Shaping a knowledge and innovation agenda for a responsible Dutch dairy transition to sustainability

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1. Introduction

Climate change and biodiversity loss are the most pressing sustainability issues worldwide. In the Netherlands and other European regions, dairy farming plays an important role in both issues. Approximately 60% of Dutch agricultural land is used by dairy farms, representing 28% of the entire country (roughly 1.2 million ha). Around 1.6 million dairy cows are present in the Netherlands in 2021 (Agrimatie, 2022), with an average milk yield of 9255 kg/animal in 2020 (FAOSTAT, 2022). This is high compared with the European Union (EU) average of 7500 kg/animal. One reason for this high production is the importation of nutrients, usually from abroad, to Dutch farms (Jukema, 2021), despite this high nutrient import and livestock density resulting in a manure surplus in the Netherlands (Oenema et al., 2019).

Making dairy farming more land-based and nature-inclusive and less dependent on external nutrients is part of the current circular agriculture policy vision of the Dutch government (LNV, 2019). The policy intends to reduce the manure surplus by either reducing the number of cows per ha or establishing partnerships between dairy farms and nearby arable farms that can use the manure (Schouten, 2021). The media reports that the Minister of Agriculture intends to meet agreements with the agricultural sector on a maximum of 2.1 cows per ha and manure disposal from farmer to farmer within a radius of 20 kilometres (Stokkermans, 2023). This is quite an ambitious plan, as it is estimated that roughly 40% of Dutch dairy farmers do not meet the target of 2.1 cows per ha and/or don't have such partnerships with nearby arable farmers (Hoes et al., 2022). Numerous contextual factors make it difficult for farmers to become land-based, such as the high prices and restricted availability of land; however, social and cultural factors also influence this decision. For example, what does it mean for dairy farmers and chain partners to be 'good' farmers? Do individual farmers want an extensive nature-inclusive farm or would they prefer a more intensive farm? How is this influenced by their social, economic and geographic environments? As a response to these issues, the Netherlands Agricultural and Horticultural Association warned that many dairy farmers will face difficulties if land-based dairy farming becomes mandatory (LTO, 2020).

To realise land-based dairy farming, it is important that dairy farmers are able to responsibly change their way of farming. Chain partners and other actors surrounding each farmer play an important role in achieving a responsible transition (Vermunt et al., 2022). This thinking triggered the present modest study, in which we organised two backcasting workshops with actors active in the entire dairy value chain. We invited them to talk about two proposed optimistic future visions of land-based dairy farming: (1) an extensive and nature-inclusive vision and (2) a more intensive dairy farming vision that includes collaborating with arable farmers. During the workshop, we invited participants to identify the facilitators and barriers to realising one of the two future visions, and we harvested the knowledge and innovation questions that participants had about the realisation of the future visions.

2. Theory

Drastic and enduring changes, such as those in the food system in the Netherlands, are often referred to as 'transitions'. This term refers both to the process and the result of fundamental and irreversible system changes for a more sustainable future. Transitions take a long time and involve replacing and adapting multiple technologies, behaviours, business models, infrastructure, regulations and standards (Köhler et al., 2019; Geels and Schot, 2007), making them a major task, particularly due to the path dependencies in the food system. Choices from the past narrow the possibilities of key players in the food system. The complexity, uncertainty and many dependencies mean that the steering possibilities in transitions are modest, and that it requires quite some effort to influence the direction and speed of transitions (van der Minne et al., 2021).

In the Netherlands, initiatives to transition towards a more sustainable food system are often undertaken by the government or by food-processing industries, who ask other groups (most often farmers) to make changes. However, scholars in transition studies state that it is impossible for one group of actors to change on their own (Sartas et al., 2020). Farmers, for example, cannot change towards new, sustainable food systems on their own, or, as stated by Siebrecht (2020; p. 20):

'To reach real progress in the implementation of sustainable agriculture in practice, all stakeholders probably have to co-operate, and joint efforts and activities are necessary. Undoubtedly, this is an ambitious project that requires patience, and detailed ideas and proposals are mandatory.'

The conviction that change has to be supported socially is also underlined by research into behavioural change, which is influenced by many factors, only a few of which originate in individual intrinsic motivations and personal moral convictions. Most drivers point towards the relationships of individual actors with other actors, indicating social preferences and social arrangements such as reciprocity and the impact of peer groups (Edwards-Jones, 2006; Chater et al., 2010; Herzfeld and Jongeneel, 2012; Pollitt and Shaorshadze, 2013; Garforth, 2015). Additionally, the economic consequences of choices, specifically economic dependencies on other actors in the market, play a role in farmers' decision making. In the reflections of farmers, for example, market considerations play an important role in their willingness to change. Farmers sometimes feel stuck in a system of supply and demand, or in prior arrangements between market actors, which push them to produce for a rock-bottom price (Vrolijk et al., 2020). This suggests that farmers cannot move towards new sustainable food systems on their own if they want their business to survive. To move successfully towards a more sustainable way to produce and consume food, it is therefore important to look beyond intrinsic motivation or the moral conviction of individuals and adopt a more social perspective to changing behaviours (Siebrecht et al., 2020).

This social approach to transitions is also supported by the two most well-known theoretical frameworks in transition studies, the Multi-Level Perspective (MLP) (Geels, 2002) and the Technological Innovation System (TIS) approach (Köhler et al., 2019). A similarity between these frameworks is that both focus on the innovations that form part of transitions and draw attention to the existing social structures that hamper the innovation from becoming the 'new' mainstream. Both argue that innovation is key to change, and that the current status quo has change-resistant dynamics, including vested economic interests, established routines, dependencies and social and institutional infrastructures. By contrast, the two frameworks provide different analyses of how innovation is initiated and its chance of success.

The MLP is a very broad framework, which distinguishes between the three levels in society at which changes can occur: the niche (micro) level, regime (meso) level and landscape (macro) level. These three levels do not exist separately in reality; as Geels says (2002, p. 1259), they "(..) are not ontological descriptions of reality, but analytical and heuristic concepts to understand the complex dynamics of socio-technical change". The current state of affairs is referred to as the 'regime' level, describing the ways in which so-called 'established' actors act and interact, which is rooted in history and is usually supported by institutional structures. Innovation that leads to sustainability in the system is thought to take place at the niche level. Long-term trends are

referred to as 'the landscape'; demographic shifts, but also the dynamics of the market economy or of globalisation, are examples of landscape dynamics. According to the MLP, transitions take place in dynamic processes within, and interactions and influences between, the three levels. A MLP makes distinctions between these levels to facilitate analyses of where transitions are fostered, or rather where they encounter obstacles. Questions typically asked include, for example, are innovations at the niche level fully developed if landscape pressure occurs? Is there a competitive or symbiotic relationship between the novelty developed at the niche level and the conventional players at the regime level? These variables influence the way in which transitions unfold (Geels and Schot, 2007).

The TIS analyses and explores the support structures around innovations, which are needed for them to mature. A framework of the following seven system functions are used to analyse innovations: F1, entrepreneurial activities; F2, knowledge development; F3, knowledge diffusion/knowledge exchange through networks; F4, guidance of the search (showing the direction in which the innovation process has to go); F5, market formation; F6, resource mobilisation; and F7, support from advocacy coalitions (Hekkert, et al., 2007). Innovations have a chance to mature when these various 'system functions' are in place; for example, a lack of knowledge diffusion (F3) means people will not know why or how they should use the sustainable innovations, which will hinder the transition process. Alternatively, when there is no market for sustainable innovations, or when the market formation around a new product is hindered by legislation, it becomes hard to achieve transitions.

Both MLP and TIS often share the starting point that the present status quo is resistant to change. Established actors, at the regime level, are motivated to maintain current (socially and technology enabled) practices, institutions and infrastructures, and may seriously hinder sustainability transformations because of their economic interests, established routines, dependencies on others, and because the rules and existing technical and digital infrastructures support their way of acting (Fresco et al., 2021; Geels, 2011). For established actors, change come with risks and uncertainty, as they often unsettle the stability of the relationships and infrastructure in which these actors usually function (Hoes et al., 2021).

Due to these change-resistant regime dynamics, most transition endeavours seek another entry point to induce change. Many authors argue that change should be expected from the niche level, where innovations are developed. The focus on niches is considered more promising and motivating as it sets aside the change-resistant established actors and develops innovations that propose an alternative to the status quo. An example of the niche-focussed approach is Strategic Niche Management, which notes that a protected space is needed in which alternatives can be developed without having to compete directly with the status quo (Rip and Kemp, 1998; Geels and Raven, 2006; Schot and Geels, 2008). Another approach is the Small Wins framework, which focusses on initiatives taken by people who are very passionate about realising a radical new idea and introducing it into the market and/or society (Termeer and Metze, 2019). When the alternatives are mature enough, established actors can be pressed to adopt them by the government or by the changing demands of customers (Bosman et al., 2014), or structural change will come about through a trickle-down effect (Smith and Raven, 2012).

Although the regime level is less often considered as an entry point in bringing about change, more attention is being paid to regime-level dynamics. This is important for phasing out the non-sustainable technologies, materials and practices currently embedded in our systems (Loorbach et al., 2017). Kivimaa et al. (2019) stated that, while transition processes often focus on niches, they cannot be successful without a supportive regime. Grin (2020) also covered these suggestions in his more overarching recommendations for transitioning processes from the heart of the regime. He suggests that, to intervene in established practices, it is important to choose methods that enhance reflexivity and that empower users and organisations to 'act otherwise'. Material problems and other barriers that are encountered when an alternative orientation is followed should be studied. Furthermore, the institutional contexts in which pilot practices take place should be

adapted to support the experiments, but also to make room to foster reflexivity and discuss the barriers to more structural change.

Building on Grin, this modest study focusses on established actors who operate primarily at the regime level, as they hold the power to maintain and change the status quo. We argue that established actors are not in principle opponents of change. After all, established actors who do not change are vulnerable; they can become outdated or socially and environmentally unacceptable. We can assume that they do not simply resist change, but are looking for a way to transition while simultaneously ensuring their business remains viable, a reliable employer and a provider of products or services for their clients (Hoes et al., 2021). In other words, established actors are seeking responsible ways to transition without taking steps that are too risky or harmful. These observations led to the research question of this modest study: which knowledge and innovation questions need to be addressed to assist established actors in sustainability transitions?

3. Method

3.1 Two workshops

To develop a knowledge and innovation agenda for a responsible Dutch dairy transition, we organised two workshops with stakeholders active in the Dutch dairy regime. Our goals were to (1) gain further understanding into the barriers to change towards the two possible futures, described in Boxes 1 and 2, and (2) start to develop a research agenda indicating how socio-economic research can support farms in making the transition. The workshops were held in April 2022 and lasted 120 minutes each. As a result of the Covid-19 restrictions, they were held online using Microsoft Teams.

For the workshops, we applied an approach that has elements of backcasting methodology. Backcasting involves developing a desirable future vision used to contemplate which changes are needed in the present to move closer to this desirable future (Vergragt and Quist, 2011). Backcasting is more often applied in sustainability transition studies to assist stakeholders in envisioning more ambitious sustainable alternatives. This is more difficult to achieve with traditional planning approaches, as these start their reasoning from the present status quo (Quist et al., 2011).

We developed two future visions for Dutch land-based dairy farming based on policy documents and sector goals: the nature-inclusive dairy farming (NI) future vision and the arable and livestock rotation (AD) future vision (see Boxes 1 and 2). Earlier versions of these visions were reviewed by dairy sector experts to check whether they were ambitious enough on the one hand, but also connected with current ways of working on the other hand, which should trigger conversation about which changes are needed in the current dairy sector.

We involved several actors involved in dairy farming (see Table 1) in the two workshops, which we organised as group interviews. In one workshop, the emphasis was on the NI vision, while the other workshop focussed on the AD vision. As one important participant could not attend in the NI workshop, we conducted an individual interview with him separately. Following a theory of change methodology, which is used to realise change in organisations, we started with the long-term sustainability goals and the presentation of the two future visions (see Boxes 1 and 2). Based on these future visions, we applied backcasting and identified preconditions for realising these futures (Brest 2010). To semi-structure the conversation, we used a list of questions, but we also remained open to all themes that respondents brought forward, allowing them to steer the conversation in directions that they saw fit for the topic. We started by asking the participants in both workshops what they thought about the two future visions, as they had received both future visions to read. After that, we zoomed in on one of the future visions and asked whether they recognised it and had anything to add or change. We then discussed to what extent their organisations undertake activities that can contribute to the realisation of this vision. Subsequently, most of the conversation was about the obstacles that stand in the way of realising the vision. The last part of the conversation was about what they needed to remove the obstacles and how

research could contribute to this. The future visions and questions led to two lively conversations, which we transcribed and analysed. As most of the conversation concerned obstacles to realising the visions, this is also the focus of the presented results in the next section.

Box 1

Future vision 1: Nature-inclusive dairy farming (NI)

Nutrient cycle in balance on the farm: extensive dairy farmers in nature-inclusive areas

Nature-inclusive land-based dairy farms focus on strengthening natural resources and minimising dependencies on external inputs. The dairy farmers do not have more cows than their land can handle. In addition to their ordinary agricultural land, they manage landscape and natural soils consisting of herb-rich grasslands with reed-collared pools for amphibians and small birds, and flower and tree strips to further promote biodiversity. The grasslands are mowed later in the summer to provide space for meadow birds. The dairy farmers often keep a more robust breed of cows that remain healthy under the various Dutch (weather) conditions and can cope with a somewhat leaner ration, so that additional feeding of concentrate is kept to a minimum and fewer medicines are needed. Most dairy farmers also grow the grains for the concentrates themselves, and if that is not possible, they only use concentrate from crops produced in the region. For crop cultivation, processing techniques are used in such a way that the soil is minimally disturbed. The milk production per cow is lower than that of the high-yielding cows of intensive dairy farms located in arable areas. As long as the weather conditions and the water level allow it, the cows can access outside day and night. Depending on the water levels/ droughts on the grassland, the herd is moved around, which is possible because the nature-inclusive land-based dairy farms manage large contiguous areas. They provide ecosystem services by having high water levels and water storage. Many nature-inclusive dairy farmers also have a mobile milking robot that is often in the meadow, so that the herd itself determines the rhythm of the milking moment and the order. Thanks to the milking robot, the dairy farmer has his hands free for the other activities on the farm, such as the production and sale of dairy products including butter, ice cream and cheese, or receiving nature lovers who have booked a farm meeting or outing. In this way, the farmer stacks sources of income; in addition to the sale of milk to the factory, they have green-blue ecosystem services management contracts with water boards and nature organisations and the sale of unique farm products and experiences. Often there are also volunteers to be found on the farm. Nature-inclusive dairy farmers also receive a higher price for their milk because consumers are willing to pay more for milk from cows that eat herb-rich grass, receive minimal medicines and are kept in a system in which (almost) no fertiliser substitutes (from animal manure) and crop protection products are used. In addition, the monthly costs are lower because less is purchased and the veterinarian intervenes less.

Box 2

Future vision 2: Arable and dairy rotation (AD)

Nutrient cycle in balance in the region: more intensive dairy farmers with larger herds in arable areas

Dairy farmers based in arable areas co-operate closely with nearby arable farmers to improve soil health and functional biodiversity and to regionally close the nutrient cycle. The dairy farmers have invested in modern stables, in which manure and urine are separated and emissions are captured. The cows stay inside more often in the well-ventilated stables, which have spacious cubicles and several milking robots, and they automatically receive a ration of concentrate and roughage that is precisely tailored to the individual animal so that they can produce the maximum amount of milk. The high milk production per cow and the larger herd make the investment in technology feasible, while maintaining a good income and contributing to reducing greenhouse gas emissions per litre of milk. These farms often use digital technology to maintain precise insight into the welfare of the cows, their cycle, how much a cow eats and the amount of milk it produces. This also allows wise decisions to be made for the breeding programme: cows that eat little and produce a lot of milk are the most environmentally friendly

cows to breed with. Emissions in the barn are also well recorded, making interventions easy. New digital approaches can also link dairy farmers and arable farmers to each other, enabling the transfer of manure to the arable farmers who need it and removing the need to obtain manure from other regions or the use artificial fertiliser. The dairy farmers and arable farmers use precision agriculture to maximise the efficacy and efficiency of the use of fertiliser substitutes (from animal manure) and crop protection products. Drones monitor the soil and crops, and robots help in the exact application of nutrients, water and crop protection products, as well as the mechanical control of weeds and insect pests. The regional building plans also include grassland plots, which serve as a resting crop for a longer period of time and provide space for meadow birds. The environmental pressure is lower than around 2020 and the landscape is more varied. This is due to the flower and tree strips and catch crops on the arable farms, and strip cultivation for some arable farmers too. These farm elements have become popular because sustainability monitor systems reward it with extra points. The sustainability performance of dairy farmers and arable farmers is accurately tracked and rewarded via digital key performance indicators and management systems. On the international market, Dutch milk still receives a premium price due to its high quality and the high degree of transparency. The other farm products are also used, both in food processing and other sectors, such as biobased construction and textiles. In addition, the agricultural entrepreneurs earn from energy production because of, among other things, wind turbines that they have strategically located.

Table 1. Overview of participants in the workshops

Workshop 1: Nature-inclusive dairy farming (NI)	
Type of actor	Number of participants
Dairy farmer	2
Advisor	1
Dairy processor	1
Follow-up interview workshop 1	
Estate manager	
Workshop 2: Arable and livestock rotation (AL)	
Type of actor	Number of participants
Arable farmer	1
Dairy farmer and representative Netherlands Agricultural and Horticultural Association (LTO)	1
Dairy processor	1
Farm input supplier	1

4. Results

Participants in our workshops reflected on the future visions and discussed what transitioning to realise these futures would mean for them. In both workshops, three themes played a particularly important role in their reflections: (a) concerns about collaboration with new and existing partners, (b) regulation and institutional arrangements that hinder the ability to realise the future visions and (c) worries about the revenue model that the future visions would bring about. In the following sections, we will consider each aspect for both future visions.

4.1 Nature-inclusive dairy farming (NI) workshop

a. Collaboration

The NI future vision involves relatively low numbers of cows per ha. Due to the high land prices and low availability of land in the Netherlands, the NI vision implies a close collaboration with landowners, such as nature organisations and estate managers or owners. The collaboration with these parties

was brought forward as an important obstacle by workshop participants. A difference in nature goals between dairy farmers and the landowners/nature management organisations made co-operation difficult; for example, the independent advisor who was present at the NI workshop explained that the dairy sector is making explicit what nature-inclusive dairy farming means for the dairy sector. He referred to the biodiversity monitor for dairy farmers[1] that includes key performance indicators, such as the proportion of herb-rich grassland, meadow bird management and the creation and maintenance of landscape elements, such as marshland, trees and hedgerows in bocage landscapes. In conversations he had with nature managers, he got the impression that they have higher ('*dark green*') nature ambitions, such as creating habitats for specific threatened species, which are unlikely to fit well with dairy farming practices. The independent advisor questioned whether the assumptions of nature-inclusive farming supporters, that farmers can contribute to achieving nature goals, is acknowledged and embraced by other stakeholders, such as nature management organisations.

One of the dairy farmers present at the NI workshop also explained that it is difficult to agree long-term land leasing contracts with nature management organisations, despite this being important for the long-term management and continuation of dairy farms. He explained that he and other dairy farmers in his area were each searching for more land to achieve lower numbers of cows per ha. An opportunity arose when a nearby nature management organisation decided to lease 250 ha of land; however, it was all leased to one partner instead of being divided into multiple smaller plots for nearby dairy farmers with nature-inclusive/extensification ambitions. The follow-up interview with the deputy estate manager gave an explanation for this: it is easier for nature organisations to negotiate and do business with one renter instead of multiple renters. For the dairy farmer present at the NI workshop (and probably his colleagues from the same area too), this meant that he had to lease land further away from his farm to achieve his ambitions.

In addition, the dairy farmer present at the NI workshop had concerns about the restrictions that some nature managers enforce; for example, the farmer explained that if the first cut of grass is harvested in August, that apparently some nature managers demand, its nutritional value is too low. He was concerned that nature managers stick to their own goals without taking into account the potential consequences for farming. The other participating dairy farmer worried more generally about the nutritional value of grass in nature areas where cows could graze.

b. Regulation and institutional arrangements

The complexity of legislation to achieve nature-inclusive farming was mentioned by the advisor workshop participant. According to him, this does not account only for rules set by the government but also for rules set by the dairy industry. For example, the NI vision includes the possibility for farmers to produce and sell dairy products themselves, such as butter, ice cream or cheese. It was explained by one of the dairy farmers and the employee of a dairy-processing co-operative that dairy farmers need to come to an agreement with their milk-processing company to be allowed to deviate from their delivery obligation. Dairy farmers are obliged to deliver all the produced milk to the dairy-processing company (except the milk that is consumed by the household), and the processing companies are obliged to buy and collect all the milk produced by the dairy farmer. This supplier–buyer agreement ensures both parties have important long-term certainties for their businesses. Dairy farmers who want to process and sell part of their milk and also want to deliver milk to the processing companies can sometimes (under conditions) receive an exception from the processing companies. There are different conditions for this for each dairy processing company.

In addition, the interviewed deputy estate manager mentioned the hygiene and tracking-and-tracing regulations that hamper on-farm dairy processing and sales. Both dairy farmers present at the NI workshop had successfully overcome these barriers and had experience with home dairy

[1] In 2019, DairyNL, WWF (World Wildlife Fund) and Rabobank started the Foundation Biodiversity Monitor and they are working on a certification scheme of biodiversity on dairy farms (BoerenNatuur, 2021).

processing and sales, although one of the dairy farmers explained that their farm stopped these practices due to the amount of work and low revenue it entailed.

In general, the dairy farmers mentioned that it is unclear who could support them in transforming their businesses towards an extensive nature-inclusive farm. Who should be contacted to discuss new farm plans that differ from the standard growth narrative? Support for this change is limited; for example, a participating dairy farmer explained the lack of guarantees that his dairy-processing company would give beforehand if farmers intend to change to organic farming. The moment the dairy farmer meets the criteria to deliver organic milk, his dairy-processing company will check whether the market for organic milk is large enough to change the delivery contract to organic milk. One of the dairy farmers present at the workshop explained that he had invested in 30 ha of land to be able to produce organic dairy without any guarantee from the dairy factory that he could sell it as organic milk.

c. Income

Concerns about the revenue model were discussed several times during the NI workshop and the interview with the deputy estate manager. The NI future vision states: "The milk production per cow is lower than that of the high-yielding cows of intensive dairy farmers located in arable areas. (…) Nature-inclusive dairy farmers also receive a higher price for their milk because consumers are willing to pay more for milk from cows that eat herb-rich grass, receive minimal medicines and are kept in a system in which (almost) no fertiliser substitutes and crop protection products are used". The NI workshop participants mentioned several reasons why it was not as easy for dairy-processing companies to sell nature-inclusive milk or other dairy products with added value. According to the representative of a dairy-processing co-operation present at the workshop, the idea of producing and branding milk from a specific dairy farm is not cost efficient and extremely difficult to achieve in the current dairy value chain. This is due to the high costs and efforts to collect, store, process and sell separate milk flows. Moreover, milk is an export product in the Netherlands, with 70–80% of the dairy products produced by Dutch farmers being sold abroad. The dairy-processing co-operation representative was also critical of the idea that international clients were willing to pay a premium price for milk that supports Dutch biodiversity. He also explained that there is a difference between consumer demands and the willingness to pay for those demands (such as nature-inclusive milk). It was argued that dairy-processing companies have to be able to find clients that are willing to pay for the nature-inclusive dairy products to be able to give better milk prices for nature-inclusive dairy farms. The dairy farmers also questioned whether enough consumers were willing to buy their nature-inclusive products. The representative of the dairy-processing co-operation concluded that research was needed to determine the international demand for nature-inclusive milk.

The idea of making and selling dairy products on the farm, using at least part of the milk produced, was also discussed as a possibility to increase profits and compensate the costs for regenerative or nature-inclusive farming. However, this takes a lot of time and effort, which negatively affects the revenue model (besides the struggles with the dairy company outlined in the previous section). Local buyers can be difficult to attract, which was highlighted by the participating dairy farmer that used to make and sell farm dairy products but stopped due to the high amount of work and low earnings. The other participating dairy farmer explained that there has been a lot of talk about the idea of being financially compensated for CO_2 storage for over 20 years, but no progress has yet been made.

Another way to increase profitability is to reduce costs; for example, landowners could lease their land for lower prices to nature-inclusive farmers both parties could reach an agreement on the strict application of nature-friendly farming approaches. However, the workshop participants were dubious about whether (most) landowners would give this discount on leases due to their revenue model. They also believed that, even for those landowners who were interested, negotiations about such contracts would entail a long process.

4.2 Arable and dairy rotation (AD) workshop

a. Collaboration

The AD vision in which arable and dairy farmers co-operate requires a closer relationship between these parties to facilitate the exchange of manure, land and animal feed, as well as the potential for shared labour, machines and knowledge. Such a close collaboration between farms would create dependencies that could also create tensions; for example, the arable farmer that participated in the AD workshop explained that differences in goals between arable and dairy farmers could result in difficult discussions. He explained that the dairy farmer with whom he co-operates has an interest in harvesting as much grass as possible and for as long as possible; however, for the arable farmer, this hampers tillage practices and he prefers that grassland is not harvested after July. The arable farmer notes that emotions can easily escalate in discussions in which you intervene in each other's core farming practices and expertise.

Issues regarding the fair distribution of costs, risks and benefits between arable and livestock farming were also mentioned during the AD workshop; for example, the arable farmer present at the workshop wants straw-rich manure, but this manure is not allowed to be stored on land. To be able to deliver straw-rich manure, the dairy farmer with whom the arable farmer co-operates had to invest in a silo that costs €60,000.

The arable farmer that participated in the AD workshop aims for a regenerative farm, and collaboration with dairy farmers helps in achieving this. The workshop participant from the farmers' association (LTO), who also has a dairy farm, explained that collaborations between dairy and arable farmers that are primarily driven by economic rather than regenerative benefits, and can have negative environmental consequences. He explains that intensive dairy farmers have to remove manure surplus, which costs money. In such situations, some dairy farmers make agreements with arable farmers for them to use the manure surplus in exchange for grass swards. In these situations, the arable farmer ploughs (tears) the grassland after the grass have been harvested to cultivate crops that give a good price, such as potatoes. Environmental experts warn that ploughing grassland can have negative effects due to the higher risks of nitrogen leakage into ground and surface water, as well as a loss of carbon storage in the soil. On the other hand, if the grass in arable areas is used as a cover crop and is only mowed, it might have environmental and economic benefits. The way in which arable and dairy farmers co-operate and exchange manure and land therefore determines whether improvements in soil and nature quality will be achieved.

b. Restrictive legislation and institutions

According to some of the participants of the AD workshop, certain rules hamper co-operation between arable and dairy farmers. We already mentioned the strict rules for straw-rich manure storage that make the exchange of manure more costly for dairy farmers. The arable farmer present at the workshop also mentioned the so-called 'farming by calendar' rules, meaning that farmers are not allowed to bring manure onto their farms in autumn and winter, are not allowed to mow or plough grassland before a certain date, and so on. These rules are in place to lower the risk of nitrogen leakage from ploughed grassland into the ground and surface water.

The farmers' association (LTO) representative present at the AD workshop stated that future legislation might hamper further co-operation between arable and dairy farmers. According to him, the government was working on regulations to promote more permanent grassland on dairy farms; however, this would mean a smaller part of the dairy farmer's land is available for the arable farmer to grow other crops instead of grass.

The participants of the workshop mentioned that they missed agricultural policy leadership from the Ministry of Agriculture. The representative of the dairy-processing co-operative noted that governmental departments were working alongside each other, but that not enough was being done to stimulate change and adapt hampering regulations. In addition, the representative of the farm input supplier noted the obstacle that farm advisers probably talk negatively about co-

operation between arable and livestock farmers, which lowers the confidence, and therefore motivation, for farmers to explore collaboration opportunities.

c. Income

In the AD workshop, participants noted that market demands play an important role in motivating farmers to produce more sustainably. The dairy-processing company participant responded that there are market opportunities for more sustainable milk, such as climate neutral and regenerative dairy, but that the added value will only be there as long as there is a shortage of these types of sustainable milk. The ambition that all Dutch dairy farms become more sustainable would make it harder to command a premium price for 'sustainable milk' from clients. However, the participant from the dairy-processing industry expected that the market demands in northwest Europe for climate-neutral, regenerative and even nature-inclusive dairy products will offer some opportunities within the next five years, although to be able to sell these specific premium dairy products in the international market, strict definitions and standards would be needed with a solid scientific basis. These standards can be used to check whether the supplying dairy farmers practise the specific sustainability claims.

Using markets and market-based instruments to achieve a more sustainable Dutch dairy sector was also discussed in the AD workshop. The arable farmer present at the workshop noted that steering farmers through market demands is very effective. He said: "The market is tough (…) and mercilessly punishes entrepreneurs [who fail to meet market demands]; (..) this has a cleansing effect.".

5. Discussion

In this modest study, in which we wanted to contribute to a responsible transition of Dutch dairy to more sustainable practices, we held two workshops with actors active in the Dutch dairy regime. Here, we discuss two future visions of land-based dairy farming to (1) gain further understanding into what hampers the transition in the dairy sector, and (2) to make a start on the development of a research agenda. The future visions and semi-structured questions led to two lively conversations, in which multiple barriers that hamper the transition of the dairy sector were discussed. Very few technical, farming or ecological issues were mentioned; rather, most were socio-economic, governance and legislative challenges.

Participants of both workshops explained that these future visions implied the establishment of new socio-economic dependencies with either nature landowners or arable farmers. In addition, these new relationships could change the dependencies between dairy farmers and current chain partners, such as farm input suppliers and dairy processors (for example, if dairy processors must allow farmers to use part of their milk for producing and selling their own home-made dairy products). This implies that these organisations have to think strategically and reflect upon their potential role in a future in which the Netherlands has a land-based dairy farming system. Exploring this topic in detail went beyond the scope of this modest study, but we do recommend these chain partners should develop and work towards these new prospects.

It was too ambitious to collectively formulate a research agenda during the two 120-minute online workshops. As a research team, we were able to formulate questions based on the conversations that took place during the workshops to make a start with shaping a research agenda (see Table 2). Both future visions generated similar types of research questions.

We found that, in the Dutch dairy sector, established actors who operate primarily at the regime level reacted positively to our invitation to join the workshop and constructively and openly discussed the future visions of a land-based dairy system. This gave us a deeper understanding of the change-resistant aspects that need to be further explored to support a transition towards a Dutch land-based dairy system.

Table 2. Formulated questions after analysing conversations during the workshops

a. Collaboration 1. To what degree do the goals and practices of dairy farming and landowners or arable farming overlap? How should the different goals and practices be weighed fairly? 2. Which risks are involved in nature-inclusive farming with regard to animal health and biodiversity? 3. Which risks are involved in partnerships between dairy and arable farmers with regard to soil, water quality and income? 4. What investments are required to realise both visions and how should the involved costs and risks be distributed fairly among the stakeholders?
b. Restrictive legislation and institutions 1. Which regulations and agreements counteract the farming practices envisioned in the two visions? What can be done to change this? 2. Which regulations and agreements are contradictory because they create unforeseen negative trade-offs on certain sustainability issues, such as biodiversity and water quality? 3. What policy instruments can be developed to support the Dutch dairy transition? 4. Which capabilities in research, policy and business are currently insufficient to facilitate the dairy sustainability transition?
c. Income 1. Do the presented visions align to consumer demands? a. What is the market potential for home-made dairy products from farms? b. What is the (international) market potential for dairy products from nature-inclusive and co-operating dairy and arable farms? 2. Which added value or ecosystem services do nature-inclusive dairy farms or co-operating dairy and arable farms provide, and how can this be rewarded? 3. What market-based instruments can be developed that support the Dutch dairy transition?

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