CIRCULAR PEAT LANDSCAPE

a spatial framework based on circular agriculture to relieve peat oxidation in the 'low midlands' in Friesland, the Netherlands

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Abstract

Peatlands are a rare landscape that only covers over 3% of the world's land mass. However, peatlands store nearly 30% of all soil carbon and the damaged peatlands account for 6% of all anthropogenic carbon emissions worldwide (Brooks, 2019; European Union, 2020). Peat oxidation, driven by the drainage of these wetlands for agricultural purposes, poses a severe threat to the ecological integrity of Friesland's low midlands. Additionally, it leads to water management challenges, such as water shortages in higher areas and flooding in lower regions.

The concept of a circular economy offers a promising solution to this complex problem. By transitioning from a linear model of production and consumption to one focused on reuse, recycling, and minimizing waste, the circular economy aims to reduce pressure on natural resources and mitigate environmental degradation. In the context of Friesland's peatlands, embracing circular agricultural practices could offer a sustainable approach to relieve peat oxidation.

To determine if circular agriculture practices will alleviate peat oxidation in Friesland's low midlands, the research question follows: What is the spatial framework based on circular agriculture to relieve peat oxidation in the 'low midlands' in Friesland, the Netherlands? With the sub questions: What are the characteristics of the peat landscapes in the low midlands, Friesland, the Netherlands? What agriculture practices have the potential of relieving peat oxidation? What is the relation of the agriculture practices that relieve peat oxidation to the circular agriculture system?

Development of the framework is done by looking into literature review, interviews with stakeholders and expert, and testing the implications of the findings through design research. Through this structured approach, the study aims to provide a comprehensive understanding of the interplay between peatlands, agricultural practices, and circular economy principles, with the goal of proposing sustainable solutions for preserving the ecosystems of Friesland's low midlands.

In conclusion, the spatial framework involves an integrated approach combining water management, circular crop and livestock practices, community engagement, and integrating peat ecotypes within the agricultural system.

Maintaining higher water levels in peatlands is crucial to reducing peat oxidation. Circular crop practices include cultivating crops such as Reed, Cattail, and Willow, which thrive in wet conditions and originate from peat landscapes, thus preventing peat oxidation. These practices also support circular livestock practices in combination with strip grazing and flooding to maintain soil health. By reintroducing wooded banks and flooding in the agricultural landscape, traditional practices are preserved and the connection between the local community, nature, and the agricultural landscape is enhanced. A green corridor acts as a vital ecological link between Natura2000 areas ensuring that species can migrate and disperse.
The local community plays a vital role in implementing and sustaining this circular agriculture system. The integration of agricultural products for housing materials or biogas creates a strong bond between the community and the landscape. Surplus products are distributed nationally and internationally, broadening market reach and economic benefits.

The study recommends expanding the range of agricultural practices suitable for high-water table environments, further research to understand the impact of different crops on specific peat strata, and investigating the detailed effects of the proposed dairy cattle system.

Keywords: circular agriculture, peat landscape, peat oxidation

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Glossary

Circular Economy An economic system aimed at eliminating waste and promoting the continual use of resources through strategies like recycling, reusing, and refurbishing.

Ecosystem A community of living organisms interacting with each other and their physical environment in a particular area.

Ecosystem Service The benefits that humans derive from ecosystems, including provisioning services (e.g., food, water), regulating services (e.g., climate regulation, flood control), cultural services (e.g., recreation, aesthetic enjoyment), and supporting services (e.g., nutrient cycling, soil formation).

Green Corridor A linear stretch of habitat that connects fragmented patches of natural areas, allowing for the movement of species and genetic exchange.

Helofytenfilters Constructed wetlands, which are artificial systems designed to treat wastewater or stormwater by using wetland vegetation and microbial processes.

Heterogeneous Landscape A landscape characterized by a variety of different elements, such as land uses, ecosystems, and habitats.

Homogeneous Landscape A landscape characterized by a uniform elements, such as land uses, ecosystems, and habitats. uniform or consistent, often at the expense of diversity or variation.

Linear Economy A traditional economic model in which resources are extracted, used to make products, and then discarded as waste after their useful life.

Peat landscapes Areas characterized by the accumulation of peat, which is partially decayed organic matter, usually found in wetlands.

Peat Oxidation The decomposition of peat in the presence of oxygen, leading to the release of carbon dioxide into the atmosphere.

Reuse Economy A step towards a circular economy where products are reused or repurposed instead of being discarded after use.

Steppingstones Small patches of habitat within a landscape that serve as intermediate points for species movement between larger habitat patches.

Strip Grazing A grazing management technique where animals are confined to a small area or strip of pasture at a time, allowing the rest of the pasture to recover and minimizing overgrazing.

Subsidence The sinking or settling of the Earth's surface, often caused by the extraction of groundwater or natural processes such as peat decomposition.

1. Scope

1. Design location
2. Motivation
3. Problem field - peat oxidation
4. Problem field - circular economy
5. Research Questions
6. Methodology

1.1 Design location

The project focuses on the geomorphological region called the ‘low midlands’ in Friesland, the Netherlands. This region has gained this nickname because it is the lowest part of the region (Wikipedia, 2023a).

The Netherlands

Friesland, The Netherlands

Low middle, Friesland, The Netherlands

Figure 1. Location Research
Sources: Kadaster (2022)

1.1 Design location

The borders of the design location are defined by four main components. The location includes the differentiation between clay on peat and peat soil. Including both peat types allows research into the implications of the different soil characteristics and their possibilities.

The design location is near Drachten, one of the four major cities in Friesland. Drachten has 45.000 inhabitants and is the second largest city in Friesland after Leeuwarden with 96.000 inhabitants (Wikipedia, 2024). Including one of the major cities enables research into the connection between agriculture, cities, and recreation and its effects on the local community.

Furthermore, the location includes National Park de Alde Feanen and Van Oordt's Mersken, which are protected peat areas that are included in the Natura2000 list. These protected areas offer an insight in how peat landscapes function and what the natural ecosystem entails and which flora and fauna partake in this system.

The location is bordered by surrounding waterways and highways and provide as natural borders of the location.

The chosen design location aims to form a basis of research that can be extended to other regions that are characterized by the peat landscape and have an agricultural purpose.

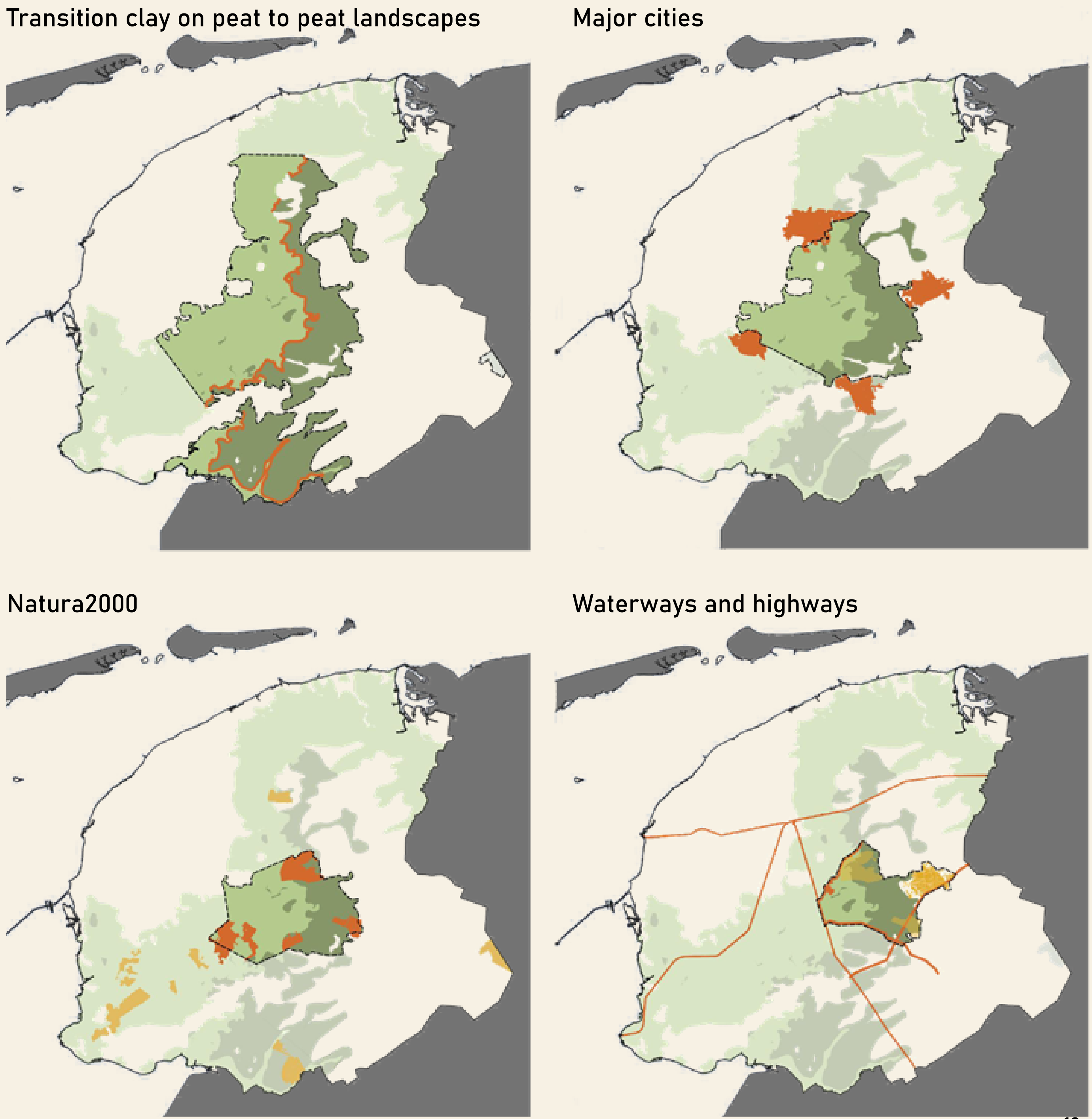


Figure 2. Definition design location
Sources: Kadaster (2022)

1.1 Design location

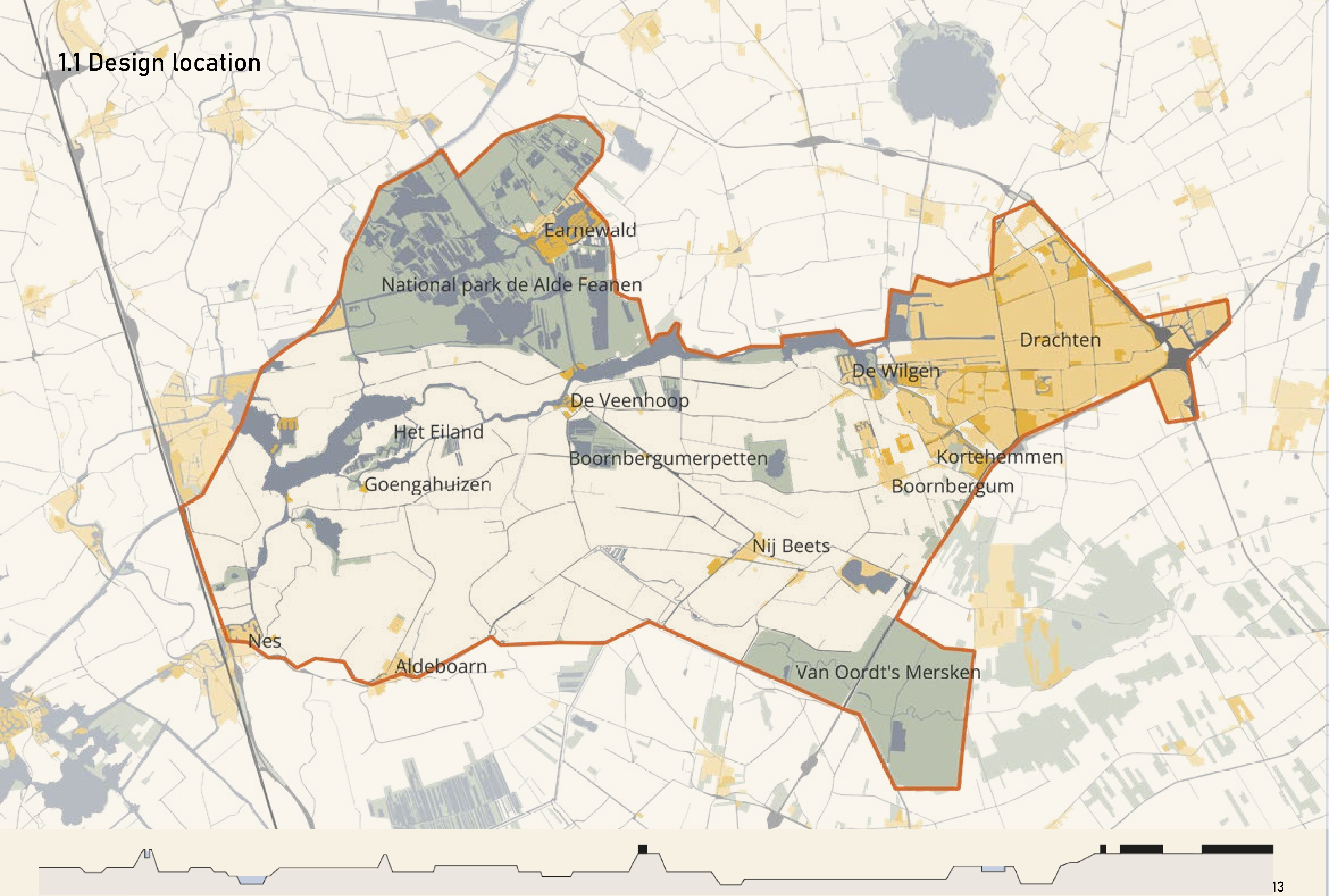


Figure 3. Situation design location
Sources: Kadaster (2022)

1.2 Motivation

Peatlands are a rare landscape that only covers over 3% of the world's land mass. The peat landscape is slowly built up from dead plant material under waterlogged conditions (Brooks, 2019). While not all peatlands are the same, differing in mosses, swamps, and fens, all require damp conditions (Friends of the earth, 2019). They form natural habitats for various flora and fauna, but also offer a natural form of water purification and flood protection (Friends of the earth, 2019).

However, when peatlands are drained or burned, they release carbon – which was stored in the dead plant material – back into the atmosphere as carbon dioxide. Peatlands store nearly 30% of all soil carbon and the damaged peatlands account for 6% of all anthropogenic carbon emissions worldwide (Brooks, 2019; European Union, 2020).

The circular economy offers a possible solution as this is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible (European parliament, 2023). With the use of this model, the life cycle of products is extended. Reusing and recycling products would slow down the use of natural resources, reduce landscape and habitat disruption, and help limit biodiversity loss (European parliament, 2023).

Additionally, this thesis is based on personal motivation and interest in the peat landscapes in Friesland and the transition towards the circular economy. I grew up in Friesland and have always been fascinated by the Frisian landscape. Over the years, this interest developed from a childish, playful enjoyment during nature outings into an understanding of the inner workings of the landscape and the current environmental challenges developing in Friesland.

The low midlands and Friesland in general, are camping with various water-related issues ranging from necessary additional water storage due to drought to pumping away excess water to allow for agricultural fields. The low midlands is also in need of more recreationally accessible nature areas as most areas are sheltered and protected given the rarity and vulnerability of peat landscapes. These challenges has resulted in a fragmented landscape, in which there are pockets of often inaccessible natural areas in between the open grasslands.

The typical Frisian is very proud of their landscape – as am I – and research and experimentation are being conducted to address these issues in a nature-inclusive way. However, effective and optimal solutions are not always easily found. With this thesis I hope to provide additional information and possible solutions towards this complex problem.

My interest into the circular economy has formed throughout my academic career through a multitude of assignments and reports written for my bachelor's. This thesis allowed me to expand on this interest and to test the implications of a circular economy on the agricultural sector and landscape architecture in general.

1.2 Motivation

Figure 4. Collage of photos taken in the low midlands
Sources: made by author

1.3 Problem field - Peat oxidation

The problem field is divided into two parts. The first part expands on the occurrence of peat oxidation in the low midlands. What is the cause of the oxidation and the implication the peat oxidation has on the landscape and the agricultural sector.

The second part expands on the circular economy. This parts explains why the transition towards the circular economy is important and how it relates itself towards the agricultural sector and the peat landscape.

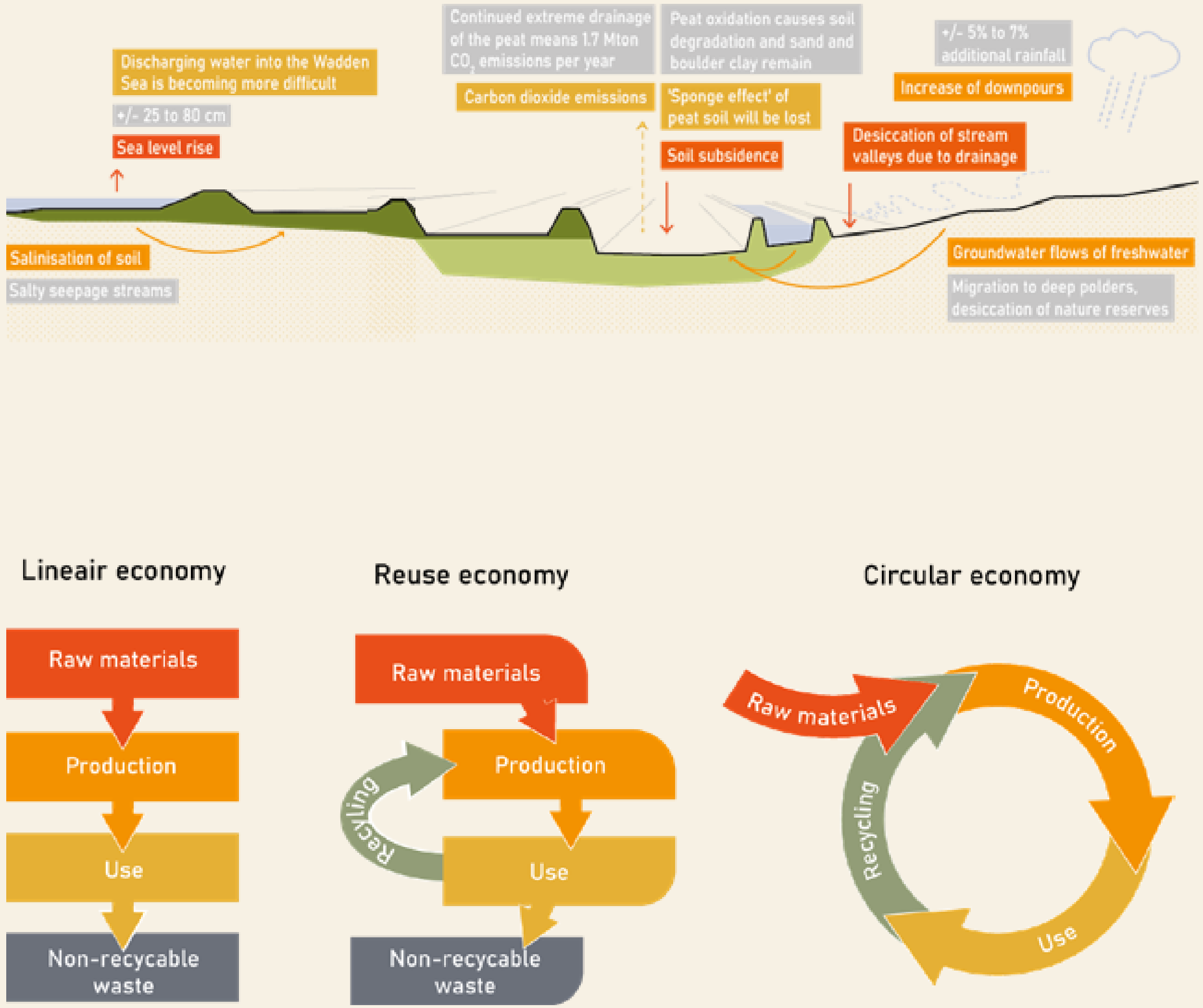


Figure 5. Introduction problem field peat oxidation and circular economy
Sources: Adapted from Buro Sant en co (2018); Adapted from Volksbank (2023)

1.3.1 Location peat

Peat soil constitutes a significant portion of the land cover in the province of Friesland, accounting for approximately 37% of the total area. This substantial presence of peat soil plays a crucial role in the region's ecological and agricultural landscape. The peat soil in Friesland can be categorized into three primary types: peat, clay on peat, and peat on a high sand ridge (Kadaster, 2022).

Pure peat soil results from the partial decomposition of plant material in waterlogged conditions. This type of soil is typically found in low-lying areas where poor drainage conditions prevail, leading to the accumulation of organic materials over centuries (Technische Adviescommissie voor de Waterkering, 1996).

The second type, clay on peat, occurs where layers of clay have been deposited on top of the peat. This usually results from historical flooding events that brought in clay sediments. The presence of clay modifies the properties of the underlying peat, often improving its structural stability and making it more suitable for certain agricultural practices (de Jong, 1987).

The third type, peat on a high sand ridge, is found in areas where peat has formed over a substrate of sand. These sand ridges provide a more stable and elevated foundation, which results in a nutrient-poor peat (Provincie Fryslân, 2021).

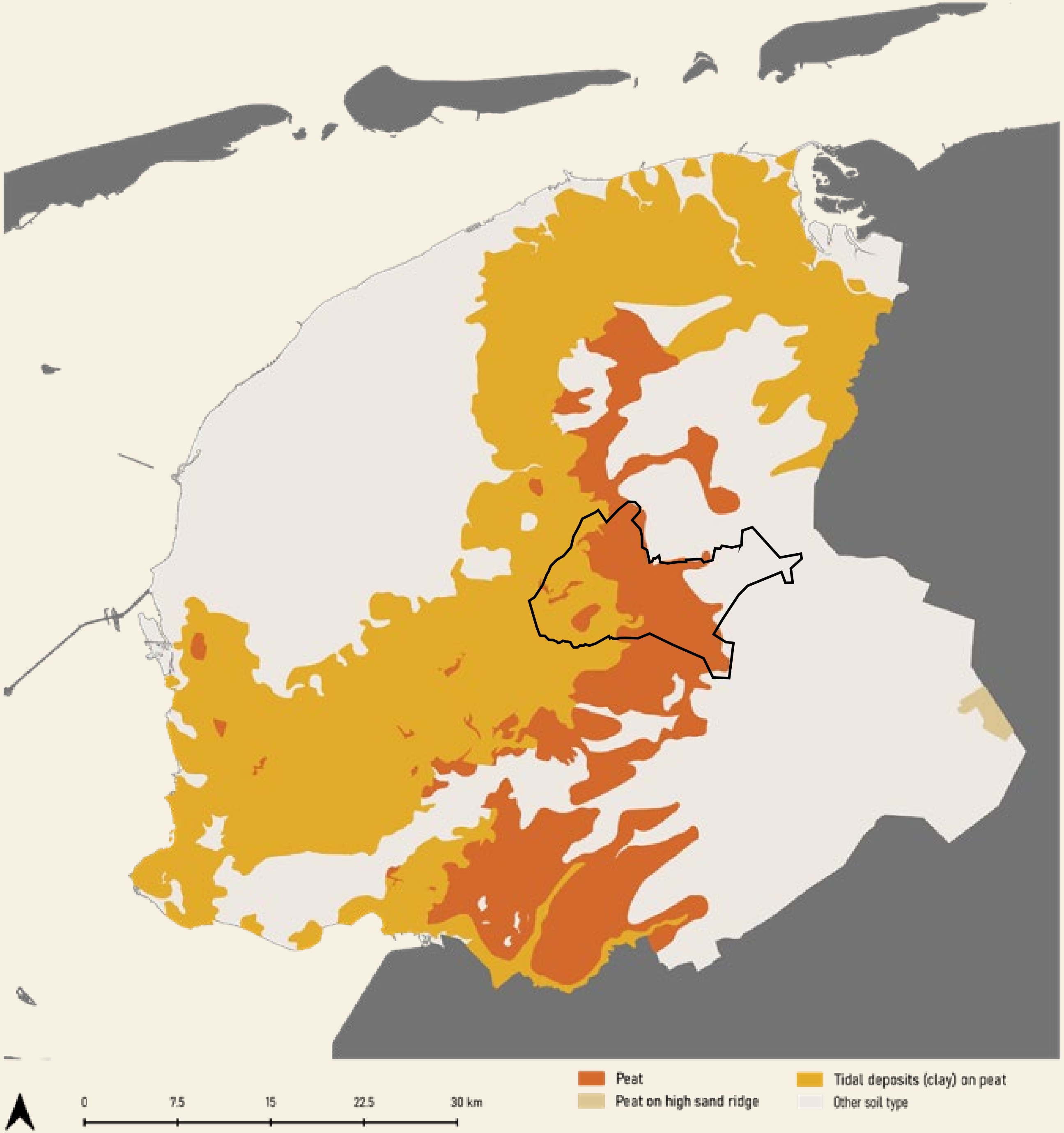


Figure 6. Location Peat soil
Sources: Kadaster (2022)

1.3.2 Elevation Friesland

The province of Friesland exhibits significant variation in elevation, with the peat areas representing the lowest regions. The lowest-lying area of Friesland, often referred to as 'the low midlands,' has undergone substantial subsidence over time. The continuous compaction and degradation of the peat soil have resulted in a progressive lowering of the terrain. Consequently, Friesland's overall topography has assumed a characteristic 'soup bowl' shape, where the central peat areas form the basin into which water naturally accumulates (De Ruyter, 2016).

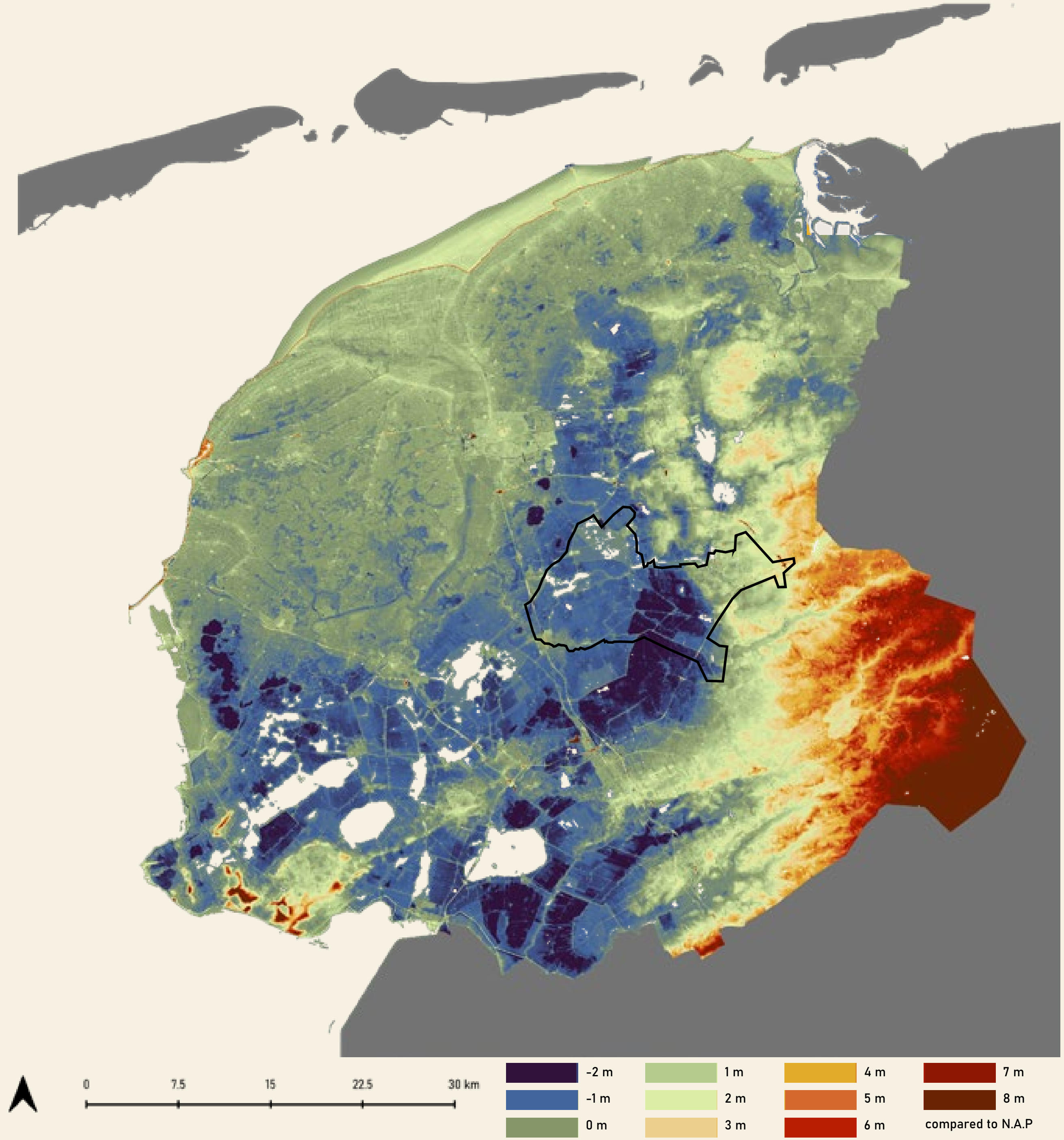


Figure 7. Elevation in Friesland
Sources: Adapted from World Bank Group (2021)

1.3.3 Water management

The geomorphological composition has profound implications for water management and agricultural practices within the province. The accumulation of water in the low midlands necessitates extensive drainage systems to prevent waterlogging and maintain agricultural productivity (De Ruyter, 2016).

However, with continued subsidence, the disparity in water distribution will worsen. This will lead to heightened water scarcity in the higher regions of Friesland and increased flooding risks in the lowest areas.

This combined with the wetter winters and summer droughts accompanied by extreme downpours and peak loads results in conditions that could complicate agricultural practices, residential water use, and overall regional hydrology. Necessitating more sophisticated and costly water management strategies to mitigate these issues, such as adding buffer capacity to the low-lying peat areas (De Ruyter, 2016).

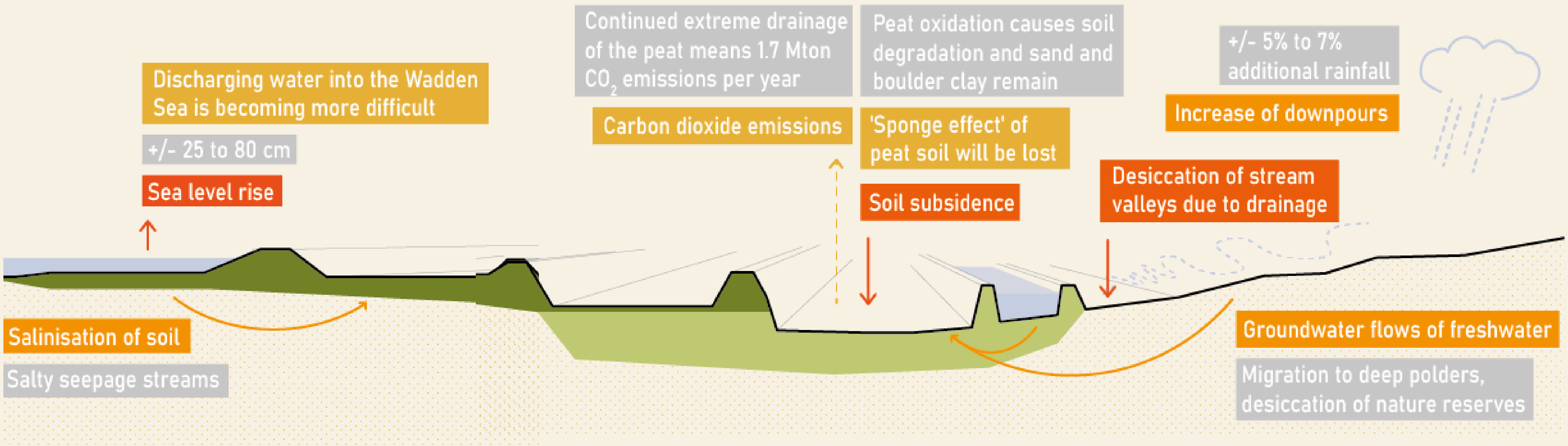


Figure 8. Water management issues due to elevation Friesland
Sources: Adapted from Buro Sant en co (2018)

1.3.4 Peat oxidation

Soil subsidence in the low midlands is caused by peat oxidation which is a result of extensive drainage in the area to allow for dairy cattle. Peat soil in its natural conditions is too wet for any agricultural use, as such the water level is kept at a set lowered level in which peat is too dry and oxidizes. This creates a vicious cycle where due to the degradation of peat, the ground level decreases, requiring further lowering of water levels for agricultural purposes, which in turn leads to oxidation and the release of carbon dioxide and phosphates (De Ruyter, 2016). This cycle is only stopped when no peat is left to oxidize leaving behind a significantly lowered clay or sand landscape of up to 2,5 m degradation (De Ruyter, 2016).

In contrast to the agricultural fields, protected peat nature areas are maintained with a suitable water level and should not oxidize. This contrast has resulted in a landscape with higher-lying nature areas and lower-lying agricultural plots. This height difference has reached the point that the dry-lying agricultural fields draw water from the protected nature areas, which are in result also too dry. This means there is not only a loss of peat in agricultural fields, but there is also a general degradation of peat landscapes and their ecosystems (It Fryske Gea, personal communication, February 2024). Royal Haskoningdhv (cited in De Ruyter, 2016) predicts that the Frisian peat landscape will not survive in its current form beyond 2100.

Throughout the low midlands, the water level is divided in numerous compartments and individual water levels. This results in a fragmentation of the water system, which can no longer effectively serve the various functions of the peat meadow area (Schouwenaars, cited in De Ruyter, 2016). The uniform mold of intensive dairy cattle farming does not fit in the peat area, and has resulted in a fragmented, degrading and unsustainable landscape.

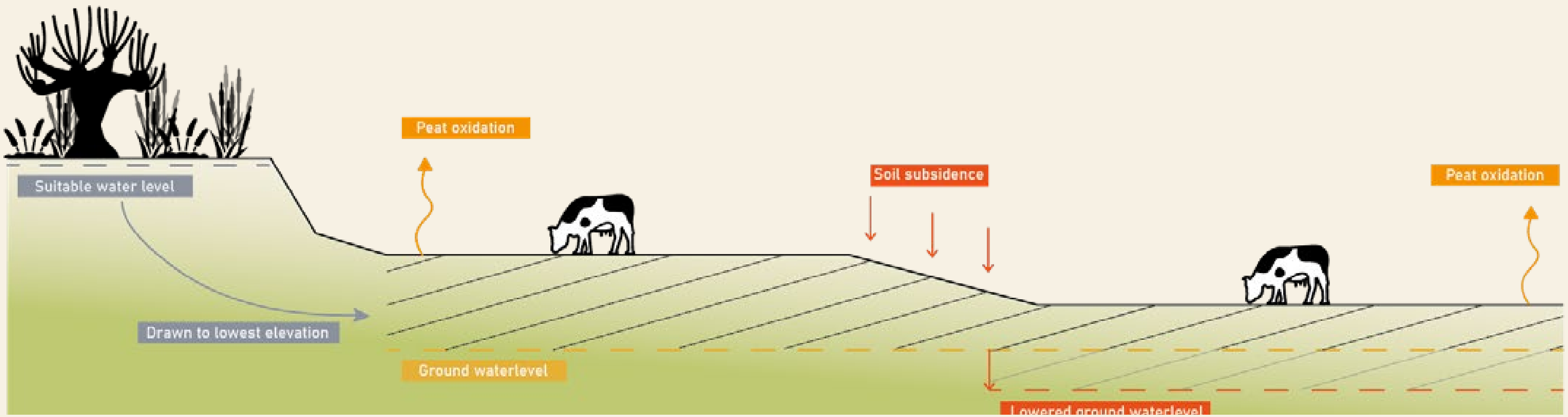


Figure 9. Peat oxidation due to agriculture
Sources: made by author

1.4 Problem field - Circular economy

Concurrently with the peat oxidation problem, the European Union is expressing the need to transition from a linear economy to a circular economy. This shift is driven by an increasing recognition of the environmental impact resulting from the linear model, influencing policy adjustments related to using raw materials and waste management strategies (European Parliament, 2023).

Currently, the European Union is navigating the transition from a linear to a reuse-oriented model. In a linear economy, raw materials are transformed into products that, following their use, become non-recyclable waste. In a reuse economy, a portion of the products are recycled and reintroduced into the consumption cycle, and all other products culminate as non-recyclable waste (de Volksbank, 2019).

In a circular economy, the recycling of raw materials occurs for every product, creating a self-sustaining loop within the economic system. This model ensures that raw materials do not terminate as non-recyclable waste, promoting a sustainable structure that minimizes environmental impact (de Volksbank, 2019).

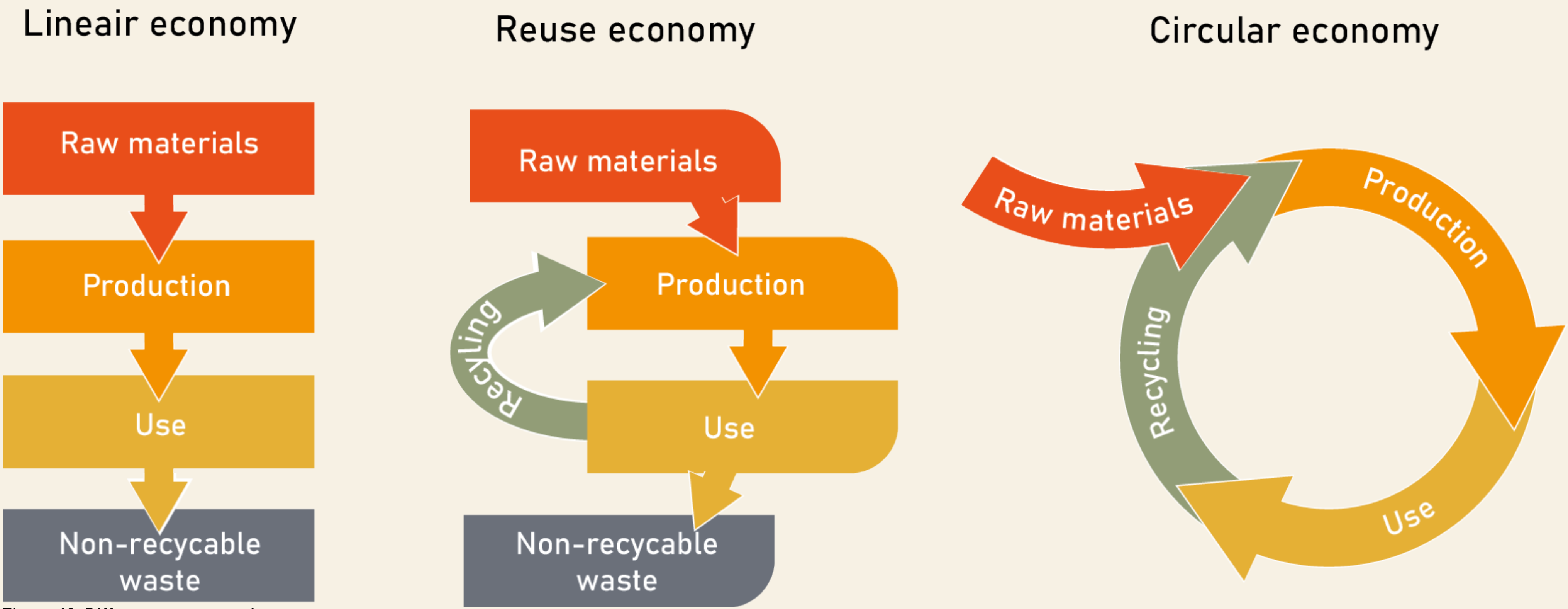


Figure 10. Differences economic systems
Sources: Adapted from Volksbank (2023)

1.4.1 Agriculture sector

By 2050, the European Union intends to fully implement a circular economy (European Parliament, 2023). Despite the vast number of producers and supply chain partners, its pivotal role in food provision, and its extensive land usage, research into the implications of a circular economy on agriculture remains surprisingly sparse (Harmsen et al., 2019). This oversight is particularly striking considering the scale of agricultural land use; for instance, in the Dutch province of Friesland, 67% of the region is dedicated to agricultural practices (Eurostat, 2020).

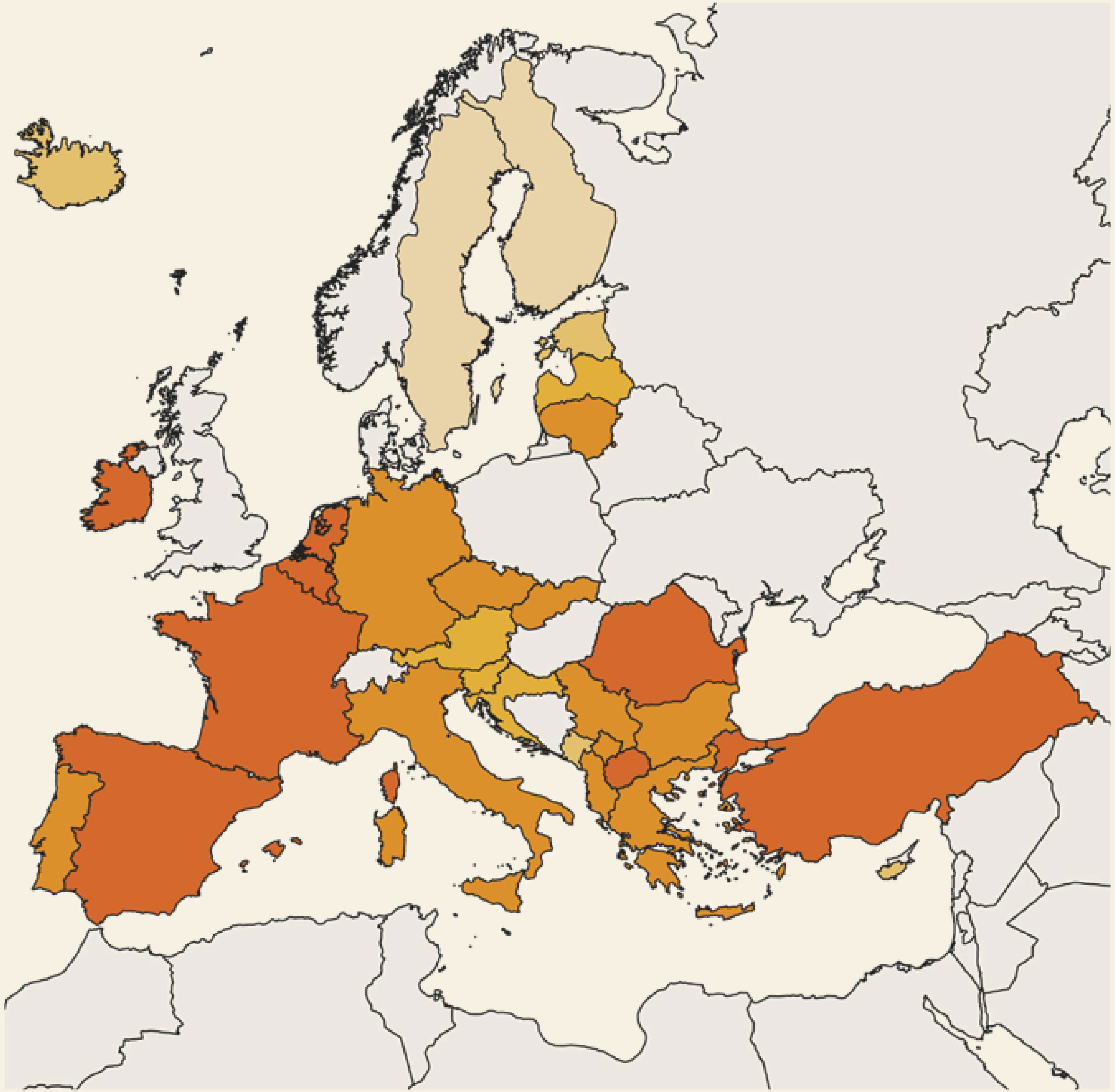
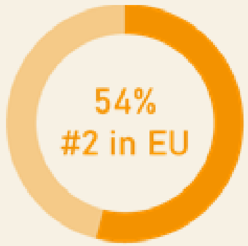


Figure 11. Area agricultural per land in EU (%)
Sources: Kadaster (2022): Eurostat (2021)

The Netherlands



Friesland

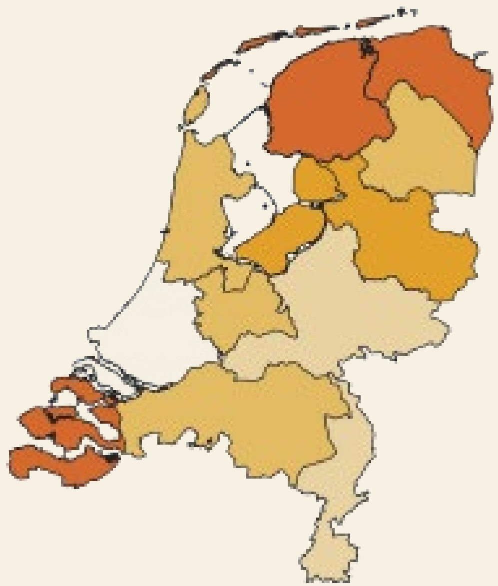


Figure 12. Area agricultutral landuse in the Netherlands (%)
Sources: Metapos (2024); CBS Opendata statLine (2023)

1.4.2 Organic agriculture sector

Organic agriculture represents an initial step towards adopting circular agricultural practices, mirroring the current transition from a linear economy to a reuse economy towards eventually a circular economy within the broader European Union framework. In the Netherlands only 4,2% of the land cover used for agriculture is organic (Metapos, 2024). The province of Friesland constitutes 14% of the total organic agricultural land cover, representing a significant portion of the country's organic farming practices (CBS Opendata statLine, 2023).

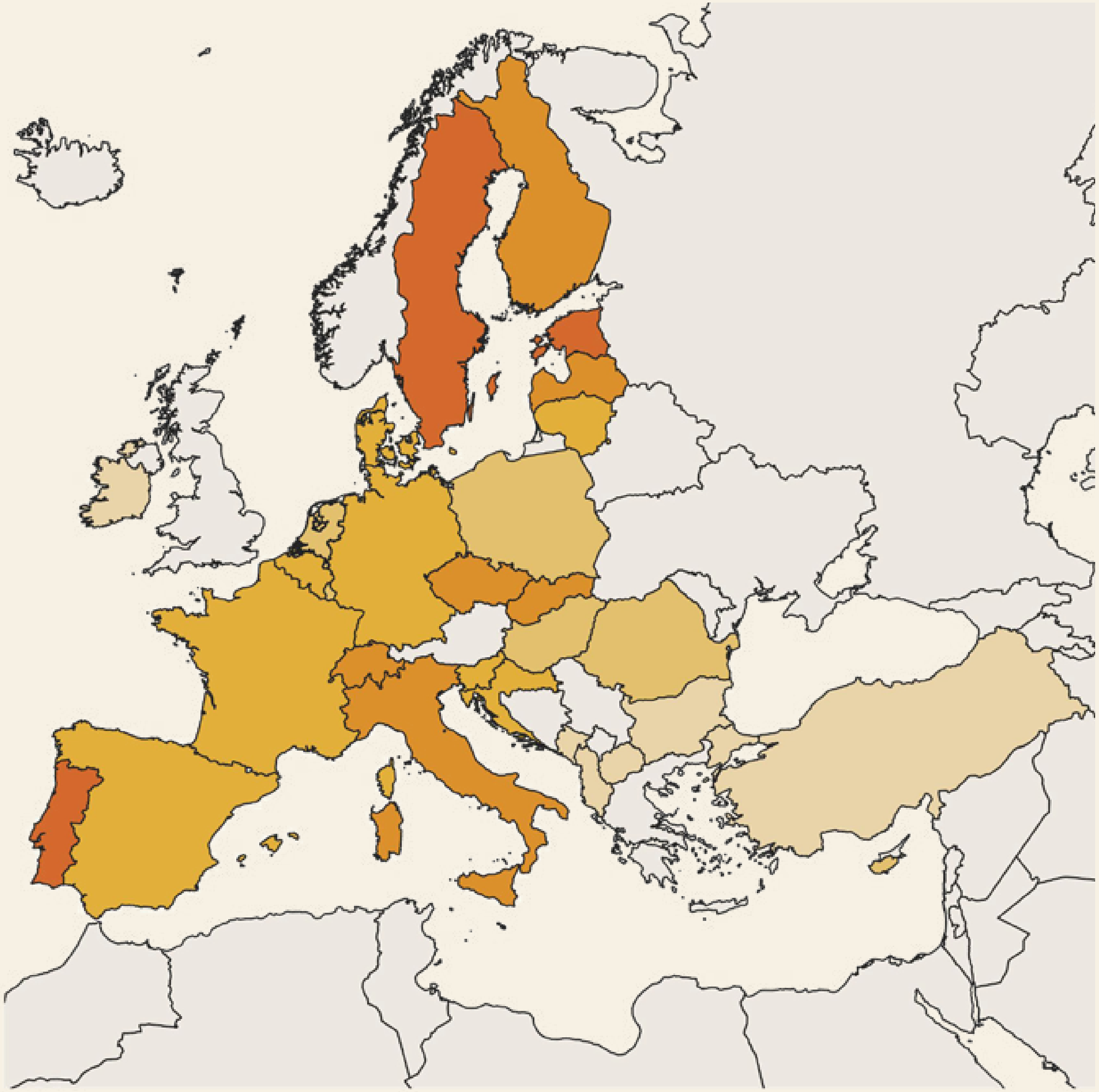


Figure 13. Area organic agricultural per land in EU (%)
Sources: Kadaster (2022): Eurostat (2021)

The Netherlands

Friesland

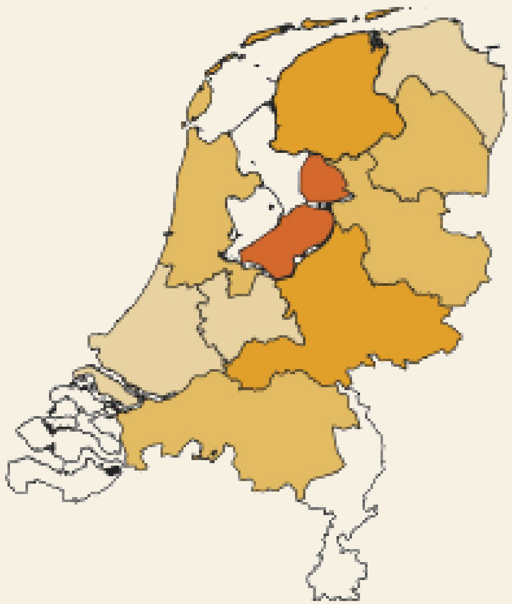


Figure 14. Area organic agricultural in the Netherlands (%)
Sources:Metapos (2024); CBS Opendata statLine (2023)

1.4.3 Circular agriculture connection to nature

The circular economy maintains a unique relationship with the natural environment compared to a linear and reuse economy. While closing the loop in a circular economy entails reusing every raw material to be utilized again, it does not exclude access to new raw materials. Rather, it requires the restoration of natural environments either through active rehabilitation efforts or by allowing nature to regenerate autonomously, before extracting the resources needed by society (The World Bank, 2021).

Within this framework, each sector is responsible for recovering and reusing its supplies internally to minimize the loss of resources (Harmsen et al., 2019). When materials are no longer viable within one sector, they are transferred and repurposed across different sectors to maximize utility and minimize waste.

Circular agriculture is directly tied to natural elements, the water system, biodiversity, and especially soil quality, which significantly impacts the health of crops and dairy production. Heterogeneity, diversity, and versatility within the agricultural system provide the best opportunities for minimizing the loss of resources and the closure of material cycles (Harmsen et al., 2019).

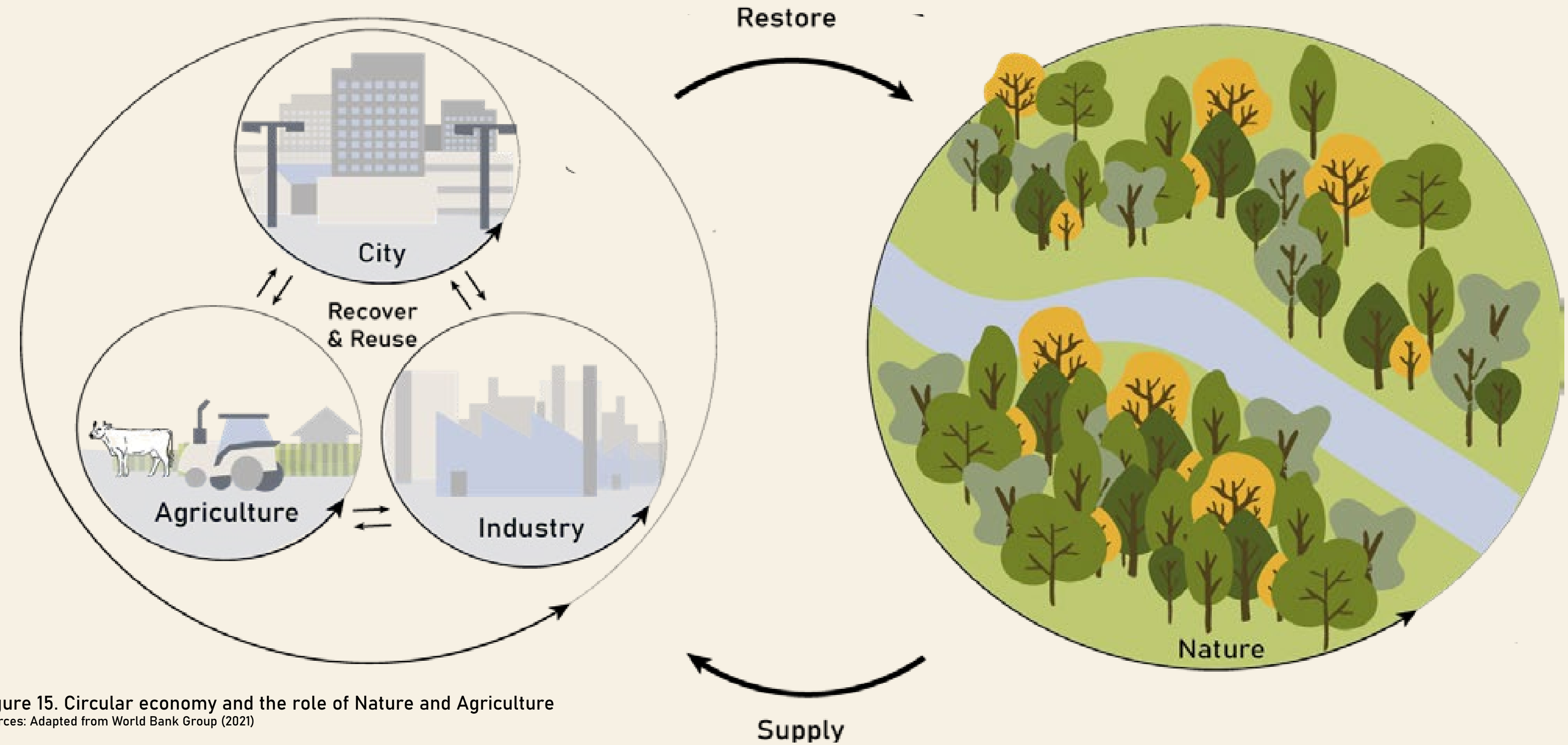


Figure 15. Circular economy and the role of Nature and Agriculture
Sources: Adapted from World Bank Group (2021)

1.4.4 Connections current agricultural system

In the current agricultural system, significant imports of inputs such as bedding materials, synthetic fertilizers, and concentrated animal feed are utilized to enhance milk production, primarily for international export, encompassing 70% of total output (ZuivelNL, 2021). This system creates a fragmented environment with distinct urban areas, natural habitats, and agricultural lands that interact minimally.

Recreational facilities offer mostly engagement with nature, often leading to the overuse of protected natural areas (It Fryske Gea, personal communication, february 2024). The homogenous agricultural landscape fails to attract urban residents, resulting in a disconnect between urban and rural areas due to the export-oriented nature of agricultural produce and the lack of appealing agricultural landscapes for city dwellers.

The relationship between nature and agriculture is largely detrimental, with agricultural practices polluting water sources through fertilizer runoff and harming ecosystems with pesticide use (It Fryske Gea, personal communication, February 2024). The separation of natural habitats, compounded by the uniform agricultural landscape, hinders the movement of flora and fauna, leading to a lack of ecological corridors and steppingstones necessary for biodiversity.

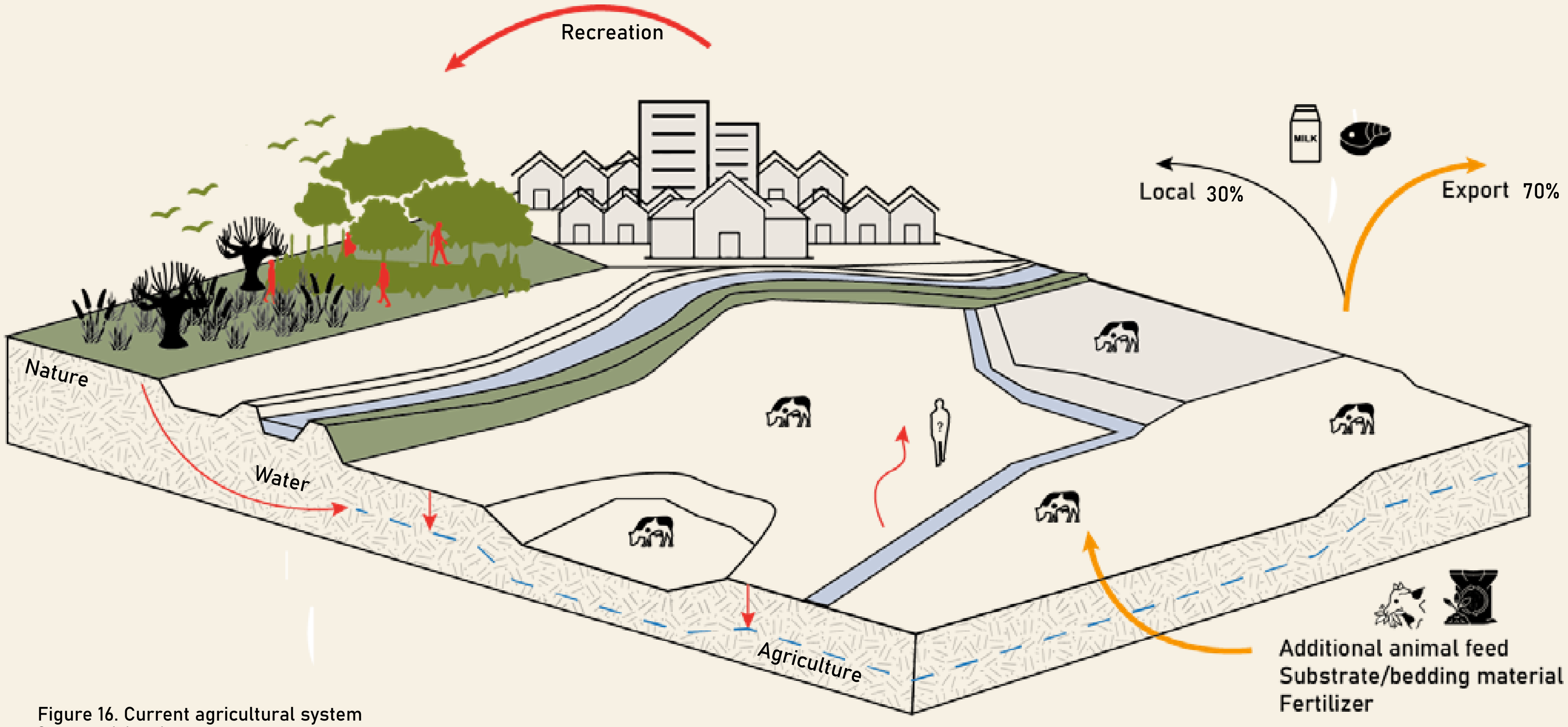


Figure 16. Current agricultural system
Sources: made by author

1.5 Research questions

The peatlands of Friesland, Netherlands, are a crucial yet vulnerable ecosystem. These landscapes are not only rich in biodiversity but also play a significant role in carbon sequestration, storing with all peat landscapes nearly 30% of all soil carbon. However, the drainage and degradation of peatlands have led to the release of stored carbon into the atmosphere, contributing to global carbon emissions.

Peat oxidation, driven by the drainage of these wetlands for agricultural purposes, poses a severe threat to the ecological integrity of Friesland's low midlands. As agricultural practices demand drier conditions than the natural wetlands provide, the water levels are manipulated, accelerating peat oxidation. This cycle of drainage, oxidation, and further drainage exacerbates the problem, leading to subsidence and water management challenges, such as water shortages in higher areas and flooding in lower regions.

The concept of a circular economy offers a promising solution to this complex problem. By transitioning from a linear model of production and consumption to one focused on reuse, recycling, and minimizing waste, the circular economy aims to reduce pressure on natural resources and mitigate environmental degradation. In the context of Friesland's peatlands, embracing circular agricultural practices could offer a sustainable approach to relieve peat oxidation.

The research hypothesis posits that circular agriculture practices will alleviate peat oxidation in Friesland's low midlands. To explore this hypothesis, the research question follows:

"What is the spatial framework based on circular agriculture to relieve peat oxidation in the 'low midlands' in Friesland, the Netherlands?"

The first subquestion: "What are the characteristics of the peat landscapes in the low midlands, Friesland, the Netherlands?" aims to unravel the complexities of the peat landscape in the low midlands. This involves an examination of the formation, ecotypes, and heritage practices that define the peat landscapes.

Following, the question "What agriculture practices have the potential of relieving peat oxidation?" will be answered. Which looks into the conditions needed to halt the degradation of peatlands and which agricultural practices are possible within this framework.

Lastly, the subquestion "What is the relation of the agriculture practices that relieve peat oxidation to the circular agriculture system?" will be looked into. This involves an analysis of the circularity of the agriculture practices and how they relate to the overall circular agriculture system.

Through this structured approach, the study aims to provide a comprehensive understanding of the interplay between peatlands, agricultural practices, and circular economy principles, with the goal of proposing sustainable solutions for preserving the fragile ecosystems of Friesland's low midlands.

1.6 Methodology

The methodology emphasizes a multidisciplinary approach, integrating various research methods to develop a comprehensive understanding of the issues at hand.

Literature reviews provide a theoretical foundation, while interviews with stakeholders and experts offer practical insights. Design research explores the implications of the findings and envisions practical applications of circular agriculture principles.

Overall, the methodology is designed to systematically address the research questions through a blend of qualitative and quantitative methods, ensuring an understanding of the peat landscape ecosystems and the potential for sustainable agricultural practices to mitigate peat oxidation.

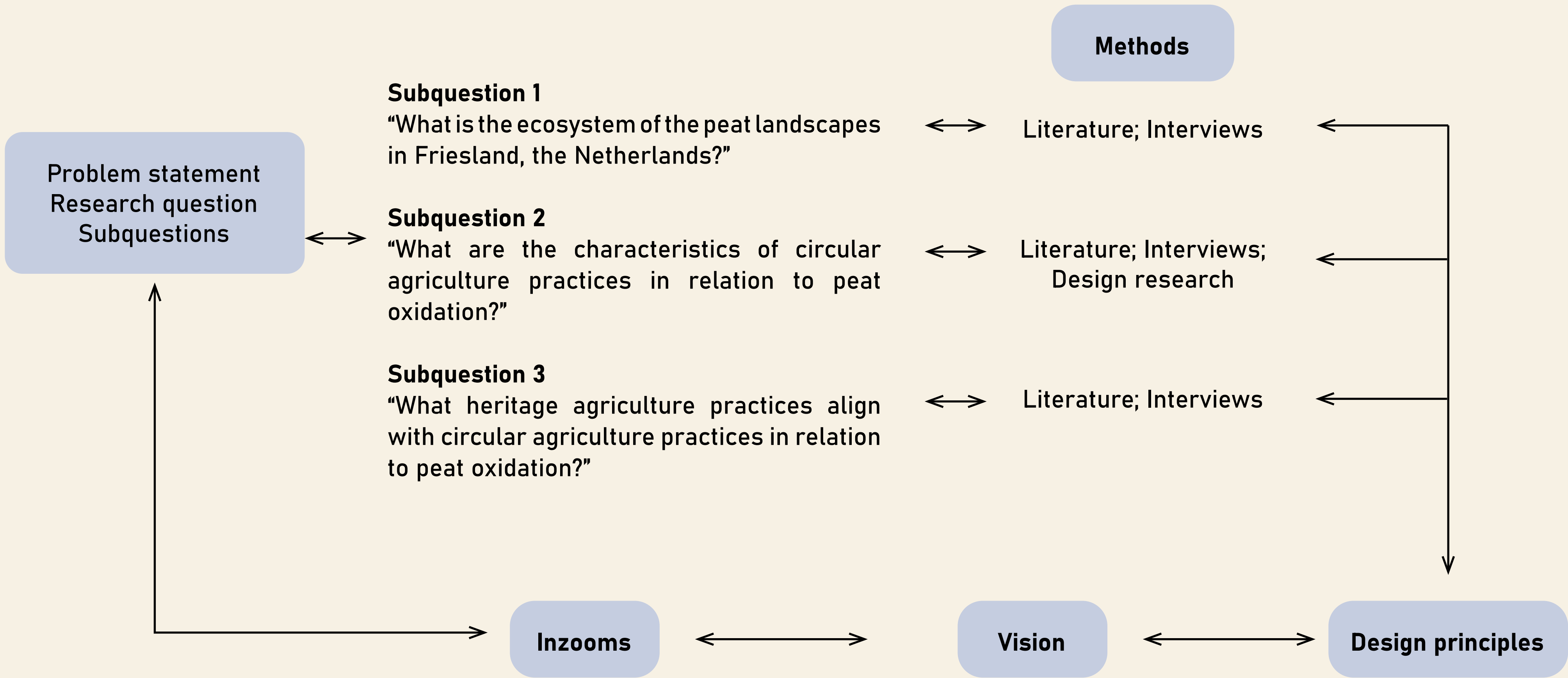


Figure 17. Methodology
Sources: made by author

2. Characteristics of the peat landscape

1. Growth of peat landscapes
2. Ecotypes in peat landscape
3. The peat landschape in the low midlands
4. Heritage related to peat in the low midlands
5. Vision for the low midlands

2.1 Growth of peat landscapes

Natura2000 is a European network of protected natural areas to safeguard specific animal species, plants, and their natural habitats. This initiative aims to preserve biodiversity and prevent the homogenization of natural environments. The natural sites designated under these directives collectively constitute the Natura 2000 network (Natura2000, n.d.).

In Friesland, nine of the twenty Natura2000 sites are dedicated to preserving peat landscapes, covering a total of 13,815 hectares, which accounts for 6.5% of the peatland in the region (Natura2000, n.d.).

Conserving peat landscapes is crucial for multiple reasons. They act as significant carbon sinks, storing more carbon than all other vegetation types combined, thus mitigating climate change. Peatlands also support diverse ecosystems, including many rare or endangered species, making their preservation vital for biodiversity. Additionally, they help regulate water by absorbing excess rainfall, reducing flood risks, and filtering pollutants to improve water quality (Friends of the earth, 2019; Natura2000, n.d.).

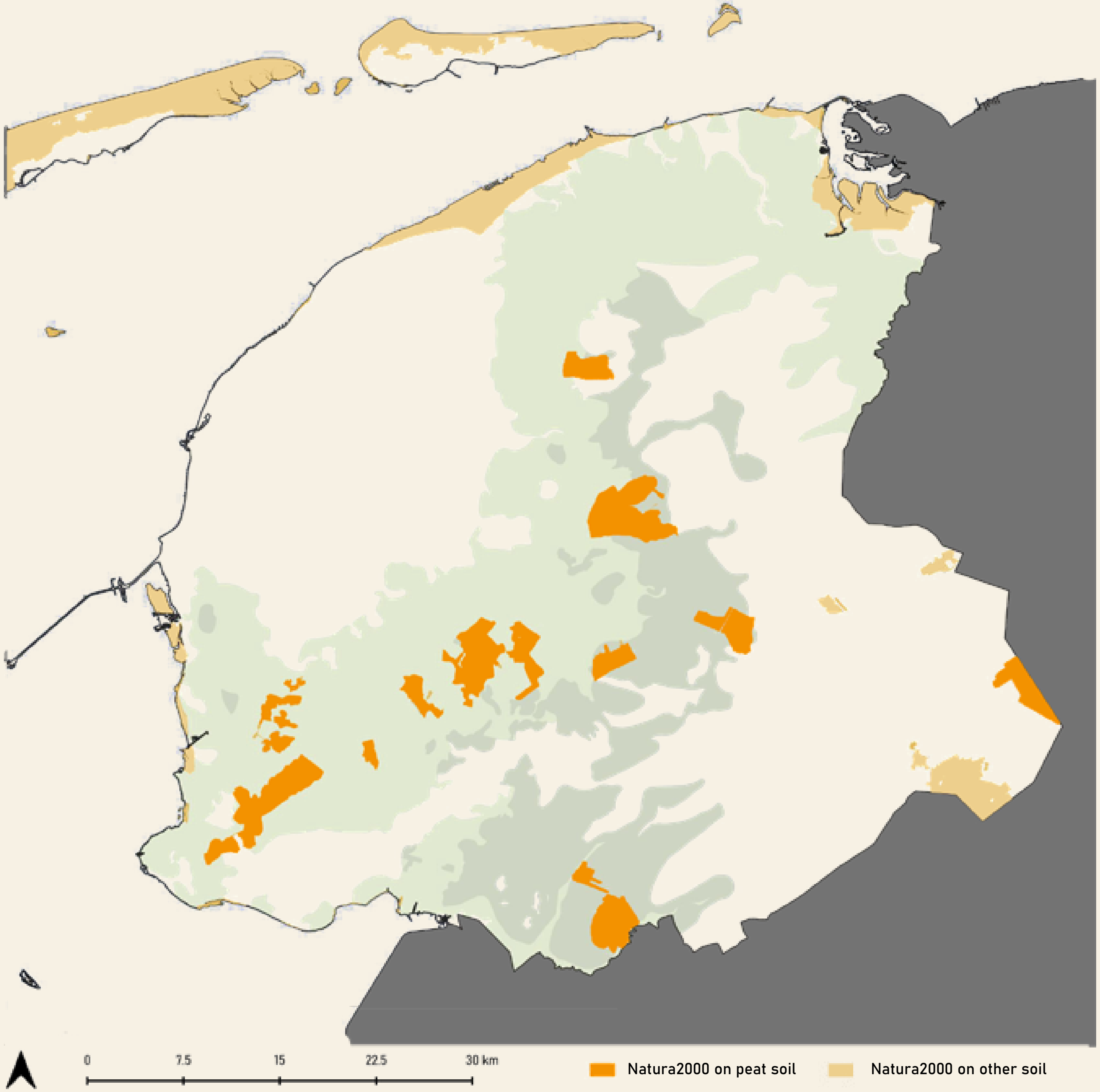


Figure 18. Natura2000 areas in Friesland
Sources: Kadaster (2022); Ministerie van Landbouw, Natuur en Voedselkwaliteit (2022)

2.1 Growth of peat landscapes

Peat landscapes are formed through a horizontal accumulation process, originating from organic materials deposited at the base of aquatic environments. In Europe, the annual growth rate of peat layers is approximately 1-2 millimeters, indicating that peatland formation is a slow process spanning thousands of years (European Union, 2020).

Each stratum of peat corresponds to the nutrient availability in the water during its formation. The initial layers - gyttja and reed peat - are formed in nutrient-rich conditions directly within the water body. Subsequent layers - carex peat and forest peat - develop with nutrients derived from both groundwater and some rainwater.

The uppermost layer - moss peat - is characterized by its formation in nutrient-poor conditions, primarily by rainwater. The first four strata are classified as peat bog, while the uppermost layer is categorized as peat moor (o+bnNatuurkennis, n.d.; Wesselingh, n.d.).

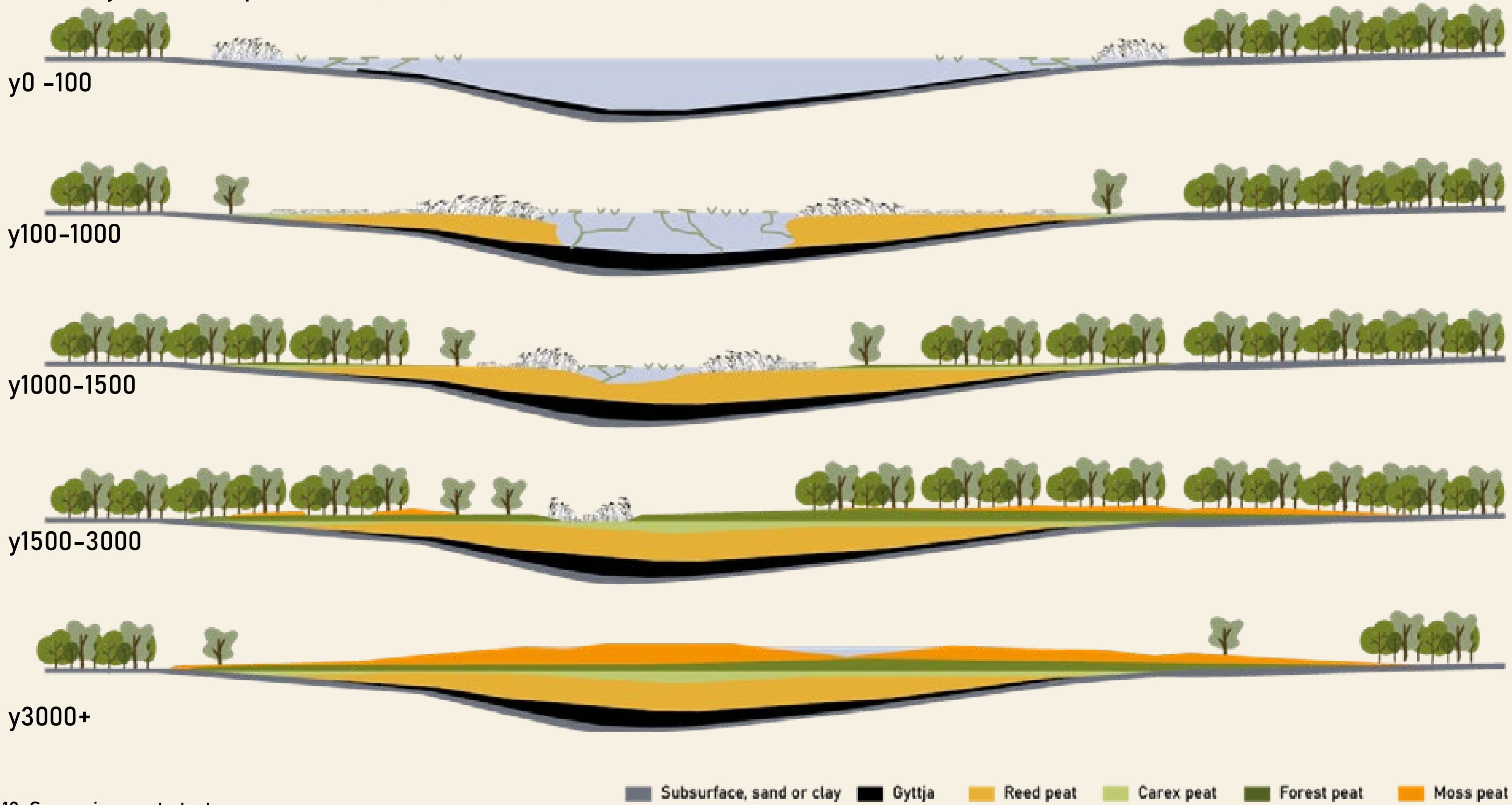


Figure 19. Succesion peat strata
Sources: Adapted from Encyclopedie Drenthe (n.d.)

2.2 Ecotypes in peat landscape

Within each peat stratum, distinct ecotypes emerge, each shaped by varying environmental conditions. This stratification can be observed in different layers such as reed, carex, and forest. Examining these strata reveals a diverse array of ecotypes, including reedland, molinia meadow, and bog woodland. These ecotypes are most occuring and relevant in the location and are taken into consideration for the project.

Each of these ecotypes within the peat strata supports a distinct community of flora and fauna, reflecting the specific environmental conditions of their respective habitats. Understanding these ecotypes is crucial for conservation efforts, as each plays a vital role in maintaining the biodiversity and ecological balance of peatland ecosystems.

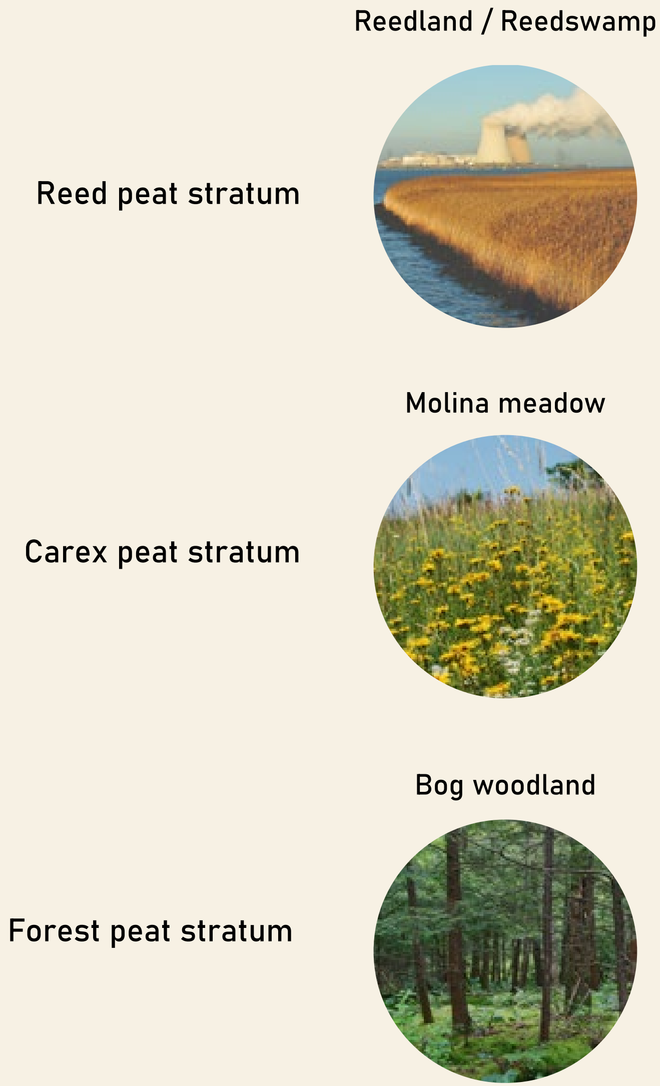


Figure 20. Overview ecotypes per peat strata
Sources: Ecopedia (2024)

2.2.1 Ecotype Reedland / Reedswamp

Reedlands, or reedswamps, are formed in the reed peat stratum characterized by their homogeneous strands of reeds near or within water bodies. They are found in relatively shallow areas of ponds, lakes, and canals, these reedlands support an array of plant species such as cattail and large sedge, and wildlife including the bittern, reed warbler, and root vole (Wikipedia, 2023).

Effective management of reedlands predominantly involves winter mowing, which is crucial for converting overgrown reed vegetations into dense, vital reed growth with varying undergrowth depending on water levels. Removing the litter layer is particularly significant, especially in eutrophic environments, where careful and prolonged mowing management is necessary to achieve a beneficial thinning effect on the reedlands. This approach supports the conservation of biodiversity and the prevention of ecological succession by trees and shrubs, thereby maintaining the reedland habitat's ecological integrity (Ecopedia, n.d.).

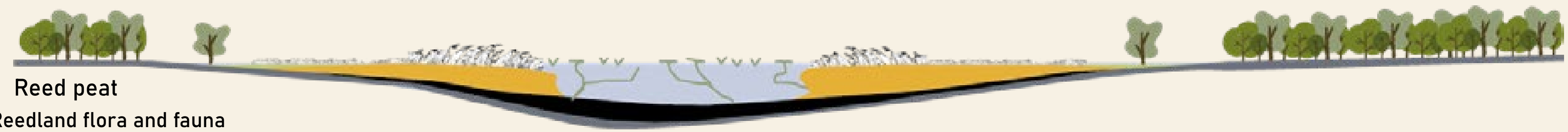


Figure 21. Ecotype Reedland flora and fauna
Sources: Ecopedia (2024); It Fryske Gea (2019); Zuidhollandslandschap (n.d.); Trunk (n.d.); Kranenborg (n.d.); Vijverplantenland (n.d.); istockphotos (2023); Brittannica (2017)

2.2.2 Ecotype Molina meadow

Molinia meadows are typically found in less waterlogged conditions within the carex peat stratum. These meadows develop in areas where the water table fluctuates, allowing for periods of drying that support the growth of a diverse array of grassland species. They thrive in moderately nutrient-poor soils, often characterized by acidic conditions and a mix of organic and mineral substrates (EUNIS, n.d.-b).

Species that occur in this ecotype are purple moor-grass, bog asphodel and various sedges. Additionally, these meadows support marsh fritillary, field voles and meadow pipit are commonly found nesting and foraging in these meadows (Kuziarin, n.d.).

Management in this ecotype include preventing encroachment of woody species like willow and birch, maintaining appropriate water levels through drainagage and irrigation systems, and minimizing nitrogen deposition and other pollutants as Molinia meadows are sensitive to changes in nutrient levels that can lead to the proliferation of invasive species and a decline in biodiversity (EUNIS, n.d.-b).

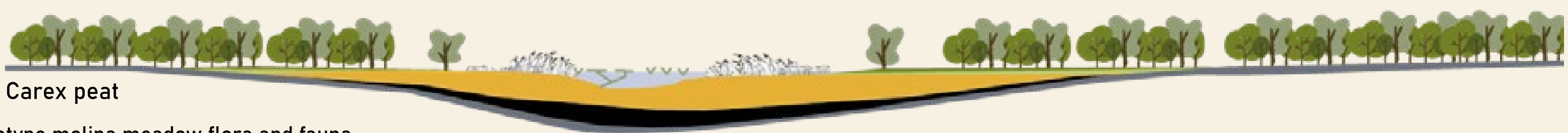


Figure 22. Ecotype molina meadow flora and fauna
Sources: freenatureimages (n.d.); flickr (n.d.); sciotogardens (2020); woodlandtrust (n.d.); rspb (n.d.); butterfly-conservation (n.d.)

2.2.3 Ecotype Bog Woodland

Bog woodland is an ecotype found in areas where peatlands transition into more forested environments. These woodlands occur after minimal to no maintenance is done in the previous peat strata (EUNIS, n.d.-a).

The flora of bog woodlands is dominated by tree species such as willow (Salix spp.) and birch (Betula spp.), and the understory is rich with mosses. Bird species such as the crossbill and the woodcock which relies on the moist ground for foraging, are common. Mammals like the roe deer are often found browsing on the understory vegetation (Forest Habitat Group, 2016).

Effective management of bog woodlands is essential for their conservation. This includes maintaining appropriate water levels to prevent the drying out of peat, controlling the encroachment of non-native species and managing tree densities through selective thinning, and protecting bog woodlands from excessive nitrogen deposition and other pollutants is crucial, as these ecosystems are highly sensitive to changes in nutrient levels (Natura2000, 2008a).

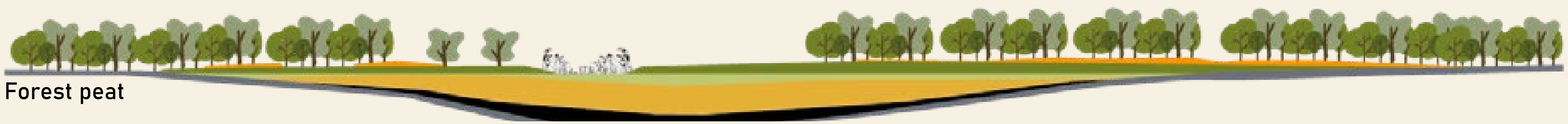
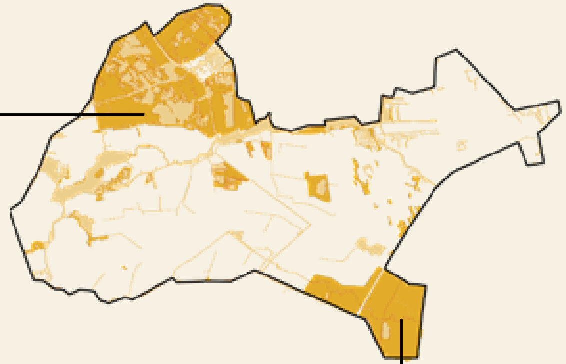


Figure 23. Ecotype bog woodland flora and fauna
Sources: Wikipedia (2024); Tsel (n.d.); ; Meyer (2018); britannica (n.d); Hefele (n.d.); treeguideuk (2020)

2.3 The peat landscapes in the low midlands

The peat landscape in the low midlands is characterized by the presence of various peat strata, including reed, carex, and forest layers. Within these strata, various ecotypes can be observed in well-preserved areas such as the national park Alde Feanen and Van Oordt's Mersken (Biodiversity Europa, n.d.).

These protected nature areas are partially accessible for recreational purposes but are mostly sheltered given the rarity and vulnerability of the peat landscapes (It Fryske Gea, personal communication, February 2024).



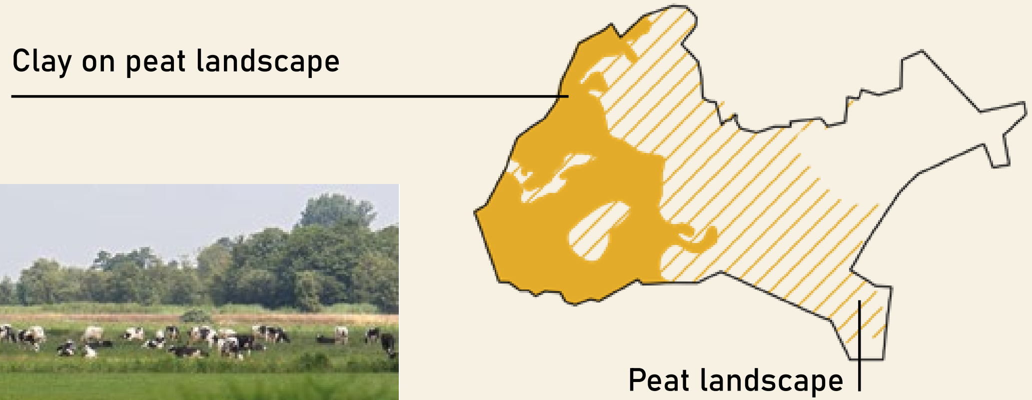

source: simmerwille


Source: vogelbescherming.nl


Source: Laima Gutmane (google earth)

Figure 24. Peat landscape in Natura2000 in design location

2.3 The peat landscapes in the low midlands



Throughout most of the low midlands, the landscape is heavily influenced by intensive agricultural practices, which have significantly altered the natural peatland habitats. As a result, clear ecotypes are not easily distinguishable in the agricultural fields. There is a notable difference in the flora between areas with clay on peat soil and pure peat soil. In the clay on peat areas, vegetation tends to be less distinct, while in the peat soil regions, species such as soft rush (Juncus effusus) are more prevalent, giving these areas a wilder appearance.

The contrast between protected peat landscapes and cultivated peat landscapes underscores the impact of human activities on the peat landscape. In areas where agriculture dominates, the natural ecotypes are largely obscured, whereas protected areas like Alde Feanen and Van Oordt's Mersken offer valuable refuges for the characteristic peatland ecotypes. Effective management and conservation efforts in these protected areas are crucial for preserving the unique biodiversity and ecological functions of the peat landscape in the low midlands.

Figure 25. Peat landscape in agriculture fields in design location

2.4 Heritage related to peat in the low midlands

The heritage of peat in the low midlands is deeply intertwined with the region's history and development. Historically, peat excavation played a pivotal role in the establishment and growth of many towns and cities. The extraction of peat for fuel and other uses was a significant economic activity, shaping the landscape and settlement patterns (De Ruyter, 2016). Today, peat excavation in these areas has largely transitioned to a recreational activity, reflecting a shift in the region's interaction with its natural resources. This has however put pressure on the National Park de Alde Feanen, which must balance recreational purposes and preserving the peat landscape (It Fryske Gea, personal communication, February 2024).

The relation towards water, crucial for a healthy peat landscape, is split in two. Local communities use water bodies for recreational and professional sailing – skûtsjesilen – and waterways run through towns and cities ensuring a strong positive connection to water. Yet, water is drained in agricultural fields, working against the natural conditions of peat landscapes, and is mostly seen in a negative light. This contrast adds to the pressure on protected nature areas as water levels are only high enough in these areas to be used recreationally. Which leads to overcrowding in the fragmented protected peat landscapes within a vast, open, and empty agricultural landscape.

Figure 26. Relation heritage of the low midlands to water and the peat landscape

2.4 Heritage related to peat in the low midlands

Before the current agricultural system, past communities used agricultural practices which worked with the unique conditions of peatlands, allowing for sustainable use of the land (Huizinga, 2014).

Throughout the Middle Ages until late 1800's, an inundation system was used to enhance soil fertility. Channels were laid between plots, allowing water to flow over the land from a supply channel to a drain (Leibundgut & Vonderstrass, 2016). This system provided nutrients to the soil boosting agricultural productivity (Huizinga, 2014). This efficient method of soil enrichment fell out of practice with the advent of artificial fertilizers, which offered a more convenient, though less sustainable, means of maintaining soil fertility (Baaijens et al., 2011; Huizinga, 2014).

Another feature of the peatland heritage is the presence of wooded banks. These lines of trees were used for a wide range of reasons. They were cultivated between plots of land and served as natural dividers and windshields. Wooded banks also served as guiding lines for the flooding of grasslands when the inundation system was still in place (Baaijens et al., 2011; Huizinga, 2014). After four years, the wood could be harvested and sold, providing an additional source of income (Huizinga, 2014).

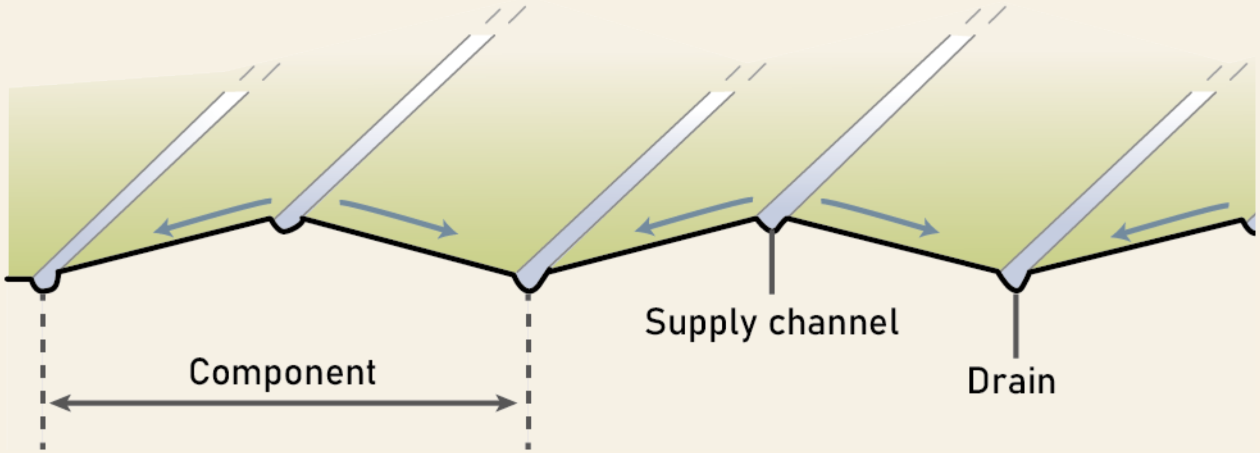


Figure 27. Heritage inudation system
Sources: adapted from Leibundgut & Vonderstrass (2016)

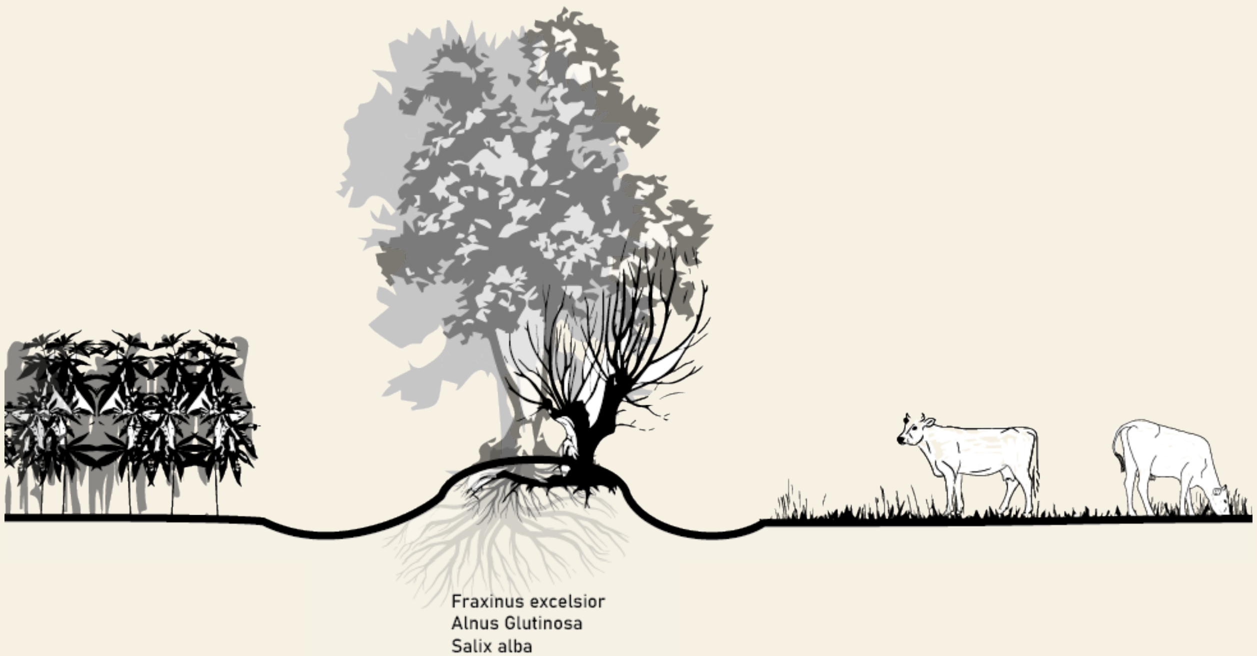
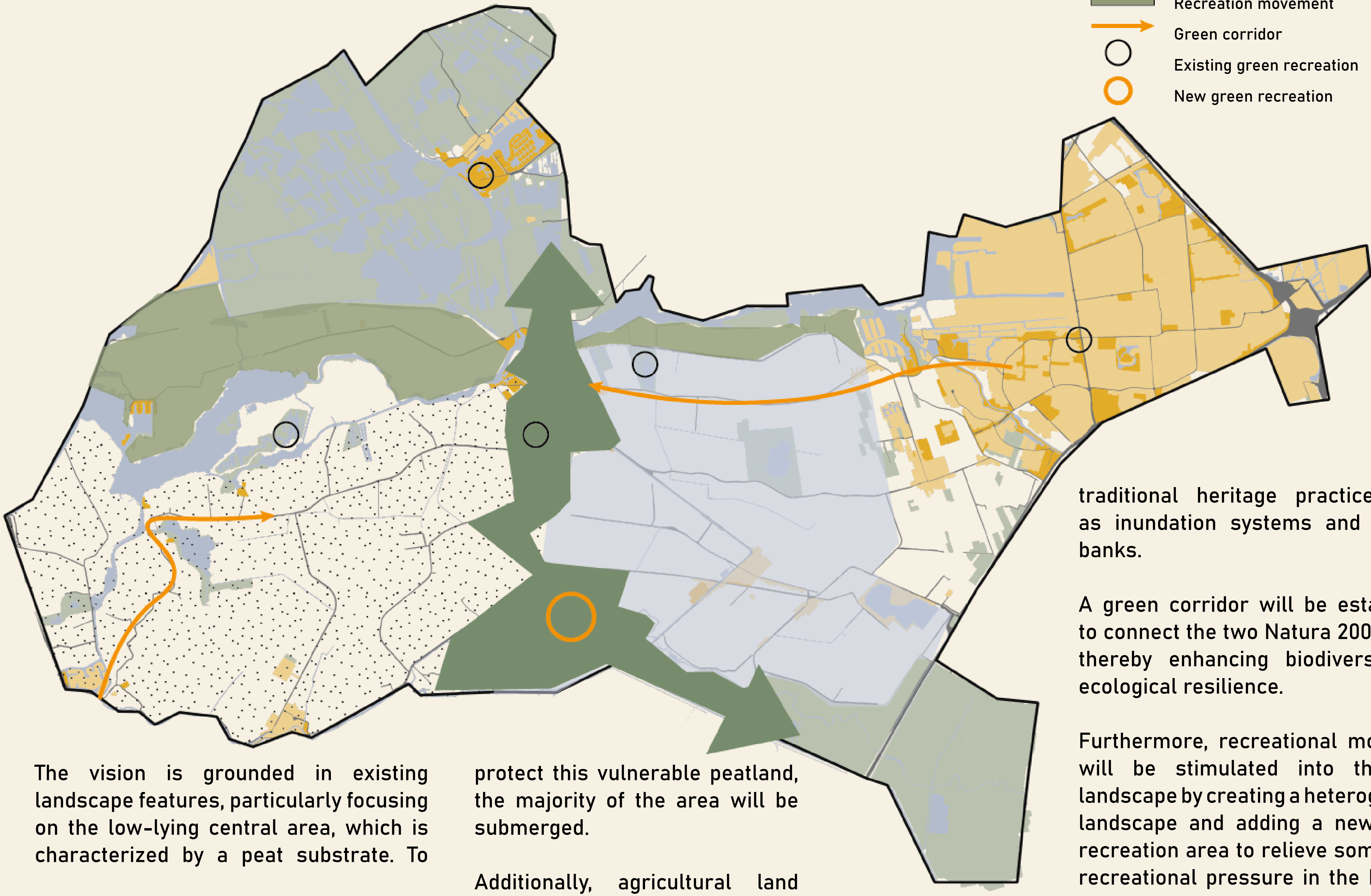


Figure 28. Heritage wooded bank
Sources: made by author

2.5. Vision for the low midlands



The vision is grounded in existing landscape features, particularly focusing on the low-lying central area, which is characterized by a peat substrate. To protect this vulnerable peatland, the majority of the area will be submerged.

Additionally, agricultural land management is combined with traditional heritage practices such as inundation systems and wooded banks.

A green corridor will be established to connect the two Natura 2000 areas, thereby enhancing biodiversity and ecological resilience.

Furthermore, recreational movement will be stimulated into the farm landscape by creating a heterogeneous landscape and adding a new nature recreation area to relieve some of the recreational pressure in the National Park de Alde Feanen.

Figure 29. Vision for the low midlands
Sources: made by author

3. Agriculture practices against peat oxidation

1. Water level to prevent peat oxidation
2. Characteristis agriculture practices

3.1 Water level to prevent peat oxidation

Peat oxidation releases the greenhouse gas carbon dioxide (CO2). The emission of CO2 equivalents decreases as the groundwater level rises but increases again when the water level rises above 0. The optimal groundwater level for reducing greenhouse gas emissions is between 0 and 20 cm below the ground surface (Jurasinski et al., 2016). In contrast to the current CO2 emissions at an average groundwater level of -100 cm, a water level that complements peat landscapes would result in between 50 and 75% reduction of emissions (De Ruyter, 2016; Jurasinski et al., 2016).

Further research indicates that the average water level throughout the year holds greater significance than water levels at any specific time. It is posited that maintaining an average water level of 30 cm below the ground surface is essential to prevent any peat oxidation (Expert peat agriculture, personal communication, March 2024).

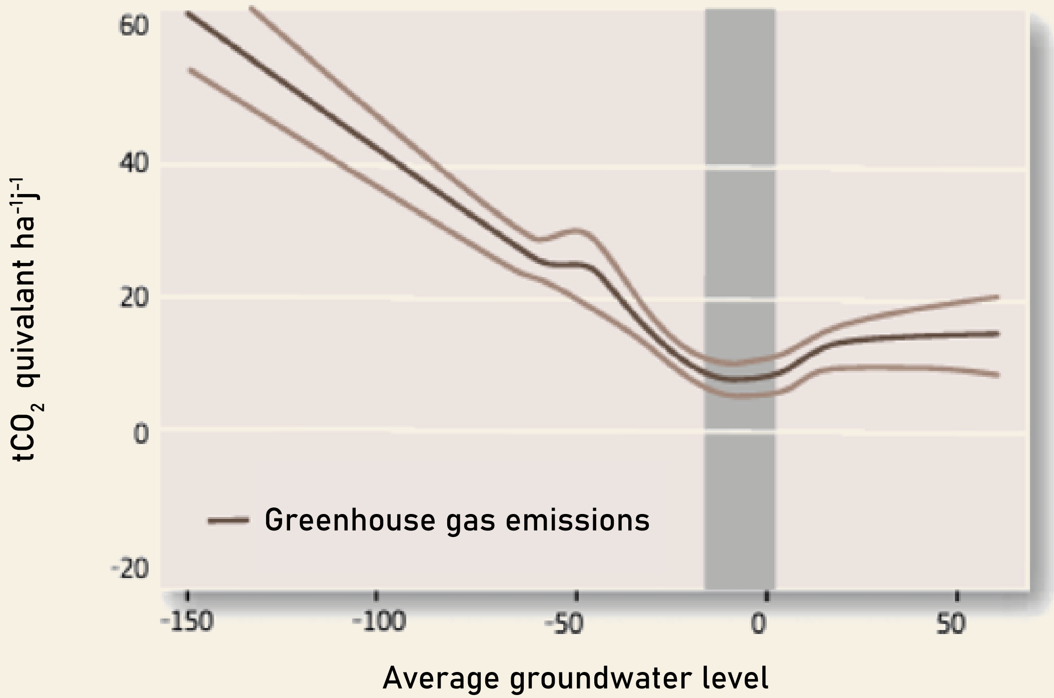


Figure 30. Water level effect on total greenhouse gas emissions
Sources: Jurasinski et al. (2016)

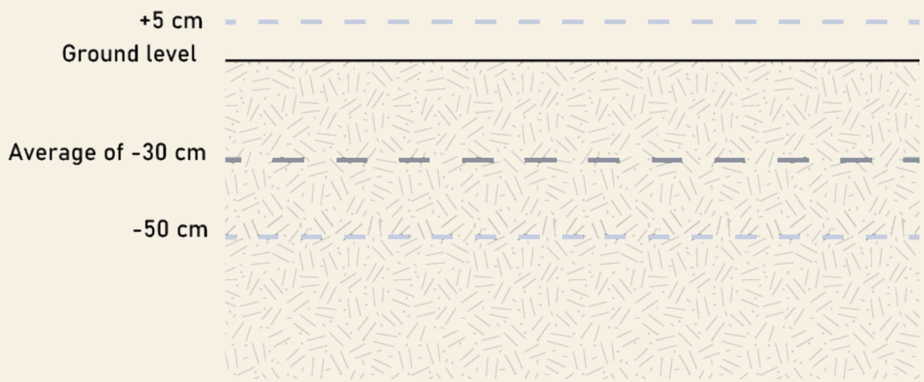


Figure 31. Average year-round water level for no peat oxidation
Sources: made by author

3.2 Characteristics agriculture practices

Based on the research three different water level strategies are chosen that will be used in this thesis. The water levels vary in the total amount of greenhouse gas emissions it causes, but they all ensure no peat oxidation occurs.

The first water level is made from a summer water level of -50 cm and a winter water level of +5 cm. This combination results from the year-round average needed to cause no peat oxidation. This water level type supports the growth of grass and enables the implementation of dairy cattle farming. It results in a reduction of 50% greenhouse emissions.

The second water level has a summer water level of -20 cm and a winter level of +5 cm. This combination falls within the minimized greenhouse gas emissions zone. This water level supports the growth of crops such as willow, reed, and cattail (Bestman et al., 2019). It results in a reduction of 75% of greenhouse emissions.

The third water level has a year-round water level of +20 cm. This water level supports crops native to peat landscapes such as reed and cattail. It results in a reduction of 60% of greenhouse emissions.

The selected crops can be used for different end uses, such as building materials for housing – insulation, roofing, biogas - or as support towards the dairy cattle farm – animal feed and substrate. Each practice either mimics an ecotype native to peat landscapes or aims to transform the agricultural field towards nature management and become the ecotype.

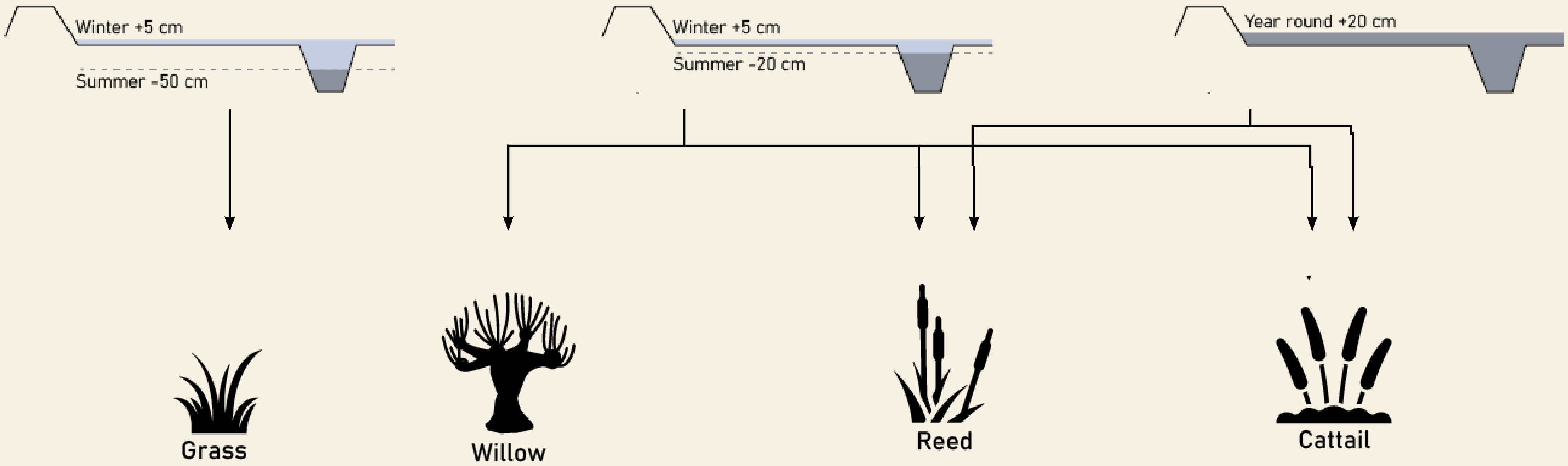


Figure 32. Implemented water levels and crops
Sources: made by author

3.2 Characteristics agriculture practices

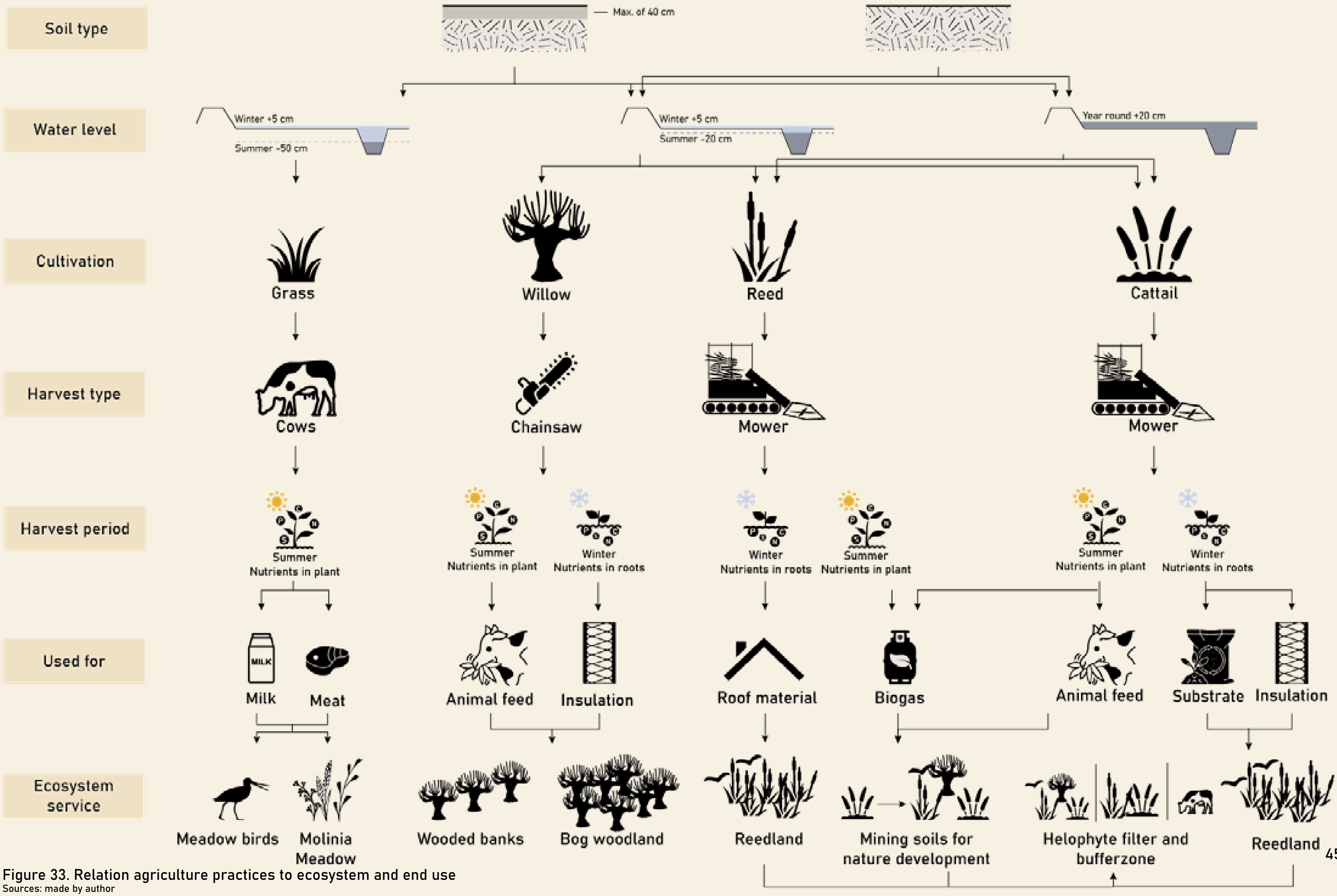


Figure 33. Relation agriculture practices to ecosystem and end use

Sources: made by author

4. Connection agriculture practices to circular system

1. Circularity of agricultural system
2. Circularity maintenance
3. Connentions circular agricultural system

4.1 Circularity of the agricultural system

Three of the four proposed agriculture practices originate from the peat landscape. By choosing crops that are native to and support peat ecosystems, these practices enhance the land's natural properties and ecological functions.

To achieve a circular dairy cattle practice that does not exacerbate peat oxidation, a more complex and integrated system is required. This system includes the incorporation of cattail and willow cultivation alongside traditional farming practices, such as wooded banks and flooding, and a practice called strip grazing.

Implementation of each crop has its effects on the circular economy. The role of the farmer expands and diversifies creating a network of actors working together in the landscape ensuring a sustainable and healthy circular peat landscape.

The agricultural system changes from a focus on export towards community-based selling. The circular system promotes interconnectivity and movement between the agricultural landscape, the peat landscape and the built environment.

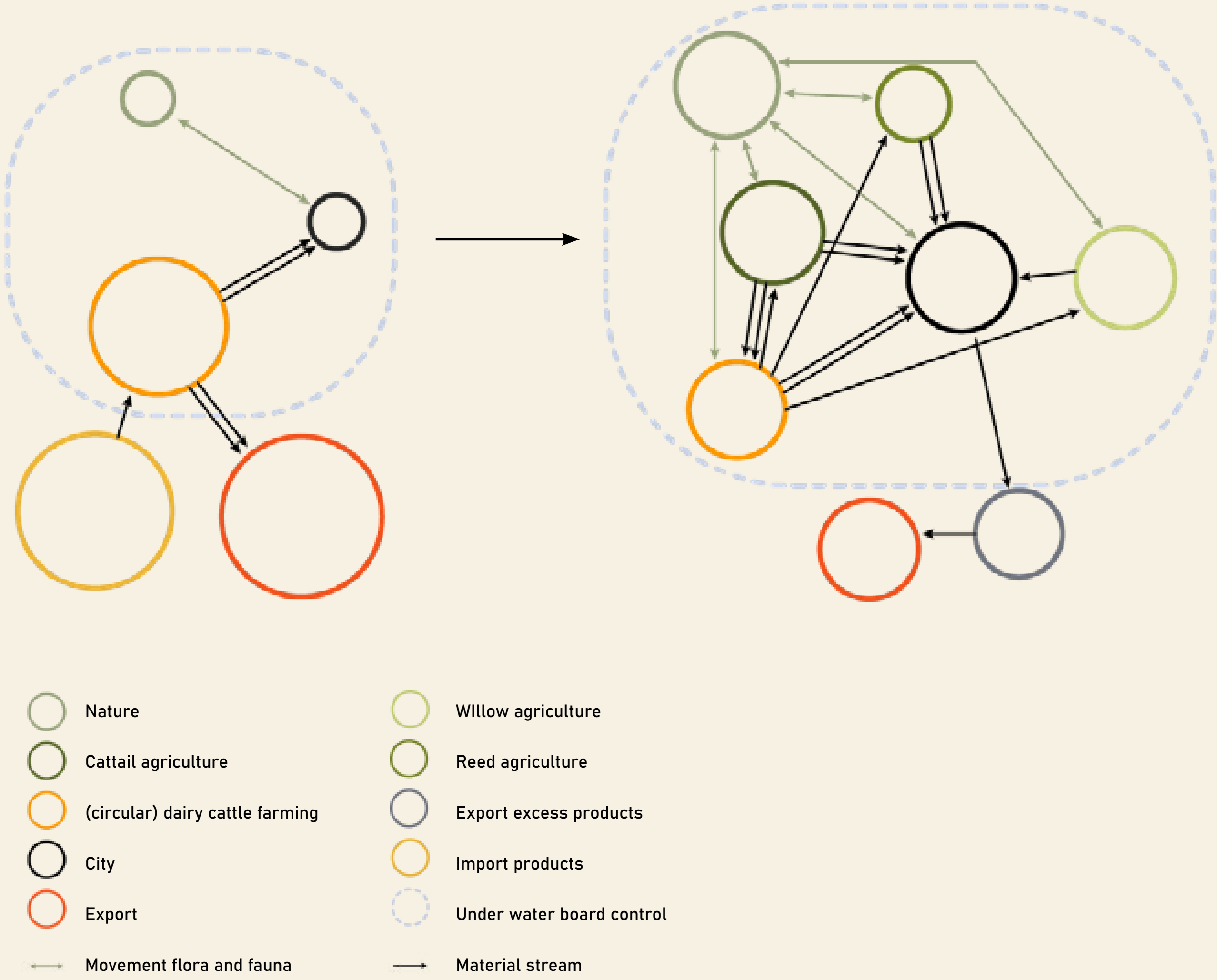


Figure 34. Transformation of network surrounding the agricultural system
Sources: made by author

4.1.1 Current agriculture system

In the current dairy cattle farming, each farmer operates independently, managing their imports and exports without collaboration. This results in a network primarily defined by the connection between farmer, import and export, while interactions with local community and nature remain minimal.

Dairy cattle farming involves the fertilization of grassland to provide nutrients to the grass. However, this continual fertilizing process causes grass roots to remain short, as they do not need to grow deep to access nutrients. Consequently, the soil life in peat soil is almost nonexistent, as roots are a crucial factor in maintaining healthy soil ecosystems (Farmer strip grazing, personal communication, March 2024).

Dairy cattle have the freedom to graze over large expanses of grassland. This allows them to be selective, choosing younger, freshly growing grasses over older, more mature ones (Farmer strip grazing, personal communication, March 2024). This selective grazing behavior reduces the efficiency of grass utilization (Schipper et al., 2015). The profit of conventional dairy cattle farming is 575 euros per hectare (Dik, 2021; Wageningen University & Research, 2023).

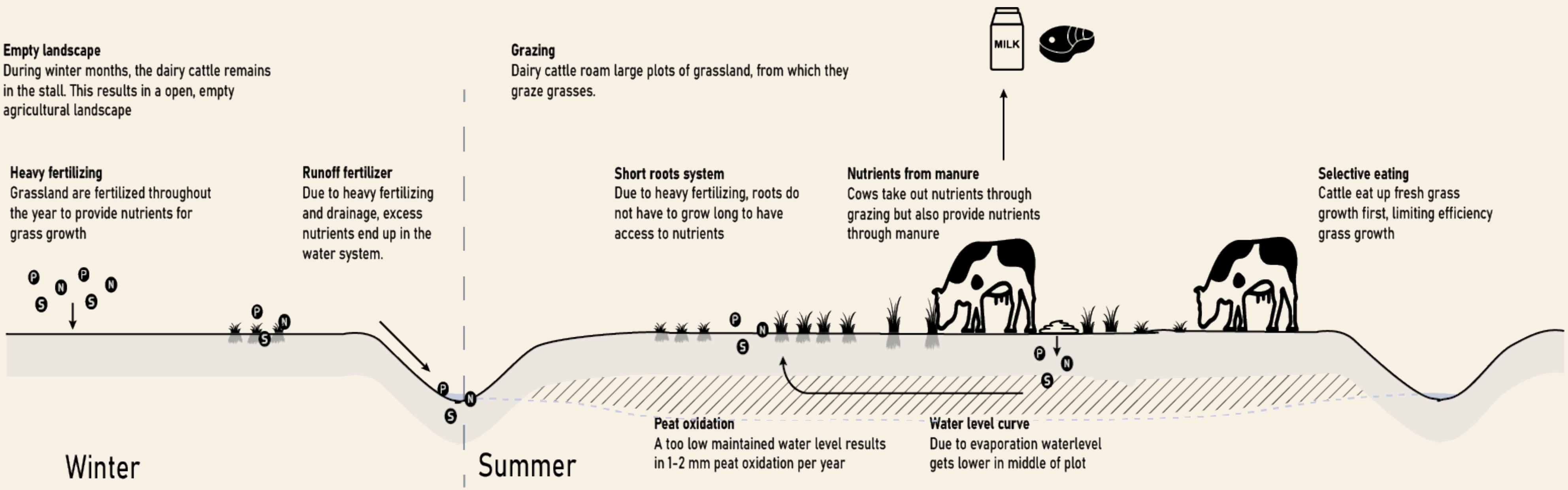
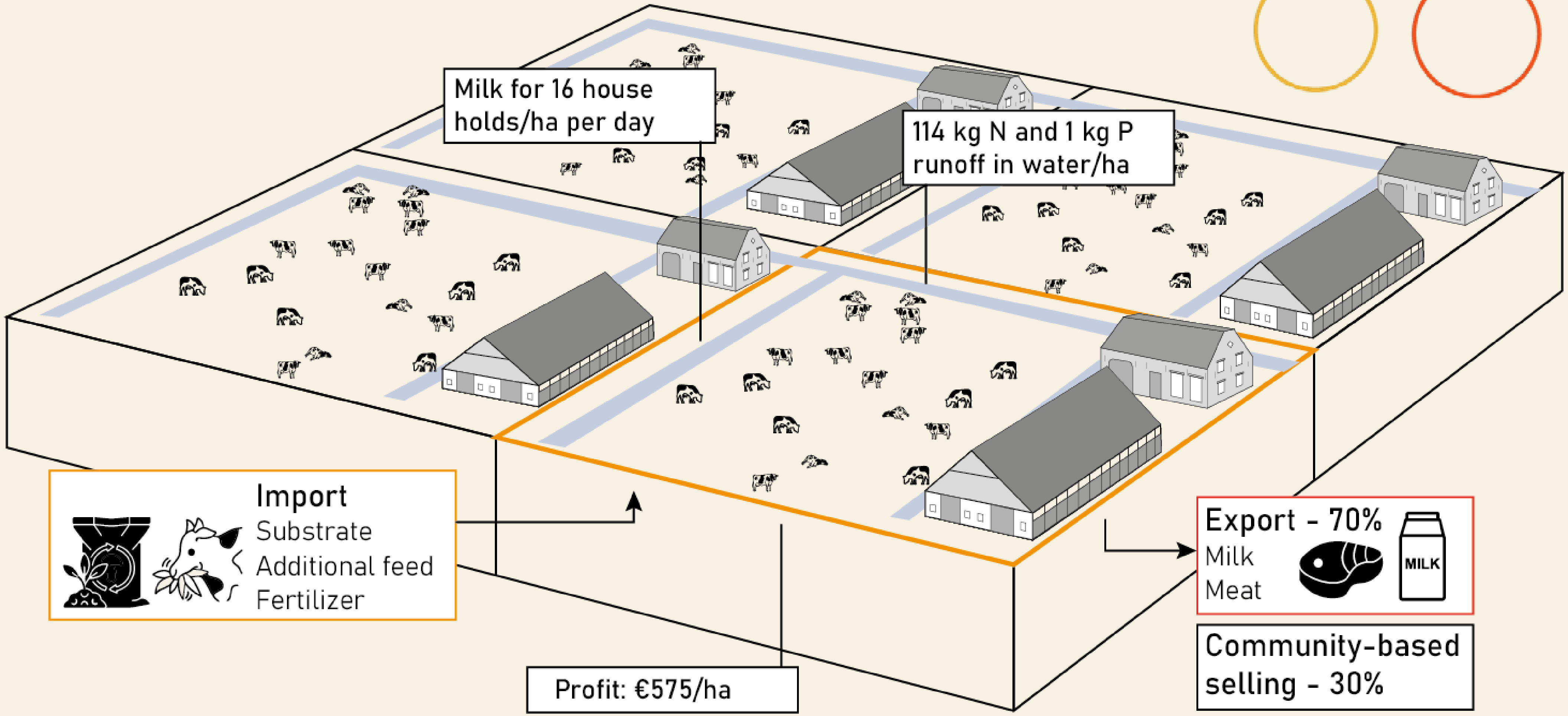


Figure 35. Nutrient cycle conventional dairy cattle farm
Sources: made by author

4.1.1 Current agricultural system



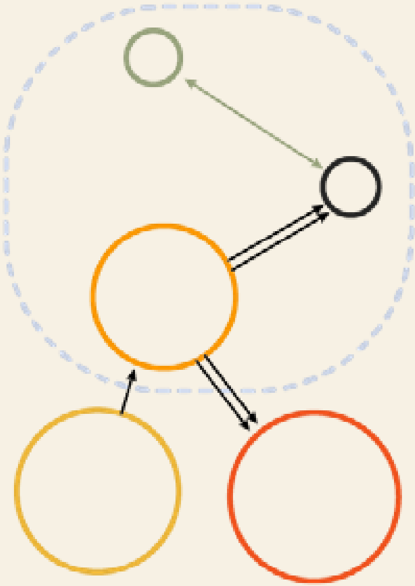


Figure 36. Conventional agriculture system
Sources: made by author

4.1.2 Circularity of cattail

Cattail typically reaches heights of 2 to 3 meters. Optimal water levels for its cultivation are maintained at 10-30 cm above the soil surface, ensuring that the plant is not fully submerged. This crop benefits from strategic water level management which serves as an effective method for weed control (Wageningen Universiteit Research, n.d.). The profit of the cattail crop is in between 400 to 1000 euros per hectare (Nij Bijvank & The Spring Company, 2021).

Management of cattail begins one year after planting. The plant can be harvested in the summer for use as additional animal feed providing for 4 to 5 cows year-round per hectare or for biogas production providing for 3 to 4 average households year-round per hectare. Winter harvests yield raw materials suitable for substrates and insulation (Bestman et al., 2019). Providing enough substrate to combine with the manure of 8 to 10 cows or insulate 4 to 5 average houses. The above-ground biomass of cattail can be harvested in both summer and winter using existing machinery equipped with tracks, as commonly used in reed cultivation (Bestman et al., 2019).

Moreover, cattail plays a crucial role in extracting nutrients from soils, serving as an intermediate stage in natural habitat development. It acts as an efficient helophyte filter, enhancing water quality by purifying it and serving as a buffer zone between natural areas and other land uses. Cattail is capable of absorbing over 500 kg of nitrogen and 80 kg of phosphorus per hectare (Bestman et al., 2019). Which could be used to absorb the average 203 kg N and 1 kg P runoff per hectare of grassland used for dairy cattle (Wageningen University & Research, 2021).

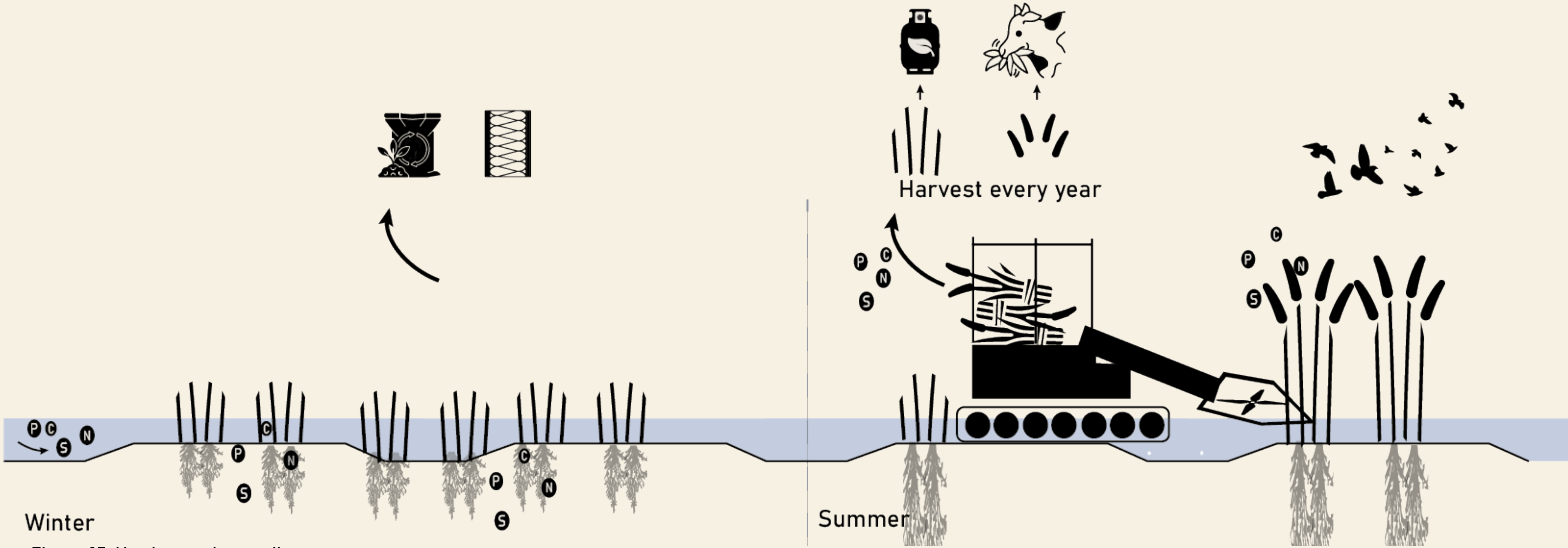


Figure 37. Nutrient cycle cattail
Sources: made by author

4.1.2 Circularity of cattail

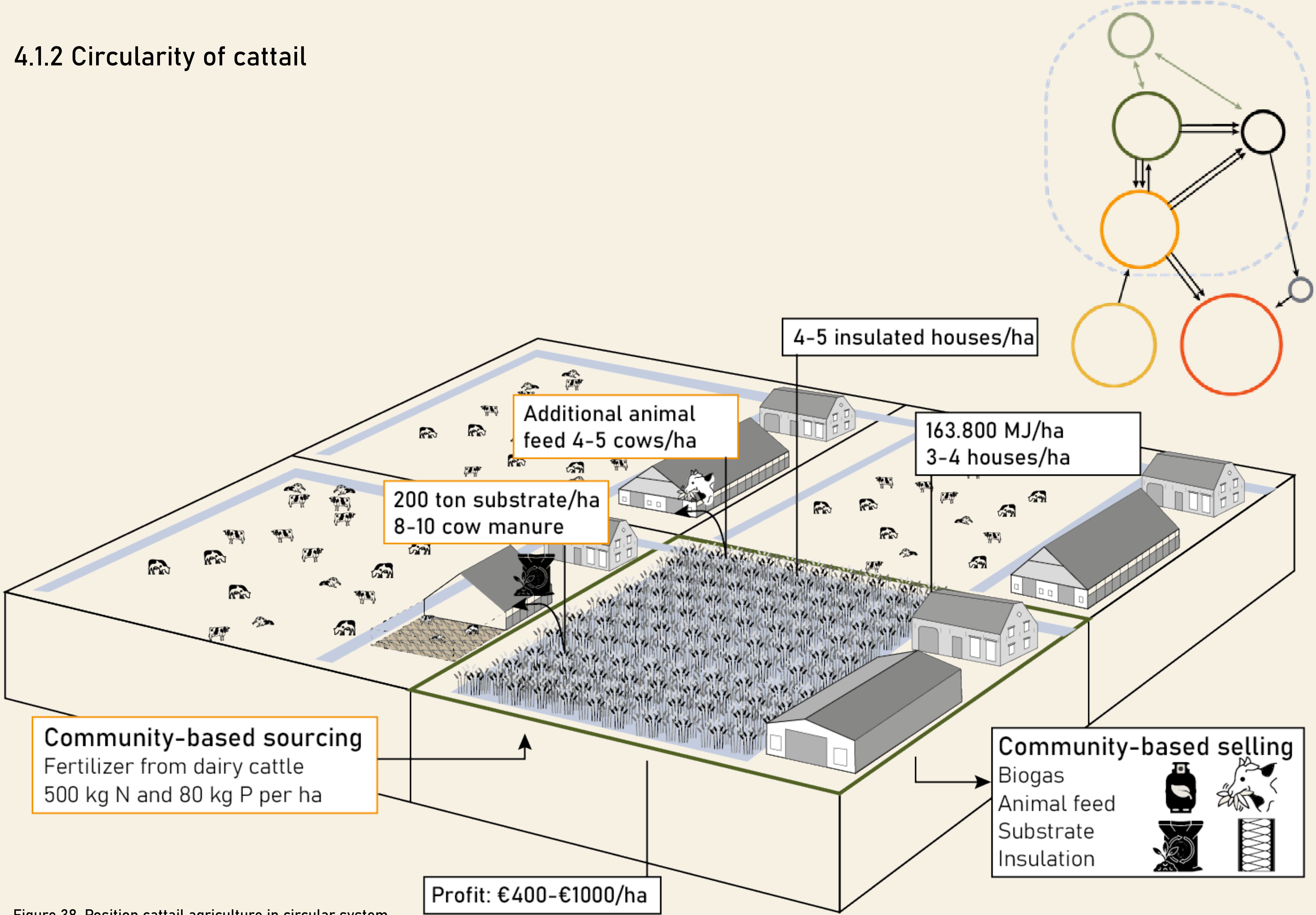


Figure 38. Position cattail agriculture in circular system
Sources: made by author

4.1.3 Circularity of reed

Reed cultivation (Phragmites australis) represents an ancient form of 'wet agriculture' practiced in the Netherlands. Belonging to the grass family, reed plants feature large plumes as flowers that measure 15-40 cm and can grow to heights of 3-4 meters. Reed's ability to root up to 2 meters deep makes it a helophyte and well-suited for drought (Geurts & Fritz, 2018).

However, it also thrives in conditions where the water level is up to 2 meters above the ground surface (Wichtmann et al., 2016). During winter, nutrients are stored in the plant's subterranean parts, ensuring that yields remain stable when harvested in the winter months.

The first full harvest of reed can typically be expected after two to three years of growth. Reed is harvested in the winter, post-leaf fall, when the plant's nutrients have retreated to the roots, facilitating a consistent yield. The harvested reed can supply roofing to 3 to 4 houses per hectare. A summer harvest would result in biogas for 4 to 5 houses per hectare. Reed cultivation results in a profit of 200 to 600 euros per ha (Nij Bijvank & The Spring Company, 2021).

Presently, there is significant importation of reed from other European countries and, to a lesser extent, from China. This importation reflects the ongoing demand and value of reed, not only in traditional settings but also in modern agricultural and environmental applications. Such cultivation and utilization practices underscore reed's importance as a sustainable resource within wet agricultural landscapes (Wageningen Universiteit Research, n.d.).

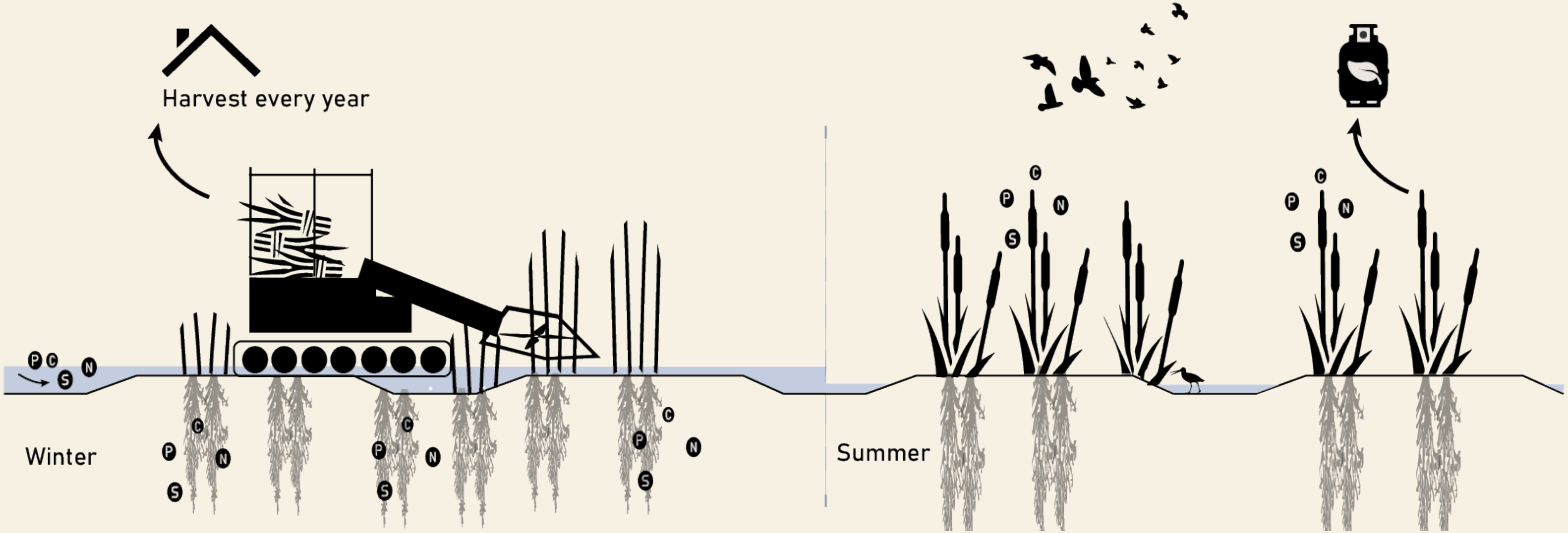


Figure 39. Nutrient cycle reed
Sources: made by author

4.1.3 Circularity of reed

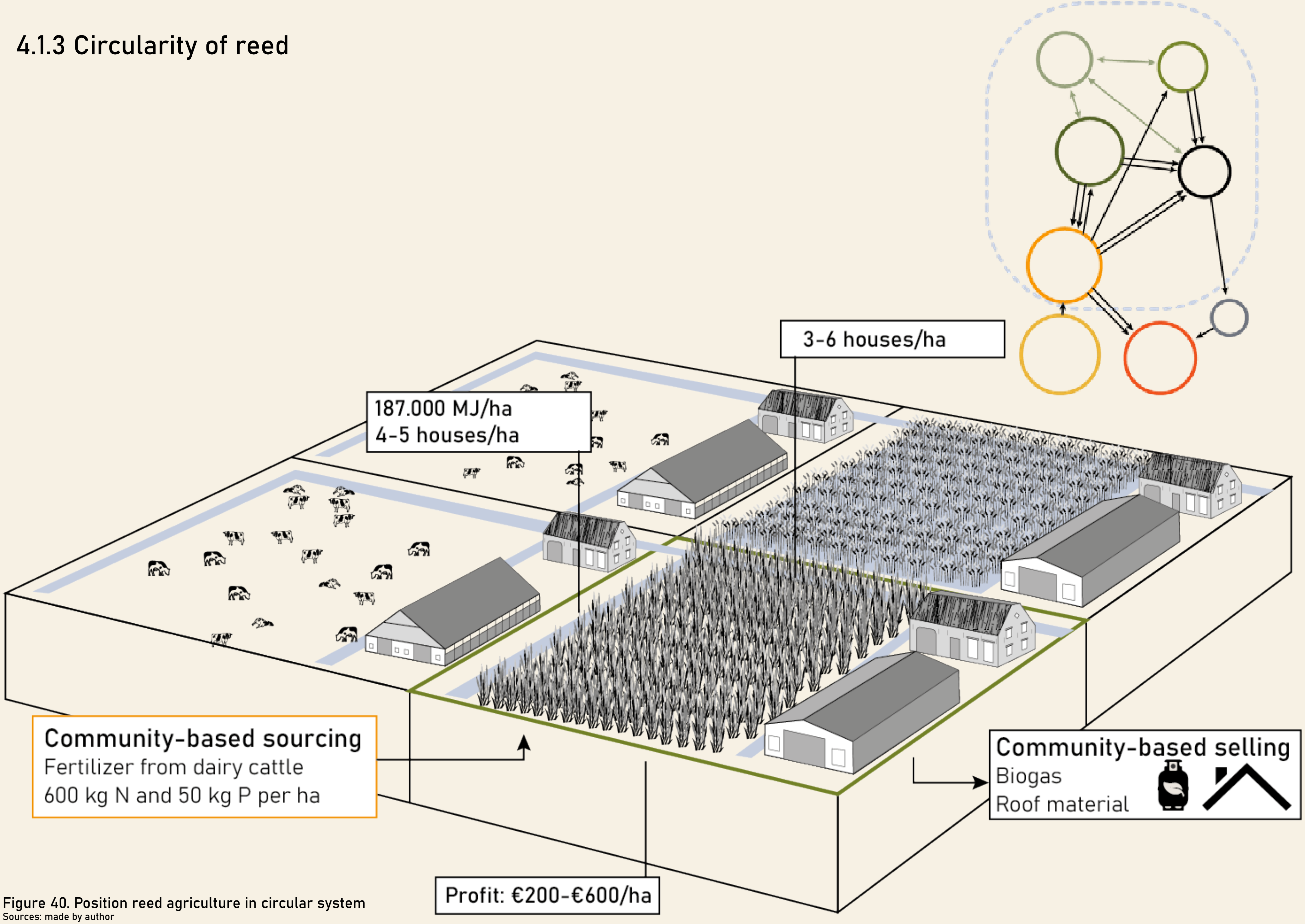


Figure 40. Position reed agriculture in circular system
Sources: made by author

4.1.4 Circularity of willow

The cultivation of willow (Salix alba) has a long-standing tradition in moist plots known as willow groves. Willow propagation involves cutting twigs into 20-30 cm segments and planting them at a density of 16,000 plants per hectare (Bestman et al., 2019). Willows are harvested every three to five years, and in more intensively managed systems, the cycle may be as short as one or two years. The profit of willow cultivation averages around 400 euros per year per ha (Agroforestrykip, 2019).

These groves feature a rich understory including hedge bedstraw and ragwort and are a haven for diverse bird and insect species, such as bluethroat and sedge warbler (Bij12, n.d.-b). A possibility for temporary flooding is possible in the grooves to provide additional water storage when needed, as long this flooding happens in winter (Bestman et al., 2019)

Young willow twigs, complete with green leaves, are utilized as additional animal feed. They have a crude protein content that can reach up to 190 g per kg of dry matter and contain high levels of trace elements such as selenium and zinc (Luske & van Eekeren, 2018). One hectare of willow cultivation could provide additional animal feed year-round for 4 to 5 dairy cattle.

In addition to animal feed, willow is suitable for use as insulation materials, whether as blown-in insulation or rigid boards. Available data suggest that willow (R=1.9-2.5) compares favorably to conventional options like rock wool (R=2.5) (Bestman et al., 2019). One hectare provides material to insulate 3 to 4 houses.

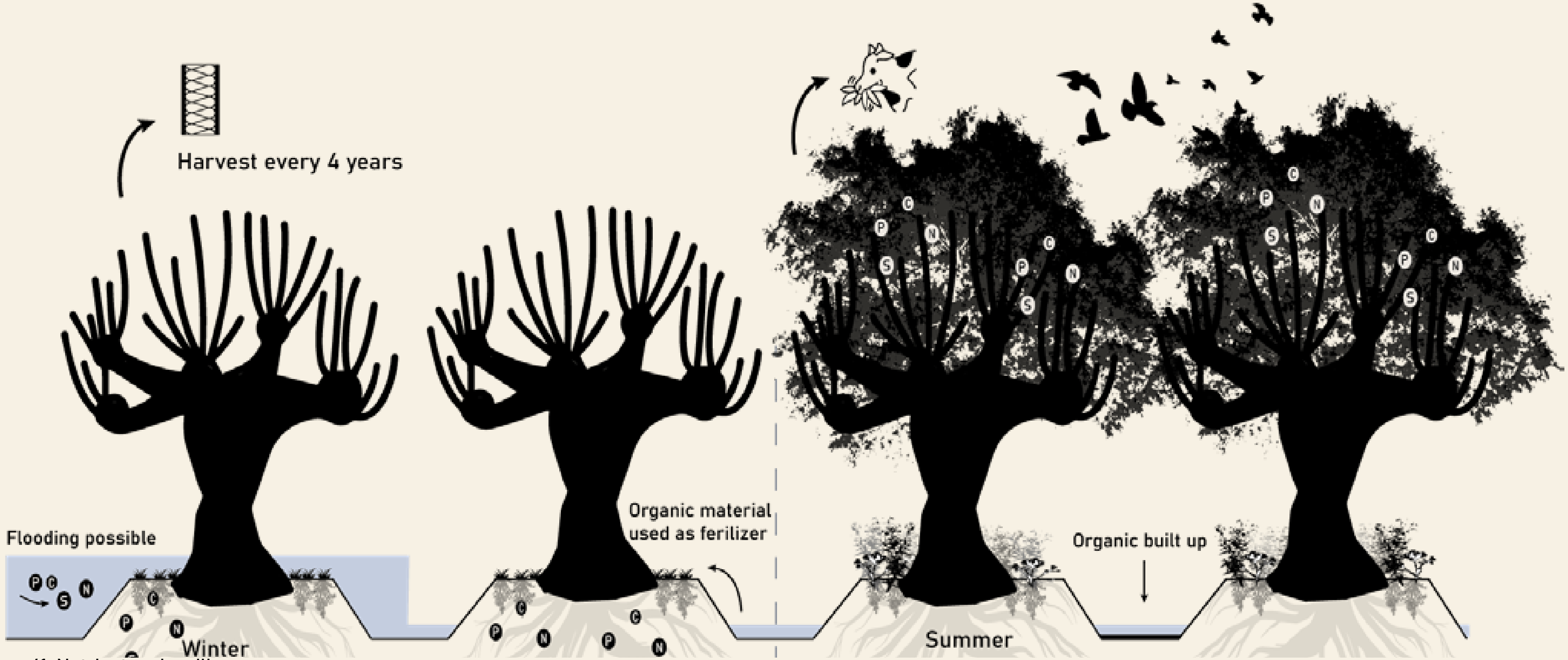


Figure 41. Nutrient cycle willow
Sources: made by author

4.1.4 Circularity of willow

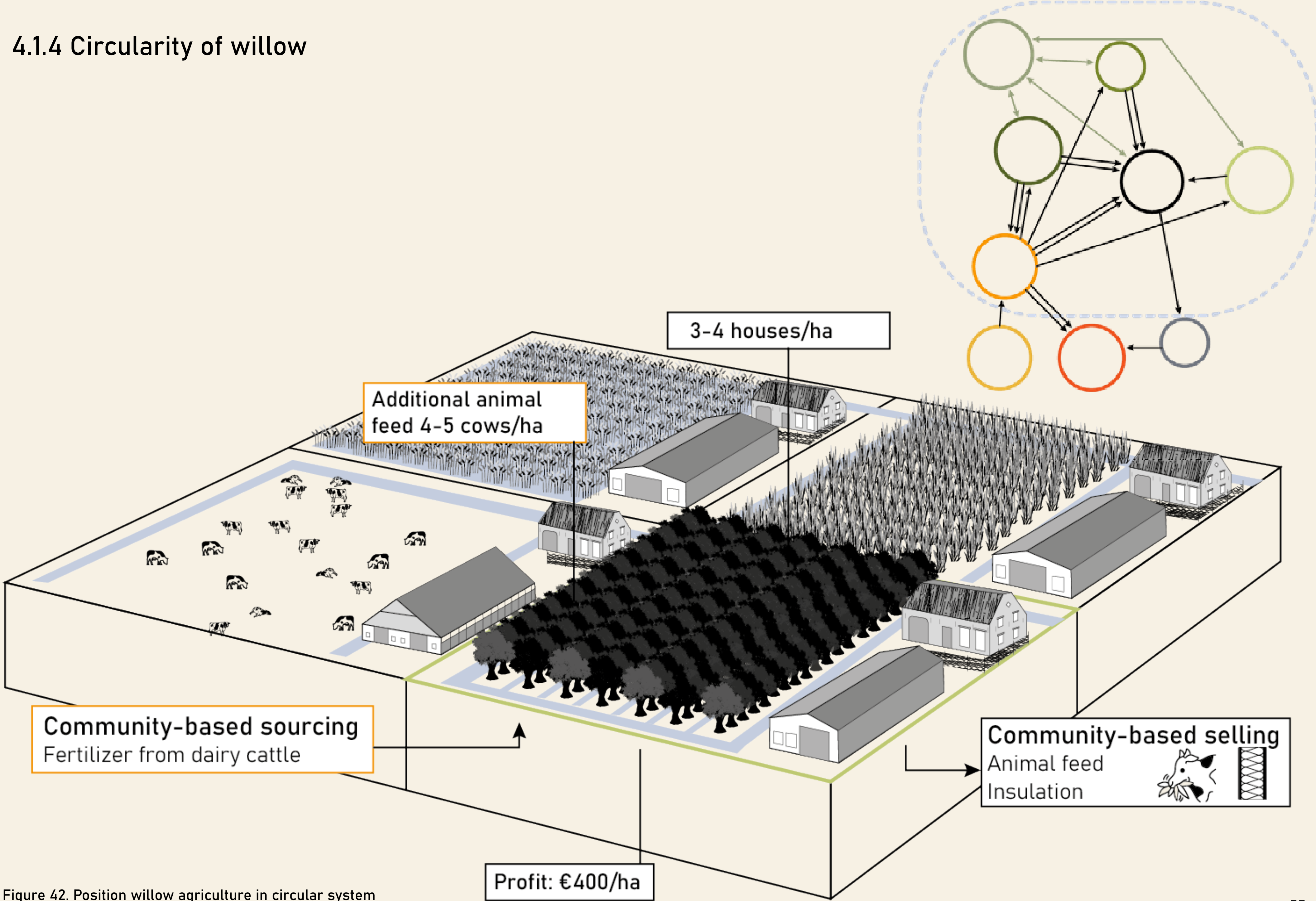


Figure 42. Position willow agriculture in circular system
Sources: made by author

4.1.5 Circularity of dairy cattle

Winter flooding serves a dual purpose by enriching the soil with nutrients necessary for grass growth, thereby forgoing the need for additional fertilizers (Huizinga, 2014). As spring progresses, the water level gradually decreases, making the land suitable for meadow birds to nurture their young and seek refuge (Baaijens et al., 2011; Huizinga, 2014).

Areas not designated for avian shelter are utilized for cattle grazing during daylight hours. From June to September, cattle are present on all fields both day and night, employing a technique known as strip grazing. In this system, small parcels ranging from 0.5 to 1 hectare are temporarily accessible to cattle for periods between three to twelve hours. Once grazed, these strips are closed off for four weeks to allow the grass to regenerate (Farmer strip grazing, personal communication, March 2024).

The efficacy of strip grazing is evident in its multiple benefits: it maximizes grass utilization by 10%, thereby enhancing milk production; it allows nature adequate time for ecological recovery; and it improves soil quality (Schipper et al., 2015; De Ruyter, 2016). Usage of the 'potstal' separates manure and urine with bedding layers, preventing the formation of ammonia and minimizing nitrogen emissions to nearly zero (De Ruyter, 2016). The spreading of the dry manure from the 'potstal' in combination with strip grazing results in herb-rich grassland, that stimulates soil life and provides sufficient food for meadow birds (De Ruyter, 2016; Farmer strip grazing, personal communication, March 2024).

The amount of dairy cattle is lowered from the average 1,7 to 1,17 cow per hectare to efficiently strip graze (Farmer Strip grazing, personal communication, March 2024). While the amount of cattle is lowered, the profit per hectare increases to 750 to 1000 euros, as the cost per cattle reduces due to the closing of the loop for additional animal feed, fertilizing, and substrate (De Ruyter, 2016).

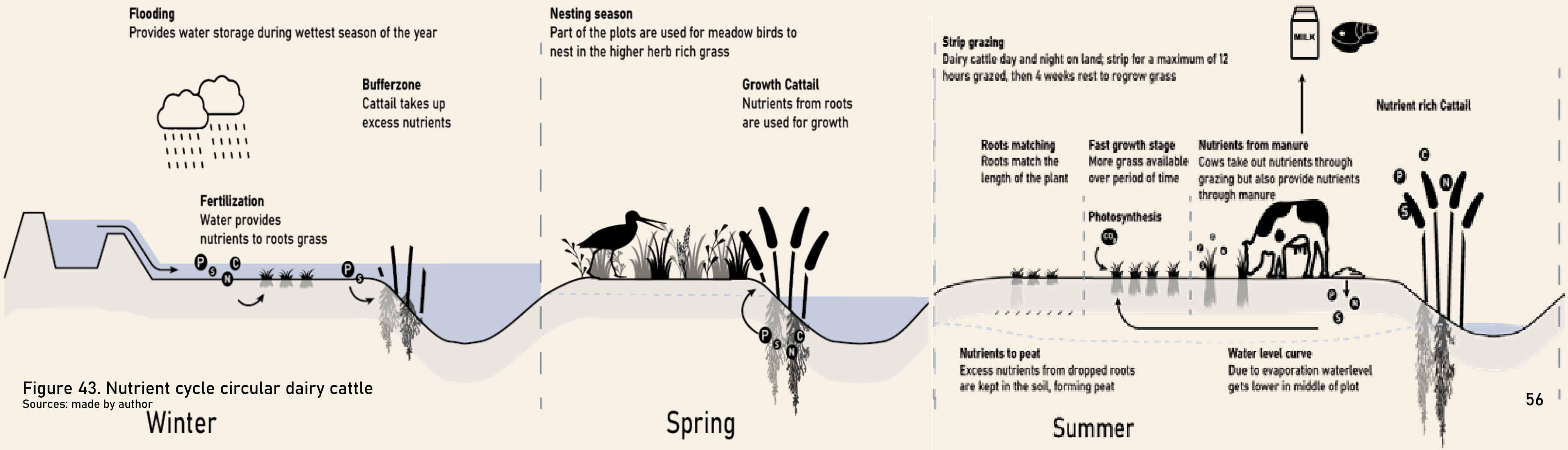


Figure 43. Nutrient cycle circular dairy cattle
Sources: made by author

4.1.5 Circularity of dairy cattle

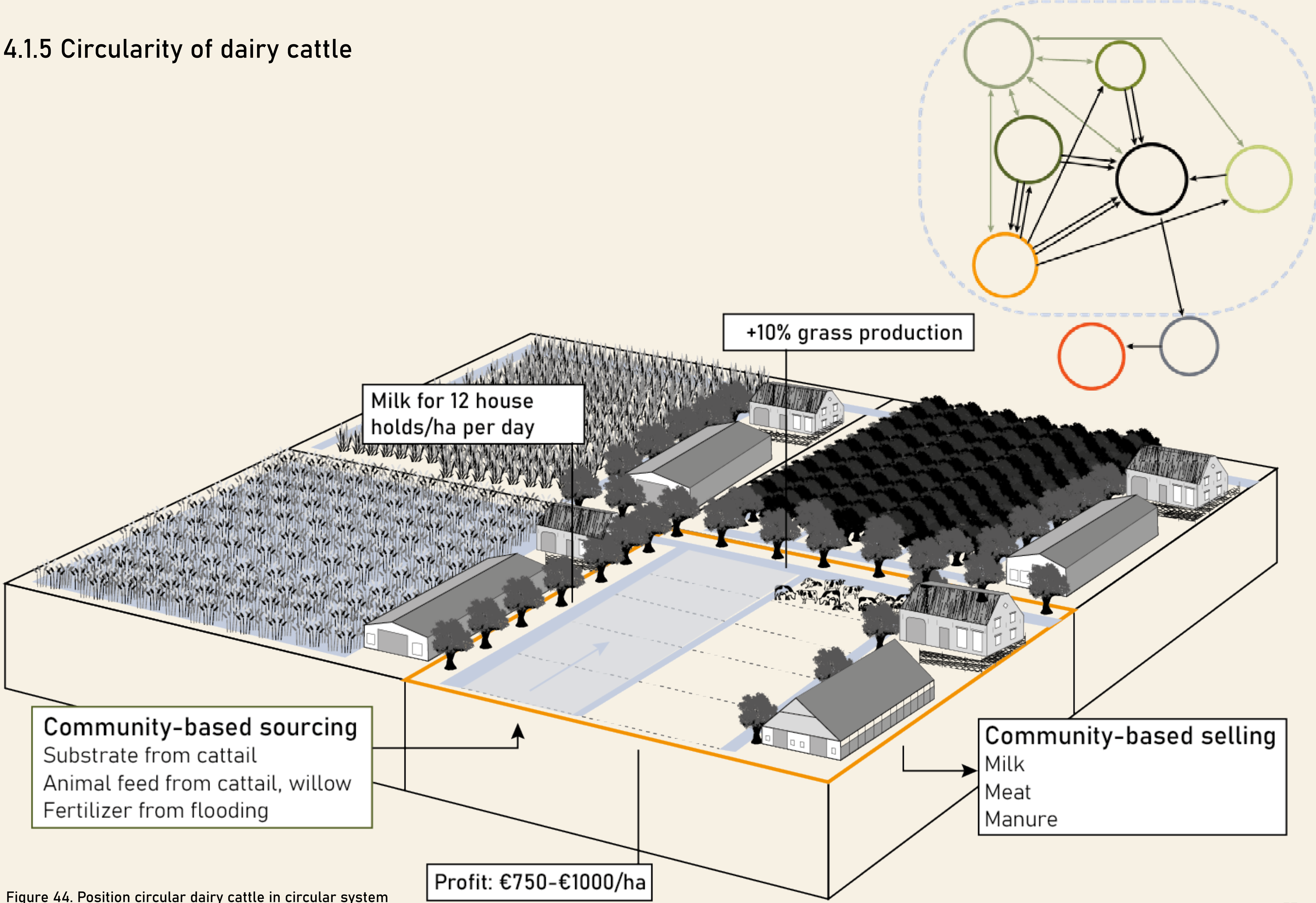


Figure 44. Position circular dairy cattle in circular system
Sources: made by author

4.2 Circularity maintenance

A difference is made in maintenance for plots that are used for agriculture with ecological benefits and plots that use agriculture as nature management. Agriculture with ecological benefits mimics certain ecotypes and maintains the plots to sustain productivity. Central to the agricultural practices are the management of ditches, weed control, and harvesting.

Proper ditch management is essential for all peat crops ensuring effective water drainage and preventing waterlogging, which can adversely affect crop health and productivity (Bestman et al., 2019; riet-teelt.nl, 2024).

Additionally, it is important to manage the plots themselves to prevent overgrowth that could obstruct crop development. For instance, in willow cultivation, the farmer must control the growth of nettles and thistles. This practice is vital for maintaining accessibility to the coppices, reducing the risk of disease, and promoting the healthy growth of willow shoots (o+bnNatuurkennis, n.d.-a).

In the cultivation of reed and cattail, maintenance activities include the removal of any emergent growth of willow, elm, or alder trees. This is necessary to prevent the establishment of forest peat, which could alter the intended composition and functionality of the peatland ecosystem (rietteelt.nl, 2024).

The timing and method of harvest are critical for optimizing yield and ensuring the sustainability of the crop and the surrounding ecosystem (Bestman et al., 2019; o+bnNatuurkennis, n.d.-a).

Plots in which agriculture is used for nature management include similar activities, though in lesser frequency and only if it promotes peat growth and establishment of a healthy peat landscape (It Fryske Gea, personal communication, February 2024).

Willow
1. Once every year
2. Twice a year
3. Once every 4 years

Reed
1. Once every year
2. Twice a year
3. Once every year

Cattail
1. Once every year
2. Twice a year
3. Once every year

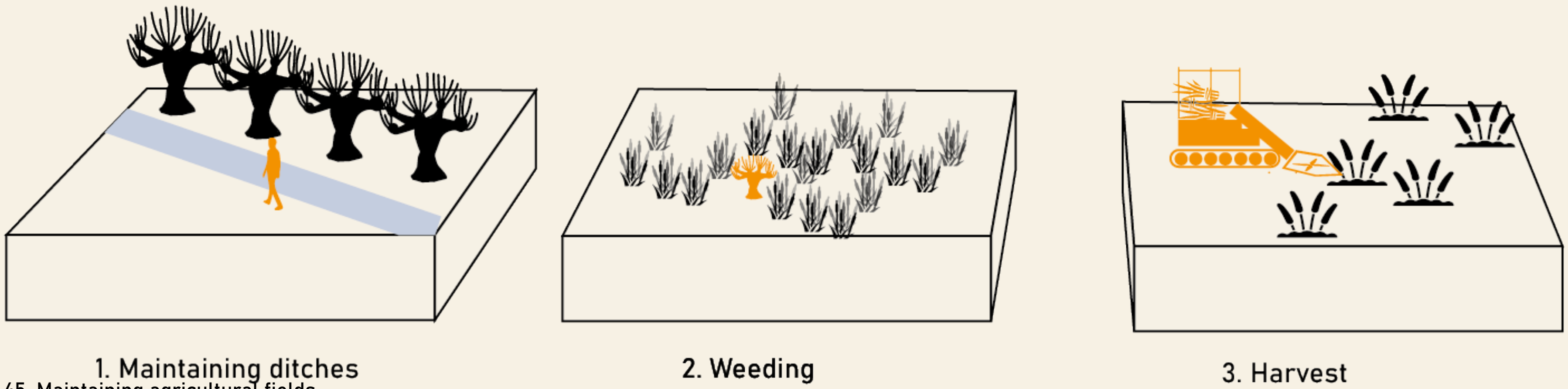


Figure 45. Maintaining agricultural fields
Sources: made by author

4.3 Connections circular agricultural system

By integrating different crops, the circular agriculture system promotes interconnectivity within the landscape, enhancing the interaction between various agricultural elements. The shift from a monotonous to heterogeneous landscape results in a more resilient and sustainable agricultural model that supports local economies and reduces dependency on external inputs (De Ruyter, 2016). The landscape diversity also mitigates the environmental degradation caused by traditional agricultural practices, such as water pollution from fertilizers and ecological damage from pesticides (It Fryske Gea, personal communication, February 2024).

Moreover, the heterogeneous landscape not only serves agricultural purposes but also creates a more engaging and diverse environment for recreational visits, fostering a stronger connection between urban and rural areas. This connection reduces the overuse of protected natural regions for recreation by providing alternative recreational spaces within the agricultural landscape.

Furthermore, the diverse landscape provides essential ecological corridors and steppingstones for flora and fauna, facilitating their movement between natural areas and within the agricultural landscape itself. These corridors are essential for maintaining biodiversity, allowing species to migrate and thrive across different habitats. The integration of agriculture and nature within this system supports both ecological health and agricultural productivity, promoting a harmonious coexistence.

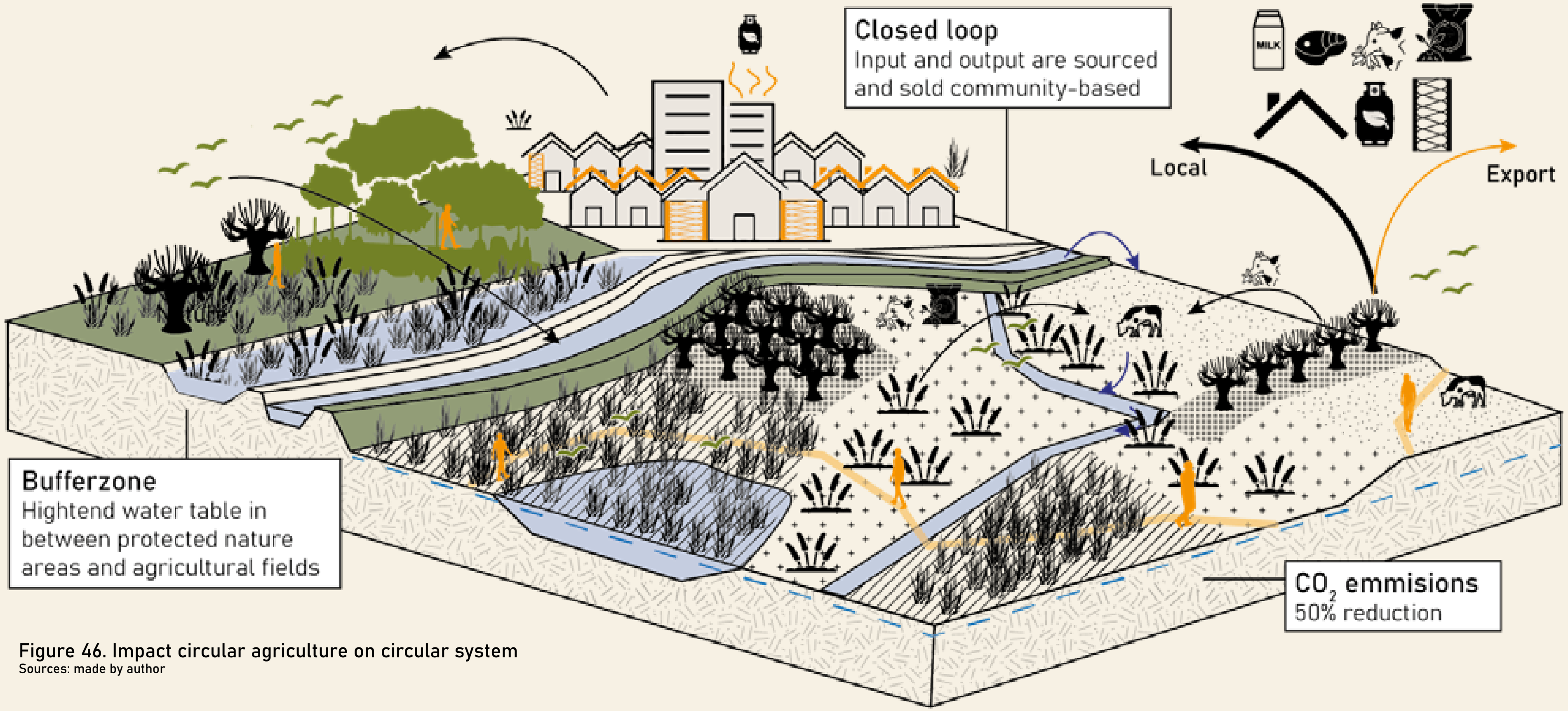
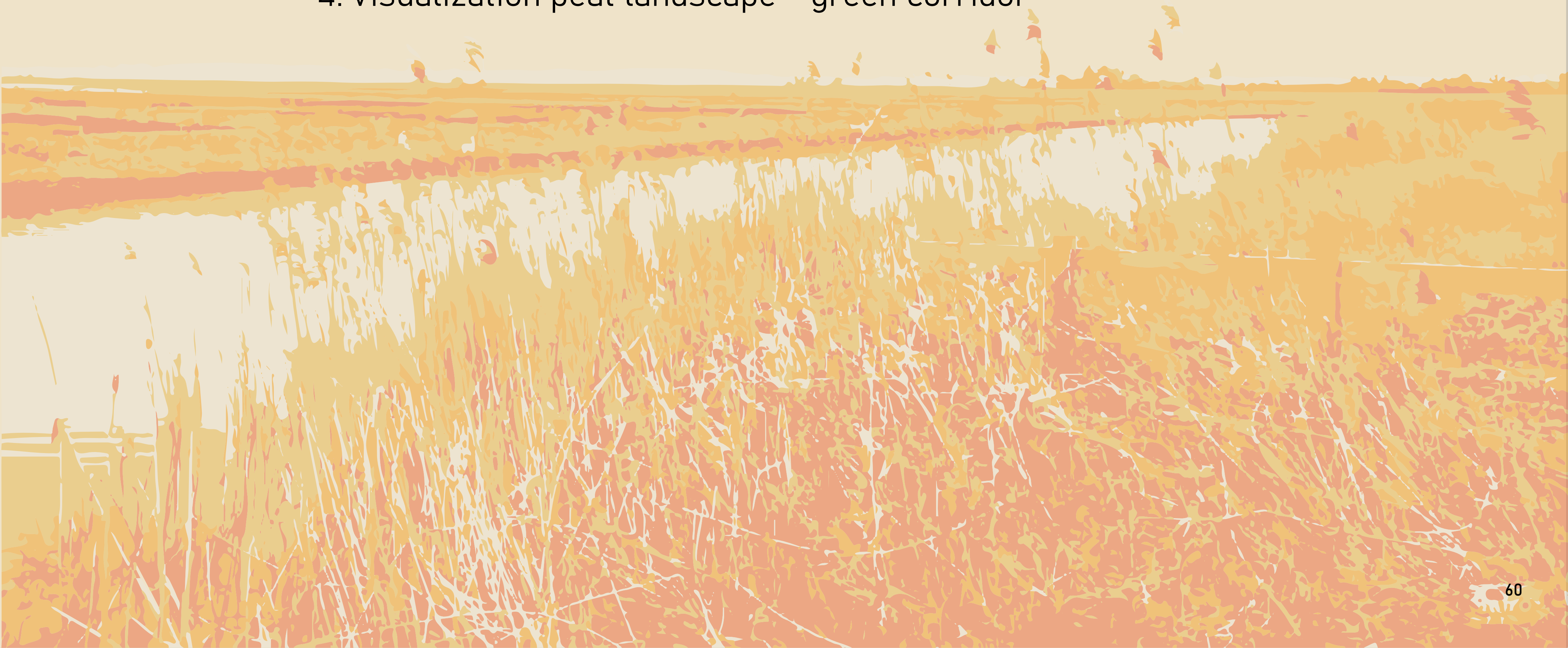


Figure 46. Impact circular agriculture on circular system
Sources: made by author

5. Implementation circular peat landscape

1. Water level approach in low midlands
2. Overview Masterplan
3. Visualization circular agricultural landscape
4. Visualization peat landscape - green corridor



5.1 Water level approach

To transform the current agricultural landscape into a circular peat landscape an alternative water level approach is employed that complements the circular agricultural system. In the current system, uniform functions across the landscape dictate the water levels, resulting in varied water levels throughout.

In contrast, the new circular system standardizes water levels across large sections, upon which functions are then based. This approach leads to a landscape that supports diverse types of cultivation. It also promotes the health of the peat landscape with an array of different ecotypes and mimicskings of said ecotypes.

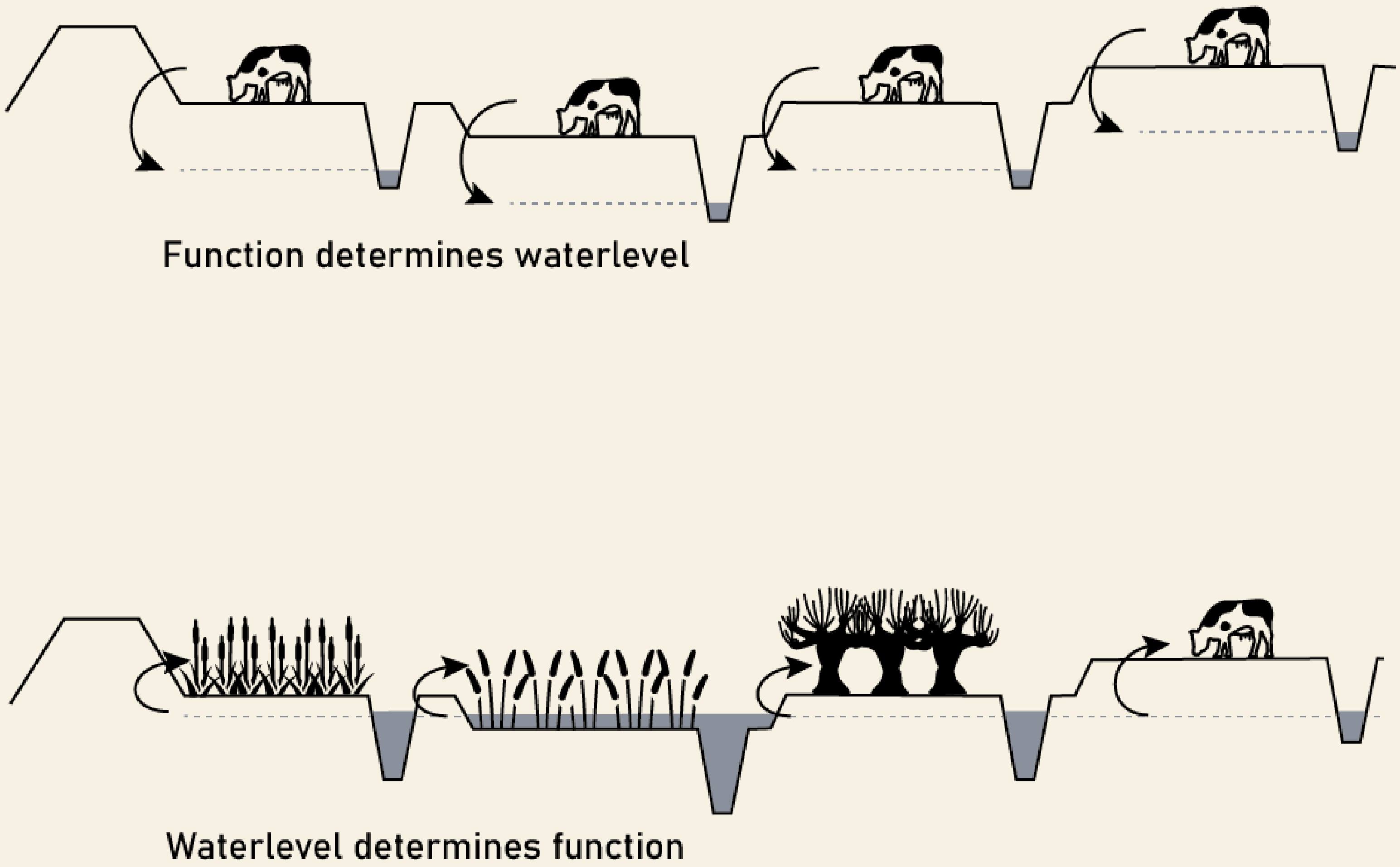
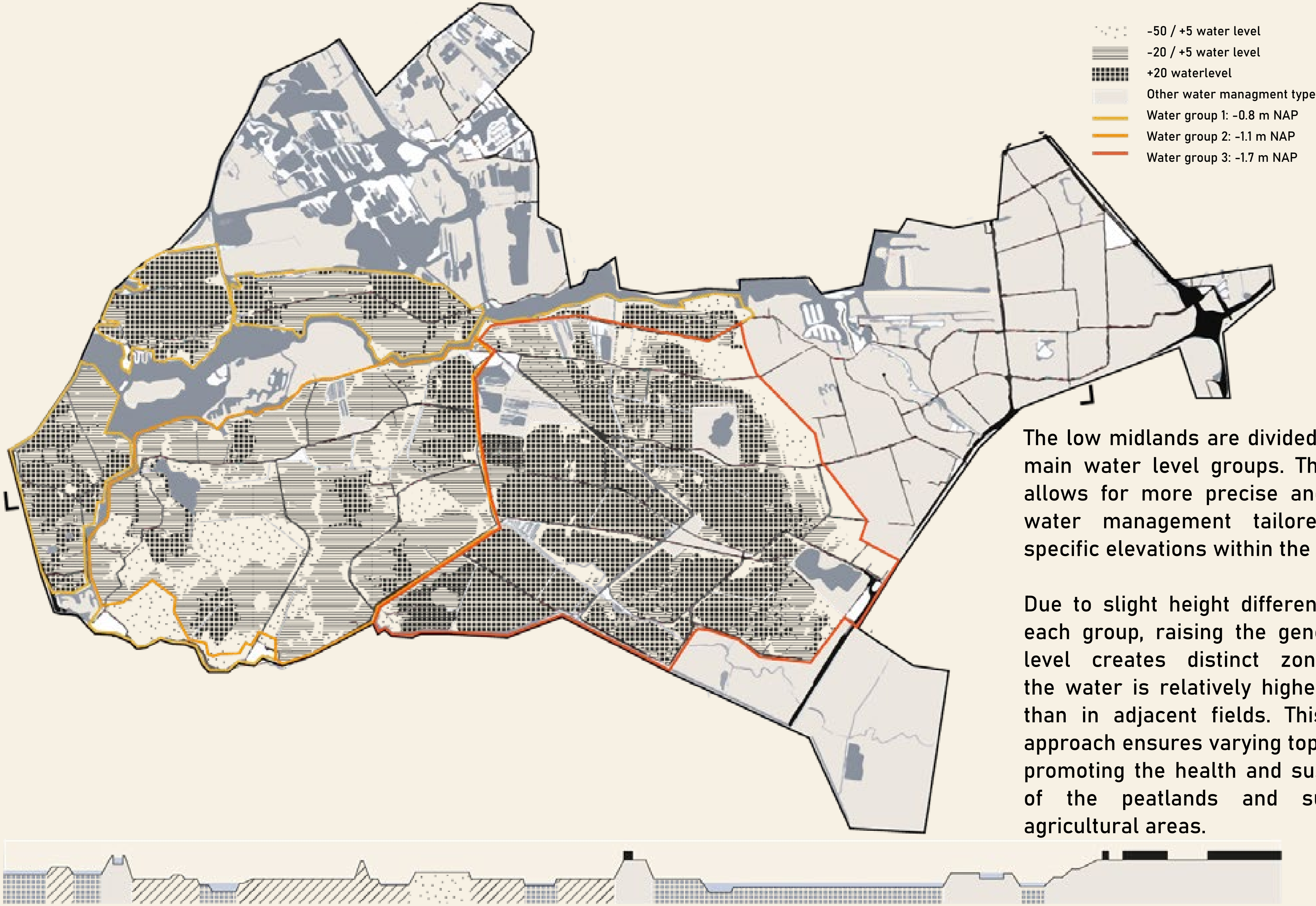


Figure 47. Water level approach for circular agriculture
Sources: made by author

5.1.1 Water level approach in low midlands

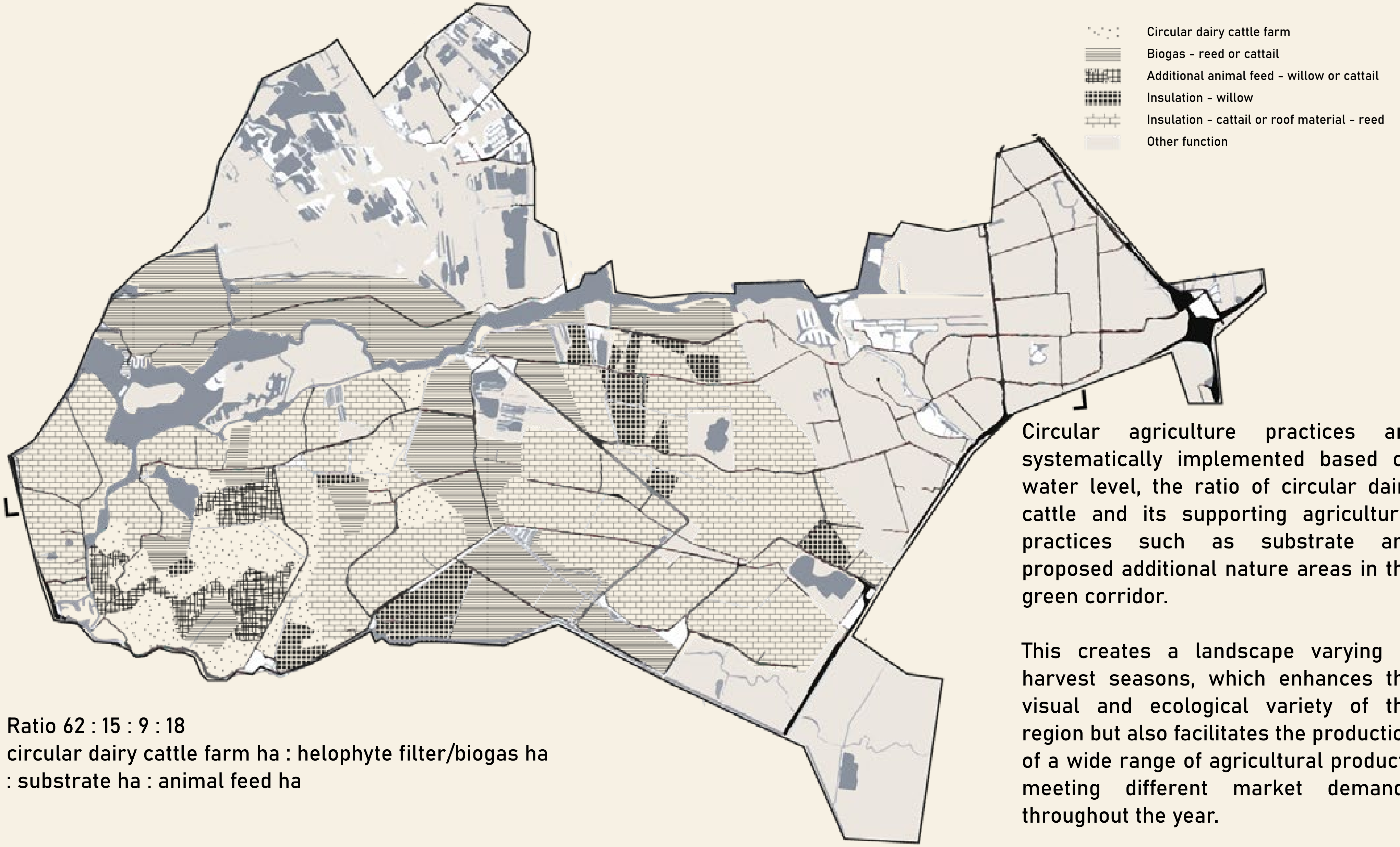


The low midlands are divided into three main water level groups. This division allows for more precise and effective water management tailored to the specific elevations within the landscape.

Due to slight height differences within each group, raising the general water level creates distinct zones where the water is relatively higher or lower than in adjacent fields. This nuanced approach ensures varying topographies, promoting the health and sustainability of the peatlands and surrounding agricultural areas.

Figure 48. Water level groups in the low midlands
Sources: made by author

5.1.2 Proprosed agricultural practices in low midlands



Circular agriculture practices are systematically implemented based on water level, the ratio of circular dairy cattle and its supporting agricultural practices such as substrate and proposed additional nature areas in the green corridor.

This creates a landscape varying in harvest seasons, which enhances the visual and ecological variety of the region but also facilitates the production of a wide range of agricultural products meeting different market demands throughout the year.

Ratio 62 : 15 : 9 : 18
circular dairy cattle farm ha : helophyte filter/biogas ha : substrate ha : animal feed ha

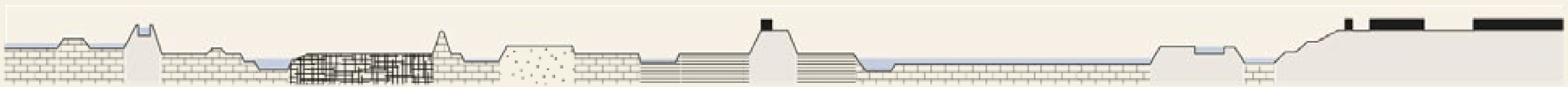
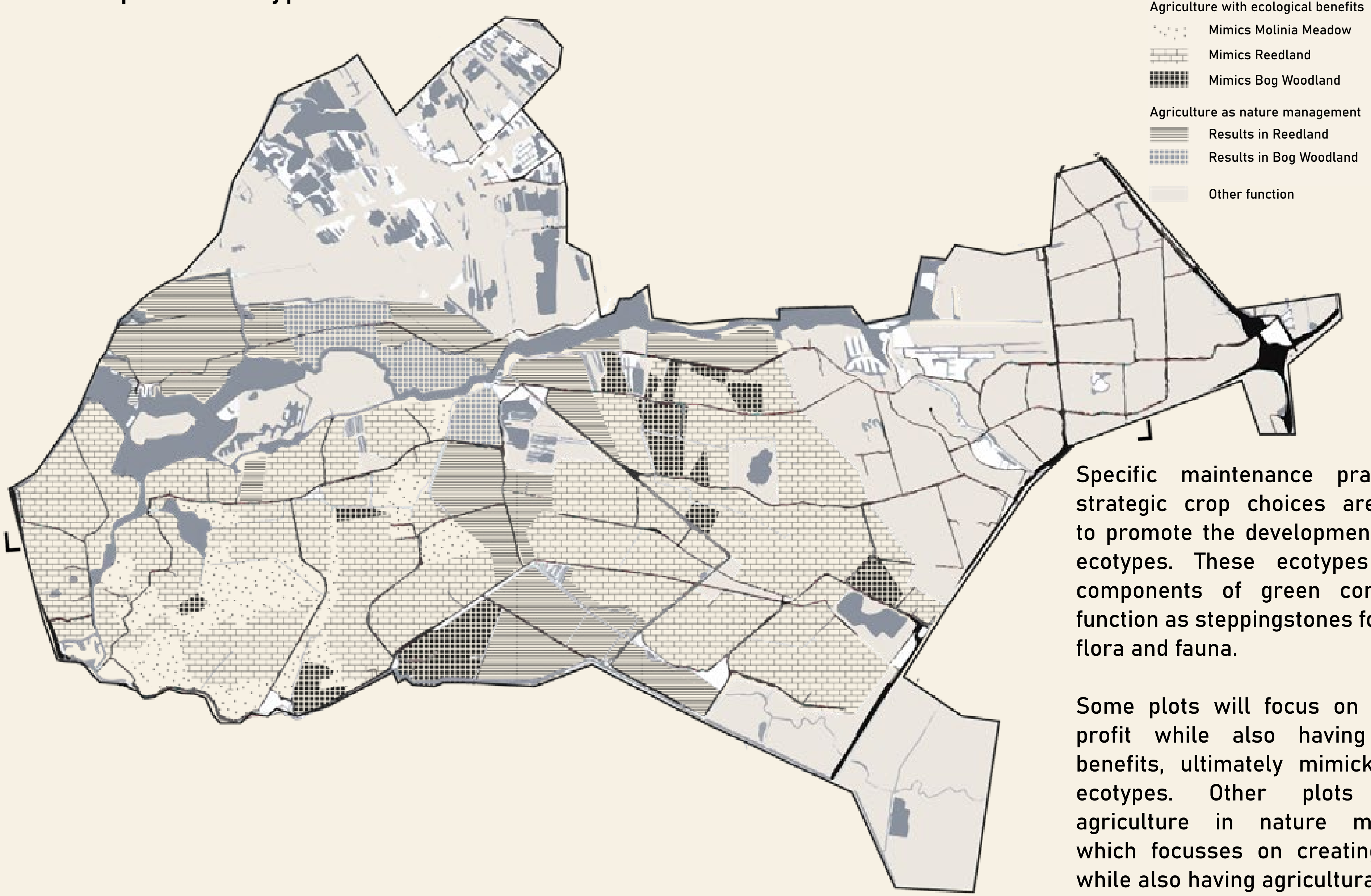


Figure 49. Implemented agriculture type
Sources: made by author

5.1.3 Proposed ecotypes in low midlands



Specific maintenance practices and strategic crop choices are employed to promote the development of distinct ecotypes. These ecotypes serve as components of green corridors and function as steppingstones for migrating flora and fauna.

Some plots will focus on agricultural profit while also having ecological benefits, ultimately mimicking certain ecotypes. Other plots transform agriculture in nature management, which focusses on creating ecotypes, while also having agricultural profit.

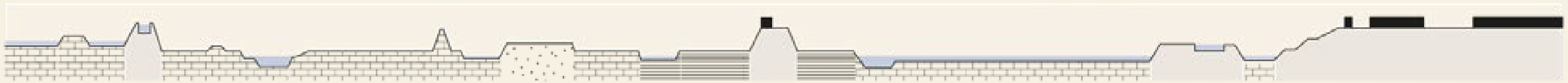


Figure 50. Implemented ecotypes and mimiced ecotypes
Sources: made by author

5.2 Overview Masterplan

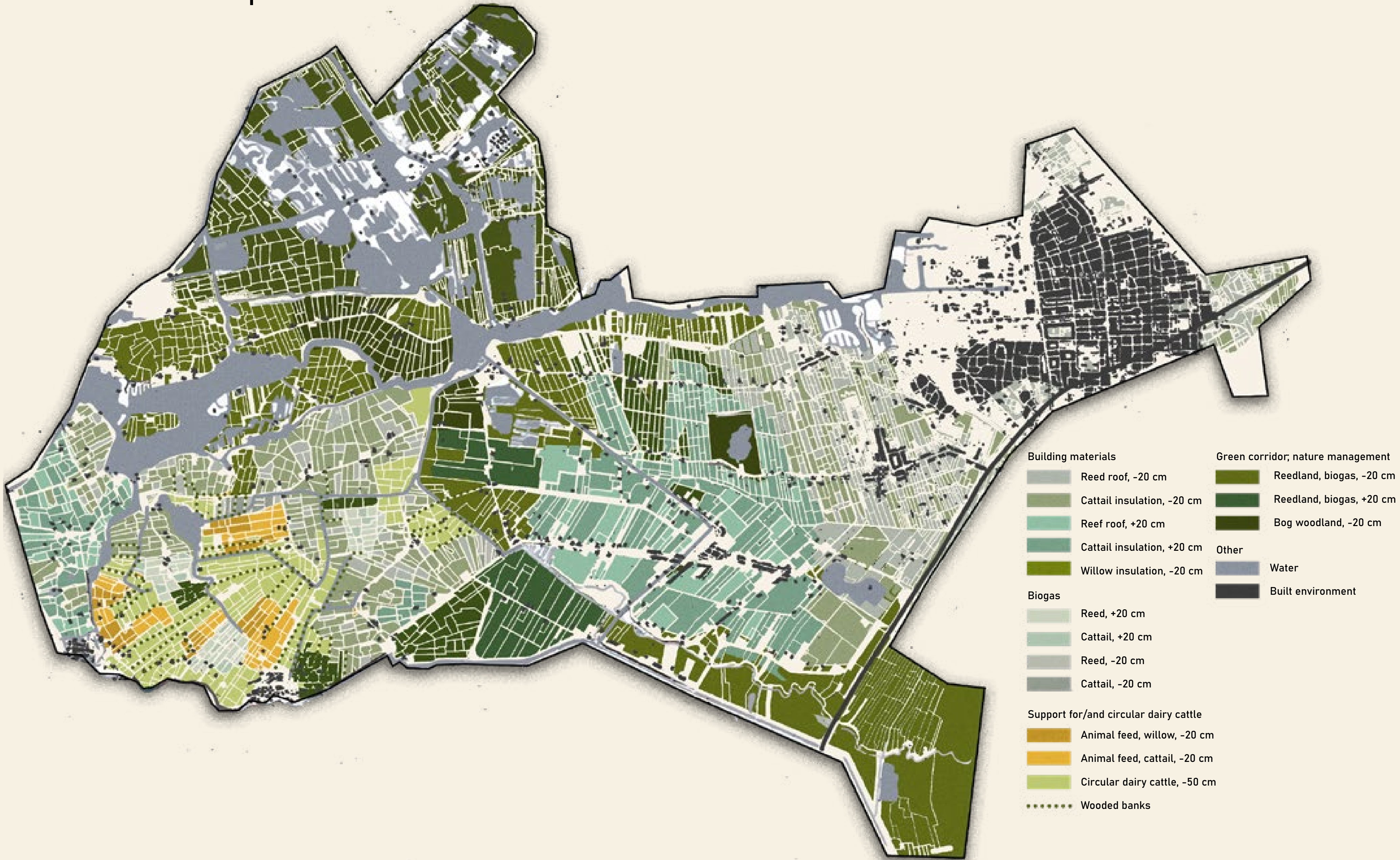


Figure 51. Spatial framework based on circular agriculture for the low midlands
Source: made by author

5.3 Spatial framework

The proposed design for the low midlands integrates multiple layers, each contributing to a spatial framework aimed at mitigating peat oxidation through circular agriculture practices. The spatial framework involves an integrated approach combining water management, circular crop and livestock practices, community engagement, and integrating peat ecotypes within the agricultural system.

Maintaining higher water levels in peatlands is crucial to reducing peat oxidation. This involves implementing a controlled water management system that regulates seasonal water levels, creating additional ditches, and establishing buffer zones to filter excess nutrients and stabilize the ecosystem.

Circular crop practices include cultivating crops such as Reed, Cattail, and Willow, which thrive in wet conditions and originate from peat landscapes, thus preventing peat oxidation. These practices also support circular livestock practices in combination with strip grazing and flooding to maintain soil health.

By reintroducing wooded banks within the landscape, the design not only preserves traditional practices but also enhances the connection between the local community, nature, and the agricultural landscape. These banks guide and manage water flows, with the reintroduction of flooding in dairy cattle plots. They also provide habitats for various flora and fauna, promoting biodiversity within the agricultural landscape. The presence of trees and shrubs adds structural diversity to the landscape, creating a more visually appealing environment.

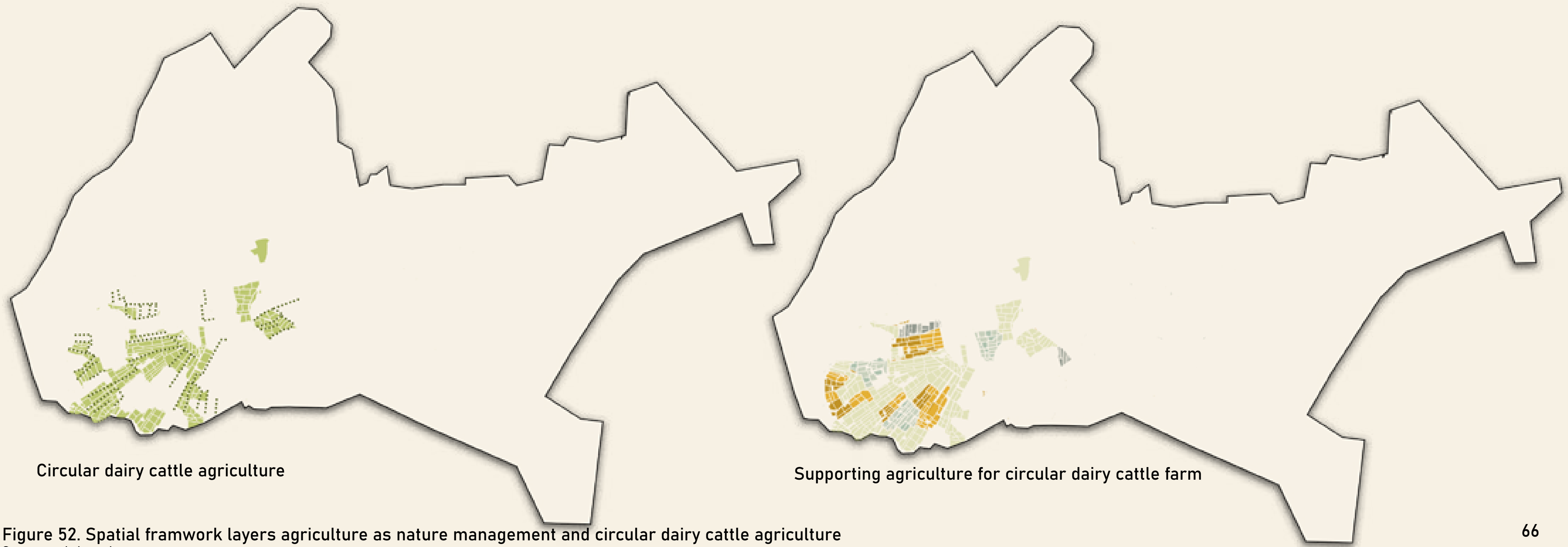


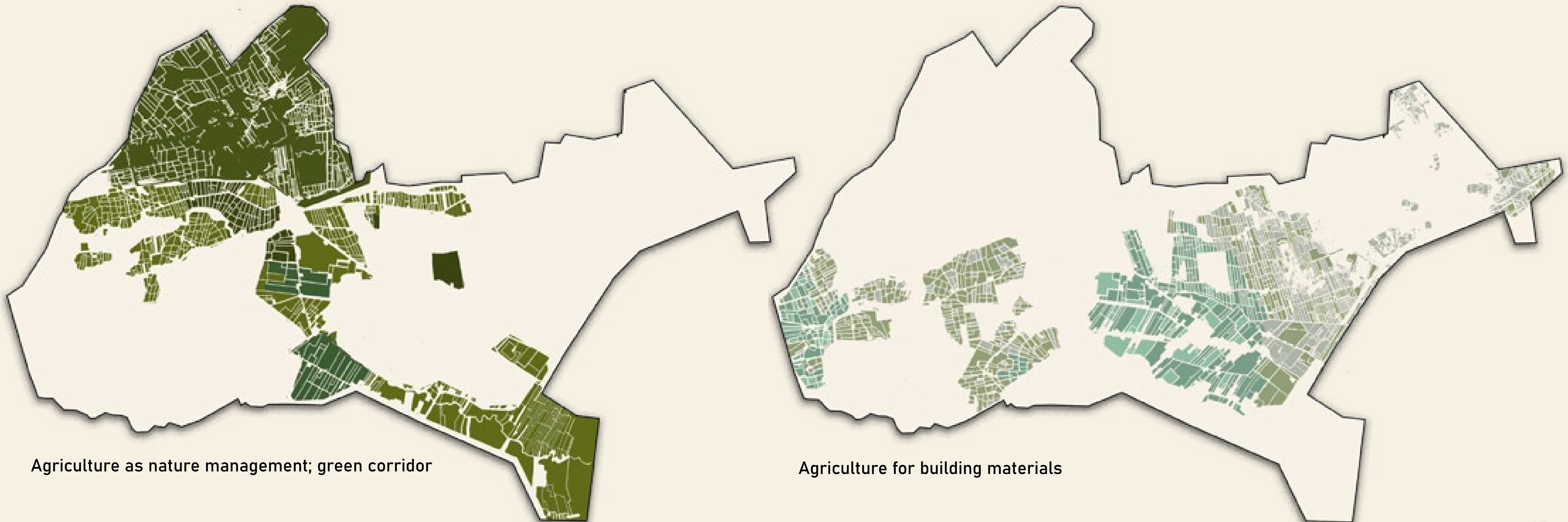
Figure 52. Spatial framwork layers agriculture as nature management and circular dairy cattle agriculture
Source: made by author

5.3 Spatial framework

A green corridor facilitates the movement of flora and fauna between the Natura 2000 areas of National Park De Alde Feanen and Van Oordt's Mersken. This corridor acts as a vital ecological link ensuring that species can migrate and disperse.

The local community plays a vital role in implementing and sustaining this circular agriculture system. The integration of agricultural products for housing materials or biogas, creates a strong bond between the community and the landscape. Surplus products are distributed nationally and internationally, broadening market reach and economic benefits. The total agricultural land used for housing materials could provide materials for 6.000 houses in terms of insulation, roofing and biogas.

By creating a diverse and heterogeneous landscape with various crops, the design contrasts sharply with the current monotonous agricultural landscape, thereby enriching the recreational experience. Visitors can enjoy a visually stimulating environment that changes with the seasons, providing different scenic views and activities throughout the year. This diversity not only enhances aesthetic appeal but also encourages a deeper connection with nature and an appreciation for sustainable agricultural practices.



Agriculture as nature management; green corridor

Agriculture for building materials

Figure 53. Spatial framework layers supporting agriculture and agriculture for building materials
Source: made by author

5.4 Visualization circular agricultural landscape

The agricultural landscape undergoes a dynamic transformation into a resilient landscape with a healthy ecosystem, by implementing native agriculture practices with varying harvest seasons. This metamorphosis enables the integration of ecological, economic, and social dimensions in the agricultural landscape, ultimately achieving an expanded network necessary within a circular system.

Through ongoing research, monitoring, and adaptive management, the landscape continues to evolve, fostering biodiversity, enhancing ecosystem services, and supporting the well-being of both human and non-human communities. This ensures the farming ecosystem remains robust and capable of adapting to changing environmental and economic conditions, ultimately contributing to the long-term sustainability and resilience of the agricultural landscape.

Figure 54. Inzoom on circular agricultural landscape
Sources: made by author

Figure 55. Visualization circular agricultural landscape
Sources: made by author

5.5 Visualization peat landscape - green corridor

The green corridor constitutes a vital component of the design linking the Alde Feanen and Van Oordt's Mersken areas. The positioning of the green corridor along a central line between Alde Feanen and Van Oordt's Mersken ensures the connectivity of ecosystems and facilitates the movement of wildlife between these two areas. By creating a continuous stretch of greenery, the corridor helps mitigate habitat fragmentation and supports the conservation of species by providing essential habitat and foraging areas.

The corridor also provides opportunities for outdoor activities and nature-based experiences, such as hiking, cycling, and wildlide observation. Through implementing specific routing, different viewpoints and framing, the green corridor enhances the connection the local community has with water and the landscape while preventing overcrowding.

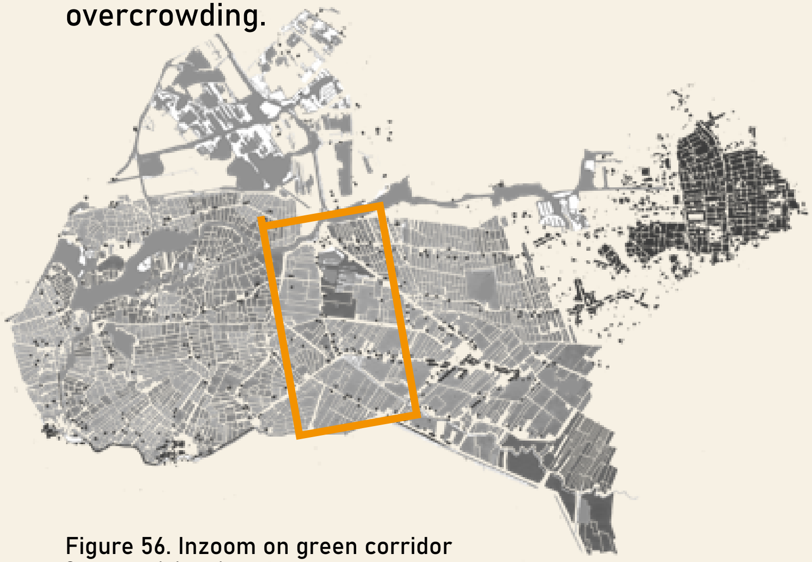


Figure 56. Inzoom on green corridor
Sources: made by author

Figure 57. Visualization green corridor
Sources: made by author

6. Conclusion & Reflection

6.1 Conclusion

The study sought to investigate the research question: "What is the spatial framework based on circular agriculture to relieve peat oxidation in the 'low midlands' in Friesland, the Netherlands?".

To develop this framework, the thesis delved into existing literature, conducted interviews, and implemented gained knowledge in the low midlands in Friesland, the Netherlands. By scrutinizing the interplay between peat ecosystems, agricultural practices, and circular economy principles, the research aimed to elucidate how these elements influence each other. The methodology enabled a comprehensive assessment of how peat management strategies, sustainable crop and livestock practices, and circular economy models can be integrated to formulate a cohesive framework, crucial for designing a system that not only mitigates peat oxidation but also promotes environmental sustainability and economic viability.

The spatial framework involves an integrated approach combining water management, circular crop and livestock practices, community engagement, and integrating peat ecotypes within the agricultural system.

Maintaining higher water levels in peatlands is crucial to reducing peat oxidation. Circular crop practices include cultivating crops such as Reed, Cattail, and Willow, which thrive in wet conditions and originate from peat landscapes, thus preventing peat oxidation. These practices also support circular livestock practices in combination with strip grazing and flooding to maintain soil health. By reintroducing wooded banks and flooding in the agricultural landscape, traditional practices are preserves and the connection between the local community, nature, and the agricultural landscape is enhanced. A green corridor acts as a vital ecological link between Natura2000 areas ensuring that species can migrate and disperse.

The local community plays a vital role in implementing and sustaining this circular agriculture system. The integration of agricultural products for housing materials or biogas, creates a strong bond between the community and the landscape. Surplus products are distributed nationally and internationally, broadening market reach and economic benefits.

The knowledge contributed by this research provides insights into the connections between agricultural practices, peatland preservation, and the circular economy. One significant finding is the potential for integrating sustainable crop cultivation with traditional farming practices to create a circular dairy cattle farm that does not cause peat oxidation. Another finding includes an alternative water level approach suitable for the peat landscape, which significantly reduces the fragmentation of the water system and provides natural water level differentiation on which agriculture can be implemented. Lastly, it was found that implementing different agriculture types within a circular economy, significantly impacts the network of the farmer and their role in the agricultural landscape, the peat landscape, and the built environment.

Several recommendations emerged from this thesis to further enhance the framework and its implementation. Firstly, expanding the range of agricultural practices suitable for high-water table environments is essential, including exploring additional crop types and innovative livestock management techniques. Additionally, further research is needed to understand the impact of different crops on specific peat strata, which will refine crop selection and management practices. Lastly, the study suggests investigating the detailed effects of the proposed dairy cattle system, including the optimal ratio to supporting agricultural practices, to ensure the sustainability of livestock farming in these regions. These recommendations aim to refine and expand the framework, ensuring its practicality and effectiveness in diverse peatland contexts.

6.2 Reflection

The peatlands of Friesland, Netherlands, are a crucial yet vulnerable ecosystem. These landscapes are not only rich in biodiversity but also play a significant role in carbon sequestration, storing with all peatlands combined nearly 30% of all soil carbon. However, the drainage and degradation of peatlands have led to the release of stored carbon into the atmosphere, contributing to global carbon emissions.

The concept of a circular economy offers a promising solution to this complex problem. By transitioning from a linear model of production and consumption to one focused on reuse, recycling, and minimizing waste, the circular economy reduces pressure on natural resources and mitigate environmental degradation. In the context of Friesland's peatlands, embracing circular agricultural practices offers a sustainable approach to relieve peat oxidation.

As mentioned in the conclusion the spatial framework involves an integrated approach combining water management, circular crop and livestock practices, community engagement, and integrating peat ecotypes within the agricultural system.

This project has broader implications for the discipline of landscape architecture and the concept of circularity in agriculture. It demonstrates how integrated approaches can address complex environmental challenges and offers a model for similar efforts in other regions. The project highlights the importance of designing with ecological processes in mind, reinforcing the role of landscape architecture in promoting sustainability.

Given the urgency of peat degradation, timely action is critical. A clear timeline for implementation is necessary, with immediate steps focusing on the most critical areas of peat oxidation. Delaying action risks losing significant amounts of peat, which would exacerbate carbon emissions and ecological degradation. Therefore, prompt research and implementation are vital.

The shift towards circularity in agriculture is poised to play a larger role in the coming years. By linking circular agricultural practices with peatland conservation, this project positions peatlands at the forefront of sustainable landscape design. The expectation is that successful implementation will not only mitigate peat oxidation but also set a precedent for integrating circular economy principles in landscape architecture and broader environmental policies.

The methodology involved a combination of design studies, stakeholder interviews, and literature reviews to understand the current state of Friesland's peatlands and the potential for circular agriculture. While the information gained from these studies is complex, it is not yet completed. Research in paliduculture, peat growth, peat oxidation, and circular agriculture is still ongoing. Available research partakes in different peat landscapes and or ecotypes and all research does not hold the same level of detail throughout. This means some assumptions had to be made based on the data and literature.

Further research needs to be done to gain a comprehensive understanding of the circular agriculture practices in peat landscapes. Additionally, other agriculture practices - such as ox, sheep, alder trees, elm trees, flax, and hemp – could be researched for their viability in wet peatlands, economic value, and effect on the circular system. Understanding the nuanced interactions between different agricultural practices and peatland ecosystems will provide a clearer picture of sustainable management strategies. Collaborative efforts between academic institutions, local governments, and farmers can help bridge existing knowledge gaps and promote practical, field-tested solutions.

While in theory, a circular agriculture system can prevent peat oxidation, translating these into real-world applications poses numerous challenges. Implementing such a comprehensive framework requires substantial resources and coordination. The complexity of integrating multiple practices and engaging various stakeholders poses significant logistical challenges. Economic feasibility for farmers, who may need to invest in new technologies and modify their current practices, is a primary concern. The framework must address financial implications and provide pathways for farmers to transition without significant financial risk.

Pilot projects and phased implementation strategies can demonstrate the practicality of these methods, allowing for adjustments based on real-world feedback. The framework should be flexible enough to adapt to varying local conditions, recognizing that a one-size-fits-all approach is unlikely to succeed across diverse peatland environments. Successful pilots can inform larger rollouts, supported by detailed implementation guides and best practice manuals. Continuous feedback loops, where stakeholders share their experiences and challenges, are vital for refining practices and addressing unforeseen issues. Training programs and workshops can further aid in disseminating knowledge and building capacity among farmers, ensuring effective implementation of practices.

Achieving the necessary policy and regulatory support can be time-consuming and uncertain, potentially hindering progress. Effective policy support is essential to drive the adoption of circular agriculture practices. Policies should incentivize farmers to adopt new methods through subsidies, technical support, and educational programs. Regulatory frameworks need to be adaptable to accommodate innovative practices like paludiculture and high-water management. Strong policy backing can also facilitate market development for new products, ensuring economic viability for farmers.

7. References

7.1 References

Actueel Hoogtebestand Nederland. (2023). ahn_dsm05m [41daef8b-155e-4608-b49c-c87ea45d931g].

Agroforestrykip. (2019). Biomassateelt met wilgen. https://agroforestrykip.nl/teeltsystemen/biomassateelt/

Amethyst Studio. (2022, september). Livestock. Nounproject. https://thenounproject.com/icon/livestock-5216846/

Amethyst Studio. (2024, march). plant nutrients. Nounproject. https://thenounproject.com/icon/plant-nutrients-6684945/

Baaijens, G. J., Brinckmann, E., Dauvelier, P. L., & van der Molen, P. C. (2011). Stromend landschap - vloeiweidenstelsels in Nederland. KNNV Uitgeverij.

Bambina, A. (z.d.). Concept on the theme racism. shutterstock. https://www.shutterstock.com/nl/image-vector/concept-on-theme-racism-stop-image-1749149210?consentChanged=true

Bestman, M., Geurts, J., Egas, Y., Van Houwelingen, K., Lenssinck, F., Koornneef, A., Pijlman, J., Vroom, R., & Van Eekeren, N. (2019). Natte teelten voor het veenweidengebied Verkenning van de mogelijkheden van lisdodde, riet, miscanthus en wilg. www.louisbolk.nl

Beuv. (2023, 20 maart). De Weerribben-Wieden het riet is net gemaaid van het land. Zoom. https://zoom.nl/foto/landschap/3540135/de-weerribben-wieden-het-riet-is-net-gemaaid-van-het-land

Bij12. (n.d.-a). N06.01 Veenmosrietland en moerasheide.

Bij12. (n.d.-b). N06.01 Veenmosrietland en moerasheide.

Bij12. (n.d.-c). N17.05 Wilgengriend.

Biodiversity Europa. (n.d.). ALDE FEANEN.

Blue. (2024, april). Chainsaw. Nounproject. https://thenounproject.com/icon/chainsaw-6823517/

Bos, H., van Groenestijn, J., Harmsen, P., Hugenholtz, J., Appelmans, W., Jetten, J., ... & Visser, S. (2019). Circulaire systemen. Wageningen University & Research.

Brittannica. (2017). Cattails lake. britannica.com. https://www.britannica.com/plant/Poales

Brooks, S. (2019, November 2). The importance of peat. National Trust for Scotland. https://www.nts.org.uk/stories/the-importance-of-peat-1

Buro Sant en co. (2018). Ontwerpatelier ‘Naar een nieuwe aanpak voor het veen in het Lage Midden van Fryslân’

CBS opendata statLine. (2023). Landbouw; gewassen, dieren en grondgebruik naar regio [80780ned].

Centraal Bureau voor de Statistie. (2015). Bestand bodemgebruik 2015 [2d3dd6d2-2d2b-4b5f-9e30-86e19ed77a56].

Collectief noord west overijssel. (z.d.). Koegezondheid en kruidenrijk grasland. collectiefnoordwestoverijssel. https://www.collectiefnoordwestoverijssel.nl/koegezondheid-en-kruidenrijk-grasland/

de Jong, B. (1987). Fries veenweidegebied, let op je kwaliteiten. Noorderbreedte.

de Ruyter, P. (2016). Vloeiend landschap: over de toekomst van het Friese landschap. Bornmeer.

De Volksbank. (2019). Circulair Ondernemen.

Dik. (2021). Analyse bedrijfsresultaten 2020 D.E. Momelkveebedrijf, KOEDORP. https://www.componentagro.nl/media/81333/demorapport-melkveehouderij-2020.pdf

DINOloket. (2021). Geologische kaart Nederland [53730e63-9a88-4ea0-a572-21ea8e37f254].

DinosoftLabs. (2024, januari). cloud rain. Nounproject. https://thenounproject.com/icon/cloud-rain-6503931/

Ecopedia. (n.d.). Natuurstreefbeeld: Rietvegetaties (rbbmr). Retrieved May 17, 2024, from https://www.ecopedia.be/natuurstreefbeeld/natuurstreefbeeld-rietvegetaties-rbbmr

Ecopedia. (n.d.). Rietkragen langs de Schelde-oevers ter hoogte van Galgenschoor (Antwerpen). https://www.ecopedia.be/basisinformatie/beheer-van-een-rietmoeras

Encyclopedie Drenthe. (z.d.). Veenvorming. https://www.geheugenvandrenthe.nl/veenvorming

Eucalyp. (2020, april). hay. Nounproject. https://thenounproject.com/icon/hay-3050923/

EUNIS. (n.d.-a). Bog woodland.

EUNIS. (n.d.-b). Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae).

European Parliament. (2023, May 24). Circular economy: definition, importance and benefits. https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

European Union. (2020). Peatlands for LIFE. https://doi.org/10.2826/089623

Eurostat, the Statistical Office of the European Union. (2021). Crop production [apro_cpsh1].

Florent B. (2019, may). Whomping willow. Nounproject. https://thenounproject.com/icon/whomping-willow-2659813/

Forest Habitat Group. (2016). G1.5 Broadleaved bog woodland on acid peat.

Friends of the earth. (2019, February 21). Why is peat good for climate and nature? Friends of the Earth. https://friendsoftheearth.uk/climate/why-peat-good-climate-and-nature

Harmsen, P., Hugenholtz, J., Appelmans, W., Jetten, J., Bussmann, P., van Bon, J., Burgering, M., Verdoes, N., Groenestein, K., Schoumans, O., de Haas, W., Regelink, I., Stuiver, M., Bakker, S., van Dijk, W., & Visser, S. (2019). Circulaire systemen.

Huizinga, H. E. A. (2014). Oogst van de veenlandschappen. Peredour.

Hulshof, H. (n.d.). Biodiversiteit van veenlandschappen. https://www.uu.nl/botanischetuinen/onderwijs-en-onderzoek/onderzoeksprojecten/biodiversiteit-van-veenlandschappen

istockphotos. (2023). Phragmites australis. Biovijver. https://biovijver.nl/vijverflora/vijverplanten/oeverplanten/riet/

It Fryske Gea. (2017, oktober). Ychtenerfeanpolder-3. https://www.itfryskegea.nl/wp-content/uploads/2017/10/ychtenerfeanpolder-3.jpg

Jonathan Wong. (2023, march). insulation. Nounproject. https://thenounproject.com/icon/insulation-5582510/

Juicy Fish (2021, march). cattail. Nounproject. https://thenounproject.com/icon/cattail-4242719/

Jurasinski, G., Günther, A.B., Huth, V., Couwenberg, J., Glatzel, S. 2016. Ecosystem services provided by paludiculture – greenhouse gas emissions. In: Wichtmann, W., Schröder, C., Joosten, H. (eds.) 2016. Paludiculture - productive use of wet peatlands. Schweizerbart Science Publishers. www.schweizerbart.de/9783510652839 (25/4/2019).

Kadaster. (2022). Bestuurlijke gebieden [208bc283-7c66-4ce7-8ad3-1cf3e8933fb5].

Kranenborg, N. (n.d.). rietzanger-1. lauwersmeerinfocus.nl. https://lauwersmeerinfocus.nl/moerasvogels/

Kuziarin, O. (n.d.). Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae).

Landan Lloyd. (2017, december). Winter. Nounproject. https://thenounproject.com/icon/winter-1472094/

Leibundgut, C., Vonderstrass, I (2016), Traditionelle Bewässerung – ein Kulturerbe Europas (band 1+2). Merkur Druck AG, Langenthal.

Metapos. (2024). Provincies eu

Ministerie van Landbouw, Natuur en Voedselkwaliteit. (2022). Natura 2000-gebieden [4bbfdba2-7687-4393-9192-35ff89e6dfd0].
Muhammad Khoirul Amal (2019, july). grass. Nounproject. https://thenounproject.com/icon/grass-2889052/

Natura2000. (n.d.). Natura 2000 in Nederland. Retrieved May 10, 2024, from https://www.natura2000.nl/gebieden/friesland

Natura2000. (2008a). Profiel_habitattype_91D0.

Natura2000. (2008b). Profiel_habitattype_7140.

Nesterenko, R. (n.d.). Overheidsprogramma's concept icoon. vecteezy. https://nl.vecteezy.com/vector-kunst/4841753-overheidsprogramma-s-concept-pictogram-kleine-bedrijven-ontwikkeling-startup-lancering-assistentie-abstract-idee-dunne-lijn-illustratie-vector-geisoleerde-omtrek-kleur-tekening-bewerkbare-slag

Nij Bijvank, G. & The Spring Company. (2021). JAARRAPPORTAGE MARKT & KETENVORMING NATTE TEELTEN 2020-2021 [Report]. https://www.veenweiden.nl/wp-content/uploads/2021/10/Jaarrapportage-Markt-Ketenvorming-Natte-Teelten-IPV-VIC-The-Spring-Company-15-05-2021.pdf

o+bnNatuurkennis. (n.d.). Vorming van veen. Retrieved May 10, 2024, from https://www.hoogveenherstel.nl/uitgebreide-info-1/hoe-werkt-een-hoogveen/veenvorming/

Paonkz. (2023, november). Summer. Nounproject. https://thenounproject.com/icon/summer-6363635/

Rove. (2020). Skûtsjesilen Championships 2020 in The Netherlands. rove.me. https://rove.me/to/netherlands/skutsjesilen-championships

Schipper, P. N. M., Hendriks, R. F. A., Noij, I. G. A. M., Honkoop, W., van Eekeren, N. J. M., & Boekhorst, L. (2015). Potentie Kringlooplandbouw en onderwaterdrainage in veenweide: Voorstudie naar de potentie van kringlooplandbouw en onderwaterdrainage in veenweidevoor minder verliezen naar bodem en water en beter bedrijfsresultaat (No. 2684). Alterra.

Stichting Demeter. (z.d.). Locaties | Stichting Demeter. Retrieved 29 januari 2024, van https://www.stichtingdemeter.nl/locaties

Supalerk Laipawat. (2020, april). reed. Nounproject. https://thenounproject.com/icon/reed-3379187/

Suyeon Kang. (2023, july). Cow. Nounproject. https://thenounproject.com/icon/cow-5928949/

Tatyana. (2018, december). Plant. Nounproject. https://thenounproject.com/icon/plant-2215385/

Tatyana. (2018, december). Plant. Nounproject. https://thenounproject.com/icon/plant-2215382/

Tatyana. (2018, december). Plant. Nounproject. https://thenounproject.com/icon/plant-2215380/

The World Bank. (2021, September 15). Water in Circular Economy and Resilience (WICER). https://www.worldbank.org/en/topic/water/publication/wicer

Tom Farrell. (2020, april). drone blades. Nounproject. https://thenounproject.com/icon/drone-blades-3697761/

Trunk, A. (n.d.). Eager. landschapnoordholland.nl. https://www.landschapnoordholland.nl/rietvogels

Vectorstall. (2020, may). Plant. Nounproject. https://thenounproject.com/icon/plant-3714647/

Vijverplantenland. (n.d.). Carex Riparia. vijverplantenland.nl. https://www.vijverplantenland.nl/shop/carex-riparia-grote-zegge/

Wageningen University & Research. (2021). Nutrienten - stikstofbedrijfsoverschot per ha. Agrimatie. Retrieved 19 juni 2024, from https://agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=2282&indicatorID=2774

Wageningen University & Research. (2023). Mestbeleid LMM. Agrimatie.

Wageningen Universiteit Research. (n.d.). FACTSHEET NATTE TEELTEN.

Wesselingh, F. (n.d.). Veenlandschap. Geologie van Nederland. Retrieved May 10, 2024, from https://www.geologievannederland.nl/landschap/landschappen/veenlandschap#:~:text=In%20laagveengebieden%20komt%20grondwater%20aan,laagveenmoerassen%20herbergden%20daarom%20diverse%20plantengemeenschappen.

Wikipedia. (2023a). Lage Midden. Retrieved 23 mei 2024 from https://nl.wikipedia.org/wiki/Lage_Midden

Wikipedia. (2023b). Rietland. In Wikipedia. Retrieved 22 mei 2024, from https://nl.wikipedia.org/wiki/Rietland

Wikipedia. (2024). Friesland. Wikipedia. Retrieved 19 juni 2024, from https://nl.wikipedia.org/wiki/Friesland

Zuidhollandslandschap. (n.d.). Noordse Woelmuis in een zompig Rietland. Zuidhollandslandschap.nl. https://www.zuidhollandslandschap.nl/over-ons/flora-en-fauna/noordse-woelmuis

ZuivelNL. (2021). Zuivel in Cijfers. www.zuivelnl.org

7.2 Table of figures

8. Appendix

8.1 Summary interview It Fryske Gea

- Interview about National Park de Alde Feanen.
- Alde Feanen is maintained to support as much different ecotypes as possible.
- Maintenance is done to preserve ecotypes or promote peat growth to establish a healthy peat landscape.
- Pressure is put on the Park due to recreation.
- The park is divided in parts where humans are welcome for recreation, and areas where they are prohibited to enter to protect the rarity and vulnerability of the peat landscapes.
- Water quality is influenced from excess Nitrogen from fertilizers used in agriculture.
- Ecosystems are harmed by pesticide use
- Agricultural fields drain water from higher lying nature areas. Which causes a general degradation of peat landscapes and their ecosystems.

8.2 Summary interview Farmer Strip Grazing

Interview about strip grazing and the conquences this practices has on soil, crop and cattle health.
- daily and yearly activitities that occur from stripgrazing. adding extra hectares to the grazing area, milking the cows twice a day. Letting them spend the night on the field in the summer.
- Some plots are used for meadow birds in spring. Government gives money to do this.
- strip grazing principle, in between 0.5 to 1 ha for 75 cows, adding one additional strip every 4 to 12 hours.
- allow grass to grow for a period of 2 to 4 weeks, ideally 6 weeks.
- Manages their own substrate, in a nature management plot.
- Substrate is used in a 'potstal', in which the manure is layered with substrate. Which then can be used to fertilize the grassland.
- Substrate with cattle manure promotes soil life, and results in herb-rich grassland.
- Herb-rich grasslands are needed for meadow birds to nestle and feed on.
- Conventional fertilizing results in shorter roots systems as roots do not need to grow deep to access nutrients. This means soil life is almost nonexistent as healthy root system is an essential factor for this.
- Cattle are selective in which crops they graze. They prefer freshly growing grass, than older mature grasses. This leads to an ineffective way of grazing.
- strip grazing puts pressure on the cattle to graze the availble grasses, resulting in evenly eaten grasses. which then can grow on their own time.

8.3 Summary interview Expert Peat Agriculture

- year round average of -30 cm needs to be maintained to not cause any peat oxidation, meaning fluctation is possible
- flooding would be a possibility to maintain enough nutrients and provide enough water when water level is at -50 cm in summer.
- introduction to paliduculture, explaining research done in reed and cattail crops.
- expresses potential peat mosses for growing and compensating any excess emmisions.

8.4 Calculations ratio

Ratio 62 : 15 : 9 : 18
circular dairy cattle farm ha : helophyte filter/biogas ha
: substrate ha : animal feed ha

Circular dairy cattle farm
- 620 ha available for dairy cattle farm in the low midlands.

Helophyte filter/biogas
- 620 ha dairy cattle results in 114 kg N * 620 = 70.680 --> 71.000 kg N
- Reed and cattail can take in beteen 500-600 kg N per ha
- 71.000 kg N / 500 = 142 ha --> 150 ha

Substrate
- 620 ha * 1,17 cows = 725 cows
- cattail can provide for 8-10 cattle manure
- 725/8 = 90

Animal feed
- 620 ha * 1,17 cows = 725 cows
- willow and cattail feed 4-5 cows
- 725 / 4 = 181 --> 180 ha

620 : 150 : 90 : 180

62 : 15 : 9 : 18