Farming practices to improve biodiversity in peat meadow areas

A portfolio of practices for improving biodiversity in the Alblasserwaard - Vijfheerenlanden and their potential for business models of Dutch dairy farmers

Lotte Yanore[1], Raimon Ripoll-Bosch[1], Vincent Oostvogels[1], Lennard de Jong[1], Hilde van Dijk[1].

1 Wageningen University

Cite as: Yanore, L, Ripoll-Bosch, R, Oostvogels, V, de Jong, L, van Dijk, H. 2024. Successful practices to improve biodiversity on dairy farms in peat meadow areas. Wageningen University & Research. DOI: 10.18174/652821

This research is conducted by researchers from Wageningen university. It is part of the "Deltaplan Living Labs voor biodiversiteitsherstel: van Landschap naar Landelijk" (No. NWA.1331.19.201) of the Dutch Research Agenda programme "Living labs for the restoration of rural biodiversity" which is (partly) financed by the Dutch Research Council (NWO). The Living Lab Alblasserwaard - Vijfheerenlanden is one of the three living labs. This is a research program from the Delta plan Biodiversity recovery with the objective to strengthen biodiversity recovery in Alblasserwaard together with the stakeholders active on this topic in the area.

This report can be downloaded for free at https://doi.org/10.18174/652821.

NWO

Table of contents

Summary

The decline of biodiversity is a growing concern not only at the global level, but also at the regional level. Food systems are a major driver of biodiversity loss (Benton et al., 2021, Dudley and Alexander, 2017, Erisman et al., 2016). In the Netherlands, biodiversity is declining in natural areas, but also in agricultural lands (i.e. the agrobiodiversity). Hence, there is a growing debate about how to tackle biodiversity loss in natural and agricultural areas, as well as addressing the interface between them both. This report is focused on a peat meadow area in the west of the Netherlands, the Alblasserwaard - Vijfheerenlanden. Generic reports describing farming practices that can contribute to recovering biodiversity already exist (Erisman et al., 2017, Nel et al., 2021). There is a need, however, to provide local contextualized portfolios of farming practices that align with the environmental, social and economic constraints of the area (Nel et al., 2021). *The objective of this report is twofold: First, to create a portfolio of biodiversity-friendly practices tailored to dairy farming in the Alblasserwaard - Vijfherenlanden*. And second, to *discuss possible economic streams to enable the implementation of these biodiversity friendly practices and redesign the business models towards biodiversity-friendly dairy systems.*

Erisman et al. (2016) developed a conceptual framework comprising of four interconnected pillars for biodiversity. Namely, 1) functional (agro)biodiversity, 2) landscape biodiversity, 3) specific species management, and 4) source areas and connection zones. Farming systems that focus on improving these four biodiversity pillars via biodiversity-friendly practices, on the other hand, also provide ecosystem services (Duru et al., 2015). These services encompass provisioning services regulating services, cultural services and supporting services (Duru et al., 2015, Millennium Ecosystem Assessment, 2005).We combine the frameworks proposed by Erisman et al. (2016) and Duru et al. (2015), to get the most out of both of them.

We mapped the biodiversity-friendly practices specific for dairy farmers in Alblasserwaard - Vijfheerenlanden through literature study, interviews with farmers and validation with experts. The total number of individual practices identified was more than 70. In this report, we cluster findings into 23 practices across 4 themes. The first theme is grassland, the second theme is arable land, the third theme is other/non-productive, and the fourth theme is livestock.

We conclude by discussing how farmers can be enabled to adopt biodiversity-friendly practices. Kleijn et al. (2020) suggest linking conservation efforts to business models to reduce economic barriers for landowners and potentially serve as an incentive. We develop a framework to depict the potential for business models to support the adoption of biodiversity friendly practices.

Amongst others, we depict that consumers and public/private institutions may be willing to pay farmers for the created value and environmental services, and thus compensate the farmer for the potential incurred costs. Such incentives should be designed through regional approaches and landscape governance and satisfy both producers and beneficiaries of environmental services.

1 The decline of biodiversity

The decline of biodiversity is a growing concern not only at global level, but also at regional level. Hence, action is being discussed at supranational level (e.g. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES), all the way to local contexts (e.g. national, regional, or historical administrative levels) and communities, including collectives, associations, and businesses. Biodiversity is described as the "variability among living organisms from all sources; this includes diversity within species, between species and between ecosystems" (UN, 1992). The decline in biodiversity spans (Erisman et al., 2016) from changes at landscape level, with degradation and loss of habitats; to decreases in richness and abundance of species, including that of iconic species and functional biodiversity; and to the erosion of the genetic diversity of wild and domesticated species. Biodiversity is essential for the functioning of ecosystems, and by extension to human society and its well-being.

"In 118 of 162 nature areas, nitrogen deposits exceed the safety threshold by on average 50%"

Food systems are a major driver of biodiversity loss (Benton et al., 2021, Dudley and Alexander, 2017, Erisman et al., 2016). The mechanisms through which food production contributes to biodiversity loss are multifaceted, encompassing: 1) the expansion of agricultural land at the expense of natural ecosystems, 2) the intensification of management in agricultural lands, 3) emissions and pollutants (including greenhouse gas emissions, inducive to climate change), and 4) related value chain impacts (Dudley and Alexander, 2017, Román-Vázquez et al., 2023). For instance, global farmland expanded by 12% in recent decades (Foley et al., 2005), and animal husbandry is behind a large portion of this expansion of farmland, with currently 50% of the habitable land being used by cropping and animal husbandry and occupies a large share of the global agricultural land (Benton et al., 2021, Mottet et al., 2017). Another example is the link between intensification and the use of practices detrimental to biodiversity, above and belowground (Cozim-Melges et al., 2024). These practices result in pollution of soils, air and fresh water (Benton et al., 2021, Dudley and Alexander, 2017).

In the Netherlands, biodiversity is sharply declining in natural areas, but also in agricultural lands (i.e. the agrobiodiversity). Hence, there is a growing debate about how to tackle biodiversity loss in natural and agricultural areas, as well as addressing the interface between them both. For instance, nitrogen emissions in the Netherlands, amongst others from the agricultural sector, have resulted in excess nitrogen deposition in nature reserves. In 118 of 162 natural areas, nitrogen deposits exceed the safety threshold by on average 50%, which damages biodiversity. Moreover, nitrogen emission results in the acidification of soils and hinder the absorption of nutrients (Stokstad, 2019). Approximately 50% of the Dutch land area is used for agriculture, and 30% of that is used for dairy farming, underlining the vital need to implement farming practices that conserve and enhance biodiversity (CBS, 2022, Cozim-Melges et al., 2024, Román-Vázquez et al., 2023). Leclère et al. (2020) highlights the important contribution of food systems to bending the curve of biodiversity loss, but conservation efforts would be in conflict with food production. Food production systems, such as the Dutch dairy sector, can both exert pressure on and contribute to biodiversity conservation (Erisman et al., 2016). Through adopting sound farming practices, the agricultural system can strike a delicate balance between exploiting and enhancing biodiversity (Cozim-Melges et al., 2024, Erisman et al., 2016).

The importance of and commitment to restoring biodiversity loss have been expressed by several organizations in the Netherlands (Deltaplan, 2018). Scientists, farmer organizations, nature and climate organizations, financiers and other stakeholders collaborate in the Deltaplan with the objective to create a more rich and diverse nature in the Netherlands. Moreover, the creation of a Dutch ministerial position in 2022 dedicated to nitrogen and nature, underlines the importance given to the recovery of nature in the Netherlands.

This report is focused on a peat meadow area in the west of the Netherlands, the Alblasserwaard - Vijfheerenlanden. The area, primarily utilized by dairy farmers, is historically known for its biodiversity rich landscape, characterized by herb-rich grasslands and meadow birds. However, this landscape is currently under pressure from decades of landscape developments and intensification of practices on dairy farms. The result of this intensification is a more monotonous landscape, less diversity in grasslands, higher use of nutrients and agrochemicals, or higher livestock densities, which results in a decline in biodiversity. Most studies on dairy farming and biodiversity decline are focused on sandy soils, leaving the effects and solutions in peat meadow areas rather understudied (van Boxmeer et al., 2021).

Generic reports describing farming practices that can contribute to recovering biodiversity already exist (Erisman et al., 2017, Nel et al., 2021). There is a need, however, to provide local contextualized portfolios of farming practices that align with the environmental, social and economic constraints of the area (Nel et al., 2021). Furthermore, a comprehensive assessment of which practices can effectively enhance specific types of biodiversity is elusive (Cozim-Melges et al., 2023). *The objective of this report is twofold: First, to create a portfolio of biodiversity-friendly practices tailored to dairy farming in the Alblasserwaard - Vijfheerenlanden*. And second, to *discuss possible economic streams to enable the implementation of these biodiversity friendly practices and redesign the business models towards biodiversity-friendly dairy systems.*

The Ablasserwaard/Vijfheerenlanden

The Ablasserwaard/Vijfheerenlanden is an agricultural area in the south-east of the province South-Holland and the south of the province Utrecht. The area inhabits approximately 170.000 people and spreads over 400 square kilometers.

The area is characterized by peat meadow areas, lying below sea level. These are mostly used by dairy farmers. In Vijfheerenlanden, there are also some sandy and clay soils used for other purposes then dairy farming. Furthermore, the area is characterized by lots of ditches, and is well-known for windmills, such as the mills at Kinderdijk.

Approximately 30% of the milk production in South-Holland comes from this area. This milk is produced by the 450 dairy farmers in the area (LTO, 2019).

In a report by the LTO, six ambitions for the area are summarized (LTO, 2019).

1. Space for entrepreneurship
2. Keeping the areal for agricultural production
3. Keep sufficient clean and fresh water
4. Agriculture contributes to energy objectives
5. Good infrastructure
6. Being in the middle of society

2 Biodiversity and ecosystem services

A framework for conceptualizing biodiversity in dairy farming in the Netherlands was proposed by Erisman et al. (2016). They argue that improving biodiversity would require embracing resilience, in contrast to current mainstream practice which strives for control of the productive environment. This means that farmers need to strategically leverage biodiversity and increase reliance on natural processes to increase the farms' resilience and mitigate risks like pests, draughts, or excessive dependence on external inputs. To this end, Erisman et al. (2016) developed a conceptual framework comprising of four interconnected pillars for biodiversity. Namely, 1) functional (agro)biodiversity, which would entail biodiversity that carry out specific functions that underpin and benefit agricultural production; 2) landscape biodiversity, which refer to elements constituent to more diverse landscapes (e.g. linear elements of trees, hedgerows or ditches); 3) specific species management, which would consider the accommodation of iconic or endangered (wild and/or domesticated) species; and 4) source areas and connection zones, which would entail coordinating the different interventions to enhance options for biodiversity at more landscape/regional level (Figure 1). The adoption of a portfolio of practices within these pillars is poised to enhance biodiversity, with added benefits accruing to the farmer.

"Farmers need to strategically leverage biodiversity and natural processes to increase the farms' resilience and mitigate risks."

Farming systems that focus on improving these four biodiversity pillars via biodiversity-friendly practices, on the other hand, also provide ecosystem services (Duru et al., 2015). Ecosystem services are the benefits and services provided by (agro)ecosystems that underpin human well-being (Duru et al., 2015). These services encompass provisioning services (such as the provision of food, timber or water), regulating services (such as climate control, water purification or pollination), cultural services (related to aesthetic values of a landscape or recreation) and supporting services (which underpin the provision of all other ecosystem services) (Duru et al., 2015, Millennium Ecosystem Assessment, 2005)). Ecosystem services and biodiversity are intertwined and, generally, increased biodiversity leads to increased provison of ecosystem services (Mace et al., 2012). Farming systems, and ultimately food production, are both dependent on biodiversity and ecosystem services, while they can also deliver ecosystem services and maintain conditions for biodiversity. For instance, farming systems rely on healthy soils, decomposition of organic matter, pest control, or pollination (Rodríguez-Ortega et al., 2014, Román-Vázquez et al., 2023). Meanwhile, farming systems can enhance the production of food while providing cultural landscapes or creating habitats for biodiversity (Rodríguez-Ortega et al., 2014).

Current mainstream agricultural production, including dairy, have usually focused on maximizing yields by increased use of anthropogenic inputs (i.e. fertilizers, pesticides or mechanization) at the expense of relying on biological processes. This is usually referred to as an intensification process (Ripoll-Bosch and Schoenmaker, 2021). In literature, the two extremes of this process are described as, on the one hand, the intensive, control (Erisman et al., 2016) or efficiency/substitution-based agriculture (Duru et al., 2015). Whereas on the other hand, you have the extensive, resilient (Erisman et al., 2016) or biodiversity-based agriculture (Duru et al., 2015).This gives scope for farming to maneuver in a degree of intensity, to optimize food production along with biodiversity and ecosystem services (Figure1).

In Figure 1, therefore, we combine the frameworks proposed by Erisman et al. (2016) and Duru et al. (2015), to get the most out of both of them. Erisman et al. (2016) proposes a range of practices applicable to dairy production in the Netherlands to increase biodiversity, while considering diverse types of biodiversity. However, Erisman et al. (2016) offers little dynamic aspect and hardly links to ecosystem services. On the other hand, Duru et al. (2015), make explicit the gradient between the more intensive (efficiency-based use of anthropogenic inputs) and the biodiversity-based agriculture, in which the reliance and effect on ecosystem services is explicit. However, Duru et al. (2015) hardly differentiates between biodiversity aspects nor delves into specific practices.

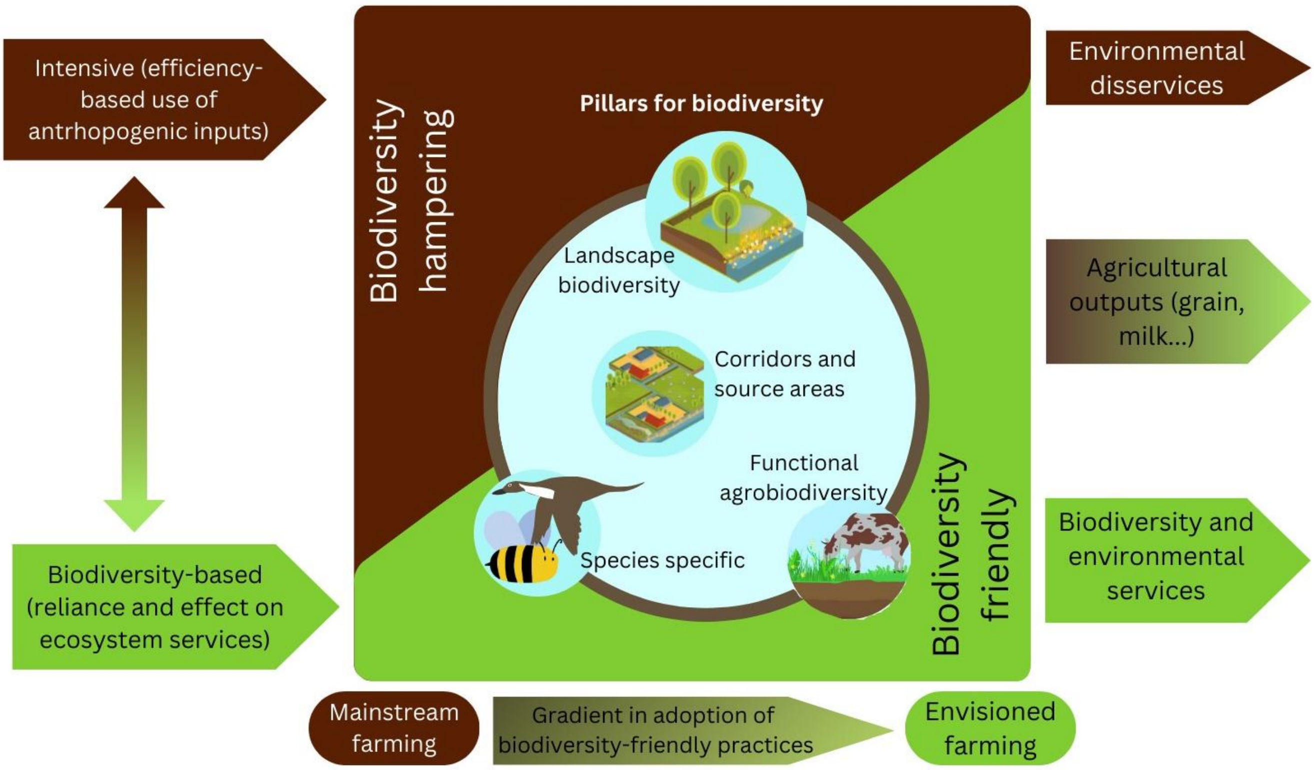


Figure 1: Biodiversity and ecosystem services (Based on Duru et al., 2015 and , Erisman et al., 2016)

The added value of combining both frameworks is to acknowledge that by adopting biodiversity-friendly farming practices, farmers create value for the environment and society, beyond the mere fact of conserving biodiversity. Moreover, we can discern which particular biodiversity is being favored/conserved (i.e particular species, functional biodiversity, or landscape elements). This opens avenues for business models wherein beneficiaries can reward farmers for the value created. For instance, payments for agri-environmental measures, ecosystem services or premiums via certification serve as tangible examples. The absence of such compensation might tip the balance where the costs for the farmers may outweigh the benefits derived from implementing biodiversity-friendly practices (this is further discussed below, in the section economic levers).

But what are these biodiversity friendly practices that farmers can adopt? How do they affect the profitability of the farm? What kind of ecosystem services could they provide? What opportunities are there for business models to compensate farmers adopting these practices?

We mapped the biodiversity-friendly practices specific for dairy farmers in Alblasserwaard - Vijfheerenlanden through literature study, interviews with farmers and validation with experts. The total number of individual practices identified was more than 70. In this report, we cluster findings into 23 practices across 4 themes.

3 Biodiversity friendly farming practices

We found four overall themes of biodiversity friendly farming practices (Figure 2). Note that some of these practices are actually a domain of practices or an outcome if a number of practices would be implemented. However, for simplicity we have called all of them biodiversity friendly farming practices and give a description in Appendix 1 of what exactly we mean with these. The first theme is grassland, a major land use in the area, and consists of practices related to herb rich grassland, mowing and grazing regimes, as well as water levels. The second theme is arable land, which mostly relates to maize production, largely overlaps with aspects of the grassland theme, such as in fertilization, the use of crop protection chemicals, tillage and removing weeds. The only practice that does not overlap with grassland is crop choice. However, and considering that the study focusses on an area dominated by peat soils, options for arable land are limited. The third theme is other/non-productive, which includes practices related to landscape elements, ecological ditches, mosaic management, flowering field margins and species-specific measures. The fourth theme is livestock and includes practices related to medical treatments, the use of concentrates, stocking rates, manure management and cow breeds. In the Appendix a table with description and source of the practices is provided. In Figure 2 we display the themes, the associated practices and its effect on biodiversity.

From Figure 2 we can see that the biodiversity-friendly practices identified can have different effects on the diverse aspects of biodiversity. Hence, while some practices can have tailored effects on particular species, such as through "wildlife-friendly mowing" or at landscape components only, other practices may have benefits for all aspects of biodiversity at once, such as through "extensive herb-rich grasslands". It is through the icons placed at the outermost part of the circle (Figure 2), that we indicate the main effect of the practice on the pillar of biodiversity as defined by Erisman et al. (2016). It is not always straight forward which practices affect which pillars of biodiversity. For example, the effect of reducing stocking rates does not clearly relate to any of the pillars of biodiversity. Moreover, the effect of using concentrates is ambiguous. By using more concentrates, farmers can choose to produce less feed on their own land, thus making it easier to have less productive grasslands such as extensive herb rich grassland. However, the locations where concentrates are produced may suffer biodiversity loss as a consequence of the production of the concentrates. For a proper enhancement of biodiversity in the area, a combination of multiple practices may be needed (Cozim-Melges et al., 2024). These practices would need to be agreed upon considering the aims and ambitions of the region and the land managers (Westerink et al., 2024).

Some of the practices in Figure 2 are directional, for example reducing stocking rates and increasing water levels. These practices come with a clear indication of what needs to happen for a positive effect of biodiversity to occur. For other practices, such as mowing regimes, crop choice or manure management a range of more detailed practices exist. As such, a more detailed description of each practice is given (Table 1, Appendix). Moreover, between some of the practices there is overlap, e.g. practices of manure management may be part of the management of extensive or productive herb rich grassland. However, we have separated these, as manure management relates more to livestock and extensive or productive herb rich grassland fit in the category grassland.

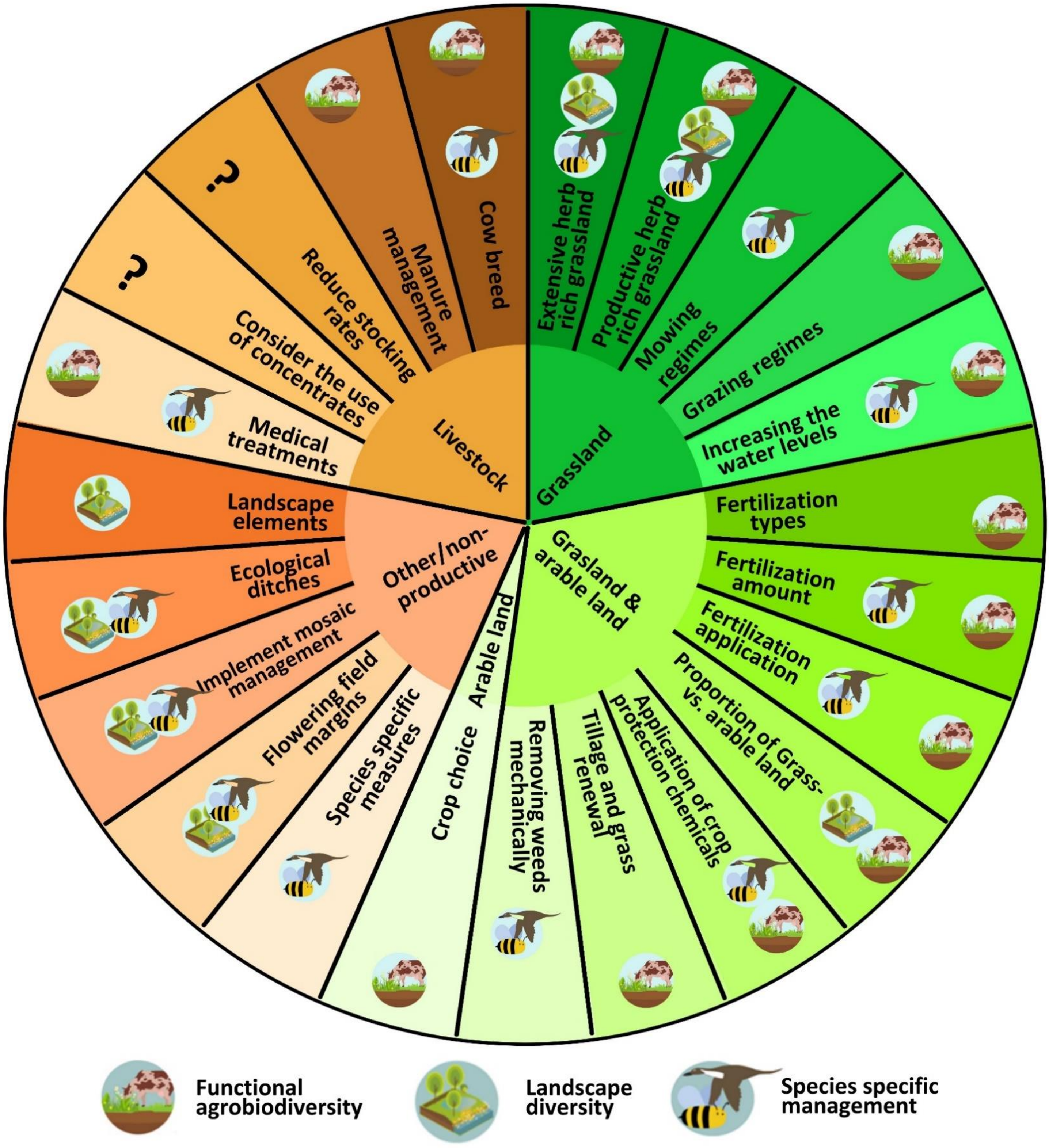


Figure 2: Biodiversity friendly practices for the Alblasserwaard - Vijfheerenlanden

4 The potential for business models

The question then is, how can farmers be enabled to adopt biodiversity-friendly practices? The value derived from adopting these practices is often positive in environmental and social benefits but tends to be negative in economic aspects, especially on the short term (Nel et al., 2021). Specifically the investment costs and short term profits may outweigh long term benefits (Nel et al., 2021). As such, adopting these practices may not be attractive for farmers in first instances. In addition, uncertainty regarding the impact of these practices on farm performance, along with policy uncertainty around farming and biodiversity may hinder their adoption (Duru et al., 2015, Voorberg et al., 2023).

Kleijn et al. (2020) suggest linking conservation efforts to business models to reduce economic barriers for landowners and potentially serve as an incentive. The Dutch delta plan also identifies biodiversity-based business models as a success factor that would make it attractive for land owners to contribute to biodiversity restoration (Deltaplan, 2018). Investing in biodiversity based business models can be enticing for companies due to their perceived long-term viability, improved stakeholder relations and lower regulatory risk (Kleijn et al., 2020). Moreover, when studying the ecological management of ditches in the Alblasserwaard, Voorberg et al. (2023) found that factors related to business models influence farmers' adoption of ecological practices. They highlight that the cooperation between farms, market parties and value chain parties have a high potential for the development of sustainable reward systems for farmers wanting to adopt more ecological practices.

4.1 What are business models?

Considering the numerous diverging definitions of business models (Zott et al., 2011), we define a business model as an architecture used to demonstrate the value created by a business in terms of the products and services the business delivers to its customers (Teece, 2010). The business model describes an organizations' mobilization of resources and activities to deliver these products or services. Magretta (2002) defines a business model as a narrative explaining how an enterprise functions, addressing questions like who is the customer, what does the customer value and how does the business generate revenue? In the context of farming, the resources the farm mobilizes can be land, labor and investments. The resources or activities the farm delivers really depend on the type of farm, and can range from only one activity (e.g. milk production) to running a multifunctional farm (e.g. running a shop or short commercialization chain, or offer recreational facilities such as a campsite).

In Figure 3, we depict the potential for business models to support the adoption of biodiversity friendly practices. The figure represents the adoption of farming practices at its center, which will have an effect on the costs and yield of the farm (and thus its revenues), as well as on the environment. The combination of farming practices will determine how the farm operates and the farms business model. For instance, some farms may aim for high yield and reach consumers in the undifferentiated market. These farms are usually associated to economies of scale, with low economic margins per unit of product (in this case kilograms of milk), but large volumes produced. Other farms, in turn, may opt for reducing costs on farm and sacrifice on yields, implement practices regarded as positive by consumers and the wider society (e.g. prioritizing biodiversity-friendly approaches or animal welfare) and aim for differentiated niche markets with higher price for unit of product (added value). These farms are usually associated with economies of scope, in which other economic stream sources enable the profitability of business models. These economic streams can relate to the differentiated milk production (e.g. extended grazing, higher welfare standards or environmentally friendly); to different products produced and/or processed on farm (capturing additional added value); to diversification of the business, such as engaging in a farm-shop, agrotourism or knowledge transfer; or accessing dedicated payments and subsidies.

We depict the access to dedicated payments and subsidies through the light green dashed line around "environmental services" in Figure 3. All farms get economic streams from customers, public institutions (through subsidies) and private institutions, such as banks and other lenders (through loans and credits). These are depicted by the solid dark green arrows. However, some farms create additional environmental services which are currently not properly valued and remunerated in the markets (environmental services). These services relate to, for instance, enhancing biodiversity, ensuring carbon storage in soils and water purification processes, or contributing to creating attractive landscapes. The dashed light green arrows in Figure 3 represent the additional economic streams that farms generating environmental services could receive.

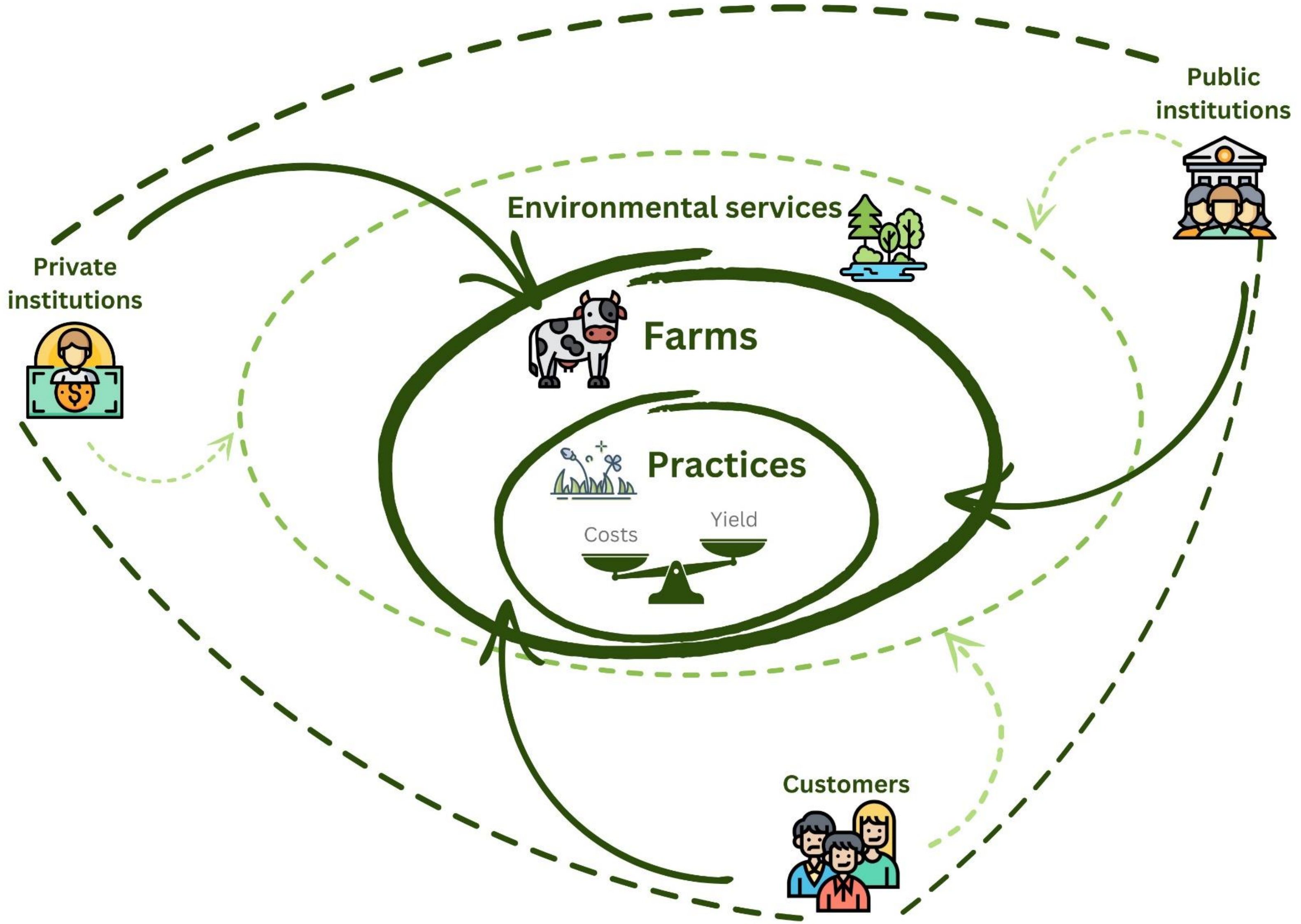


Figure 3. The potential for business models to support the adoption of biodiversity friendly practices.

4.2 Farms and practices

At the center of Figure 3 is the farm with its practices that results in certain costs and yields. Some farms may focus on increasing production, whereas others may focus on reducing costs. Here we discuss how these farming practices relate to the costs and yields of the farm.

4.2.1 Increasing production

Practices aiming to increasing yield (e.g. fertilization, crop protection or mechanization), also lead to increasing production costs. At first, when increasing production, one may benefit from economies of scale and as a consequence increase the profit margins. These fit in the farming style we earlier described as intensive (efficiency-based). At a certain point, however, the increased production cost may no longer offset the benefits of economies to scale. At this point, increasing production would reduce the profit margins (or require a new investment to e.g. enlarge or modernize the business). Such an intensive (efficiency-based) farming style is often accompanied by the idea to deploy high inputs to achieve high outputs. This strategy, however, might exert high pressure on natural resources, resulting in negative externalities and negative effects on biodiversity.

4.2.2 Reducing costs

Practices aiming to increasing yield (e.g. fertilization, crop protection or mechanization), also lead to increasing production costs. At first, when increasing production, one may benefit from economies of scale and as a consequence increase the profit margins. These fit in the farming style we earlier described as intensive (efficiency-based). At a certain point, however, the increased production cost may no longer offset the benefits of economies to scale. At this point, increasing production would reduce the profit margins (or require a new investment to e.g. enlarge or modernize the business). Such an intensive (efficiency-based) farming style is often accompanied by the idea to deploy high inputs to achieve high outputs. This strategy, however, might exert high pressure on natural resources, resulting in negative externalities and negative effects on biodiversity.

4.3 Environmental services

The adoption of one or several biodiversity friendly practices may generate value for society, many times referred to as environmental services and/or ecosystem services. In other words, the ecosystem services provided when adopting biodiversity friendly practices may generate more human well-being. The additional benefits and human well-being generated by certain farming systems, however, is usually not considered, quantified, nor remunerated (Millennium Ecosystem Assessment, 2005, Rodríguez-Ortega et al., 2014). Aspects related to environmental services and additional well-being are elusive to current market structures (environmental services) and remain under remunerated. Hence, ultimately eroding the supply of those services, while still demanded by society. The existence of such 'environmental services' usually require the intervention of government (through subsidies) to ensure the continued supply of services, and maintenance of farming practices and systems that underpin the services. The framework, depicted in Figure 3, shows the potential money streams from costumers and private and public institutions to incentivize the provision of environmental services and stimulate alternative and/or innovative business models.

4.4 Public institutions, private institutions and consumers

Consumers and public/private institutions may be willing to pay farmers for the created value and environmental services, and thus compensate the farmer for the potential incurred costs (e.g. in terms of reduced yield or increased labor) of implementing biodiversity-friendly practices along with the additional benefits generated to society. For example, the maintenance of the beautiful grasslands and flowering strips besides canals and ditches, the grasslands with a diversity of species, the aesthetic value of rows of willow trees, the conservation of natural areas full of windmills, and the cultural value of the cows grazing outside. Consumers may be willing to pay a premium for milk produced by farmers implementing a variety of biodiversity-friendly practices. Public institutions may want to dedicate funding to maintain and coordinate those initiatives to generate wider outcomes at landscape level. Concomitantly, private institutions may offer support (e.g. access to credit with particular conditions) based on the understanding of the "alternative" business model. Meanwhile, these alternative business models could be developed, while private and public institutions help mitigating the potential associated risks regarding business operations, transition costs or knowledge gaps.

There are growing calls to develop innovative schemes to financially support businesses that generate environmental services, such as payment for ecosystem services, green bonds, biodiversity offsets and credits, benefit-sharing mechanisms, along with environmental and social safeguards (COP 15, 2022).

We believe that regional approaches and landscape governance have huge potential to design incentives that satisfy both producers and beneficiaries of environmental services. Hence, the Alblasserwaard - Vijfheerenlanden, with its rich history in agri-environmental management and a very active agri-environmental collective (Westerink et al., 2024), has a unique opportunity to bring together producers of environmental services and the beneficiaries. Together they can explore which scheme to develop, as well as how costumers and public and private institutions should support.

5 References

Benton, T. G., Bieg, C., Harwatt, H., Pudasaini, R., Wellesley, L. (2021). Food system impacts Benton, T. G., Bieg, C., Harwatt, H., Pudasaini, R., Wellesley, L. (2021). Food system impacts on biodiversity loss. *Three levers for food system transformation in support of nature. Chatham House, London*: 02-03.

CBS (2022). Toename bebouwd gebied ten koste van landbouw.

COP 15 (2022). Nations adopt four goals, 23 targets for 2030 in landmark un biodiversity agreement. In C. o. B. Diversity (ed). Montreal, Canada.

Cozim-Melges, F., Ripoll-Bosch, R., Veen, G. F., Oggiano, P., Bianchi, F. J. J. A., van der Putten, W. H., van Zanten, H. H. E. (2024). Farming practices to enhance biodiversity across biomes: A systematic review. *npj Biodiversity* 3: 1.

Deltaplan (2018). Deltaplan biodiversiteitsherstel: In actie voor een rijker nederland.

Dudley, N. and Alexander, S. (2017). Agriculture and biodiversity: A review. *Biodiversity* 18: 45-49.

Duru, M., Therond, O., Martin, G., Martin-Clouaire, R., Magne, M.-A., Justes, E., Journet, E.-P., Aubertot, J.-N., Savary, S., Bergez, J.-E., Sarthou, J. P. (2015). How to implement biodiversity-based agriculture to enhance ecosystem services: A review. *Agronomy for Sustainable Development* 35: 1259-1281.

Erisman, J. W., Eekeren, N. v., de Wit, J., Koopmans, C., Cuijpers, W., Oerlemans, N., Koks, B. J. (2016). Agriculture and biodiversity: A better balance benefits both. *AIMS Agriculture and Food* 1: 157-174.

Erisman, J. W., van Eekeren, N., van Doorn, A., Geertsema, W., Polman, N. (2017). Measures for nature-based agriculture, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.

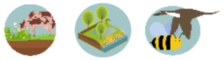
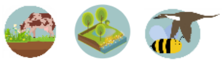
Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K. (2005). Global consequences of land use. *science* 309: 570-574.

Kleijn, D., Biesmeijer, K. J. C., Klaassen, R. H. G., Oerlemans, N., Raemakers, I., Scheper, J., Vet, L. E. M. (2020). Integrating biodiversity conservation in wider landscape management: Necessity, implementation and evaluation. In D. A. Bohan and A. J. Vanbergen (eds), *Advances in ecological research*. Academic Press, 127-159.

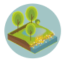
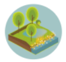
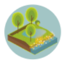
Leclère, D., Obersteiner, M., Barrett, M., Butchart, S. H. M., Chaudhary, A., De Palma, A., DeClerck, F. A. J., Di Marco, M., Doelman, J. C., Dürauer, M., Freeman, R., Harfoot, M., Hasegawa, T., Hellweg, S., Hilbers, J. P., Hill, S. L. L., Humpenöder, F., Jennings, N., Krisztin, T., Mace, G. M., Ohashi, H., Popp, A., Purvis, A., Schipper, A. M., Tabeau, A., Valin, H., van Meijl, H., van Zeist, W.-J., Visconti, P., Alkemade, R., Almond, R., Bunting, G., Burgess, N. D., Cornell, S. E., Di Fulvio, F., Ferrier, S., Fritz, S., Fujimori, S., Grooten, M., Harwood, T., Havlík, P., Herrero, M., Hoskins, A. J., Jung, M., Kram, T., Lotze-Campen, H., Matsui, T., Meyer, C., Nel, D., Newbold, T., Schmidt-

Traub, G., Stehfest, E., Strassburg, B. B. N., van Vuuren, D. P., Ware, C., Watson, J. E. M., Wu, W., Young, L. (2020). Bending the curve of terrestrial biodiversity needs an integrated strategy. *Nature* 585: 551-556.
LTO (2019). Landbouwvisie alblasserwaard-vijfheerenlanden 2030.
Mace, G. M., Norris, K., Fitter, A. H. (2012). Biodiversity and ecosystem services: A multilayered relationship. *Trends in Ecology & Evolution* 27: 19-26.
Magretta, J. (2002). Why business models matter. Harvard Business School Boston, MA, USA.
Millennium Ecosystem Assessment (2005). *Ecosystems and human well-being*. Island Press, Washington, DC.
Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C., Gerber, P. (2017). Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. *Global Food Security* 14: 1-8.
Nel, J., Elbersen, B., Bolt, J., Cormont, A. (2021). Guidelines report: Managing healthy and resilient ecosystems in the bioeconomy, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.
Ripoll-Bosch, R. and Schoenmaker, D. (2021). Impact of finance on biodiversity: How agricultural business models get financed and promoted, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.
Rodríguez-Ortega, T., Oteros-Rozas, E., Ripoll-Bosch, R., Tichit, M., Martín-López, B., Bernués, A. (2014). Applying the ecosystem services framework to pasture-based livestock farming systems in europe. *Animal* 8: 1361-1372.
Román-Vázquez, J., Moreno-García, M., Repullo-Ruibérriz de Torres, M. A., Veroz-González O., Agüera-de Pablo Blanco, B., Kassam, A., Basch G., González-Sánchez, E. J. (2023). Conservation agriculture: Moving towards the preservation and improvement of biodiversity in agricultural ecosystems, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.
Stokstad, E. (2019). Nitrogen crisis threatens dutch environment—and economy. *science* 366: 1180-1181.
Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning* 43: 172-194.
UN, I. (1992). Convention on biological diversity. *Treaty Collection*.
van Boxmeer, E., Modernel, P., Viets, T. (2021). Environmental and economic performance of dutch dairy farms on peat soil. *Agricultural Systems* 193: 103243.
Voorberg, W., Spekkink, W., Westerduin, H., Korf, W. (2023). Participatory system mapping in de alblasserwaard, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.
Westerink, J., Hassink, J., Plomp, M., van Os, J. (2024). Towards more biodiverse agricultural landscapes: How to make species-rich grassland a desirable and feasible option for dairy farmers. *Journal of Rural Studies* 105: 103195.
Zott, C., Amit, R., Massa, L. (2011). The business model: Recent developments and future research. *Journal of Management* 37: 1019-1042.

6 Appendix 1

Practice	Arable	Grassland	From which source	Elements (Erisman)	Description
Extensive (permanent) herb rich grassland			Literature, interviews		Several practices can be combined to create permanent extensive herb rich grassland. For example, reducing the fertilizer application and use of other agro-chemicals.
Productive herb rich grassland			Literature, interviews		Several practices can be combined to create productive herb rich grassland. In most cases, it requires sowing of herbs and legumes. However, in peatland this type of grassland is more difficult to maintain as the herbs and legumes often disappear after a few years.
Mowing regimes			Literature, interviews		Examples include: - Delayed mowing requires leaving the meadow uncut from 1 April to at least 1 June. - Phased mowing leaves an uncut grass refuge on a fraction of the meadow. - Mowing from the middle of the field towards the outside
Grazing regimes			Literature, interviews		Examples include: - Increase the length of the time spent grazing - An earlier the start date on which the animals are allowed outside access - A lower stocking rate during grazing.

Increasing the water levels			Literature, interviews	Increasing water levels helps reduce peat oxidation and reduces CO_2 emissions.
Fertilization types			Interviews	Examples include: Artificial fertilizer, solid manure, slurry, slurry with water
Fertilization amount			Literature	Crops and grassland receive an adjusted and balanced amount of nutrients to prevent leeching and runoff.
Fertilization application			Interviews	Examples include: - Slurry in soil - Slurry with dragline
Proportion of grassland vs arable land				The proportion of grassland vs arable land.
Reduced application of crop protection agro chemicals			Literature	Examples include: - Reduce or avoid pesticides: Replacing pesticides with alternative pest control such as landscape diversity - Reduce or avoid herbicides use: Apply alternative methods to reduce weeds on the grasslands.
Low or no tillage/renewal			Literature	Examples include: - Tillage: With conservation tillage, organic matter is preserved, and crop residues are retained in the top soil. - Renewal: Percentage of the grassland on site and the age of the grassland as functional indicators of water, soil and nutrient circularity.
Removing weeds mechanically				Instead of using agro-chemicals, weeds are removed mechanically.

Crop choice		Literature		Green manure: Cover crops that are planted to be incorporated into the soil while still green Protein rich crops: Protein in feed is largely sourced from grass and concentrate crops such as soya. Crop management: Increasing field heterogeneity by shifting from monocultures to polycultures via inter/strip/mosaic cropping. Diversification: Increasing crop diversity involves diversifying main cultivation crops to contribute to biodiversity.
	Other	**Livestock**		
Species specific measures		Literature, interviews		Examples include: - “Plasdras” (wet areas) - Nesting boxes
Flowering field margins			 	Examples include: - Establish perennial margins with grass and wildflower mixes - Use nectar flower mixes
Implement mosaic management		Interviews	 	Spatial differentiation of land types including differentiation of grassland management use and intensity.
Ecological ditches			 	Ecologically managed ditches are an example of landscape elements and are closely related to flowering field margins, as field margins in Alblasserwaard – Vijfheerenlanden are often ditches. Ecologically managed ditches form a habitat for flora and fauna and can form ecological connection zones.

Other landscape elements	Literature, interviews		Examples include: - Extracting land from agriculture for 'heavy nature' - Ecological corridors: Connected features that allow traffic of organisms through the landscape, such as rivers, streams and natural strips of vegetation. - Wet landscape/inundating land: Raising the groundwater table to 20 cm below field level.
Medical treatments	Interviews		Treatments for parasites or the use of antibiotics
Considering the use of concentrates	Interviews	-	Could include increasing the protein production on own land or importing feed and to supplement lower grass production from herb rich grasslands. It's delicate practice at which many trade-offs are at work.
Reduce stocking rates	Literature, interviews	-	Number of cows per hectare, extensification.
Manure management	Literature, interviews		High quality, fresh manure produced on site. Preferably enriched with straw and the fibers in the vicious fraction of slurry.
Breed of cows	Literature, interviews		Switching to Blaarkopppen, Maas-Rijn-Ijsselvee or Jersey cows, breeds that are more adapted to wet conditions.