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Research Paper

# How can networks address barriers to nature-based solutions? The case of agriculture and construction in the Netherlands

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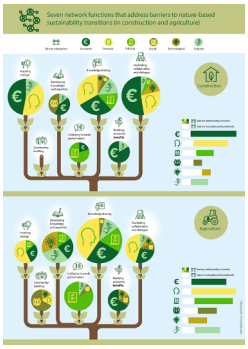
## HIGHLIGHTS

- Networks are important to address barriers to nature-based sustainability transitions.
- Networks in the Dutch agriculture and construction sector fulfil seven functions.
- Four *broad* network functions address multiple types of barriers.
- Three *targeted* network functions aim at alleviating one specific barrier type.
- Networks also leave certain barriers unaddressed.

## GRAPHICAL ABSTRACT



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## ABSTRACT

Nature-based solutions (NBS) can play a critical role in sustainability transitions in both urban and rural areas, but their uptake is hindered by a wide variety of barriers. While networks have been identified as a support structure for mainstreaming NBS, it is unclear what specific roles networks play in addressing the multiple barriers that NBS mainstreaming faces. Through qualitative research using focus group meetings and semi-structured interviews within two sectors in the Netherlands where attempts towards a nature-based transition are observed – i.e., agriculture and construction – we identify seven different functions through which networks address six specific barrier categories. We find *broad* network functions (e.g., knowledge sharing) that address multiple types of barriers simultaneously and *targeted* network functions (e.g., lobbying towards policy makers) aimed at alleviating one specific type of barrier. We also document that networks leave certain barriers unaddressed, such as technological and political barriers in the construction sector and social barriers in both sectors. Our results contribute to a more in-depth understanding of network function – barrier combinations for nature-

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based sustainability transitions, both in an urban and a rural context, which can help networks to further strategize and allocate their resources.

## 1. Introduction

Nature-based solutions (NBS) have recently emerged in the policy realm as a promising transformation path to sustainable development for both rural and urban areas, representing interventions that can support economic targets such as job creation, innovation and growth, while simultaneously addressing global environmental challenges and supporting human wellbeing beyond material welfare (Maes & Jacobs, 2017; Seddon et al., 2020). NBS are commonly described as cost-effective solutions that use, and are inspired by, nature, and are designed to simultaneously address economic, environmental, and social challenges (Dorst et al., 2019; European Commission, 2015). NBS include a spectrum of rural – urban interventions including wetlands, green roofs and facades, sustainable drainage systems, trees, parks and forests, and ecosystem-based approaches to agriculture (Seddon et al., 2020). All NBS types represent the use of nature delivering multiple benefits targeting various needs and stakeholders (Raymond et al., 2017).

While benefits of NBS are increasingly evident, nature-based sustainability transitions face significant barriers (Dorst et al., 2022; Kabisch et al., 2016; Seddon et al., 2020; Vermunt et al., 2022). Many barriers that NBS face coincide with core problems associated with nature conservation and the protection of the services nature provides. As a consequence of its silent, invisible and mobile characteristics nature is often ignored and therefore underprovided (Dasgupta, 2021). For example plants don't speak, and we don't see soil bacteria and hence in our current economic system we tend to ignore the air purification and soil purification they provide. Similarly, wildlife and fish move across territories but our economic system makes us care only about them as long as they are in "our territory". Thus the multiple services nature and NBS provide are not priced in the market, in spite of monetary value calculations of NBS in both urban and rural contexts (Bockarjova et al., 2020; Losey & Vaughan, 2006). Moreover, many of the benefits nature generates are non-excludable (Bockarjova et al., 2020; Dasgupta, 2021; Toxopeus & Polzin, 2021), so do not accrue to those actors who bear the investment costs and are therefore also underprovided.

However, barriers faced by nature-based sustainability transitions go beyond externalities. Dorst et al. (2022) identified seven main barriers that prevent the scaling up of nature-based solutions in the urban environment in Europe: 1) limited collaborative governance, 2) knowledge, data, and awareness, 3) low private sector engagement, 4) competition over urban space, 5) insufficient policy development, implementation, and enforcement, 6) insufficient public resources and 7) challenges around citizen engagement. Similarly, van der Jagt et al. (2020) disentangle barriers faced by *technical* versus *nature-based* sustainability transitions: of the eight main dimensions of barriers (and enablers) that they identify, in nature-based sustainability transitions there is a larger role for place-based factors, agency and the role of the government.

In the light of these barriers to NBS uptake, several studies have been conducted into what can be done to mitigate barriers and support a nature-based sustainability transition. In a large European study, Tozer et al. (2022) uncover 20 potential interventions that can function as 'stepping stones' for mainstreaming urban NBS, such as providing a public mandate, developing markets and generating partnerships. Similarly, van der Jagt et al. (2023) argue that comprehensive policy mixes – consisting of regulatory, financial and soft instruments – are necessary to mainstream urban NBS. Other scholars (e.g. Frantzeskaki, 2019; Malekpour et al., 2021) highlight the importance of collaborative governance in mainstreaming NBS. Specific for mainstreaming NBS into agriculture in the Netherlands, Runhaar (2017) propose four priorities: 1) effective agri-environmental schemes, 2) mainstreaming of nature conservation in agricultural policy and value chains and 3) developing a shared understanding of 'nature-inclusive agriculture'[1] and 4) knowledge generation in line with farmer needs.

Most studies also point at the importance of *networks* in supporting sustainability transitions in general (Engwall et al., 2021; Loorbach et al., 2017) and nature-based sustainability transitions in particular (Kampelmann et al., 2016; Tozer et al., 2022). Networks can for example enable knowledge development, knowledge sharing and lobbying (Planko et al., 2019; Planko et al., 2016; Runhaar & Polman, 2018). Such network functions might help to overcome certain barriers. While we know that nature-based sustainability transitions face a specific set of barriers and that networks can play an important role in addressing (some of) them, a specific understanding of the different functions of networks is missing as well as insight into which network functions help to overcome which barriers. The central research question of this paper is therefore: *What role(s) can networks play in addressing barriers to nature-based sustainability transitions?*

We address this research question by studying networks in two sectors where nature-based sustainability transitions take place: construction (urban) and agriculture (rural), both in the Netherlands. The focus on two different sectors across the urban and rural context, both working towards a nature-based sustainability transition, allows us to analyse what role networks can play in mitigating barriers in the uptake of rural and urban NBS. We build on insights regarding benefits of sustainability-related networks to empirically establish a coherent overview of the functions of networks and what specific barriers these address to support the mainstreaming of NBS and thereby driving nature-based sustainability transitions. This ensuing fine-grained understanding of network function – barrier combinations can increase the effectiveness of networks, supporting their strategizing and use of resources.

Our paper proceed as follows. In section 2 we take stock of the academic literature on barriers to NBS for both the construction and agriculture sector and the role of networks in sustainability transitions. In section 3 we outline our method, a qualitative sector-specific study for both sectors, combining focus group discussions and interviews with network representatives. In section 4 we present our results, in particular the role(s) that networks can play to overcome specific barrier types to NBS in construction and agriculture. In section 5 we discuss our contribution to the academic literature as well as practical implications.

## 2. Theoretical background

### 2.1. Barriers to nature-based solutions in agriculture and construction

Barriers faced by nature-based sustainability transitions have been reported on in the literature. In order to develop an integrative overview of barriers, we searched and combined literature that focuses on NBS in agriculture and construction. Given that different terms are used for concepts that are similar to, or encompassed in, NBS, we included sector-specific search terms for our literature search, such as 'nature-inclusive agriculture', 'climate smart agriculture' and 'nature-based construction', 'nature-inclusive construction' (see Appendix I for a full overview of the terms used in this search). Given the relatively recent emergence

[1] In the Netherlands nature-based solutions are often referred to as nature-inclusive solutions Runhaar, H. (2017). Governing the transformation towards 'nature-inclusive' agriculture: Insights from the Netherlands. *International Journal of Agricultural Sustainability*, *15*(4), 340–349. https://doi.org/10.1080/14735903.2017.1312096 .

of the NBS concept (Dorst et al., 2019; "'Nature-based solutions' is the latest green jargon that means more than you might think," 2017) we did not limit ourselves to academic literature, but also looked at grey literature (also included in Table 1) for a more complete overview of sector-specific barriers. This resulted in overview of barriers, some of which were identified for both construction and agriculture (e.g. 'high perceived costs of NBS'), while others were sector-specific (e.g. 'lower yield and revenues' for agriculture; 'planning policies' for construction). Similar barriers were clustered resulting in a coherent overview of five main barrier categories (see also Table 1): Economic, Personal, Political, Social and Technological. Below we will briefly discuss each category.

The 'economic' category consists of barriers that relate to the (opportunity) costs and benefits that NBS represent, such as higher costs of production, lack of demand for products or market power of agricultural incumbents in the supply chain. The 'personal' category includes barriers that relate to personal characteristics of entrepreneurs and/or their customers; for example, an entrepreneur may lack innovativeness or knowledge to implement NBS. The 'political' category contains barriers related to policy and politics, such as political opposition, lack of standards or enforced planning policies. 'Social' barriers relate to peer groups, including a lack of community support, diverging perspectives that hamper cooperation, or peer pressure. Finally, the 'technological' category relates to the (lack of) technical expertise or solutions available to implement NBS, such as uncertainties and risks surrounding innovations, conflicting scientific reports, or technical disadvantages connected to NBS.

### 2.2. The role of networks in mainstreaming nature-based solutions

A network can be defined as "a set of nodes and the set of ties representing some relationship, or lack of relationship, between the nodes" (Brass et al., 2004: 795). This broad definition covers a wide range of network types as the nodes as well as the ties in the network can refer to many different things/objects. For the nodes, it can amongst others refer to individuals, organizations, technologies, R&D projects, or countries. With respect to the ties, relations based on for instance friendship, advice, knowledge, finance, co-applicants, trade, etc. can be included. Several academic literature streams, such as environmental governance (Driessen et al., 2012; Peterman et al., 2020; Ponte & Cheyns, 2013; Schroeder et al., 2013) or innovation studies (Edquist, 1997), address the potential relevance of networks. Popp et al. (2014) for instance, provide an overview of potential benefits of interorganizational networks, such as access to and leveraging of resources; shared risk; efficiency; advocacy; learning and capacity building.

Also from a sustainability transitions perspective, the usefulness of networks has been highlighted, as transitions require changes in socio-technical systems and therefore forerunners often collaborate in networks to realize these changes (Khan, 2013; Musiolik et al., 2012; Planko et al., 2017).

The benefits of networks aimed at driving sustainability transitions overlap with the functions of networks that are highlighted more generally. For example, transition literature confirms that networks enable knowledge development and/or sharing (e.g. Engwall et al., 2021; Goyal & Howlett, 2020; Kundurpi et al., 2021; Tziva et al., 2021). In addition, collaboration through sustainability-related networks can create economic benefits (Nuhoff-Isakhanyan et al., 2017) through resource- and risk-pooling (e.g. Engwall et al., 2021; Planko et al., 2019) as well as by mitigating externalities (Punt & Wesseler, 2018).

The focus on sustainability, however, might alter, or impact the importance of, functions of a network due to the specific barriers that require attention in sustainability transitions, such as strong competition within locked-in socio-technical systems (e.g., the carbon lock–in in the energy transition (Unruh, 2000)) and their collective good character (benefits are for society, costs are for firms or users) reducing incentives to invest (Geels, 2011). Specifically, transition literature shows that networks can create user awareness (e.g. Planko et al., 2019; Planko et al., 2017), maintain learning communities (Sørensen et al., 2021), build supportive coalitions (Bos et al., 2015) foster social learning (Bos & Brown, 2012) and connect forerunners and entrepreneurs (Khan, 2013). Moreover, networks aimed at sustainability transitions are used for lobbying (Tziva et al., 2021) and for influencing the development of supportive policy/legislation (Bos & Brown, 2012; Goyal & Howlett, 2020; Planko et al., 2016; Sol et al., 2018). Literature on public–private partnerships is also relevant in this context: these partnerships help with starting a debate on a new topic (agenda setting) and the development of policy (Runhaar & Polman, 2018; Visseren-Hamakers, 2013).

Our focus on NBS might make network functions even more specific. NBS and their innovative aspects are also influenced by the context in which they are placed, as argued by Van der Jagt et al. (2020) in their paper. They argue that the networks in which NBS-stakeholders are located can support them in overcoming challenges between the sectors and scales where they operate. The functions of these networks can be more salient based on the context; examples include the importance of stimulating public participation in urban contexts with high levels of private landownership, and trust building in contexts where discrepancies between interests and concerns of stakeholders hinder the development of NBS (van der Jagt et al., 2020). In the current paper, we build on these insights regarding benefits of sustainability-related networks to empirically establish a coherent and comprehensive overview of the functions of networks and what specific barriers they address to support the mainstreaming of NBS, thus driving nature-based sustainability transitions.

## 3. Method

### 3.1. Empirical setting

As an empirical setting, we focus on two sectors in the Netherlands where efforts are made to realize a nature-based sustainability transition, namely agriculture (rural) and construction (urban). Globally, agriculture and construction are important sectors causing humanity to cross several planetary boundaries, e.g. the N-P cycle, biosphere integrity and climate change (Rockström et al., 2009; Steffen et al., 2015), and for both sectors the adoption of NBS can play a major role in mitigating these effects. Dutch agriculture has been hailed as one of the most productive systems in the world, but simultaneously puts significant pressure on the environment and biodiversity (Jongeneel et al., 2016). In a similar vein the Netherlands is one of the most densely populated countries in the world, yet according to some predictions it needs at least 1 million new houses, putting further pressure on the environment and the scarce space available (Hamers et al., 2021). The two sectors in the Dutch setting are by no means representative of other sectors in other settings, but nevertheless allow us to study the role of networks more in-depth in order to further theorize their role in alleviating barriers.

### 3.2. Data collection

To answer our research question – understand the role of networks in addressing barriers to nature-based transitions – we took an abductive approach (Dougherty, 2017; Mantere, 2008; Toxopeus et al., 2021), engaging in an iterative process going back and forth between theory and data. The data collection consisted of two phases. See also the upper part of Fig. 1.

During the first phase, we first presented the identified barrier categories to two academic experts on NBS, together with examples of barriers per category. This enabled us to confirm, expand and sharpen our barrier categories. Next, we organised two online focus groups, one for agriculture and one for construction. The objective of these focus groups was twofold: (1) to empirically validate the identified barriers from the literature and see if important barriers and/or categories were missing according to experts from sector networks; and (2) to get a basic understanding of the roles networks can play in mitigating these

**Table 1**
Overview and explanation of barriers to NBS in the construction and agriculture sector.

| Barrier category | Subcategory | Description | Source | Sector |
|---|---|---|---|---|
| **Economic** | Costs | Costs of NBS are higher because they are more expensive to implement, maintenance costs are higher or there are costs of adoption or investment. | Bouma et al. (2020); Brudermann and Sangkakool (2017); Gosnell et al. (2019); Hammitt (2010); Hendricks and Calkins (2006); Peck et al. (1999); (Sauer, 2017; Schoonhoven & Runhaar, 2018; Spiegal et al., 2018; Stamatelos, 2012; Wreford et al., 2017) | Both |
| | Subsidies | There are no subsidies available for NBS or other non-NBS techniques are subsidized | Lin (2011); Peck et al. (1999); Sangkakool et al. (2018); Schoonhoven and Runhaar (2018); Tayouga and Gagné (2016) | Both |
| | Credit & Finance | There is a lack of possibilities to finance NBS | Schoonhoven and Runhaar (2018); Wreford et al. (2017) | Agriculture |
| | Demand | There is limited demand for NBS products | Schoonhoven and Runhaar (2018) | Agriculture |
| | Influence conventional agribusiness | The economic power lies with the conventional agribusinesses including the upstream and downstream firms in the supply chain | Gosnell et al. (2019); Runhaar (2017) | Agriculture |
| | Revenues | NBS results in lower yields and lower revenues. | Wreford et al. (2017) | Agriculture |
| | Time | NBS require more time because of frequent moving of cattle, and time commitments for ecological monitoring and meticulous bookkeeping | Gosnell et al. (2019) | Agriculture |
| | Competing pressure from other activities | Farmers have limited time and face multiple (environmental) demands. | Wreford et al. (2017) | Agriculture |
| | Value of ecosystem services | There is a lack of knowledge on the value of ecosystem services that are provided by green infrastructure | Tayouga and Gagné (2016) | Construction |
| **Personal** | Knowledge | The people that could implement NBS do not know about them or have incorrect beliefs about them | Bouma et al. (2020); Brudermann and Sangkakool (2017); Gosnell et al. (2019); Hammitt (2010); Hendricks and Calkins (2006); Lin (2011); Peck et al. (1999); Sangkakool et al. (2018); Sauer (2017); Schoonhoven and Runhaar (2018); Spiegal et al. (2018); Stamatelos (2012); Šūmane et al. (2018); Tayouga and Gagné (2016); Williams et al. (2010); Wreford et al. (2017) | Both |
| | Resistance to change | People resist change out of fear, habit or past choices (path dependency) | Davies and Lafortezza (2019); Gosnell et al. (2019); Hammitt (2010) | Both |
| | Values | People do not value the environment high enough to implement NBS | Bouma et al. (2020); Hendricks and Calkins (2006); Schoonhoven and Runhaar (2018) | Both |
| | Views on self and "good farming" | People do not use NBS because their views on themselves and what constitutes good farming are in conflict with NBS practices, e.g. proud of what is achieved with conventional farming, notions of success is associated with production or the aesthetics that involve preferences for a tidy farm. | Gosnell et al. (2019) | Agriculture |
| | Innovativeness | People do not adopt NBS because they do not want to innovate. | Schoonhoven and Runhaar (2018) | Agriculture |
| | Scepticism | People are sceptical about the potential results of NBS and doubt their solidity | Brudermann and Sangkakool (2017) | Construction |
| **Political** | Laws and policies | Laws and institutions constrain the adoption of NBS | Bouma et al. (2020); Brudermann and Sangkakool (2017); Runhaar (2017); Sauer (2017); Schoonhoven and Runhaar (2018); Stamatelos (2012); Tayouga and Gagné (2016); Williams et al. (2010); Wreford et al. (2017) | Both |
| | Political context | Aversion of politicians or local politics blocking NBS | Gosnell et al. (2019); Hammitt (2010); Schoonhoven and Runhaar (2018) | Both |
| | Planning policies | Planning policies only encourage NBS rather than oblige it | Tayouga and Gagné (2016) | Construction |
| | National standard | Lack of a national standard or industry guidelines on NBS | Williams et al. (2010) | Construction |
| **Social** | Lack of coordination among actors | NBS often require people working together on the same problem both within and across sectors and coordination is difficult | Schoonhoven and Runhaar (2018); Tayouga and Gagné (2016); Wreford et al. (2017) | Both |
| | Community support | There is no active community in the field to fall back upon | Schoonhoven and Runhaar (2018); Williams et al. (2010) | Both |
| | Scepticism within academia | There is scepticism from research community regarding NBS | Gosnell et al. (2019) | Agriculture |
| | Community pressure to comply with norm | There is pressure to conform to the conventional norm from family, friends, the industry and society in general | Gosnell et al. (2019); Schoonhoven and Runhaar (2018); Spiegal et al. (2018); Wreford et al. (2017) | Agriculture |
| | Public awareness | Lack of public awareness of citizen's effects on NBS | Hammitt (2010) | Construction |
| | Untidiness with poor maintenance | Public rejection if poor maintenance of NBS results in untidiness | Hammitt (2010) | Construction |
| | Space constraints due to public preferences | The public preferences for other things may not leave enough room for NBS | Hammitt (2010) | Construction |
| **Technological** | Uncertainty about and risks associated with the use of new techniques | New techniques often still have to prove their worth and may bring (yet unknown) risks | Brudermann and Sangkakool (2017); Gosnell et al. (2019); Hammitt (2010); Peck et al. (1999); Williams et al. (2010); Wreford et al. (2017) | Both |
| | Shortage of knowledge | Little scientific knowledge available about NBS | Gosnell et al. (2019); Williams et al. (2010) | Both |
| | Compatibility of NBS with surroundings | Not all NBS are compatible with the environment they are placed in | Gosnell et al. (2019); Stamatelos (2012); Williams et al. (2010) | Both |
| | Competing techniques | Other techniques to deal with the environment are more pushed (such as biotechnology solutions) | Lin (2011) | Agriculture |

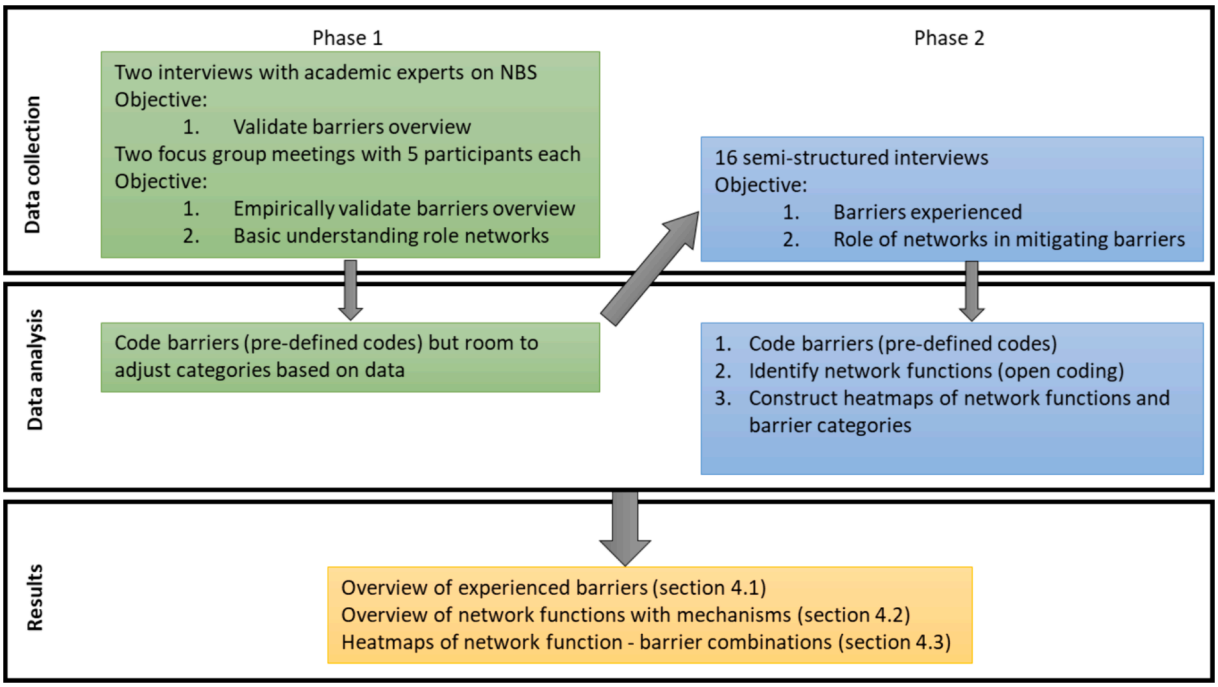


**Fig. 1.** Visualization of the steps and phases of the research process.

barriers. We created, based on the knowledge of the researchers involved and an internet search, a list of key individuals within these two sectors actively working on nature-based sustainability transitions. They were invited to participate in the focus groups. Each focus group meeting was attended by five key individuals from the respective sectors. The experience and knowledge of the participants of the two focus groups allowed for lively discussions in which participants complemented each other. The focus group meetings lasted approximately 90 minutes and were recorded and summarized afterwards.

During the second phase we collected data by means of semi-structured interviews with representatives of networks active or interested in NBS in the two sectors in the Netherlands. The objective of these semi-structured interviews was twofold (1) to collect data on the barriers experienced; and (2) to gain an understanding if and how the network played a role in overcoming these barriers. We created a list of potential networks based on the knowledge of the researchers involved, the network of the Groene Brein, the referral of focus groups participants, and an intensive internet search. These networks can be considered goal-directed networks (Provan et al., 2007) of actors active or related to the sector (the members). Within the networks different types of ties could be distinguished, e.g. collaboration, knowledge sharing or information exchange. In this paper our interest is not to analyse the network structure, but gain insight in functions the network fulfil to mitigate barriers.

In order to get a good representation, different types of networks (e.g. in terms of size, legal status and focus) were approached for an interview. The interviewees partly overlapped with the network representatives present in the focus group discussion, but also included representatives of additional networks. In total we interviewed 16 (representatives of) networks, 8 agriculture and 8 construction networks (for descriptive data of the interviewed networks see Table 2).

All networks studied in the interviews were founded in or after 2008, except for Warmonderhof (a foundation for biodynamic farming started in 1947). The networks vary considerably in size with small networks such as Living Lab Fryslân (7 members) and large ones such as Heerenboeren, with almost 4000 members (mean: 354 members; median 87 members; s.d.: 975 members). The network size, however, is hard to compare because networks have different definitions of a 'member'. For example, BoerenNatuur has 40 members, but each of these members is a cooperation of farmers. In total these 40 cooperatives together have around 11,000 member farms.

The interviews followed a semi-structured interview protocol. The first part of the interview focused on understanding the characteristics of the specific network. Second, we introduced each of the six barrier categories and asked respondents if they recognized and experienced barriers in these categories. If that was the case, we asked them to elaborate on barriers they experience in this category and explain if, and how, their network played a role in overcoming these barriers. The interviews lasted approx. 60 minutes each and were recorded and transcribed.

**Table 2**
Overview and description of the networks included in this research.

| Sector | Network name | Size (# members)* | Founding year | Legal status |
|---|---|---|---|---|
| Construction | Dutch Green Building Council | 350 | 2008 | Foundation |
| | C-creators | 53 | 2018 | Foundation |
| | Cirkelstad | 87 | 2010 | None |
| | Rooftop Revolution | 19 | 2016 | Foundation |
| | NL Greenlabel | 180 | 2008 | Company |
| | Stichting Biomimicry | 40 | 2010 | Foundation |
| | Steenbreek | 14 | 2015 | Foundation |
| | Stichting Nieuwe Helden | 66 | 2018 | Foundation |
| Agriculture | BoerenNatuur | 40 | 2014 | Association |
| | Caring Farmers | 263 | 2018 | Foundation |
| | CSA netwerk | 89 | 2020 | Association |
| | Heerenboeren | 3862 | 2012 | Foundation |
| | Living Lab Fryslân | 7 | 2016 | Foundation |
| | Voor de Oogst van Morgen | 61 | 2017 | None |
| | Transitie Coalitie Voedsel | 104 | 2015 | Foundation |
| | Warmonderhof | 115 | 1947 | Foundation |

*At the time of data collection

### 3.3. Data analysis

For the analysis of the focus group data on barriers we started with our pre-defined categories of barriers based on the literature and adjusted these through comparison with the data collected during the focus groups, in line with our abductive method (Suddaby, 2006). New barriers mentioned in the focus groups were added to a matching category in the conceptual framework until saturation was reached. This produced our final overview of barriers to nature-based sustainability transitions (see results section 4.1). The focus group meetings also confirmed the importance of networks for addressing these barriers.

For the analysis of the interviews, the transcribed data were entered into NVivo and coded in several consecutive steps (Gioia et al., 2013). First, all barriers identified by the networks as relevant for the nature-based sustainability transition in their sector were coded and added to the respective barrier categories. Most of the mentioned barriers fitted our overview of barriers, some barriers were new or specifications of already existing barriers in the overview. There was no need to add new categories.

We took an inductive approach to identify network functions and their role in addressing the identified categories of barriers (Corbin & Strauss, 2014). We started with open coding, identifying segments from interviews in which respondents explained a specific role that their network took to address a certain barrier. For example, one network explained their role in setting up conversations and sharing factual data on the benefits of nature-inclusive buildings, which we coded as 'stimulating conversations between actors for knowledge sharing'. In a second iteration, all codes were reviewed and clustered into more abstract, 2nd-order themes (Gioia et al., 2013), similar to axial coding (Corbin & Strauss, 2014). For example, the above code was clustered under the theme we labelled 'facilitating collaboration and dialogue'. The clustering of open codes into themes was carried out by two researchers to increase reliability of the analysis and continued until consensus was reached. This resulted in a list of network functions with specific mechanisms underlying each one (see result section 4.2).

As a final step, to think about the data theoretically in terms of relationships between network roles and barriers, we created a data structure that combined network functions and the categories of barriers they were addressing (Gioia et al., 2013). To create this data structure, we followed the procedure described in Xie et al. (2020) and Tozer et al. (2022) to generate matrices of barriers and network functions ('heat maps'). To fill these heat maps, we counted the number of interviews in which a combination of a network function and barrier category was mentioned by the interviewees when describing the role of their network (once or more per interview was counted as 1), in order to get a better insight into patterns regarding which functions were used for which barriers, and to look for similarities and differences in how network functions were used within and between sectors. We created heat maps for both sectors together (agriculture and construction) and for the separate sectors (see results section 4.3). This allows us to distinguish between oft-mentioned and less mentioned roles of networks in combination with barriers, and to identify differences between sectors. See also Fig. 1 for a visualization of the research process.

For clarity we present network function – barrier combinations per categories of barriers, clustering the underlying barriers together. If a specific barrier-network function combination is mentioned in an interview more than once by the same respondent we only count it once. As a consequence, the maximum number a specific barrier-function combination can be mentioned is 16 times overall, and 8 times per sector. However, as barrier categories contain several barriers the totals mentioned in the heat maps can be higher than 16. As a robustness check, we re-did the analysis while counting the double barrier-function combinations, but these alternative heat maps generated similar results (see Appendix II).

We realize this "quantitative" approach might result in losing some of the nuances of our qualitative data and approach. It is, however, not so much about the exact numbers, but instead this approach enables us to gain insight into relevant patterns. In addition, we use concrete insights and examples from the interviews to support our findings.

## 4. Results

### 4.1. Barriers to nature-based transitions

The focus group participants confirmed the importance of the barriers we identified in the literature (see section 2.1). They did also add one additional category of barriers, namely cultural barriers, such as (1) existing underlying narratives, (2) the societal role of science and (3) the influence of media. Based on this feedback we extended the conceptual overview of barriers, which resulted in six categories: 1) Economic, 2) Personal, 3) Political, 4) Social, 5) Technological and 6) Cultural barriers. These barrier categories were used for the interviews.

During the interviews, interviewees raised 150 barriers in total within their nature-based sustainability transition across the two sectors, with the majority of barriers in the categories economic, personal and political. Looking at the categories of barriers, there are some differences between the construction and agriculture sector. For the construction sector economic barriers are mentioned most often, followed by the categories personal and political. For agriculture personal and political barriers are mentioned most often followed by economic barriers. Cultural and social barriers are observed more often in the agriculture sector, whereas technological barriers are observed more in the construction sector.

### 4.2. Network functions

From the interviews we identified seven network functions through our coding procedure: (I) inspiring change, (II) developing knowledge and expertise, (III) knowledge sharing, (IV) facilitating collaboration and dialogue, (V) community building, (VI) lobbying towards policymakers and (VII) realizing economic benefits. In Table 3 we describe each network function, illustrated with an interview quote that was coded under this function.

### 4.3. The role of networks in addressing barriers for NBS transitions

Building on our overview of barrier categories (4.1) and our identified network functions (4.2) we can answer our main research question: *what role(s) do networks play in addressing barriers for NBS transitions?* Our data collection approach elicited from the interviewees the connections between identified network functions and the specific barriers that networks report to address with their activities. We show these connections also in heat maps (Table 4).

Our results show that across the two sectors (see heat map in panel A), networks often report being active in *(III) knowledge sharing*: in most cases this is in response to personal and economic barriers and more infrequently to address political and cultural barriers. This function can include the use of educational facilities such as trainings on for example agro-ecological dairy production to increase personal knowledge (one of the personal barriers), but also sharing practical experience. Knowledge can also be shared with external stakeholders, through social media or newsletters: thus, knowledge sharing includes a wide range of activities which can be linked to various barrier types. *(IV) Facilitating collaboration and dialogue* is another often-reported function that networks perform in both sectors, although more in construction than in agriculture. This function also addresses economic and personal barriers, such as the lack of monetization for nature-inclusive benefits, and increasing the willingness to change by bringing together all stakeholders in the chain to discuss mutually beneficial options.

While the two network functions discussed above address multiple barriers, other network functions are aimed at alleviating just one type of barrier. The network function *(VII) realizing economic benefits* is

**Table 3**
Overview and description of seven network functions with an illustrative example, used to address barriers to NBS.

| Network function and description | Illustrative quote from the interview data describing this network function |
|---|---|
| **(I) Inspiring change**<br>Showcasing (good examples of) NBS, for example through guest lectures, exhibitions, events, campaigns, leadership training, case studies and rewards for frontrunners. | "We tell our story as much as possible. Through our own channels, but we also try to involve the media, for example through …. an event with real estate actors and people from the sector who we bring together to talk about this [greening building rooftops] together, share practices and discuss." *Representative of construction network* |
| **(II) Developing knowledge and expertise**<br>Engaging in research, carrying out monitoring activities, developing practical tools for members, sourcing scientific research questions, developing knowledge coalitions or investing money for research. | "We created a knowledge coalition, from different institutes, we have eleven now. These are two-way partnerships. We also approached eleven scientists and told them, we need to do something about this. We need to break out, so we are building our own consortium and research programs to contribute to this. It's a huge theme, we cannot do this by ourselves. The only thing we said is what we need to know, we need to organize ourselves. Therefore a knowledge consortium." *Representative agriculture network* |
| **(III) Knowledge sharing**<br>Networks share knowledge with relevant groups in society, e.g. through teaching programs, facilitating internships, giving trainings and workshops, communicating expertise through social media, websites and newsletters, organizing practitioner meetings and informing consumers. | "We work on training farmers ourselves, so the farmers that already work with us. New farmers are then trained internally by those farmers that are already there. To ensure that we have that knowledge we now have ….. specialists, so soil experts, pig farmers, vets, you name it. They support farmers to increase their knowledge level. We participate in all kinds of networks, to support our farmers to also increase their knowledge level. These are things we actively offer to them." *Representative agriculture network* |
| **(IV) Facilitating collaboration and dialogue**<br>Networks facilitate a safe space for collaboration and dialogue between different types of actors, for example across a value chain, supply and demand parties, science and practice, or even between networks. | "We can only do that from our strength and that is through storytelling and imagination. And by connecting by bringing all those partners together. And that they also inspire and influence each other in this. Of course, we ourselves are not builders, material developers … we have a very small, modest role, but try yes try to do that especially that way. " *Representative of construction network* |
| **(V) Community-building**<br>Networks engage in community building by bringing similar and like-minded actors together for mutual support. | "What we find important ….is stimulating solidarity regionally, nationally and internationally. The …network works from market gardens, but we are also active in setting up food cooperatives to make as much local food available as possible. That includes a national and international dimension. Also for those products we import from further away, how can we develop ourselves to make those relationships one of solidarity, as well? We're working on building a different type of community. Not on competition and lowest price, but on relationships, fair income, and solidarity. That is what we are building." *Representative agriculture network* |
| **(VI) Lobbying towards policymakers**<br>Networks allow actors to bundle their influence for lobbying policymakers on their cause, for example improving regulatory measures. | "We sent a letter at the end of 2019. That letter came from us and we received a lot of support. Kind of weird, that we as a mini-calimero organization need to be the ones to do such things, but anyway. Lobby and contacting members of parliament and all kinds of manifestos that fly around. And on the other hand we have developed our methodology that fits closely to our lobbying activity." *Representative of construction network* |
| **(VII) Realizing economic benefits**<br>Networks are used to realize economies of scale, collective buying power, crowdfunding, collective search for subsidies/funding and sustainability labels for increased market access. | "So we can kickstart the conversation with the investors about this. We also want them to jointly make a statement, for example by being transparent about the current status of the sector [on nature-inclusive building]. And then you can compare this to my urban heat stress map. And this way you can more quickly realize collective action. Undertake investment in the joint public space, instead of each one trying to make adjustment to their own buildings." *Representative of construction network* |

documented in both sectors, specifically to address economic barriers. The same applies to the function of *(VI) lobbying towards policymakers*, which is used very specifically to address political barriers (and occurs more often in agriculture than in construction).

The sector-specific analyses (see separate heat maps in Panel B and C) uncovers sector-specific patterns. In the **construction sector**, three network functions are most often used to address barriers to NBS uptake. In addition to the *(III) knowledge sharing* and *(IV) facilitating collaboration and dialogue,* construction networks also report to actively engage in *(I) inspiring change* (unlike agricultural networks), for example through providing examples of successful case studies, or offering leadership training which focuses on personal ambitions and how to achieve these. Such tools are used mainly to address economic and personal barriers that prevent a transition, but in some cases are also used to address cultural barriers in their sector, such as conservative mindsets.

Networks in the **agricultural sector** are more often engaged in *(II) developing knowledge and expertise* and *(VI) lobbying towards policymakers* than construction networks. The function *(II) developing knowledge and expertise* is used to address technological, cultural, economic, and political barriers. For example, monitoring local biodiversity is done by farmers in order to provide more insights into the costs and benefits of nature-inclusive farming and thus contribute to their monetization. In addition, the focus group discussion uncovered the need for developing expertise for place-based nature-inclusive farming, e.g., taking into account soil type and environment, a requirement for successful NBS. At the same time, developing knowledge and expertise was also aimed at understanding how to change (siloed) regulation for agriculture so that it can facilitate NBS implementation. The function *(VI) lobbying towards policymakers* addresses political barriers mainly: for instance, agricultural networks used meetings with, and letters to, government officials to address the lack of integral and meaningful policy concerning nature-inclusive approaches, and to influence policies and regulations.

Also, agricultural (but not construction) networks engage in *(V) community building* in response to sector-specific social barriers; for

**Table 4**
Heat maps indicating how often barriers and functions were matched. Panel A shows the count of the two sectors combined, Panel B shows construction, and Panel C shows agriculture. The first column shows the category of barriers, the second the total number of barriers mentioned in that category, the third the number of barriers mentioned without a network function and all further columns to which network function the barriers were matched. It is possible that a barrier that is mentioned by an interviewee is addressed by different network functions.

**Heatmap A: both sectors (construction and agriculture) combined**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 33 | 6 | 10 | 6 | 13 | 13 | 0 | 1 | 9 |
| Personal | 33 | 7 | 11 | 0 | 18 | 10 | 1 | 0 | 0 |
| Political | 27 | 9 | 1 | 2 | 8 | 1 | 0 | 13 | 0 |
| Social | 18 | 9 | 0 | 2 | 2 | 1 | 4 | 1 | 1 |
| Technological | 18 | 9 | 0 | 4 | 1 | 3 | 1 | 0 | 1 |
| Cultural | 21 | 6 | 2 | 5 | 6 | 2 | 0 | 1 | 1 |
| Total | 150 | 46 | 24 | 19 | 48 | 30 | 6 | 16 | 12 |

**Heat map B: Construction**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 19 | 3 | 8 | 3 | 6 | 10 | 0 | 1 | 5 |
| Personal | 16 | 4 | 7 | 0 | 7 | 5 | 0 | 0 | 0 |
| Political | 11 | 5 | 0 | 0 | 3 | 1 | 0 | 4 | 0 |
| Social | 7 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| Technological | 10 | 7 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| Cultural | 9 | 3 | 2 | 1 | 3 | 1 | 0 | 0 | 1 |
| Total | 72 | 26 | 17 | 6 | 21 | 19 | 0 | 5 | 6 |

**Heat map C: Agriculture**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 14 | 3 | 2 | 3 | 7 | 3 | 0 | 0 | 4 |
| Personal | 17 | 3 | 4 | 0 | 11 | 5 | 1 | 0 | 0 |
| Political | 16 | 4 | 1 | 2 | 5 | 0 | 0 | 9 | 0 |
| Social | 11 | 5 | 0 | 0 | 1 | 1 | 4 | 1 | 1 |
| Technological | 8 | 2 | 0 | 4 | 0 | 1 | 1 | 0 | 1 |
| Cultural | 12 | 3 | 0 | 4 | 3 | 1 | 0 | 1 | 0 |
| Total | 78 | 20 | 7 | 13 | 27 | 11 | 6 | 11 | 6 |

example, they collectively handle pressure by mainstream farmers – to not change – and they set up local networks for food pick-ups by citizens. For networks in the agricultural sector, *(III) knowledge sharing* is clearly the most important network function followed by *(II) developing knowledge and expertise, (IV) facilitating collaboration and dialogue* and *(VI) lobbying towards policymakers*.

Importantly, our results are also able to show that about one-third of the mentioned barriers identified by the networks' representatives are left unaddressed. Unaddressed barriers are spread across categories, with some differences. For the construction sector roughly half of the mentioned social, technological, and political barriers are not addressed by the networks. For the agriculture sector mainly social barriers are left unaddressed: almost half of the mentioned barriers were not addressed by the networks.

## 5. Discussion and conclusion

While the importance of networks for addressing barriers to sustainability transitions (Loorbach et al., 2017), including nature-based sustainability transitions (Tozer et al., 2022) has been acknowledged, what role networks exactly play in addressing these barriers is not clear. A comprehensive overview of network functions and what specific barriers they address is missing in the NBS and transition literature. In our study, we shed light on this role of networks for both the urban and rural context. Using a qualitative approach we identify barriers experienced by 16 networks in the Dutch agriculture and construction sector and gain an in-depth understanding which networks functions help to overcome these barriers. Our findings show there are seven different functions through which networks address six specific barrier categories.

The first function, *(I) inspiring change*, links to the work of Engwall et al. (2021) who show that networks claim space in a future transition. It also relates to the agenda-setting role of networks that has been highlighted in the context of public–private partnerships (Runhaar & Polman, 2018; Visseren-Hamakers, 2013). The second function *(II) developing knowledge and expertise* has been identified by transition

scholars (Sol et al., 2018; Tziva et al., 2021; Westley et al., 2011) as well as function three, *(III) knowledge sharing* (Tziva et al., 2021), also referred to as access to knowledge (Engwall et al., 2021; Planko et al., 2019). Planko et al. (2016; 2017) also show the importance of collaborative marketing to raise user awareness. The fourth function *(IV) facilitating collaboration and dialogue* aligns with research that shows that networks can help to create a safe environment, like a protected niche space (Schot & Geels, 2008) to enable small scale testing (Engwall et al., 2021) or supportive discussions (Bos & Brown, 2012; Wutich et al., 2020). These first four network functions can be considered *broad* network functions as they typically address multiple barrier types.

The fifth function of *(V) community building* confirms the idea that by collaborating in networks, communities are established (Bos et al., 2015) and support for specific solutions is created (Bos & Brown, 2012; Wutich et al., 2020). Scholars also showed that networks can intervene in the policy process by function six, *(VI) lobbying towards policymakers* (Runhaar & Polman, 2018; Tziva et al., 2021) and through involvement in the development of policy and legislation (Planko et al., 2016; Sol et al., 2018). Finally, earlier research highlighted the relevance of the seventh network function *(VII) realizing economic benefits* (Nuhoff-Isakhanyan et al., 2017). Specifically, scholars refer to the cost-effectiveness of resource sharing and co-creation (Engwall et al., 2021; Planko et al., 2019; Planko et al., 2016) and the benefits that can be obtained by mitigating externalities (Punt & Wesseler, 2018). The latter three network functions are *targeted* network functions aimed at alleviating one specific type of barrier.

The key finding of our paper, however, is that we also show *how* (i.e. through what functions) network address specific NBS barriers, offering a systematic analysis of network function – barrier connections. With respect to the broad network functions our study shows that in both sectors *(III) knowledge sharing* is the most often mentioned network function, and that it is mainly used to address economic and personal barriers and to a lesser extent also political and cultural barriers. Economic and personal barriers are also addressed by means of *(IV) facilitating collaboration and dialogue* (both sectors) and by *(I) inspiring change* (more often in the construction sector). *(II) Developing knowledge and expertise* (more often used in the agricultural sector) addresses all categories, with the exception of personal barriers.

For the targeted network functions results show that *(VII) realizing economic benefits* is used to address economic barriers (both sectors), *(VI) lobbying towards policymakers* to address political barriers (more often used in the agriculture sector) and *(V) community building* to address social barriers (not used in the construction sector).

Although a large part findings are applicable to both sectors and thereby to both the urban as well as rural context, some are sector-specific. There are a number of potential explanations for these more sector-specific findings. First, the two sectors differ in how they are structured and operate. For example, whereas the Dutch construction sector is dominated by one person companies and a few very large companies, agriculture has mainly small companies up to 5 people. Similarly, the added value of the construction sector in 2021 was 130,543 million euro whereas it was 34,915 million euro for agriculture (Centraal Bureau voor de Statistiek, 2022a, 2022b). Moreover, in Dutch agriculture there is a long tradition of cooperation through farmer cooperatives to generate economies of scale as well as environmental cooperatives to navigate Dutch environmental policy and agri-environmental schemes (Termeer et al., 2013). This for instance explains the importance of *(V) community building* for the agricultural sector.

Second, both sectors may be in a different phase of or have a different view on nature-based sustainability transitions. As a consequence, these sectors might perceive different barriers as more pressing and therefore, use different network functions (e.g., *(III) knowledge development* in the agricultural sector, and *(I) inspiring change* in the construction sector).

### 5.1. Theoretical implications

We advance the understanding of the role of networks in nature-based sustainability transitions by providing a coherent understanding of network function – barrier combinations. While we know that NBS face key barriers (Dorst et al., 2022; Sarabi et al., 2020; Sarabi et al., 2019) and that networks can play an important role in addressing (some of) them (Tozer et al., 2022), literature did not capture sufficiently the exact role of networks. Whereas previous studies focused on the role of actors in sustainability transitions such as intermediaries (van Lente et al., 2020) or entrepreneurs (van Doren et al., 2020) or key stakeholders and their network positions within environmental planning processes in the context of NBS (Mitincu et al., 2023), or on the importance of collective system building and networks in transitions (Khan, 2013; Musiolik et al., 2012; Planko et al., 2016; Planko et al., 2017) our study complements this literature and unravels the role of networks by identifying seven network functions. The key contribution of our paper is that we show through what functions networks address specific NBS barriers. This overview of network function – barrier connections can also be used strategically to alleviate specific barriers and allow networks to better allocate their resources to transition towards NBS, supporting nature-based sustainability transitions in both urban and rural areas.

### 5.2. Practical implications

Our results and contributions can help networks aiming to support a nature-based sustainability transition become more effective by understanding (1) what barriers their sector faces and (2) what roles (functions) they can take up to address specific barriers. In particular, when networks have to choose what to do with limited resources, they can strategize to carry out certain activities rather than others, depending on what they perceive as the main barriers that are preventing a transition.

Furthermore, our overview shows which barriers networks are currently *unable* to address, which can inform networks' strategies (e.g., rethinking their activities to try to address these bottlenecks) or may trigger/call for activities by other organizations, like governments, NGOs, citizens and/or research institutes, to complement the capabilities of networks in the sector. Our paper can also inform public authorities who may also choose to strategically 'fill the gaps' that networks cannot take up, such as the technological barriers that a sector faces.

Because our research spans two different sectors, agriculture, and construction, both working on a nature-based sustainability transition, we are able to show to practitioners that the roles taken up by networks is not one-size-fits-all but should consist of a well-considered approach in response to sector-specific barriers, encompassing both 'broad' and 'targeted' network functions.

Finally, our results imply that, in a sector, networks can also play complementary roles. To spend scarce resources of networks effectively, we suggest that networks in a specific sector map out the roles of other networks in the sector, to act in complementary ways, together addressing a broad set of barriers and supporting transformative change through parallel actions (Tozer et al., 2022). To support practitioners in applying our research results, Fig. 2 summarizes network functions – barrier combinations for both construction and agriculture in the Netherlands.

### 5.3. Limitations and future research

Our study provides several avenues for future research. First, we studied a limited number of networks in two sectors and our findings show that there are sector-specific findings. Future studies might focus on networks in different sectors such as textile and fisheries to improve the generalizability of our findings.

Second, we performed a static analysis resulting in insights into how

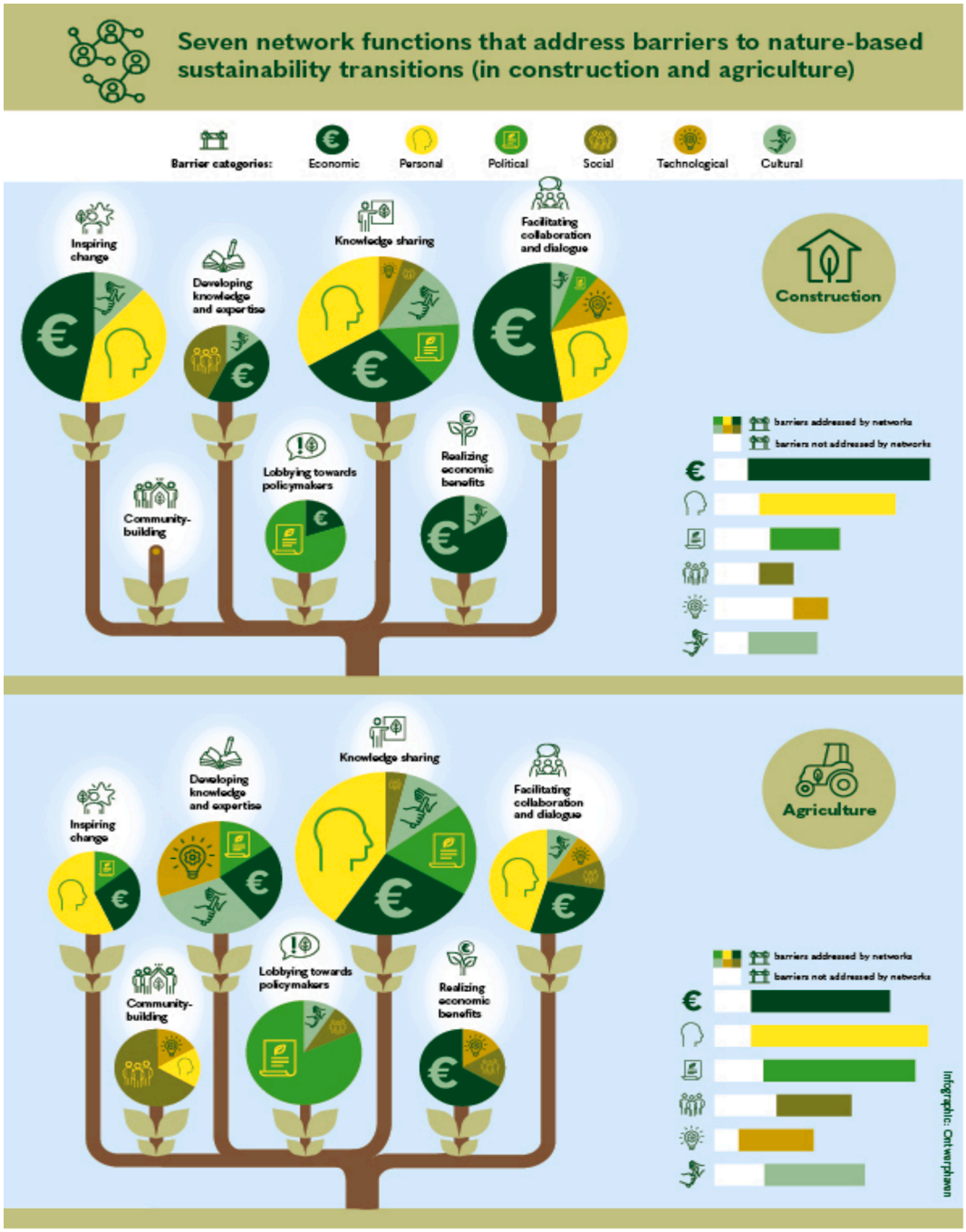


**Fig. 2.** Graphical summary of the network function-barrier combination and the barriers unaddressed by the networks for the construction and agriculture sector.

networks functions address NBS barriers. Future research could take a dynamic approach to identify if the relevance of barriers and functions change over time, in particular as the sustainability transition proceeds. In addition, it might be useful to delve deeper into the functions, which can be performed in various ways, e.g., different approaches to lobbying (letters, meetings) or share knowledge. We do, however, not explicitly take this into account in the analysis. Future research could focus on this by explaining their use change over time and which way is most effective when.

Third, in our analysis we focused on identifying networks functions that the respective networks fulfilled to overcome barriers. We do, however, not look at the specific network structure of these networks or governance used by the networks. Mitincu et al. (2023) for instance used social network analysis to identify positions of key stakeholders in collaboration networks in the context of NBS environmental planning process. In future research it would be interesting to study what network structures and/or governance would fit which network function(s) best.

Finally, our analyses of network functions in combination with barriers, revealed that networks are no silver bullets: there are ample barriers that they do not address, in particular technological, political (construction sector) and social barriers (both sectors). Future research could explore how unaddressed barriers can be addressed and by whom.

### 5.4. Conclusion

Given the importance of nature-based solutions (NBS) in both rural and urban areas in the transition towards sustainability, insight in how barriers to NBS uptake can be overcome is crucial. In this paper we

contribute a fine-grained understanding of how networks can address barriers by studying the empirical contexts of networks engaged in the Dutch agriculture and construction sectors. We find that networks possess four 'broad' functions that address multiple barriers: *(I) inspiring change* to address economic and personal barriers; *(II) developing knowledge and expertise* to addresses all categories, with the exception of personal barriers; *(III) knowledge sharing* to address economic and personal barriers and also political and cultural barriers; and *(IV) facilitating collaboration and dialogue* to address economic and personal barriers. Moreover we find that network possess three targeted functions that address a specific barrier type: *(V) community building* to address social barriers; *(VI) lobbying towards policymakers* to address political barriers; and *(VII) realizing economic benefits* to address economic barriers. The extent to which certain functions are being used depend on the sector as sectors differ in how they are structured and the barriers they face.

Even though networks help to overcome barriers to nature-based sustainability transitions, it is important to realize that networks do not address all barriers. Certain barriers, such as technological and political barriers in the construction sector and social barriers in both sectors are less addressed.

To conclude, we developed a coherent understanding of network function – barrier combinations that can be used strategically to alleviate specific barriers and allows networks to better allocate their resources to transition towards NBS, supporting nature-based transitions in both urban and rural areas.

*CRediT authorship contribution statement*

**Maryse M.H. Chappin:** Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Maarten J. Punt:** Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Helen S. Toxopeus:** Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Nina van Tilburg:** Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Cathy L. de Jongh:** Writing – original draft, Visualization, Formal analysis. **Hens A.C. Runhaar:** Writing – review & editing, Methodology, Conceptualization. **Godelieve H.J. Spaas:** Writing – review & editing, Methodology, Conceptualization.

## 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.

## Data availability

The data that has been used is confidential.

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## Appendix I:. Search terms used for literature review

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**Table A1**
Keywords considered synonym or encompassing NBS for agriculture and construction.

| NBS in agriculture | NBS in construction |
|---|---|
| Nature based agriculture | Nature based buildings |
| Nature inclusive agriculture | Nature based construction |
| Sustainable intensification | Nature inclusive buildings |
| Agroecosystems agroecology | Nature inclusive construction |
| Resilient agriculture | Green roofs |
| Farmer-managed public goods | |
| Climate smart agriculture | |
| Nature driven agriculture | |

## Appendix I. I: Alternative heat maps.

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**Table 5**
Heat maps of how often barriers and functions were matched. Panel A shows the count of the two sector combined, Panel B shows construction, and Panel C shows agriculture.. The first column shows the category of barriers, the second the total number of barriers mentioned in that category, the third the number of barriers mentioned without a network function and all further columns to which network function the barriers were matched.

**Alternative heat map A: both sectors combined**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 33 | 6 | 12 | 8 | 23 | 16 | 0 | 1 | 13 |
| Personal | 33 | 7 | 13 | 0 | 25 | 12 | 1 | 0 | 0 |
| Political | 27 | 9 | 1 | 2 | 8 | 1 | 0 | 18 | 0 |
| Social | 18 | 9 | 0 | 2 | 2 | 1 | 5 | 1 | 3 |
| Technological | 18 | 9 | 0 | 4 | 1 | 3 | 1 | 0 | 1 |
| Cultural | 21 | 6 | 3 | 5 | 8 | 2 | 0 | 1 | 1 |
| Total | 150 | 46 | 29 | 21 | 67 | 35 | 7 | 21 | 18 |

**Alternative heat map B: Construction**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 19 | 3 | 9 | 3 | 10 | 13 | 0 | 1 | 7 |
| Personal | 16 | 4 | 9 | 0 | 7 | 7 | 0 | 0 | 0 |
| Political | 11 | 5 | 0 | 0 | 3 | 1 | 0 | 7 | 0 |
| Social | 7 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| Technological | 10 | 7 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| Cultural | 9 | 3 | 3 | 1 | 5 | 1 | 0 | 0 | 1 |
| Total | 72 | 26 | 21 | 6 | 27 | 24 | 0 | 8 | 8 |

**Alternative heat map C: Agriculture**

| Network functions / Barriers | Total | None | (I) Inspiring change | (II) Developing knowledge and expertise | (III) Knowledge sharing | (IV) Facilitating collaboration and dialogue | (V) Community-building | (VI) Lobbying towards policymakers | (VII) Realize economic benefits |
|---|---|---|---|---|---|---|---|---|---|
| Economic | 14 | 3 | 3 | 5 | 13 | 3 | 0 | 0 | 6 |
| Personal | 17 | 3 | 4 | 0 | 18 | 5 | 1 | 0 | 0 |
| Political | 16 | 4 | 1 | 2 | 5 | 0 | 0 | 11 | 0 |
| Social | 11 | 5 | 0 | 0 | 1 | 1 | 5 | 1 | 3 |
| Technological | 8 | 2 | 0 | 4 | 0 | 1 | 1 | 0 | 1 |
| Cultural | 12 | 3 | 0 | 4 | 3 | 1 | 0 | 1 | 0 |
| Total | 78 | 20 | 8 | 15 | 40 | 11 | 7 | 13 | 10 |

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