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Five mechanisms blocking the transition towards 'nature-inclusive' agriculture: A systemic analysis of Dutch dairy farming

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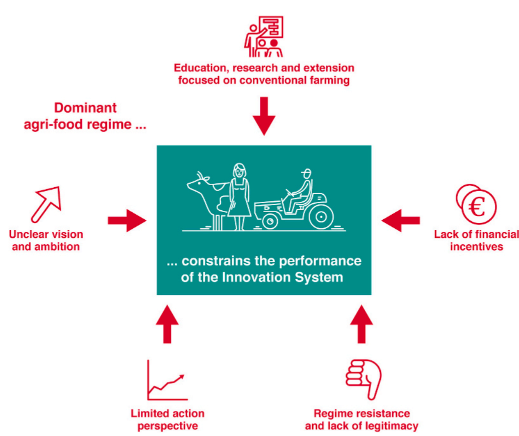
HIGHLIGHTS

- Uptake of nature-inclusive practices in the Dutch dairy sector is currently low.
- Through Innovation Systems Analysis we identified five blocking mechanisms hindering uptake.
- These include lack of financial incentives and shared visions, limited action perspectives and knowledge transfer problems
- The productivist agriculture paradigm is a recurring blocking mechanism requiring institutional change
- Change needs to come from incumbents, requiring policies aimed at regime transformation

GRAPHICAL ABSTRACT



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ABSTRACT

CONTEXT: As elsewhere in Western Europe, large scale intensive agriculture dominates the landscape of the Netherlands. Grassland for dairy production occupies more than a quarter of its land surface. The high production intensity on conventionally farmed grassland leads to poor habitat quality, resulting in sharp declines in bird and insect numbers. Nature-inclusive agriculture (NIA) comprises innovations in farm management, technology and resource use that have the potential to address farmland biodiversity decline, but few Dutch farmers implement these.
OBJECTIVE: We aim to analyze the adoption of NIA practices in the Dutch dairy sector. Specifically, we study the influence of the dominant agri-food regime on the innovation system for NIA.
METHODS: Innovation Systems Analysis was performed to identify the various structural barriers which hinder adoption. Our study used a multi-method design in which data on NIA in the Dutch dairy sector was collected via a literature study, four workshops and a focus group discussion.
RESULTS AND CONCLUSIONS: We identified five key blocking mechanisms that hinder adoption of nature-inclusive agriculture in the Dutch dairy sector: (1) insufficient economic incentives for farmers, (2) limited

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action perspective of many dairy farmers in the Netherlands, (3) lack of a concrete and shared vision for NIA, (4) lack of NIA-specific and integral knowledge and (5) regime resistance, which moreover is connected to each of the previous blocking mechanisms. Our analysis shows that one of the empirical novelties of this paper is that these blocking mechanisms are strongly interlinked in the Dutch dairy sector, thereby perpetuating a situation of lock-in. We conclude that in order to accelerate adoption of nature-inclusive farming practices, problems need to be addressed in conjunction with one another, and therefore holistic approaches are key. A second important conclusion is that in order to foster growth of the innovation system around NIA, the focus should not only be on innovation, but also on transforming current regimes, in particular the currently dominant economic paradigms of growth and yield maximization.

SIGNIFICANCE: By unraveling strongly interlinked blocking mechanisms, this paper provides intervention points to accelerate the transition towards NIA in the Netherlands. These intervention points are not only located within the innovation system, but should preferable be sought for in the broader structures and institutions of the dominant agri-food regime.

1. Introduction

There have been numerous and high-level calls to transform dominant industrial agricultural production systems into sustainable ones that deliver food production within ecological limits (FAO, 2018; Springmann et al., 2018; IPBES, 2019; European Commission, 2020a). As the FAO notes, "It is unlikely that high-input, resource-intensive farming systems – which have been blamed for deforestation, depletion of land and water resources, loss of biodiversity and high levels of GHG emissions – will deliver sustainable agricultural production." (FAO, 2018, 33). Agroecology, a farming practice that "seeks to boost the resilience and the ecological, socio-economic and cultural sustainability of farming systems" (Oberč and Schnell, 2020 p. 10), has been promoted as a promising and innovative alternative to dominant agricultural systems. However, its uptake is limited. Organic agriculture, for instance, which is a farming practice that shares some characteristics with agroecology (see Oberč and Schnell, 2020), only covers 1.5% of agricultural land worldwide and 7.5% in the European Union (IFOAM, 2020; European Commission, 2020c).

The Netherlands is a prime example where highly intensive agriculture dominates the landscape; with grassland for dairy production covering more than a quarter of its land surface (Centraal Bureau voor de Statistiek, 2019). The country has more than four times the average European livestock density and is the EU's fourth-largest milk producer by volume (European Commission, 2020b). However, this production intensity comes at a high cost for biodiversity. Mean Species Abundance and the Living Planet Index (both measures of biodiversity intactness) have decreased from around 40% in 1900 to 15% in 2010, and from 1 in 1990 to 0.8 in 2018 respectively (Planbureau voor de Leefomgeving, 2014; Wereld Natuur Fonds, 2020). In addition, the dairy sector is responsible for 25% of the country's nitrogen deposition (Sikkema, 2019). This has detrimental effects on biodiversity, and the legislative response led to social unrest and economic uncertainty in recent years (de Heer et al., 2017; K. van Laarhoven, 2020).

In response to these problems, farmers, scholars and policymakers in the Netherlands have fairly recently developed the concept of nature-inclusive agriculture (NIA). It was introduced as a policy term in a vision document for Dutch nature by the Ministry of Economic Affairs (Ministerie van Economische Zaken, 2014). Its three underlying and interconnected principles are to "employ ecosystem services rather than external inputs; minimize environmental pressures and contribute maximally to 'non- functional' biodiversity and landscape quality" (Runhaar, 2021, 228). To that end, practicing NIA implies conserving, improving and exploiting the services of water and soil; closing nutrient cycles and minimizing harmful emissions to water, soil and air; and constructing and conserving landscape elements (Erisman et al., 2017).

Despite this concept being specifically used in the Netherlands, there is some overlap with other sustainable agriculture approaches (see Fig. 1, which illustrates the three dimensions of nature-inclusive agriculture (1A) and the conceptual similarities and overlap between NIA and other sustainable agriculture approaches (1B)). This is further explored in Section 2. All approaches, implicitly or explicitly, assume that agriculture should be profitable for the farmer. The intensity of dairy farming and spatial competition between agriculture and other types of land use in the Netherlands make such an approach particularly timely, but also challenging. Currently, less than 10% of Dutch dairy farmers are considered nature-inclusive (Bouma et al., 2019b; also see Section 4). A much larger group of farmers would like to become more nature-inclusive, however, or feels s/he is required to do so (Trouw, 2018). This requires better insight into the typical barriers hampering the adoption of nature-inclusive agriculture in the Dutch dairy sector, to understand how a sustainability transition in this sector could be

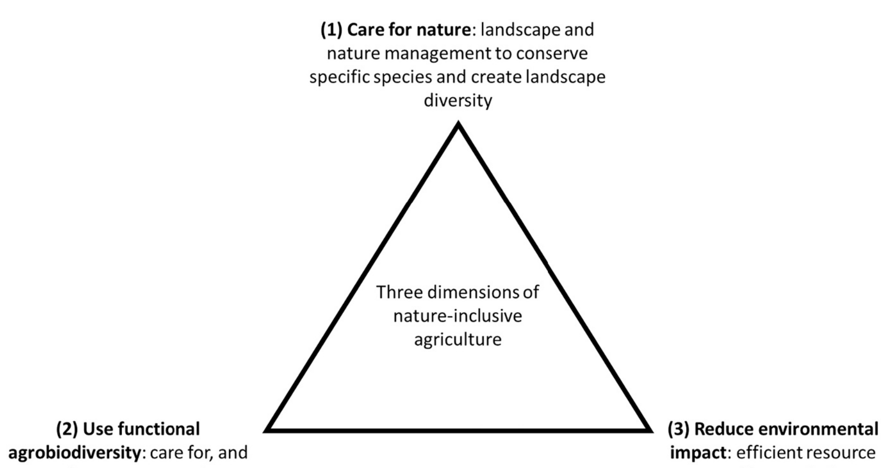

Fig. 1A. Figure 1A Three dimensions of nature-inclusive agriculture. Adapted from van Doorn et al., 2016, 12.

supported. In addition, in order to understand systemic change, linkages between problems (e.g. problem chains) need to be understood. This in turn enables identification of more specific interventions. Earlier studies have already highlighted various barriers to adoption of sustainable farming practices (e.g. in the context of organic agriculture, low-external input farming or agro-ecology, see Hermans et al., 2010; Vanloqueren and Baret, 2009; Levidow et al., 2013). While these studies provide vital insights into typical adoption problems, interlinkages between key types of barriers are understudied. We therefore aim to explore which barriers prevent a further uptake of NIA by a larger proportion of farmers in the Dutch dairy sector, and investigate how these barriers are connected.

To this purpose, we draw from the sustainability transitions literature, which focuses on processes of change of large complex systems towards a more sustainable state (Köhler et al., 2017). The Innovation Systems Analysis (ISA) is a widely applied framework, which has been used to study the "weaknesses in innovation networks, institutional failures and infrastructure failures that explain the limited dissemination and adoption of niche innovations as well as how these mechanisms are affected by interactions among actors" (El Bilali, 2020, 22:1712). Whereas this framework has originally been applied to technological innovation in energy and utilities sectors (Dewald and Truffer, 2011; Negro et al., 2008; Foxon et al., 2010), it has also been applied to innovation in the agricultural sector (see for instance Spielman et al. (2008), Klerkx et al. (2010), Lamprinopoulou et al. (2014), Garb and Friedlander (2014), Kruger (2017). Other examples are studies on irrigation practices in Jordan (Sixt et al., 2018), the fresh produce sector in the UK (Menary et al., 2019), and the agroecological transition of Nicaragua (Schiller et al., 2020). Therefore, this framework is well-suited to studying the diffusion of NIA practices in the Dutch dairy sector. In this paper, we consider NIA as a niche innovation because it is a way of farming that has not been widely adopted and the meaning of which has not crystallized yet (van Doorn et al., 2016; Runhaar, 2017).

The contribution of this paper is twofold. First, it aims to gain insights into key barriers hindering adoption of nature-inclusive practices in the Dutch dairy sector. By unraveling interlinkages between these barriers, this paper identifies intervention points to accelerate the transition towards NIA in the Netherlands. This provides handholds for policymakers. Second, this paper aims to make a specific contribution to the (agricultural) innovation systems literature (e.g. Hekkert et al., 2007; Klerkx et al., 2012) by further development of the conceptual framework. Most Innovation Systems Analyses have a primary focus on the internal processes and a secondary focus on the external factors that influence innovation system functioning. In this paper we aim to unpack niche-regime interactions through an explicit focus on how regime factors influence the functioning of the NIA innovation system.

This leads to the following research questions:

1. *Which aspects of the innovation system currently hamper a large scale uptake of nature-inclusive agriculture (NIA) in the Netherlands?*
2. *What is the role of the current dairy regime in preventing the transition towards this form of agriculture?"*

2. Background: NIA in the Netherlands

As mentioned in the introduction, NIA is defined as "the pursuit of a positive, reciprocal relationship between farm management and natural capital" (van Doorn et al., 2016, 5). Nature-inclusive dairy farming practices include (Erisman et al., 2017):

- Manure management (such as applying solid manure instead of slurry) to improve soil structure and soil health;
- Local feed production to eliminate overseas impact of feed production (primarily deforestation for soy production);
- Primarily grass-based feeding due to higher soil organic content of grassland relative to arable (feed crop) land;
- Diversification of the sward and more permanent grassland for improved above- and below-ground biodiversity as well as soil carbon storage;
- Grazing to improve botanical composition and biodiversity of meadows, close nitrogen cycles and reduce ammonia emissions;
- Use of lightweight machinery to reduce soil compaction;
- Phased mowing to reduce direct impacts on ground-breeding birds and to improve survival chances of chicks;
- Creating landscape elements such as marshland systems, dykes, ditch banks, living fences and tree alleys to provide habitat for species;
- Extensification of the farm, i.e. reducing the number of livestock units per hectare of grassland.

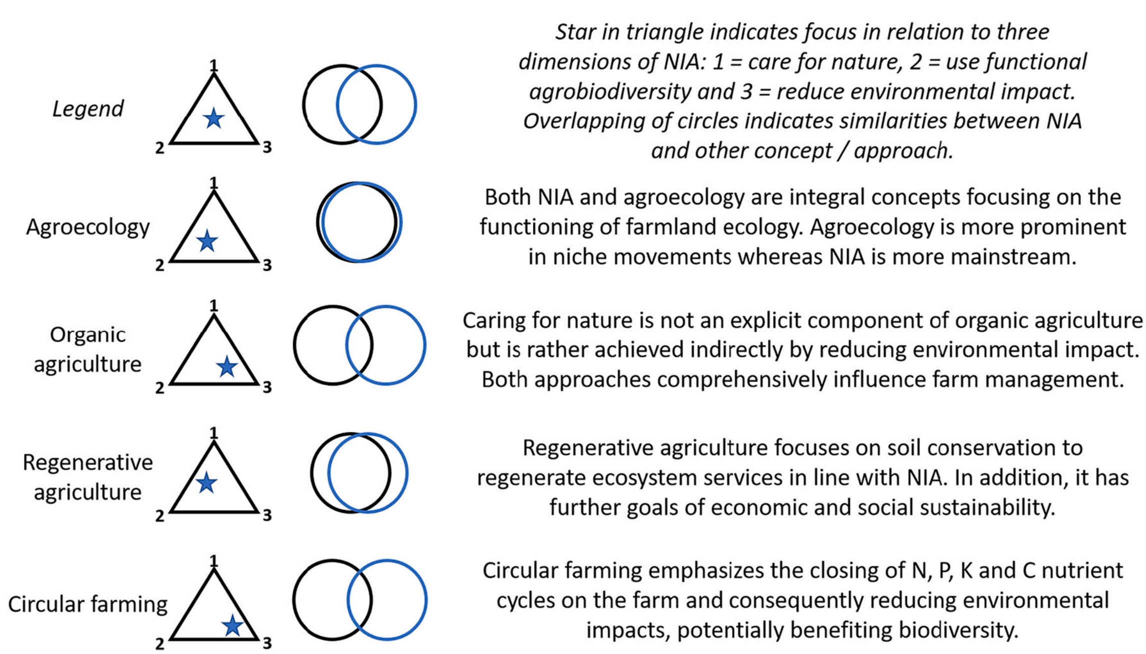

Fig. 1B. Figure 1B Similarities and differences between NIA and other sustainable agriculture approaches. Adapted from van Doorn et al., 2016, 25–30; definition of regenerative agriculture taken from Schreefel et al., 2020.

These measures can be applied in different intensities and combinations, leading to a range of possible sustainability and productivity outcomes (Erisman et al., 2016). These practices above can be classified into three main dimensions in Fig. 1A: (1) care for nature, (2) use functional agrobiodiversity and (3) reduce environmental impact (van Doorn et al., 2016). Van Doorn et al. (2016) further compares these three dimensions of NIA (see Fig. 1A), to the focus of other sustainable agriculture approaches (see Fig. 1B). For instance, some other approaches overlap on the dimensions of using functional agrobiodiversity and caring for nature (regenerative agriculture), whereas other concepts overlap more on reduced environmental impact (organic agriculture and circular farming). While the latter concepts indirectly target biodiversity by reducing environmental impacts, NIA and agroecology also directly target biodiversity and integrate nature in farm management. As the concept of NIA has emerged recently in Dutch policy-making, further comparisons between NIA and other concepts have not been undertaken yet.

In 2019, grassland for dairy production covered 907,000 ha or 27% of Dutch land (Centraal Bureau voor de Statistiek, 2019). This land was used by 16,256 dairy farms who together held 1.6 million dairy cows; this translates to an average farm size of 55.8 ha and 98 cows. There is a clear trend of farm upscaling, as average farm size has almost doubled from 30.7 ha and 51 cows in 2000 (Van der Meulen, 2020).

There are no clear statistics on the exact number of farmers applying NIA. Based on a survey among farmers and expert judgement, Bouma et al. (2019a, 2019b) and Erisman and Verhoeven (2019) estimated that less than 10% of Dutch farms can be considered fully nature-inclusive.[2] The picture that emerges is that of a small proportion of "frontrunners" who practice NIA, with the vast majority of "conventional" farmers not practicing NIA in a substantial way. However, a larger group of farmers is willing to become more nature-inclusive, or feels s/he is required to do so. Tellingly for this study, in a 2018 newspaper survey involving 2287 Dutch farmers, approximately 50% of respondents agreed with the statements "we need to switch to nature-inclusive agriculture, considerate of the environment and biodiversity" and "in the next ten years I will switch to a more sustainable form of agriculture" (Trouw, 2018; author's translation). This dichotomy between actual farming practice and the wishes of farmers to make a switch both individually and as a sector informs the scope and direction of this paper.

This study took place against the backdrop of an agri-environmental crisis which manifested itself, among other things, in unprecedented farmer protests and increased attention on the impact of agriculture on the environment and society (van der Ploeg, 2020; Bouma et al., 2020; Schouten, 2018). As NIA offers a possible solution to agri-environmental issues, policymakers from the Netherlands Enterprise Agency and Ministry for Agriculture, Nature and Food Quality commissioned the research which produced this paper. In addition to sharing the results of our analysis, we participated in five workshops with policy makers; made preliminary findings available to advisory commissions; and shared our recommendations with the government of the province of Gelderland.[3] These interactions highlight the societal relevance of our research, as well as the utility of the approach we followed.

3. Analytical framework

This paper takes an innovation system approach, in line with previous work published in this journal (Kruger, 2017; Lamprinopoulou et al., 2014). We consider an innovation system to extend beyond technology or knowledge transfer and its associated support systems or infrastructures (see also Klerkx et al., 2012). In this view, innovation systems are "societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation" and serving a particular societal need such as transport or food provision (M.P. Hekkert et al., 2007). Innovation systems are composed of structural elements (see Table 1).

An innovation system should be seen as a complex system with many feedback loops between its elements and complex, non-linear dynamics. How well an innovation system is performing can initially be assessed through analyzing how well innovation system functions are fulfilled, as defined in Table 2. The assessment of innovation system functioning can be done using a number of "diagnostic questions" (Wieczorek and Hekkert, 2012) or indicators (M.P. Hekkert et al., 2007), as is further elaborated in the methodology.

Poor fulfillment of innovation system *functions* can be explained by underlying *systemic problems* related to either the *structural elements* of the innovation system or to factors external to the innovation system. In case of structural elements usually a distinction is made between an element's presence or absence, as well as its quality or capacity, which both can negatively affect innovation system functioning and thereby hinder the diffusion of the innovation. Systemic problems may also be external to the innovation system. In Bergek et al. (2015) several contexts of innovation systems are proposed where these systemic problems may be found. In this paper we will show that many of these systemic problems are related to the dominant dairy regime. As such these contextual systemic problems provide insight in the regime-niche interactions that slow down niche development and uptake in the regime.

The literature makes a distinction between systemic problems and blocking mechanisms, see Kieft et al. (2017). Sometimes definitions of both terms are used interchangeably. We follow Kieft et al. (2017) and De Oliveira and Negro (2019) by defining systemic problems as isolated factors that influence innovation system functioning while blocking mechanisms are sets of systemic problems that through interaction impact innovation system functioning. Blocking mechanisms therefore indicate a more dynamic account of the factors that influence innovation system functioning than systemic problems (see for example De Oliveira and Negro, 2019; Schiller et al., 2020; Turner et al., 2016). In order to speed up the development and diffusion of innovation, systemic problems and blocking mechanisms may be targeted by governments, private sector or civil society.

While our understanding of innovation is chiefly based on a framework originally termed "*Technological* Innovation System", we note that this framework has increasingly been applied to the study of agricultural innovation (El Bilali, 2020), where the term "*Agricultural* Innovation System" is used. The core concepts contained in Tables 1 and 2 are often shared between the two approaches (Klerkx et al., 2012).

Table 1
Structural elements of an innovation system (Wieczorek and Hekkert, 2012).

Structural element	Definition
Actors	Individuals, organizations and networks engaged in the development, experimentation and diffusion of innovation. This includes companies of all sizes, government entities at different levels (national, provincial, municipal), research and education organizations, civil society and others such as banks.
Institutions	The "rules of the game". This encompasses hard institutions like laws and regulations, and soft institutions like shared social and cultural values
Interactions	Relationships between actors, both bilateral (such as between a company and its bank) and in networks (such as in an industry association).
Infrastructure	Physical (machinery, roads, ports, buildings), knowledge (data, expertise, information) and financial infrastructure (grants, subsidy schemes).

[2] This was confirmed in our focus group meeting.
[3] https://www.gelderland.nl/programmaAgrifood

Table 2
Functions of an innovation system (Hekkert et al., 2007: 421–425).

Function	Definition
1. Entrepreneurial activity	Firms using the potential of new knowledge, networks and new markets to experiment with novel technologies, introducing these innovations to the market and investing in production capacity to diffuse the innovations and take advantage of business opportunities
2.Knowledge development	The generation of new knowledge, both tacit (learning by doing) and formal (through research and development)
3. Knowledge diffusion	The exchange of information and knowledge between actors
4. Guidance of the search	Steering the directionality of the innovation process through the articulation of expectations and preferences
5. Market formation	Opening a market for the innovation, for example by means of a protected niche market, by raising consumer interest or by creating a level playing field through legal, economic and tax-based policy instruments
6. Resource mobilization	Allocating financial and human resources to functions 1 and 2 to allow for successful entrepreneurship and learning
7. Legitimacy creation	Overcoming resistance to change caused by 1) powerful incumbents with vested interests in the technology, 2) unsupportive legal conditions, 3) unawareness in society regarding the novelty, 4) deeply embedded societal norms and habits that are at odds with the novelty in question.

4. Methodology

4.1. Data collection

Data was collected from different sources and was organized around the innovation system functions as described in Table 1 (Section 2). Firstly, a review was conducted of grey and academic literature. Academic literature was searched for using Scopus and the search terms (biodynami* OR agroecolog* OR agro-ecolog* OR nature-incl* OR nature OR biodiversity) AND (farm OR agricul*) AND (dairy OR milk) AND (Netherlands OR Dutch). We limited ourselves to these terms as they cover the most prominent alternatives to conventional dairy farming that share the aim of NIA to improve ecosystem functioning. “Organic” and “circular” were not included due to the limited overlap with nature-inclusive farming and especially their less explicit focus on nature and biodiversity, see for example van Doorn et al. (2016) as well as Fig. 1B. A full review of the prominence in academic literature of different concepts, including for example “regenerative” or “high nature value” farming, is beyond the scope of this paper. A second search was performed with the search terms (farm OR agricul*) AND (dairy OR milk) AND (Netherlands OR Dutch) to put this in the context of research on conventional Dutch dairy production systems in general. Secondly, we performed a review of 271 newspaper and trade magazine articles published on the topic using the Lexis Nexis search engine using the search terms “nature-inclusive” (natuurincl*) AND “dairy sector”/“dairy” (melkveehouderij OR zuivel). This allowed us to get an understanding of the recent debates and discourse on the topic. Thirdly, additional information was gathered through four meetings with experts: two workshops with academic researchers at the authors' university in December 2019 and January 2020 to operationalize the ISA framework for the case study and generate a coding scheme and indicators for the structural-functional analysis; a meeting with government representatives, dairy sector representatives and stakeholders in January 2020 to collect these actors' perspectives on the system functions and barriers; and a focus group session with sector experts to validate initial findings and score the system functions in February 2020. During multiple workshops with a small group of people, discussions were held in which the authors actively took part, while in a single focus group discussion only authors three and eight were present to elicit responses from experts. We note that a focus group is specifically interesting compared with individual interviews since it allows for interactions between participants, which makes individual reasoning more explicit, and results in richer discussions and reflections on the subject (Säynäjoki et al., 2014; H. A. C. Runhaar et al., 2016). The focus group session was attended by 12 experts from sustainable farming initiatives, NGOs, the financial sector, government agencies, research institutes, the financial sector as well as independent advisors. The experts were chosen based on two criteria: for having a broad overview of the sector, and for collectively representing a large group of stakeholders. The focus group session allowed us to validate our findings regarding the functioning of the innovation system for nature-inclusive dairy farming and to identify barriers[4] underlying poorly performing functions. Additional information and perspectives were sought through personal communication from those dairy cooperatives, educational professionals and government actors who were unable to attend the focus group session. Literature, news articles and transcripts of meetings and personal communication were analyzed after the focus group session using a coding scheme based on the ISA framework described in Section 2. A full overview of the number of workshops for data collection and verification can be found in the appendix.

4.2. Data analysis

Data analysis followed common steps for an ISA (Wieczorek and Hekkert, 2012). Firstly, the structure of the innovation system was mapped by identifying relevant actors, institutions, networks and infrastructure (see Section 2). Secondly, system functions were assessed using diagnostic questions in line with Wieczorek and Hekkert (2012) such as “Is there sufficient market demand for nature-inclusive dairy?” or “Do existing networks sufficiently spread knowledge about NIA among conventional dairy farmers?” (c.f. Wieczorek and Hekkert, 2012). The authors' initial assessment of the state of each system function, based on desk research, was presented to the focus group to verify and enrich this assessment, by asking experts to give scores between 1 and 5, qualitatively described as follows:

1: Function forms no barrier for further adoption and diffusion of nature-inclusive practices
2: Function forms a slight barrier
3: Function forms a moderate barrier
4: Function forms a considerable barrier
5: Function forms an extreme barrier

Each function was discussed separately. Consensus was sought via a discussion in which each expert had the opportunity to express her or his opinion, and after which the group was explicitly asked whether they agreed with the proposed score. Discussions during the workshop provided insights into the reasons for poorly scoring system functions. These findings were then further enriched with results of desk research (see Section 3.1). Thirdly, part of the research team (the two first authors and the last author) determined together which structural elements posed systemic problems for the poorly performing functions. They then added further underlying reasons to explain the systemic problems. Information on these problems was gathered across data collection steps and recorded as such. Fourthly, the systemic problems were mapped visually using a whiteboard and post-it notes, creating a web of blocking mechanisms; this was informed by the assumption in the ISA framework that problems are connected (Wieczorek and Hekkert, 2012). This fourth step was simultaneously performed by authors 1 and 2 independently of each other and then compared. A small number of differences (<5) were identified and discussed, which ultimately led to a version commonly agreed upon. Lastly, problems were identified that had multiple links to

[4] For the purposes of the workshops and focus group session we simply used the term “barrier” as a commonly understandable descriptor of limitations to the innovation system, rather than introducing the terminology of systemic problems and blocking mechanisms at each meeting.

other problems, as these can be assumed to present a priority for policymakers and other actors.

5. Results

5.1. Structural-functional analysis

For each of the 7 system functions (see Table 2) we first describe the extent to which each function is already performing well (e.g. to what extent are networks, financial resources, and stimulating policies already present?), and then elaborate on factors (or barriers) that hamper the performance of each function. Here, we provide both statements from the focus group to illustrate these barriers, as well as evidence from desk research. We also provide the result of the focus group score for each function (grade on a Likert scale from 1 to 5, 1 = function forms no barrier and 5 = function forms an extreme barrier), see Table 3 for an overview. Following this assessment of system functions we explore the relationships between barriers that surfaced for each function. Here we uncover underlying issues that are shared across the innovation system and which, through their interactions, constitute blocking mechanisms.

5.1.1. Function 1: entrepreneurial activities

Regarding what is already working well, different business models for nature-inclusive agriculture are currently emerging (Polman et al., 2015). The business model of nature-inclusive farmers is often based on selling products at a price premium in the consumer market. Environmental NGO's are important actors that create legitimacy for these products by endorsing and advertising the premium brands developed by these farmers (Vermunt et al., 2020a, 2020b). Unfortunately, the market for these premium products is limited. Therefore, the first reason for this low uptake of the innovation is a lack of economic incentives for farmers. The majority of conventional Dutch dairy farmers produce for the bulk market (domestic and export) at persistently low prices. Therefore, efficiency measures, such as cost reduction and scale enlargements are the main business strategies in the sector (Maij et al., 2019). Implementing NIA, however, may imply a decrease in farming intensity, an increase in the cost of production, or both (see Section 4.1 and Erisman et al., 2017). This impacts farmers' financial bottom lines, and currently is not fully compensated for by the market (a sufficiently high price premium) or other incentives like payments for ecosystem services. This lack of economic incentives was stressed as the most important barrier by our focus group.

A second and related barrier is the limited action perspective of farmers. One participant in the focus group stated: “In recent decades many possibilities to be an entrepreneur as a farmer have been eliminated. Farmers are often trapped in a specific situation, facing many risks. And a lot of risks are passed on to the farmer.” In financial terms, this is best illustrated by the fact that a Dutch dairy farmer has an average debt of €12,700 per cow; this is four times higher than in Germany or France (de Beer et al., 2019). In operational terms, farmers are often limited in the extent to which they can implement NIA practices: switching to fully grass-based feed for example requires additional hay storage capacity that may not exist on the farm. Furthermore, current regulations are at times too strict to allow optimal implementation of NIA practices, for example regarding mowing or the application of manure as fertilizer (Maij et al., 2019; Westerink et al., 2018). Farmers are price-takers, with a small number of value chain actors “dictating prices” and leaving farmers with little power to negotiate (Berkhout et al., 2019: 52). Their high dependencies on other actors limits the freedom to shift to different practices (H. A. C. Runhaar et al., 2017; Vermunt et al., 2020b). According to a 2018 survey, 55% of Dutch farmers have experienced pressure to accept lower prices from buyers (Baltussen et al., 2018), prompting regular calls to make sales of agricultural goods below the cost of production illegal (e.g. ChristenUnie, 2016).

Despite the limited number of farmers who are currently implementing NIA practices on substantial parts of their farm, the focus group participants concluded that entrepreneurship was in itself not a major limiting factor for further adoption of NIA: “It isn't that there is not a large group of entrepreneurs, it's mainly that the entrepreneurial interest is missing: there is no economic relevance yet” (participant focus group). Providing farmers with adequate incentives and a broader action perspective would enable them to experiment with, and implement, NIA practices. Therefore, the focus group of experts considered the lack of entrepreneurial activities taken by farmers as only a slight barrier (score: 2 out of 5).

Table 3
Results of focus group scores for each function (grade on a Likert scale from 1 to 5, 1 = function forms no barrier and 5 = function forms an extreme barrier). These scores were jointly agreed upon by the 12 participants.

Functions	Score: 1–5
1. Entrepreneurial activity	2
2. Knowledge development	4
3. Knowledge diffusion	4
4. Guidance of the search	5
5. Market formation	4
6. Resource mobilization – financial	4–5
6. Resource mobilization – human	4
7. Legitimacy creation	3

5.1.2. Functions 2 and 3: knowledge development and exchange

Several knowledge structures for NIA already seem to work well. In the Netherlands, there is a growing number of on-the-ground knowledge networks for NIA. Several ‘living labs’ have been established at the provincial level, in which practical knowledge is developed, exchanged and implemented within local networks of farmers and other stakeholder organizations (Prins, 2019). Furthermore, the national government has issued several ‘Green Deals’ to cover legislative risks to support farmers who are experimenting with innovative nature-inclusive approaches that do not fit the incumbent regime (Rijksoverheid, 2019).

However, several barriers are currently hindering knowledge development and dissemination. A first barrier is the lack of integral knowledge that can be applied by farmers. Scientific knowledge on NIA for instance, is considered too focused on details and abstract understanding. This was identified in the focus group workshop as an essential characteristic for knowledge to be effective in engaging farmers outside the niche experiments, i.e. the large group of farmers that currently farm in a conventional way, but would be interested in adopting nature-inclusive practices. This can be illustrated by the following quote from a participant in the focus group: “The majority of farmers do not need detailed knowledge, instead they want handholds. We haven't organized this well at the moment”.

Second, organized monitoring and knowledge dissemination to others outside the current knowledge networks is limited, and knowledge that is documented and published was perceived as too scattered by our expert consultation. This notion is supported by Cuperus et al. (2019), who identified 117 different offline and online information sources about nature inclusive dairy farming. This is in sharp contrast to knowledge available for conventional dairy farming, which enjoys strong support from agricultural universities as well as the value chain, including institutionalized data collection, yearly updated information reports supported by the main agricultural university and online feedback and support tools (Wageningen University and Research, 2019; Tittonell, 2013). A Scopus literature search performed by the authors yielded only 44 peer reviewed scientific papers on nature-inclusive dairy farming, against 1098 papers on conventional dairy farming in 2019.

As a consequence of the predominant focus of current knowledge systems on conventional farming specific knowledge supportive of NIA is missing. This concerns in particular knowledge on creating an adaptive and holistic perspective, rather than conventional farming (Erisman et al., 2016); knowledge specific to the local context of the farm and its environment (van Dijk et al., 2020); knowledge on value creation beyond food production (Polman et al., 2015; van Dijk et al., 2020); and knowledge on alternative business models, organizing societal support, market creation and access, and the acquisition of subsidies for societal services. (Cuperus et al., 2019; van Dijk et al., 2020). To some extent this lack of knowledge is understandable, as the "market" for this knowledge (from the perspective of knowledge providers) is small compared to the type of knowledge demanded by the conventional dairy sector. Since advisory services in the Netherlands are dominated by private organizations (Knierim et al., 2017), these new forms of knowledge that could support a transition remain marginalized.

A high dependence of farmers on commercial actors (usually suppliers and other value chain parties) for knowledge acquisition and exchange was also identified as a barrier by our focus group. One participant stated: "Knowledge should not be supplied by the animal feed industry or other stakeholders with a commercial interest" and another said: "This discussion requires more focus on advice provided by commercial stakeholders. It is an enormous struggle to get rid of this knowledge, and this is blocking innovation". These findings are confirmed by recent studies (Cuperus et al., 2019; van Loosdrecht, 2019). Dependence on commercial actors reinforces innovation that matches the status quo and the interests of current regime actors, who often lack knowledge on alternative ways of farming. The focus group emphasized the need for a 'nature-inclusive agricultural information service' – similar to a previous information service run by the government until the 90s. The focus group confirmed the importance of empirical knowledge that fits farmer knowledge needs and empowering farmers again in knowledge structures: "Farmers need to be given the lead more in developing knowledge questions and in knowledge exchange. Other stakeholders should only facilitate this process."

Our focus group workshop regarded this function as highly problematic and hindering the growth of the innovation system, mainly due to the lack of integral and applicable knowledge, the current knowledge structure which is steered by commercial interests, and the fact that it is not sufficiently built up around farmers themselves and their knowledge questions (score: 4 out of 5: considerable barrier).

5.1.3. *Function 4: guidance of the search*

Different institutional levels already provide guidance on NIA. At the European level the Common Agricultural Policy's second 'pillar' includes the objective of "restoring, preserving and enhancing ecosystems dependent on agriculture and forestry" (Nègre, 2020). The EU Habitats and Birds Directives also provide context for agricultural areas (European Commission, 2018). In addition to implementation of EU policy, the Dutch government provides guidance in the form of the 2018 vision "Agriculture, nature and food: valuable and connected" (Schouten, 2018). Provincial governments and other stakeholders, like NGOs and farmer associations, also publish visions for agriculture and rural areas, containing goals for biodiversity restoration (Wojtynia et al., 2021, under review). The three Northern provinces of Drenthe, Friesland and Groningen as well as the national government have also signed the "Regional Deal Nature-Inclusive Agriculture Northern Netherlands" to promote NIA in the region (Rijksoverheid, 2019). Stakeholders from the private sector and civil society have also published visions for the Dutch agri-food system, many of which contain goals for biodiversity restoration (e.g. Commissie Grondgebondenheid, 2018; LTO, 2017; Natuur and Milieu, 2017). In addition, a large dairy cooperative, a bank and an NGO developed an instrument to value biodiversity with key performance indicators for biodiversity. This instrument, called the "biodiversity monitor", can be used by supply chain actors, or different actors, to provide direction and incentivize farmers (van Laarhoven et al., 2018). In the aforementioned visions, biodiversity is one of the most prominent issues. The term NIA is explicitly mentioned in at least four visions, including that the Ministry of Agriculture (Schouten, 2018). This indicates a broad recognition of the need to restore biodiversity in agricultural areas, including grassland used for dairy production.

However, despite these positive elements, there are still considerable barriers related to the current institutions, which were considered confusing rather than helpful in guiding farmers towards NIA. The main barriers are related to a lack of clarity, consistency and coordination. The focus group found the government's vision to be ambiguous and therefore not sufficiently clear for farmers. While the governments' vision states that NIA can be an instrument in achieving its vision of sustainable agriculture, it also endorses scale enlargement and export orientation (Schouten, 2018). Furthermore, the government's use of the term "circular agriculture" in the title of its vision and other policy strategies indicates a lack of conceptual clarity and prioritization of a different concept. The export orientation of the current regime is reflected in multiple visions (Wojtynia et al., 2021). Many Dutch farmers endorse this vision, though almost 60% of farmers feel this model is not sustainable in the long run (Trouw, 2018; van der Ploeg, 2020). Under these circumstances, stakeholders are struggling to provide an alternative vision that would help motivate farmers to transition to NIA, as illustrated by the following quote: "Farmers won't make big investments because they don't know what will be required of them in the future. How can we still offer guidance? It is not just about herb-rich grassland, it is also about sustainable management of soils, nitrogen, water and animal welfare. This is a struggle for us as well. What is the action perspective that we can offer farmers, in such a way that they feel confident enough to invest?" (participant focus group).

Second, focus group participants mentioned a lack of clear ambition levels, setting targets and requirements for more nature-inclusive dairy farming by the various actors involved in developing guidance. The focus of the vision and its implementation plan is mostly to facilitate and experiment on a voluntary basis, without aiming to make nature-inclusive practices a legal requirement. Furthermore, to date, only a voluntary target of growing 65% of feed protein on the farm itself or within a 20 km distance from the farm has been set by the main dairy farmers' association (Commissie Grondgebondenheid, 2018).

Both the ambiguity in direction and the lack of clear ambition levels are compounded by the complexity of the topic, the potential tradeoffs between different ecosystem services, and the differences between regions and landscapes (Zijlstra et al., 2019; H. A. C. Runhaar, 2020). Based on a lack of clarity and a lack of clear ambitions and targets, the focus group of experts judges this function as an extreme barrier for the further diffusion of nature-inclusive practices (5 out of 5).

5.1.4. *Function 5: market formation*

Recent efforts by the dairy industry and civil society have focused on the development of labels and certification of nature inclusive practices: the NGO Bird Association labeled various brands as "meadow bird friendly" since they complied with the requirements for meadow bird protection (creating herb-rich grassland and wetland areas). Such labels also include a price premium. Most of those brands are relatively small and collaborate with small groups of farmers who operate locally: "Weerribben Zuivel" from the North of the Netherlands for example processed 9 million kg of milk in 2019, or only 0.1% of Dutch production (Mons, 2019). Another example of a recent effort is the development of the "On the way to planet proof" label owned by FrieslandCampina, the largest dairy cooperative in the Netherlands. About 700 farmers participated in this label in 2019 and as of 2020, these farmers receive a premium of €0.02 per liter. While public information NGO Milieu Centraal rated "On the way to planet proof" a 'top label', it was rated the least nature-inclusive of a number of labels by the Bird Association

NGO.[5] The cooperative has furthermore slowed down the uptake of new farmers participating in the scheme in February 2021 due to low demand.[6]

The benefits that NIA provides, such as higher biodiversity levels, improved water quality and carbon sequestration, are not captured in current market prices or financial incentives. It is estimated that an additional €0.02–0.03 per liter of milk (i.e. 6–10% above current prices) is required to compensate the costs a "conventional farmer" makes in the shift to NIA (Beldman et al., 2019). However, a recent choice experiment showed that a price increase of 10% would only motivate 5–7% of participating conventional farmers to switch to some form of NIA (Bouma et al., 2019a). In consumer surveys conducted in 2017 and 2018, between 41.6% and 86% of respondents stated a willingness to pay such a price premium for sustainably produced milk (I&O Research, 2017; Morren et al., 2018), though this might potentially be the result of differences between stated and revealed preferences (Huang et al., 1997). In sum, although there seems to be some potential for a consumer market for NIA dairy products, at present such a market is quite small. This lack of markets for most of the benefits provided by NIA led our focus group to assess this function as facing considerable barriers.

The focus group participants pointed to the lack of willingness from supermarkets to pay price premiums. This can be explained by the intense price competition between supermarkets and the resulting focus on cost-reduction, which is considered a major barrier to the development of markets for nature-inclusive dairy (Erisman and Verhoeven, 2019).

Another barrier mentioned by the focus group is the current export of Dutch dairy products, which makes accounting for NIA in product prices more complicated: "Export makes it all very complicated. Where do you account for the extra costs of NIA: the price for the farmer, prices in the supply chain, or retail? It is really very complicated. The government should play a role here." (participant focus group). Two thirds of Dutch dairy products are exported, the majority of which to countries nearby like Germany and France (Nederlandse Zuivel Organisatie, De, 2020). While these countries have the world's second and third largest markets respectively for organic products, it is unknown whether consumers in these countries can present enough demand for Dutch-produced nature-inclusive dairy to "move the needle" in the domestic production system, especially considering that nature-inclusive dairy is not necessarily organic certified (FiBL, 2020). This barrier was difficult to corroborate: while foreign organic brands for example are available in Dutch supermarkets, the companies behind them have operations based in the Netherlands. The Danish cooperative Arla for example has Dutch dairy farmer members and operates a milk factory in the Netherlands, though it is unclear how much of the milk processed there is in fact produced or consumed in the Netherlands.[7]

A final barrier mentioned was the lack of focus on other services that farmers deliver with nature-inclusive agriculture, next to dairy or other 'common' commodities. This was illustrated by the following quote: "There are a lot of services that farmers deliver, I think we should see these as markets as well. It's just a different market, with different customers." (participant focus group). In this case dairy consumers are not the customer, but for instance municipalities, companies, water authorities or nature conservation organizations. Related to this, the participants noted that "stacking" multiple incentives or subsidies from different sources that are sometimes available (e.g. from government agencies, the supply chain or nature protection organizations) is difficult to coordinate.

Based on the problems related to a lack of willingness to pay the price premium, the export focus, and also the lack of markets for ecosystem services provided by NIA, the focus group rated this function as considerably hindering the growth of the innovation system (4 out of 5*)*.

5.1.5. *Function 6: resource mobilization – financial*

Currently, the Common Agricultural Policy (CAP) forms an important source of financial resources to farmers. Greening measures and agri-environmental schemes are supported within Pillar 2 at approximately €61.4 million, which is less than 10% of Pillar 1 (direct income support). Agri-environmental schemes are provided as subsidies to collectives of farmers. However, by 2018, only 9% of grassland was managed according to such schemes (Boonstra and Nieuwenhuizen, 2019).

Furthermore, if farmers have transitioned to NIA, there are no structural financial resources to compensate for the lower yields due to extensification or higher costs. Farmers cannot cover these lower yields or higher costs themselves. To illustrate this, in the period 2014–2018, the average income of a dairy farmer's household was only €59,600. However, 35% of dairy farmers had an income below the national 'low income' level in the same period. Financial debts are high, in particular due to the high land cost of grassland of €59,000 per hectare, the highest in the EU (Eurostat, 2018; Silvis, 2020). Structural budget shortages are common among farmers, with average long-term debts of €1.1 million and an average solvency of 73% (Van der Meulen, 2019). In addition, 88% of dairy farmers lease at least some of their land, and 11% of these farmers are for more than 30% dependent on short-term lease contracts. This means they are unsure if they can implement a long-term management plan with insecure but higher lease costs (Silvis and Voskuilen, 2018). Moreover, a shift towards NIA can involve depreciation costs due to extensification of farms, e.g. overcapacity of barns (van Veluw and de Wit, 2017).

However, a switch to NIA often implies more extensive farming systems, which in turn often results in writing off costs. An example is depreciation costs due to overcapacity of barns, as reducing herd sizes implies redundant stable capacity (van Veluw and de Wit, 2017). Our focus group mentioned a lack of financial support in such situations as an obstacle, for instance from banks. Nature-inclusive business models don't "fit the mold" of how banks evaluate business prospects, and banks consider such business models too risky (Drion, 2018). Farmers making the switch to NIA often experience a decrease in revenues while they have to continue to pay off loans for buildings or machinery that the conventional production system requires. In addition, buying or renting additional land to extensify without reducing herd size is difficult due to the high cost of land mentioned above. Also, the focus group mentioned that in order to stimulate farmers, a different focus of the government is needed in terms of financial resources: "The government focuses on the few frontrunners with subsidies. But for the group of farmers behind the frontrunners, incidental subsidies will not help" (participant focus group).

Based on the barriers mentioned by the focus group, this group of experts assessed this function of financial resource mobilization as representing a considerable to extreme barrier, hampering farmers to transit to NIA (*4–5 out of 5)*.

5.1.6. *Function 6: resource mobilization – human (education and training)*

In recent years, there have been several positive developments regarding education on NIA. Courses have been developed by nature management organizations and agricultural education institutes for current farmers. Furthermore, with a new national agreement (a "Green Deal nature-inclusive education"), several agricultural education institutes have pledged to increase their focus on nature inclusive teaching by developing new teaching material for vocational and professional training institutes.

The overall performance of this function, however, was still judged to be problematic for the transition. The focus group mentioned several barriers. A first barrier is the lack of teaching materials. Despite

[5] https://www.vogelbescherming.nl/bescherming/wat-wij-doen/onze-boerenlandvogels

[6] https://www.nieuweoogst.nl/nieuws/2021/02/10/frieslandcampina-gaat-verder-met-minder-planetproof-boeren

[7] https://www.arla.nl/arlafoods/over-ons/onze-geschiedenis/

increased attention on the topic, our focus group found that teaching materials are still not adjusted to the requirements of NIA; they are not developed integrally; and they are dispersed over different educational institutes and not equally available. A second barrier mentioned is a continued high legitimacy of the dominant "productivist" agricultural model. Many students grow up on farms that follow this model and expect in their education to be taught how to efficiently produce large volumes of food, which often requires practices that are not in line with NIA. This was expressed by a dairy sector specialist in our focus group with experience in educating young farmers. One of the participants stated, however: "Some students do it differently than their parents. This has a lot to do with norms: what makes a good farmer? When you talk about change, this is a key issue." This same way of thinking is prominent among agricultural extension workers and advisors, who similarly receive little training on NIA (van Loosdrecht, 2019).

The focus group judges this function as a considerable barrier hampering farmers to transition to NIA, mainly based on a lack of sufficient teaching material, and the "productivist" culture which is still dominant in most educational institutes (*focus group score: 4 out of 5)*.

5.1.7. Function 7: creation of legitimacy/counteract resistance to change

The small group of farmers that have adopted NIA includes grassroot initiatives or niches that experiment with new approaches, techniques and business models that deviate from those of the current regime. Front runners in NIA seek to increase their legitimacy by demonstrating the value and viability of NIA. A common strategy is to try to counteract the arguments of critics with data and information about the performance of NIA on environmental, social and economic aspects (Farjon et al., 2018; van Dijk et al., 2020), and to demonstrate that viable business models based on multiple value creation are possible (Polman et al., 2015). This reinforces the need for new knowledge and monitoring systems that specifically focus on NIA (ISA functions 2 and 3) and that use indicators that go beyond efficient food production as the main performance indicator (De Olde et al., 2016; van Dijk et al., 2020). The creation of certified labels for NIA can be successful in creating legitimacy (e.g. Vermunt et al., 2020a, 2020b). Furthermore, monitoring and assessment schemes have been set up by value chain parties to stimulate nature-inclusive production through price premiums (van Laarhoven et al., 2018). This is therefore a good example of an effort to coordinate monitoring NIA.

On the whole however, NIA does not nicely fit within cultural norms according to which a good farmer is highly productive, has a "neat" farm (precluding possibilities to include landscape elements for increased biodiversity), and perhaps most importantly does not deviate too much from the mainstream (de Westerink et al., 2019). These new practices are therefore often regarded as alien by regular farmers and fall outside of what is considered 'good farming practice' (Burton, 2004; de Westerink et al., 2019). This extends to the value chain, as well as financers, research and educational institutes, and policy makers, leading to a lack of the legitimacy that is needed to warrant access to financial, scientific and policy support (Van Oers et al., 2018; Geels, 2010). Decades of success in producing cheap food at high volumes mean the value chain has difficulties adjusting to a move away from this model (van der Ploeg, 2020; Erisman and Verhoeven, 2019). Similarly, Dutch consumers have become used to cheap food: household spending on food is in the bottom quartile of EU countries, explaining the low demand for and market share of nature-inclusive dairy (European Commission, 2019; see also 5.1.4).

This deviation from conventional agriculture in turn leads to the sense that NIA challenges the incumbent way of working, which is generally oriented at incremental and predictable change rather than radical innovations of business models (Geels, 2010), and in response to that a resistance against adopting newly developed nature-inclusive practices. This is clearly manifested in the public discourse in opinion pieces advocating against NIA. These opinions not so much oppose the urgency of more sustainable farming but tend to focus mainly on pragmatic difficulties, and try to undermine the legitimacy of NIA. Our analysis of 277 news articles contained 31 definitively negative statements on the topic. These mainly concerned the conceptual clarity and definition of nature-inclusive farming, the perceived lower productivity and feasibility of such a farming model, and that such an approach would be too ambitious for most farmers. However, most positive or neutral articles also contained doubts or mentioned barriers pertaining to feasibility of viable business models, regime resistance and regulatory issues, indicating legitimacy problems for NIA.

The legitimacy of NIA was considered a moderate barrier by our focus group. While we observe a growing number of advocates of NIA from various initiatives, the focus group asserted that these actors insufficiently cooperate to amplify their advocacy. Another reason is the absence of farmer figure heads to which the majority of the farmer community could relate to. The focus group judged this function as a moderate barrier *(3 out of 5)*.

5.2. Blocking mechanisms

Section 5.1 outlined the state of each innovation system function, providing an overview of the barriers to mainstream adoption of NIA practices in the Dutch dairy sector. In this section we explore the connections between the weak system functions and the underlying systemic problems to better understand why the innovation system is not functioning well (Wieczorek and Hekkert, 2012). We unravel five blocking mechanisms that each cover a distinct theme, and highlight links between them.

5.2.1. Blocking mechanism 1: missing financial incentives

The first blocking mechanism revolves around the lack of a business case for NIA and insufficient economic incentives for farmers, which negatively influence the system functions resource mobilization and entrepreneurial activity (see Fig. 2). As shown in the functional analysis above, farmers do not receive sufficient premiums from the value chain, including consumers, supermarkets and cooperatives, to stimulate a transition to NIA; farmers are price takers given the export orientation of the sector; the provision of ecosystem services is not compensated by alternative markets; and stacking incentives is difficult to coordinate.

An underlying systemic problem for the aforementioned problems is that externalities from conventional farming are not priced, so a level playing field is missing in the market (TEEB, 2018; Farjon et al., 2018): agricultural practices which negatively impact biodiversity are not taxed, and those practices that enhance biodiversity are not sufficiently rewarded or compensated. Ultimately these problems result from a lack

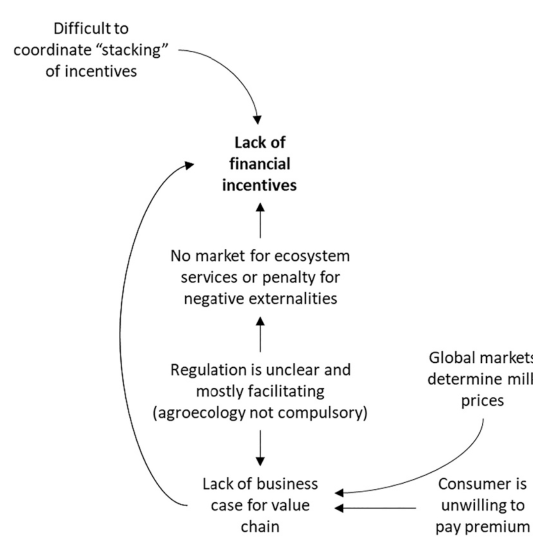

Fig. 2. Blocking mechanism around missing financial incentive systems.

of regulation and binding agreements which would oblige value chain actors to account for biodiversity and ecosystem services in product prices, and to pay for negative externalities, such as water pollution or soil depletion (Van Grinsven et al., 2015).

5.2.2. Blocking mechanism 2: limited action perspective of farmers

A weak spot identified in our desk research and confirmed in the focus group session was the limited action perspective of many dairy farmers, which negatively influences entrepreneurial experimentation. Multiple factors negatively influenced farmer perspectives to act (see Fig. 3). A first one is that structural budget shortages are common among farmers, as we identified in the functional analysis. Budget shortages can in turn be attributed to a lack of financial incentives for nature-inclusive practices (see 5.1.1) and to the high capital intensity of the sector (see 5.1.5).

Another factor contributing to a limited action perspective is the vulnerable position of farmers in the value chain, as they are the price-takers (see 5.1.1). Further, dependencies on short-term lease contracts and depreciation costs of land contributed to farmers' limited action perspectives (see 4.3.6). Structural funds that could cover some of these transition costs are not widely available. A last problem is lack of access to finance from banks (see 5.1.5). This in turn is partly a result of the nature of NIA, which in the current agri-food system implies higher costs and therefore higher (perceived) risks to be unable to pay loans back.

5.2.3. Blocking mechanism 3: lack of a shared and concrete vision for NIA

Another blocking mechanism we identified is the lack of a unified vision and concrete ambition levels for NIA, which negatively influence function four (guidance of the search). Various underlying factors are at play here (see Fig. 4). Firstly, the relation between biodiversity and agriculture is complex (Fijen et al., 2019), which makes setting tangible goals and standards difficult. This is further complicated by regional differences in soil type and landscape characteristics, as the development of the Biodiversity Monitor showed (Vermunt et al., 2020a, 2020b).

Secondly, as shown in the function analysis (see 5.1.3) the vision is ambiguous; endorsing both regional approaches as well as upscaling and export orientation, the latter being in line with the paradigm of the current regime (Gaitán-Cremaschi et al., 2019). Another challenge is the strong compartmentalization of dossiers within the Ministry of Agriculture (e.g. on issues like biodiversity, nitrogen and phosphate) and even between Ministries. This policy-making "in silos" hampers an integral approach to providing guidance.

5.2.4. Blocking mechanism 4: obstacles to knowledge transfer

Obstacles to knowledge transfer are caused by various underlying problems (see Fig. 5). Some of these were already noted in Section 5.1.2: knowledge is scattered and barely existent on several topics; not integral

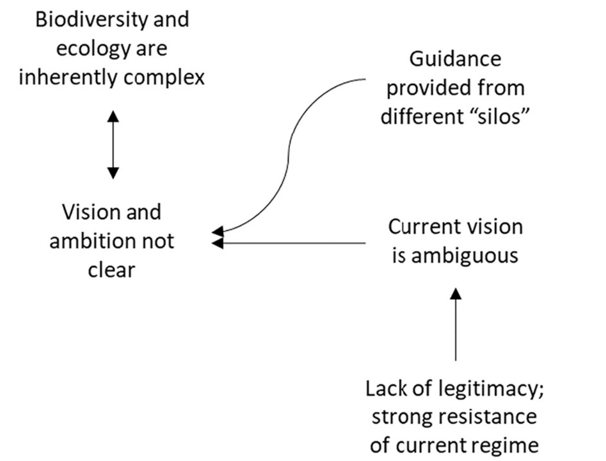

Fig. 4. Blocking mechanism around vision and ambition.

enough; too reliant on commercial actors; and complicated by the complexity of biodiversity. Moreover, an unclear vision and liberal regulations hamper knowledge transfer (see 5.1.3). This has led to a situation in which farmers, according to our focus group session, often simply do not know what types of knowledge and information they need to switch to NIA (see in Fig. 5: "knowledge requirements are not clear to farmers").

One underlying reason put forward by the experts we consulted is that knowledge development tends to be a top-down, expert-driven process without sufficient involvement from farmers. Another is the absence of an independent extension or information service, a result of privatization and the prevalence of public-private partnerships as a model for knowledge development (Hermans et al., 2015; van der Heide et al., 2011). A further underlying reason is the strength of the current regime, which directly affects knowledge and human resource development by perpetuating a demand for education according to the "productivist" model (see 5.1.6), and which also indirectly leads to a lack of clarity for farmers on knowledge requirements because in the current regime nature-inclusive farming is "just" an option, not a requirement.

5.2.5. Problem set 5: regime resistance against nature inclusive agriculture

Since this paper studies regime transformation, change is dependent on existing regime actors, and requires a change in regime configurations. Regime resistance contributes to each problem set described in the preceding sections (see Fig. 6).

Regime resistance leads to a lack of incentives in two ways. First, given the strength of the conventional "productivist" model, NIA is an

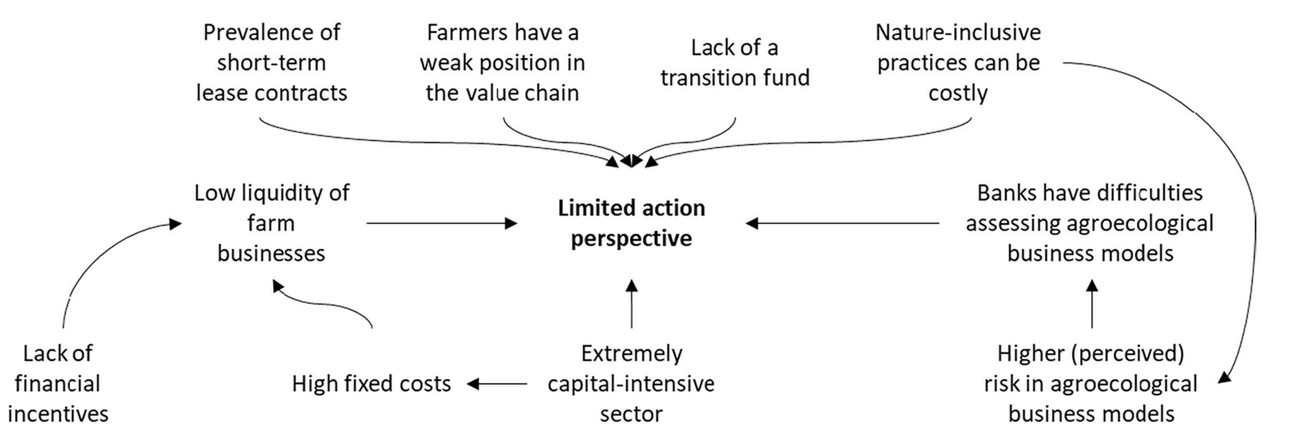

Fig. 3. Blocking mechanisms around limited action perspective for farmers.

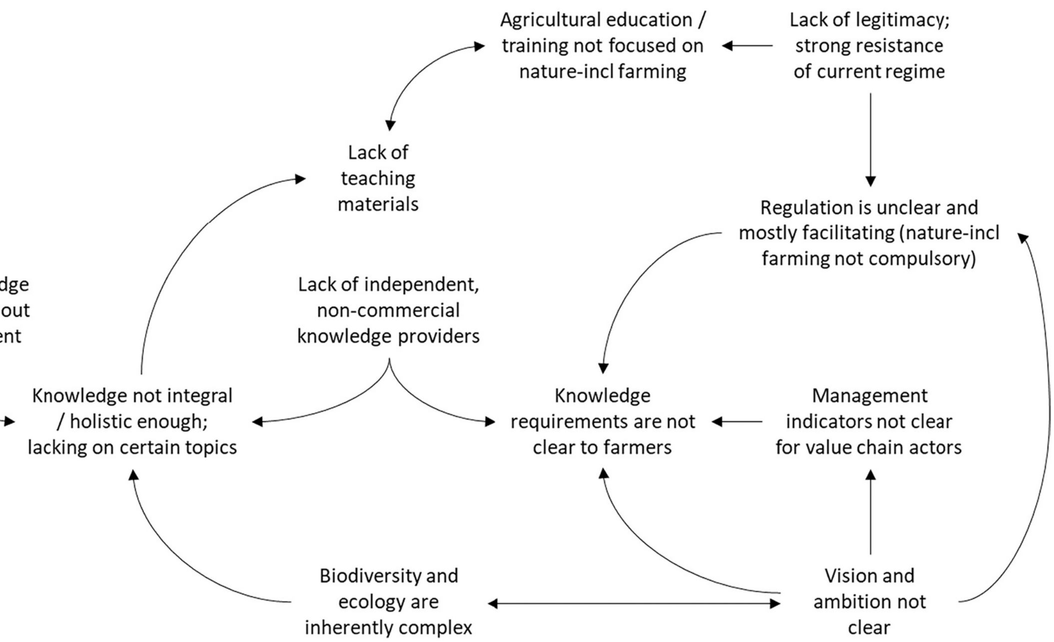

Fig. 5. Systemic problem around knowledge development and exchange.

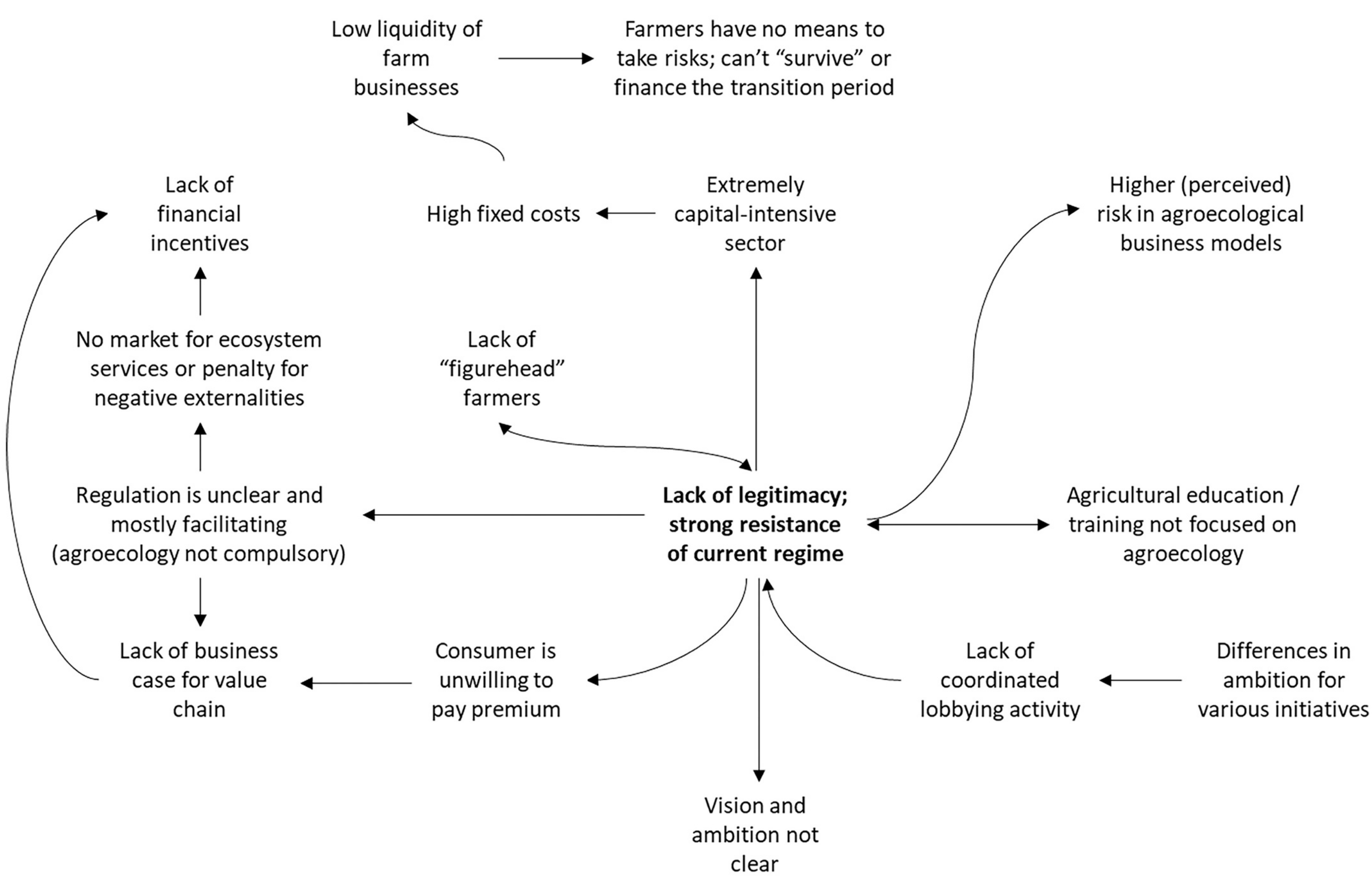

Fig. 6. Systemic problem around regime resistance.

option rather than a requirement. Regulations and markets reflect this: in the current system farmers are not sufficiently compensated for the benefits that NIA provides (see 5.1.1 and 5.1.5). Second, as stated in 5.1.7, decades of success in producing cheap food at high volumes mean the value chain and consumers have difficulties adjusting to a move away from this model (Erisman and Verhoeven, 2019; van der Ploeg, 2020). Furthermore, cost-efficient and capital-intensive production systems are culturally valued and considered an ideal by many farmers in the current regime (de Westerink et al., 2019). These factors limit farmers' financial action perspective, as they have a high perceived need to invest in expensive machinery and therefore have relatively low liquidity, limiting their ability to switch to NIA.

Problems with regard to vision and ambition are also affected by the regime, as the export orientation of the current regime is reflected in multiple visions including the government's (see 5.1.3). Simultaneously the differences in ambition between proponents of NIA, as well as the pillarization within the Ministry of Agriculture (see 5.1.3), do not amount to a sufficiently strong challenge to the conventional model, thus keeping the regime intact.

As stated above, knowledge is often provided by commercial actors whose business models depend on the high-input/high-output farming model (see 5.1.3). Independent advisors are concerned advice to switch to NIA may lead to drops in revenue or other risks contrary to expectations of growth and predictability (van Loosdrecht, 2019). Moreover, agricultural education is still heavily focused on the conventional model, with many students growing up on conventional farms demanding education in line with what they have experienced so far (see 5.1.6). This is not only a barrier to more education on NIA, but also another dynamic that keeps the regime intact.

Lastly, the cumulative effect of the aforementioned systemic problems is that only a few farmers farm in a nature-inclusive way which also means that there are few “figurehead farmers” who can showcase their success to neighbors and in broader farmer networks. This lack of figureheads is another underlying reason for the strength of the regime, since NIA is often regarded as alien by regular farmers and fall outside of what is considered ‘good farming practice’ (Burton, 2004; de Westerink et al., 2019).

6. Discussion and conclusion

This paper aimed to understand the factors that prevent the mainstream adoption of nature-inclusive dairy farming practices in the Netherlands, by applying an innovation system approach. We identified knowledge development and exchange, guidance of the search, market formation and resource mobilization as weak system functions. The causes for these weak functions can be explained through five blocking mechanisms, each of which contains several systemic problems that interact and collectively influence the innovation system. The blocking mechanism are centered around five themes: (1) missing financial incentives, (2) limited action/financial perspective of farmers, (3) lack of a shared and explicit vision and ambition for NIA, (4) problems in knowledge transfer and (5) regime resistance. We showed that that the most important barriers to NIA's lack of mainstream adoption lie in the “productivist” regime. These barriers reinforce and compound each other, which makes challenging this regime increasingly difficult. One example is that non-binding regulations and an uneven playing field in the regime, combined with little financial incentives to transition to NIA, are compounded by the fact that the sector is geared towards a capital-intensive business model that restrict farmers' liquidity. Together, low liquidity and limited financial incentives severely limit farmers' action perspectives, which in turn reduces the number of positive examples that could stimulate farmers to switch to NIA – a mechanism long recognized to be key in the diffusion of innovation (Rogers, 2005).

The explicit focus on the blocking mechanisms that affect innovation system performance for a specific subsector is an important contribution of our paper to the literature on system innovation. The geographical scope of a single region allows us to highlight problems in a specific institutional context (see also Kruger, 2017; Schiller et al., 2020; Sixt et al., 2018; Klerkx et al., 2010). Unlike most other ISA, this paper focuses on a particular farming style or approach (NIA) and subsector (dairy production). This focus allowed for a concrete investigation of the innovation system functions, particularly market formation and resource mobilization. In contrast to many ISA that focus on the *nature* of problems (e.g. Kieft et al., 2018), the approach taken in this paper enabled the exposure of *linkages* between problems as well as their *relative importance*. This approach allows us to highlight niche-regime interactions in transition processes and the identification of promising policy interventions needed to promote system change.

Considering the growing attention for adjacent concepts such as regenerative agriculture (Giller et al., 2021; Schreefel et al., 2020), as well as for agroecology in contexts beyond Europe (Bellwood-Howard and Ripoll, 2020), using our approach to study such concepts in the same and other contexts would be appropriate aims for further research. A broader evidence base for the barriers to alternative agricultural approaches can furthermore help confront detrimental policies at EU level and beyond (Pe'er et al., 2020). Another avenue for further research would be to empirically test the novel framework of mission-oriented (agricultural) innovation systems in similar cases, given the increasing popularity of mission-oriented policymaking (Klerkx and Begemann, 2020; Hekkert et al., 2020). It is already apparent from prior research that clear definitions of, and directionality for, alternative agricultural approaches are lacking (Turner et al., 2016; Menary et al., 2019; Bellwood-Howard and Ripoll, 2020). This presents a dilemma: on the one hand, added clarity could aid in the diffusion and upscaling of such approaches; on the other hand, narrowing them down further risks promoting a “silver bullet” attitude that is difficult to reconcile with a growing recognition of the existence of – and need for – a diversity of solutions to agri-food system challenges (Gaitán-Cremaschi et al., 2019; Berthet et al., 2018; Niederle, 2018).

Challenging the current “productivist” regime requires a well-functioning innovation system. But, as we have shown, the development of such an innovation system is dependent on exactly the same regime actors, institutions and infrastructure which hamper development of this innovation system at the same time. In other words, there is a chance of remaining in a vicious cycle as change needs to come from within the regime. In the transition literature this type of transition pathway is described as ‘regime transformation’, instead of pathways of ‘substitution’ where new entrants play an important role (Runhaar et al., 2020; Vermunt et al., 2020b). This shows that only stimulating niche innovation will not suffice, as was already noted over two decades ago (Kemp et al., 1998). Accordingly, where policy has tended to focus on strengthening emerging innovation systems, in this and similar cases it would be effective to more strongly focus on intervening in current regime dynamics. This would not only benefit NIA but also other alternative farming methods and technologies. But what is needed to stimulate action by key stakeholders to remove barriers and bring about regime change (Runhaar, 2021)?

A growing body of literature on regime destabilization (for an overview, see Frank et al., 2020) provides a number of avenues to deal with regime resistance and, more broadly, puts our findings in perspective. First, various authors note the importance of visions and discourses as having the potential to both “prop up” regimes and to delegitimize dominant logics, practices and technologies (Turnheim and Geels, 2013; Stegmaier et al., 2014; Kuokkanen et al., 2018). While we have shown that the Dutch government's vision in fact legitimizes export-oriented “productivist” agriculture, we can also observe a variety of stakeholders challenging this logic with their own visions. In addition to sharing their visions, these stakeholders can also point more specifically to the ways in which the political economy of food production leads to adverse socioecological outcomes. Second, rules can be changed to facilitate the phase-out of practices and technologies that are not sustainable (Heyen et al., 2017; Kivimaa and Kern, 2016; Van Oers et al., 2021). This pertains to our finding that for NIA to have a chance of success, regulatory changes are needed to bring about a level playing field for all farmers in the dairy sector. To this end, a broader valuation of agricultural products and services based not only on their financial value but based on their sustainability and product quality needs to be institutionalized. Valuing ecosystem services provided by NIA, as well as accounting for the ecosystem ‘disservices’ brought about by conventional agriculture, could contribute to this leveling of the playing field (Swinton et al., 2007; Zhang et al., 2007). Third, architects of transition strategies must be considerate of the potential socioeconomic, cultural and political impact of such strategies (van der Ploeg, 2020; Stegmaier et al., 2014). To that end, the design of new business and organizational models, as well as policy-making, need to take place in dialogue with those who are directly affected by them. Recent efforts to draw up a new social contract for Dutch agriculture – a "landbouwakkoord" analogous to the "klimaatakkoord", or climate agreement, of 2019 – are promising.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Table of workshop participants and activities

Activity	Aim	# of participants	Participant background	Role of authors	Length	Data capture
Internal author workshop 1	Operationalize IS framework	8	Researchers	Active discussion	1 h	Written notes
Internal author workshop 2	Develop indicators and coding scheme	8	Researchers	Active discussion	1 h	Written notes
Stakeholder workshop 1	Discuss stakeholder perspective on issues	6	Researchers, policy-makers, civil servants	Active discussion	2 h	Written notes
Focus group session	Verification of initial desk research and score system functions	12	Researchers, policy-makers, sector representatives, independent experts, NGO, financial institutions	Moderation	3 h	Written notes; audio recording
Stakeholder workshop 2	Verification of results	12	Researchers, policy-makers,	Active discussion	2 h	Written notes

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