Consultancy Advice

A Multifunctional Landscape for the Future

Combining innovative and traditional forestry practices to address long-term goals in the IJsselvallei

Commissioner:

Bureau Peter de Ruyter Landschapsarchitectuur

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A Multifunctional Landscape for the Future: Combining innovative and traditional forestry practices to address long-term goals in the IJsselvallei

ACT number 2645:
Reintroducing traditional 'Rabatbos' practise for a vital, resilient and multicoloured IJssel-landscape of the future

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LEAFIX
FORESTS OF THE FUTURE

Preface

This report is conducted by Leafix in commission of Peter de Ruyter Landschapsarchitectuur and Shavonne Korlaar of the municipality of Voorst. The project was supervised by our coach Ir. JM (Jim) van Laar and our academic advisor Prof. Dr. Ir. GJMM (Gert-Jan) Nabuurs. We would like to thank both Jim and Gert-Jan for their enthusiasm and the feedback they gave us, which helped the Leafix team to move forward during the process. Also, we want to thank Waterschap Vallei en Veluwe for the information they provided about the hydrology in the IJsselvallei, and a special thanks to Maarten Veldhuis who shared with us some very helpful information about the project area. Next to that, Ir. M (Marjan) Wink supervised our team process-wise, which we are thankful for since it allowed us to learn more about the team dynamics in our group and hence contributed to the final products.

Team Leafix is proud to present this report and enjoyed working on the project. We all learned a lot along the way, both process-wise as content-wise. For this opportunity we would like to thank our commissioners, and we hope the final products will be a helpful contribution in the challenge to make the IJsselvallei more 'future-proof'.

Executive Summary

Leafix Consultancy was commissioned by Peter de Ruyter Landschapsarchitectuur to investigate the role that rabatbossen could take in addressing the current and future challenges faced in the southern IJsselvallei area. The challenges are both ecological (increasing summer droughts due to climate change, and loss of biodiversity due to land use change) and social (the need to draw tourism pressure away from the neighbouring Veluwe) and must be addressed in a way that maintains economic viability. As such, the long-term goal is to take these into consideration leading to a more vital, resilient, and colourful landscape. Within the target area, there are multiple stakeholders that are involved in reinventing the area, such as the VeluweAlliantie, The Province of Gelderland, landowners - including nature and tourism-oriented organisations -farmers, and the Water Authority *Waterschap Vallei en Veluwe*.

The original purpose of the rabatbos was to create forest in places that were otherwise too wet. As this is no longer the case in the IJsselvallei, the focus instead becomes creating new types of forest and adapting forests to increase water retention. Traditional rabatbossen should be maintained for cultural heritage purposes or adapted for biodiversity and recreational use to increase tourism to the IJsselvallei.

Leafix proposes the introduction of a multifunctional landscape consisting of four different types of forest. Each one addresses the main challenges in different ways and to varying degrees, in order to create an aesthetically pleasing landscape that is climate change resilient and provides revenue for landowners. The four types of forest are Food Forest, agroforestry, rabatbos and our innovative new Toekbos. Conceptual designs and implementation strategies are presented for each of the four suggestions, as well as a combination of the forest types in a mosaic design.

Samenvatting

Leafix adviesbureau is de opdracht gegeven om onderzoek te doen naar de rol die rabatbossen kunnen vervullen in de huidige en toekomstige uitdagingen in het zuiden van de IJsselvallei. Deze uitdagingen zijn zowel ecologisch (toenemende droogte ten gevolge van klimaatverandering en het verlies van biodiversiteit door verandering in landgebruik) als sociaal (het verminderen van de druk van toeristen in de Veluwe) georiënteerd, en moeten op een dusdanige manier worden aangepakt die past binnen een duurzaam economisch systeem. Het lange termijn doel is om, met het oog op deze uitdagingen, een levendig, veerkrachtig en kleurrijk landschap te creëren. Binnen het onderzoeksgebied zijn meerdere belanghebbende betrokken, waaronder de VeluweAlliantie, Provincie Gelderland, landeigenaren - inclusief natuur- en toerisme georiënteerde organisaties -, boeren, en het Waterschap Vallei en Veluwe.

Het oorspronkelijke doel van het rabatbos was om bos te creëren in gebieden die te nat waren. Omdat de IJsselvallei momenteel niet meer nat is, is de huidige focus in het gebied om bossen te creëren en huidige bossen aan te passen op een zodanige manier dat het gebied beter in staat is water vast te houden. De rabatbossen - zijnde cultureel erfgoed - moeten worden beheerd of aangepast, zodat het gebied beter geschikt zal zijn voor meer biodiversiteit en recreatief gebruik door toeristen.

Leafix presenteert een multifunctioneel landschap dat bestaat uit vier verschillende type bossen. Ieder type bos adresseert de uitdagingen in de IJsselvallei op een verschillende manier en met verschillende mate. De combinatie van deze bossen levert een esthetisch en aantrekkelijk landschap op dat veerkrachtig is tegen klimaatverandering terwijl ook de landeigenaren van inkomsten worden voorzien. De vier bostypes zijn het rabatbos, een voedselbos, een boslandbouwsysteem, en ons innovatieve ‘Toekbos’. In dit rapport worden voor ieder type bos conceptuele ontwerpen en implementatie strategieën gepresenteerd.

Contents

Part I: Leafix Advice

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Reforestation of the IJsselvallei

The IJsselvallei is facing multiple challenges in the future such as climate change, loss of biodiversity, intensification of agriculture, and ever-increasing tourism. In the southern part of the IJsselvallei, new forested areas can help to meet these goals. As climate change is an ongoing battle, these new forested areas should be able to adapt to, and mitigate, future climatic challenges while maintaining viable income streams. The proposed advice includes four different types of forest that will be combined in the IJsselvallei to create a mosaic of different forest types and create a diverse, attractive landscape that tackles all the stated challenges.

The location of each forest is determined by the presence of landscape elements, such as the proximity of a city or village, an existing forest or agriculture. The four different types of forest including their main functions are:

- Food Forest - Biodiversity & economic viability
- Agroforestry - Economic viability
- Traditional rabatbos - Tourism & educational based
- Toekbos - Biodiversity, water retention & tourism

All these different forests can be used in relation to climate mitigation by carbon sequestration, as trees take up carbon no matter where they are planted.

The four different types of forest should be implemented in existing forests or on agricultural fields to enhance the current values regarding the four challenges in the IJsselvallei. The old rabatbos should be kept or maintained, or even brought back to old glory, however, they should not be created in new areas. An important challenge in the IJsselvallei is water retention. Although only the Toekbos is stated to focus on water retention, it is important to remember that forests in general are better for water retention than open fields. This is due to the strong groundwater effects of the roots and their ability to store water during the wet months and retain it during the drier months. In this sense, water retention implies the slowing down of the hydrological system as well as the increase in water storage capacity. The other challenge for the IJsselvallei is to encourage tourism and recreation within the IJsselvallei instead of the Veluwe. Again, it is important to remember that a diverse landscape is more aesthetically pleasing, so incorporating these approaches across the landscape will have a positive effect.

Within the study area, the already existing forest can be connected with these proposed forests, which will help strengthen the ecological connection zones (*Gelders Natuurnetwerk*). In some places within the study area, there are opportunities to create a forest that contains all four different forest types, which will be referred to as a mosaic forest in this advice. Several elements can be found in all the different types of forest, for instance the use of *Klompenpaden*, which can connect the forests for tourists but also increase local participation. The interpretation of the different forests, and what should be included and why, will be explained per forest with an illustration and explanatory text. Suggestions are made regarding where to place them within the study area. However, these locations are determined based on generic landscape elements, meaning the suggestions are not so precise and the forests can be implemented in different locations (Figure 1).

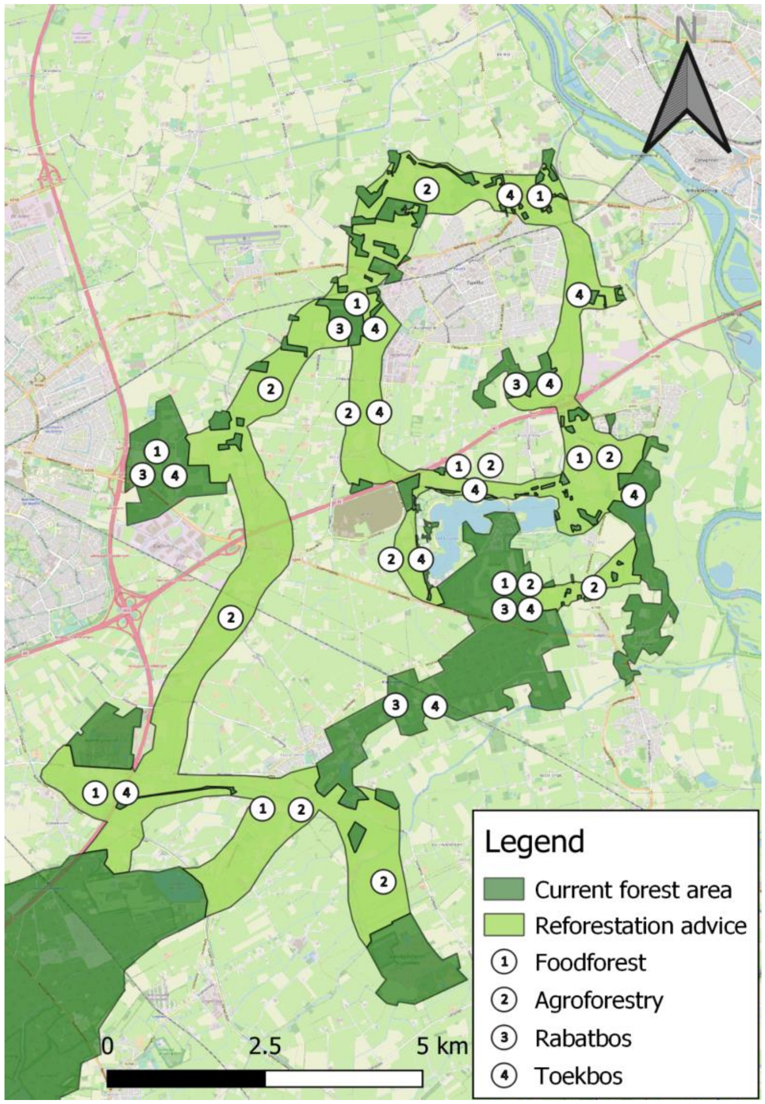

Figure 1: overview of the southern IJsselvallei with the current forest area and suggested reforestation areas (2146 ha). The general location of the four advised forest types is given.

Food Forest

A Food Forest will have the climate mitigation functionalities of a forest while providing a possible source of income from the production of fruits, vegetables, and herbs. Before the implementation of a Food Forest, it is fundamental to have a well thought-out and detailed design as this will play an important role in the development of the forest. To facilitate this phase, it is advised to divide the forest into nine layers and make considerations for all of them as represented in Figure 2. Before the implementation, it is also important to have information about environmental factors influencing the area such as soil, pH, groundwater, nutrients, temperature, and wind. Furthermore, in the design it is advised to consider factors such as the spaces between plants and the exact position of each species as this will influence the competition between plants for light, water and nutrients but will also have an influence on the positive (synergy) or negative (allelopathy) relationship between them. While planning a Food Forest there are several adjustments that can be made to facilitate its implementation. The introduction of vegetated windbreaks made with tall trees to protect wind-sensitive species and crops or the introduction of drought-resistant species to gradually recreate a suitable microclimate for desired but drought-sensitive plants.

In addition, it is important to consider a business plan with all factors, such as the delayed income due to the time it takes to be at full production capability and loss of harvest due to wildlife, birds or pests. Establishing and implementing a Food Forest will require local cooperation and volunteer groups. Food Forests should therefore be implemented close to villages to ensure easy access for locals. It could be implemented in existing forest or agricultural land or as a connection between urbanised areas and forest. To further increase its value and attract the public's interest it is advised to combine the Food Forest with other elements such as the introduction of a particular type of animal (e.g. peacocks), a B&B in the middle of the garden or a system that allows people to rent a part of the forest as a vegetable garden. It can also be combined with farm-to-fork selling of produce or paid guided workshops for tourism revenue.

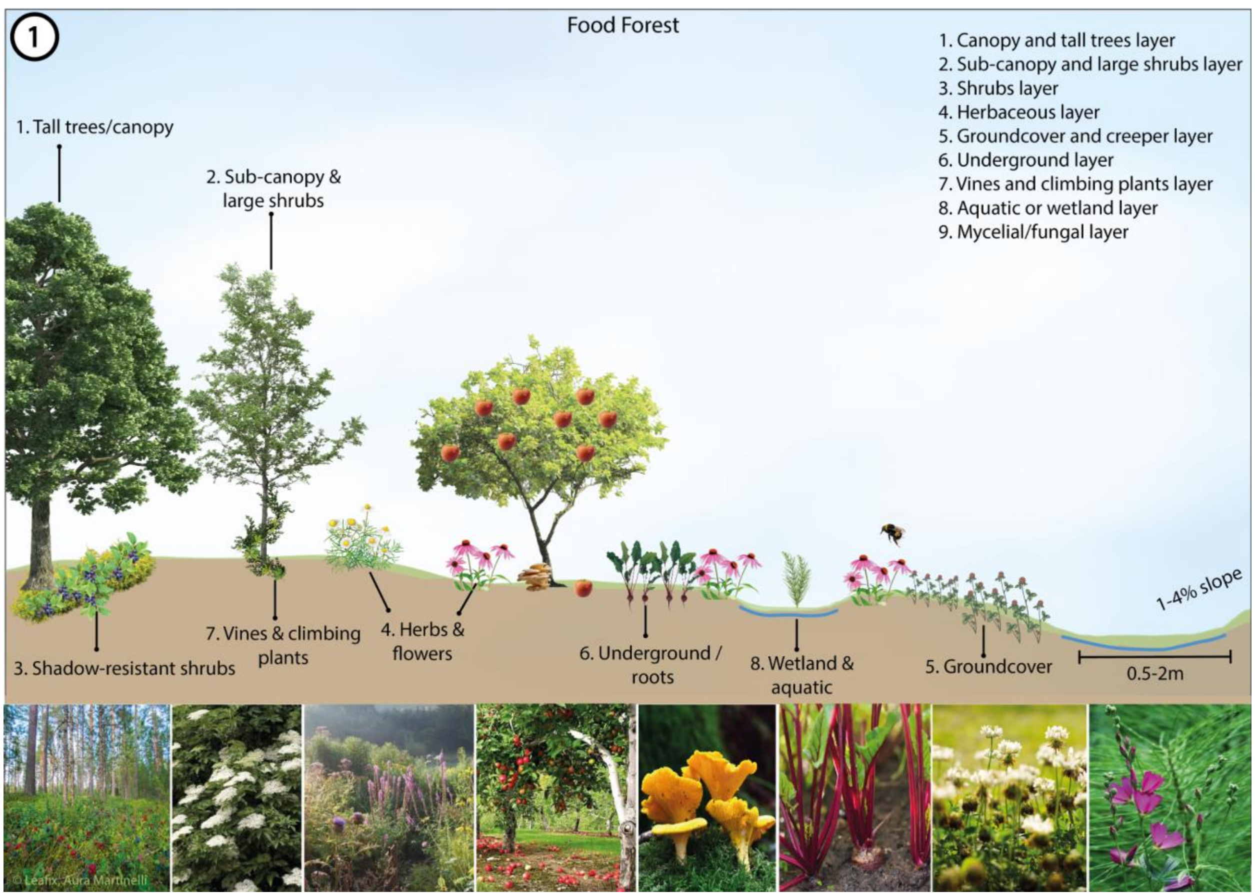

Figure 2: A cross section of the Food Forest type

Agroforestry

As trees are important for water retention, but costly to implement with a delay until any harvest, it may be difficult to ask farmers to convert parts of their land. However, the benefits of combining trees and crops have been demonstrated, so agroforestry is a good method to persuade farmers to plant trees as they will still receive their annual income from crops until the trees are harvestable. If well managed, over a slightly longer timeframe their revenues can increase.

A version of alley cropping is the best option. This allows wide rows of crops (or pasture) that are accessible via machine, so no impact to current farming practices. The rows of trees are narrower and the optimal distance between the rows of trees is 20 times the height of the tree. If they can be aligned north-south, this will limit any competition for light. More north-west to south-east alignment would cross the direction of the gradient from the Veluwe towards the IJssel so will have the greatest effect of water retention within the soil as seepage will be slowed by the changes to the soil structure and hydraulic lift from the tree roots. Rows of trees can also be seen as biodiversity corridors, linking separated forest areas. To further diversify the revenue streams of the farmers, the trees could be a combination of short rotation coppice, such as poplars, and high value fruit trees. Fruit trees are also multipurpose. Next to fruit production they can be used for timber or foliage kept for compost or winter animal feed.

Although agroforestry cannot be adapted from an existing rabatbos, where one is present next to a crop field it could be used in a similar way, with fruit trees or coppice. The lower height of such trees allows more light to reach the crops so it is a better transition between tall forest and cropland. Trees with nitrogen-fixing properties, such as *Robinia* could add a further advantage. For small crop fields, a surrounding hedgerow may be all that is possible, rather than alleys. Where soil has become compacted, swales following the alleys may help with water infiltration. This could also give a similar look to a rabatbos while not preventing the use of machinery (Figure 3).

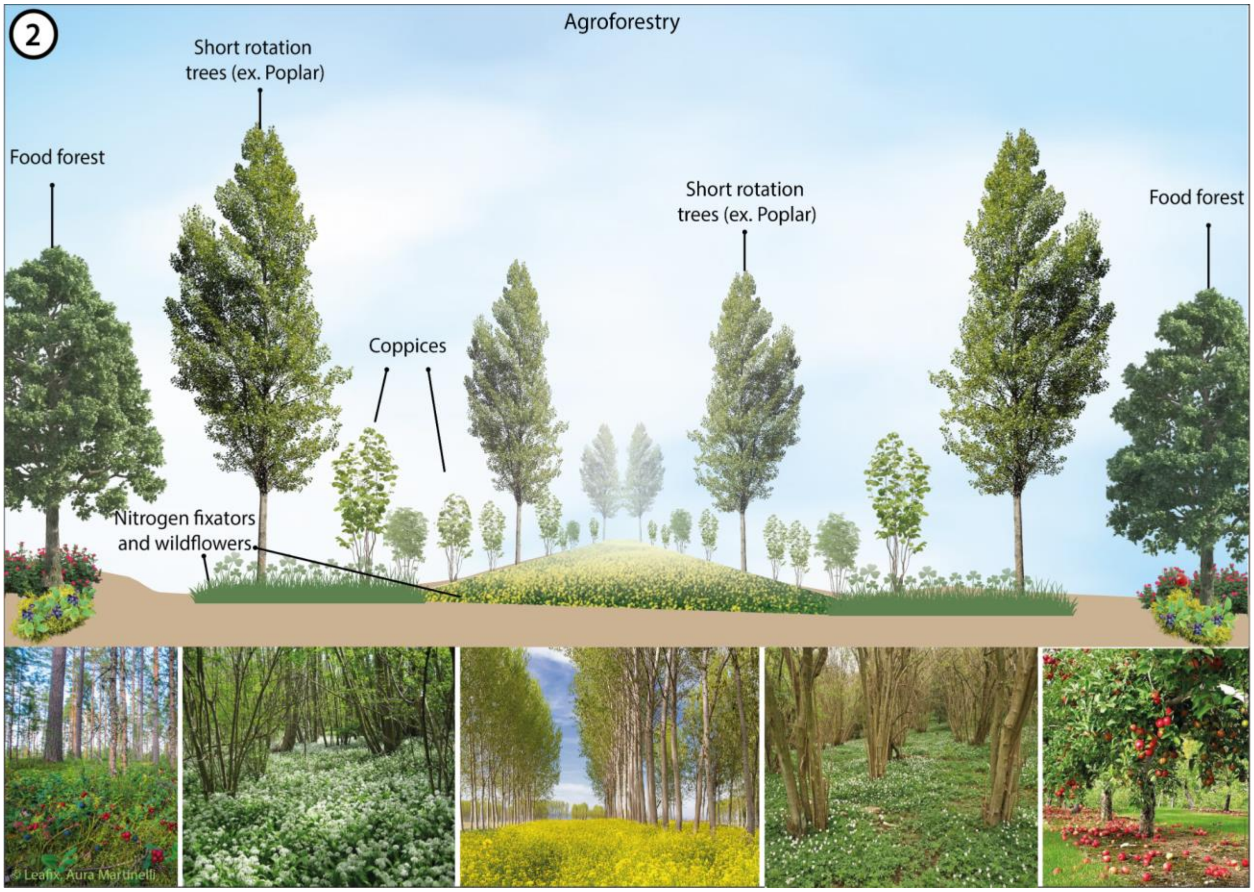

Figure 3: Cross section of the agroforestry forestry type combined with Food Forest. The lower bar provides possible examples of how agroforestry could look.

Rabatbos

Within the study area there are multiple rabatbossen located in forested areas and most of them are part of estates (*Natuurschoonwet Landgoederen*). The rabatbossen originally - until the late 19th century - served as a forestry practice to make the wet soils drier in order to increase efficiency for coppice production. Hence rabatbossen are considered a cultural heritage by the Dutch Government. The rabatbossen are characterised by an alternation of ditches and dykes across the landscape, where the dykes serve as suitable dryer soils for trees to grow. This functioning of the rabatbossen does not match the current and future hydrological situation in the IJsselvallei. Therefore, it is not advised to expand the current rabatbossen, and other types of forests are needed in order to improve the capacity of the IJsselvallei to adapt and mitigate to current and expected climate change. However, if groundwater levels were to recover to their former levels, the rabatbossen could regain their original purpose.

Nevertheless, a forest on rabatten is an interesting forestry practice that could attract tourists, partly due to the outstanding appearance of the forest and partly due to its historical background. There are several options that contribute to the attraction of tourists in the area. First, the rabatbossen are interesting for educational purposes (e.g., school visits and workshops), for which information signs can be used as a main tool. Second, hiking trails (*Klompenpaden*) can be extended and used as a connection between the different types of forests proposed in this advice. These two options are further elaborated on in the last part of this advice. Thirdly, the wavy shape of rabatbossen is attractive for mountain bikers. Nowadays, no mountain bike trails are found in the IJsselvallei, hence it is proposed to implement these trails in the rabatbossen indicated on the main map.

In order to make rabatbossen more attractive for tourists they need to be restored to their historical appearance, meaning a clear difference between the ditches and dykes. Because of the large amount of present rabatbossen in the area, it is advised to select several rabatbossen that will be restored to their original shape. Ideally, this selection is based on the accessibility for tourists, the possibility to connect the rabatbos with other forest types and the proximity to other tourist attractions (e.g., recreational area of *Bussloo*). After restoration of the selected rabatbossen, they need to be conserved, meaning for instance litter removal. Landowners will be free to decide how to manage the revenue, for example maintaining a tall timber forest or a coppice, but there will need to be much collaboration with the tourism sector to install features like the information boards and maintain the site.

Toekbos

In order to combat droughts and to increase the climate adaptability of the IJsselvallei, it is proposed to introduce a new type of forest. For this new type, a new name has been thought of the Toekbos, which comes from a contraction of *toekomstig bos* in Dutch. This Toekbos can either be converted from a traditional rabatbos or from previous agricultural fields. Several components are needed in this forest to be sustainable regarding biodiversity and water retention. An overview of these components can be seen in Figure 4a and Figure 4b. The emphasis of the Toekbos is to create a heterogenous landscape that reflects the original character of the IJsselvallei.

The current amount of water in the soil is not sufficient for a wet habitat to exist, hence measurements should be implemented to increase the water table. In order to do this, ditches should be closed, and swales should be constructed in the landscape. In these swales, water is able to slowly infiltrate the soil beneath due to their size and shape. As this happens, swales allow water to remain more easily in the system compared to the ditches in traditional rabatbossen, where the water is extracted from the surrounding soils and pools in the ditches. An important aspect to consider here is the size of the swales and the scale on which they should be implemented. It is proposed to have a length of at least 30 meters, a base width of 0.5 to 1 meter and a slope of 1 to 4 percent. Moreover, they should be placed perpendicularly to rivulets or to the slope of the area, in order to intercept the run-off of water. As these swales also imply a gradient - from dry to wet - in the landscape, a diversity of different habitats will be created. This will allow different both dry and wet tolerant plant species to settle. In the lower parts of the swales, seasonal flooding gives rise to the wet alluvial forests, which have disappeared from the area. This should benefit the biodiversity while also providing water sources during dry periods. On the drier parts the current species composition can persist. As a consequence, a more heterogeneous landscape is created, from which multiple groups of animal species can benefit, for instance insects, soil organisms and birds.

When this method is insufficient to restore the hydrology, other approaches are possible. Another proposed implementation for the Toekbos are weirs. These can be constructed in the main brooks in the area, and they are expected to increase the water table in their vicinity. The third proposed component is to restore some of the brooks to their natural state by closing surrounding ditches and lowering the banks. This will increase the groundwater table and allow the brooks to have a more natural watercourse. Moreover, these measurements - in combination with an expansion of forested areas - will cause a slowing down of the groundwater system. Consequently, water will be discharged from the area less easily and thus more water can be retained.

Although the main services provided by the Toekbos are biodiversity and water retention, the forest is also appealing for tourists to visit due to its high nature value. Nevertheless, the core area of these forests should not be accessible for tourists in order to minimise disturbances so that plant and animal species can thrive. Therefore, it would be best for tourists to remain at the borders of the Toekbos. Attractions that make the area appealing for tourists are birdwatching towers and viewing screens. Other facilities that attract tourists to the Toekbos are the presence of *Klompenpaden* and information signs. This forest type will require action from the tourism-related stakeholders. As there is limited scope for revenue, it is proposed to implement the Toekbos in natural areas or with compensation to landowners.

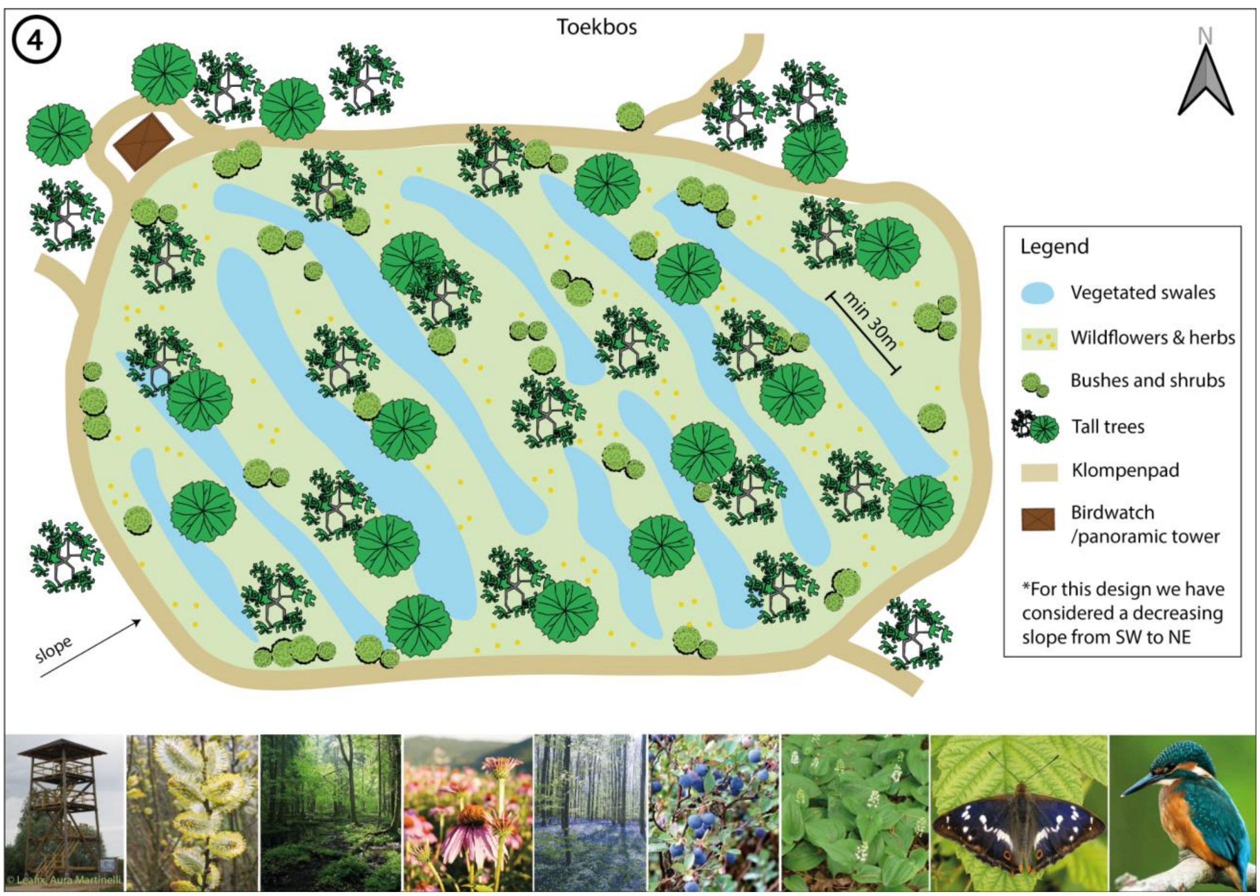

Figure 4a: Birds-eye view of the newly developed Toekbos

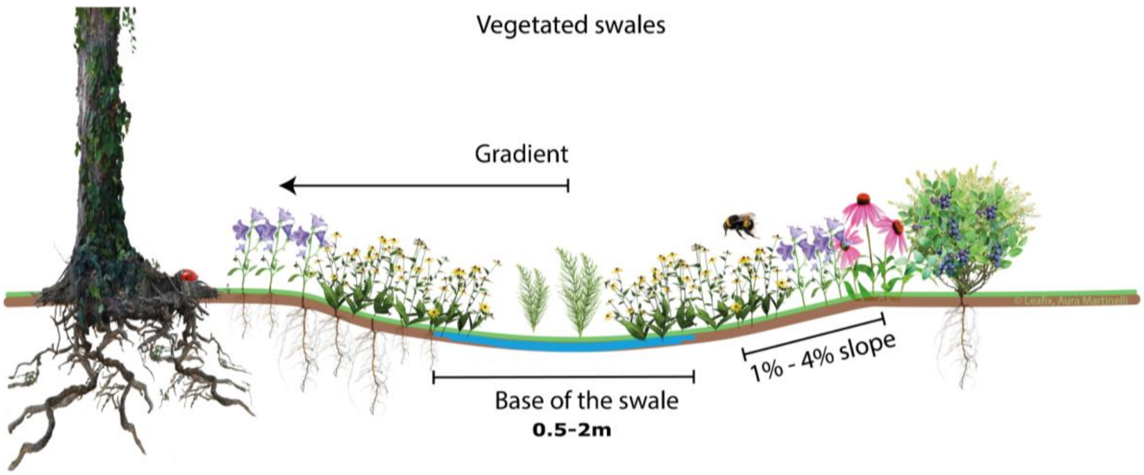

Figure 4b: Cross section of the newly developed Toekbos

A Mosaic Landscape

Within certain parts of the study area, all the different types of forest can be combined, and a mosaic landscape can be created (Figure 1). In this landscape all the different functions come together, while the different types of forest are still distinguishable (Figure 5). Within the mosaic, the four types of forests will be connected by trails and transition zones. This landscape will be a perfect place to create educational hiking trails that will guide you through the area, providing information about the different kinds of forests and their functions. The mosaic landscape can also attract nature-based tourism with features like birdwatch towers, viewing points or wildlife walls (e.g., for the Sand-Martin or *Oeverzwaluw*), particularly in places with a high natural value like the Toekbos. Another focus for tourism attractions that is suggested to implement in the area is family-based tourism that may include a labyrinth, an adventure forest, a barefoot path, or gnome trail. These would be implemented in the less fragile forests (e.g., the *rabatbossen*), so that the high biodiversity value forests (i.e., the Toekbos) are avoided to give nature some tranquillity.

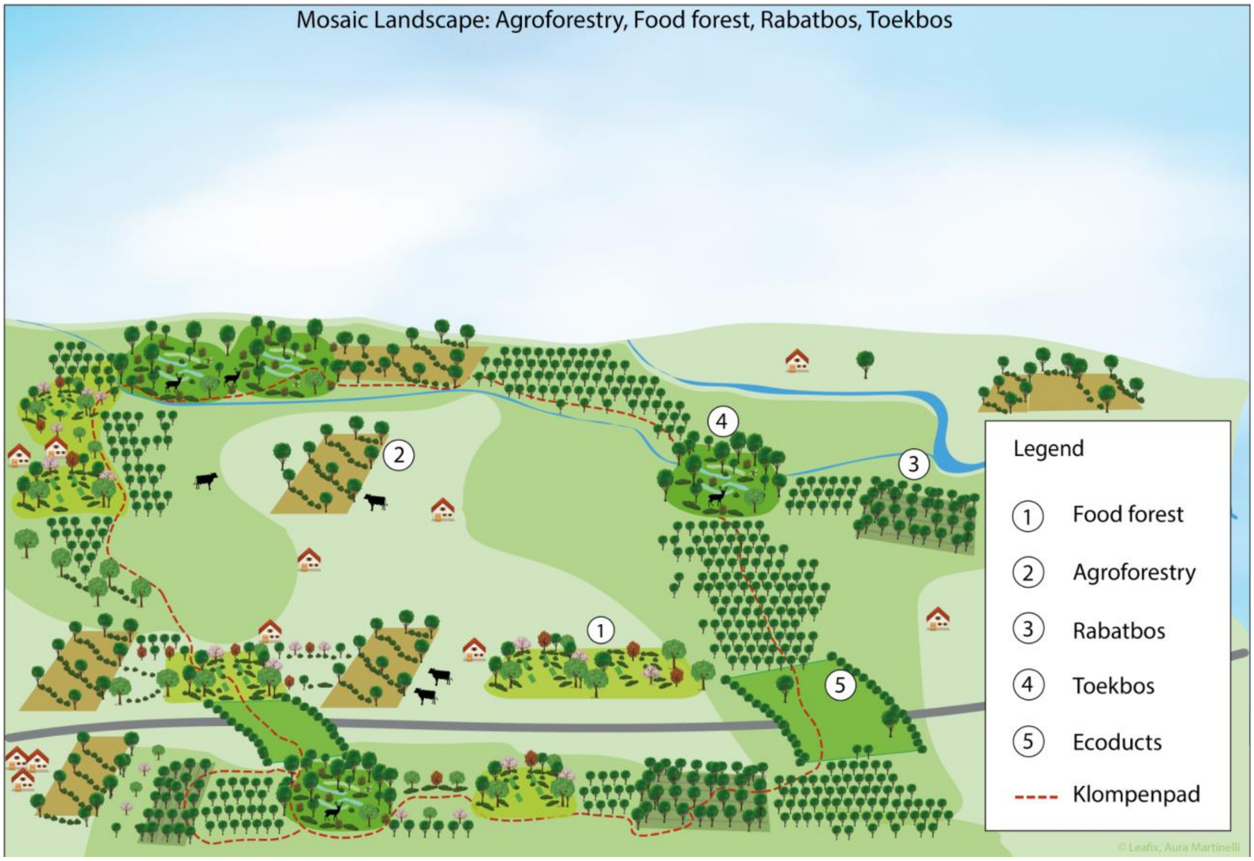

Figure 5: Conceptual design of the suggested mosaic landscape

As can be seen on the main map, the combinations of types of forests assigned to a certain area regularly include just two or three types of forest. This has to do with the suitability of the area for each type of forest, for instance the Food Forests should be close to a village and the Toekbos should be in the proximity of an already existing nature area. Depending on the combination used in the mosaic, different synergies are possible.

A combination of Food Forest and agroforestry focuses more on biodiversity and sustainability while offering room for economic diversification. In the landscape there are parts that have a good accessibility for machines, which makes harvesting of wood and food products easier. This will most likely increase the willingness of farmers to cooperate as this would make it more economically attractive. Another opportunity for farmers that supports short product chains, are *Klompenpaden* located past the combined farmland. Farmers can sell their products to tourists and locals, and they can also offer interactive activities in order for the general public to enhance their positive attitude towards farmers and enlarge their support base.

A second possible combination is the *rabatbossen* with the Toekbossen. The *rabatbossen* mainly function for wood production and tourism, whereas the Toekbossen are delivering biodiversity, water retention and tourism services. This transition is interesting for education purposes, such as the changes of the landscape since rabatbossen were used and the ecosystem services that a forest provides. The latter emphasises the current need for climate adaptability in the IJsselvallei as well as the role of biodiversity and water retention in the Toekbossen.

Final Considerations

We were commissioned to investigate the possibility of creating new rabatbossen. However, under the current and future conditions in the IJsselvallei, creating dry elevated banks is no longer required or economically viable. Instead, any other type of forest will help address the water retention challenges.

Existing rabatbossen can be restored to encourage tourism to the area or converted to a food forest or Toekbos. Furthermore, food forests, agroforestry, and Toekbos can be implemented across the wider landscape. To construct an integrated mosaic landscape, additional water retention measures can be implemented, and greater connectivity for both biodiversity and tourism. One thing to keep in mind with the mosaic landscape is that the four types of forests and the transition zones occupy an area of large extent, meaning that only one hectare is not sufficient in order for the forests to acknowledge their functions.

One individual forest concept will not meet all of the goals for the future of the IJsselvallei, but by combining these four strategies we can create a multifunctional and climate resilient landscape that supports landowners, locals, and tourism.

Part II: Literature Study

1. Introduction

The IJsselvallei is an area located between the Veluwe and the river ‘’de IJssel’’. The area has a dynamic natural landscape, including different estates, holds different natural values and is close to several old Dutch Hanzesteden. Due to this, the IJsselvallei can function as a recreational area and can help alleviate recreational pressure from the Veluwe. The strain of visitors adds to the problem of climate change, for it puts pressure on the natural systems. On the other hand, the rising number of visitors could also provide opportunities for valuable forms of revenue, with the development of sustainable tourism, for example. The recent Covid-19 pandemic has brought with it a range of societal consequences. Nowadays short chain markets are favoured, putting ‘Farm to Fork’ concepts in a lucrative position. Shortening the chain and connecting visitors directly with farmers has its benefits for the farmer, visitors, and is in line with government regulations.

Another issue that affects the Veluwe and IJsselvallei area is climate change, which in turn induces disturbances in the ecosystem. Two interconnected aspects of climate change are the increase in summer temperatures and the decrease in average precipitation during the summer (Spek et al., 2010). Extreme weather events are more likely to occur due to climate change, which causes winters to be wetter and summers to be dryer (Spek et al., 2010). As a consequence, less water will be available in summer for agriculture. Another aspect of climate change is the increase of carbon dioxide in the atmosphere in the Netherlands. Carbon dioxide (CO_2) is one of the greenhouse gasses that cause temperatures to rise, and concentrations are expected to increase in the coming decades (Bresser et al., 2005). Furthermore, the increasing intensification of land use has caused habitats to be fragmented and degraded, hence biodiversity levels have declined in the Netherlands (Barends, 1989). This trend makes the area more vulnerable since biodiversity is important for ecological resilience. The problems that arise from climate and land use changes stress the importance of climate mitigation and adaptation within the Netherlands.

The commissioner’s ambition is related to the above-stated disturbances in the IJsselvallei area. One goal of the commissioner is to develop an area that is resilient to the different disturbances the area will encounter in the future. This resilient ecosystem would consist of multiple aspects that enhance climate adaptation and mitigation, for instance a sufficient capacity for water retention, increased carbon sequestration and the maintenance or enhancement of biodiversity (de Ruyter, P., personal communication, March 19, 2021). A second goal of the commissioner is to manage the increasing flow of tourism in a way that benefits the natural environment and cultural heritage and is economically feasible as well.

The focus of this report will be on the area within the IJsselvallei that is situated between Apeldoorn, Twello and Voorst. This area is a source area of multiple streams and is intended for reforestation to mitigate climate change by increasing the carbon storage capacity. The historical, current, and future state of the IJsselvallei will be investigated in order to create a more vital, resilient, and colourful landscape, while taking into consideration socio-ecological challenges such as climate mitigation, nature-based agriculture, and tourism.

Following the above advice and the conceptual design, the scientific background is provided in this report. In chapter two a stakeholder analysis will be made, whereafter chapter three will provide a historical background of the IJsselvallei region. The following chapter will then define the current situation with respect to land use changes, environmental conditions, and climate change. The fifth chapter will touch on future challenges to consider as well as the opportunities, which include water retention, tourism, and the exposition of alternative forest management systems. Finally, these results will be concluded in chapter six and then a discussion will follow.

2. Stakeholders

Within this area and this project, there are many stakeholders to keep in mind. Stakeholders can vary from companies/people/governing bodies who are directly involved to people that are indirectly affected. The focus of this advice is not on the implementation of the plans and how to involve the stakeholders. However, the different kinds of stakeholders and what to keep in mind related to the stakeholders are mentioned during the report.

The main stakeholders who are directly or indirectly involved with the rabatbossen project are shown in Figure 6 and are: the VeluweAlliantie, Bureau Peter de Ruyter, landowners (including nature and tourism-oriented organisations), farmers, and the Water Authority (Waterschap Vallei en Veluwe). However, the locals must not be forgotten, as the advice is aiming for a big change in the landscape and locals can have an emotional connection with the area. It is thus important to inform them well and create a support base.

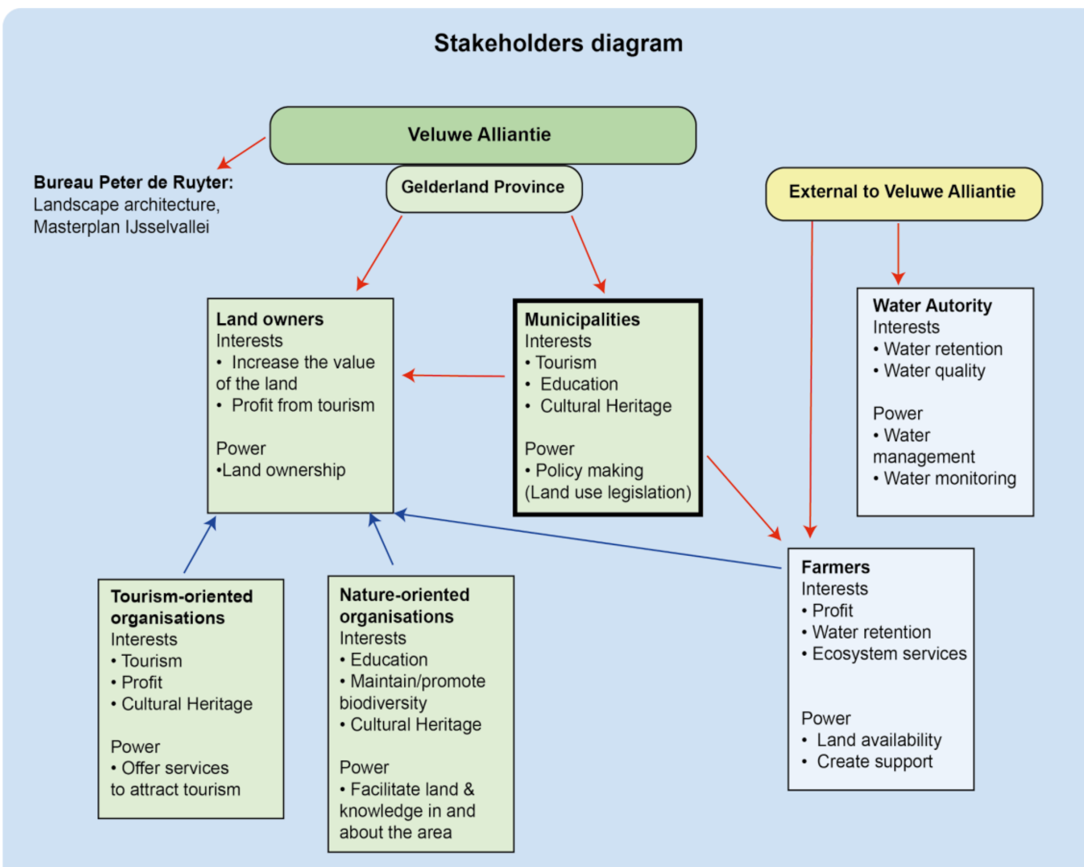

Figure 6: Stakeholder diagram showing the main stakeholders that are involved and/or affected by the rabatbos project as well as their interests and power. Some stakeholders are part of the Veluwe Alliantie (indicated in green) and other stakeholders are external parties (indicated in light blue). The arrows show the different relations between the stakeholders; blue arrows refer to an affiliation and red arrows refer to an authoritative power.

2.1 Large Organisations with Direct Power

The stakeholders who play an important role within the project, those who have decisional power in whether the project is implemented or not, are the Province of Gelderland and the municipalities. These stakeholders are responsible for providing funding and destination approval. For these stakeholders it is important that the project matches their vision, but as this project is part of the VeluweAgenda it is likely to match. VeluweAgenda wants to improve the ecological diversity and the tourism outlook, and to protect the already existing landscape (Veluweop1, 2020).

Since Provincie Gelderland and most of the municipalities are part of the VeluweAlliantie, opposition from them directly concerning the project is not expected. However, despite the fact that our advice is focused on the same principles of the VeluweAgenda, later in the timeline of this project these powerful stakeholders will have to agree with our suggestion to fund and implement it. One of the other stakeholders that should also be taken into account is the water authority. The creation of a forest can have a big influence on the water flow/quality/quantity, so it is important to keep them on board.

While the majority of important stakeholders who are involved in this project are part of the VeluweAlliantie in some way, the water authority is not. Since one of the ambitions of this project is to increase water retention and help to adapt to climate change, it is important to be aware of the vision of the water authority. The water authority in this area released a vision for 2050, 'Blauwe Omgevingsvisie 2050', where it is stated that they want a transition from a focus on water drainage to a focus on climate mitigation and thus water retention (Waterschap Vallei en Veluwe, n.d.). They also aim for a more robust water system which can better respond to more extreme weather events in the future and better retain water. One of the goals of the water authority is to create, or help, create a climate corridor in the southern part of the IJsselvallei. The location for this corridor overlaps with our study area, and thus our plan contributes to the vision of the water authority.

2.2 Directly Affected

The second group of stakeholders will be directly affected by the land developments described in this project. This group contains tourism-oriented organisations, landowners, and farmers. Tourism attraction is one of the goals of the newly adapted rabatbos and is of interest for tourism-oriented organisations that can profit from the increased tourism. However, these organisations also play a vital part in the success of the tourism goal because they can offer services like guided tours or horeca establishments. For this reason, it is important to consult with these organisations on tourism accessibility and hotspots. Perhaps the most important directly affected stakeholders are farmers and landowners in the area of interest. Their income is directly linked to the land they cultivate and thus their income can be heavily affected by changes in the surrounding area such as water management, light competition, biological pest control and pollination services. Therefore, it is of great importance to involve farmers and landowners in the entirety of the project and inform them of the benefits of this newly adapted rabatbos. Convincing farmers to change their current land management is likely to be more effective when involvement and information distribution are well managed.

2.3 Citizens: Visitors and Local People

Visitors and inhabitants of the IJsselvallei are indirectly affected by changes in the environment but should be informed about the activities that can take place, like cutting down trees or digging swales. Providing information can be done by placing information signs, hosting talks/workshops or placing articles in the newspaper. Lack of information could lead to a negative experience for people visiting the area.

3. Historical Situation

3.1 Environmental Characteristics

Before the 14th century, the IJsselvallei was a swampy area located in between the borders of the Veluwe and the banks of the IJssel river (Stuurman & Griffioen, 2003). Due to this hydrological gradient, a wide variety of environmental conditions were present, including a variety of forest types, located on areas that range from dry to wet soils. This heterogeneity is a precondition for high biodiversity. In other words, the IJsselvallei was characterised by its soils, hydrology, and ecology. However, anthropogenic expansion caused these characteristics to be affected, mostly in a negative way regarding ecosystem resilience.

In the west of the IJsselvallei, close to the Veluwe, the topsoil layer consists of a sandy layer that is, in some places, tens of meters thick and decreases in thickness towards the IJssel. This layer is characterised by a high permeability, which means water can easily flow through it (DINO, 2020). Towards the IJssel, the fluctuating water table was closer to the surface and could influence the soil characteristics through seepage. The base rich groundwater buffered the pH and ensured the replenishment of minerals. Originally, wet forests such as *elzenbroekbossen* occurred in the valley. These forests are characterised by seasonal flooding events and harbour a great amount of biodiversity (Burg et al., 2016).

Humans had several effects on the hydrology in the IJsselvallei, partly to control the hydrology and partly to use the water for practical purposes. The first dikes around the River were constructed in the late 14th century to allow mining activities of the fertile sandy and clay soils in the swampy area. In the 17th century, flour and paper mills were installed in the IJsselvallei as the wet IJsselvallei area could deliver hydropower. To deliver power to the mills, brooks ('sprengen') and streams ('weteringen') were dug and excess water was being discharged from the area by these. The brooks and streams ensured continuous water discharge throughout the year, which allowed the mills to function both in winter and summer (Stuurman & Griffioen, 2003). In 1825, a canal (‘Het Apeldoorns Kanaal’) was constructed between Apeldoorn and Zwolle. The canal was extended to Dieren somewhere in the first half of the 20th century for several reasons: to further extend surrounding villages and agricultural land; to make use of the delivered hydropower; and to improve connectivity for cargo ships (Stroming, 2005; Jansen, n.d.). This canal affects the original water characteristics of the IJssel discharge area (among which the IJsselvallei) by suppressing the natural local groundwater system.

3.2 Rabatbossen

The deforestation of the Netherlands started as early as the 15th century, as a result of population growth. At the end of the 17th century, most natural forests were gone or degenerated to coppice due to over-exploitation and grazing (Mulder, 2020). To meet the demand for wood products, new ways for wood production in swampy areas were explored, which resulted in a new forest management system.

This new forest management system is called a *rabatbos*, which was used to convert wet areas to areas where some form of forestry could take place where it was usually not possible. To convert wet areas, ditches were dug and the ground from the ditches was used to heighten the areas between the ditches. This resulted in the typical rabatbos shape with the alternating ditches and dykes (Jansen & Bentem, 2005). The transformation of an area into a rabatbos, as well as the maintenance and management was labour intensive. The rabatbossen became even more popular due to the high demand for oak bark as this was used in the tannery business. The high demand for oak bark justified the efforts required to convert wet alder coppice forests to drier oak coppice forests using rabatten. This use of rabatbossen lasted far into the 19th century (Jansen & Bentem, 2005).

The downturn of the rabatbossen started in the beginning of the 20th century. Around this time criticism on the rabatbossen grew as it was believed, it played a part in the acidification of the ground and it also was not needed anymore for the dewatering as these areas became drier (Mulder, 2020). Around this time, synthetic tannins became available, and the wages started to increase, which made the use of rabatten for oak coppice less appealing. New rabatten were not made any more and the old ones slowly converted to forests with high canopies. The old rabatten were still maintained until the Second World War. As the welfare and wages in the Netherlands grew in the succeeding period, this was the final nail in the coffin and maintenance of the old rabatbossen was halted (Mulder, 2020). The silviculture sector (i.e., the growth and cultivation of trees) also switched to heavy machine management practised on a larger scale.

Today many rabatbossen can still be found in the Netherlands. However, as previously stated, the rabatbossen are not managed hence their original shape is slowly disappearing. For a rabatbos to keep its historical appearance, the mud in the ditches must be removed and the banks must be kept straight (Jansen & van Benthem, 2005). Also, the use of big machines should be avoided. Nowadays the historic functioning of rabatbossen is not relevant anymore. However, the rabatbossen are considered to be cultural heritage in the Dutch forests and it does offer opportunities for the future regarding educational or nature value purposes.

4. Current Situation

4.1 Climate Change

Two of the most important effects of climate change in the Netherlands are the rising sea level and the increase of frequency and strength of weather extremes (De Ruyter, 2020). The latter has the most direct effect in the IJsselvallei area regarding ecology and hydrology, hence mitigation of these weather extremes is required. According to measurements in our study area, the groundwater levels in the summers of 2018, 2019 and 2020 were remarkably lower than the groundwater levels of the summers in the years before. Moreover, the temperatures in the summers of 2018, 2019 and 2020 were much higher than the average (KNMI, n.d.), which suggests the dryer summers have a severe effect on the water availability in the IJsselvallei area.

The effects of climate change on water availability in Europe are expected to be even more severe in the near future (2030-2040) as well as in the long term (2080-2100), where the trend of increasing temperatures and extreme weather events are considered to be the main climatic drivers (IPCC, 2014).

4.2 Land Use and Hydrology

Currently, water from the IJsselvallei region is still being discharged towards the River IJssel via streams (northern part of the IJsselvallei) and smaller brooks (southern part of the IJsselvallei). This distinction in discharging water characterises the area's hydrology. The northern part is in direct connection with the IJssel, which allows it to be waterlogged in dry periods. This is not possible in the southern area due to the gradient in the landscape and the indirect connection of the brooks, hence rewetting the southern part of the IJsselvallei in dry periods is more challenging than in the northern part (De Ruyter, 2020). In addition, the development of streams and brooks in combination with mining activities have caused moist areas such as the *Empense* and *Tondense Heide* to dry out. Consequently, several peatlands have been dewatered and marshlands, for instance the *Beekbergerwoud*, have lost their original water level (Stroming, 2005).

In Figure 7, the hydrological characteristics in between the city of Apeldoorn and the IJssel can be seen. As the IJssel River has been deepened for the purpose of shipping, the River has a strong effect on the groundwater systems within the IJsselvallei (BOVI2050, n.d.). A local groundwater system and a regional groundwater system can be distinguished in the area. Previous to the severe effects of water use by humans, the water infiltrated in the Veluwe area exfiltrated (i.e., upward seepage) both in several parts within the IJsselvallei (local) and in the IJssel River (regional). Furthermore, a local system most likely existed in the IJsselvallei itself, where water infiltrated on sandy soils and upward seepage in the IJssel River. A cross section with its natural groundwater characteristics can be seen in Figure 7a.

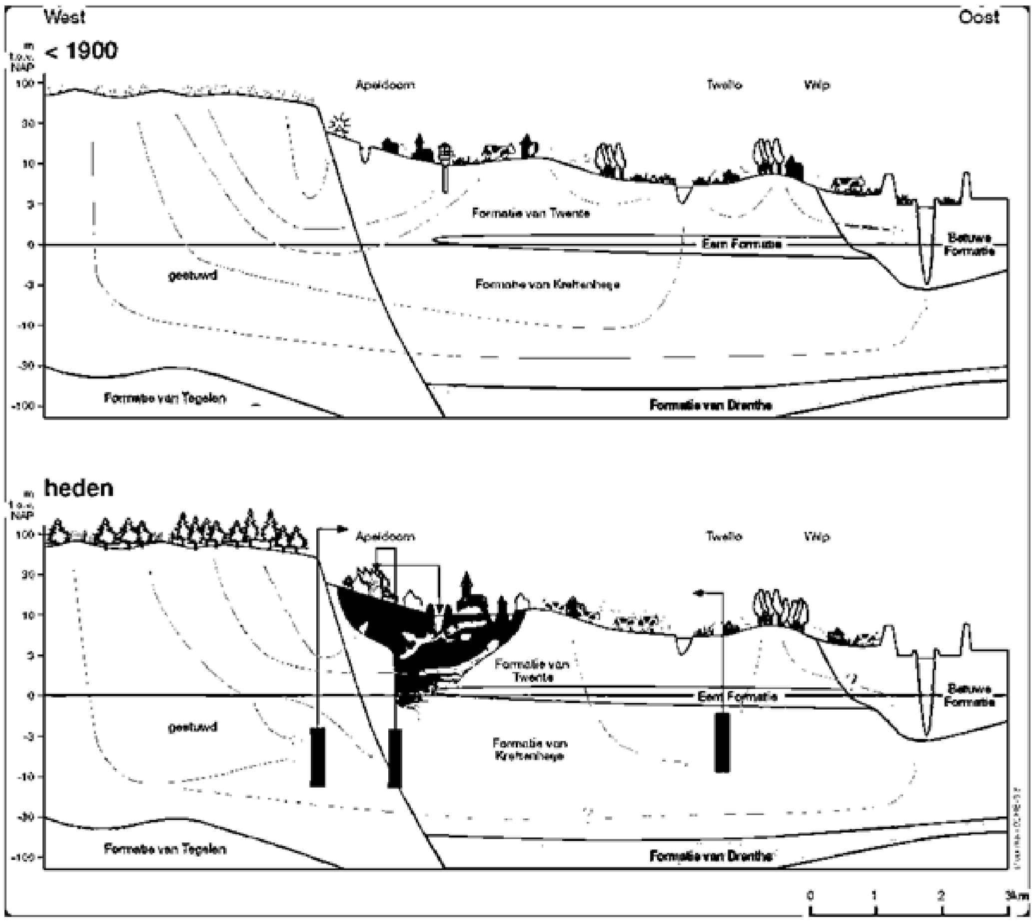

Figure 7: (a) The natural regional and local groundwater systems within the IJsselvallei area ('< 1900') and (b) the affected groundwater systems due to human interventions ('heden'). The black vertical rectangles in the latter represent the different locations of groundwater extraction. Retrieved from Stuurman & Griffioen (2003).

The natural groundwater mechanisms have been disturbed by several human interventions in the IJsselvallei and its surroundings. One of the main disturbances is groundwater extraction for industrial purposes, among which the paper industry. Although the impact of these in the surrounding area of Apeldoorn decreased in the 20th century - to combat the effects of drought - the effect on hydrological mechanisms was still discernible at the start of the 21st century (Stuurman & Griffioen, 2003). Two other disturbances with extensive impact on the local water systems within the IJsselvallei are drinking water use and irrigation water extraction (Van Huijgevoort et al., 2020). In the IJsselvallei there are seven areas allocated for drinking water supply, among which three on the border of the Veluwe in the Southern part of the IJsselvallei and one within the IJsselvallei itself, just north of the village Twello (Provincie Gelderland, n.d.).

Groundwater extraction interrupts the natural local mechanisms that supply the IJsselvallei area with upward seepage (Figure 7b), causing the groundwater level to decrease and the soils to dry out. This effect is more severe in dry periods, for instance in the summer of 2018, where both drinking water and irrigation water usage increased due to extreme drought. It is expected that water use will even further increase in the future, since an increase in frequency of drought events is expected (Van Huijgevoort et al., 2020). Although there still seems to be some upward seepage in the IJsselvallei area, the majority of local infiltration and seepage mechanisms have disappeared. This leaves the regional groundwater system to discharge most of the infiltrated water in the Veluwe towards the IJssel River.

Aside from the changes in hydrology, land use has had a great impact on the environmental conditions as well. With the increase in drainage activities, possibilities opened up to convert the swampy area to agricultural fields. Currently, the majority of the area is used for agriculture. In order to make these soils more fertile, they have historically been fertilised with sheep dung and heather. As a result, a thick humus layer has formed on top of the sandy soil and the nutrient availability increased in the area (Haartsen, 2009). Following the expansion of intensive agriculture, these fields are fertilised with high amounts of phosphorus and nitrogen, which enriches the soil even further. This eutrophication in combination with groundwater reduction induced desiccation, acidification of the soils has occurred as well. With the presence of the natural buffering effect of the groundwater in the IJsselvallei, the environment would not have suffered from the negative effects of acidification.

Acidification and eutrophication are unfavourable for several reasons. First of all, there has been a loss of environmental heterogeneity, meaning the natural variation in wetter and dryer systems disappeared from the IJsselvallei in favour of only dry and nutrient rich systems. As a result, there is a switch towards species poor systems. Fast-growing species such as grasses, bramble, or nettle benefit from an increase in nutrient availability. These species groups can form dense vegetation clusters and may therefore outcompete more vulnerable species. Accordingly, systems that are less rich in nutrients are typically the most biodiverse (Ceulemans et al., 2014). Secondly, these developments cause an imbalance in minerals in the soil which can lead to vulnerability to droughts and pests (Vries et al., 2019).

In order to counteract the loss of biodiversity due to a change in natural processes, the upward seepage of groundwater should be restored. This is to improve soil quality and to restore the natural variation (i.e., heterogeneity) in the area. Moreover, it provides opportunities to better retain the water in the IJsselvallei. Rewetting the area will not only allow water to remain in the system for a longer time period, but it will also enhance plant diversity. The current state and characteristics (ecological, soil and hydrological) of the southern IJsselvallei stress the need to counteract the current and expected effects of drought. As previously described, water inflow from the IJssel River in the southern part of the IJsselvallei cannot be managed due to the apparent gradient in the landscape. Hence it is crucial for the area to find ways to mitigate the risks of drought. A more heterogeneous, biodiverse, and thus resilient ecosystem is much needed in light of climate change.

5. Future Perspectives

5.1 Challenges

As outlined in previous chapters, there is a clear need to develop resilience to the expected future climate, in particular the increasingly severe summer droughts. In this chapter, management strategies will be discussed that can be implemented to increase water retention and biodiversity. Economic viability is an important precondition for a successful transition towards a more resilient system. Therefore, sustainable systems that combine economic viability with encouraging tourism and recreation, as well as increasing water retention and natural values are explored.

5.2 Water Retention to Restore Hydrology

5.2.1 Forests

Trees affect the hydrological system in a plurality of ways, among which evapotranspiration (evaporation and transpiration) and groundwater flow dynamics. Although there are multiple underlying mechanisms related to tree characteristics (e.g., tree density, rooting depth), it is important to understand how forest - hydrology interactions affect the ecosystem at a somewhat larger scale. How hydrological processes are related to a forest stand can be seen in Figure 8. In forested areas, the main components determining the amount of water in the soil are precipitation (e.g., rain), total evaporation, and the amount of water discharged (Moors, 2012). With (extreme) rainfall events, trees intercept water with their canopy either causing the water to directly evaporate or to slow the discharge of water down, which offers more time for water to infiltrate the soil and increases the water availability for plants (Veraart et al., 2020). Besides, trees can improve the water use efficiency of understory and neighbouring plants by creating a cooler, moist microclimate and by reducing wind speeds, thereby reducing the loss of water via transpiration as well as reducing surface evaporation (Kanzler et al., 2019). Changes to the soil structure caused by the presence of roots, reduce the subsurface flow of water through the soil. So, the water retention capacity is higher compared to open fields, especially along a slope (Wang et al., 2017).

Additionally, water that infiltrates the soil and reaches below the root zone of the trees, enhances the retention of water in deeper layers of the soil (Veraart et al., 2020). Trees improve the water infiltration rate of the soil due to the roots of trees channelling deep into the soils, which can be called the ‘root channelling effect’ (Kazemi Zadeh & Sepaskhah, 2016). This effect is even larger for sandy soils (bigger soil particles) than for clay soils (smaller soil particles) (Kazemi Zadeh & Sepaskhah, 2016). Moreover, it is found that trees can induce the process of ‘hydraulic lift’ to occur. This process implies water transport from deep wet layers to shallow dry soil layers via the roots of trees, resulting in an increase of the water table (Veraart et al., 2020).

Next to infiltration, evaporation is found to be an important component regulating the hydrology in a forest, because it controls the interaction between land and atmosphere regarding hydrology (Moors, 2012). The evapotranspiration capacity of plants is dependent on the plant species; hence land use is found to highly influence evaporation (Van Huijgevoort et al., 2020). Van Huijgevoort et al. (2020) concluded in their study that, during the 20th century, the plantation of coniferous trees - at the expense of heather and sandy areas - in the Veluwe was the largest contributor to the decrease in groundwater levels in the Veluwe. This can be explained by the coniferous trees having a higher leaf area than deciduous trees, hence they have a higher rate of transpiration. As deciduous trees shed their leaves in winter, this reduces their transpiration even further, while still retaining the positive effects on water retention in the soil (Gehrels, 1999). It can be concluded that - although deciduous trees have a higher evapotranspiration capacity than heather and sandy areas - on balance they will have a positive effect on water retention due to the greater effects on groundwater flow dynamics, especially since most of the IJsselvallei is characterised by sandy soils (Van Huijgevoort et al., 2020).

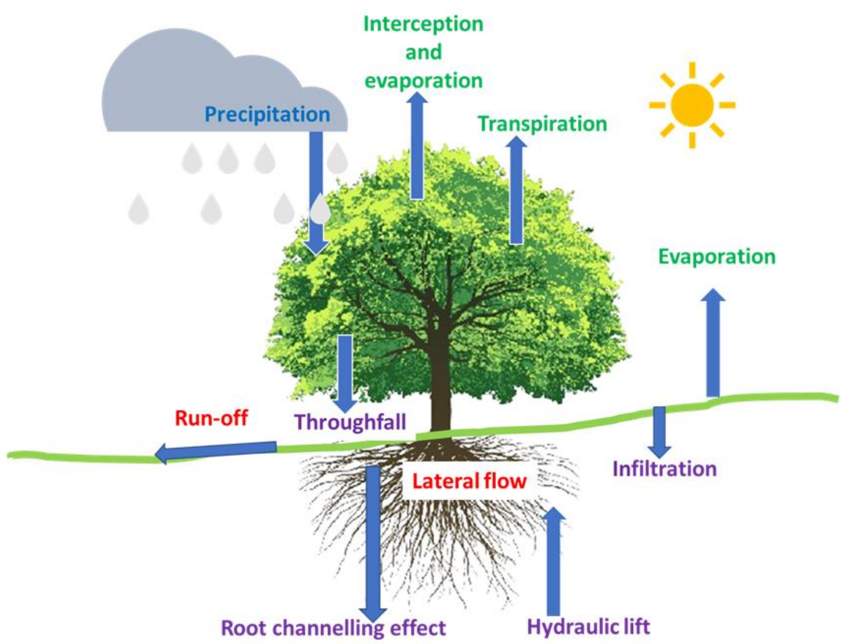

Figure 8: The hydrological cycle of a forest stand.

Lastly, the model presented by Van Huijgevoort et al. (2020) describes a positive effect of rainfall peaks in winter on groundwater levels in the higher elevated parts of the Veluwe, whereas the surrounding areas of the Veluwe - among which the IJsselvallei - are expected to suffer from severe droughts in summer. As the differences in the effect of extreme weather events within the Veluwe area and the surrounding areas are contradicting, it can be concluded that management approaches in the IJsselvallei should include the retention of water infiltrated in the Veluwe in order to mitigate water stress.

5.2.2 Swales and Ditches

Swales and ditches influence the soil water table by altering infiltration and discharge rates. Water infiltration depends on several factors such as soil porosity, shape, texture and composition, the presence of plant roots and topographic values (Pachepsky et al., 2001). The shape of the soil influences the infiltration of rainwater into the ground as a larger available soil surface increases the residence time of water in the soil. A furrow in the ground with the shape of a swale (Figure 9a) - which is broad and shallow - allows the water to stay longer on the surface, thus has more time to infiltrate into the ground. On the other hand, ditches (Figure 9b) - which are deep and narrow - are designed to remove water from the system and are therefore not suitable to retain water (Whitefield, 1996). Ditches cause the groundwater to be redirected to them, thereby lowering the influence of groundwater on the higher elevated parts. Whitefield (1996) suggests digging swales across a slope to catch the rainwater preventing it from running off while also preventing soil erosion. The optimal dimensions of a swale regarding its impact on infiltration capacity, would be a base width of 0.5 to 2 metres with a slope of about 4 percent and a length of the swale of 30 metres (NWRM, n.d.). As the IJsselvallei is largely drained by ditches, a logical measure would be to remove or partially fill in the ditches to reduce the drainage of the area, thereby increasing the effect of groundwater again.

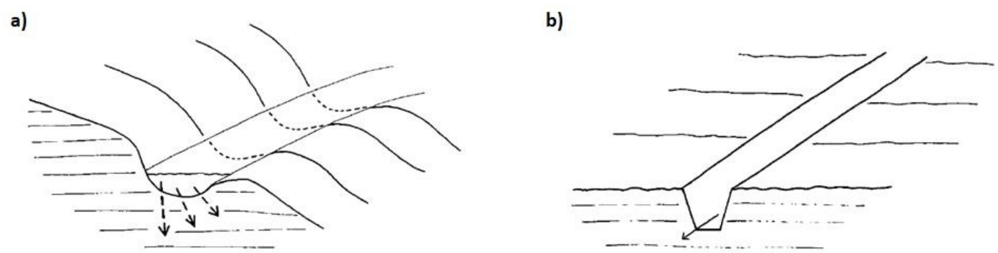

Figure 9: Graphical representation of swales on a slope (a) and ditches (b). Retrieved from Whitefield, (1996).

5.2.3 Dams and Weirs

Another possible measurement to retain water in the area is to construct dams and/or weirs within the streams and brooks. According to Van der Burg et al. (2014), such hydrological interventions in flat landscapes or landscapes where upward groundwater seepage occurs have a larger effect than in landscapes with a (slight) gradient. As for the intensity of the effect the importance of natural values should be taken into account, meaning that a large effect of hydrological interventions could be severe in vulnerable areas. Hence in landscapes with a (slight) gradient, as exist in the Southern IJsselvallei, somewhat more robust hydrological measurements can be implemented. It is found that in order to rewetting forests located on sandy soils (*dekzandbossen*), the implementation of a weir in the main brooks likely increases the groundwater table (Van der Burg, 2014). This effect was mainly noticed on a local level in the vicinity of the weir and it is only sufficient as a first step in the rewetting process. A next step that further enhances a rising groundwater table might be the implementation of dams, which have a more severe effect on the water availability in the area. Implementing the different steps separately allows the environment to adapt to the new conditions, which is beneficial for the development of vulnerable plant species (Van der Burg, 2014).

5.2.4 Changing Streams

When the filling of ditches and construction of dams and weirs prove to be unsuccessful in rewetting the area, rerouting streams could be an option. Here the originally straight irrigation channels are closed and instead a more meandering natural stream can be obtained. The more free-flowing water represents the natural fluctuations in hydrology and also slows down the discharge of water (BOVI2050, n.d.).

5.3 Tourism Opportunities

Of all domestic travel within the Netherlands, the Veluwe is the most visited area, attracting both Dutch and visitors from other countries (Omroep Gelderland, 2020). In 2019 the national park De Hoge Veluwe, welcomed 625,000 visitors that paid entrance, opposed to the previously expected 590,000 (Stichting Het Nationale Park de Hoge Veluwe, 2020). The Veluwe needs to manage pressure from an ever-increasing flow of visitors and recreationists, and the hope is that the IJsselvallei can take some of this burden. There is a need to alleviate tourism pressure from the Veluwe, and to redirect them to the IJsselvallei. This chapter will discuss the various opportunities for increasing the number of visitors in the IJsselvallei. Aside from alleviating tourism pressure on the Veluwe, the creation of a new landscape should provide the local stakeholders an alternative income.

First, the target group of the Veluwe will be introduced, and the different forms of tourism. These include recreational tourism, cultural tourism, and ecotourism; all of which can be linked to the visitors of a rabatbos. Then opportunities can be discussed that could steer the tourists away from the area and move them towards the IJsselvallei. Next, the infrastructure and accessibility of the IJsselvallei area are described. Afterwards, various concepts will be presented that, if implemented successfully, could aid in attracting tourism to the IJsselvallei. These concepts include tourist information signs, farm-to-fork, and Food Forest. Lastly, a conclusion will be provided that will encompass a summary of the suggestions discussed in this chapter. Added to the conclusion will be a table that provides an overview of all the tourism and recreation opportunities and their corresponding target groups.

5.3.1 Target Group

Stated in the aforementioned paragraph, the Veluwe attracted more visitors than expected in 2019. The Kröller-Müller Museum also welcomed more visitors than expected (Stichting Het Nationale Park de Hoge Veluwe, 2020). This means that the combination of a natural environment, cultural heritage and art is being appreciated by both national visitors and international tourists. The centre of the Veluwe, where the museum is located, is the most crowded area. This is the same location where the ‘educational path’ starts. The national park of the Veluwe welcomes people who ride horses, go for hikes, cyclists and those who enjoy art and architecture (Alterra, 2007). Of all the park visitors, 47% visit the museum, meaning that 53% of visitors come there for the nature-aspect and recreational activities.

All in all, it can be stated that the target group of the Veluwe includes both Dutch people and visitors from other countries. Furthermore, it can be concluded that the target group can be distinguished between recreational tourists, cultural tourists, and eco-tourists.

Recreational Tourism

Recreational tourism implies active involvement of tourists in activities during their free time (Markus et al., 2019). In the Journal of Outdoor Recreation and Tourism, Chakraborty et al. (2020) suggest that recreational experiences create two different perspectives when it comes to human-nature interaction with a cultural ecosystem service. For tourists, value is created because of the recreational aspects whereas the local people gain a different set of values and cultural attachments with the local environment.

Cultural Heritage Tourism

Because of the current rabatbossen being part of cultural heritage, it could provide opportunities to attract cultural tourists. According to Csapó (2012), cultural tourism can be defined as ''*the movement of persons to cultural attractions away from their normal place of residence, with the intention to gather new information and experiences to satisfy their cultural needs*'' (p. 205). To attract cultural tourists the tourism activity should be aimed at the visitor's main motivational pulls, which are to ''*learn, discover, experience and consume the tangible and intangible cultural attractions/products in a tourism destination*'' (Richards, 2018, p.13). For place-based cultural tourism to be successful, it is required for the visitor to develop a sense of connection with the location; a sense of place (Smith, 2015). Place-based cultural tourism focuses on articulating the history and culture of the place for visitors, and connects visitors with the stories and experiences associated with that place. The elements worth mentioning when creating a sense of place include the following: ''*history, local traditions and cultures, religion, industry, the natural environment, cuisine and arts, as well as attractions and events*'' (Smith, 2015, p. 2020). Smith also highlighted the key aspect of place-based product development being the identification and telling the story of a place through a variety of narrative techniques.

The following list includes the different narrative techniques that can be implemented when promoting place-base tourism in a destination, described by Smith (2015):

(1) *Human or social heritage*: products and experiences arising from the social and human legacy of the destination, including historical origins and subsequent developments.

(2) *Industrial and agricultural heritage*: products and experiences that reflect the historical or contemporary economic base of the destination.

(3) *The arts*: architecture, visual and performing arts, literature and media, including digital art forms.

(4) *Cuisine*: beverages, food products and traditions typical of the destination, including ingredients, styles of cooking and modes/ rituals of dining/drinking.

(5) *Natural history*: phenomena and activities that illuminate the interconnectedness of the natural and human environments and regional development.

Ecotourism

Within the tourism field, the distinction between sustainable tourism and ecotourism remains blurry. Both concepts have overlapping elements to consider. As Negrusa et al. (2015) stated, sustainable tourism practises ''*should take full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities*'' (p. 11161). Ecotourism, on the other hand, takes place in relatively natural settings, attracts tourists that highly appreciate nature, and is an economically viable form of tourism (Sirakaya et al., 2016). Whereas

sustainable tourism focuses more on minimising harmful human impact on the social, economic and natural environment, ecotourism is more directed towards generating revenue from wildlife areas and natural parks (Das & Chatterjee, 2015). These revenues could then be allocated to conservation efforts of the natural environment. Ecotourism has become the fastest growing sector within the tourism industry (Bryant, 2020). Tour operators noticed this, and have been marketing their tourism products as ecotourism, and using the labels *eco* and *green*, which seem to attract this target group (Tripathi, 2016).
Within this project the focus will be on ecotourism rather than sustainable tourism. The reason for this is because the core concept of the renewed rabatbos is already based on sustainability and designed to adapt to climate change. Sustainable tourism implies, amongst other factors, limiting the number of tourists within a group (Agyeiwaah et al., 2017). Our objective for the new rabatbos concept, however, is the opposite.

5.3.2 Infrastructure and Accessibility

The construction of highways form barriers to the Veluwe area. The ever-increasing economic development of the cities of Deventer and Apeldoorn poses threats to the Veluwe area, as the construction of industrial sites and corporations will disrupt the natural environment and existing bike and hiking trails.

Within the Ijsselvallei, people can navigate themselves by using the footpaths, bike trails, as well as the *klompenpaden*. Klompenpaden are hiking trails, once constructed by the local inhabitants themselves, and are frequently crossed by daily visitors (de Ruyter, 2020). An opportunity for making these paths more accessible is to improve infrastructure, in a way that enhances the interconnections between the paths and different areas within the forest. Moreover, since the target group includes horse riders and cyclists, another opportunity lies in developing horse riding and (mountain)bike trails. Lastly, a way of including children is the introduction of gnome trails (*kabouterpaden*). These educational paths function as a scavenger hunt for the children, and can be organised as group activities as well (Staatsbosbeheer, n.d.)

5.3.3 Tourist-information Signs

Tourist-information signs are a perfect way to combine all three types of tourism into one instrument. Pictograms can be used to indicate the recreational activities within the area, and additional information can be included that can be of added value to the eco-tourists and cultural tourists. The use of signs also proves to be a form of sustainable tourism management, as the use of teleological signs (instructions with explanation) show to be effective when wanting to modify the general visitor behaviour in a manner that benefits the natural environment (Marschall et al., 2017). In the case of the redefined rabatbossen, information about the different plant and animal species can be included together with instructions such as for example *watch your step to avoid damage*, or *please, do not litter*. Below in Figure 10, examples of visitor information signs are provided.

Figure 10: Example of a visitor information board in Smolník (on the left), and information board along an educational mining trail in Nováky (on the right), adapted from ''Analysis of notice boards (panels) as general information media in the outdoor mining tourism'', retrieved from Weis, K., 2019, *Acta Montanistica Slovaca*, 24(3), p. 276.

In the Journal of Outdoor Recreation and Tourism, Marschall et al. (2017) provided the following guidelines that can be used when designing interpretive signs:

- Visitors should be provided with teleological (instructions with explanation), rather than ontological (instructions without explanation), information;
- Signs should include illustrations with informative text;
- The information should be directed towards families because they show the most intrusive behaviour;
- Information should be offered in multiple languages to make information accessible to the greatest number of visitors;
- The content of the information should include practical information about wildlife protection, take home messages, and comparisons between wildlife and humans. This will enable visitors to more readily establish a psychological connection with the wildlife.

5.3.4 Farm-to-Fork

Agriculture supply chains nowadays are especially at risk, mainly due to the imposed travel bans, border controls, and import and export restrictions on food commodities (Sharma et al., 2020). In the Netherlands, agriculture suffered from loss of export opportunities within and outside the EU, as well as loss of domestic demand due to for example closed restaurants (Beldman et al., 2020). Due to the government-imposed measurements against the Covid-19 pandemic, short chain markets are favoured, putting ‘Farm-to-Fork’ concepts in a lucrative position (de Ruyter, P., personal communication, March 19, 2021). Implementing a farm-to-fork strategy could provide farmers an alternative form of income, for when their other sources of income come to a stop. Farm-to-fork can best be understood as a strategy to permatourism. Permatourism ''*requires the creation of a grassroots business development strategy that aligns local entrepreneurs with expected business opportunities generated by existing or upcoming big* *tourism investments in the region*'' (Ferreira, 2018). Shortening the chain and connecting visitors directly with farmers has its benefits for the farmer, visitors, and is in line with government regulations. Not only does eliminating steps in the supply chain align with government regulations, the farm-to-fork initiative adds value to the tourism experiences (Star et al., 2020). Combining the rabatbossen with Farm-to-Fork initiatives could lead to sustainable food tourism, meaning ''*it sustains activities, person and institutions in harmony with a place's other elements, such as natural resources, history and sociocultural values*'' (Star et al., 2020, p. 326). An agreement as such will both benefit the farmers as well as the tourists. The visitors gain a unique experience by combining scenery, cultural heritage, and a cultural food experience that supports the local economy. For their benefit, food affordability is endorsed because transport costs will no longer be included (Arabska, 2021). In turn, by reconnecting the farmers with the consumers, it not only stimulates the economy's health, but also helps preserve food quality as transportation is minimised (Slocum & Everett, 2010). Moreover, the implementation of sustainable food systems can be a competitive advantage and allow for new business opportunities for the farmers (Arabska, 2021).

The following list contains successful case studies that are considered to be good practices, when it comes to farmers that operate in light of the Covid-19 pandemic:

1. Practices across Bulgaria, Italy, Hungary, France and Spain have established online platforms for local food producers and connections with the customers;
2. Drive in/drive by services to sell locally grown food;
3. 'Local Heroes', a Dutch application service, providing a new online platform connecting food providers and customers (Abraska, 2021).

Challenges:

- Identifying the varying needs between small and large farm operations;
- Building effective marketing chains and making sure a large market reach is accomplished;
- Allocating recovery funds/government incentives that help cope with the loss of job opportunities due to Covid-19;
- Uncertain and unanticipated demand (Sharma et al., 2020).

Aside from the social benefits and economic advantages, farm-to-fork strategies have the potential of being environmentally sustainable. It aids by mitigating climate change for it minimises transportation and subsequent CO_2 emissions, and pollution due to less packaging. Combining farm-to-fork initiatives with a diverse Food Forest opens up the possibility of agri-tourism. As stated by Giaccio et al. (2017), agri-tourism is a method of integrating *''farm incomes in various ways and increase awareness on the role that agriculture plays in relation to natural resources and rural areas*'' (p. 216).

5.3.5 Education

The educational elements of a restored traditional rabatbos can be a unique selling point for inviting school children to come visit the area, especially in combination with the surrounding landscape. Children can learn a lot from its biodiversity, the history (cultural heritage), and learn about farmers and agriculture. According to a report about *National Park de hoge Veluwe*, an educational program for schools is lacking (Alterra, 2007). An intermediary organisation such as the IVN can be used to connect the area to future visitors. IVN *Natuureducatie* is an organisation that strives to connect humans to nature (IVN, n.d.). They aim to achieve this by organising nature-based activities, providing workshops, projects and campaigns. Partnering up with the IVN could also contribute to the maintenance of the area, for projects could be designed around taking care of the rabatbos. Moreover, the IVN's employees consist of volunteers that aim to educate people of all ages about sustainable behaviour and the importance of the natural environment. Another suggestion for volunteers would be to help out with food harvesting or wood coppicing.

5.3.6 Tourism Within the IJsselvallei

In conclusion, it can be established that the target group of the Veluwe - and therefore the IJsselvallei - involve recreational tourists, cultural heritage tourists, and eco-tourists. Diversifying different forest elements and land-use areas within the IJsselvallei creates opportunities for achieving a larger market reach. The following table presents an overview of the various opportunities discussed within this chapter, categorised under *people*, *planet*, and *profit*. This allows for a clear overview of the opportunities that arise when designing a new rabatbos, and to be able to pinpoint each guideline to its designated socio-ecological system.

Table 1. Tourism Opportunities for innovative rabatbossen.

Tourism Opportunity	People	Planet	Profit
Enhance the interconnections between the klompenpaden and the different areas within the forest, to improve infrastructure and accessibility.	**X**		
Develop horse riding and (mountain)bike trails.	**X**		
Create a forest with a high biodiversity to attract ecotourists.	**X**	**X**	**X**
Construct tourist-information signs in both Dutch and English. In order to attract cultural tourists, include an educational aspect by, for example, telling a story that will create a sense of place.	**X**		
Offer Farm-to-Fork strategies to farmers as an alternative source of income, which will add value to local residents as well.	**X**	**X**	**X**
In order to gain competitive advantage, farms should establish online food services that could connect the farmer with the customers directly.			**X**
A modified rabatbos includes elements of cultural heritage and is composed of a wide variety of plant species including fruits and vegetables. Partnering up with a nature-based educational activities organisation such as the IVN could provide opportunities for volunteers and schoolchildren to come visit the area for educational purposes. The volunteers could help in the maintenance of the area (wood coppicing) or food harvesting (Food Forest).	**X**	**X**	**X**

Table 2. Tourism and recreation opportunities per target group

	Recreational Tourism	Cultural Heritage Tourism	Ecotourism
Rabatbos		X	X
Rabatbos-inspired forest			X
Information sign	X	X	X
Viewpoint/tower	X		X
Wildlife walls/bird-watching points			X
Coppice	X		
Mountain bike/horse trails	X		
Klompenpaden	X	X	
Gnome trails	X		
Labyrinth	X		

5.4 Management Practices and Revenue

5.4.1 Forestry

Use of forests

Forests have been used by humans to supply food and medicinal goods a long time before forests were used for their wood products (Sheppard et al., 2020). However, in the past centuries the forestry practice has primarily focused on the production of timber. Timber is used for a wide range of applications such as paper production, fuel, and numerous construction purposes (Buongiorno, 2014). This forest management type can result in extremely high value logs, for example the common oak has a value of around 576€/m³ (Jansen, 2018). However, reaching this quality of logs is very time consuming and can take up to 120 years in the case of common oak (Appendix 1). Usually, shorter rotation cycles are used, and forests are thinned throughout this rotation cycle to provide income in a shorter time period. This reduces the value of the produced timber since smaller sized timber is not suitable for many high-end building applications (Boosten et al., 2017). However nowadays fast-growing species can be transformed to be more sustainable and suitable for construction. This is done by a new technique, acetylation, where non-durable wood is treated to make it more durable and resistant. In the Netherlands there is the company *Accoya*, situated in Arnhem, which uses this technique. Their wood is being used all over the world, ranging from indoor biking tracks to bridges (Accoya, 2021).

Another type of forest management practised until the 19th century is coppice production. Coppice is produced by cutting the shoots of a stump every 3 to 20 years. This short rotation coppice is not focused on high value timber but is mainly used for energy production by generating as much biomass as possible over a short time period (Jansen, 2016). After the 19th century coppice production has been largely abandoned, but new interest has developed since production of biomass can substitute fossil fuels and mitigate climate change by reducing CO_2 emissions (Hansen, 1991; Londo, 2002). This provides landowners with a quicker return on investment with an income generated every 3 to 20 years depending on the tree species. Rejuvenation of the forest - which is a big cost in high value timber production - is almost entirely eliminated in coppice production since shoots remerge from the stump every time it is cut (Faash, 2012). Wood for energy production barely differs in value between species, thus, to maximise economic output a fast-growing species is preferred (Jansen, 2016). Nowadays not many coppice forests can be found in the Netherlands, as coppice is labour intensive and mostly done by hand, and subsidies are more difficult to receive for a new coppice forest. Coppice also provides a natural value to the forest, as many different niches are created in coppice areas. These niches are the result of the different heights and canopy layers of coppice, which cause different levels of light intensity - on which plant species are dependent - in the forest (Jansen & Kuiper, 2001).

Forest contribution to carbon sequestration

Another important function of forests regarding the IJsselvallei and its future challenges is that trees are able to sequester CO_2 from the atmosphere. The amount of CO_2 taken up depends on several variables. In general, a newly planted hectare of forest can take up an average of 4.6 ton CO_2 per year in its first 10 years, and after it is 9.1 ton CO_2 per year (Lerink et al., 2020). Once a forest gets older, less carbon sequestration takes place. This is one of the reasons that the Dutch Government wants to increase the total forest area in the Netherlands. They strive towards an increase of 10 percent, which is approximately 37.000 hectares of new forest area (Rijksoverheid, 2020).

Tree species that have a fast growth in the beginning, such as poplar and maple, can take up more CO_2 in a short term than slow-growing trees, such as oak. Oak on the other hand, provides a long horizon for carbon sequestration, they can become 1000 years old and during those years they keep taking up CO_2 (Lerink et al., 2020). The use of wood in products should be focused on longer-lasting products to keep the carbon secured in the wood, for instance buildings or furniture.

Apart from CO_2 uptake, trees but also bushes take up nitrogen and particulates. This is an interesting feature for transition zones in between different forested areas. Trees are more sufficient in catching these particulates due to their high leaf area. Coniferous trees have a better capture capacity of particulates than deciduous trees, due to their high leaf surface area. Deciduous trees are more suitable for uptake of nitrogen and ozone - captured via their leaf stomata - than coniferous trees due to their large flat leaf surface (Lerink et al., 2020).

5.4.2 Agroforestry

Benefits

The ecological, social, and economical components of forestry practices have led to an increased interest for inclusion of forest elements in agricultural landscapes (Rigueiro-Rodriguez et al., 2008). Modern agroforestry in Europe has been growing since the 1990s as a sustainable solution to some of the environmental problems caused by intensive land use methods. Agroforestry involves two components: tree/shrub and crop. Silvopasture includes livestock as a third element and is one of the more common types of agroforestry in Europe, both currently and historically (Rigueiro-Rodriguez et al., 2008; Pantera et al., 2018).

Mixed systems have a number of benefits over monoculture if managed appropriately. Ecological benefits include increases in biodiversity and carbon sequestration (Nair, 2011) as well as provision of ecosystem services, such as improved water quality by reducing flow of chemical pollutants into water sources (Nair, 2011). There are also economic benefits that come from synergies between the chosen species, for example nitrogen fixation to improve soil quality, or access to more soil nutrients via deeper roots for extraction followed by leaf litter dropped to the surface (Nair, 2011). Taking advantage of the right species combinations and management schemes can see up to 30% overall increase in biomass compared to separated trees and crops (Rigueiro-Rodriguez et al., 2008).

Agroforestry has been shown to improve water retention compared to monoculture or grassland (Wang et al., 2017). Microclimate effects from hedgerow shelter have been shown to improve the efficiency of soil water usage in crops, which could mitigate increasingly extreme summer droughts (Kanzler et al., 2019). As improved water retention is one of the main goals of this project, agroforestry may be a key approach to consider in the IJsselvallei.

Implementation

Existing rabatbossen could be adapted to an agroforestry management system, or even new rabat-style agroforestry elements can be created to enhance existing agricultural land but use of machinery would be difficult so labour costs would be higher. In general, deep-rooted trees will be competing less with shallow-rooted crops, and deciduous trees add more leaf litter to the soil, aiding nutrient cycling. Low leaf density, or evenly spread branches, allows more light to reach the understory (Rigueiro-Rodriguez et al., 2008). Beyond these factors, many of the previously mentioned forestry strategies can be applied to the trees in an agroforestry system to increase economic viability.

Using walnut/crop agroforestry as an example, over a 20-year horizon, net revenue is increased compared to either crop or walnut monoculture (Newman, 2004). The initial establishment costs may be above 4000€/ha for planting, protection, and maintenance, and it may take over ten years to recover the invested money (Godsey & Peters, 2000), but Newman (2004) calculated it was possible to even double the net revenue from 9000€ to over 18000€ after 20 years, using walnut agroforestry instead of arable monoculture.

Tree and crop combinations

There are various concepts that can be used to combine forestry and crop production. Alley cropping (Figure 11a) comprises rows of trees with wide rows of crops (10-100m) to allow crop harvest by machine. Scattered trees (Figure 11b) are another approach. Riparian buffer strips (Figure 11d) can protect water quality and reduce eutrophication by preventing run-off of agricultural chemicals, as well as stabilising the soil along the bank. Such strips also provide a biodiversity corridor. Forest farming (Figure 11c) is an option whereby specialty crops are grown within the forest itself. This could be medicinal, ornamental, or culinary plants that prefer the forest understory habitat. Fast-growing leguminous woody species can also be used as part of shifting cultivation as an improved fallow. This would require a 10-20 year rotation but improves the soil quality while also yielding economic products (Rigueiro-Rodriguez et al., 2008; Pantera et al., 2018).

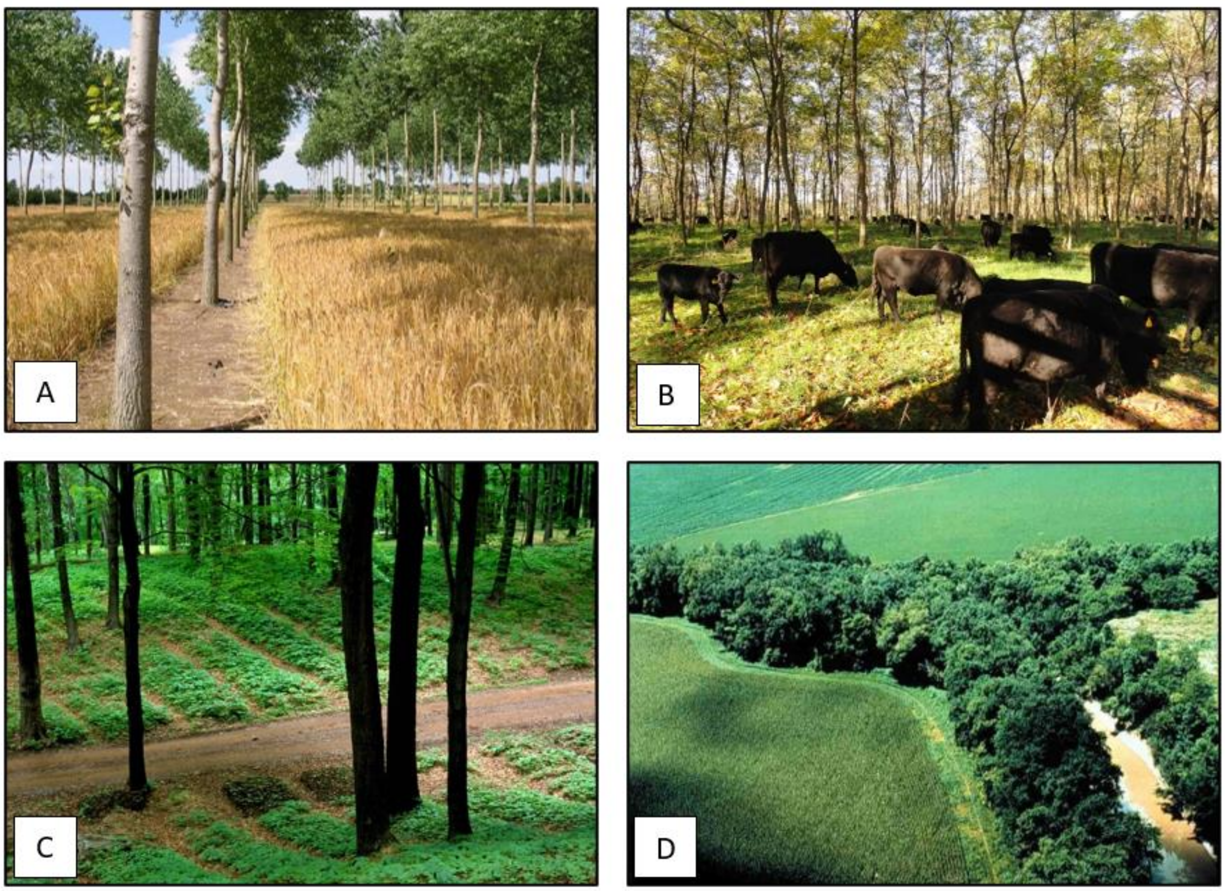

Figure 11: some types of agroforestry. a) alley cropping, b) scattered trees, c) forest farming, d) riparian buffer strip. Retrieved from a) www.agroforestry.co.uk b) www.ashfount.com c) www.wvtf.org d) www.morningagclips.com

However, the trees and crops are arranged, there can be a loss of crop yield close to the trees compared to monoculture due to competition for light, water, and nutrients, but an increase in yield outside of this area due to changes in the microclimate (Kang, 1993). The negative effects usually reach to a distance around 1.5 times the tree height, but the positive effects can be seen up to around 10 times the tree height (Kanzler et al., 2019; Sweiter et al., 2019). Depending on the topography of the area and prevailing wind directions, north-south aligned and relatively low height tree lanes limit the competition for light (Kanzler et al., 2019) Decisions need to be made based on the prevailing conditions. For example, if strong winds are a problem, narrower crop alleys are more appropriate to maximise the protective effect but if drought is the main concern, wider crop alleys take advantage of the water retention effects of the trees without increasing the tree-crop competition (Swieter et al., 2019). If managed well, the loss of cropland to trees is compensated for by the increase in yield and eventual income generated on a longer timescale by the trees. In fact, yield increases are even more apparent under drought conditions, where the area with reduced yield may decrease and the beneficial effects area increases (Swieter et al., 2019). Examples of agroforestry systems used in and around the Netherlands are shown in Appendix 2.

Silvopasture

In the past, new forests were planted to prevent soil erosion and protect villages from wind-blown drift sands, which led to forest grazing being prohibited in 1938 to protect these forests (Rigueiro-Rodriguez et al., 2008). However, at low intensity (1-3 animals per 100 ha on nutrient-poor sandy soils) grazing can improve natural tree regeneration by reducing the litter layer, but only with some investment to protect new trees, which can limit net income for the first few years (Newman, 2004). The trees also provide shelter for livestock, which can lead to higher milk production in cows (Rigueiro-Rodriguez et al., 2008). Higher livestock intensity may be possible with poultry where soil compaction is not a problem. As only low intensity grazing is sustainable, another option is to grow grass as a crop in an agroforestry system, which can then be mowed for hay or silage (Newman, 2004).

In the Netherlands, forest grazing areas are a minimum of 5 ha, with an average size of around 50 ha and can reach livestock densities of up to 30 animals/100 ha, depending on the season and amount of grassland cover. The meat can reach a higher price due to its 'greenness', with no fertilisers, pesticides or antibiotics used (Rigueiro-Rodriguez et al., 2008).

As a further economic benefit, multipurpose trees can be used such as fruit trees, for example pigs grazing in chestnut woodlands is a traditional agroforestry practice that is returning (Pantera et al., 2018). If the current trend of increasing summer droughts continues, reducing the yield from pastures, pruned leaves and fruits from the forest elements of a silvo-agricultural system can be used to supplement animal feed during these shortages. Again, this was a more common practice in the past with species such as *Castanea sativa Mill.*, *Fraxinus* spp., *Betula* spp. and *Quercus* spp. (Rigueiro-Rodriguez et al., 2008). Examples of silvopasture systems used in and around the Netherlands are shown in Appendix 3.

5.4.3 Food Forest

Layers of a Food Forest

A Food Forest is a carefully designed and maintained heterogeneous ecosystem which requires a very low external input, as it does not need water, fertilisers, expensive machines nor pesticides (Crawford, 2010). Taking inspiration from the principles of agroforestry, Food Forests - or 'voedselbos' - have become a subject of particular interest especially in urban and peri-urban habitats. These wild gardens can be designed in a variety of compositions and species selection, in order to best suit the environmental conditions of their geographic location and desired functionalities. A Food Forest consists of a completely different way of growing food than traditional agriculture or traditional gardens. This technique is inspired by nature and forests and focuses on maintaining natural ecosystem interactions and by using a mix of annual and perennial plants on our behalf, to perform functions that we usually have to do to maintain a garden like weeding, fertilising, or watering. The harvest is simply the natural result of nature's abundance. To determine and understand the complex system of a Food Forest, it is possible to identify nine layers in total (Wilde, 2018). This clear distinction is fictional and has the only scope to help understanding the composition of a Food Forest, in reality all these layers overlap and interact with each other. These layers are also helpful in designing and structuring the Food Forest, while maintaining the important interactions between plants. A list of possible species per layer is shown in Appendix 4.

1. Canopy and tall trees layer: this layer consist of tall trees such as timber trees (for example Poplars), nut trees and nitrogen-fixing trees.
2. Sub-canopy and large shrub layer: this layer include the majority of fruit trees.
3. Shrub layer: this layer consists in the majority of fruiting bushes with currants and wild berries.
4. Herbaceous layer: in this layer the plants are annual and therefore die every winter. It includes medicinal herbs, culinary herbs, and flowers for pollinators.
5. Groundcover and creeper layer: plants in this layer are often shade tolerant, they densely cover the soil and can tolerate foot traffic.
6. Underground layer: root crops are part of this layer. Many of these plants can be used in combination with the other layer as they do not require light, the only factor to take into consideration is the competition within the roots for the space.
7. Vines and climbing plants layer: this layer consist in vines and climbing plants. It can be combined with the sub-canopy and large shrubs layer in order to allow the vines species to be supported by the trees. This layer is perfect to increase productivity in a restricted area.
8. Aquatic and wetland layer: these plants are able to grow and thrive in wet areas or at the edge of a water source.
9. Mycelial and fungal layer: this layer mostly consists of the fungal networks and soil microfauna that dominates the soil of the forest. These mushrooms and microorganisms are essential to decompose the organic matter and make nutrients available for the plants. However, edible mushrooms are also part of this category and can be cultivated within a Food Forest.

These layers are often combined with vegetated swales, in order to increase the effect of vegetation on the water retention.

Benefits of a Food Forest

Because of its sponge effect, like every forest, it is very efficient in storing water during the wetter months and retaining it in the drier months. The accumulated layers of dead organic matter in the soil and the microclimate created within the forest make this small ecosystem very resistant and resilient in times of drought (Hart, 1991). Because of these characteristics and because the soil is constantly covered by a vegetated layer which keeps the moisture in the soil, a Food Forest does not need to be watered. Furthermore, the trees and shrubs layers cast precious shade and protect the vegetables during the warmest days of summer.

On an ecological level, a Food Forest provides the conditions for the increase of biodiversity and natural succession of species, and creates habitat for a wide variety of wildlife. For example, herbs and wildflowers will attract a large number of pollinators. The heterogeneity of this small ecosystem makes the forest, and the fruits and vegetables within it, more resilient in case of plant diseases. Insects and pests tend to be specific for only a few species, which means, if pests attack a monoculture, it is very likely that the majority of the crop will be destroyed or ruined. Having multiple plants and species in a mixed landscape reduces the chances of the pest reaching each individual of that species because of the natural barriers created by other species (Crawford, 2010). Furthermore, compared to a traditional agricultural field, it gives the advantage to produce more food in the same amount of space, using the vertical dimension of the area using trees, shrubs and climbing plants such as grapes.

A Food Forest is also good for the mitigation of climate change effects. Firstly, the growth of the trees will capture an important part of CO_2 becoming an important carbon sink. Secondly, the forest will capture moisture and have a refreshing effect on its microclimate (Crawford, 2010). Thirdly, some species are particularly resistant to climate change effects and can be integrated in a Food Forest, making the whole system stronger and more resilient in case of extreme climate change effects such as droughts. Some of these species are indicated in the table in Appendix 5 and 6.

Being a self-sustaining and resilient system, a Food Forest does not need much maintenance (with the exception of some species and dwarf trees). Ultimately, Food Forests can be designed to attract the attention of the public and can be used for educational and recreational purposes with the reintroduction of practices such as the harvest and use of herbs, but also as a community project (for example, the Food Forest *Nieuwe Erven*).

Limitations of a Food Forest

Although Food Forests have many advantages, there are also some limitations. The initial cost of starting a Food Forest is relatively high. Purchasing and planting of vegetation are the main investment cost (Voedsel uit het bos, n.d.). Secondly, a Food Forest needs extensive time before it becomes productive. Generally, it should take about 5 years to reach a good level of productivity, but the timings are in reality longer (Elvers et al., 2019). Income generated by Food Forests will keep rising because many fruit-bearing species will take some time before harvesting is possible. In slow growing species like walnuts and chestnuts, it can take 10 years before the first harvest (Voedsel uit het bos, n.d.). This means that the investment in a Food Forest will be compensated only after a long time. This will, of course, depend on the type of species planted. For example, for the majority of fruit or nut trees this time varies between 15 and 50 years (De Groot & Veen, 2017).

Moreover, because a Food Forest is a diverse and important ecosystem, it will attract many wild animals. Although many of them will provide beneficial services to the forest such as eating insects, they will eat a part of the Food Forest. Birds in particular, will be responsible for taking an important part of the fruits, an amount that varies depending on the type of fruits present (van Eeden, 2020).

However, there are different options to complement a Food Forest in order to increase the income. Some of these possibilities include: the introduction of farm animals such as pigs or peacocks in the trees or shrub layers in (order not to damage the vegetables), a B&B for tourists interested in spending some time in nature, giving courses and workshops, the creation of a particular design of Food Forest (such as a labyrinthic shape) to attract people, and other creative solutions to attract the public. A potential way to reduce labor costs is the involvement of volunteers for harvesting and maintenance of the forests. People can be repaid for their efforts in experience/schooling or through part of the forests. Another solution could be a system that allows people to rent a part of the forest as a vegetable garden as willingness for personal food growing is on the rise in Europe (Church et al., 2015).

Factors to consider when planning a Food Forest

As Food Forests do not differ from any type of forests in terms of complexity, there are several factors to take into consideration which can make a difference in the success of a Food Forest (Crawford, 2010). These factors are plant spacing and allelopathy (chemical competition between species), light, changes in the amount of water, soil characteristics (pH, texture, composition, nutrients), changes in temperature (frost, extreme heat), wind (and the effect of vegetated windbreaks), plant diseases and auto-fertilisation of species (Appendix 4 and 5).

The Design

Most of the problems that could emerge in a forest due to the factors indicated above, can be solved with a good design (Lucas, 1991), for example by placing tall trees to protect fruit trees from the wind.

It is important to develop a design which considers the future evolution and challenges of the forest and takes into consideration all of the previously mentioned factors. The design of a Food Forest for a given area can also be adapted according to the necessities and desired outcomes such as increasing biodiversity, producing a wide variety of fruits and vegetables, producing important amounts of fruits and vegetables, or creating a recreational and educational Food Forest.

Existing examples of Food Forests in the Netherlands

In recent years, Food Forests have become popular also in the Netherlands (Van Dooren, 2018). Following are some interesting examples of Food Forests in the Netherlands, each one with its own unique characteristics. Most of them measure about 0.5 to 5 hectares (Van Dooren, 2018).

- Wouter Van Eck's Ketelbroek near the city of Nijmegen is one of the leading examples. This Food Forest started in 2009 on a surface of 2.4 hectares in an ex agricultural plot (Ottema, 2020).
- Food Forest Nieuwe Erven: is a community project of the city of Brummen started in 2017 on an area of 3 hectares.
- Den Food Bosch, an experimental Food Forest started in 2017 on a surface of 0.8 hectares on an ex agricultural field. It is located in Sint-Michielsgestel, in the province of Noord-Brabant. This forest was initiated by highly motivated students who got the funding from the local government (Den Food Bosch, 2021).

- The Schijndel Voedselbos is probably one of the largest Food Forests. Split between two locations, it includes a total of 20 hectares. The Food Forest was started in 2019 and is located in the province of Brabant (Foodbos Schijndel, 2019).

Food Forests in Research

Currently a lot of research is being done to find alternatives to the devastating effect of traditional agriculture. At Wageningen University & Research (WUR) the researcher Jeroen Kruit, originally a landscape architect, is conducting research specifically about Food Forests and leads the project Green Deal Food Forests which has received the attention of government authorities.

There is also the existence of The Measure Your Food Forest Harvest tool for which Marieke Karssen is the lead of the underpinning project at WUR. This tool allows Food Forest owners to compare the revenue of their forests to others, while being supported and contributing to the scientific framework. More information about this tool can be found here: https://voedseluithetbos.nl/en/.

Economical estimates of a Food Forest

According to Lerink et al. (2020), the costs of the implementation (e.g., planting the desired trees and creating the swales) and management of the Food Forest should be covered within 10 years. However, this is an estimate, because the success of a Food Forest depends on several factors such as its location, the soil, the extension of the area considered, and the species planted. *Voedsel uit het bos* (Karssen et al., 2018) provides detailed information suggesting it is better to have parcels bigger than 1 hectare with a good choice of productive and climate-resistant species. According to the data provided from Karssen et al. (2018), the net revenue for the first year is about 428€/ha while in the 6th year is about 5.700€/ha.

5.5 A new type of forest: Toekbos

The current state of the IJsselvallei regarding its hydrology, ecology, and soil characteristics - as explained in Chapter 4 - highlights the need for the area to be adapted to a resilient system. This resilient system should take the effects of climate change into account, among which the most important in the IJsselvallei are drought events and the loss of biodiversity. Currently, the target area is characterised by its dry and sandy soils, a homogeneous landscape (with low biodiversity value in the forests and agricultural monocultures) and fast hydrology system (i.e. fast discharge of rain- and groundwater via the regional hydrology system and surface water runoff). In order to improve the capability of the forest to combat the current and future climate-related challenges, a new type of forest has been thought of. A new name has been assigned to this forest: the *Toekbos (toekomstig bos)*.

The main characteristic of the Toekbos are the swales, which focus on the retention of water in the system instead of discharging the water like ditches do. These swales have a slight slope and should have a sufficient width (as explained in 5.2). As the amount of exposed surface is larger compared to a flat, horizontal surface, rainwater can more easily infiltrate the soil without discharging the water. Moreover, swales go hand in hand with a gradient in the landscape that creates a variety of habitats. The lower parts of the swales will be wetter than the higher parts, and - because of the slight slope - multiple microhabitats will exist in between. This gradient therefore allows plants to grow with different habitat criteria (e.g.

seasonal flooding, humidity and amount of shade). Consequently, biodiversity levels will be boosted and a more heterogeneous landscape is created, which in turn improves the suitability for a plurality of animal species like birds and insects.

The cost for implementing new forest on agricultural land can range from €7.600 up to €136.500 per hectare, depending on whether or not the land has to be bought. For management costs of a forest can be expected to be approximately €270 per year for each hectare (Probos, 2020).

6. Conclusion

The literature study in this report was used to design/adapt areas that tackle current and future challenges in the IJsselvallei. To achieve this, the designed and adapted areas should provide the following functions: climate change mitigation, water retention, biodiversity, economic viability, and tourism release of the Veluwe. Literature study showed that only adapting the current rabatbossen in the area could not achieve all the above-mentioned functions, due to the main underlying processes of each function being mutually exclusive. Therefore, the functions were split among four different types of forest that all offer room for the functions of climate change mitigation and water retention. However, the different forest types do not contain all the different functions. They should be combined in the IJsselvallei to create a mosaic forest landscape and to develop a diverse, attractive area that achieves all the desired functions. The four forest types are Food Forest, agroforestry, rabatbos and our newly designed Toekbos.

First of all, Food Forests can be a good solution to combine the ecological services of a forest with the provision of fresh and healthy food. They combine water retention, biodiversity, and food production all in one forest. These forests can be designed in several different ways according to desired outcomes and to cope with the environmental conditions present in the place. Before implementing a Food Forest, it is important to have information about the environmental factors of the area. This will determine the selection of the best suitable species and improve the success of a Food Forest.

Agroforestry is another forest type which focuses on economic viability and can be implemented on a large scale as opposed to the Food Forest. Alley cropping is found to be the best solution where farmers can still farm the same crop or keep the same livestock as before but add rows of trees in between these alleys. Coppice of poplar in between the larger timber or fruit trees is a good way of providing income from trees in a shorter time period. Spacing between rows will need to be sufficient in order to avoid light competition.

A third type of forest is the traditional rabatbos. These forests were once implemented to convert swampy areas into dry land. Since the hydrology of the area has changed, however, constructing more rabatbossen for the purpose of water retention, would not be practical. Wood production was another element of a traditional rabatbos. While some income can still be maintained from forestry practises, the rabatbossen do offer opportunities for tourism, since it is part of cultural heritage and therefore adds value to its visitors. As a result, the aesthetic of the rabatbossen will be used to create a new and functional type of forest. These could, in combination with the existing rabatbossen, provide educational aspects for its visitors.

Lastly, in order to combat the future climatic challenges a new type of forest needs to be reintroduced in the IJsselvallei. The Toekbos is found to be a sustainable solution regarding water retention and biodiversity challenges. One component of the traditional rabatbos that should be transformed is the shape of the landscape: the ditches should be closed, and swales should be constructed. These swales have a slight slope, which is associated with a gradient from dry to wet and thus more heterogeneity. This will boost biodiversity as well. In the Toekbos, water can be retained due to improved infiltration in the swales and by re-establishing a sufficient groundwater level (for instance by constructing weirs and restoring natural waterflow). Lastly, as the Toekbos is a forest that highlights the importance for ecological resilience, it is also interesting for tourists and educational purposes.

7. Discussion

This study suggests that creating a mosaic landscape by including different types of forests in the IJsselvallei will help solve some of the current and future challenges facing the area. These include solutions to climate change mitigation, improving water retention, increasing biodiversity, developing tourism, and all combined in a way that is economically viable. As stated in the previous chapter, trying to resolve all these issues by designing one forest proved neither feasible nor practical. Different types of forest offer different functions. For example, agroforestry with alley cropping, contrary to an ecotourism forest, is not designed to cater to visitors' needs. For each type of forest, there is a trade-off for different stakeholders. For this reason, we suggest creating a mosaic landscape, which encompasses different elements that administer to each of the different problem areas. Although this project aims to address these issues, certain limitations do arise that could affect the results of this study.

One important step for the future is to assess the willingness of farmers and other landowners of the area to participate, as their exact needs and wishes are unknown. How to include the different stakeholders, how to inform them, and the role they could play in implementing this project, fall beyond the scope of this study.

Economic viability is an important precondition for farmers to change their practices. However, it is difficult to assess the direct economic benefits of conversion to other management practices. Initially, profits after conversion are expected to be lower, at least in the short term. This is due to the high establishment costs and low short-term returns of investment. However, purely focusing on short-term profits from the land is not the only aspect that should be considered. In time, farmers that have diversified become more resilient to pests and economic fluctuations due to the production of multiple crops. Also, the development of tourism in the area can provide an additional stream of income for the farmers. Here, the farm-to-fork strategy or facilitation (e.g., bed and breakfast, campsites) are just two of the potential ways farmers could benefit from the increased tourism. Moreover, alternative ecosystem services, such as water retention and biodiversity, should be valued as well. These ecosystem services benefit the whole IJsselvallei and are vital to ensure a productive landscape in the future. When a farmer decides to convert their land to provide these services, their loss in productivity should be compensated. Here, the government/water authorities and/or the farmers themselves should take an active role to make subsidies available to assist engaged farmers to change their practice. It is only fair that all stakeholders who benefit from these changes help with this. These factors could make the conversion financially interesting, although admittedly, further research is still needed to get a more complete picture.

Another limitation of this study is the lack of extensive research done on the productivity and efficiency of the Toekbos. We have designed a new type of forest that, in theory, encompasses elements that stimulate tourism, aid water retention, and increase biodiversity. However, certain aspects that come into play when launching the project remain unexplored. Here, one could think of management activities and maintenance schedules, for example. A more detailed analysis of the potential labour practises, costs and revenue would be more likely to encourage landowners to implement the Toekbos as part of their strategy. This forest, however, will most likely be part of nature areas rather than farmlands as its primary value is biodiversity and water retention, rather than profit.

Furthermore, the maps (Figure 1 and Figure 5) should be considered as a concept, and further research is required before the actual implementation of the forests. The exact size and scale of the forests are not specified, and the demarcations of the different forests can deviate. Essentially, these schematic overviews of the mosaic forest on the GIS maps are suggestions. In order to design a realistic plan that includes the implementation of the four different types of forest, sufficient sizes and locations should be investigated. This can be done by an assessment of the present landscape elements that define the locations of the forests, and by an analysis of the local scale soil and water characteristics that might affect the choices of species in the forest.

Finally, as stated by Maarten Veldhuis, the water table has been steadily declining every year (Veldhuis, M., personal communication, April 30, 2021). If this is the case for the future, the IJsselvallei area will become drier, which will affect the entire ecosystem including biodiversity. Although the present advice clearly supports climate change mitigation, its efforts might still not be sufficient to alleviate the effects of climate change. As mentioned by Pielke (1998), those that aspire to minimise drastic changes to the weather and climate, ''*must be prepared to face the possibility that there does not exist a single global solution to the problem of climate change*''. May the droughts indeed be the case in the future; follow-up research must be catered to species that are more resilient and adapted to drier climates.

Despite these limitations, the present study has enhanced the current understanding of the IJsselvallei area and the relationship between rabatbossen, their history and future opportunities. Every different type of forest serves a function; it simply shifts over time. Rabatbossen used to be implemented to create dry areas in swamps, where they could plant trees for coppice. Whereas nowadays, they have become landmarks of cultural heritage, while at the same time providing biodiversity and supporting carbon sequestration. This shift can be exploited to meet the goals of the IJsselvallei Masterplan.

Our suggested mosaic landscape, and especially the combination of the rabatbos and the Toekbos, aims to create a vital, resilient, and multifunctional IJssel-landscape of the future. An effort that combines both innovative and traditional forestry practises to address long-term goals in the IJsselvallei.

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Appendix

Appendix 1: commonly used species for forestry systems in Europe with rotation age, volume increment, value and other information

English	**Latin**	**Rotation age**	**Mean annual volume increment to rotation age per hectare**	**Small timber 15-55 cm diameter value (€/m³)**	**Round wood > 55 cm diameter value(€ /m³)**	**Information**
Scots pine	Pinus sylvestris	65	6,8	15-45,6	174	pioneer species tolerate poor soil conditions very shade intolerant timber/pulpwood
Black pine	Pinus nigra	50	15,8	15-45,6	-	pioneer species tolerate poor soil conditions timber is not very durable good stand volume
Douglas fir	Pseudotsuga menziesii	55	14,5	15-45,6	173	valuable timber tree pulp/sawnwood
Japanese Larch	Larix kaempferi	55	9,6	15-45,6	200	pioneer species highly adaptable light-demanding durable wood (timber/pulpwood)
Norway spruce	Picea abies	50	12,5	15-45,6	-	good yield good performance in diverse site conditions Seedling growth is very slow for the first few years encourage high-quality trees

						timber/pulpwood
Common oak	Quercus robur	70	5,9	17,7 – 75,0	576	high-quality timber for construction and furniture long rotation
Red oak	Quercus rubra	80	5,7	17,7 – 75,0	-	mid-tolerant species mostly used for biodiversity
Common beech	Fagus sylvatica	70	7,7	17,7 – 75,0	-	high quality hardwood timber sensitive to repeated flooding large market for beech wood
Poplar	Populus cultivars	25	13,3	11,6 – 45,6	-	fast growing strong light demander sensitive to drought older trees susceptible to pests good for coppicing
Aspen	Populus tremula	15	10,5	11,6 – 45,6	-	fast growing pioneer species large water demand strong light demander good for coppicing older trees susceptible to pests
Silver birch	Betula pendula	50	4,3	17,7 – 75,0	-	fast growing tolerant to low temp., little water., infertile soils
Ash	Fraxinus excelsior	65	8,7	17,7 – 75,0	219	fast growing high quality wood not ideal for large scale planting
Black alder	Alnus glutinosa	45	8	17,7 – 75,0	-	pioneer species excellent agroforestry tree especially when planted along ditches

						good for coppicing
Sycamore	Acer pseudoplatanus	40	9,8	17,7 – 75,0	-	soft timber used for musical instruments fast growing highlight demand not attractive to wildlife except aphids and bees.

sources used: (Jansen, 2016), (Jansen, 2018), (Forestry compendium,2021)

Appendix 2: Examples of agroforestry systems from the Netherlands and nearby countries

Tree Species	**Trees/ha, rotation, etc.**	**Crop**	**Synergies**	**Economics compared with separate elements**	**Source**
Poplar (for energy wood production)	6 rows of fast-growing trees per 13m-wide strip (3 or 6 year rotation) between 48 or 96m crop alleys (30 ha total area)	Oilseed rape (*Brassica napus*) and wheat (*Triticum aestivum*)	Reduced yields 1m from tree strip edge, 77/55% due to leaf litter. Effects up to approx. 2x tree height. Oilseed yields at 1m windward 0.1t/ha, in centre leeward 3.6t/ha. Lowest wheat yield 3.1t/ha, highest 7.6t/ha, MC lowest 6.3, highest 8.1t/ha	On average no overall change in crop yield compared to MC. (Swieter) 16% ave yield increase of wheat compared to MC. (Kanzler) greater effect in dry years	Kanzler, et al., 2009; Swieter, et al., 2009
Apple	50 trees/ha, 215 hazel shrubs/ha	Hazel, Raspberries, Red currants			Prins., E (2017)
Robinia (black locust)		potatoes	Acacia honey, N fixation tree	High value hardwood	Rigueiro-Rodríguez, et al., 2008

Chestnut	100-150/ha	mushrooms	Understorey not suitable for crops but ideal for edible mushrooms	2-2.5t/ha/yr chestnuts 0.2t/ha mushrooms	Pantera, 2018

Appendix 3: Examples of silvopasture systems from the Netherlands and nearby countries

Tree species	**Strategy/ use**	**Trees/ha, rotation**	**Crop**	**Animal**	**Economics or synergies**	**Source**
Poplar	veneer for matchsticks	100-200 trees/ha	grass: Dactylis glomerata L., Holcus mollis L. and H. lanatus L.	cattle		Rigueiro-Rodríguez, et al., 2008
Alder along edges of wetland	pruned vertically (for firewood) or felled (for construction timber)	25 year rotation	Grass	mowed	N fixation by alder helps grass grow	Rigueiro-Rodríguez, et al., 2008
Apple (*Malus domestica*) (pear or cherry could also be used)	Dessert (Jonagold) or cider (Coet-de-linge) Orchards arranged in rows. Animals graze seasonally or at least not during harvest.	Bushes (H=2.5m) at 600-1000+ trees/ha with 4-15 sheep/ha Trees (H=7m) at 500/ha with 20 sheep/ha	Perennial ryegrass: (*Lolium perenne* L.)	Sheep Control of apple scab/ reduction in pesticide costs by eating fallen leaves that would harbour the pest.	Apples up to 50t/ha/yr 2 lambs per ewe Mowing costs reduced but increased labour to manage sheep.	Pantera, et al., 2018

Chestnut (or plum)	Low input (labour etc) but high output	Scattered trees 100-150/ha	Low under-storey production	Pigs 1.5/ha	2-2.5t/ha/yr chestnuts + meat and fuelwood.	Pantera 2018; Rigueiro-Rodríguez, et al., 2008
Walnut	2m wide strips. 2004 establish-ment cost of 4253 eur/ha	100 trees/ha first yield at year 10 then 1t/ha/yr. net income 953 eur/ha. +733eur/ha for winter cereals (assuming low yielding arable land)	Grass (or crops) 3-9t dry matter/ha/yr. no evidence of negative effects on arable crops or grass from trees.	Mowed After 10 yrs access with arable equipment becomes difficult, need to switch from arable crops to grass sward.	with a 20 year horizon and higher yielding (3t/ha) precocious varieties (1st crop in 3rd yr), more profitable as agroforestry than either arable or walnut MC.	Newman, 2004

Appendix 4: Example of species for the different layers in a Food Forest in the IJsselvallei

Food Forest Layer	**Possible species to plant***
1. Tall trees / Canopy	Poplar (for timber), Sweet chestnut (castanea sativa), black walnut (Juglans nigra), walnut (Juglans regia), sweet cherry (Prunus avium), American bird cherry (Prunus serotina), small-leaved lime (Tilia cordata), large-leaved lime (Tilia platyphyllos), Hazel (Corylus colurna),
2. Sub-canopy/ large shrub layer	Elderberry, Aprium (Prunus salicina, Prunus armeniaca), Siberian pea shrub (N fixator),Fig (Ficus carica)
3. Shrubs	Blackberries, raspberries (Rubus idaeus), blueberries, jostaberry (Ribes x nidigrolaria), red berry (Ribes rubrum),
4. Herbaceous layer	Blueberries, strawberries, nasturtium, , medical herbs (echinacea), gooseberry (Ribes uva crispa),
5. Groundcover / Creeper layer	clovers (N fixators)
6. Underground species	beetroots, carrots, potatoes
7. Vines/Vertical/Climber species	grapes,
6. Aquatic/ wetland species	comfrey
9. Mycelial layer	Some edible mushrooms can be cultivated in the surface.

*the trees species mentioned here are for climate smart forests, taken form website: https://www.vbne.nl/klimaatslimbosennatuurbeheer/boomsoorten#

Appendix 5: Factors affecting the implementation of a Food Forest

Factors	Problem	Reference
Plant spacing and allelopathy	The space between plants determines the competition for light, the space to grow, the supply of water and nutrients. The distance between the trees should be bigger than the one usually recommended for each species, in order to let some light pass through the branches and reach the lower layers. **Allelopathy** between species. Allelopathy occurs between herbs but also between trees and shrubs, decreasing the capacity of a species to grow fast or even produce fruits.	*Whitefield, 1996*
Light	Light is an important factor to take into consideration when designing a Food Forest as plants have different needs as far as light is concerned and will compete between them for this resource.	*Whitefield, 1996*
Water	Plant species have different tolerances to changes in water level. Some species are more resistant to these changes while others do not tolerate drastic changes. Therefore, it is important to select species which can tolerate future water fluctuations, especially due to climate change effects.	*Whitefield, 1996*
Nutrients	Clay soils have a greater ability to hold plant nutrients than sands. Nutrients can be lost quickly from a sandy soil, especially in wet weather when water flowing freely through the sand carries them away. But sandy soils can be improved with the provision of organic matter which has at least twice the ability of clay to hold nutrients.	Caravaca & Albaladejo, 1999;
Soil composition/ texture	Soil composition and texture affect mostly plants through their water holding capacity and their ability to retain nutrients.	*Whitefield, 1996*

pH	Soils with high clay content are more resistant to acidification and tend to have a higher pH. Sandy soils however are very sensitive to acidification and have the tendency to have a low pH. The majority of fruit trees and garden plants do not like extreme pH conditions. The best pH to grow a Food Forest is around 6.5-6.7. Groundwater is generally more alkaline, has a lot of Ca2+ ions (higher pH) Rainwater is more acidic as it contains more H+, Na+K cations and Cl- anions as well as SO42- (S comes from traffic pollution and is bad for vegetation).	*Whitefield, 1996*
Temperature (frost, extreme heat)	Some species do not tolerate drastic changes in temperature (either too warm or too cold). With the effect of climate change these changes will be more accentuated.	*Whitefield, 1996*
Wind	The effects of wind on plant growth and development are direct and indirects. Fruit trees are especially sensitive to wind, therefore, Whitefields (1996) suggests building wind fences with tall trees/canopy in order to protect small fruit trees and shrubs. The efficiency of windbreak depends on the width between trees, the number of rows, the height of the trees and the forest type.	Hodges & Brandle, 1996; Schroth et al., 2004; Bitog et al., 2012; Wu et al., 2018
Auto-Fertilisation of species	Some species of plants have the ability to auto-fertilise. However, others are divided into 'female' and 'male' and need both individuals in order to be fertilised and produce fruits.	*Whitefield, 1996*

Appendix 6: Factors affecting the implementation of a Food Forest and some advice

Factor	Advice
Plant spacing and allelopathy (chemical competition between species)	Between the herbs, three main families are known to create negative allelopathic effects interfering with the germination and growth of other plants: the labiates (mint, thyme and sage), the umbellifers (including fennel, angelica and lovage) and the daisy family (including chamomile and marigolds). Within the trees, walnuts, elders and sages are known to have allelopathic effects on other species. Plants react differently to negative allelopathy depending on their sensitivity. Generally, this effect can be avoided by placing suitable neighbours close to allelopathic plants.
Light	The trees in the Tall trees/Canopy layer and in the Sub-canopy/ Tall shrubs layer should be spaced so as to allow light to reach the lower layers. Big and tall trees that cast a lot of shade are not suitable as they will prevent the light from penetrating the lower layers of the forest. Dwarf trees need to be taken care of, so if one of the goals of the Food Forest is to have no maintenance then the dwarf trees should be excluded as they could not survive beneath trees. The shrubs will tend to grow taller and thinner under a continuous canopy than they would in full sun. If they are planted at the normally recommended spacing this thinning of the shrub layer should allow enough light to reach the vegetable layer. Shrubs fruit best either on an edge or in the early years of the garden, before big trees grow and take away light.
Water	To favour vegetation and a healthy soil, groundwater should be favoured over rainwater.
Nutrients	Some plants are able to increase the availability of nutrients in the soil, such as Nitrogen fixating species.
Soil composition/texture	The perfect soils to plant a Food Forest are the loamy soils which are composed of almost equal parts of sand and silt, with a little less clay.

	The input of organic matter from the decomposition of parts of the Food Forest will change the soil composition increasing the soil water retention capacity.
pH	Some plants and trees can adapt to pH conditions and there are species which are more adaptable than others. Here is an example of trees that grow in sandy, acidic soils: https://www.vbne.nl/klimaatslimbosennatuurbeheer/boomsoorten#.
Temperature (frost, extreme heat)	It is possible to plant plants more resistant to changes in temperature on the outside of a Food Forest, while keeping the most fragile species in the inside of the forest.
Wind	\Examples of trees suitable for windbreaks are: Rowans (*Sorbus acuparia)*, Elderberry (*Sambucus canadensis)*, Beech (*Fagus sylvatica)*, Black walnut (*Juglans nigra*), Hawthorn, Arnold (*Crataegus arnoldiana*), Poplar (*Populus Spp.)*.
Diseases	Some species, especially herbs such as mint, have the ability to keep pests away and, if combined close to some plants, can have a very effective repellent action, avoiding the need for pesticides (Whitefield, 1996). This effect is sometimes called 'plant synergy' .
Auto-Fertilisation of species (in order to have the fruits)	It is important to be aware of which species can auto-fertilise and which need both individuals in order to plant the latter close to each other.