmland to adapt plant layers

To ensure an effective implementation of food forest systems, proper spatial awareness is a requirement. As food forests take up part of the land, instead of coexisting with cattle (Chapter 3), it is beneficial to transform otherwise unproductive land into a food forest system (Chapter 3, 3.3.2.2). If farmers do not possess unproductive land, food forests might not be the most suitable option for them. Furthermore, the ecological properties of the land need to be considered, such as water level, nitrogen deposits and soil erosion (Chapter 2, 3.3.1.3) . When these factors are considered, the appropriate plant species can be selected which will thrive in the right circumstances (Chapter 2, 3.2).

Advice 2.2: Alternative revenue streams

The second point of advice for establishing a successful food forest is to add an alternative revenue stream to the business model that can complement the core business of the direct selling of products. This is necessary as direct selling from food forests alone has not been proven sufficient for an economically viable business model (section 3.2.2.2). Hence, a majority of case studies we found had a significant part (upto 40%) of their revenue come from income sources other than the (direct) sale of products. These alternative revenue streams can include recreational services such as the provision of event space, workshops and tours as well as other services including subscription-based harvesting and hospitality (for full overview Appendix 9.6). If the farmer is planning on leaving the dairy farming business largely intact this could also represent the alternative revenue stream. Food forests have high potential for a lot of these revenue streams, as they are aesthetically pleasing and, therefore, desirable to be around and learn about (section 3.2.2.2).

Apart from economic implications, these revenue streams also have practical and ecological implications. Each of these alternatives is accompanied by a different set of practical challenges and ecological implications. Some overarching themes can be identified: for practical challenges, the need for knowledge, initial funds, and legal challenges related to the different revenue streams. For ecological reasons the most important overarching challenges are related to the (carbon) emissions associated with the different revenue streams and the impact on the food forest ecosystem of each of the revenue streams. These challenges will need to be dealt with for the addition of any revenue stream to be successful.

CHAPTER 1
Practical considerations of farmers

Namara van Bekkum, Roos van Elk, Ferry Tjeertes,
Eva Drooglever

Word count: 4996

2.1 Introduction practical considerations of farmers

The Utrechtse Heuvelrug is a diverse natural area, with multifold farmers located in the flanks which produce mainly dairy products. While one farmer has transitioned to a silvopastoral agroforestry system, other farmers have been held back to implement this new system. Besides silvopastures, food forests are also identified as a prominent nature-inclusive agricultural system. For every organisation, a transition in strategies requires convincing reasons to do so. According to Pontara (2019), farmers' decisions to adopt agroforestry are significantly influenced by perceptions, such as how they view benefits, hazards, and barriers. Farmers must consider the economic feasibility, the ecological benefits and the practicalities of their day-to-day life when considering agroforestry. Some of the obstacles that already could be identified for farmers are insufficient economic incentives, limited action perspective, and a lack of a concrete and shared vision (Vermunt et al., 2022).

In every sector, there are organisations that are unwilling to implement sustainable practices unless it is obliged, or everyone has preceded them. For this reason, we focus on farmers who are open to investigating agroforestry on their farms but still have some concerns and obstacles which hold them back. Once these primary factors are clearly identified, it is possible to find ways to overcome them. Of particular importance is the question of how to integrate agroforestry into the current practices of farmers.

Moreover, while scientists, policymakers and other stakeholders can encourage agroforestry, the farmers will make the decision to plant trees on their farms or not. It is therefore important that farmers are involved in the discourses, policy-process, and scientific research around agroforestry. In addition, in other regions in the Netherlands agroforestry has been implemented on a wider scale. Key lessons from their experiences on how to implement agroforestry successfully could be helpful for farmers in the Utrechtse Heuvelrug to make the transition. Therefore, this subchapter focuses on the question:

"How can the main obstacles and concerns of farmers be bridged in order to implement agroforestry in the Utrechtse Heuvelrug?"

2.2 Advice

The overarching advice of our research is to offer farmers a future perspective of a successful agroforestry system for their farms, this can be achieved through the following two sub-advices. In Figure 2.1 the advice is summarized and visualized.

Figure 2.1. Summary of the advice

2.2.1 Provide practical knowledge though good examples and agroforestry farmers' network

There is more practical knowledge needed in the form of knowledge diffusion and development through good examples and an agroforestry farmers network in Utrecht. This will enable farmers know what to expect, where to start and how to work consciously and effectively. Especially encouraging farmers who can be a good example provides perspective and shows that agroforestry not only in theory but in practice is also possible. Farmers, advisory services, and policy-making organisations need field-based evidence to make educated decisions (see section Legitimacy). In addition, a network of agroforestry farmers in Utrecht, and a group of farmers that are interested in agroforestry, supported by an advisory service will help to increase knowledge amongst farmers. In other provinces, such as Brabant, Gelderland, and Limburg there is already an agroforestry network for farmers (section Entrepreneurial activity). For example, partnerships of agricultural entrepreneurs can play an important role here. An experienced fruit or nut grower could advise the farmer about woody crops (see section Respects current practices).

2.2.2 Provide concrete financial advantages

Currently, there is no clear positive outlook for the financial viability of agroforestry. It lacks prospects which makes it highly unlikely for farmers to transition without any guarantees (expert 2). The initial costs are high, and it takes a long time for the system to generate money (section Resource mobilisation). Therefore, our advice would be to provide farmers with financial security through future-proof subsidies, tax cuts and by offering perspective on its viability (section Resource Mobilisation), either through government run information campaigns or by establishing/expanding farmers networks. As mentioned by expert 2 a subsidy system which rewards progressive farmers and penalises polluters could benefit this situation (section Guidance of the Search). Furthermore, focussing on the amount of money saved by introducing agroforestry will also give a more positive outlook on agroforestry as a functional system. By using agroforestry, the costs for running the system are lowered compared to regular farming, with the prices for the product being higher, due to consumers being willing to pay a higher price for the biological benefits of the product. Therefore, the discourse surrounding the financial viability should focus on the amount of money saved instead of made.

2.3 Results and evidence

2.3.1 Seven functions of an innovative system

The seven functions represent the main thresholds for the implementation of a system which functions outside of the established norm. These seven functions are graded from 1 to 5, low being of little influence and 5 forming a high barrier for the implementation of the system. This framework gives a clear overview of the hurdles that the innovation system needs to overcome and the focus points for future developments. In Figure 2.2 an explanation and overview of the scores for the different functions is given. In Table 2.1 the meaning of the scores is represented

Table 2.1. The different scores of the framework and their meanings

Meanings of the function scores	
5	Function forms an extreme barrier
4	Function forms a considerable barrier
3	Function forms a moderate barrier
2	Function forms a slight barrier
1	Function forms no barrier for further adoption and diffusion

Figure 2.2. Overview of the framework and scores to the different functions for agroforestry

2.3.1.1 Entrepreneurial activity

There are several networks, businesses, organisations, institutes, and authorities that are having a stake in the transition to agroforestry. An agroforestry network in Utrecht is currently not present yet, while it already exists in other provinces (organisation 2). The silvopasture farmer mentioned that he received financial support from several actors, including the POP3 subsidy from the province, in which 40% of the investment is reimbursed on the condition that the investment is a certain minimal amount. In addition, the NMU has been helpful with providing and meeting the conditions and requirements of the *Plan Boom* subsidy. Agricultural collective also has several financial flows running from Europe which were contributing to the transition of the farmer. Furthermore, *Rijksdienst Ondernemend Nederland* (RVO) has a stake in the transition to agroforestry, since the farmer expressed that he is a duo company with RVO and thereby gets reimbursed hours to illustrate the practicalities of agroforestry. This company also has financial resources to facilitate quality measurements and sensing of soil and water. Lastly, for both the NMU and the RVO the farmer writes progress reports of his agroforestry practices.

What makes it more complicated is the cooperation between national authorities, the province, and the municipalities (organisation 1). All these layers may contain different political parties with different interests. Agriculture is regulated at a national and EU level, while nature is covered by the provinces. Since agroforestry is a type of nature inclusive farming, this can be difficult regarding regulations.

Furthermore, organisation 2 mentioned Agri Firm, which is a large bio industry organisation that is investing in agroforestry. They are selecting farmers that are interested in transitioning to agroforestry and provide them with proper advice and a business model. Moreover, N-LTO and agroforestry Netherlands are setting up several newsletters, seminars, excursions, and webinars on agroforestry with the aim of providing knowledge and advice for farmers, which would enable them to implement agroforestry practices. Considering this, the lack of entrepreneurial activities is a *slight barrier* (score: 2 out of 5).

2.3.1.2 Knowledge development

Expert 3 explains that knowledge development is very important, precisely because agroforestry is a new branch of agriculture, so not all knowledge is available. A lot of knowledge is not present among farmers and not even in agricultural education, since it is not tailored for agroforestry yet. Organisation 1 states that while research is increasing, the integration of all the components around agroforestry is still missing so that farmers know where to start. It demands bringing together knowledge about nature and agriculture. Practical knowledge is needed more, the silvopasture farmer, mentions that one of his obstacles is a lack of knowledge, which takes a lot of working time. He continues to say that more knowledge is being developed but stresses that it should become and remain bundled. Organisation 2 argues that having example roles of farmers who have transitioned to food forests or silvopasture is experienced to be a great help in overcoming obstacles for farmers who are open to transition. The biggest and oldest food forest where most data is used from in the Netherlands is only 10 years old and there is still a lot of unknown practical knowledge. Demo farmers who have transitioned to an agroforestry system, such as farmer silvopasture, are at present sharing their experiences and this gives a perspective. The silvopasture farmer talks about the exchange of knowledge by making progress reports, to exchange experiences:

"I think that is the fastest way to learn and give farmers examples to see how it is possible".

Thus, insufficient knowledge development is seen as a considerable *barrier* (score: 4 out of 5).

2.3.1.3 Knowledge diffusion

Many traditional agroforestry systems in Europe disappeared in the 20th century due to intensification and mechanisation of agriculture, and the disappearance of these traditional systems in Europe resulted in a loss of the knowledge base amongst farmers (Sollen-Norrlin et al, 2020). As organisation 1 mentioned, a farmer can know everything about cows, but absolutely nothing about fruit or nut trees. It is therefore important to provide farmers with opportunities to obtain knowledge on these subjects, without overcomplicating it. It should focus on how it impacts their work environment and their profitability (organisation 1). An issue raised in the interview with organisation 1, it is more useful for agroforestry farmers to obtain a broad overview of the system instead of an in-depth knowledge on all its functions. Therefore, it is suggested to only provide the fundamental information on agroforestry which is necessary for it to function.

This lack of knowledge and advisory service support in the implementation and management of agroforestry systems is a significant barrier to implementation. Currently, awareness amongst farmers of the benefits of silvopastures and food forests is lacking and to overcome the barriers to implementation of agroforestry in the Utrechtse Heuvelrug, raising awareness and experiential learning through exchange of experiences amongst farmers. Already, steps are taken to inform farmers through seminars or workshops. However, this only reaches a small part of the farmers who already show interest in its possibilities and are aware of the concept. To achieve a broader reach an agroforestry network of farmers could be realised. According to expert 5 the province Utrecht was until last year not ready to form a network amongst farmers who implemented agroforestry, however a knowledge sharing network with farmers who are planning to do agroforestry can already be implemented. This will enable the farmers to join forces and to exchange existing and new insights and help to lower the barriers for farmers. According to the paper of Sollen-Norrlin et al. (2020) exchange opportunities amongst farmers can be useful tools to achieve successful implementation of profitable agroforestry systems. Considering all this knowledge diffusion *forms a slight barrier* (score: 2 out of 5).

2.3.1.4 Guidance of the search

The direction of the development of agroforestry is mainly aimed at creating a viable and economically beneficial system, which also provides ecosystem services (Robotics). Governmental institutions show an increasing willingness to experiment with agroforestry as an alternative agricultural method (Vermunt et al, 2022) with increased pressure from for instance the European Union to reduce environmental impact through several directives such as the Natura 2000 initiative and the Habitats and Birds directives (European Commission, 2018). This push for a more Nature inclusive agriculture system also has a positive effect on the viability of agroforestry, as more funding and resources are allocated to its development and implementation (VLAIO, 2023).

However, when interviewing stakeholders and experts, several issues came to light. It was mentioned that a top-down approach is very unlikely to be successful, due to regime resistance. Dutch culture, and especially surrounding farmers, are very traditional and resistant to change (expert 2). It is therefore important to consider that it might not be possible to enforce agroforestry, but rather to stimulate it. He suggests several possible tools, such as a reward system for farmers willing to innovate, or a penalty system for the farmers who are not. This goes hand in hand with a functional monitoring system, which should be based on criteria which the client finds significant, such as: water level/quality, nitrogen/phosphorus levels or carbon/methane emissions. This depends on what the focus point of the innovation is based on. It is therefore suggested to approach the introduction of agroforestry on a small scale, with individual farmers.

Until it has been proven a successful system, it is very unlikely to convince large parts of the sector to consider transferring to agroforestry, due to it being yet unproven. In addition, there is a lack of direction from national and regional governments, with very mixed signals towards farmers surrounding this innovation. With constantly changing policy and unclear futures, many farmers are unwilling or unsure about agroforestry due to the chaotic nature of the agricultural sector (expert 2). This became evident when trying to contact farmers to conduct interviews. Almost all declined, with the reason that due to the rapid changes in the agricultural sector, they were unsure about their future as a business and could therefore not really give us any information about their stance on agroforestry. Therefore, this function of agroforestry as an innovation system *forms a moderate barrier* (score: 3 out of 5).

2.3.1.5 Respects current practices

To implement silvopasture or food forests, it is vital that in the process farmer's current practices are respected and it does not give the farmers more work unnecessarily. Regarding practical considerations of the implementation of agroforestry, there are two main aspects which should be given due attention: the agroforestry design at the farm and the maintenance of the trees.

2.3.1.5.1 Design plan

First, it is important to implement the agroforestry system step-by-step. As stated by organisation 1, "normally, when we draw up design plans or have them drawn up, we look at a very step-by-step, both in volume and time, implementation of such a design plan." Moreover, questions regarding what it means for the farmer, what it means in his daily practice, for his machines and other devices and how he should integrate that from morning to evening in his way of working and working, must be addressed in this design plan.

In addition, organisation 2 compares the implementation of silvopasture with food forests, mentioning that the change from conventional to silvopasture is smaller since you can still use the rest of the land, where there are no trees for the current conventional situation. Therefore, it is still possible to do whatever you have done and use the same equipment, on the contrary, food forests need other equipment. The silvopasture farmer mentions the practical components in his design plan:

"I think about 15% of an acre has trees and cows can't graze there. I had thought about the design for quite a long time because that is very important, and I arranged it quite practical. The plot where agroforestry now is, is a pasture plot for the cows. But we also must work with machines, so it must always remain workable. There are rows of 20 metres between the trees, which practically means that you can go back and forth with a lawnmower. That means that you will lose a little more time than if the row of trees were not there, but not much more time."

Lastly, Etienne & Rapey (1999) recognise that farmers design their agroforestry projects to combine farm and personal objectives and restrictions, as well as to distribute the expenses and earnings of their forestry activities over time and place.

2.3.2.1.2 Maintenance

Next to the design plan, considering the current practices of conventional farmers, it is important to assess how maintenance will change with the implementation of silvopasture systems and food forests. According to organisation 2, the maintenance of silvopasture does not change significantly if the methods of the farmer do not change. However, he states that with food forests, then the maintenance and the work of the farmer will dramatically change. It is completely different from what farmers do because in the food forest, you do not use any chemicals and you do not have manure. You do very little maintenance, primarily cutting and pruning.

The silvopasture farmer mentions that it takes more labour, mainly on maintenance. Outside the good season there is no extra work, in the good season it is half to a whole day a week of additional labour. Regarding the machine work on the land, he says that it is a little more working time, but minimal and negligible. In addition, he states that trees of a lower quality demand more work. Furthermore, the type of tree also matters, fruit trees often need to be processed before sold or freshly sold so it takes more time and energy. Nut trees are easier since they have to be dried so the farmers can contain the nuts well and they do not have to be sold immediately. Organisation 4 advises particularly the use of walnut trees for dairy farmers since they can be spread over the land so the farmer can drive around it well, and it provides scattered shade for the animals. An important consideration for the farmer in order to harvest the nuts easily, he should have the grass short in the period of September and October. Because dairy farmers are busy throughout the year, hazelnuts are less practical due to the higher labour intensity. Another consideration addressed by farmer silvopasture is the period of planting the trees, which is between September to March; also, if there is too much precipitation, the parcel will be destroyed by the ploughing. Lastly, agroforestry is especially in the first five years extremely demanding in labour, due to the planting and thinning operations (Etienne & Rapey, 1999). For these reasons additional financial and workforce support for farmers making the transition to agroforestry is advised in the first years of the implementation.

For these reasons, this function is *a moderate barrier* (score: 3 out of 5).

2.3.1.6 Resource mobilisation

Currently, the Common Agricultural Policy (CAP) forms an important source of financial resources to farmers (Vermunt et al., 2022). The new legislation, which entered into force in January 2023 focuses more on a fairer, greener, and performance-based CAP. For example, at least 25% of the budget for direct payments is allocated to eco-schemes, providing stronger incentives for climate-and environment-friendly farming practices and approaches (CAP 2023-27, 2023). However, the implementation of silvopastures and food forests requires a significant investment, especially at the beginning. Several experts, like organisation 2 and 3, and expert 3 indicated that banks are hesitant to finance these investments because they already expect interest the following year but the farmers' revenue from the investment won't be certain for another 5 to 10 years. Banks often consider these business models too risky (Drion, 2018). In addition, farmers who practise sustainable agriculture are generating or preventing benefits, such as ecosystem services, pollution and emissions that are frequently not capitalised and monetised. When requesting a loan from a financial institution that does not automatically recognize and capitalise these benefits, this can be difficult (Drion, 2018).

For younger farmers and the next generation of farmers it is more rewarding to invest in agroforestry and food forests as it is a long-term investment. If a farmer who is 50 years old, who has no heir to inherit the land, started agroforestry, he would be almost ready to retire when the system just starts producing. How long the start-up period is also differing per agroforestry system and the combination of crops, but it usually requires five to ten years.

A more positive aspect is that according to numerous interviewees (organisation 1 and Silvopasture farmer) there is a lot of willingness and interest from policy makers and researchers to help farmers. In addition, there are subsidies released to initiate the transition to silvopastures or food forests. It was stressed by numerous interviews that subsidies should go hand in hand with However, there is a lack of structural financial resources to compensate for the temporarily lower yields and higher costs during the transition phase (Vermunt et al., 2022), which makes the transition phase for farmers economically more uncertain. Especially since agroforestry needs a long time to develop (organisation 4). Currently, most subsidies available are focused on taking away the financial uncertainty for farmers right at the beginning of the implementation stage, but do not consider the financial risks later in the transition phase. Therefore, resource mobilisation in terms of finance is considered a *considerable or extreme barrier* (score: 5 out of 5).

2.3.1.7 Legitimacy creation

There is a small number of farmers that have adopted agroforestry in the Utrechtse Heuvelrug. These front runners try to increase the legitimacy by demonstrating the value and viability of agroforestry with regards to environmental, social, and economic aspects. However, organisation 2 mentioned that there are still little food forests in production. Furthermore, there is a lot of uncertainty amongst farmers with regards to their future especially due to the current nitrogen crises, which results in a lack of perspective. According to organisation 1 you only get people involved in a transition if you can make clear what the transition aims for and when it will take place and what influence it will have for you as a farmer.

Another obstacle that was mentioned by almost all experts was the legislation. There are all kinds of rules that are not conducive of what farmers are and are not allowed to do according to organisation 1. For example, organisation 2 mentioned that some farmland must be an open landscape and therefore it is not allowed to plant trees there. In the current destination plans it is sometimes simply not allowed to plant trees (organisation 3). However, expert 3 mentioned that it is not the case that those laws and regulations make that impossible, as the government also really wants farmers to become nature inclusive. But currently the legislation does make the transition more difficult for farmers. Therefore, legitimacy creation is considered *a considerable barrier* (score: 4 out of 5).

2.4 Methodology

2.4.1 Analytical framework

For this subchapter one analytical framework was used to provide a structured approach to the research and operationalized specifically for agroforestry. This framework helped to organise data collection and analysis and ensured that all relevant factors are considered. In the paper by Hekkert et al., (2007), the framework outlined underneath is used to analyse the level of innovation in Dutch dairy farmers, a topic which is related to this project. It can therefore be used to study the requirements and progress in the innovation towards agroforestry. In this framework the fifth aspect, market incentive, has been replaced with Respect Current Practices to comply with the request made by the client, as they made it clear that we should place emphasis on this aspect. In the framework by Hekkert et al., (2007), 7 functions of an innovation system are provided.

Table 2.2. Functions of an innovation system (Hekkert et al., 2007: 421-425)

Function	Definition	Operationalization
1. Entrepreneurial activity	Institutions using the potential of new knowledge, networks, and markets to experiment with novel technologies. Introducing new innovations to the farmers and investing in production capacity to spread the innovations and take advantage of windows of opportunity.	New innovations in agroforestry are driven by innovators, both private and public. There is an active push for these new techniques and resources are invested into its implementation.
2. Knowledge development	The generation of knowledge, both tacit (learning by doing) and formal (through research and development)	Active knowledge production into agroforestry is performed, taking information from multiple credible sources.
3. Knowledge diffusion	The exchange of information and knowledge between actors	Produced knowledge surrounding agroforestry is communicated to the actors involved in a coordinated and efficient manner.

4. Guidance of the search	Steering the directionality of the innovation process through the articulation of expectations and preferences	Open communication between stakeholders allows for a critical discussion about the direction of the innovations in agroforestry. All relevant actors have appropriate input into the process and the trajectory is open to critique from all parties to ensure a holistic and professional innovative system.
5. Respects current practices	Builds on and enhances upon the current system, without replacing the already functioning components	In the innovation process, farmers' current practices are respected and incorporated into an efficient and collaborative system which does not give the farmers more work unnecessarily.
6. Resource mobilisation	Allocating financial and human resources to functions 1 & 2 to allow for successful entrepreneurship and learning opportunities	Necessary resources for development and implementation are outlined and allocated to their respective part of the development chain regarding agroforestry.
7. Legitimacy creation	Overcoming resistance to change caused by: 1) powerful incumbents with vested interests in the technology. 2) unsupportive legal conditions 3) unawareness in society regarding the novelty 4) deeply embedded societal norms and habits that are at odds with the novelty in question	The playing field for the implementation of agroforestry is levelled as much as possible, taking away unnecessary boundaries either from institutions with opposing interests (industry farms), complicated politics (long processes, unnecessary paperwork, difficult conditions for subsidies), lack of knowledge around agroforestry (no public interest, no driving force), or through the current trend of distrust from farmers against state mandated initiatives.

These 7 functions outline the points of significance for a new practice or technology to be successful. By analysing the interview data scores can be attached to these functions, giving an indication of the effectiveness of that function when it comes to agroforestry. In combination with desk research, scores from 1 to 5 can be appointed to the functions, giving a clear insight into the strengths and shortcomings of agroforestry.

2.4.2 Data collection

To address the research question, data collecting is essential. This data was collected through both interviews and a literature review and was organised around the framework explained above. The next section discusses the approach for the methods used to gather data and the justification for these methods.

2.4.2.1 Literature review

Firstly, a literature review was conducted of grey and academic literature to improve our interview guide, obtain information about the current situation, and further develop the analytical framework indicated above. Google Scholar was used to search for academic literature, and the search terms used were ("agroforestry" AND "obstacles" AND "Dutch dairy farming") and ("agroforestry AND "challenges" OR "Dutch dairy farming" OR "benefits"). Our review focused on scientific and grey literature published between 2010 and 2023 that was either done in Europe or (temperate) North America. In addition, relevant literature suggested by interviewees was also reviewed. This allowed us to get an understanding of the recent findings and debates on the topic.

2.4.2.2 Interviews

To investigate our research question, in-depth interviews were conducted with experts in the field of silvopastures and food forest to obtain relevant and in-depth information on agroforestry and specifically for the Utrechtse Heuvelrug. The interviews were performed utilising a semi-structured interview guide and addressed subjects such as the motivations and obstacles to the implementation of agroforestry. The benefit of semi-structured interviews is that they are flexible, allowing the interviewee to talk more freely. Furthermore, a semi-structured interview allowed us to fully explore the context and develop a deeper understanding of the topic (Harrell & Bradley, 2009).

In total 10 interviews were conducted of which 8 were performed through video calling with Microsoft Teams and 2 interviews were held face-to-face. The experts were chosen based on their ability to represent a wide range of stakeholders and to have a comprehensive knowledge of the sector. The interviews were conducted with sustainable farming initiatives, NGOs, government agencies, research institutes and with a farmer who implemented agroforestry. This way it was ensured that a broad range of perspectives were included in our research. Each expert received similar questions, although the interview guide was slightly altered for all experts depending on their expertise and knowledge. Each interview took around 50 minutes and included approximately 15 questions (see Appendix 7.1).

To ensure that the interviews were conducted in an ethical and consensual manner the purpose of the study and how the data will be collected and used was communicated to the interviewees prior to the interviews. The interviews were recorded with the interviewees' permission, and they were also informed of their right to withdraw from the study at any moment. Finally, we asked whether we could mention their name in the report or if they preferred to keep their identity private.

2.4.3 Data analysis

The obtained data was analysed to be incorporated into the framework. Two methods of data analysis were applied to the two data collection methods mentioned above.

2.4.3.1 Literature review

The earlier-mentioned literature review can be seen as a method for simultaneously gathering and analysing data. By analysing the literature trends and patterns in the field were identified. The literature review will be used to support the outcomes of the data from the interviews.

2.4.3.2 Interviews - Qualitative text analysis

An in-depth text analysis was conducted to transform the data collected from the interviews. The purpose of this analysis is to organise the text into observable patterns. The steps taken in this analysis are outlined below. First, the interviews were transcribed with the help of online transcribe tools and were checked manually as well. It was transcribed by using an intelligent verbatim approach. This means that the interviews were transcribed exactly as what is said, except for fillers words that do not change the meaning. This way we can ensure that we keep everything from the interview that is important while also prioritising the ease of reading and therefore also ease the analysing of the transcript. Second, the analysis of the interviews was done by colour coding to identify patterns, similarities and differences in the data based on the different concepts of the framework. This method of data analysis was efficient given the time constraints and allowed us to analyse all the data. All 7 functions of the framework were given a colour, which were used to highlight the text relevant for each specific function (See Appendix 7.3). The data collected from the interviews is not presented anonymously as all the interviewees gave us the permission to use their name in the report.

CHAPTER 2
Ecological conditions

Nelleke Bekkers, Sanne Bekkering, Jara Coenen, and Jay Loman

Word count: 4818

3.1 Introduction Ecological conditions

Agroforestry has been gaining attention in the past decade by academia and farmers as it is seen as a sustainable alternative for current agribusinesses (Schoutsen, 2019). Next to the production of a variety of crops and, in this case, the raising of cattle, agroforestry provides many ecosystem services, which are "the benefits that people obtain from ecosystems" (Nair et al., 2021, p. 477). For example, restoring biodiversity, enhancing water quality and quantity, and improving climate mitigation. On the flanks surrounding the Nationaal Park Utrechtse Heuvelrug (NPUH), a number of cattle farms are located. The location of the flanks and the NPUH are visualised in Figure 3.1. The upper flank is called flank North (N), the flank on the right side of the NPUH is called flank North-East (NE), and the left-sided flank is called flank West (W). The flank under the NPUH is called flank South-East (SE). Currently, the NPUH and the province of Utrecht are planning for an expansion of the nature area towards the North which is indicated as "Working area North".

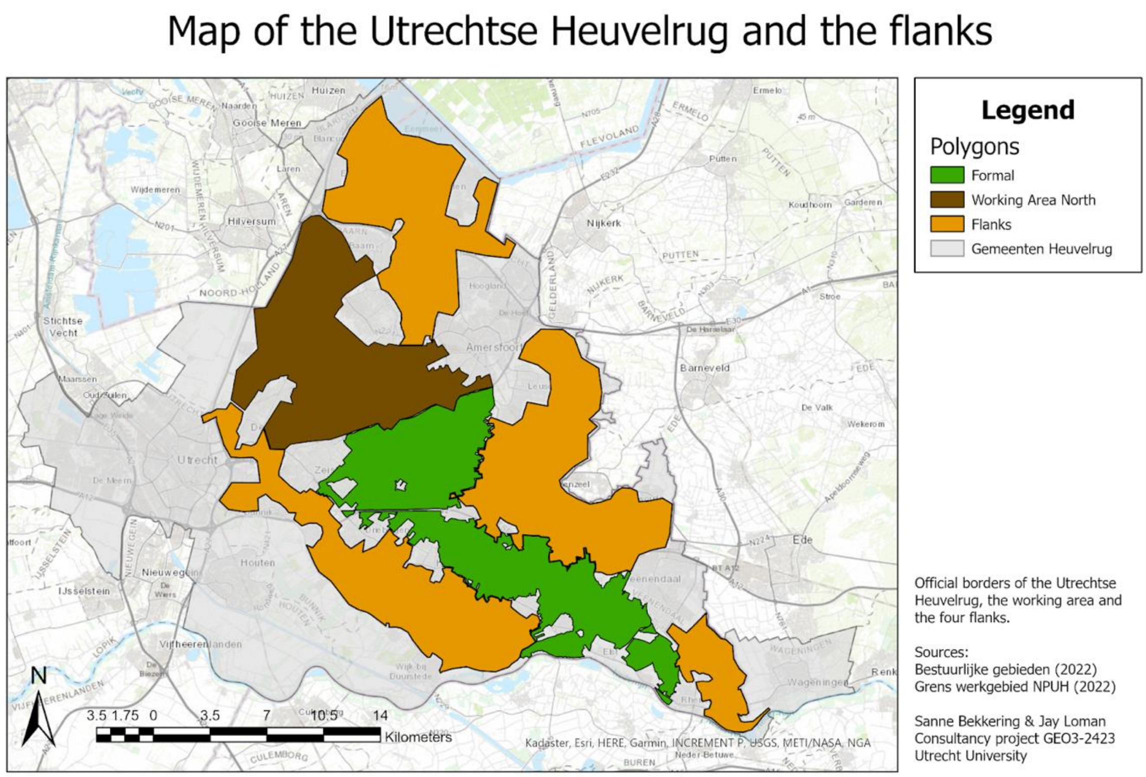

Figure 3.1. Formal area of the Utrechtse Heuvelrug, the Northern working area, municipalities and the 4 flanks.

The nature area of NPUH has a high ecological and cultural value for the province of Utrecht (Provincie Utrecht, n.d). Agroforestry can serve as a solution to maintain biodiversity levels in Utrechtse Heuvelrug (UH) itself, and possibly even increase the biodiversity levels of the flanks (Louis Bolk Instituut, 2020). However, developing a successful agroforestry system from an ecological perspective is context-specific (Raintree, 1987). An in-depth analysis of abiotic and biotic factors in the target area and its surroundings is necessary. Only then, the benefits of agroforestry can reach their full potential. In this chapter, silvopastoral agroforestry (combination of livestock with trees) and food forests (multilayer of edible plants) are studied and compared. The complication is that given the heterogeneous environmental conditions it is not clear which plants are most suitable in which flanks. Ecological conditions have not earlier been linked to finding possible agroforestry crops in the UH. NPUH and the NMU proposed research that looks at whether agroforestry can make the NPUH more climate adaptive. Therefore, the aim of this chapter is to investigate what agroforestry type would enhance the nature of Utrechtse Heuvelrug and its surrounding flanks. The main research question is:

"What types of vegetation and what type of agroforestry system would support or boost the surrounding natural landscape best in terms of climate adaptation?"

This question is broken into two sub-questions. The first subquestion **"**What are the ecological conditions on the agricultural flanks of the NPUH?" will provide insight into the ecological context of the Utrechtse Heuvelrug, taking biotic and abiotic factors into account. Secondly, "How do silvopastoral systems and food forests work? What are their strengths and weaknesses?" explains more about the different agroforestry types and which would be most suitable for the environmental characteristics.

3.2 Advice

Table 3.1. Plant combinations based on Ellenberg F & R and Water (GLG) and Soil classes.

Scientific name	Dutch Name	F	R	N	Category	GLG	Soil code
dry sand							
Mespilus germanica	Mispel	4	6	x	fruit	6	4
not on the map							
Vitis vinifera	Druif	4	7	x	fruit	6	1
Cornus sanguinea	Rode kornoelje	5	7	x	fruit	5	1
Pyrus communis	Peer	5	8	x	fruit	5	1
Fagus sylvatica	Beuk	5	x	x	wood	5	/
Prunus domestica	Pruim	5	7	6	fruit	5	1
Sambucus nigra	Gewone vlier	5	x	9	fruit	5	/
Acer campestre	Veldesdoorn	5	7	6	wood	5	1
wet loamy sand							
Malus domestica	Appel	5	6	7	fruit	5	2
Fagus sylvatica	Beuk	5	x	x	wood	5	/
Sambucus nigra	Gewone vlier	5	x	9	fruit	5	/
moderate clay							
Juglans regia	Walnoot	6	7	7	nuts	4	1
Acer pseudoplatanus	Gewone esdoorn	6	x	7	wood	4	/
moderate sand							
Acer pseudoplatanus	Gewone esdoorn	6	x	7	wood	4	/
Rubus fruticosus	Braam	6	6	6	fruit	4	4
wet clay							
Alnus incana	Witte els, grijze els	7	8	x	wood	3	1
Ulmus laevis	Fladderiep	8	7	7	wood	2	1
wet sand							
Ribes rubrum	Aalbes	8	6	6	fruit	2	4
Alnus glutinosa	Zwarte els	9	6	x	wood	1	4
Everywhere / Nowhere							
Quercus robur	Eik	x	x	x	wood	/	/
Rubus idaeus	framboos	x	x	6	fruit	/	/
Ribes Uva-Crispa	kruisbes	x	x	6	fruit	/	/

Soil code	Soil name
1	clay
2	loamy sand
3	peat
4	sand
5	sandy clay
6	sandy peat

We have found the most suitable tree types for each specific soil type (Table 3.1). These were matched by using the Ellenberg values. Based on this data we have provided advice per flank. For explanation on the matching process, see section 3.4.3.

3.2.1 Flank North

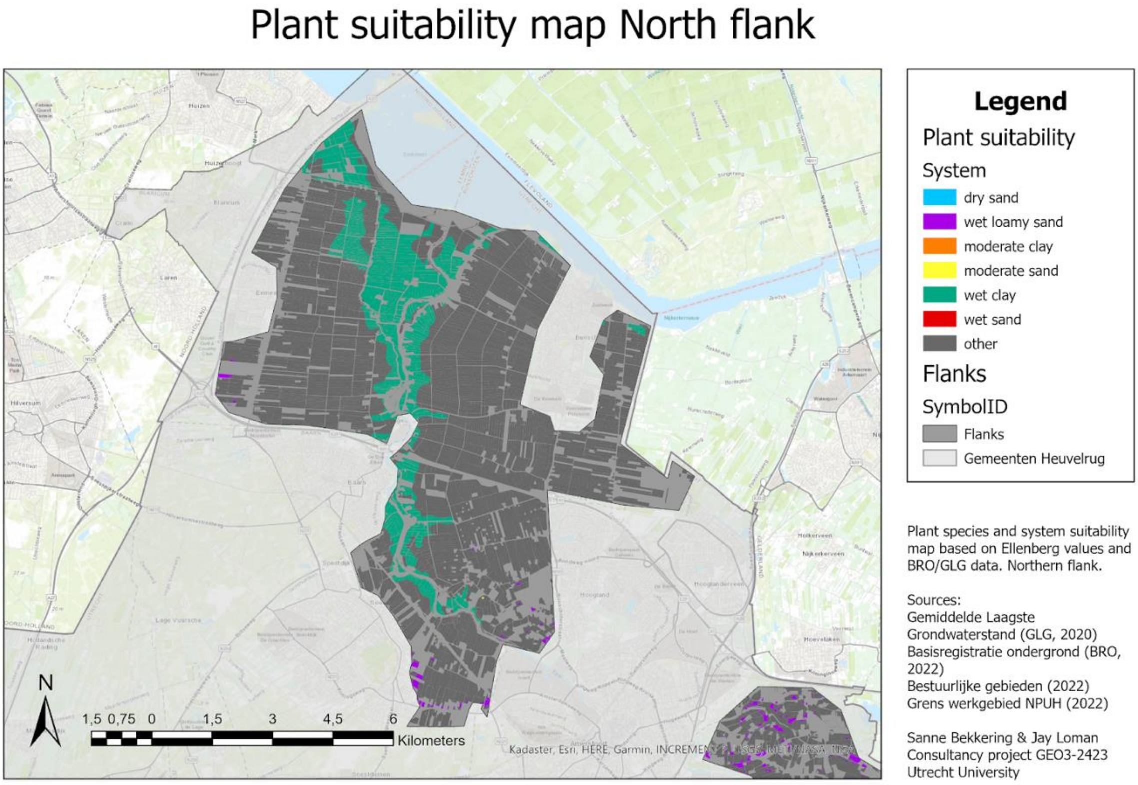

Figure 3.2. Plant suitability map for the Northern flank.

The North flank consists largely of wet clay, mostly along the riverbanks (Figure 3.2). There are also some spots of wet loamy sand. These soil types are suitable for *Alnus icana* and *Ulmus laevis*. Additionally, the plots of wet loamy sand also allow for *Malus domestica*, *Fagus sylvatica*, and *Sambucus nigra*. For flank N, we recommend implementing food forests since part of the area is *Weidevogelkerngebied* (Section 3.3.1.1). All soil types in the area are nutrient rich as is explained in section 3.3.1.1. As a result, the nutrient-rich soils will complement the characteristics of the food forest and birds can reproduce undisturbed since this type of agroforestry is low-maintenance (Section 3.3.2.2).

3.2.2 Flank North-east

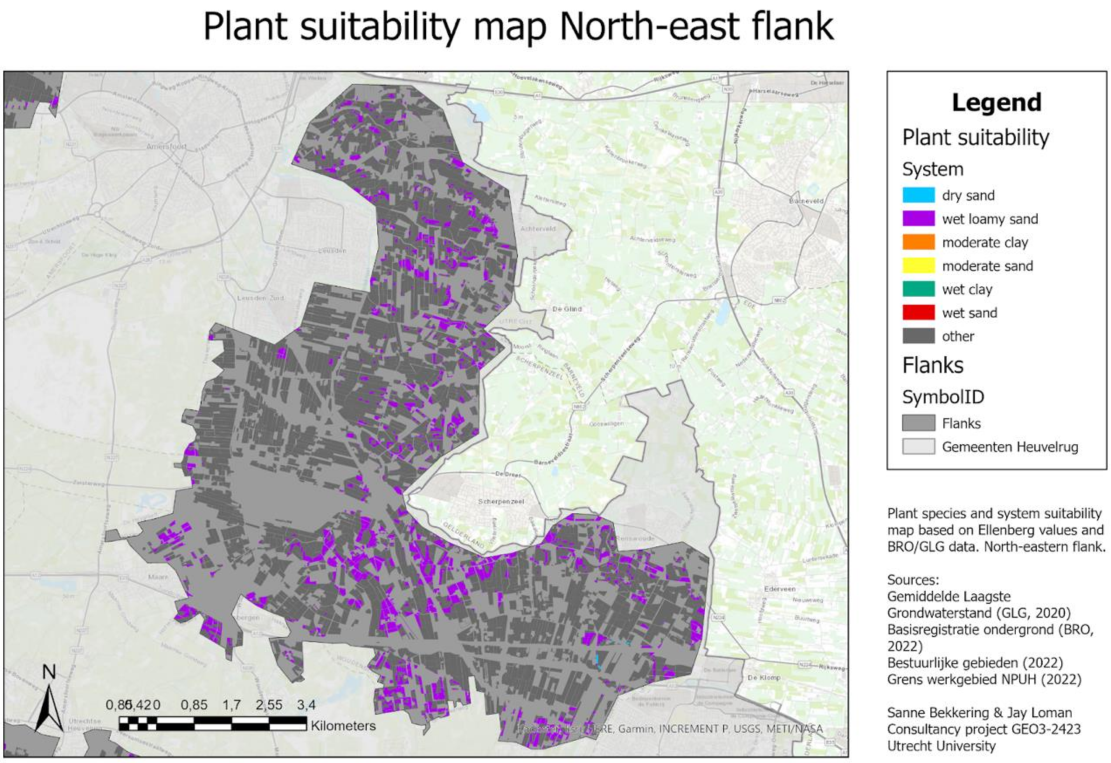

Figure 3.3. plant suitability for North-eastern flank.

The North-east flank is shown to consist of wet loamy sand pastures (Figure 3.3). This means that the *Malus domestica*, *Fagus sylvatica*, and *Sambucus nigra* are the most suitable tree species for this flank. Furthermore, flank NE is close to the heathlands of Leusderheide and Soesterberg (Section 3.3.1.4). Since heathlands need active monitoring to remain its ecological value, food forests are not suitable for this area since this agroforestry type mostly requires low maintenance (Section 3.3.2.2). Therefore, a silvopastoral system is preferred here, it can also reduce the risk of forest fires in the heathlands (Section 3.3.2.1).

3.2.3 Flank South-east

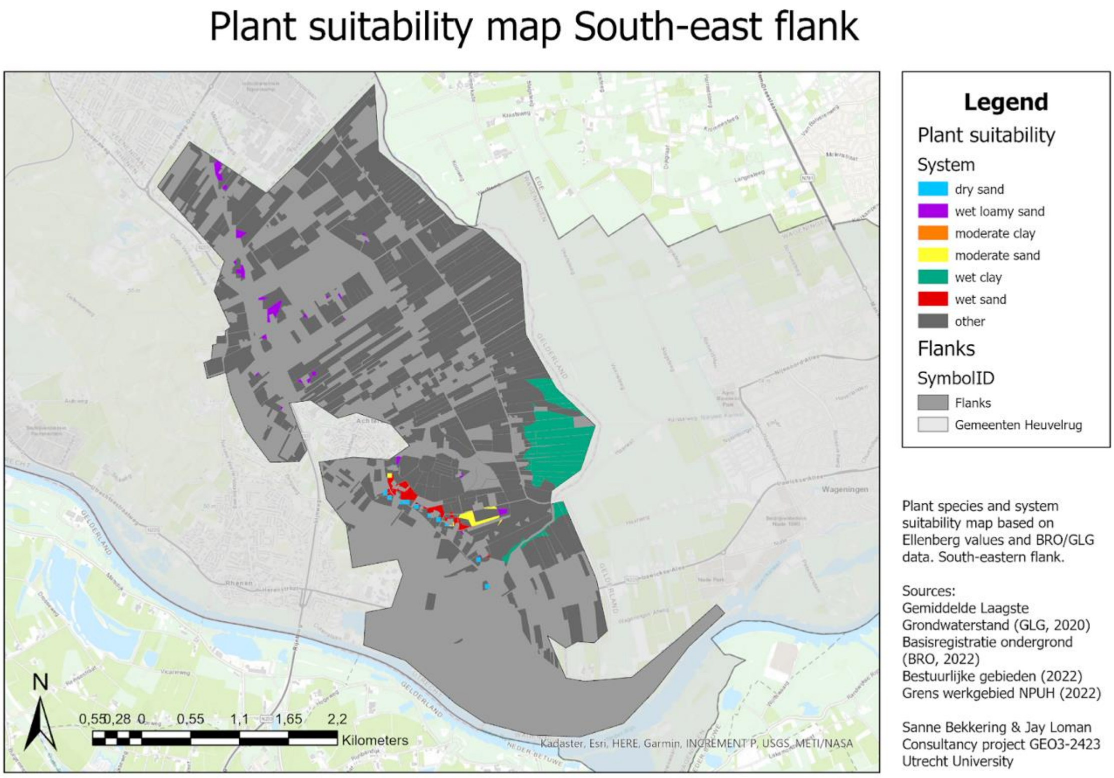

Figure 3.4. Plant suitability map for the South-eastern flank.

The South-east flank is the most diverse, yet the smallest (Figure 3.4). This flank includes all soil types except moderate clay. The biggest area of adjacent pastures is the wet clay area. The small spot of wet sand is suitable for *Ribes rubrum* and *Alnus glutinosa*. Because of the diversity in soil types in the flank, no specific advice can be given on what agroforestry type is most suitable.

3.2.4 Flank West

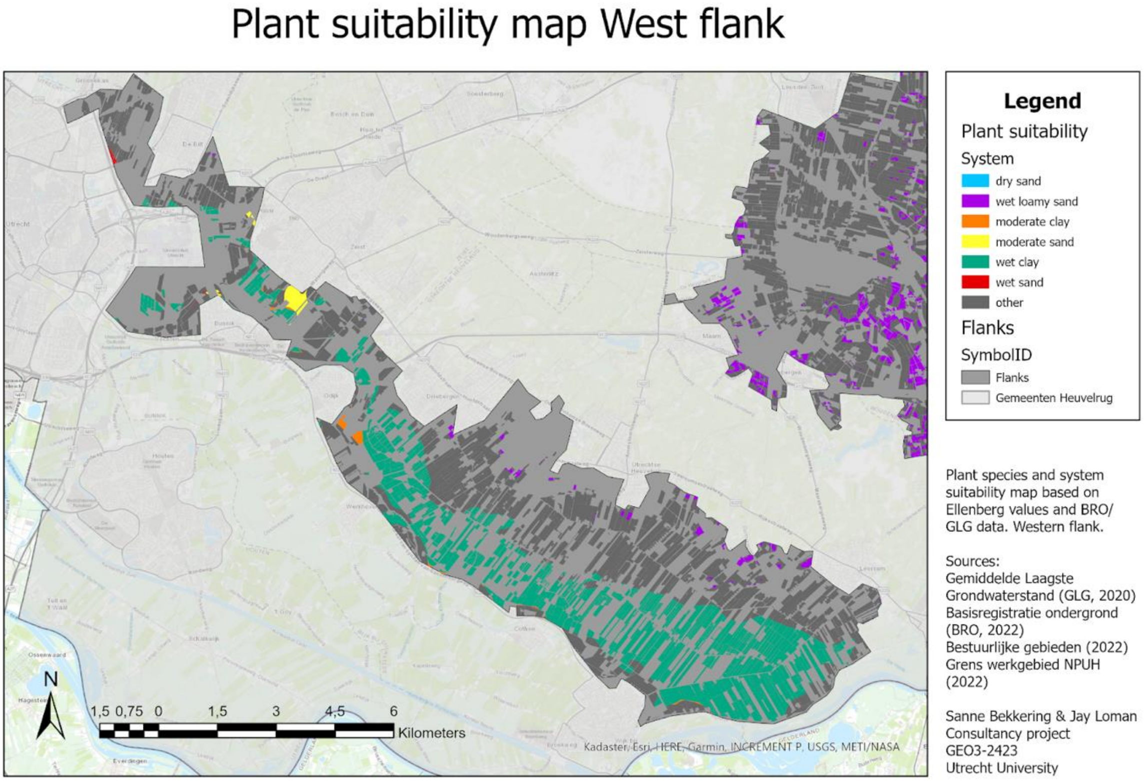

Figure 3.5. plant suitability map for the Western flank.

The West flank contains all soil types, except dry sand (Figure 3.5). The predominant soil type is wet clay. This means that the *Alnus incana* and the *Ulmus laevis* are the most suitable tree species. Because of the diversity in soil types in the flank, no specific advice can be given on what agroforestry type is most suitable.

3.3 Results and Evidence

3.3.1 What are the ecological conditions on the agricultural flanks of the NPUH?

3.3.1.1 Soil characteristics of the flanks

The characteristics of the soil determine the suitability to transition to sustainable types of agriculture, because it is linked to soil fertility and crop productivity (Johnston et al., 2009) The Utrechtse Heuvelrug consists of different soil types, with each specific properties. There are three basic soil types: clay, sand and silt. To give a short overview, the basic characteristics of the soil types are presented: Clay has a small particle size (>0.002mm) and a large surface area (Firoozi et al., 2017). Clay has a high water-holding capacity, making the substance prone to swelling in wet conditions and shrinking in dry conditions. Therefore, Kumari & Mohan call clay "chemical sponges", as they also have the capacity to hold cations and anions and thus dissolved plant nutrients (2021). These nutrients can be exchanged with the plant root because of their high cation exchange capacity, making them suitable for improving soil fertility (Kome et al., 2019). Sand is the opposite of a "chemical sponge": water is not retained, but easily drains through the substance (high drainage). Also, sand has a low nutrient availability and is warmed up and dried out in dry periods. According to AHDB, this soil is relatively sensitive to runoff and soil erosion (n.d). Sand has a bigger particle size than clay, between 2 mm and 0.05 mm (RHS, n.d.) The pH is slightly acidic and in general has low soil fertility according to Mujtaba et al. (2013). In terms of water-holding capacity, nutrient availability and particle size (0.05 mm - 0.002 mm) silt lies in between clay and sand. It is fertile soil making it good for agricultural activities (Jones, 2012). Soils often consist of a combination of these three types. Figure 3.6 represents a "soil triangle", where different quantities of clay, silt and sand are presented on the side. The soil within the triangle is a combination between clay, silt, and sand and thus has a mix of the characteristics. The flanks around the UH consist, for example, of loamy sand (10-20% clay, 70-90% sand, 0-30 % silt, and also a high content of organic matter). These soil ratios make loamy sand beneficial for agriculture (Purdue University, 2017). Sandy clay consists of (35-55% clay, 45-65% sand, 0-20% silt.

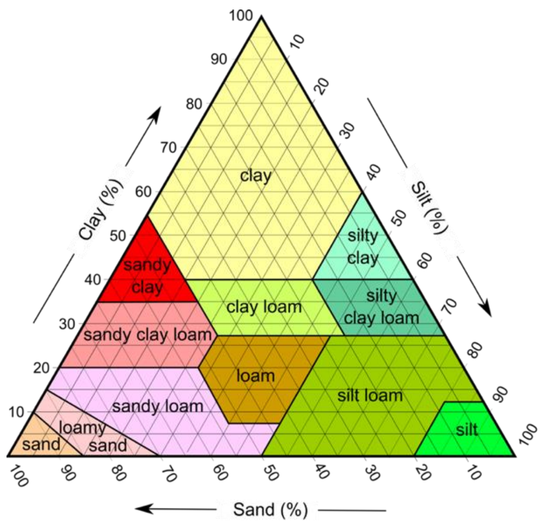

Figure 3.6. soil classification pyramid (Huntley, 2023).

Peat is an organic soil layer, meaning that it mainly consists of decomposed organic matter such as plant material (IPS, 2019.). The soil contains many microorganisms. Therefore, under aerobic (oxygen-rich) conditions, the decomposition of plant material goes rapidly. Under anaerobic (no oxygen) conditions, decomposition rates are slowed down and acids are formed, resulting in a low pH. It has a high moisture content, high water holding capacity and high cation exchange capacity. Furthermore, peat soils can capture high amounts of atmospheric carbon (Topcuoğlu & Turan, 2018)

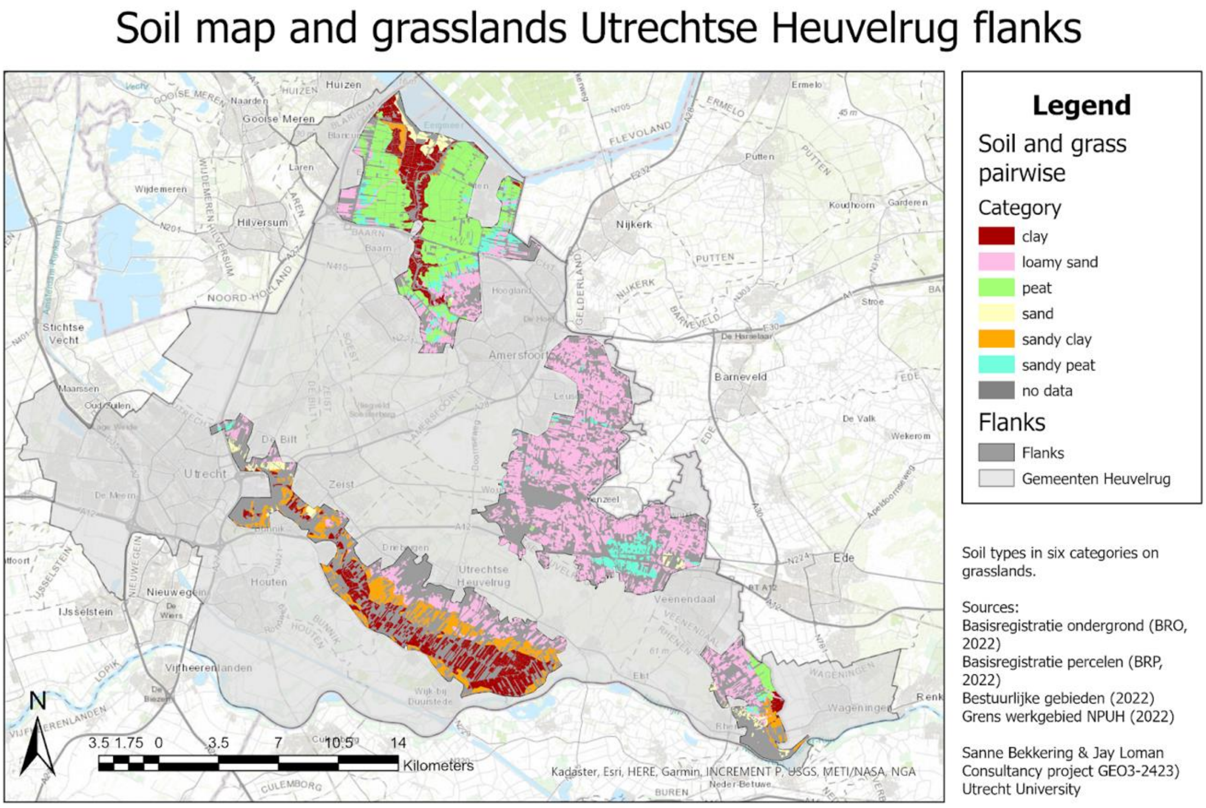

Figure 3.7. map showing the soil types (reclassified into 6 classes) intersected with grasslands for all the flanks.

Figure 3.8. Weidevogelkerngebieden (Provincie Utrecht, 2012)

Figure 3.7 shows the distribution of the different soil types on the four flanks around the Utrechtse Heuvelrug: North (N), North-east (NE), South-east (SE) en West (W). For more detail, an overview of the soil type per flank can be found in Appendix 8.1 in the form of maps and Appendix 8.3 in detailed tables. 53% of flank N consists of peat soil, with clay along the river *Eem* and loamy sand towards the southern part of the flank. It is important to note that this area includes a "meadow bird core area (in Dutch: weidevogelkerngebied)" which means that farmers have to follow special guidelines to protect the nature area (Provincie Utrecht, 2012). Flank NE significantly consists of loamy sand with areas of sandy peat and sand. Flank SE has the most soil type variation, however, it mainly consists of loamy sand. Flank W consists of clay, sandy clay and loamy sand. Overall, loamy sand is the most common soil type.

3.3.1.2 Hydrology characteristics of the flanks

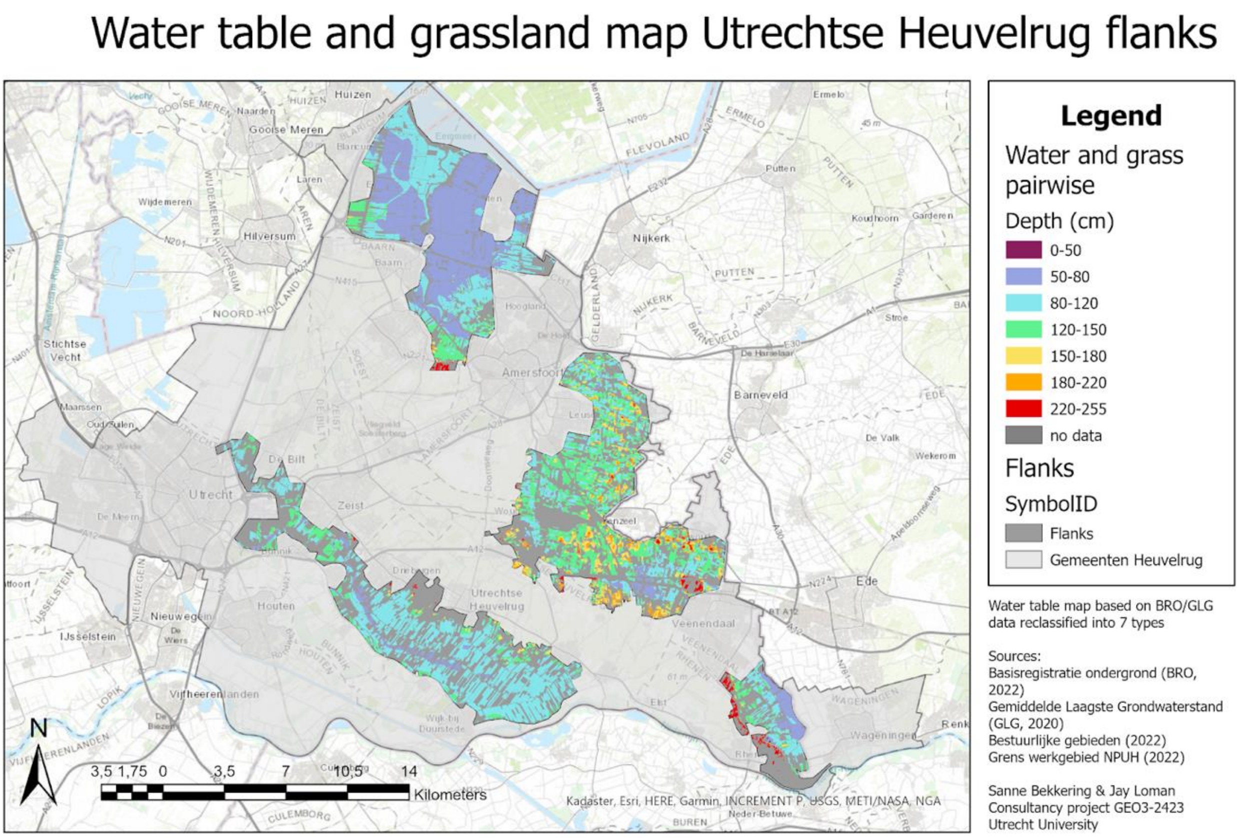

Figure 3.9. water table and grasslands map for the flanks.

Figure 3.9 gives an overview of the water table of the four flanks. The lowest measurement has been taken for this research, for an explanation see section 3.4.2 *(Soil types: BRO)*. The water table is the underground boundary between the soil saturated with water (saturated zone) and the unsaturated soil (United States Environmental Protection Agency, 2020). The lower the depth (legend, figure 3.9), the higher the water table and the more saturated soil close to the upper ground (Rajakaruna & Boyd, 2018). Overall, the higher the water table, the more water can be taken up by the soil (Moene & van Dam, 2014). How much water actually is taken up, depends on the type of soil. In Appendix 8.2, separate maps of the flanks can be found, with the lowest water table level to show drought variation in the Utrechtse Heuvelrug, in sequence flank N, W, NE, SE. Currently, the area has a temperate maritime climate with mild winters and summers with average temperatures of 3°C and 17°C respectively and there is precipitation all year round (mean annual precipitation is 801.17 mm) (World Bank Climate Knowlegde Portal, n.d). Therefore, it is suitable for agricultural crop production.

3.3.1.3 Current baseline from an ecological perspective

As is stated in introduction 1.1 this research is focussing on the transitions of cattle (cow) farms to agroforestry. In the Netherlands, the cows are kept in stables during winter and from April to October most cows are kept on pastures. However, livestock plays an important role in the current biodiversity crisis, as well on a global and local level (Steinfield et al., 2006, p. 182). Although environmental degradation by the livestock sector is complex, two main effects on a local and/or regional scale are touched upon below:

1. **Land-use change and habitat destruction.**
   Agricultural intensification for livestock lowers biodiversity in the flank (Steinfied et al., 2006). According to CSAR, a Dutch Committee on crop varieties *Lolium Perenne L.* (Dutch: Engels Raaigras) is one of the most popular feed crops for cows (2022). A mix of the *Lolium Perenne L.* varieties is utilized on pastures and this has led to a decrease of endemic (native) species in the agricultural areas. Furthermore, the nature area of the Utrechtse Heuvelrug is elongated. This shape of the NPUH makes the area more prone to effects outside the natural area such as agricultural activities. According to Dorresteijn (2021), the habitat at the edge of the nature

area is fragmented and decreased by agricultural intensification. As a result, plant and animal species are pushed back further into the landscape.

2. Habitat degradation by nitrogen surplus.

Because of excretion through cow faeces nitrogen surplus is leaching into the environment (Castillo et al., 2000). A surplus of nitrogen leads to a decrease in natural soil fertility and an increase in weeds or undesired plants (Steinfield et al., 2006). To control these weeds, herbicides are used. Nitrogen can leach to the environment outside the pasture, where it can damage the surrounding ecosystems of NPUH. The RIVM drew up a plan for Nitrogen emission reduction targets whereby total agriculture emissions in the province of Utrecht have to be reduced by 46% by 2030 (2022).

→ In short, the nature of Utrechtse Heuvelrug has become more prone to biodiversity loss because of the way the surrounding area (the flanks) is managed.

One of the biggest current threats NPUH faces are droughts. Because of climate change, the average precipitation across the year is decreasing. However, the amount of rainfall at a time sharply increases (Gemeente Heuvelrug, n.d). As a result, rainwater cannot be absorbed well by the soil. This leads to increased runoff and leaching of nutrients. Problems with water scarcity will likely increase in the future (Expert 7). Furthermore, expert 7 mentioned that water management has to be improved in a sustainable way since water in the region of the UH is used as drinking water but is also important for agriculture and nature.

3.3.1.4 Blue Agenda and "Natuur Beheerplan"

The province of Utrecht is collaborating with multiple stakeholders by taking action via the Blue Agenda (in Dutch: Blauwe Agenda). This initiative "strives to tackle problems related to freshwater shortages and flooding on the Utrechtse Heuvelrug" (Bekkum et al., 2021, p.4). Their goal is to develop techniques to 1) retain water; 2) improve water drainage; 3) provide cleaner water; 4) Integrative water solutions for multiple stakeholders (Utrecht Province, 2020).

The annual "Natuur Beheerplan" sets up policy plans to restore and maintain agriculture landscape quality and nature in the province of Utrecht (Utrecht Province, 2022). One of the main goals for NPUH is to improve ecological consistency between patches with different flora and fauna (Utrecht Province, 2021). The Natuur Beheerplan 2021 stated that restoration of heathland around Soesterberg, Het Leersumse Veld, en Leusderheide requires active management.

3.3.2 How do silvopastoral systems and food forests work? What are their strengths and weaknesses?

Compared to current agricultural practices, agroforestry has a lot of ecological advantages. Firstly, decreased nutrient losses may occur due to the addition of organic matter to the soil by the trees in an agroforestry system (Palm, 1995). Additionally, the roots of trees can hold onto the soil and thereby decrease soil erosion (Idassi, 2012). More tree cover will also increase carbon dioxide uptake and counteract global climate change (Idassi, 2012; Rigueiro-Rodríguez et al., 2009). Nocker and Gobin (2013) estimated this potential at 2,75 tons of carbon per hectare per year, which is 5 to 10 times more than conventional agriculture. Besides, trees may provide shelter to all kinds of animals which will increase biodiversity (Idassi, 2012; Rigueiro-Rodríguez et al., 2009). Lastly, agroforestry can increase the water retention capacity of the soil, because the roots of the trees can retain water and take up soil pore space (Leung et al, 2015).

3.3.2.1 Silvopastoral system

In silvopastoral systems, trees are combined with livestock (Dupraz & Newman, 1997) (Figure 3.10). In this system, trees can protect livestock against sun, wind and rain, while the livestock enriches the soil with manure (Sayner, 2021). Furthermore, it is one of the best agroforestry systems that reduces the risk of forest-fires and heat stress according to Nair et al. (2021). A disadvantage of silvopastoral agroforestry is that livestock can damage the trees that grow in the pasture by eating or stepping on the trees. Fencing or special materials can be used to keep animals away. Besides, pollarding (removing upper branches) is a technique that can be used to keep livestock from damaging wooden trees such as oak, but this requires a lot of time and effort (Sayner, 2021).

In silvopastoral systems, trees are placed in pastures where they can be spaced in rows or clusters or widely spread around the pasture (Buijs et al, 2021). The advantage of cluster planting compared to row spacing is that cluster planting “provides more localised shade” (Sayner, 2021). The disadvantage of wide spacing compared to the other types is that it can lead to additional tree damage from the foraging animals and “increased problems with weeds.” (Sayner, 2021). The spacing is, however, very dependent on the specific context of the piece of land (Silvopasture Farmer).

Common types of trees in temperate silvopastoral systems are fruit trees, nut trees and timber trees (Buijs et al, 2021). Examples of fruit trees that are commonly planted include apples, pears, plums and peaches (Franke, 2017). Examples of nut trees are chestnuts and walnuts (Dupraz & Newman, 1997). Timber trees are grown in silvopastoral agroforestry systems for their valuable wood products. Examples of timber trees that are commonly planted include oak, beech and hornbeam (Dupraz & Newman, 1997).

Trees in silvopastoral systems can also be used as fodder trees to provide livestock with feed. These trees are often fast-growing and can be pruned to provide a continuous supply of foliage. Common fodder trees used in temperate agroforestry systems include poplars, oaks, ashes, and elms (Dupraz & Newman, 1997)

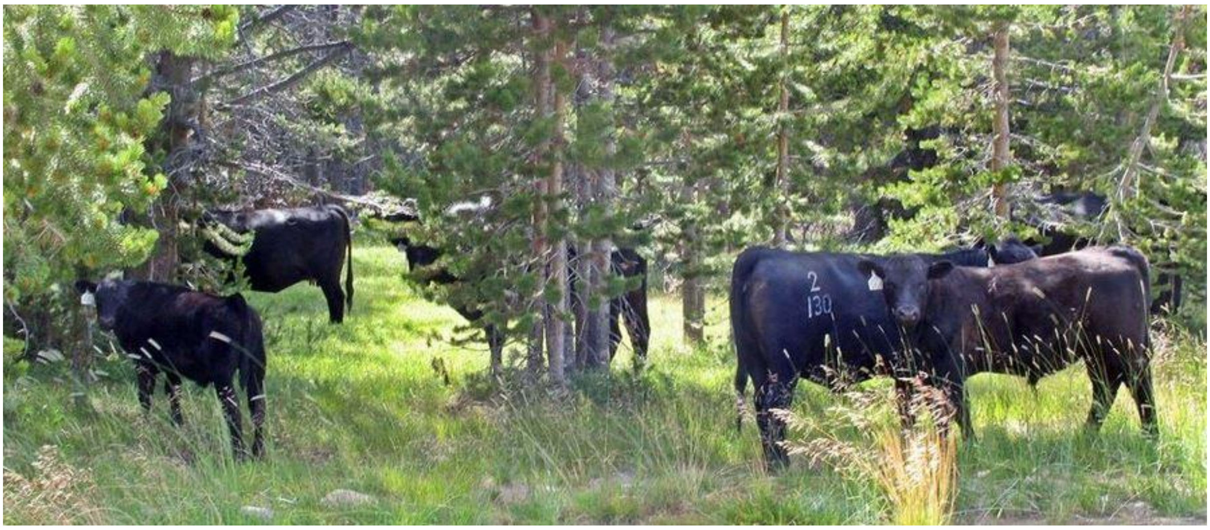

Figure 3.10. Silvopastoral agroforestry (Silvopastoral system, 2015)

3.3.2.2 Food forests

Food forests are human-designed ecosystems based on a natural forest and the principles of permaculture. In total there are about 48 hectares of food forests in the Netherlands with plans from the government and Staatsbosbeheer to expand this (van Drop & Stobbelaar, 2020). Food forests consist of multifunctional biodiverse plant layers of which several (3 to 7) are used at the same time (Albrecht & Wiek, 2021). These layers are the Canopy Layer, Understory Layer, Shrub Layer, Herbaceous Layer, Root Layer, Ground cover Layer and Vine Layer (Buijs et al., 2021) (Figure 3.11).

The canopy layer is composed of tall trees that provide shade and shelter to the layers below. In a food forest, nut and timber trees such as walnut, oak or pine can be planted as the canopy layer. These trees also provide an important source of food for animals and humans (Knight-Lira, 2014; GroCycle, 2021). The understory layer is composed of smaller trees and shrubs that grow in the shade of the canopy layer. Some common understory trees in food forests include apples, pears, cherries or apricots (Permaculture Plants, n.d.; GroCycle, 2021). The Shrub Layer includes perennial plants that are not as big as trees but are bigger than most herbaceous plants. Plants like blueberries, raspberries, currents or smaller nut species often grow in this layer (Frey & Czolba, 2017; GroCycle, 2021). The herbaceous layer consists of low-growing plants such as herbs and groundcovers. This layer is often the most productive in terms of food production. Unlike the upper layers, the plants in this layer often die back in the winter due to their lack of thick, woody stems and come back in the spring (Food Forests Grow, n.d.; GroCycle, 2021). The root layer consists of plants whose roots grow deep into the soil, helping to improve soil structure and fertility. Carrots, potatoes, beets and other vegetables are often planted in this layer (Marsh, 2023; Jamie, n.d.). The Groundcover Layer fills in the spaces where herbaceous plants are not already growing (GroCycle, 2021). These plants are tolerant of shade and can survive being stepped on, making them a viable option for covering walkways and paths in food forests. Some edible plants that grow in the groundcover layer include mint, strawberries and sorrel (GroCycle, 2021; Marsh, 2023). The vine layer is composed of climbing plants such as grapes. These plants can be trained to grow up the trunks of larger trees in the canopy layer, maximising vertical space in the food forest (Marsh, 2023).

The layers all have different spatial functions but strengthen each other in a system where production features can be shared (Buijs et al., 2021). A benefit of food forests is that once they are planted, many food forests are easy to manage because they are quite self-sufficient (Albrecht & Wiek, 2021). Another benefit of food forests is that one can use land that might be unsuitable for growing crops conventionally. By cultivating a diverse range of crops that are well-adapted to the particular environmental conditions of the area, even very dry soil can get turned into a food forest (GroCycle, 2021). Additionally, food forests have a very high biodiversity, due to the different layers with different species (Buijs et al., 2021). A disadvantage of food forests is that a lot of knowledge is needed about plant combinations and local conditions like the soil for the initial design and setup of the system (Buijs et al., 2021; GroCycle, 2021).

Food Forest

1. The Overstory Tree Layer
2. The Understory Tree Layer
3. The Shrub Layer
4. The Herbaceous Layer
5. The Root Layer
6. The Ground Cover Layer
7. The Vine Layer

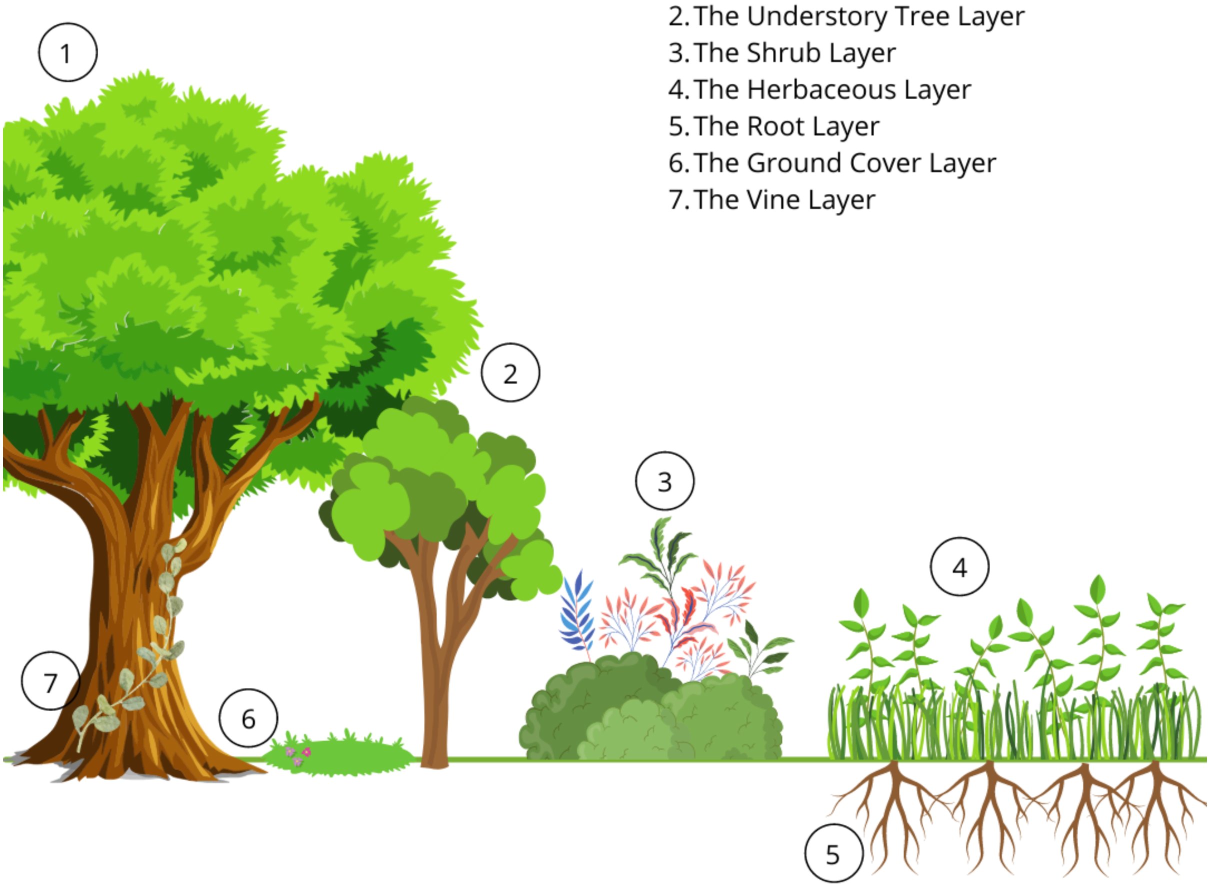

Figure 3.11. The different layers of a food forest (Buijs et al., 2021)

3.4 Methodology

3.4.1. Analytical Framework

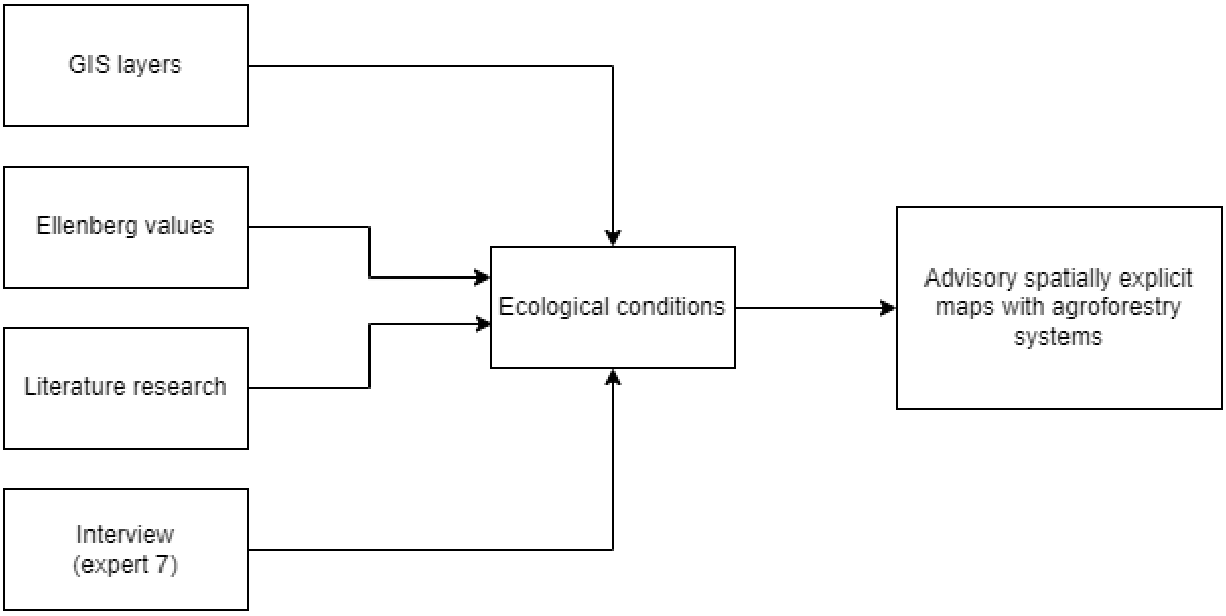

Figure 3.12. Overview of framework

To determine the ecological conditions of the flanks of the Utrechtse Heuvelrug we used a combination of methods to then further determine the most suitable agroforestry system based on these conditions. We used ecological GIS layers as explained in the data collection and analysis sections in combination with Ellenberg values to see what plants thrive in which ecological context as well as literature research.

3.4.2. Data collection

Data collection is divided into three main parts: Geographical Information System (GIS) data, literature research and an interview with an expert on the governance of the hydrology of the NPUH (expert 7).

GIS data, including base maps and other informative layes is used to create maps of the flanks of the Utrechtse Heuvelrug. The GIS data can be found in databases from the Provincie Utrecht, as they provide open data. Furthermore, the University of Utrecht has a large L: drive with the most recent data, including proprietary data. Below, a list of GIS layers that were used to determine the ecological context of the Heuvelrug flanks, are presented:

1. Land use: BRP

The BRP (Basisregistratie Percelen) shows all the agricultural plots of land in the Netherlands and their use. We filtered out the grassland plots by selecting per attribute because we are interested in the transition for dairy farmers specifically.

2. Soil types: BRO

   The BRO (Basisregistratie Ondergrond) classified the soil into 74 soil classes. However, too many classes make the data indistinguishable on a map. Therefore, we reclassified the soil categories into six different classes. The six classes and the colour codes for the six classes were based on the soil classification pyramid (figure 4). The 74 BRO classes were exported into an Excel sheet. We then looked up all types of specific soil classes to put them into a broader category by colour coding, assigning a number per category in a separate column (e.g., sand = 1), and lastly adding a column with the soil category (see: Appendix 8.4). With this reclassification table, we assigned the 6 new classes to the 740 entries in the original map with all soil observations. Then, using the new classes we joined the new data (the six classes) to reclassify the data. We ended with six different soil classes, each with distinct colours and clear borders which can be seen in Appendix 8.5.

3. Water levels: GLG

   The GLG (Gemiddeld Laagste Grondwaterstand) layer is made by taking the average of the three lowest observed/measured groundwater levels per year and then taking the average of a minimum of 8 years. Data from the most dry summer periods was used, because NPUH is expected to face more droughts in the future (expert 7). The cells of this map are divided into 250 x 250 meters. The version used is from 2022. Therefore, the GLG shows the mean lowest water table levels during the driest 3 months of the year, which is normally in the summer months.

Literature and interview

Literature was gathered in two ways; suggestions from the client and own research. The suggested literature was from the NPUH Kennisbank and other suggestions from the NMU and WUR. The NPUH kennisbank is a collection of data created by our client. Therefore, it was convenient for us to use this knowledge as a baseline for our research to assure that the literature used is relevant to the client. We also conducted our own literature research. With the university's search engines such as Google Scholar, Scopus, or Web of Science we used keywords related to agroforestry. By conducting this literature research with articles from outside NMU, NPUH and WUR, the goal is to provide a literature review with new or additional information that our client has previously taken into account while implementing agroforestry projects.

An interview was conducted with a farmer in the Utrechtse Heuvelrug that has already implemented agroforestry. We first asked about the ecological status of the farm and then we asked what kind of vegetation is used. This provided more information about what kind of vegetation suits certain ecological conditions. Additionally, expert 7 was interviewed to get to know more about the ecological problems that the NPUH is dealing with currently.

3.4.3. Data Analysis

For section 3.3.2, literature research about different agroforestry practices (silvopastoral systems and food forests) is conducted. A comprehensive overview was made of the overall practices to gain the highest ecological value through agroforestry.

In section 3.3.1 and the advice, we used GIS data to create maps showing the ecological conditions. The ecological data that were focused on are groundwater level, land use, and soil type. The program that we used for spatial analysis is ArcGIS Pro. ArcGIS Pro is convenient to use, fast, and can generally process a large amount of data. The process is shown in a flowchart (Figure 3.13).

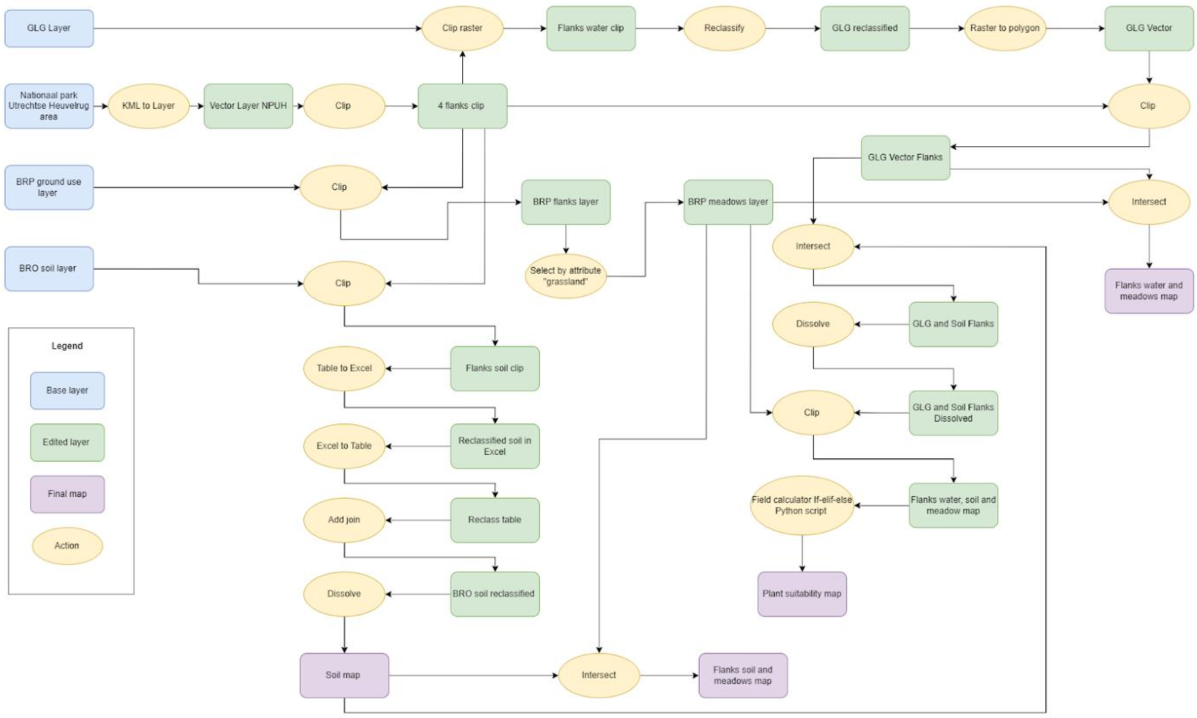

Figure 3.13. flowchart showing the ArcGIS Pro process for creating all maps.

Tables in Appendix 8.3 were made using the Summarise Attributes tool in ArcGIS and converting the outputted tables to Excel where the conversion from square metres to hectares and percentages were made per flank.

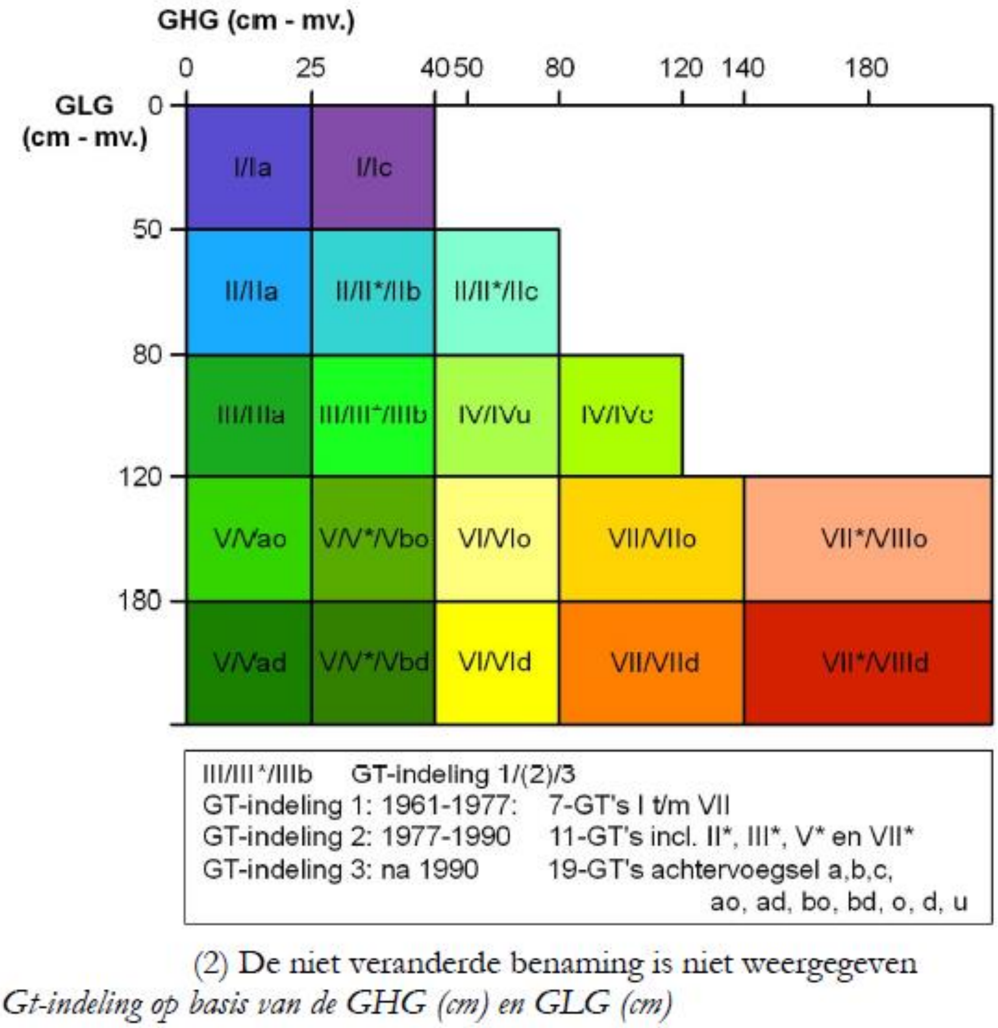

Figure 3.14. Classification of "grondwatertrappen" based on GLG and GHG (Van der Gaast et al., 2006)

The water levels (GLG) were "reclassified" based on the figure from Alterra (2006). The 7 categories of GLG water level were based on these intervals with some additions (Figure 3.14).

The Excel reclassification that was conducted for the Soil maps can be found in Appendix 8.5.

For the advice, a plant list from an Excel model made by "Werkgroep Ketens en Verdienmodellen" from "Agroforestry Netwerk Nederland" obtained from Maureen Schoutsen (researcher at Wageningen University), was reduced to include only endemic agroforestry species. This endemic database consisted of roughly 30 species. For all these species the Ellenberg values for moisture (F), acidity (R), and nutrients (N) were looked up (Table 3.2). Ellenberg values are values per plant species found in Western Central Europe that give an indication of their preferred environmental conditions, such as moisture availability, acidity and nutrient/nitrogen availability.

Table 3.2. Explanations for moisture (F), pH (R), and nutrients/nitrogen (N) adapted from Hirv et al. (2010).

Table 1 Ellenberg indicator values

Values	Environmental condition		
	Moisture	Soil pH	Nitrogen
1	Indicator of extreme dryness, restricted to soils that often dry out for some time	Indicator of extreme acidity, never found on weakly acid or basic soils	Indicator of extremely infertile sites
2	Between 1 and 3	Between 1 and 3	Between 1 and 3
3	Dry-site indicator, more often found on dry ground than in moist places	Acidity indicator, mainly on acid soils, but exceptionally also on nearly neutral ones	Indicator of more or less infertile sites
4	Between 3 and 5	Between 3 and 5	Between 3 and 5
5	Moist site indicator, mainly on fresh soils of average dampness	Indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils	Indicator of sites of intermediate fertility
6	Between 5 and 7	Between 5 and 7	Between 5 and 7
7	Dampness indicator, mainly on constantly moist or damp, but not wet soils	Ndicator of weakly acid to weakly basic conditions, never found on very acid soils	Plant often found in richly fertile places
8	Between 7 and 9	Between 7 and 9	Between 7 and 9
9	Wet-site indicator, often on water-saturated, badly aerated soils	Indicator of basic reaction, always found on calcareous or other high-pH soils	Indicator of extremely rich situations, such as cattle resting places or near polluted rivers

Ellenberg values with an “x” mean the particular species has no preference for that environmental factor.

Then only species with an N-value higher than 5 were considered because we only consider pastures where former agricultural activity has probably increased the nutrient levels of the soil. Moisture (F) levels corresponded with GLG and acidity was correlated with soil class. From the GLG map, 7 classes were created from wettest (1) to driest (7) which could be corresponded to Ellenberg 9 through 3. F1 and F2 were considered to be too dry for the Utrechtse Heuvelrug as these are plants that grow on desiccated soils, which is why Ellenberg F3-9 was used. A correlation between soil types and soil acidity (R) was drawn based on information from RHS (n.d.). Correlations between Ellenberg values and spatial data can be found in Appendix 8.4.

Based on the derived GLG and soil code values, species were grouped into 7 different systems (see *Advice* and Appendix 8.4). Using a Python script in the ArcGIS field calculator (see flowchart and Appendix 8.6) the corresponding groups were assigned based on the present water and soil codes or values. This resulted in the maps shown in Advice, section 3.2.

CHAPTER 3
Economic feasibility

Archie Redman, Jonathan Jaquet, Minou van den Doel

Word count: 4998

4.1 Introduction Economic feasability

With the increasing effects of climate change, the nitrogen crisis and the negative externalities of conventional farming, there is pressure to transition towards sustainable agriculture in the UH. Agroforestry can provide a solution to dairy farmers on the flanks of the UH by adapting to the effects of climate change and increasing robustness of the incumbent revenue model (Ruijtenberg, 2022; Wigboldus, 2022). However, a complication arises as the transition to AS requires capital and much is uncertain on the economic feasibility of these systems. Without an economically feasible business plan, farmers will not be incentivised to transition (Polman, 2020). Therefore, practical guidelines for an economically viable AS are needed (Pulleman, 2022). Thus, this chapter answers the question:

''What is required for an economically viable agroforestry BM in the market context of dairy farms at the UH?''

To aid with answering the overarching question, three sub questions were created.

''What do the most prominent dairy farming BMs in the flanks of UH look like?''

The incumbent BMs used by farmers are investigated. This forms the baseline to compare AS to. Moreover, this will provide information to incentivize the shift to more sustainable and potentially economically beneficial agroforestry practices.

''What are the most attractive BMs for AS in the flanks of the UH?''

Research into the most successful agroforestry BMs, which have the potential to replace the status quo will be conducted. To do so, the strengths, weaknesses, threats, and opportunities associated with each candidate model are investigated. Lastly, an overview of the most promising systems and their respective BMs will be presented.

''What is the most promising revenue model for agroforestry farmers in the flanks of the UH? ''

This chapter will explore potential revenue models and additional revenue streams for agroforestry farmers. Moreover, we elaborate on promising sales channels and markets in the context of the UH. (For overview abbreviations used in this chapter, see Appendix 9.11)

4.2 Advice

To start with a disclaimer, we cannot advise with certainty or quantitative substantiation on an economically viable BM. There is still a large knowledge gap and considerable uncertainty on the economic feasibility of Agroforestry (expert 4; organization 3; Wigboldus, 2022) (for full disclaimer, see disclaimer Appendix 9.1). However, literature does show that agroforestry can strengthen the incumbent BMs of dairy farmers (expert 4; organization 3). Therefore, we will advise on a BM that has the most potential for farmers in the flanks of the UH.

We advise a silvopastoral or food forest BM that revolves around direct sales of high-quality (processed) products through short-chain sales channels. Our final advice does not specify one ultimate BM, rather it proposes a basis (direct selling) and a set of choices which vary based on the specific preferences and environmental conditions of each farmer. To arrive at this conclusion, our proposed advice is threefold:

Firstly, to derive an economically viable BM for Agroforestry we advise dairy farmers in the flanks of UH to implement a SPS or FFS. On a general level, a SPS is the most promising in terms of revenue and low transition costs, however based on the specific ecological conditions and motivations of each farm FFS might be more suitable. To arrive at this advice, we analyzed the incumbent BMs of farmers in the UH, which focus on bulk production of dairy to supermarkets with a long supply chain (Ningjing et al., 2018). Disadvantages of this BM include farmer's sensitivity to milk price fluctuations, low profit margins, stricter sustainability regulations and livestock diseases (Kropshofer, 2020). Our proposed AS bridges these weaknesses through a diversification of revenue streams, potential yield increase, decreased external costs and ecosystem benefits (Wigboldus, 2022; Buijs, 2021; Luske et al, 2020). Of the possible AS, a SPS and FFS (applied on unproductive land) have the most potential for dairy farmers on the flanks of the UH, both systems can be viewed as an addition to the farmers current revenue model (Buijs, 2021; expert 4; expert 1).

Secondly, with the chosen AS in mind, we advise on a direct-sales BM with a B2C and B2B approach. In this BM, farmers create value by selling organic, high-quality raw products and processed products for a premium price. Depending on the ecological conditions of each farm, farmers choose the vegetation types which maximize yield, allowing for the processing of the preferred higher-valued products (e.g., cheese, ice cream, yogurt). Direct selling has the most potential since it allows farmers to sell a smaller quantity of products for a premium price, increasing their profit margin (Wigboldus, 2022; silvopasture farmer). Moreover, processing harvested products into higher-valued products (e.g. cheese, yogurt), increases profit margins even more (silvopasture farmer). Effective sales channels are crucial for the success of this revenue model (Wigboldus, 2022). Therefore, farmers should cooperate with short-chain initiatives such as Local2Local and Rechtreex to increase sales (Bodewes, 2021; Splinter, 2022).

Thirdly, depending on the BM, the size of the AS and conditions such as the farmers motivation, we advise adding additional revenue streams in addition to the main revenue stream. Alternative revenue streams will strengthen the direct-sales model, increasing economic viability (organisation 4). In some cases, such as in the case of FFSs, alternative revenue streams might even be necessary to ensure economic viability (organisation 4).

To flesh out our advice, we will clarify it through a scenario sketch. This scenario roughly describes our proposed economic BM and how this will turn out for a farmer in the UH (see Appendix 9.2).

4.3 Results and evidence

The results section consists of three chapters. First the current BMs and market for conventional (dairy) farming is explored, establishing the baseline. Next, the most economically viable BMs for agroforestry are explored followed by a comparison of the different systems to the baseline. Chapter 3 researches the economic viability of agroforestry as well as, potential sales channels and alternative revenue streams.

4.3.1 Baseline: Conventional Farming

4.3.1.1 Market Context

The Netherlands is one of the top 5 dairy producing countries in the world, with 7% of the Netherlands trade surplus originating from the dairy industry (Kwakman, 2021). However, due to phosphate legislation and the nitrogen crisis the number of farmers is decreasing (Kwakman, 2021). There are two dominant BMs for dairy farming, conventional farms and pasture farms, organic farming is also used but to a lesser extent (Yang et al., 2019). Pasture farming lies between conventional and organic farming, chemicals can be used but the cows have to spend time outdoors (Ningjing et al., 2018). Conventional farming on the other hand has less strict regulation and focuses on producing high fat and protein rich milk over the welfare of the animal (Ningjing et al., 2020). Organic farms, on the other hand, are forbidden to use chemicals and focus on producing dairy products as naturally as possible (Ningjing et al., 2020). An overview of the market trends can be viewed in Table 4.1.

Table 4.1. PESTEL framework of conventional dairy farming

Political	Economic	Social	Technological	Environmental	Legal
Nitrogen debate and phosphate legislation leading to decrease in number of farms (Kwakman, 2021)	High volatility of milk prices, due to demand fluctuations Müller et al., 2018)	Increasing unrest in the agriculture sector amongst farmers (Holligan, 2022)	Improvements in precision farming reduce overall costs and increase productivity. (Vaintrub et al., 2021)	Stricter regulations as a result of the Nitrogen crisis (Van Halm, 2022)	Strict animal welfare laws prohibit the use of certain drugs on cattle (MEZK, 2017).

4.3.1.2 BMs for dairy farming

Conventional farming is the most prevalent BM in the Netherlands. The product range that farms offer differ depending on the market the farm is trying to sell to (Yang et al., 2019). Cooperatives such as FrieslandCampina facilitate the sales to supermarkets through long supply chains (FrieslandCampina, n.d.). While, the other practiced BMs differ in the production methods used, for the most part, they have the same business structure. Current farming BMs place an emphasis on bulk supply and long supply chains (Ningjing et al., 2018). As such, we can use a single simplified BMC to create a baseline to compare the agroforestry BMs against. Table 4.2 contains conventional and organic farming BMs. Black text represents conventional farming, green represents organic farming. Table 4.3 displays a SWOT analysis of the conventional baseline.

Table 4.2. BMC on conventional and organic farming purple text represents organic farms.

Element	Parameter
Value Propositions	**Milk** (and other processed dairy products) **Pasture farming creates added value** to people as the cows are allowed to graze. (Ningjing et al., 2020). **Organic farming practices** without the use of chemicals create added value (Ningjing et al., 2020). **Grass sales** (silvopasture farmer)
Key Activities	**Manufacturing of raw milk** into other products i.e cheese. **Ensuring maximum yield from each cow** (organization 2) **Meat production** once cow is no longer producing milk (Da Cunha Moreira et al., 2021) **Implementation of organic farming practices** (Ningjing et al., 2020)
Cost structure	**Maintenance** is the largest cost in terms of nominal costs (DDB, 2021). **Depreciation** is the biggest cost incurred by farmers, if real costs are included (DDB, 2021).

Revenue streams	**Subsidies** provided by EU (Evers, n.d.) **Revenue collected from transactions** with supermarkets etc. who supply the public with dairy products (FrieslandCampina, n.d.). **A premium price** of the products created as a result of organic farming methods. (Durham & Mizik, 2021) **Organic products are still sold to supermarkets**, which are then sold to the end customer. (Times & ANP, 2023)
Channels	Long value chains **Cooperatives** such as FrieslandCampina supply supermarkets and other distributors (FrieslandCampina, n.d.). **Processing:** Milk is passed on to other firms that process it into other dairy products, which are in turn passed on to supermarkets.

Table 4.3. SWOT analysis of the current BMs (black text represents conventional farming, teal represents both, purple represents organic)

Strengths	Weaknesses
High subsidies for dairy (European Commission, 2023) **High productivity,** less regulations when compared to organic farming (Van Asselt et al., 2015) **Good support network**: Cooperatives and organizations such as ZuivelNL (ZuivelNL, n.d.) **Large amount of knowledge** **Value creation** comes from the production not the good itself (Ningjing et al., 2020)	**Very small profit margin** (Kropshofer, 2020) **Power imbalance** between dairy farmers and processors (Kropshofer, 2020) **Few social benefits** (organisation 2) **Dependence on fossil fuels** for production (expert 6) **Increased risk** due to dependence on one form of produce (organisation 2)

Better nutritional value (Van Asselt et al., 2015) **Social benefits** as a result of increased animal welfare (Van Asselt et al., 2015) **Increased price of end product** when compared to other forms of dairy farming (Durham & Mizik, 2021)	**High volatility** of milk prices, caused by fluctuations in demand (Müller et al., 2018) **Land restrictions** as the cows need more room to graze (Vaarst et al., 2001) **Lower productivity** when compared to conventional dairy farming methods (Van Asselt et al., 2015) **Smaller and fewer farms** leading to less structured organization between them (Verburg et al., 2022) **Tight regulation** (Ningjing et al., 2020)
Opportunities	Threats
Transition towards more sustainable farming methods (Laylin, 2021) **Potential to export** goods to other countries (Laylin, 2021)	**Livestock diseases** (Maye & Chan, 2020) **Risk of being bought out** (Boztas, 2022) **Risk of being undercut** by other countries with lower production costs (Eurostat, 2022)

4.3.2 BMs for Agroforestry

4.3.2.1 Agroforestry Market

In order to contextualize this report's research, the agroforestry market context will be analyzed.

Market size and segments

The Netherlands has one of Europe's largest agricultural sectors, generating a revenue of over €29 billion (CBS, 2020). However, most of this is generated by conventional agriculture. Currently, the market share of agroforestry is small: EU-wide the market share is around 0.9% (excluding reindeer agroforestry) and growing (Herder et al., 2017). Within agroforestry, the most commonly employed systems are silvoarable, silvopastoral and agrosilvopastoral, but there are also other forms such as permaculture and food forests (Buijs et al., 2021).

Market Trends

Table 4.4 contains a PESTEL analysis showing trends in the market important for (the transition to) agroforestry. These trends form the basis for the SWOT analysis (see Table 4.6).

Table 4.4. PESTEL analysis of the two agroforestry models

Political	Economical	Social
Increased number of subsidies for agroforestry from (local) governments are becoming available (silvopasture farmer; ANN, n.d.)	**Cost of living** in the Netherlands is rising (CBS, 2023).	Consumers are **consuming more sustainably** (CBS, 2022). There is a **limited demand** for organic products (expert 4).
Technological	Environmental	Legal
(scientific) **knowledge on agroforestry practices** has been increasing (organisation 4). **Technological developments** in the mechanization of harvesting AS (expert 1)	Due to the nitrogen crisis, **sustainable forms of agriculture are at an increasing advantage** (MAZ, 2023). The global **climate system is changing** (UN, 2022). **Biodiversity is decreasing** worldwide (and in the Netherlands) (UN, 2022).	The highest court in the Netherlands has ruled that the country's **nitrogen policy is insufficient**, leading to increasing uncertainty for farmers (Stokstad, 2019).

4.3.2.2 BMs for Agroforestry

Agroforestry + incumbent BM

Our research focuses on two systems: a SPS and an FFS as they are the most suitable for farmers on the flanks of UH (see integrative section). Both systems relate to the incumbent BM of farmers differently.

In SPS, trees can be applied to the existing pastures and can therefore be viewed as an addition to the farmer's existing dairy BM. The system can provide additional revenue through the production of timber-, fruits- or nuts. Or it can provide food for their cattle, which could allow up to 4 times as much livestock on the same piece of land (FOA, 2019).

In FFS, trees are not combined with cattle, but farmers can plant a FFS on sections of unsuitable or unproductive land (expert 1). In practice this could be used alongside existing dairy farming, creating an extra source of income, although we were unable to find many practical examples of this. Apart from production, both systems can also provide other possible services to enhance the farmer's BM.

BM and SWOT analysis

Determining one ultimate quantified BM for each of our proposed systems is complex. Due to the novelty of Agroforestry, there is insufficient quantitative data available, and each BM is tailored to the conditions of each AS (Shoutsen, 2023; organisation 3). However, case studies can help us determine the best practices and possibilities for agroforestry farmers' BMs. Hence, we have created a qualitative BM.

Several BMs are possible in these systems: care farming, direct selling, shared ownership, subscription-based harvesting, and wholesaling. Although the subscription-based model has potential and is used in FFSs. Direct selling to consumers and businesses is most commonly used and has the most potential, based on the case studies observed (organisation 4; food forest factory, n.d.). This model works well for the smaller in quantity, higher in quality products from agroforestry farmers (organisation 4). Moreover, the short supply chain allows farmers to maintain a higher profit margin (Wigboldus, 2022).

Both proposed BMs will center around direct selling, specifically around B2C and B2B sales. In addition, farmers can explore other revenue streams such as carbon credits or recreational opportunities (section 4.3.3.3). Below a BMC and SWOT analysis of our proposed BM are provided (Table 4.5 & 4.6). Note, that the BMC describes the BM on a more general level. The specific type of trees planted, and the additional revenue streams generated is specific to each farmer's context. Although the BMC applies to both systems, there are some differences indicated with color coding (green = FFS, blue= SPS).

Table 4.5. Adjusted BMC for a SPS

Element	Parameter
Value Proposition	The BM delivers value to people, planet and profit: **People** (Wigboldus, 2022) High quality, organic and environmentally friendly products for a premium price **Planet** (Buijs et al., 2021; Wigboldus, 2022) Increased biodiversity, carbon sequestration and other ecosystem services (especially in FFS) (silvopasture farmer) Efficiënt land use No/reduced use of pesticides or chemicals

	Decreased nitrogen deposition of farm Improved well-being of cattle (through provision of shade etc) **Profit** Reduced risk through diversified production, decreased dependence on dairy fluctuations and powerful stakeholders (supermarkets, agri-businesses) (silvopasture farmer) Increased profit margin through direct sales of products (with a premium price) (Wigboldus, 2022) Additional value creation through processing of harvested products into higher valued products (cheese, yogurt) (organisation 4)
Key Activities (Wigboldus, 2022)	Agriculture: farming, harvesting, maintenance of the land and livestock Product Development: processing of ingredients into new products (yogurt, cheese etc) Business activities: Sales and marketing. Research and development
Cost structure (Wigboldus, 2022)	**Main costs:** Production and operation costs (livestock, fuel etc) Research and development costs (new equipment) Increased business development and marketing costs in comparison to baseline Increased costs of labor (for sales, harvesting, marketing etc). Higher costs of labor in the FFS due lack of mechanization possibilities. Increased maintenance costs (expert 1) **Potential cost savings:** Cost savings on manure, pesticides and possibly feed for cattle (Buijs et al., 2021) Savings on maintenance, system is mostly self sustaining (expert 1) (See overview of inputs/ outputs in Appendix 9.3 and 9.4)

Revenue streams	**Main revenue stream:** Direct sale of processed/harvested products for a premium price The sale of a diversity of high quality, local and organic dairy/meat/vegetable products The sale of processed products (e.g. cheese/ ice cream) made from the produced raw ingredients (Wigboldus, 2022) Reduced revenues from grassland production (organisation 3) **Subsidies**: Current EU subsidies for cattle farmers (MEZK, 2022) Additional subsidies for sustainable and agroforestry farming (ANN, n.d. -b) Optional: Additional Revenue stream (See section 3.4.3)
Channels	B2C: Direct sales through own local shop or via short-chain initiatives (see section 3.4.2) B2B: Direct sales to local shops (e.g. bakeries, restaurants) via short-chain cooperation's and initiatives
Ease of Transition	**Agroforestry:** Investment costs: purchasing new machines, planting trees Transition costs: no revenue made in the first years, so costs of maintenance need to be covered (organisation 4) Transition costs: Initial maintenance costs need to be covered, after that system is largely self-sustaining (Buijs et al., 2021) Other Factors: Existing dairy business might be scaled down, but the BM remains the same → no additional investment needed. **Direct selling:** (Wigboldus, 2022) (Increased) Marketing costs Costs for setting up sales channels

Table 4.6. SWOT analysis of the two AS, where text in green is specific for FFSs and text in blue is specific for SPS

Strengths	Weaknesses
More robust revenue model through diversification of revenue streams (Wigboldus, 2022) **Increased power in supply chain** through direct sales, increasing profit margin (Wigboldus, 2022; organisation 2) **Positive ecological and climate impact** of AS can help combat the biodiversity, climate crises and provide more ecosystem services (USDA, 2017; Luske et al, 2020). **Decreased costs on external resources** such as manure, pesticides and feed (Buijs, 2021; expert 4) **Retention of dairy farming business**, forming a backup for the agroforestry revenue **High potential for alternative revenue streams**, due to aesthetic value (organisation 4) **Largely self-sustaining**, resulting in low maintenance costs and high resilience (expert 1) **Potential of yield increase** in arable and woody crops, however the design of the system and the density and methods used, are crucial for the success (Selin, 2019) **High efficiency, output of biomass,** due to different layers (expert 1)	**Long transition period in which no revenues are generated**, while costs are still incurred (Selin, 2019; Wigboldus, 2022) **Barriers in scaling up:** agroforestry is new, thus the associated business and revenue models have not yet optimized efficiency. (Wigboldus, 2022; expert 4). **Uncertainty**: Due to its novelty a lot is still **unknown, including the economic viability,** making transition riskier (Wigboldus, 2022: Nworij, 2020). **High initial implementation costs,** making it less accessible (to a lesser degree also applicable to SPS) (Albrecht & Wiek, 2021) **Labor intensity**: Labor needed is uncertain and expensive (to a lesser degree also applicable to FFS) (Luske et al, 2020)
Opportunities	**Threats**
Increased sustainable behavior among consumers and resulting demand for ecologically friendly products, including agroforestry products (CBS, 2022) **Potential for a robust BM** against the nitrogen crisis and risk of being bought out (MAZ, 2023).	**Financial resources**: Current farmers lack the financial resources to invest in agroforestry (Luske et al, 2020). **The price of land** in the Netherlands is very high, making it unprofitable to switch to FFSs on a large scale (Baayen et al, 2021).

Increased incentive to invest in sustainable agricultural practices for stakeholders (ngo's, municipalities etc) due to nitrogen crisis (expert 4) **Increased knowledge** on agroforestry practices, making transitioning easier (organisation 4) **Increased number of subsidies** facilitates transition (silvopasture farmer; ANN, 2022) **Technological advancements** in agroforestry machinery make employing an AS easier (expert 1)	**The cost of living** in the Netherlands is increasing, resulting in people having less money to spend (CBS, 2023). This could be a short-term threat for the sale of premium-priced agroforestry products. **The legal uncertainty** (including the risk of being bought out) surrounding the nitrogen crisis makes it riskier for farmers to invest in a new BM, such as agroforestry (silvopasture farmer). **Rules on food safety** surrounding products from FFSs make the sale of these products less certain (organisation 4). **Other legal challenges** including *zichtlijnen* (organisation 4) **A limit to the demand** for high end sustainable products: there is also a limit to the number of agroforestry farmers that can successfully employ the described BM (expert 4).

4.3.3 Differences between SPS, FFS and baseline

Compared to the baseline, the agroforestry models have a plethora of benefits. Firstly, the AS make the incumbent regime more robust by diversifying the product offerings and reducing farmers' reliance on monoculture dairy systems that are susceptible to fluctuating milk prices (organization 2). Moreover, our proposed AS focus on direct selling, granting higher profit margins.

On the other hand, the initial investment, and the transition costs to kickstart an AS are high (silvopasture farmer). Furthermore, there is a large quantity of pre-existing knowledge on conventional dairy farming systems whilst there is very little on AS. The economic uncertainty, knowledge gap and the costs of transitioning are paired with a lot of risk and decreases the incentive to transition to a long-term focussed AS BM. Finally, AS counteract the negative effect that dairy farming has on the ecosystem by improving the soil quality, biodiversity, and water retention (organization 2) for an elaborated view, refer to Table 4.8.

Comparing our two proposed AS in Table 4.7, each has its distinct advantages and disadvantages. SPS have lower implementation and transition costs, less land restrictions and increased potential for scalability (expert 4). Whilst, FFSs have high transition costs, but have more ecological advantages than SPSs (expert 1) and a greater possibility of additional revenue streams (expert 6).

Table 4.7. Comparison between agroforestry model advantages is in green and disadvantages in red

SPS	FFS
SPS is relatively easy to implement (silvopasture farmer) SPS does not require minimum amount of land or species (expert 4) SPS has more potential for scalability compared to FFSs (expert 4)	FFS have higher productivity (expert 1) FFS have lower maintenance costs (Buijs et al., 2021) FFS can be built on unused land (expert 1) FFS have more benefits resulting from ecosystem services (e.g. soil quality) (expert 1) FFS have higher water retention potential (organisation 4) FFS can potentially become community spaces, as people can source the majority of their diet from one place (Veen & Groot, 2017) FFS have high resilience once established (Veen & Groot, 2017) FFS are a lot more complicated and require more time and education (Veen & Groot, 2017) FFS takes longer and is more effort to establish than SPS (organisation 4) FFS requires a minimum land area and species variety (Veen & Groot, 2017) with FFS less interactions between cattle and crops → cattle products might be less high quality (can be prevented) (Veen & Groot, 2017) FFS has higher implementation costs (silvopasture farmer) FFS provides a wider variety of crop products (expert 1)

Table 4.8. Comparison between agroforestry models and conventional dairy farming models advantages are in green and disadvantages in red

Agroforestry	Conventional
Cost savings: generally saves costs on external resources such as manure, pesticides and possibly less feed. (organisation 2; Buijs, 2021) Agroforestry models have Increased Biodiversity (organisation 2) Agroforestry models have improved water conservation and improved soil quality (organisation 2) Agroforests have diversified products. (Wigoldus) Agroforestry are more productive to monocultures / have higher yields (Wigboldus, 2022; Lehman, 2020) AS have the potential to draw investment as a result of a push towards sustainable practices. (Netter et al., 2022). The effects of agroforestry in terms of return of investment is a lot more uncertain compared to traditional models (Expert 4; Wigboldus, 2022) Transition costs; in terms of investments, knowledge needed etc are relatively high, while payback is uncertain (Expert 4; Wigboldus, 2022)	Dairy farming is well understood and has a large knowledge base More certainty, especially with EU subsidies (Evers, n.d.) Dairy farms face the issue of land degradation (organisation 2) Dairy farms have high greenhouse gas emissions (Verburg et al., 2022). Dairy farming is facing high external pressures

4.3.4 Revenue model

4.3.4.1 Economic viability of Agroforestry

Identifying the most common and economically viable BMs for AS in the UH is a complex question. In current scientific and gray literature there is insufficient knowledge for determining the economic viability of AS (Wilgboldus, 2022; expert 4).

Studies have shown that AS are uncompetitive when compared to monoculture systems, despite the total production of agroforestry being higher (Sereke, 2015; Kay, 2019; Graves, 2007, Giannitopoulos, 2020). The viability of AS depends on a multitude of factors, such as the type of agroforestry and the presence of beneficial governmental policies, subsidies, design and productivity of the system (Wigboldus, 2022).

Thus, a structured AS and business case is imperative for economic success. In some cases, farmers implemented agroforestry alongside conventional farming to supplement their existing income (silvopasture farmer) or relied on other revenue streams alongside agroforestry (Buijs et al., 2021). Combining agroforestry and conventional dairy farming mitigates the risks associated with agroforestry. Therefore, our BM allows for both.

This chapter explores the possibilities of direct selling in the context of the UH. Moreover, the chapter explores the potential of additional revenue streams, alongside main BM activity.

4.3.4.2 Direct sales and sales markets

Direct sales in the province of Utrecht

We propose a BM focusing on direct selling both to customers (B2C) and businesses (B2B). The short supply chain favors the low yield, high quality nature of AS and maximizes the potential profits. In the province of Utrecht, 10% of dairy farms and 44% of the 125 organic farms supply their products through a short chain, this is 5% higher than the national average (Venema, 2021; Splinter, 2022). Table 4.9 details the types of agricultural businesses selling through a short chain.

Farms that focus on short supply chains tend to incorporate multi-functional activities (Venema, 2021). Forty-nine percent of dairy farm companies supplying to the short-chain do not derive more than 10% of their total sales from short-chain sales, followed by 29% that derive more than 50% of their total sales from short-chain sales (Spinter, 2022). Figure 9.1 provides an overview of the percentage of total revenue made through direct sales per type of agriculture business. The results show that direct selling is commonly used in this province, however most farms incorporate multi-functional activities and revenue streams to make the BM economically viable (Venema, 2021).

Table 4.9. Number of agri-businesses, percentage of businesses with sales via short chain, classified on multifunctional activity in Utrecht, 2020 (source: Venema 2021)

Multifunctionele landbouw	Aantal bedrijven	Percentage korte keten	Verschil t.o.v. Nederland
agrarische kinderopvang	12	17%	3%
agrotoerisme	136	31%	2%
boerderij educatie	93	40%	-4%
natuurbeheer	737	15%	-1%
opwekking duurzame energie voor leveri	171	23%	6%
stalling van goederen / dieren	274	16%	0%
verwerking landbouwproducten	82	92%	4%
zorgboerderij	47	30%	-6%

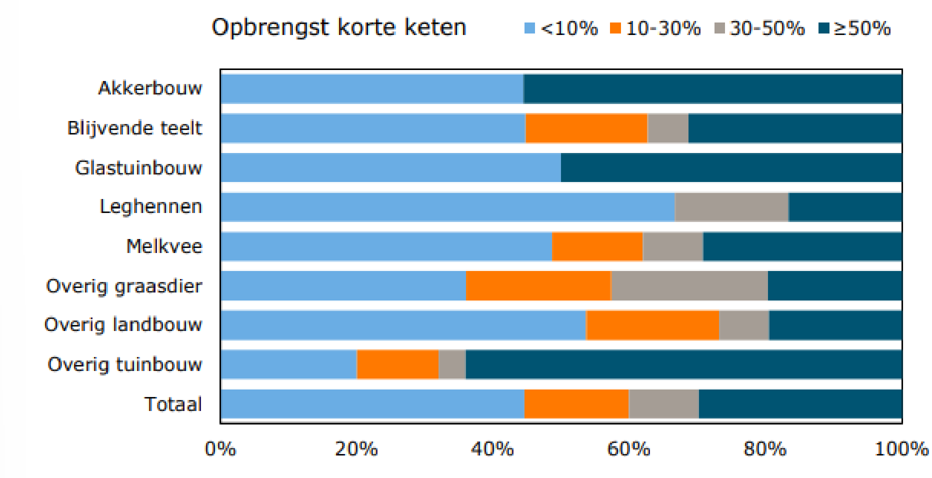

Figure 4.1. Classification agri-business (with sales via short chain) to the percentage of total revenue that's acquired via short chain, classified on business type in Utrecht, 2020 (Venema, 2021)

Sales channels, distribution, and production

To ensure success, local markets and sales channels are crucial for direct sales (Wigboldus, 2022). In the UH, there are several sales channels for selling produce. In terms of B2B sales, supermarkets and restaurants prefer to buy from one supplier. A solution could be increased cooperation between farmers and other chain partners to achieve sufficient scale. Initiatives such as Local2Local, Oregional, Boerschappen and Rechtstreex Utrecht help with this. They are building a local, short food chain together with a network of customers and suppliers (Splinter, 2022).

In terms of B2C sales, initiatives such as Voedselcollectief Utrecht, de Lokalist and Local Utrecht create sales channels, through a network of farmers and consumers. Besides these, there are more initiatives in the province of Utrecht that are committed to improving the short chain and aim at increasing information for farmers (see Appendix 9.5 for overview).

For the processing of harvested products into higher-valued products, there are food processing locations which can perform the processing for local farmers. Lokaal Voedsel Utrecht provides an overview of different processing locations which facilitate processing of (smaller) volumes for third parties (LVU, n.d.) They also provide an overview of companies offering the distribution and logistics for short chain supply (LVU, n.d.).

4.3.4.3 Alternative Revenue Streams

To supplement the revenue made from direct sales, several alternative revenue streams are possible. These can be divided into three categories: ecosystem service related, recreational and other revenue streams. Of these categories, recreational and hospitality-related other revenue streams seem to be the most well proven. While ecosystem service-related revenue streams are not yet common but seem to have high future potential. A summary is provided in Appendix 9.9.

4.4. Methodology

4.4.1 Research Scope

To effectively set the scope, sub-sub questions were created to clarify the different aspects of our subquestions. Moreover, for each of the sub-sub questions we determined various methods. An overview of the sub-sub question and methods can be found in Appendix 9.7.

4.4.2 Analytical Frameworks

To structure the research, we made use of various frameworks. Each of the frameworks and the relevance to our sub-questions are explained below.

4.4.2.1 PESTEL analysis

A PESTEL framework (Figure 4.2) was used to analyze the Political, Economic, Social, Technological, Environmental and Legal factors that influence the macro-environment that our firm operates in. This allowed us to identify the key drivers of change that will ultimately dictate the future success or failure of the business strategy (Johnson et al, 2014).

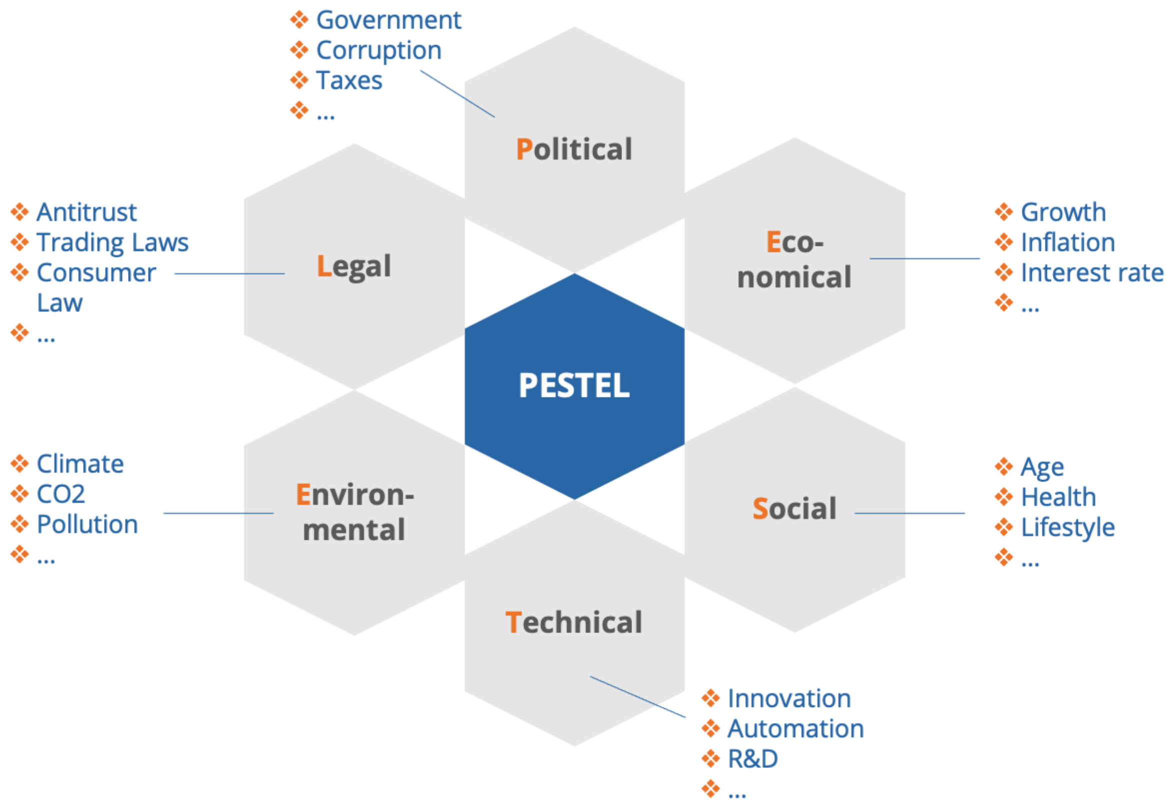

Figure 4.2. PESTEL framework (Johnson et al, 2014)

4.4.2.2 SWOT framework

A SWOT analysis (Figure 4.3) was used to highlight the strengths, weaknesses, threats, and opportunities of the business' models. This allows us to create mechanisms that capitalize on the opportunities whilst creating resistance to the threats present in the system (Johnson et al, 2014).

	External Opportunities	External Threats
Internal Strengths	**Strength-Opportunity strategies** Considering the opportunities we've identified, what are the company strengths we can use to maximize them?	**Strength-Threat strategies** Considering the threats we've identified, how can we leverage the company's strengths to minimize them?
Internal Weaknesses	**Weakness-Opportunity strategies** Considering the opportunities we've identified, what can we do to minimize the company's weaknesses?	**Weakness-Threat strategies** Considering the threats we've identified, how can we minimize the company's weaknesses to avoid them?

Figure 4.3. SWOT analysis framework (Bank of America, 2022)

4.4.2.3 Adjusted BMC Framework

An adjusted BMC (Appendix 9.10) was created by taking aspects from the conventional BMC (Osterwalder, 2013) and the transition BM (Beers, 2021) (Figure 4.4 & 4.5). The adjusted BMC was then used to describe our proposed BMs: the ways in which our systems can make revenue from providing products and services (Boons et al, 2013). Subquestions 3.1c seeks to create a baseline to compare the agroforestry models against by analyzing current dairy farming practices. Whilst 3.2c analyzes the AS to illustrate their viability when compared to the existing status quo. An array of factors was also used to determine the ease of transition (Appendix 9.10).

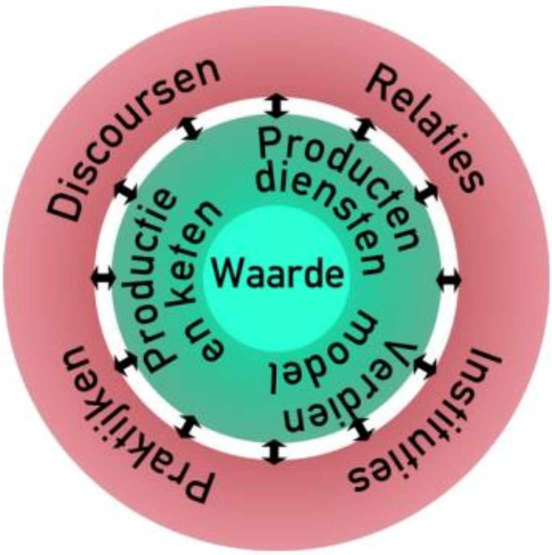

Figure 4.4. Transition BM (Beers, 2016)

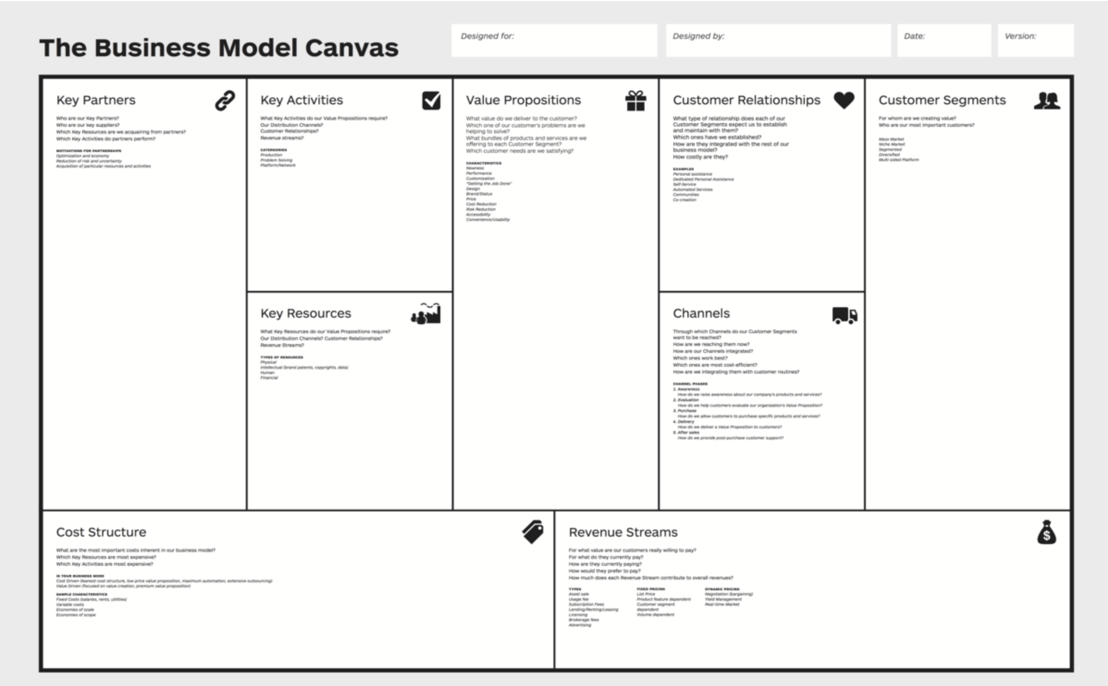

Figure 4.5. Traditional BMC (Osterwalder, 2013)

4.4.3 Data collection

Each of the frameworks described above requires specific data. This data was collected in two ways: through interviews and literature review. The methodologies for these two data collection methods as well as how they apply to the frameworks used, are discussed below.

4.4.3.1 Literature review

Literature review was used in answering all subquestions. The structure of this literature review was determined by the data required per subquestion, as indicated by the framework used and by the question itself. E.g., When answering question 3.1c, which makes use of the BMC, only the information relevant to the 5/6 categories of the BMC was extracted from literature sources. The search terms in Appendix 9.8 provide an indication of the direction of the literature review per question. To scope the literature review, boundaries were set: it was limited to scientific and grey literature; to articles with data collected in either Europe or the (temperate parts of) North America; to articles with data collected in the timeframe 2010-2023; and only google scholar (for scientific literature) and google (for grey literature) were used as search engines.

4.4.3.2 Interviews

The second data collection method that was used is interviews. This method was not of equal importance for all sub-questions. The main purpose of conducting the interviews was determining which dairy farming BMs are currently most common in the Netherlands (3.1b&c) and which agroforestry BMs would be most suitable for implementation at the UH

(3.2b&c). Apart from that, interview data was also used to inform the BMC and SWOT analyses (3.1d and 3.2d) and to a lesser extent the agroforestry PESTEL analysis (3.2a), differences (3.2e) and revenue streams (3.3). The importance of interview data per sub-question is reflected in the focus of the questions asked. The interviews were conducted between March 7th and March 30th, 2023, and were semi-structured, to allow more flexibility and more freedom for stakeholders to give information about themes and concepts and to avoid creating bias by limiting answer options. They were conducted in Dutch and English with a range of different stakeholders: 1 interview with a silvopasture farmer, 3 interviews with experts, and 3 interviews with organizations (see integrative Table 1.1). Each stakeholder received several general questions as well as several questions specific for their expertise. This ensures inclusion of a broad range of perspectives in answering the research questions, ultimately leading to a more representative research outcome.

4.4.4 Data Analysis

For the two data collection methods mentioned above, two data analysis methods were used; Literature review and qualitative text analysis (see Appendix 9.9 for data analysis methods per sub-question).

4.4.4.1 Literature review

Literature review is a method for both data collection and data analysis simultaneously. As the data collected from this method was specifically extracted in relation to the frameworks used, there was no further data analysis method required to use the data in answering the research questions.

4.4.4.2 Interviews - Qualitative text analysis

To transform the data collected through the semi-structured interviews, qualitative text analysis was performed. This analysis aimed to transform unorganized text into observable patterns. Several steps were conducted during this analysis;

1. The interviews were recorded and transcribed, transforming audible data into written data.
2. Subsequently, these transcripts were prepared for analysis using an intelligent verbatim approach.
3. After that, nodes were determined corresponding to the information required for answering the different sub-questions (see Appendix 9.8). These nodes were then used to code the interview transcripts, dividing the data into different themes of interest. The coded information could then be used in answering the research questions, using the frameworks.

5 Bibliography

Aertsens, J.; De Nocker, L.; Gobin, A. Valuing the carbon sequestration potential for European agriculture. Land Use Policy 2013, 31, 584–594.

Agroforestry Netwerk Nederland (ANN). (n.d.). Retrieved 7 April 2023, from https://www.agroforestrynetwerk.nl/

Agroforestry Netwerk Nederland (ANN). (n.d.-b). Subsidiemogelijkheden. Retreived 7 April 2023, from https://www.agroforestrynetwerk.nl/kennisbank/subsidiemogelijkheden

AHDB. (2023). Characteristics of different soils. Agriculture and Horticulture Development Board . Retrieved April 10, 2023, from https://ahdb.org.uk/knowledge-library/characteristics-different-soils

Albrecht, S., & Wiek, A. (2021). Food forests: Their services and sustainability. Journal of Agriculture, Food Systems, and Community Development, 10(3), 91–105. https://doi.org/10.5304/jafscd.2021.103.014

Appelman R., Biegel J., Droogleever E., Geluk D., Voorwald N. (2022) Measures to tackle the effects of droughts on farmers in the Utrechtse Heuvelrug. Utrecht University.

Azungah, T. (2018). Qualitative research: deductive and inductive approaches to data analysis. Qualitative Research Journal, 18(4), 383–400. https://doi.org/10.1108/qrj-d-18-00035

Baayen R.P., Berkhout P. Candel J.L, van Doorn A.M., Eweg A.Y., Jager J.H., Jellema A., Jongeneel R.A. (2021) Naar een doeltreffend en doelmatig. Nationaal Strategisch Plan Effectenanalyse van beleidsvarianten voor de Nederlandse invulling van het nieuwe GLB. Wageningen University and Research.

Bergmeier E, Petermann J, Schröder E (2010) Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. Biodivers Conserv 19:2995–3014

Bodemzicht. (n.d.). Bodemzicht. Retrieved 30 March 2023, from https://www.bodemzicht.nl/?lang=en

Bodewes (2021) Het Utrechtse Alternatieve Voedselnetwerk Een meta-analyse van de werkzame online initiatieven binnen het Utrechtse alternatieve voedselnetwerk. Retreived on 7 April 2023, from, https://lokaalvoedsel-utrecht.nu/wp-content/uploads/2022/03/Bodewes_Bianca_6474438.pdf

Boztas, S. (2022, 30 november). Up to 3,000 ‘peak polluters’ given last chance to close by Dutch government. The Guardian. Retrieved 6 April 2023, from https://www.theguardian.com/environment/2022/nov/30/peak-polluters-last-chance-close-dutch-government

Brouwer, F. et al., 2018. Private sector actions to valorise public benefits from agriculture and forestry. EuroChoices, 17: 16-22

Buijs, P., Van Gaalen, M., Van den End, K., & Lambert, T. (2021). Landbouw van de toekomst - Agroforestry systemen, toepassingen en transitie in een landgoederenlandschap [Onderzoeksverslag Ateliergroep Kromme Rijn]. Wageningen University & Research.

Calker, K. J. (2005). Sustainability of Dutch Dairy Farming Systems: A Modelling Approach.

CAP 2023-27. (2023, 7 maart). Agriculture and rural development. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en

Castillo, A., Kebreab, E., Beever, D., & France, J. (2000). A review of efficiency of nitrogen utilisation inlactating dairy cows and its relationship withenvironmental pollution. Journal of Animal and Feed Sciences, 9(1), 1–32. https://doi.org/10.22358/jafs/68025/2000

Centraal Bureau voor de Statistiek (CBS). (2020, May 6). Feiten en cijfers over de landbouw. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/achtergrond/2020/19/feiten-en-cijfers-over-de-landbouw

Centraal Bureau voor de Statistiek (CBS). (2022, September 18). Stijging supermarktomzet voeding met duurzaamheidskeurmerk. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/nieuws/2022/38/stijging-supermarktomzet-voeding-met-duurzaamheidskeurmerk#:~:text=Consumenten%20kochten%20in%202021%20voor,naar%20bijna%2029%20miljard%20euro.

Centraal Bureau voor de Statistiek (CBS). (2023, January 10). Inflatie 10 procent in 2022. Centraal Bureau Voor De Statistiek. Accessed on 7-4-2023, retrieved from: https://www.cbs.nl/nl-nl/nieuws/2023/02/inflatie-10-procent-in-2022#:~:text=De%20prijsstijging%20van%20goederen%20en,4%20procent%20in%202022.

CSAR. (2022). *Aanbevelende rassenlijst 2023 Akkerbouw en Veehouderij* (98th ed.) [Ebook]. Plantum, Gouda. https://rassenlijst.info/ajax_frontoffice/filemanager/files/2023/Aanbevelende-Rassenlijst-Akkerbouw-en-Veehouderij-2023.pdf

Da Cunha Moreira, L., Rosa, G. J. M., & Schaefer, D. M. (2021). Beef production from cull dairy cows: a review from culling to consumption. Journal of Animal Science, 99(7). https://doi.org/10.1093/jas/skab192

DDB. (2021, 7 januari). Wat kost het produceren van melk?. http://ddb.nu/site/assets/files/5196/20210701_-_kostenstudie_-_versie_nl.pdf

De Gloepe (n.d.). Hotel Boerderij Restaurant De Gloepe. Retrieved 19 March, 2023, from https://www.degloepe.nl/

Dorresteijn, I. (2021) *Landscape Change* [Powerpoint-slides]. Copernicus Institute for Sustainability. Utrecht University. Retrieved April 3, 2023.

Drion, S. (2018). Financing Future Farming: an Exploration of Alternative Financing Constructions to Enhance Sustainability at Farm Level'. Msc-thesis Wageningen University, Wageningen. Wageningen Environmental Research Rapport 3110| 49.

Dupraz, C., & Newman, S. M. (1997). Temperate agroforestry: the European way. Temperate agroforestry systems., 181-236. https://www-cabidigitallibrary-org.proxy.library.uu.nl/doi/epdf/10.1079/9781780644851.0098

Durham, T. B., & Mizik, T. (2021). Comparative Economics of Conventional, Organic, and Alternative Agricultural Production Systems. Economies, 9(2), 64. https://doi.org/10.3390/economies9020064

Ellenberg, H., & Leuschner, C. (2010, September 15). Vegetation Mitteleuropas mit den Alpen (6th ed.).

Etienne, M., & Rapey, H. (1999). Simulating integration of agroforestry into livestock farmers' projects in France. Springer Netherlands EBooks, 257–272. https://doi.org/10.1007/978-94-017-0679-7_16

Eurostat. (2022, 15 december). Comparative price levels for food, beverages and tobacco. Eurostat.

Evers, A. (n.d.). Subsidie belangrijke inkomstenbron in Europa. verantwoorde veehouderij.nl. Retrieved 6 April 2023, from , van https://www.verantwoordeveehouderij.nl/show/Subsidie-belangrijke-inkomstenbron-in-Europa.htm

FAO. (2019). Silvopastoral Systems and their Contribution to Improved Resource Use and Sustainable Development Goals: Evidence from Latin America. Food and Agriculture Organisations of the United Nations Food forest factory. https://www.foodforestfactory.eu/voedselbos-ontwerpcursus

FAO. (2021). Agroforestry. http://www.fao.org/forestry/ agroforestry/80338/en/

Firoozi, A. A., Firoozi, A., & Baghini, M. (2016). A Review of Clayey Soils. Asian Journal of Applied Sciences, 4(2321).

Food Forests Grow. (n.d.). Layers of a Food Forest. Weebly. https://foodforestsgrow.weebly.com/layers-of-a-food-forest.html

Forest to Plate (FP). (2023, March 2). WILD FOOD DINNER BRUSSEL. Retrieved29 March, 2023, from https://www.foresttoplate.com/activities/wild-food-dinner

Franke, C. (2017) Silvopastoral farming systems – Consequences of trees on pastures for an organic dairy farm in North-Brabant, in the south of The Netherlands. https://edepot.wur.nl/416399

Frey, D., & Czolba, M. (2017). The Food Forest Handbook: Design and Manage a Home-scale Perennial Polyculture Garden. New Society Publishers.

FrieslandCampina. (n.d.). Story of Milk. https://www.frieslandcampina.com/nutrition/story-of-milk/

Gemeente Utrechtse Heuvelrug. (2022, December 12). Blauwe agenda: Droogte en wateroverlast Beperken. Heuvelrug. Retrieved April 10, 2023, from https://www.heuvelrug.nl/droogte

Giannitsopoulos, M. L., Graves, A. R., Burgess, P. J., Crous-Duran, J., Moreno, G., Herzog, F., Palma, J. H. N., Kay, S., & García de Jalón, S. (2020) Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe. Journal of Cleaner Production, 269. https://doi.org/10.1016/j.jclepro.2020.122283

Graves, A.R., Burgess, P.J., Palma, J.H.N., Herzog, F., Moreno, G., Bertomeu, M., Dupraz, C., Liagre, F., Keesman, K., van der Werf, W., de Nooy, A.K., & van den Briel, J.P. (2007) Development and application of bio-economic modelling to compare silvoarable, arable, and forestry systems in three European countries. Ecological Engineering, 29(4), 434–449. https://doi.org/10.1016/j.ecoleng.2006.09.018

GroCycle. (2021). Food Forest Layers: How to Create a Low-Maintenance System for Abundant Crops. Retrieved from https://grocycle.com/food-forest-layers/.

Harrell, M. C. & Bradley, M. A. (2009). Data collection methods. Semi-structured interviews and focus groups. Rand National Defence Research Institute Santa Monica.

Hendriks, K. et al., 2021. Private verevening voor ecosysteemdiensten in de landbouw. Notities met voorbeelden. Wageningen University & Research, https://edepot.wur.nl/547609

Herder, M. D., Moreno, G., Mosquera-Losada, R., Palma, J. H., Sidiropoulou, A., Freijanes, J. J. S., Crous-Duran, J., Paulo, J. A., Tomé, M., Pantera, A., Papanastasis, V. P., Mantzanas, K., Pachana, K., Sidiropoulou, M., Konstantinou, I., Peco, B., del Río, M., Rois, M., … Burgess, P. J. (2020). Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe. Journal of Cleaner Production, 269, 122283. https://doi.org/10.1016/j.jclepro.2020.122283

Hirv, M., Tali, K., Haldna, M. & Kull, T. (2010). Habitat preferences as related to the prolonged dormancy of perennial herbs and ferns. Plant Ecology. 210. 111-123. 10.1007/s11258-010-9742-9.

Holligan, B. A. (2022, 29 juli). Why Dutch farmers are protesting over emissions cuts. BBC News. Geraadpleegd op 6 april 2023, van https://www.bbc.com/news/world-europe-62335287

https://nora.nerc.ac.uk/id/eprint/6411/1/ECOFACT2a.pdf

Huntley, B. J. (2023). Soil, water and nutrients. Ecology of Angola, 127–147. https://doi.org/10.1007/978-3-031-18923-4_6

Idassi, J. (2012). Profitable farms and woodlands: A practical guide in agroforestry for landowners, farmers, and ranchers. Government Printing Office.

IPS. (2019, July 2). *What is peat?* International Peatland Society. Retrieved April 4, 2023, from https://peatlands.org/peat/peat/

Jamie. (n.d.). Food Forest. Retrieved from https://rennieorchards.com/food-forest/

Johnston, A., Poulton, P. R., & Coleman, K. (2009). Chapter 1 Soil Organic Matter. *Elsevier EBooks*, 1–57. https://doi.org/10.1016/s0065-2113(08)00801-8

Jones, J. B. (2012). Plant Nutrition and Soil Fertility Manual. CRC.

Kay, S., Graves, A., Palma, J. H. N., Moreno, G., Roces-Díaz, J. V., Aviron, S., Chouvardas, D., Crous-Duran, J., Ferreiro-Domínguez, N., García de Jalón, S., Măcicăşan, V., Mosquera-Losada, M. R., Pantera, A., Santiago-Freijanes, J. J., Szerencsits, E., Torralba, M., Burgess, P. J., Herzog, F. (2019) Agroforestry is Rapport WPR-OT-978 | 71 paying off – Economic evaluation of ecosystem services in European landscapes with and without agroforestry systems. Ecosystem Services, 36 https://doi.org/10.1016/j.ecoser.2019.100896

Knight-Lira, A. (2014). Food forest gardens: A report addressing the benefits of the establishment of food forests in communities. Critical Food Forest Scan & Ideas for a Food Forest in Peterborough, 9.

Kome, G. K., Enang, R. K., Tabi, F. O., & Yerima, B. P. K. (2019). Influence of Clay Minerals on Some Soil Fertility Attributes: A Review. *Open Journal of Soil Science*, *09*(09), 155–188. https://doi.org/10.4236/ojss.2019.99010Kropshofer, K. K. (2020). Milk Production | What Really Drives the Price of Milk? Retrieved 23 March 2023, from rhttps://www.foodunfolded.com/article/milk-production-what-really-drives-the-price-of-milk

Kumari, N., & Mohan, C. (2021). Basics of clay minerals and their characteristic properties. Clay and Clay Minerals. https://doi.org/10.5772/intechopen.97672

Kwakman, R. (2021, 28 september). The Netherlands: Facts, figures, and farm trends in the dairy sector. Dairy Global. Retrieved 23 March 2023, from https://www.dairyglobal.net/world-of-dairy/the-dutch-dairy-industry-facts-figures-and-farm-trends/

Laylin, T. (2021, 31 augustus). Third largest dairy producing country embraces sustainability - Darigold. Darigold. https://www.darigold.com/third-largest-dairy-producing-country-sustainability/

Lehmann, L. M., Smith, J., Westaway, S., Pisanelli, A., Russo, G., Borek, R., Sandor, M., et al. (2020). Productivity and Economic Evaluation of Agroforestry Systems for Sustainable Production of Food and Non-Food Products. Sustainability, 12(13), 5429. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su12135429

Lerner, R. (2017, March 1). What is loam? Indiana Yard and Garden - Purdue Consumer Horticulture. Retrieved April 10, 2023, from https://www.purdue.edu/hla/sites/yardandgarden/what-is-loam/

Leung, A. K., Garg, A., & Ng, C. W. W. (2015). Effects of plant roots on soil-water retention and induced suction in vegetated soil. Engineering Geology, 193, 183-197.

Lokaal Voedsel Utrecht. (n.d.). Retrieved March 30, 2023, from https://lokaalvoedsel-utrecht.nu/

Louis Bolk Instituut. (2019). Agroforestrysystemen en verdienmodellen. Louis Bolk Instituut

Louis Bolk Instituut. (2020). Masterplan Agroforestry: AdAdvies voor het realiseren van een schaalsprong van agroforestry in Nederland. In *Kennisbank NPUH*. Retrieved April 1, 2023, from https://www.np-utrechtseheuvelrug.nl/wp-content/uploads/2022/03/masterplan-agroforestry.pdf

Luske B., Bestman M, van Veluw K., Prins E, Rombouts P. (2020) Masterplan Agroforestry - Advies voor het realiseren van een schaalsprong van agroforestry in Nederland. Louis Bolk Instituut. 2020-017 LbD

Marsh, J. (2023) What is a Food Forest? https://environment.co/what-is-a-food-forest/#:~:text=The%20rhizosphere%2C%20sometimes%20called%20the,turnips%2C%20beets%20and%20other%20vegetables.

Maye, D., & Chan, K. S. (2020). On-farm biosecurity in livestock production: farmer behaviour, cultural identities and practices of care. Emerging topics in life sciences, 4(5), 521–530. https://doi.org/10.1042/etls20200063

McKinsey & Company. (2021, January 29). A blueprint for scaling voluntary carbon markets to meet the climate challenge. Retrieved March 29, 2023, from https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

Ministerie van Algemene Zaken (MAZ). (2023, March 24). Sterke en duurzame landbouwsector in 2040. Landelijk Gebied: Aanpak Stikstof, Natuur, Water En Klimaat, Rijksoverheid.nl. retrieved 6 april 2023, from https://www.rijksoverheid.nl/onderwerpen/aanpak-stikstof-natuur-water-en-klimaat/sterke-en-duurzame-landbouwsector-in-2040

Ministerie van Economische Zaken en Klimaat (MEZK). (2022, August 1). Landbouwsubsidies. Landbouw En Tuinbouw. Rijksoverheid.nl. Accessed on 7-4-2023, retrieved from:https://www.rijksoverheid.nl/onderwerpen/landbouw-en-tuinbouw/landbouwsubsidies#:~:text=Landbouwers%20die%20hun%20landbouwgrond%20natuurvriendelijk,natuur%20en%20landschap%20(SKNL).

Ministerie van Economische Zaken en Klimaat. (2017, 16 mei). Welfare of animals kept commercially. Animal welfare | Government.nl. Geraadpleegd op 6 april 2023, van https://www.government.nl/topics/animal-welfare/welfare-of-animals-kept-commercially

Moene, A. F., & Dam, J. C. van. (2014). Transport in the atmosphere-vegetation-soil continuum. Cambridge University Press.

Mujtaba, H., Farooq, K., Sivakugan, N., & Das, B. M. (2013). Correlation between gradational parameters and compaction characteristics of sandy soils. International Journal of Geotechnical Engineering, 7(4), 395–401. https://doi.org/10.1179/1938636213z.00000000045

Müller, M., Hanisch, M., Malvido, A., Rommel, J., & Sagebiel, J. (2018). The structural effect of cooperatives on price volatility in the European dairy sector. Applied Economics Letters, 25(8), 576–579. https://doi.org/10.1080/13504851.2017.1346358

N. Rajakaruna, R.S. Boyd. Edaphic factor. Encyclopaedia of Ecology. Elsevier (2018), pp. 361-367

Nair, P. K., Kumar, B. M., & Nair, V. D. (2021). Agroforestry systems in the temperate zone. An Introduction to Agroforestry, 195–232. https://doi.org/10.1007/978-3-030-75358-0_10

Netter, L., Luedeling, E., & Whitney, C. (2022). Agroforestry and reforestation with the Gold Standard-Decision Analysis of a voluntary carbon offset label. Mitigation and Adaptation Strategies for Global Change, 27(2). https://doi.org/10.1007/s11027-021-09992-z

Ningjing, L., Koot, A., Hettinga, K., De Jong, J., & Van Ruth, S. M. (2018). Portraying and tracing the impact of different production systems on the volatile organic compound composition of milk by PTR-(Quad)MS and PTR-(ToF)MS. Food Chemistry, 239, 201–207. https://doi.org/10.1016/j.foodchem.2017.06.099

Ningjing, L., Pustjens, A., Erasmus, S. W., Yang, Y., Hettinga, K., & Van Ruth, S. M. (2020). Dairy farming system markers: The correlation of forage and milk fatty acid profiles from organic, pasture and conventional systems in the Netherlands. Food Chemistry, 314, 126153. https://doi.org/10.1016/j.foodchem.2019.126153

Nworji, Michael. (2020). Bioeconomic potential for silvopastoral agroforestry system in North Wales. Journal of Agricultural Policy. 3. 41-66. 10.47941/jap.385

Palm, C. A. (1995). Contribution of agroforestry trees to nutrient requirements of intercropped plants. In Agroforestry: science, policy and practice: selected papers from the agroforestry sessions of the IUFRO 20th World Congress, Tampere, Finland, 6–12 August 1995 (pp. 105-124). Springer Netherlands.

Permaculture Plants. (n.d.). Understory. Permaculture Plants. https://permacultureplants.com/forest-layer/understory/

Pimentel, D., & Burgess, M. M. (2014). An Environmental, Energetic and Economic Comparison of Organic and Conventional Farming Systems. Springer eBooks, 141–166. https://doi.org/10.1007/978-94-007-7796-5_6

Pontara, G. (2019). Analysing farmers' perceptions towards agroforestry adoption in Southern Belize [MA thesis]. Wageningen University.

Prins E. (2017) Exploring the potential of agroforestry integration in arable and dairy farms in The Netherlands – an ex-ante assessment at field and farm level. Farming Systems Ecology Group. Wageningen University and Research. https://edepot.wur.nl/416387

Provincie Utrecht. (2012). Weidevogelvisie. Provincie Utrecht. Retrieved March 28, 2023, from https://www.provincie-utrecht.nl/onderwerpen/natuur/natuurbeheer#weidevogelbeheer

Provincie Utrecht. (n.d.). Nationaal Park Utrechtse Heuvelrug. Provincie Utrecht. Retrieved April 10, 2023, from https://www.provincie-utrecht.nl/onderwerpen/natuur/nationaal-park-heuvelrug

RHS. (n.d.). Soil types . RHS Gardening. Retrieved April 10, 2023, from https://www.rhs.org.uk/soil-composts-mulches/soil-types

Rigueiro-Rodríguez, A., Fernández-Núñez, E., González-Hernández, P., McAdam, J. H., & Mosquera-Losada, M. R. (2009). Agroforestry systems in Europe: productive, ecological and social perspectives. Agroforestry in Europe: current status and future prospects, 43-65.

RIVM. (2022, June 9). Toelichting bij richtinggevende emissiereductiedoelstellingen per gebied. Rijksinsituut voor Volksgezondheid en Mileu. Retrieved April 10, 2023, from https://www.rivm.nl/sites/default/files/2022-06/RIVM-AERIUS_21-083_Toelichting%20bij%20richtinggevende%20emissiereductiedoelstellingen.pdf

Robotics, P. B. O. (n.d.). Agroforestry Research Developments – Nova Science Publishers. https://novapublishers.com/shop/agroforestry-research-developments/

Rocha, A. R. (2021, 5 november). Organic vs. Conventional: How do Dairy and Beef Production Systems Impact Food Quality, the Environment, and Social Perceptions? CLEAR Center. https://clear.ucdavis.edu/explainers/organic-vs-conventional-how-do-dairy-and-beef-production-systems-impact-food-quality

Rougoor C., van der Schans F. (2015) Ontwikkelingsruimte melkveebedrijven West-Nederland. CLM-882

Ruijtenberg N. (2022) A stakeholder perspective on overcoming governance gaps in order to create a climate-adapted landscape at the Utrechtse Heuvelrug. Utrecht University.

Sayner, A. (2021). Agroforestry Ultimate Guide and Examples. GroCycle. https://grocycle.com/agroforestry-ultimate-guide/

Schoutsen, M. A. (2019, January 1). *Agroforestry*. WUR. Retrieved April 8, 2023, from https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksprojecten-lnv/soorten-onderzoek/kennisonline/agroforestry-1.htm

Selin Norén, I., Dawson, A., van der Voort, M. P. J., & Vijn, M. P. (2019). Agroforestry, wat levert het financieel op? Handreiking voor agrarisch ondernemers die bomen willen planten op hun bedrijf. (Factsheet Agroforestry; No. 4). Stichting Wageningen Research, Wageningen Plant Research, Business unit Open Teelten. https://edepot.wur.nl/507628

Selin-Norén, I., Dawson, A., & Van der Voort, M. (2019). Factsheets Agroforestry. In WUR. Wageningen University & Research. https://edepot.wur.nl/507628

Sereke, F., Graves, A. R., Dux, D., Palma, J. H. N., & Herzog, F. (2015) Innovative agroecosystem goods and services: key profitability drivers in Swiss agroforestry. Agronomy for Sustainable Development, 35(2), 759–770. https://doi.org/10.1007/s13593-014-0261-2

Silvopastoral system. (2015). The Cattle Site. https://www.thecattlesite.com/articles/4268/silvopastoral-could-it-work-on-my-farm

Soler, R., Peri, P. L., Bahamonde, H. A., Gargaglione, V. B., Ormaechea, S. G., Herrera, A. A., Jardón, L., Lorenzo, C., & Pastur, G. M. (2018). Assessing Knowledge Production for Agrosilvopastoral Systems in South America. Rangeland Ecology & Management, 71(5), 637–645. https://doi.org/10.1016/j.rama.2017.12.006

Sollen-Norrlin, M., Ghaley, B. B., & Rintoul, N. L. J. (2020). Agroforestry Benefits and Challenges for Adoption in Europe and Beyond. Sustainability, 12(17), 7001. https://doi.org/10.3390/su12177001

Splinter, G., Tacken, G., & Venema, G. (2022). Omvang

Stokstad, E. (2019). Nitrogen crisis threatens Dutch environment—and economy. Science, 366(6470), 1180–1181. https://doi.org/10.1126/science.366.6470.1180

Subsidies & financiering | Agentschap Innoveren en Ondernemen. (n.d.). https://www.vlaio.be/nl/subsidies-financiering

The Habitats Directive - Environment - European Commission. (n.d.). https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

Times, N. & ANP. (2023, 28 maart). Dutch public bought organic products more often last year. NL Times. Geraadpleegd op 9 april 2023, van https://nltimes.nl/2023/03/28/dutch-public-bought-organic-products-often-last-year

Topcuoğlu, B., & Turan, M. (2018). Introductory Chapter: Introduction to Peat. *InTech EBooks*. https://doi.org/10.5772/intechopen.79418

United Nations (UN). (2022). Biodiversity - our strongest natural defense against climate change | United Nations. Accessed on 7-4-2023, retrieved from: https://www.un.org/en/climatechange/science/climate-issues/biodiversity#:~:text=The%20risk%20of%20species%20extinction,destroy%20almost%20all%20remaining%20reefs.

United States Environmental Protection Agency. (2020). Groundwater. In *epa.gov*. Retrieved April 2, 2023, from https://www.epa.gov/sites/default/files/documents/groundwater.pdf

USDA (2017). How can agroforestry support climate change mitigation in the Northeast? Accessed on 7-4-2023, retrieved from: https://www.climatehubs.usda.gov/hubs/northeast/topic/how-can-agroforestry-support-climate-change-mitigation-northeast#:~:text=Agroforestry%20contributes%20to%20climate%20change,and%20energy%20usage%20on%20farms

Utrecht Province. (2020). De Blauwe Agenda van de Utrechtse Heuvelrug. *Naar Een Robuust En Toekomstbestendig Watersysteem*. Retrieved April 4, 2023, from https://www.stateninformatie.provincie-utrecht.nl/Vergaderingen/Statencommissie-Ruimte-Groen-en-Water/2020/09-september/13:00/2020RGW115-02-De-Blauwe-Agenda-van-de-Utrechtse-Heuvelrug.pdf

Utrecht Province. (2022). Natuurbeheerplan 2023. *Bij12.Nl*. Retrieved April 5, 2023, from https://www.bij12.nl/wp-content/uploads/2022/10/Natuurbeheerplan-2023-provincie-Utrecht.pdf

Utrecht Province (2021). Natuurbeheerplan 2022. *Provincie-Utrecht.nl* Retrieved April 5, 2023, from https://www.provincie-utrecht.nl/sites/default/files/2021-03/Natuurbeheerplan%202022.pdf

Vaarst, M., Alban, L., Hermansen, J. E., Milan, S., T., & Kristensen, E. (2001). Health and Welfare in Danish Dairy Cattle in the Transition to Organic Production: Problems, Priorities and Perspectives. Journal of Agricultural & Environmental Ethics, 14(4), 367–390. https://doi.org/10.1023/a:1013060304868

Vaintrub, M. O., Levit, H., Chincarini, M., Fusaro, I., Giammarco, M., & Vignola, G. (2021). Review: Precision livestock farming, automats and new technologies: possible applications in extensive dairy sheep farming. Animal, 15(3), 100143. https://doi.org/10.1016/j.animal.2020.100143

Van Asselt, E., Capuano, E., & Van Der Fels-Klerx, H. (2015). Sustainability of milk production in the Netherlands – A comparison between raw organic, pasteurised organic and conventional milk. International Dairy Journal. https://doi.org/10.1016/j.idairyj.2015.02.007

Van der Gaast, J.W.J., Massop, H.Th.L., Vroon, H.R.J., Staritsky, I.G. (2006). Hydrologie op basis van karteerbare kenmerken. Alterra. https://edepot.wur.nl/28844

van Dorp, D., & Stobbelaar, D. J. (2020). Voedselbossen: een landbouwsysteem met veel potentie. Van Hall Larenstein

van Gelder, K. v. G. (2022, 15 september). Number of organic farms in the Netherlands 2021, by province. Statista. Retrieved 15 March 2023, from https://www.statista.com/statistics/986585/number-of-organic-farms-in-the-netherlands-by-province/

Van Halm, I. (2022, 16 augustus). The Dutch nitrogen crisis shows what happens when policymakers fail to step up. Energy Monitor. Retrieved 21 March 2023, from https://www.energymonitor.ai/policy/the-dutch-nitrogen-crisis-shows-what-happens-when-policymakers-fail-to-step-up/

Veen, E., & De Groot, E. (2017). Food Forests: An upcoming phenomenon in the Netherlands. In Wageningen University and Research. Retrieved March 25, 2023, from https://edepot.wur.nl/448781

Venema G., Vijn M. Benus M.(2021) Agrarische afzet via korte ketens in Utrecht. Wageningen Economic Research

Verburg, R., Verberne, E., & Negro, S. (2022). Accelerating the transition towards sustainable agriculture: The case of organic dairy farming in the Netherlands. Agricultural Systems, 198, 103368. https://doi.org/10.1016/j.agsy.2022.103368

Vermunt, D., Wojtynia, N., Hekkert, M., Van Dijk, J., Verburg, R., Verweij, P., Wassen, M., & Runhaar, H. (2022). Five mechanisms blocking the transition towards 'nature-inclusive' agriculture: A systemic analysis of Dutch dairy farming. Agricultural Systems, 195, 103280. https://doi.org/10.1016/j.agsy.2021.103280

vraag en aanbod lokale producten in de provincie Utrecht. (Rapport / Wageningen Economic Research; No. 2022-038). Wageningen Economic Research. https://doi.org/10.18174/575970

Waalgaard. (n.d.). Oogstgenoot. Retrieved March 20, 2023, from https://www.waalgaard.nl/product-page/oostgenoot-xl

Welke ecologiesubsidies kan jouw onderneming aanvragen? | Agentschap Innoveren en Ondernemen. (n.d.). https://www.vlaio.be/nl/nieuws/welke-ecologiesubsidies-kan-jouw-onderneming-aanvragen?gclid=Cj0KCQjwlPWgBhDHARIsAH2xdNek5gM6LjSdFCWVcGPqnGigMZOolIiAho-jRVeFi8IYRibfrtRNwC8aAgHAEALw_wcB

White, K. (2023b, March 1). *How is the dairy industry addressing climate change?* The Grocer. https://www.thegrocer.co.uk/the-dairymen/how-is-the-dairy-industry-addressing-climate-change/659387.article#:~:text=With%20total%20global%20emissions%20currently,emanating%20from%20enteric%20fermentation%20emissions.

Wigboldus, Seerp & Leeuwen, Sanne & Schoutsen, Maureen & Vijn, Marcel & Kruit, Jeroen. (2022). Agroforestry kansrijk(er) maken in Nederland. Hoe rekenen, waarmee rekening houden, en waaraan werken?. 10.18174/585185.

World Bank Climate Change Knowledge Portal. (n.d.). https://climateknowledgeportal.worldbank.org/country/netherlands/climate-data-historical

Yang, Y., Huisman, W., Hettinga, K., Liu, N., Heck, J., Schrijver, G., Gaiardoni, L., & Van Ruth, S. (2019). Fraud vulnerability in the Dutch milk supply chain: Assessments of farmers, processors and retailers. Food Control, 95, 308–317. https://doi.org/10.1016/j.foodcont.2018.08.019

ZuivelNL. (n.d.). ZuivelNL - Organisation of the Dutch dairy supply chain - ZuivelNL EN. https://www.zuivelnl.org/en

6 Appendix: Integrative chapter

Appendix 6.1: Gantt Chart whole group process

	Start Date	End Date	Timeline	Status
Consultancy project	Feb 6, 2023	April 13, 2023		
Subquestion 1	Feb 6, 2023	April 13, 2023		Complete
Subquestion 2	Feb 6, 2023	April 13, 2023		Complete
Subquestion 3	Feb 6, 2023	April 13, 2023		Complete
Project Proposal draft	Feb 6, 2023	Feb 19, 2023		Complete
Project Proposal	Feb 19, 2023	Feb 26, 2023		Complete
Literature review	Feb 27, 2023	Mar 5, 2023		Complete
Aquire contacts	Feb 27, 2023	Mar 3, 2023		Complete
Interview Questions	Feb 27, 2023	Mar 5, 2023		Complete
Data collection (interviews)	Mar 6, 2023	Mar 19, 2023		Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023		Complete
Data analysis	Mar 13, 2023	Mar 24, 2023		Complete
Peer feedback	Mar 24, 2023	Mar 28, 2023		Complete
Integrative part	Mar 27, 2023	Apr 7, 2023		Complete
Implement feedback	Mar 29, 2023	Apr 1, 2023		Complete
Impact deliverable	Mar 31, 2023	Apr 9, 2023		Complete
Presentation	Apr 8, 2023	Apr 13, 2023		Active
Finalize deliverable and report	Apr 10, 2023	Apr 13, 2023		Complete
		Time elapsed		

7 Appendix: Practical considerations

Appendix 7.1: Interview guide Dutch version

Introductie

1. Bedanken voor tijd en interview
2. Kort voorstellen wie je bent en waar ons onderzoek overgaat

Wij zijn studenten Global Sustainability Science van de Utrecht Universiteit en zijn bezig met een consultancy project voor *Natuur & Milieufederatie Utrecht* en *Nationaal Park Utrechtse Heuvelrug*. Wij onderzoeken hoe melkveehouderij boeren die openstaan voor agroforestry in de omgeving van de Utrechtse Heuvelrug kunnen transitioneren naar agroforestry. Dit interview zal gebruikt worden om kennis over agroforestry systemen op te doen.

Ethische vragen

1. Geeft u toestemming als wij dit interview opnemen? Het interview zelf blijft vertrouwelijk.
2. Wilt u dat de data anoniem verwerkt wordt of mogen wij uw naam gebruiken in ons onderzoek?
3. Wilt u als ons onderzoek klaar is ons rapport ontvangen met onze uitkomsten?
4. Verder kunt u zich altijd terugtrekken uit het onderzoek. U kunt ons mailen of bellen als u zich bedenkt en toch niet betrokken wilt worden in het onderzoek.

Kennismakingsvragen

1. Wat houdt uw functie binnen organisatie … in?
2. Waar ligt uw expertise met betrekking tot agroforestry?
3. Hoe lang heeft u al ervaring op dit gebied?

Interview

1. Kunt u iets vertellen over het transitieproces van conventioneel naar agroforestry?
    a. Wat zijn de grootste obstakels?
        i. Hoe kunnen boeren die oplossen?
    b. Zijn er regels/wetten/subsidies die het transitieproces makkelijker maken of juist moeilijker?
2. Wat is voor de meeste boeren de reden dat zij overstappen naar agroforestry?
3. Hoeveel steun ontvangen de boeren tijdens het proces? Vanuit de gemeenten/beleid instituten, steunnetwerken (boerenorganisaties)
    a. Tijdens het besluitvormende periode
    b. Tijdens de implementatie
    c. Na de implementatie
4. Wat is volgens u nodig om een effectieve transitie te faciliteren voor boeren die willen overstappen naar agroforestry?
5. Hoe kan agroforestry het beste worden geïntegreerd in de huidige praktijken van conventionele boeren?

   a. Op wat voor manier verandert het dagelijks leven van boeren samen met agroforestry?
   b. Hoe gaat de fluctuerende intensiteit van het werk op de boerderij samen met het onderhoud van agroforestry?
6. In hoeverre zijn boeren betrokken bij het proces en hebben boeren invloed op het transitieproces naar agroforestry?
7. Hoe zouden boeren het beste betrokken kunnen worden tijdens het proces?
8. Hoe is de communicatie tussen boeren en wetenschappers/beleidsmakers?
9. Zijn er nog andere stakeholders betrokken bij de transitie naar agroforestry?

Afsluitende vraag: Wat denkt u dat er moet gebeuren om agroforestry aantrekkelijker te maken voor boeren? -

a. Perspectief beelden, voorbeeld boerderijen

Appendix 7.2: Interview guide English version

Introduction

1. Thanks for the time and interview
2. Briefly introduce who we are and what our research is about

We are students of Global Sustainability Science from Utrecht University, and we are working on a consultancy project for *Natuur & Milieufederatie Utrecht* and *Nationaal Park Utrechtse Heuvelrug*. We investigate how dairy farmers who are open to agroforestry in the surroundings of the Utrechtse Heuvelrug can transition to agroforestry. This interview will be used to gain knowledge about agroforestry systems.

Ethical questions

1. Do you give permission if we record this interview? The interview itself will remain confidential.
2. Do you want the data to be processed anonymously or can we use your name in our research?
3. Would you like to receive our report with our results when our investigation is finished?
4. You can also withdraw from the study at any time. You can email or call us if you change your mind and do not want to be involved in the study.

Introductory questions

1. What is your position within the organisation… ?
2. Where does your expertise lie with regards to agroforestry?
3. How long have you had experience in this field?

Interview

1. Can you tell us something about the transition process from conventional to agroforestry?
    a. What are the biggest obstacles?
        i. How can farmers solve them?
    b. Are there rules/laws/subsidies that make the transition process easier or more difficult?
2. What is the reason for most farmers to switch to agroforestry?
3. How much support do the farmers receive during the process? From the municipalities/policy institutes, support networks (farmers' organisations)
    a. During the decision-making period
    b. During implementation
    c. After implementation
4. What do you think is needed to facilitate an effective transition for farmers who want to switch to agroforestry?
5. How can agroforestry best be integrated into the current practices of conventional farmers?
    a. In what way does agroforestry change the daily life of farmers?
    b. How does the fluctuating intensity of farm work interact with the maintenance of agroforestry?

6. To what extent are farmers involved in the process and do farmers influence the transition process to agroforestry?
7. How could farmers best be involved in the process?
8. How is the communication between farmers and scientists/policy makers?
9. Are there other stakeholders involved in the transition to agroforestry?

Closing question: What do you think should be done to make agroforestry more attractive to farmers?

a. Perspective images, example farms

Appendix 7.3: Colour codes

Red = Entrepreneurial activities
Yellow = Respects current practices
Green= Knowledge development
Blue= Knowledge diffusion
Orange = Advantages
Light blue= Resource mobilisation
pink = Legislation

Appendix 7.4: Gantt Chart subgroup 1

Ferry	Feb 6, 2023	Apr 13, 2023	
Proposal writing-analytical framework	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 20, 2023	Complete
Interviews	Mar 6, 2023	Mar 30, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews	Mar 16, 2023	Mar 30, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

Roos	Feb 6, 2023	Apr 13, 2023	
Proposal writing-methods	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

Eva	Feb 6, 2023	Apr 13, 2023	
Proposal writing-expected results	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

Namara	Feb 6, 2023	Apr 13, 2023	
Proposal writing-intro&feasability	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

8 Appendix: Ecological conditions

Appendix 8.1: Soil maps on pastures

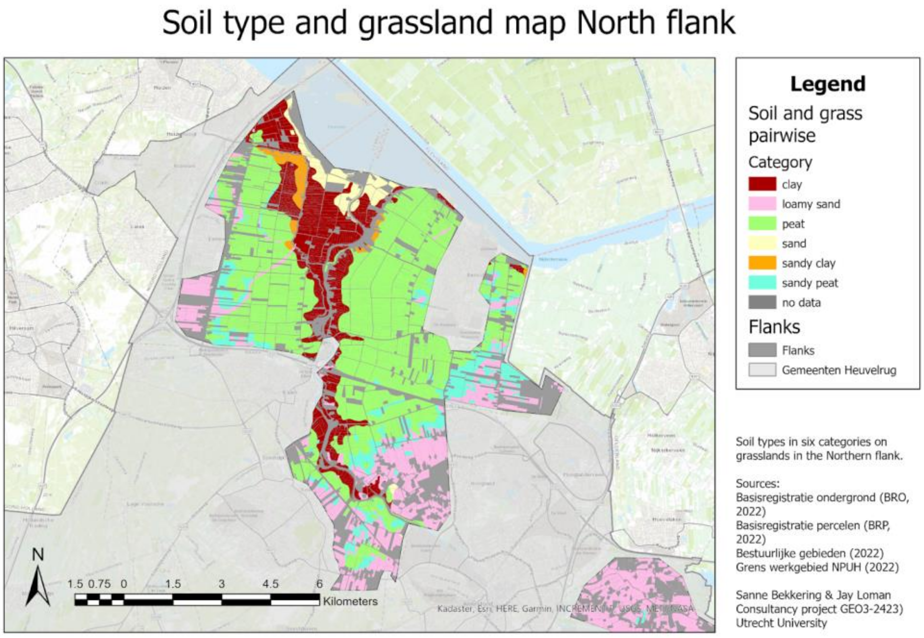

Figure 3.15. soil and grassland map of the northern flank.

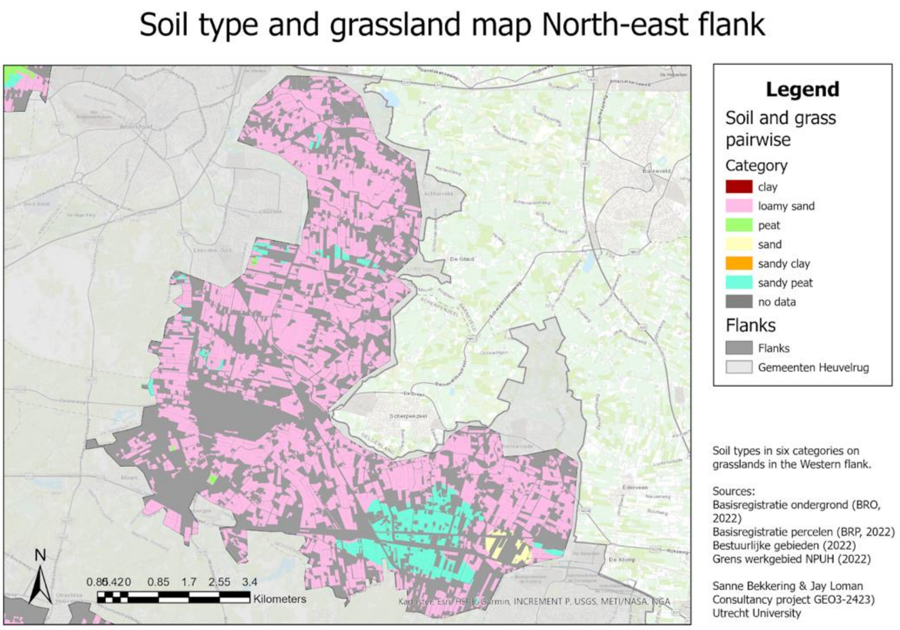

Figure 3.16. soil and grassland map of the north-eastern flank.

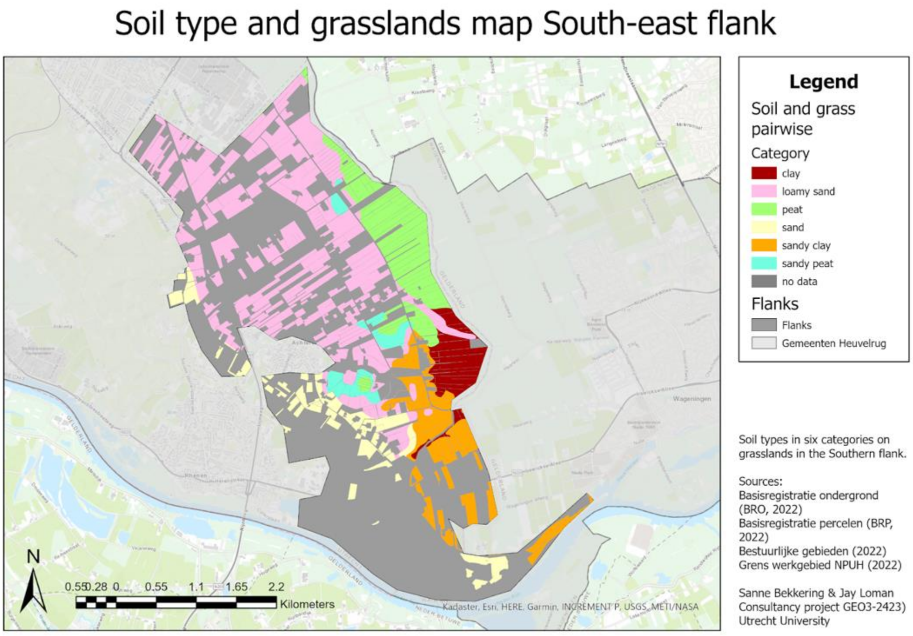

Figure 3.17. soil and grassland map of the south-eastern flank.

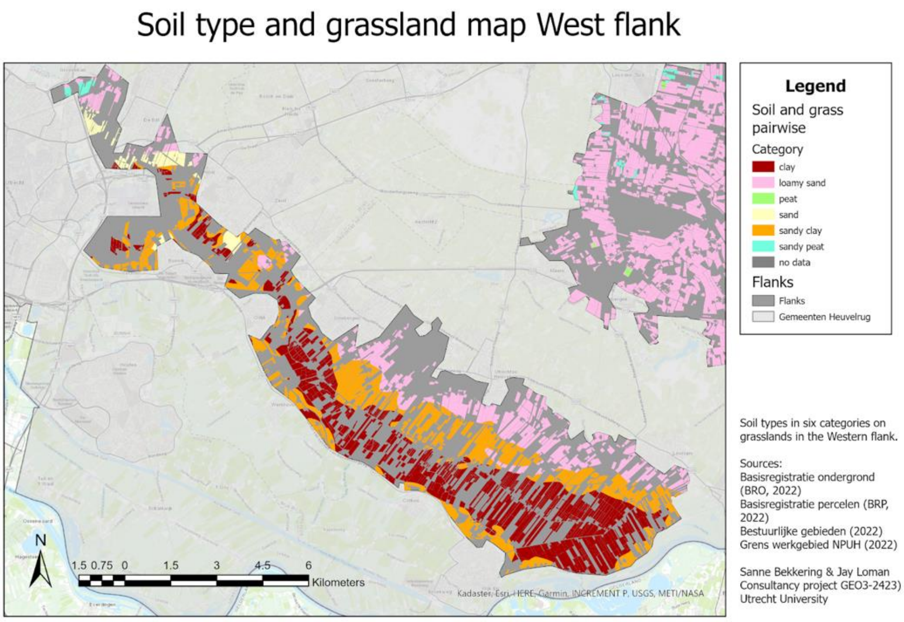

Figure 3.18. soil and grassland map of the western flank.

Appendix 8.2: Water maps on pastures

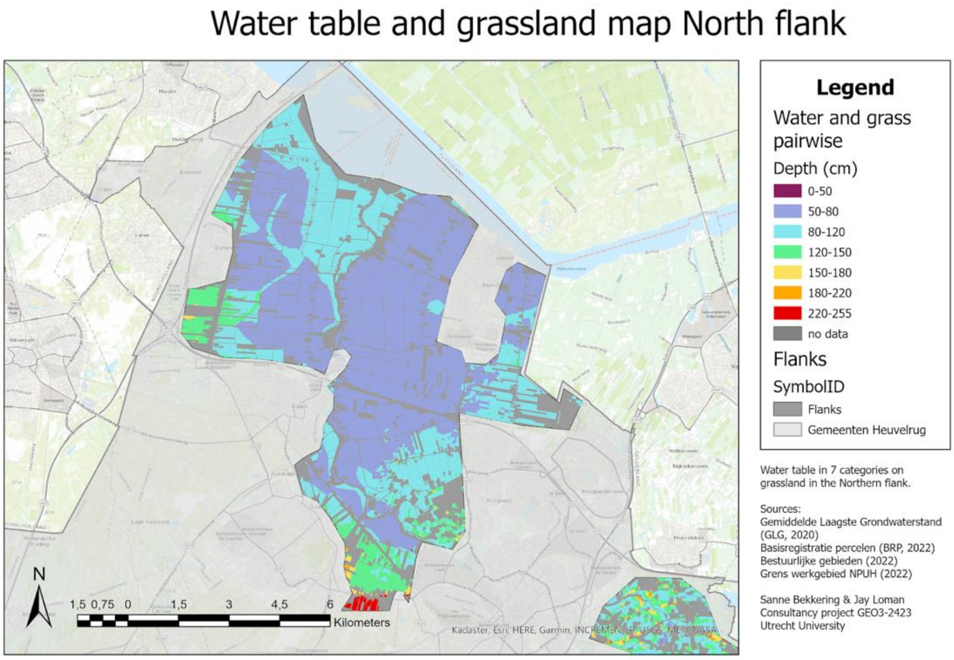

Figure 3.20. water table and grassland map northern flank.

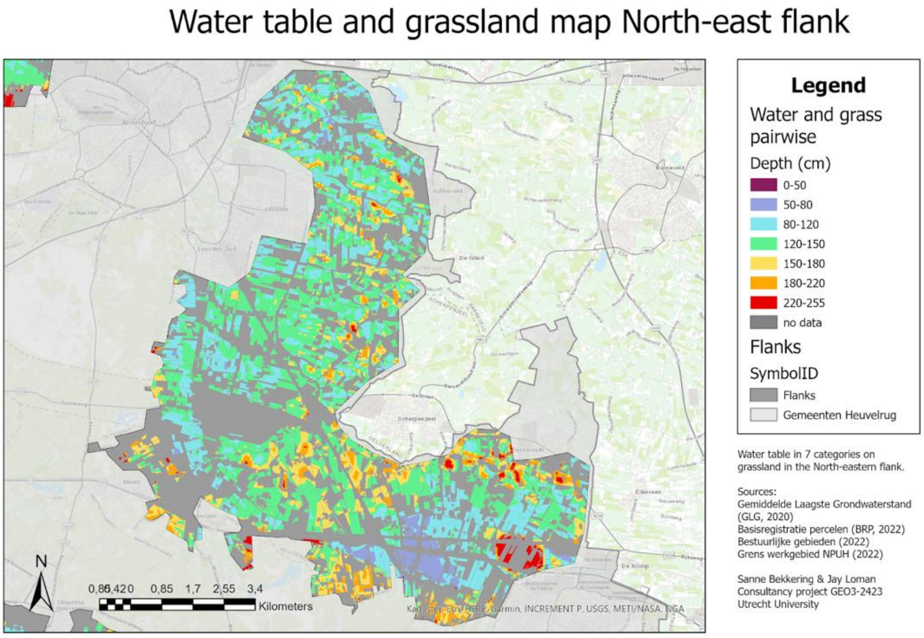

Figure 3.21. water table and grassland map north-eastern flank.

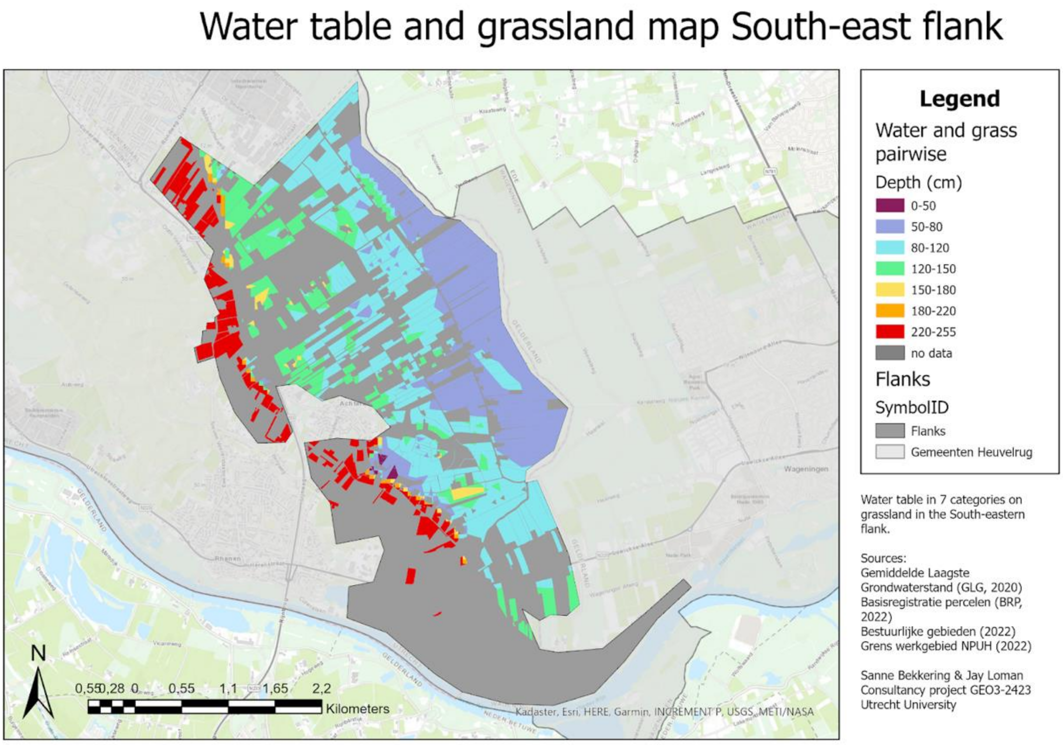

Figure 3.22. water table and grassland map south-eastern flank.

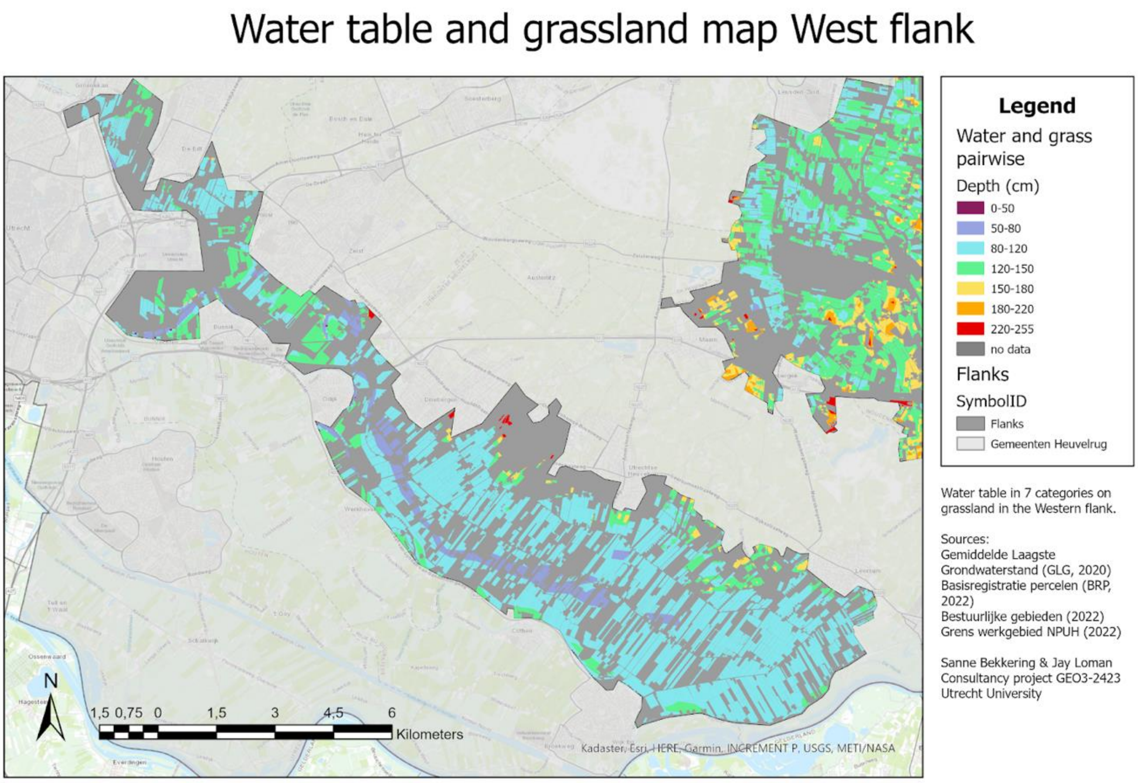

Figure 3.23. water table and grassland map western flank.

Appendix 8.3: Tables land area (ha) of soil, water, and plant system categories per flank

Table 3.30. Area in hectares and percentages per flank per soil class on grassland.

Flanks/Soil class	Clay (ha/%)	Loamy sand (ha/%)	Peat (ha/%)	Sand (ha/%)	Sandy clay (ha/%)	Sandy peat (ha/%)	Total (ha/%)
N	925.71 (16.66)	897.11 (16.14)	**2967.27 (53.39)**	167.83 (3.02)	94.40 (1.70)	505.21 (9.09)	5557.54 (100)
NE	-	**4186.83 (89.81)**	8.47 (0.18)	37.06 (0.79)	-	429.64 (9.22)	4662.00 (100)
SE	58.98 (6.79)	**439.45 (50.59)**	137.68 (15.85)	82.74 (9.53)	115.69 (13.32)	34.11 (3.93)	868.65 (100)
W	**1535.92 (42.53)**	722.81 (20.02)	-	126.26 (3.50)	1207.56 (33.44)	18.57 (0.51)	3611.14 (100)

Table 3.31. Area in hectares and percentages per flank per water table depth category on grassland.

Flanks/Water table (cm)	0-50 (ha/%)	50-80 (ha/%)	80-120 (ha/%)	120-150 (ha/%)	150-180 (ha/%)	180-220 (ha/%)	220-255 (ha/%)	Total (ha/%)
N	0.48 (0.01)	**3293.94 (59.80)**	1781.41 (32.34)	378.91 (6.88)	22.64 (0.41)	3.70 (0.07)	27.12 (0.49)	5508.20 (100)
NE	0.42 (0.01)	148.73 (3.29)	1330.20 (29.45)	**2011.80 (44.54)**	685.77 (15.18)	264.54 (5.86)	75.11 (1.66)	4516.57 (100)
SE	2.45 (0.30)	256.93 (31.13)	**323.08 (39.15)**	133.53 (16.18)	13.04 (1.58)	5.71 (0.69)	90.54 (10.97)	825.28 (100)
W	1.16 (0.03)	244.64 (6.87)	**2762.16 (77.57)**	502.73 (14.12)	39.52 (1.11)	1.40 (0.04)	9.41 (0.26)	3561.02 (100)

Table 3.32. Area in hectares and percentages for potential agroforestry plant combinations on grassland

Flanks/Plant system	**other**	**1 (ha/%)**	**2 (ha/%)**	**3 (ha/%)**	**4 (ha/%)**	**5 (ha/%)**	**6 (ha/%)**	**7 (ha/%)**	**Total (ha/%)**
N	4524.16 (82.87)	-	-	22.30 (0.41)	0.11 (0.00)	0.18 (0.00)	**912.53 (16.72)**	-	5459.29 (100)
NE	3826.60 (84.87)	1.73 (0.04)	-	**680.38 (15.09)**	-	0.01 (0.00)	-	-	4508.72 (100)
SE	745.76 (90.37)	2.29 (0.28)	-	8.50 (1.03)	-	3.13 (0.38)	**58.60 (7.10)**	6.92 (0.84)	825.21 (100)
W	1953.99 (54.95)	-	-	36.69 (1.03)	18.99 (0.53)	28.89 (0.81)	**1513.77 (42.57)**	3.40 (0.10)	3555.74 (100)

Appendix 8.4: Plant groups

See Excel file Appendix_plants_environmentalconditions. It contains 2 workbooks.

Appendix 8.5: Soil reclassification

See Excel file Appendix_soil_reclass_table_consultancy. Colour codes are based on soil pyramid (figure 3.6) for clarity.

Appendix 8.6: Python script in field calculator

Expression:

getSystem(!gridcode!, !FID_BRO_flanks_dis!)

Code Block:

#this function uses the code for the water level and the code for the soil category to assign a code for plant system/group. If none of the water and soil combinations are fulfilled, 0 is assigned as a placeholder

```
def getSystem(water, soil):
    if water == 6 and soil == 4:
        return 1
    elif (water == 6 or water == 5) and soil == 1:
        return 2
    elif water == 5 and soil == 2:
        return 3
    elif water == 4 and soil == 1:
        return 4
    elif water == 4 and soil == 4:
        return 5
    elif (water == 3 or water == 2) and soil == 1:
        return 6
    elif (water == 2 or water == 1) and soil == 4:
        return 7
    else:
        return 0
```

Appendix 8.7: Gantt Chart subgroup 2

Sanne	Feb 6, 2023	Apr 13, 2023	
GIS research for draft	Feb 6, 2023	Feb 26, 2023	Complete
Work on GIS	Mar 1, 2023	Mar 18, 2023	Complete
Combine literature and GIS	Mar 1, 2023	Mar 18, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Integration	Mar 27, 2023	Apr 7, 2023	Complete
GIS poster	Mar 28, 2023	Apr 13, 2023	Active
Presentation	Apr 8, 2023	Apr 13, 2023	Active
Final deliverable	Mar 28, 2023	Apr 13, 2023	Active
		Time elapsed	

Nelleke	Feb 6, 2023	Apr 13, 2023	
Literature research for draft	Feb 6, 2023	Feb 26, 2023	Complete
Literature + Excel	Mar 1, 2023	Mar 18, 2023	Complete
Interview	Mar 1, 2023	Mar 18, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Combine literature and GIS	Mar 1, 2023	Mar 11, 2023	Complete
Integration	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Active
Final deliverable	Mar 28, 2023	Apr 13, 2023	Active
		Time elapsed	

Jay	Feb 6, 2023	Apr 13, 2023	
GIS research for draft	Feb 6, 2023	Feb 26, 2023	Complete
Work on GIS	Mar 1, 2023	Mar 18, 2023	Complete
Combine literature and GIS	Mar 1, 2023	Mar 18, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Integration	Mar 27, 2023	Apr 7, 2023	Complete
GIS poster	Mar 28, 2023	Apr 13, 2023	Active
Presentation	Apr 8, 2023	Apr 13, 2023	Active
Final deliverable	Mar 28, 2023	Apr 13, 2023	Active
		Time elapsed	

Jara	Feb 6, 2023	Apr 13, 2023	
Literature research for draft	Feb 6, 2023	Feb 26, 2023	Complete
Literature + Excel	Mar 1, 2023	Mar 18, 2023	Complete
Interview	Mar 1, 2023	Mar 18, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Combine literature and GIS	Mar 11, 2023	Mar 31, 2023	Complete
Integration	Mar 27, 2023	Apr 11, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Active
Final deliverable	Mar 28, 2023	Apr 13, 2023	Active
		Time elapsed	

9 Appendix: Economic feasibility

Appendix 9.1: Disclaimer

Disclaimer: we cannot advise with certainty or quantitative substantiation on an economically viable BM. There is a lot of uncertainty on the economic feasibility of Agroforestry due to a knowledge gap and agroforestry still being in its infancy (expert 4; organization 3; Wigboldus, 2022). However, this does not mean that AS does not have economic potential. Literature and case studies show that agroforestry can strengthen the incumbent BMs of dairy farmers (expert 4; organization 3). For that reason, our research will advise on a BM that has the most potential for farmers in the flanks of the UH. Nevertheless, within our proposed BM, farmers need to be aware of the high investment costs, the transition period in which no revenue is made, and the economic uncertainty of AS (Selinc, 2019; Wigboldus, 2022; Nworij, 2022; Luske er al, 2020). Threats include strict political regulations, legal uncertainty, and high land prices. Agroforestry is in its infancy, therefore farmers transitioning to these systems face the burdens as pioneers.

Appendix 9.2: Scenario sketch of an Agroforestry farmer

Scenario: Henk Silvopastoral Agroforestry Farm

Henk is 40 years old and has a dairy farm with 100 cows on the flanks of the UH. His farm has been in the family for generations. With the changing climate, the nitrogen crisis and risk of being bought out, Henk is worried about the future of his farm. Henk wants to transition to a more sustainable form of farming; however, he lacks the knowledge and financial resources to do so. Fortunately, a local NGO wants to help Henk with the initial investment in an agroforestry farm.

With the extra money from the NGO to help him get past the initial investment barrier, Henk decides to start transitioning towards a SPS with a BM based on direct sales. He first plants 30 hazelnut trees. After 5 years the trees start producing their first nuts. He keeps these to enjoy for himself. A year later, the number of nuts is still small but large enough to start selling some to the local community from his farm shop. Over the next few years, he steadily builds a customer base in the local community through word of mouth. With his yield increasing every year, Henk can take on larger orders: The owner of the local bakery first tried Henk's hazelnuts a couple of years ago and now orders larger quantities of Henk's nuts to be used in his pastries.

After 10 years, the hazelnut production is running at full capacity. By this time, Henk has engaged with initiatives such as local2local to get his products to customers around the country. At the same time, he has started processing his hazelnuts into other products such as oil and nut butter. This has further increased his profit margins. Being a seasoned silvopasture farmer, Henk has also started giving workshops to other farmers interested in transitioning to a SPS and to interested citizens. With this, he can supplement his income from direct sales. He is now running a profitable, sustainable, and above all rewarding business.

Appendix 9.3: Overview potential inputs/outputs of SPS

Input: Potential Costs of the business with a SPS system	
Category	*Example*
Costs of woody trees - Investments of planting - Costs of maintenance - Costs of marketing - Costs of cutting	- Design, planting material, tree protection, irrigation system - Crop protection, fertilizers - Packaging, delivery
Allocated livestock costs	- food for cattle, medication, transport products
Costs of other business units:	
Material and equipment costs	- Depreciation, maintenance and/or lease for machines, - tools, land and buildings
Costs of labour	- for woody elements e.g. pruning, harvesting, management of the undergrowth, but also sorting, processing, packaging and sell products
Work by third parties Contract work	- loans
Energy and fuel	- for buildings, machines, watering installations
Additional	- financing costs, marketing
Transition costs: Potential changes (increase) in costs switching_to SPS are	
Category	Example
Costs of investments	Costs of investments; planting, maintenance and cutting of trees - Costs of setting up new sales channels - Purchase new machines - Increase in paid work or work by third parties -
Reduction of productivity of cattle or crops	Decrease in yields from crops or livestock due to reduction of land area
Reduced rate or return due negative interactions	Less yields (per ha) from woody elements, crops or livestock due to negative interactions between these components, for example: - Woody elements: higher exposure to wind than in sheltered orchard - Annual crops: increase in fungal infections due to higher humidity at lower temperatures - wind speed - Dairy and beef cattle: - Poultry: more eggs laid in outdoor areas

	instead of in stables
Losses	- Losses due to negative interactions between woody elements, crops, livestock and/or others business units
Outputs: Potential economic benefits of business with SPS	
Category	*Example*
Products from woody trees	- fruits, nuts, timber
Products from cattle	- milk, meat, wool
Revenue streams from other business units	- farming camping, rental of land or buildings, energy production, recreation or local stores (direct selling of products)
Benefits of other ecosystem services - To be expressed in € - To be expressed in value	- CO_2 compensation schemes - Biodiversity, landscape quality, soil and - water quality, increased job satisfaction
Subsidies	- Cap basic premium, eco-schemes, ANLb allowances - Subsidies from Duurzame Landbouw
Potential (social and ecological) additional returns due transition to SPS	
Category	*Example*
Direct benefits from woody trees	Sale of products Increase in subsidies such as eco-schemes Increase in ecosystem services, either in € or in value
Additional benefits of positive interactions between cattle and trees	- Woody elements: reduced disease/pest attack when fruit trees are in SPS instead of monoculture - Annual crops: less wind damage, improved pollination, improved microclimate - Dairy and beef cattle: improved milk yield or faster growth through shelter from sun, wind,rain, improved microclimate, more diverse diet → healthier cattle - Poultry: improvement of egg quality through improved use of free range
Additional benefits of other business practices as results of system	- Additional revenues of other business units due to positive influence of woody elements, for example: - Additional revenue from farm shops, due to the positive image of agroforestry farming - Farm camping: Increase in tourism due to improved landscape quality

	- Daytime activities: Greater diversity in work and improved work distribution over all seasons
Savings as a results of positive interaction between elements	Savings through positive interaction between woody elements, crops, livestock and/or others business units - Less or no crop protection due to better pest control - Less medication due to healthier livestock - Less irrigation due to lower evaporation of crops (thanks to a decrease in wind speed) - Use your own wood (chips) as stable bedding, compost or fuel - Increase in own animal feed production (feed hedges)

source: Wigboldus et al (2022)

Appendix 9.4: Overview inputs/ outputs of FFS

Input: Potential Costs of the business with a food forest-based AS	
Category	*Example*
Costs of woody trees Investments of planting Costs of maintenance Costs of marketing Costs of cutting	Design, planting material, tree protection, irrigation system Crop protection, fertilizers Packaging, delivery
Allocated livestock costs	food for cattle, medication, transport products
Costs of other business units	
Material and equipment costs	Depreciation, maintenance and/or lease for machines, tools, land and buildings
Costs of labour	for woody elements e.g. pruning, harvesting, management of the undergrowth, but also sorting, processing, packaging and sell products
Work by third parties Contract work	loans
Energy and fuel	for buildings, machines, watering installations
Additional	financing costs, marketing
Transition costs: Potential changes (increase) in costs switching to FFSbased AS are	
Category	Example
Costs of investments	Costs of investments; education, planting, maintenance and cutting of crops Costs of setting up new sales channels Purchase new machines Increase in paid work or work by third parties High initial cost of implementation due to complex nature of FFSs Costs of education Costs of maintenance and planting before the forest becomes productive
Reduction of productivity of cattle or crops	Decrease in yields from crops or livestock due to reduction of land area
Reduced rate or return due negative interactions	Less yields (per ha) from woody elements, crops or livestock due to negative interactions between these components, for example: Woody elements: higher exposure to wind than in sheltered orchard

	Annual crops: increase in fungal infections due to higher humidity at lower temperatures wind speed Dairy and beef cattle: Poultry: more eggs laid in outdoor areas instead of in stables
Losses	Losses due to negative interactions between woody elements, crops, livestock and/or others business units
Outputs: Potential economic benefits of business with a FFSbased AS	
Category	*Example*
Products from woody trees	fruits, nuts, timber
Products from perennial crops	carrots, potatoes
Products from other crops	berries, herbs
Products from cattle	milk, meat
Processed products	cheese, jam, ice cream
Revenue streams from other business units	farming camping, rental of land or buildings, energy production, recreation or local stores (direct selling of products)
Benefits of other ecosystem services - To be expressed in € - To be expressed in value	CO2 compensation schemes Biodiversity, landscape quality, soil and water quality, increased job satisfaction
Subsidies	CAP basic premium, eco-schemes, ANLb allowances Subsidies from Duurzame Landbouw
Potential (social and ecological) additional returns due transition to AS	
Category	*Example*
Direct benefits from woody trees	Sale of products Increase in subsidies such as eco-schemes Increase in ecosystem services, either in € or in value
Additional benefits of positive interactions between cattle and trees	Woody elements: reduced disease/pest attack when fruit trees are in AS instead of monoculture Annual crops: less wind damage, improved pollination, improved microclimate Poultry: improvement of egg quality through improved use of free range
Additional benefits of other business practices as results of system	Additional revenues of other business units due to positive influence of woody elements, for example:

	Additional revenue from farm shops, due to the positive image of agroforestry farming Farm camping: Increase in tourism due to improved landscape quality Daytime activities: Greater diversity in work and improved work distribution over all seasons
Savings as a results of positive interaction between elements	Savings through positive interaction between woody elements, crops, livestock and/or others business units Less or no crop protection due to better pest control Less medication due to healthier livestock Less irrigation due to lower evaporation of crops (thanks to a decrease in wind speed) Use your own wood (chips) as stable bedding, compost or fuel Increase in own animal feed production (feed hedges)

source: Wigboldus (2022)

Appendix 9.5: Overview short chain initiatives in Utrecht

	Type of initiative	Description
	Business initiatives:	Facilitating connection between supply and demand. Logistical organization that decreases threshold for entry of new participants for both new producers and also consumers.
	For large-scale purchase	
1	Local2Local	Online platform that not only facilitates local consumption through direct sales, but also supports young talents who want to take initiative in the food transition. Through collaborations, local2local is involved in the food transition. In Utrecht, the initiative has been operating for five years and has built a network of more than fifty producers with whom it delivers orders in the area.
2	Boerenhart	The Boerenhart initiative delivers products from producers from the Veluwe and Gelderse Vallei throughout the Netherlands, including in Utrecht. The network consists of more than twenty-five hundred producers.
3	BD-totaal	BD-Totaal supplies a wide range of producers to the volume of a wholesaler to retail and cater customers from all over the Netherlands. Private customers who live near their warehouse in Houten may place orders with BD-T. Products are sourced from a limited number of food producers in the province of Utrecht.
	For private purchase	
4	PuurDichtbij	PuurDichtbij is an initiative that aims to connect twenty-five local providers with local consumers. On the website, which is designed as an e-business hub tool, consumers can order products, pay for them and have them delivered free of charge.
5	Locals Utrecht	The initiative focuses on helping local providers with short-chain sales through a parcel service. It tries to make local consumption more accessible with a parcel service. They have a network of currently forty producers who assist in marketing.
6	De Lokalist	Lokalist wants to make local product offerings accessible to consumers from all over the country. They call this creating what they call a "with-each-other market. The initiative brings together several smaller vendors, retailers and farmers who want to market locally. These are now forming into a network of more than 100 providers where consumers can order products, which are picked up by DL and taken to the sorting center, or hub. After the orders are sorted together, they are delivered to their homes.

	Consumer initiative	Facilitates sales markets in the form of a collective or network of private consumers. Makes entry of new consumers more accessible. Contributes to expanding the sales market.
7	Voedsel Collectief Utrecht	Food Collective Utrecht is a consumer initative dedicated to making local food available in Utrecht. All farmers the collective works with live at a maximum distance of 35 kilometers from Utrecht city. Bi-weekly, the collective collectively places orders with their partner farmers. Participants share responsibility for communication to the collective, contact with the farmers, administration, technology, distribution and transportation.
8	Voedsel Kollectief Amersfoort	Voedselkollektief Amersfoort is an initiative that aims to encourage social connection between farmers and neighbors by supporting local and organic agriculture. They want to do this by shortening the food chain and reaping the associated economic, social and ecological benefits. The initiative maintains a reach for producers within a 25 kilometer radius of Amersfoort.
	Producenten Initiatief	Facilitates farmers in the form of a collective or network of private producers. Makes entry of new producers more accessible. Contributes to the expansion of the production network, enabling scale-up.
9	Groene Hart Cooperatie	The Groene Hart Coöperatie (GHC) delivers producers from the rural area between the Randstad, called the Green Heart, to consumers in that same area. The initiative does this under the STREEK brand. The initiative has a network of 35 producers, whose production is connected to the market online
	Overarching initiative	Supports accession of small producers to the AVN, which promotes expansion
10	Utrecht Food Freedom	The initiative is facilitated by the province and focuses on making the urban food culture in this area more sustainable. It aims to use the existing expertise within the Utrecht network to support the short food chain and make food consumption more sustainable. To this end, they act as a platform that shares information and connects different parties. The initiative supports producers in obtaining knowledge and expertise. The initiative also encourages citizen participation.
11	Food-print Utrecht Region	Food-Print Utrecht Region is an initiative resulting from a collaboration between Rabobank Utrecht and a variety of different organizations working together on the food transition in Utrecht by sharing knowledge, networking and inspiration.
12	Taskforce Korte Keten	Short Chain Taskforce (TKK) is a foundation that supports entrepreneurs with an active short chain initiative or with the desire to start such an initiative. They do this by sharing knowledge and tools. According to the Ministry

		of Agriculture, Nature and Food Quality, TKK is the leading organization in the development of short food chains.
13	Food Volk	Since 2019, GoedVolk is a foundation initiated by a group of residents of the UH who want to make a positive contribution to the sustainability of the UH region. Through working groups they contribute to the producer market and increase knowledge among consumers about local consuming
	Government Driven Initiative	
14	Leader Utrecht Oost	European grant program for bottom-up rural developments. Its grants are given to ideas that strengthen the urban-rural connection, including in the area of food. For example, LEADER wants to achieve a better match between supply and demand to meet the growing demand for local food
15	Lokaal Voedsel Utrecht (LVU)	This is a government-commissioned initiative that aims to connect supply and demand through the regional short chain. LVU works on behalf of the government and carefully links buyers and suppliers of local products at so-called 'meet & match' meetings. Here the emphasis is on 'business' matches between, for example, catering or retail buyers and producers

Source (Bodewes, 2021)

Appendix 9.6: Alternative revenue streams

Revenue stream type	Revenue stream	Description	Potential	Financial considerations
Ecosystem service-related	Carbon credits	Farmers are paid for carbon sequestration by vegetation on their land	Lot of research and political attention, likely to become more common (McKinsey&Company, 2021) Agroforestry farms have higher potential than conventional farms (silvopasture farmer) - Still highly uncertain (Prins, 2017)	Clear-cut economic value of the different ecosystem services has not yet been determined (Wennink, 2021; Prins, 2017). Negligible investment costs Not likely to form a large part of revenue (organisation 3)
	Water retention (organisation 4)	Farmers are paid for water retained on their land	High potential for FFSs, as they retain most water. When retention is part of *waterschap*'s* water plan, farmers are paid for retaining water . System is still new and has not been used by a lot of farmers.	
	Ecosystem fees (Hendriks, 2021; Brouwer, 2018).	Farmers are paid for the ecosystem services produced on their land	Pilots are running in different parts of the world Still very rare Higher potential for FFSs	
Recreation	Tours	Farmers provide (educational) tours of their land for citizens and other farmers	Tours for other farmers have similar potential for SPS and FFSs (silvopasture farmer) Tours for citizens have higher potential	Low investment costs Requires extra labour and skills (bodemzicht, n.d.) Depending on frequency can be a significant

			for FFSs (bodemzicht, n.d.)	revenue stream (bodemzicht, n.d.)
	Events (FP, 2023)	Farmers make their land available for events	Potential for smaller events (e.g. dinner parties) Higher potential for FFSs	
	Workshop (silvopasture farmer; organisation 4)	Farmers provide workshops to citizens and other farmers	Potential for workshops on agroforestry practices Potential for workshops on raw product processing	
Other	Subscription (Waalgaard, n.d.; Veen & Groot, 2017)	Farmers adopt a subscription-based harvesting system	Part of the harvest is done by people with a subscription High potential for FFSs	Less labour costs Investment in system required
	Renewable energy (organisation 4)	Farmers dedicate a section of their land to renewable energy generation	Could be done on unproductive land Large land area required	High costs Takes up space Potential for high revenue
	Hospitality	Farmers open a hotel/camping/restaurant on their farm	Most suited for farmers with experience in this sector (organisation 4) Lot of successful casestudies (De Gloepe, n.d.)	Has potential to form large part of revenue (upto 50%) (organisation 4) Relatively high (investment) costs (organisation 4)

Appendix 9.7: Sub-sub questions and methods used for research scope

Overarching Subquestion 3: What is required for an economically viable agroforestry BMin the market context of dairy farms at the UH?	
3.1 What does the most prominent dairy farming BMin the UH look like?	a. How can the market context of dairy farming in the Netherlands be described? (PESTEL) b. Which BMs are currently the most common in the Netherlands (and, by extension, at the UH)? c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure)? (BMC) d. What are the main strengths, weaknesses, risks and opportunities of these BMs? (SWOT)
3.2 What are the most attractive BMs for agroforestry farming systems in the context of the UH?	a. How can the market context of agroforestry in the Netherlands be described? (PESTEL) b. Which agroforestry BMs would be most suitable for implementation at the UH? c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure, ease of transition)? (BMC) d. What are the strengths, weaknesses, risks and opportunities of these candidate BMs? (SWOT) e. How do the candidate systems compare to each other and to the baseline?
3.3 How viable are the proposed BMs when focusing on direct selling within the context of the UH flanks?	a. What is the economic viability of the proposed AS? b. How can direct selling be incorporated in these systems' BMs? c. What are alternative revenue streams that could supplement direct selling?

Appendix 9.8: Search terms used for literature research

Sub-question	English search terms	Dutch search terms
3.1a. How can the market context of dairy farming in the Netherlands be described?	Business models dairy farms EU dairy market Netherlands dairy export	Zuivelmarkt Nederland Zuivelboerderijen
3.1b. Which BMs are currently the most common in the Netherlands (and, by extension, at the UH)?	Dairy farms netherlands conventional agriculture economics organic dairy farming pasture farming	Melkveehouderij Utrechtse Heuvelrug melkveehouderij business model verdienmodel melkveehouderij
3.1c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure)? (BMC)	conventional agriculture economics agriculture costs Business models european agriculture BMC dairy farms	Businessmodellen Nederlandse melkveehouderij
3.1d. What are the main strengths, weaknesses, risks and opportunities of these BMs? (SWOT)	Dairy farming SWOT framework Netherlands dairy farming weaknesses dairy farming strengths dairy farming threats	SWOT analyse melkveehouderij melkveehouderij businessmodel
3.2a How can the market context of agroforestry in the Netherlands be described?	agroforestry market netherlands agroforestry market trends	agroforestry markt nederland stikstofcrisis
3.2b. Which agroforestry BMs would be most suitable for implementation at the UH?	Agroforestry business models Agroforestry implementation costs	Bos-landbouw nederland Agroforestry Nederland
3.2c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure, ease of transition)? (BMC)	Agroforestry systems activities Agroforestry systems value creation	Agroforestry systemen Agroforestry kosten en inkomsten
3.2d. What are the strengths, weaknesses, risks and opportunities of these candidate BMs? (SWOT)	food forest strengths silvopastoral strenghts food forest weaknesses	Food forest sterktepunten Food forest bedreigingen Silvopasture sterktepunten

	silvopastoral weaknesses food forest risks silvopastoral risks food forest opportunities silvopastoral opportunities	Silvopasture bedreigingen
3.2e. How do the candidate systems compare to each other and to the baseline?	agroforestry strengths food forest advantage silvopastoral advantage conventional dairy farming advantage,	verschillen food forest silvopasture verschillen agroforestry conventionele landbouw voordelen conventionele landbouw voordelen agroforestry
3.3a. What is the economic viability of the proposed AS?	Agroforestry viability Agroforestry best practices	Agroforestry haalbaarheid Agroforestry succesverhalen
3.3b. How can direct selling be incorporated in these systems' BMs?	Direct sales agroforestry Direct sales advatages Direct sales channels farmers Netherlands	Directe verkoop agroforestry Directe verkoop boeren Utrecht
3.3c. What are alternative revenue streams that could supplement direct selling?	Agroforestry revenue streams Agrofrorestry alternative revenue streams	Agrofrestry inkomstenbronnen Agroforestry alternatieve inkomstenbronnen

Appendix 9.9: Data Analysis method used for each subquestion

Sub-questions	Data Analysis
3.1a. How can the market context of dairy farming in the Netherlands be described?	Literature review
3.1b. Which BMs are currently the most common in the Netherlands (and, by extension, at the UH)?	Literature review Qualitative text analysis
3.1c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure)? (BMC)	Literature review Qualitative text analysis
3.1d. What are the main strengths, weaknesses, risks and opportunities of these BMs? (SWOT)	Qualitative text analysis Literature review
3.2a. How can the market context of agroforestry in the Netherlands be described? (PESTEL)	Literature review Qualitative text analysis
3.2b. Which agroforestry BMs would be most suitable for implementation at the UH?	Literature review Qualitative text analysis
3.2c. What do these BMs look like (key activities, revenue streams, value creation, channels, cost structure, ease of transition)? (BMC)	Literature review Qualitative text analysis
3.2d. What are the strengths, weaknesses, risks and opportunities of these candidate BMs? (SWOT)	Literature review Qualitative text analysis
3.2e. How do the candidate systems compare to each other and to the baseline?	Literature review Qualitative text analysis
3.3a. What is the economic viability of the proposed AS?	Literature review Qualitative text analysis
3.3b. How can direct selling be incorporated in these systems' BMs?	Literature review
3.3c. What are alternative revenue streams that could supplement direct selling?	Literature review Qualitative text analysis

Appendix 9.10: Adjusted BMC

Element	Parameters
Value Proposition	What different types of value (people, planet, profit) are delivered by the business model, and for whom? What value do we deliver to the costumer? Which one of our costumer's problems are helping to solve? What bundles of products and services are we offering to each costumer segment? Which costumer are we satisfying?
Key Activities	What are the key activities of the business?
Cost structure	What are the most important costs inherent in our business model? Which key resources are most expenses? Which key activities are most expensive?
Revenue Streams (Only used for conventional farming BMC)	What do I get in return for the added value I deliver How do I get paid? (subsidies) How is revenue assessed and collected? (subscription)
Channels	Through which channels do our customer segments want to be reached? How are we reaching them now? How are our channels integrated? Which ones work best? Which ones are most cost-efficient?
Ease of transition (only used in Agroforestry BMC)	What is the ease of transitioning to this BM? Parameters: costs of implementation, rate of return, timespan of return

Appendix 9.11: Abbreviation table

Abbreviation	Meaning
AS	Agroforestry System
B2B	Business to business
B2C	Business to consumer
BMC	Business model canvas
BM	Business model
UH	Utrechtse Heuvelrug
FFS	Food Forest System
SPS	Silvopastoral System

Appendix 9.12: Nodes used for coding the interviews

Color	Theme
Red	Dairy Farming
Dark Blue	Silvopastoral
Green	Food Forest
Yellow	Agroforestry
Purple	Revenue Model
Pink	Alternative Revenue Streams
Orange	Transition
Light Blue	Market Trends

Appendix 9.13: Gannt Chart subgroup 3

Archie	Feb 6, 2023	Apr 13, 2023	
Proposal writing-analytical framework	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews (NVIVO etc..)	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

Jonathan	Feb 6, 2023	Apr 13, 2023	
Proposal writing-analytical framework	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews (NVIVO etc..)	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	

Minou	Feb 6, 2023	Apr 13, 2023	
Proposal writing-analytical framework	Feb 6, 2023	Feb 26, 2023	Complete
Final proposal	Feb 20, 2023	Feb 27, 2023	Complete
Interview questions/preperation	Feb 27, 2023	Mar 5, 2023	Complete
Literature review	Feb 27, 2023	Mar 3, 2023	Complete
Search for interview contacts	Feb 27, 2023	Mar 1, 2023	Complete
Interviews	Mar 6, 2023	Mar 19, 2023	Complete
Draft chapters	Mar 6, 2023	Mar 24, 2023	Complete
Analysis interviews (NVIVO etc..)	Mar 16, 2023	Mar 23, 2023	Complete
Integrative part	Mar 27, 2023	Apr 7, 2023	Complete
Presentation	Apr 8, 2023	Apr 13, 2023	Complete
Final paper and deliverable	Mar 28, 2023	Apr 13, 2023	Complete
		Time elapsed	