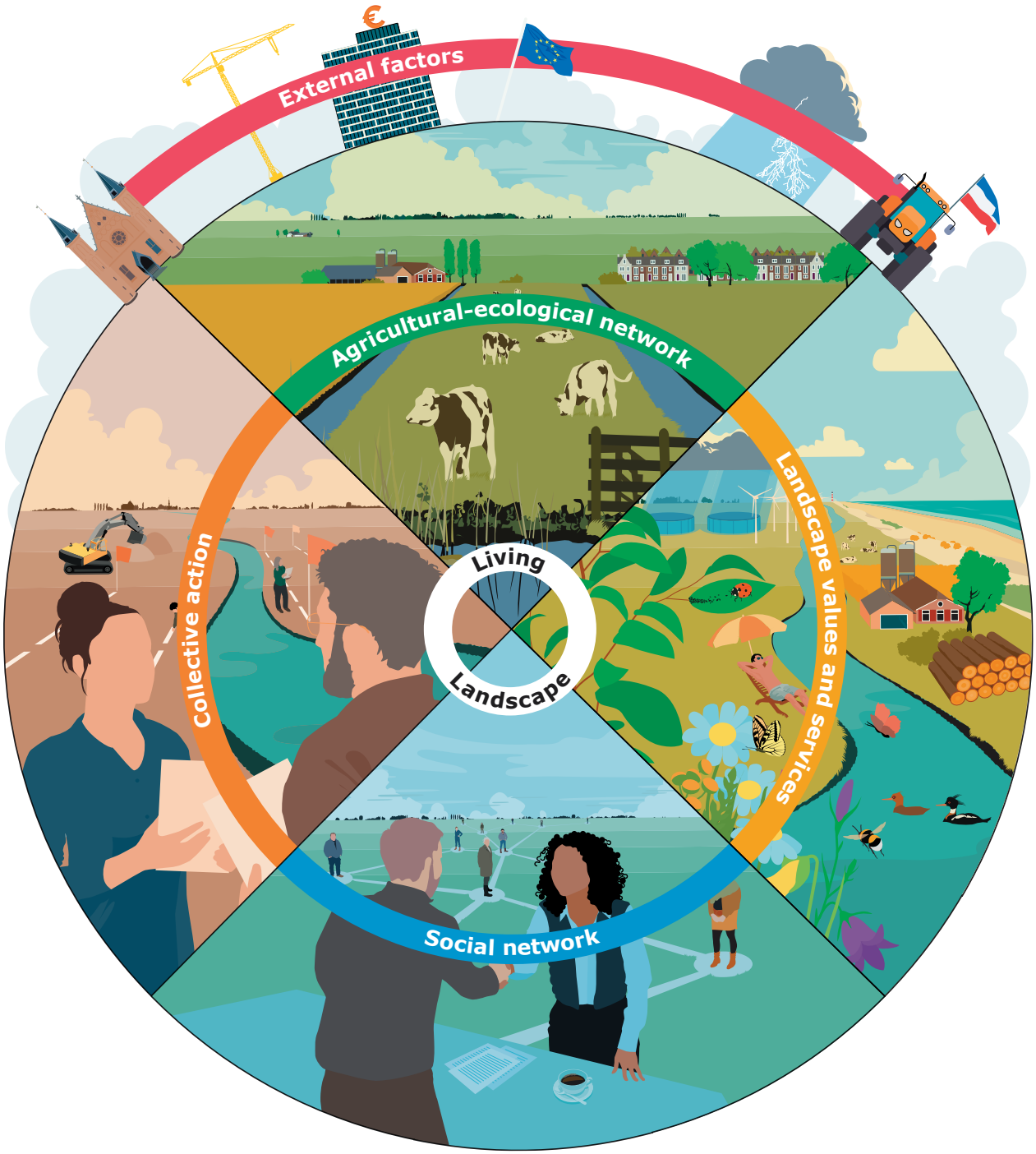

Living Landscapes (LiLa) assessment framework

Presenting a framework for evaluating & improving social-ecological functioning of agricultural landscapes

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Living Landscape assessment framework

Evaluating & improving the social-ecological functioning of agricultural landscapes

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Preface

The restoration of ecosystem quality, biodiversity, and the provision of ecosystem services in agricultural landscapes has gained increasing prominence in public and policy discussions. Landscape-level strategies are inherently complex due to the involvement of a diverse array of stakeholders with differing priorities and relationships to various land uses. This study aimed to contribute to socially and ecologically functional agricultural landscapes through the development of the Living Landscape (LiLa) assessment framework.

The LiLa assessment framework integrates concepts such as social-ecological networks, participatory change, and landscape services. It was developed by a multidisciplinary research team and tested in workshops with researchers from Wageningen University and Research and landscape professionals. The framework consists of five core elements: (i) the social network, (ii) collective action, (iii) the agricultural-ecological network, (iv) landscape services and values, and (v) external factors. For each element assessment questions are formulated to facilitate participatory assessment and reflection on the social and ecological functioning of a landscape. The framework was operationalised as a practical tool for stakeholders through the use of question cards, which can be used during workshop sessions.

This report represents the culmination of two years of collaboration among researchers from four institutes: Wageningen Plant-, Environmental-, Economic-, and Livestock- Research. Over the course of the project, we held numerous discussions during meetings and organised both internal and external workshops. We are pleased and proud that this report, along with other project outputs—such as the practice tool (available in English and Dutch) and a submitted scientific publication—represents the result of our shared motivation, dedication, and enriching collaboration.

Throughout the project, we collaborated with a large and diverse group of people. We are grateful to Jolanda van den Berg and Reina Ferwerda for their substantive contributions at the start of this project. We also thank all participants in the expert and case study workshops for their constructive feedback on the framework. Furthermore, we deeply appreciate the detailed feedback and constructive suggestions on the report from reviewers Vincent Linderhof and Theo van der Sluis. Finally, we extend our gratitude to the Wageningen University Knowledge Base program, KB36: Biodiversity in a Nature-Inclusive Society (project number KB-36-006-001), which is supported by funding from the Dutch Ministry of Agriculture, Nature, and Food Quality.

Summary

There is growing momentum in public and policy discourse to restore nature quality, biodiversity, and ecosystem and social services in agricultural landscapes. Re-designing these landscapes holds great potential to halt biodiversity loss while contributing to sustainable and resilient food systems. However, measures for restoring biodiversity often have limited effects when implemented on a small scale or in isolation. Compared to farm-level measures, landscape-level measures are more complex due to the involvement of numerous stakeholders with varying interests and stakes in different land uses. This complexity underscores the need for an integrated landscape approach that considers the needs and interests of all stakeholders.

Several approaches have been proposed to support landscape improvement efforts. However, many of these focus on a single goal, geographic area, or scale, lack participatory elements, or prioritiae either social or ecological aspects. To the best of our knowledge, no existing framework enables stakeholders to mobiliae and self-organiae for creating socially and ecologically well-functioning agricultural landscapes. This study aims to address that gap through the development of the **Living Landscape (LiLa) assessment framework**.

The LiLa assessment framework is designed to help stakeholders identify and assess ways to improve the social and ecological functioning of their landscapes. It builds on existing frameworks, tools, and concepts, including social-ecological networks, participatory change, and landscape assessment. Using these concepts the framework was further developed by the research team and validated through workshops with researchers and landscape professionals. The LiLa assessment framework for evaluating and improving social-ecological functioning of agricultural landscapes consists of five core elements: the i) **social network** of stakeholders, that can engage in ii) **collective action**, to influence the iii) **agricultural-ecological network**, to provide the desired iv) **landscape values and services** within the v) context of **external factors** that influence the landscape but cannot be changed in the short term. For each element a literature review was done to identify indicators and criteria for assessment. Reflection questions were also formulated to facilitate participatory assessment. These questions were operationalised into a workshop tool with downloadable question cards, designed to enable stakeholders to collaboratively evaluate and improve their landscapes. This tool can be downloaded via the Website or Research@WUR.

The LiLa assessment framework translates the theoretical foundations of social-ecological networks into a practical, participatory tool that empowers stakeholders to collaboratively assess and improve the functioning of their agricultural landscapes. Developed with input from internal discussions and external workshops with WUR researchers and landscape professionals, the framework is adaptable, applicable across diverse contexts, and can be customised to meet specific landscape needs. Its success depends on stakeholders' willingness to collaborate, but it is designed to incorporate diverse perspectives and objectives, facilitating participatory and inclusive landscape improvements.

At the time of finalising this report, a peer-reviewed paper based on this work has been submitted for publication. This report contains content that overlaps with the forthcoming manuscript, including some identical or closely related sections, figures, and tables. This statement is provided in the interest of transparency.

1 Introduction

1.1 Problem statement

There is increasing momentum in public and policy discourse to restore nature quality and biodiversity in agricultural landscapes (Westerink et al., 2017; CBD, 2022). Agricultural systems, at their core, are modified ecological systems designed for biomass production and are heavily dependent on ecological processes. However, agricultural land use is also one of the primary drivers of biodiversity loss worldwide (IPBES, 2019). Re-designing agricultural landscapes offers great potential to halt biodiversity loss and can also contribute to the creation of sustainable, resilient food systems.

Agricultural landscapes also play a crucial role in meeting a broad range of sustainability goals, such as enhancing landscape resilience to climate change, improving water and soil quality, preserving cultural heritage, and generating sustainable energy. Thus, landscapes should be viewed not only as physical (ecological or agricultural) entities but also as social phenomena.

Improving biodiversity, while also addressing other environmental and socio-economic goals that meet the needs of local communities and stakeholders, requires an integrated landscape approach. These approaches address the landscape scale, are interdisciplinary, social-ecological, and inclusive (Arts et al., 2017; Reed et al., 2022). Freeman et al. (2015) identified five main concepts that characterise integrated landscape approaches: multifunctionality, transdisciplinarity, participation, complexity and sustainability. Well-functioning landscapes contribute to both sustainability and fairness, implying that stakeholders must not only have a say in governance but also in the evaluation of their landscape.

A critical part of this integration is a process through which stakeholders can develop a shared understanding of the landscape's current state, the values and services it provides, and the conditions necessary to maintain these services (Sayer et al., 2013; Arts et al., 2017; Van Oosten, 2021). Furthermore, re-designing agricultural landscapes requires a landscape approach, as to include influences from the wider environment. It is well known that measures for restoring biodiversity can have limited effect when they are implemented at a small scale or in isolation (e.g. Westerink et al. (2017); Bianchi (2022)). Thus, farm-level measures for biodiversity are often insufficient, as the surrounding landscape largely determines their success. Compared to farm-level measures, landscape-level measures are more complex due to the involvement of a larger number of stakeholders with varying interests and stakes in different land uses. In short, an integrated landscape approach encompasses the broader interactions, interlinkages, and influences between socio-economic and ecological systems within a given landscape.

Existing frameworks for evaluating agricultural systems or landscapes based on ecological and/or social functioning are not suitable for integrated landscape approaches. These frameworks typically focus on farm-scale indicators, lack social or biophysical components, or do not assess the interrelations between ecological and social aspects. Moreover, to the best of our knowledge, current frameworks, tools, and concepts do not offer a way to use these indicators for participatory assessments of social and ecological functioning in agricultural landscapes. Therefore, the goal of this study was to develop an assessment framework for agricultural landscapes that addresses these gaps, drawing on existing frameworks and concepts.

1.2 Objectives and demarcation

The goal of this study was to contribute to socially and ecologically well-functioning agricultural landscapes by developing a framework that stakeholders can use to assess and improve the functioning of social and ecological components within their landscapes.

We defined a set of requirements and guiding principles for this framework, which we refer to as the Living Landscape (LiLa) assessment framework. The framework should support the development of socially and ecologically well-functioning landscapes by helping target users organize their landscape processes, with a bottom-up approach. Target users include citizens, farmers and farmers' groups, site managers, animal welfare organizations, nature and landscape conservation groups, water boards, provincial and local governments, NGOs, and applied researchers. The framework is specifically designed for use in rural landscapes, where agriculture is the dominant land use. Political analysis, including policy instruments such as monetization, subsidizing, and sanctioning, falls outside the scope of this framework.

We consider biodiversity both a prerequisite for and a producer of landscape services, which is why we address biodiversity and landscape services separately in the framework. Additionally, we recognise the intrinsic value of nature and biodiversity. Therefore, we find it important to account for their needs by inclusion of nature and landscape organisations in the process of evaluating and improving social-ecological functioning of landscapes. While the concept of landscape services is by definition anthropocentric and utilitarian, we emphasise the need to acknowledge the intrinsic value of nature and biodiversity. To reflect this, we use the terms "*landscape values*" and "*landscape services*." Here, "values" refers to the intrinsic worth of nature and biodiversity, while "services" refers to instrumental and relational values. Further details on our approach to landscape values and services are provided in section 3.5.

1.3 Report outline

In section 2, the methodology of the study is outlined. Section 3 presents the developed assessment framework. Section 4 discusses the development, applicability and limitations of the framework, followed by concluding remarks. In the Appendix, we first provide a review of existing frameworks, concepts, and tools. This is followed by an exploration of the barriers and opportunities for functioning landscapes in The Netherlands, offering additional context and input for the framework.

2 Methodology

This chapter outlines the development of the Living Landscape (LiLa) assessment framework. In section 2.1, we review existing frameworks, tools, and concepts. In section 2.2, we describe the development of the first draft of the assessment framework based on this review. Finally, in section 2.3, we explain the reviewing and optimization process of the developed framework.

2.1 Review of existing frameworks, tools and concepts

An assessment framework is described as a '*provider of a structured conceptual map'* of what needs to be assessed (Pearce et al., 2015). The objective of the assessment framework in our study is to "*assess and identify points of improvement for the functioning of social and ecological components of a defined agricultural landscape*." To begin, we conducted an inventory of existing approaches—assessment frameworks, evaluation tools, and concepts—that assess the social and/or ecological outcomes of agricultural systems or landscapes. Using expert knowledge from all research team members and following a snowball methodology, we selected 14 approaches. The team included experts from various domains: transition studies, economics, sociology, ecology, agronomy, and animal sciences.

Each approach was reviewed by individual team members, who answered a set of questions about its context, use, target user group, limitations, assessment criteria, scale, role of biodiversity, landscape values and services, and relevance to our framework. This review is available in Appendix 1, and a summary of the findings is provided in Table 1.

Several reviewed approaches proved valuable for developing the LiLa assessment framework. Based on the review and internal workshops with the research team, two approaches were selected as the foundation for our framework: the theory of social-ecological systems (SES) (Ostrom, 2009; Ostrom and Cox, 2010), and specifically, social-ecological networks (SEN) (Opdam, 2014; Barnes et al., 2017). These frameworks were chosen because they account for both ecological and social aspects, as well as their interrelations. This interrelation is crucial for assessing landscape functioning, as it is necessary to determine what needs to function and for whom.

SEN has primarily been used by researchers as a conceptual framework for analysing human-nature interdependencies (Bodin, 2023). It has proven useful in landscape planning for collaborative transformation with local stakeholders (Opdam, 2014). The SEN approach begins by creating a shared vision for the future, followed by defining the supply (through the landscape values and services concept) and demand (through workshops) for the landscape. Ultimately, it encourages local actors to work together toward this shared vision (Opdam, 2014). SEN aims to create a common language to facilitate communication within networks and with other communities, including scientists and local actors.

Table 1. List of the reviewed frameworks, concepts and tools and their use in the framework.

	Approach	Summary	Key references	Use in the LiLa framework
1	Social-ecological networks (SEN)	Landscape as social-ecological network. Social and ecological networks interact through landscape services and collective action.	Opdam (2014); Barnes et al. (2017)	Forms the base of the framework in terms of developing its structure and elements.
2	Social-ecological systems (SES)	Describes social and ecological systems as interrelated. Diagnostic of social dilemmas.	(Ostrom, 2009; Ostrom and Cox, 2010)	Inspired the selection of criteria of our framework.
3	Landscape Approaches	A range of approaches in research, planning and governance that consider the landscape level, the interactions between people and the environment, and different disciplines and scales.		Confirmed our use of the term landscape.
4	Landscape sustainability science	A framework for research and planning relating biodiversity to ecosystem services to human well-being.	Wu (2013); Wu (2021)	Inspired our cross-disciplinary approach.
5	Participatory Theory of Change (ToC)	Methodology to develop a Theory of Change with stakeholders for an area or a natural resource.	Reed et al. (2022)	Partly integrated in the element Collective action.
6	Ecoprofiles	Requirements of species groups in terms of habitat quality, size and connectedness.	Opdam et al. (2008)	Integrated in the element Agricultural-ecological network.
7	Multi-level perspective (MLP)	Considers niches, regimes and 'landscapes' in processes of socio-technical transition.	Geels (2004)	Included to look at stakeholders at different levels and at external factors that are beyond the local sphere of influence.
8	Tool for Agroecology Performance Evaluation (TAPE)	Assessment framework for agroecological farms and farming systems.	Mottet et al. (2020)	Elements and indices used as inspiration for our assessment criteria.
9	Agroecology Criteria Tool (F-ACT) and framework	Assessment framework for agroecological farms and farming systems.	Gliessman (2016); Barrios et al. (2020)	Elements and indices used as inspiration for our assessment criteria.
10	Critical performance indicators	Indicators for environmental performance of farms, mostly set at the level of environmental conditions (not species).	Van Doorn et al. (2021); Baayen et al. (2022)	Elements and indices used as inspiration for our assessment criteria.
11	Landscape services	Alternative conception of ecosystem services: benefits from nature to people provided by the landscape.	(Termorshuizen and Opdam, 2009); Opdam (2019)	Fully integrated concept.
12	Circularity	Considers the flows of materials (such as biomass), nutrients (such as nitrogen) and energy to retain those as much as possible within the defined system, in order to reduce losses and emissions.	Jurgilevich et al. (2016); De Boer and van Ittersum (2018); Muscat et al. (2021)	No concrete use in framework.
13	Nature-inclusive agriculture	Forms of agriculture that combine taking care of nature with using ecosystem services and reducing negative impact on nature.	Van Doorn et al. (2016)	No concrete use in framework other than inspiration.
14	Bee Landscape	Social-ecological design principles for landscapes that support pollinators.	Van Rooij et al. (2021)	Used as inspiration for the operationalisation as a tool.

2.2 Establishing a draft LiLa assessment framework

Based on the review of existing approaches and the selection of SES and SEN as foundation for the assessment framework (section 2.1), a draft framework was developed through internal workshops with members of the research team. This draft framework incorporates the main elements of SEN, namely the social network and the ecological network. However, the research team introduced additional elements to the framework to connect the social network and ecological network. Furthermore, since SEN does not provide a direct method to assess and improve the ecological and social aspects of the landscape, the research team added specific indicators to operationalise SEN within the framework.

The dynamics between the social network and the ecological network are central to the SEN, and we concluded that "*collective action*" is a relevant concept to link the actions of the social network to the ecological network. Collective action refers to individuals coming together to achieve common goals (Schlager, 1994). We consider collective action essential in the governance of landscapes (Bodin, 2017). Ostrom (2009) developed varying indicators associated with collective action that were used as inspiration for the indicators in this framework (see section 3.2). Furthermore, we included participatory creation of goals since such an approach can aid in organizing the collective and improve the landscape towards the goals (Reed et al., 2022). The elements of the LiLa assessment framework "*social network*", "*collective action*" and "*agricultural-ecological network*" are elaborated on in sections 3.2, 3.3 and 3.4 respectively.

In reviewing the SEN literature, we found that adopting the *ecosystem services* concept can help actors organise collective action in a way that enables their landscape to provide the ecosystem services that they desire (Opdam et al., 2015; Opdam et al., 2015; Opdam, 2016). We incorporated ecosystem services into the LiLa assessment framework in the element of "*landscape values and services"* (section 3.5).

In addition to viewing the landscape as a social-ecological network, we discussed the need to incorporate the context into the analysis, as it influences the extent to which a landscape can be altered. The landscape is embedded within broader national or global policies, economics and culture. Our initial attempt was to apply the multi-level perspective theory (Geels, 2011), but we found that the broader socio-economic drivers in which we were interested in were challenging to assess using analytical conceptual theory. To better incorporate landscape context (i.e. factors beyond the direct influence of stakeholders) into the LiLa assessment framework, the element "*external factors*" was included in the framework (section 3.6).

After the research team selected the five main elements of the draft assessment framework (social network, collective action, agricultural-ecological network, landscape values and services, and external factors), smaller multidisciplinary teams identified the subcomponents and indicators relevant for each element of the framework. In this process, the teams used indicators from earlier assessment frameworks and evaluation tools (Table 1), as well as new literature sources (section 3). Afterwards, the team reviewed each other's work and refined the list of elements based on expert knowledge. This process resulted in a set of assessment questions for each core element of the draft LiLa assessment framework (Tables 2 to 7 in sections 3.2-3.6).

2.3 Review and optimisation of the LiLa assessment framework

The draft assessment framework was presented in an internal workshop with Wageningen University & Research colleagues from diverse scientific backgrounds, including (landscape) ecology, soil management, agronomy and economics. The core elements of the framework were discussed in four rounds with smaller groups, using the following evaluating questions:

1. What is your overall opinion of the framework?
2. Are any elements or indicators missing from the framework?
3. What should be removed from the framework?
4. What (contextual) factors are important for determining why it is difficult to achieve functioning landscapes, and explain why functioning landscapes are uncommon?

The input from the internal workshop was incorporated into the assessment framework by the research team.

After incorporating the feedback of the internal workshops discussing the draft assessment framework, the assessment framework was tested in three Dutch case studies focused on biodiversity restoration. In these case study workshops, researchers and landscape professionals applied the assessment framework to their agricultural landscapes, and reflected on its applicability, providing feedback that was subsequently incorporated into the assessment framework. In preparation for these workshops, the academic language of the questions and explanation was simplified in multiple rounds based on participants' feedback.

In addition to the steps mentioned above, the research team explored the barriers and opportunities for well-functioning landscapes, using the Netherlands as a case study. Relevant literature was consulted and summarised in appendix 2. The results of this exploration was used as an input to the "external factors" element of the framework (3.6).

3 LiLa assessment framework

In this chapter, we describe the main elements of the LiLa assessment framework (section 3.1) and elaborate on each element in subsequent sections (3.2 – 3.6).

3.1 Main elements of the LiLa assessment framework

In the LiLa assessment framework, we conceptualise landscapes as social-ecological networks. The five main elements are: i) social network, ii) collective action, iii) agricultural-ecological network, iv) landscape values and services, and v) external factors (Figure 1). The first four elements together form the *landscape*. In brief, a functioning *social network* engages in *collective action* to influence the *agricultural-ecological network*, thereby providing the desired *landscape values and services*. *External factors* refer to influences from outside the landscape that cannot easily be changed in the short term. The following sections provide a brief explanation of each of the five elements.

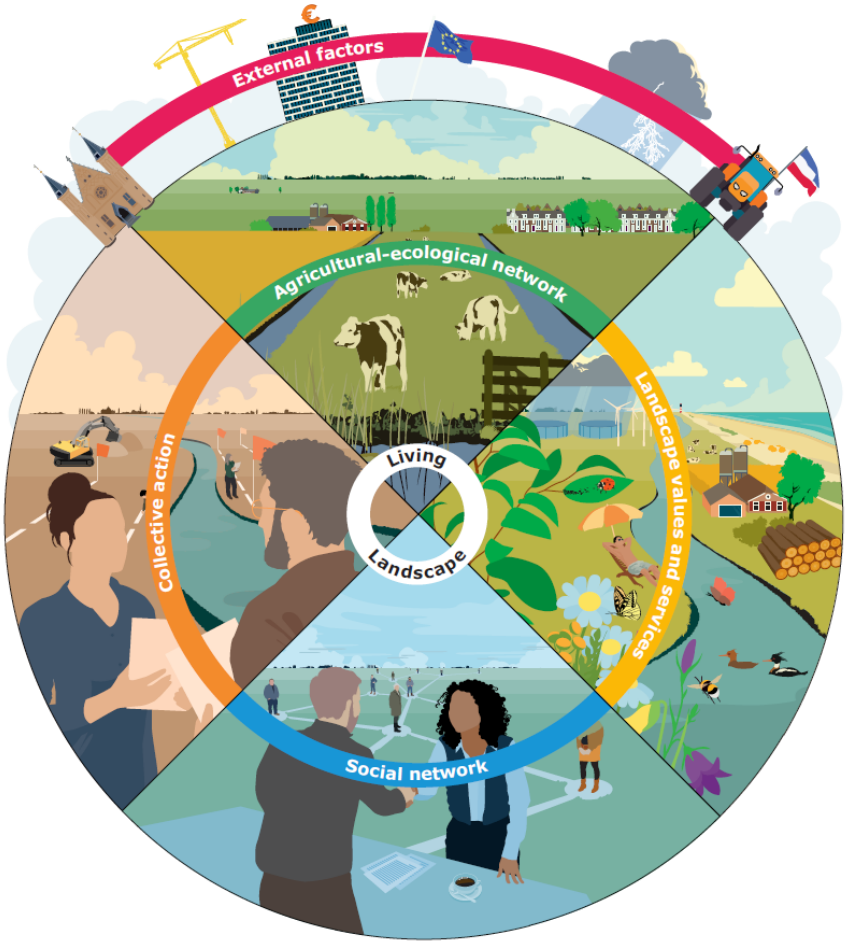

Figure 1. A visual representation of the assessment framework showing the five elements.

Effective improvement of a landscape requires a well-functioning *social network*, which is characterised by its ability to mobilise and self-organise around goals in a way that is flexible, responsive and effective. The social network is evaluated based on the types of stakeholders involved, their connections and the quality of these relationships (see section 3.2).

To optimise landscape values and services, the social network adapts the agricultural-ecological network through *collective action*. Collective action is a participatory process of self-organisation by the social network to achieve common goals (Reed et al., 2022). Self-organisation can be described as the process of coming together in a group in a decentralised way, on the basis of collectively agreed rules for decision-making. Furthermore, in collective action, a theory of change approach is used to identify shared goals and the steps needed to achieve them (see section 3.3).

For collective action, the social network agrees on measures to modify the *agricultural-ecological network*. We chose the term "agricultural-ecological network" instead of the original "ecological network" to better suit the scope of our framework which is agricultural landscape and their relevant stakeholders. The agricultural-ecological network consists of different elements, such as agricultural fields, watercourses, landscape features, animal and human populations, buildings and infrastructure. It is assessed based on its structure, management, quality, and biodiversity. Its structure is defined by land use types, spatial diversity, scale, and connectedness of elements within the landscape. Management and quality are evaluated based on how the landscape elements are managed, which determines their quality for biodiversity and landscape services. Biodiversity indicates the ecological quality of a landscape but is also an output of the landscape and in itself a prerequisite for delivery of landscape values and services (see section 3.4).

The agricultural-ecological network provides *landscape values and services* to beneficiaries within the social network. We included 'landscape values and services' in the assessment framework because expressing and describing the relevance of the landscape to (and by) society is essential for participatory planning (Termorshuizen and Opdam, 2009). Here, we predominantly use the term "landscape services" instead of "ecosystem services" to emphasise our focus on interdisciplinary and participatory landscape planning (Termorshuizen and Opdam, 2009). An important advantage of the term landscape services in planning is that the term "landscape" has a clear spatial connotation (Bastian et al., 2014). It is also suggested that people can connect more easily to "landscape" than to "ecosystem" as the term landscape is frequently used in various domains (Termorshuizen and Opdam, 2009). Furthermore, landscape values and services are related to cultural services and other non-monetary values of the landscape (Van der Sluis et al., 2019). We qualitatively assessed landscape values and services based on their diversity, quality, and security, and not on their monetary value, as the latter would require significant resources, and lacks consensus on the quantification methodc(see section 3.5).

The element "external factors" was added as the fifth element of the LiLa assessment framework based on input from the case study workshops. Contextual aspects to be assessed include business models, policy and regulations, knowledge availability, and technological developments (see section 3.6).

For each of the five elements of the LiLa assessment framework, a literature review was conducted to identify the most important components (variables, criteria) that influence the functioning of the element. The research team translated these variables into reflection questions for participatory assessment. Sections 3.2 (social network), 3.3 (collective action), 3.4 (agricultural-ecological network), 3.5 (landscape values and services), and 3.6 (external factors) describe the results of the literature review. Each section concludes with a table, describing the most important elements from the literature review, the associated variables, and the reflection questions. These tables form the basis for assessing and evaluating the social-ecological functioning of agricultural landscapes in a participatory manner. The practice tool is introduced in section 3.7.

3.2 Social network

3.2.1 Introduction

The complexity of most ecological systems is mirrored by complex social dynamics, and these social contexts must be considered to understand how landscapes can be governed justly for all members of society (Crona et al., 2011; Westerink et al., 2017; Van Oosten et al., 2018). In the LiLa assessment framework, we assume that the formation of a well-functioning social network is essential for fostering collaboration and collective action, which can lead to local, self-organised landscape governance (Lauber et al., 2008; Mills et al., 2014). However, simply establishing collaboration is not enough to address complex environmental challenges. This

section, therefore, explores when and how collaboration within social networks is effective in generating collective action for landscape governance.

A social network can be described as a "set of relations that apply to a set of social entities" (Prell, 2011). This section presents indicators related to the *structure* and *quality* of the social network, which we consider crucial network's ability to generate collective action. However, as argued by Lauber et al. (2008), the different characteristics of networks, while serving diverse purposes and functions, highlight the need to tailor local strategies for forming effective social network structures that result in high-quality networks.

When discussing social networks, it is also important to consider the concept of social capital. The concepts of social networks and social capital are closely related. Some authors view social networks as part of social capital (Dasgupta and Serageldin, 2000) while others see social capital as describing the relationships within the network. We follow Putnam et al. (2004), who define social capital as relationships of trust embedded within social networks. Thus, we conceptualise social capital as an attribute of a social network that informs the network's quality. According to Putnam et al. (2004), this means that action can be enabled whenever relationships of trust are embedded in the social network. Conversely, social capital can be built through collaboration (Van Dam, 2016). Additionally, we assume that "network structures can create enabling conditions for the mobilization of social capital within communities and for people to feel empowered to act" (Dale and Sparkes, 2008). Thus, we recognise that forming a social network requires social capital, while social capital can also be created and strengthened within the social network.

In essence, social capital refers to the relationships within and between social groups and the nature of those relationships. Three mechanisms of social capital can be distinguished: bonding, bridging, and linking. Bonding social capital occurs *within* a group or community, while bridging social capital happens *between* social groups. Linking social capital describes relationships at different levels of power, such as between a citizen and a government official (Claridge, 2018). Social capital can be seen as a resource used by members of a social network (Ostrom, 2009) and as a way to conceptualise intangible resources, such as shared values or trust within a community (Field, 2016). Ostrom (2000) stresses that social capital, unlike physical or economic capital, cannot easily be constructed through external intervention. Building social capital can be facilitated through physical capital, such as by providing sufficient organisational structures, but local knowledge is essential in its development.

3.2.2 Structure

A social network consists of nodes and ties. Nodes represent various actors, while ties are the relationships between these nodes. The network's structure is determined by its composition, including nodes and ties, as well as by its embeddedness. In other words, by internal factors and external environmental factors that affect the network.

Composition of the network

- Group size: The group size of the network defined as the number of nodes and ties (Hahn et al., 2008). According to Ostrom (2019), the size of the network is always important. However, its impact on the success of the network, and its capability to self-organize for collective action, depends on other variables within the social-ecological system (Poteete and Ostrom, 2004). For example, involving more actors in the network allows more resources to be mobilised for collective action. On the other hand, increasing group size can reduce the chances of successful collective action due to fewer opportunities for frequent interaction, which can negatively affect trust within the network (social capital). When group size becomes too large, smaller subgroups with a specific focus may form to maintain a strong network structure, resulting in specialised subgroups distinct characteristics and purposes (Table 2, Q2).
- Heterogeneity, diversity and inclusion: In addition to the number of nodes, it is also important to consider the heterogeneity of nodes, or the number of different types of nodes. Poteete and Ostrom (2004) argue that, like the group size, the level of heterogeneity in the network can have both positive and negative effects for the success of the network. Although sharing important characteristics can be a basis for trust between the actors in the network and therefore may prevent internal conflicts, a diversity of different actors in the network can also increase the legitimacy of the network by appealing

to a broader audience, representing multiple diverse perspectives and experiences (Poteete and Ostrom, 2004). According to Van Rooij et al. (2021) diversity in the network can also decrease its vulnerability. In addition, Prager et al. (2012) argue the need for different types of knowledge to be brought together in the social network. This will result in opportunities for joint learning, as well as developing plans for landscape governance in a collective manner. Hereto a diversity of both producers and beneficiaries of landscape values and services needs to be engaged, ensuring that the land can be used in multiple ways for all the different perspectives that are represented in the network, while also providing the landscape values and services that are demanded by different actors in the network (Prager et al., 2012). Inclusion is specifically focused on the network's relation to its environment. The concept of inclusion is based on the idea that all who are affected by the landscape should have the possibility to be involved in decision-making processes that influence the landscape (Prell, 2011). Inclusion thus concerns whether all relevant actors are involved in the network, and whether the network is accessible for possible new participants. This means that both providers and beneficiaries of certain landscape values and services should be included in the social network and in particular those that are currently not involved in the decision making (e.g. citizens) (Westerink et al., 2017). The issue of inclusion was also raised during our internal workshop. A participant mentioned that people who are not interested in landscape governance may not participate in a network that aims to generate collective action for landscape governance. However, without knowing, this actor may be a beneficiary of the landscape services. This is also connected to the idea that the goal of landscape governance may determine who should be included in the network, as different actors may need to get involved for different issues (Table 2, Q3).

- Centrality: Centrality is a key concept in social network analysis, referring to the position of certain actors in the network in terms of their level of centrality. There are multiple concepts that feature different types of centralities in the network. These concepts are degree centrality (the number of immediate contacts an actor has in the network), eigenvector centrality (the sum of an actor's connections to other actors, weighted by those other actors' degree centrality), betweenness centrality (the number of times an actor functions as the shortest path between two actors) and closeness centrality (the number of intermediaries that need to be passed to reach a certain actor). These concepts thus encompass the integration of an actor in the network, whether an actor is connected to other central actors, the potential control an actor has over the flows of information, and the distance between actors (Prell, 2011). Centrality is therefore closely connected to power: the ability of certain actors to influence the behavior, actions and decisions of other actors within the social network. Understanding and managing power relations in the network is crucial for equal, informed and effective decision-making, and for successful collective action (Table 2, Q4).
- Network density: Network density refers to the number of actual connections in the network compared to the total possible connections. In other words, network density is the ratio of actual connections to the total possible connections in the network (Bodin and Crona, 2009). According to Lauber et al. (2008) low network density may give space to different types of knowledge and capacity. On the other hand, "high density interactions help facilitate trust, make collective memory and experiences accessible, and provide buffering capacity in case actors are lost" (Lauber et al., 2008) (Table 2, Q4).

Embeddedness of the network

- Open vs. closed network: This includes whether the network is considered an open or a closed network (Dale and Sparkes, 2008). A closed network means that the network consists of a closed circuit of nodes and ties, where ties of information, trust and common goals are shared among members of the networks, but not necessarily with actors outside of the network. In an open network structure, direct information flows to and from the outside of the network are more easily facilitated. This characteristic of the network has consequences, as open networks facilitate the assimilation of new thinking, people and diverse values, whereas closed networks enable efficient establishment of shared norms but restrict entry of new ideas or members with different values or beliefs (Table 2, Q5).
- Bridging and linking ties: Whether the network is open or closed links to the importance of bridging and linking ties with actors outside the network and other networks in general. According to Barnes-Mauthe et al. (2015) individuals whose ties bridge different social groups gain access to diverse information and resources, increasing their opportunities for action. The same goes for linking ties that link actors at different hierarchical levels: they can provide access to a diversity of information and resources at different scales and levels of power (Barnes-Mauthe et al., 2015). In addition, other

regional or local networks may exist that focus on the governance of the landscape. It is important to check how these different networks relate to each other, and it may be beneficial to connect and work together where necessary and possible to see how these networks can reinforce each other. Alignment of networks should take place at organizational and management level; overlap in people alone is not sufficient. It is possible that networks will move towards each other and even merge, because they pursue the same goals. However, different networks with overlap in their objective(s) can also coexist perfectly well. An exchange of information and cooperation can enhance the effectiveness of the networks (Van Rooij et al., 2021) (Table 2, Q6).

3.2.3 Quality

We see that certain factors contribute to the quality of the network. These factors may very well be (in)directly resulting from the structure of the network.

- Strength of ties: Tie strength can be described as the intensity of the relationship between actors (Barnes-Mauthe et al., 2015). Tie strength is associated with social capital: generating trust, facilitating information exchange, providing key resources and social support, and enhancing productivity (Granovetter, 1973; Barnes-Mauthe et al., 2015). Although it seems obvious that strong ties improve the ability of the network to generate collective action, it can also lead to a strong sense of otherness, negatively influencing bridging and linking ties (Baycan and Öner, 2023). The quality of the network depends on the strength of different types of ties in the network. The strength of a specific relationship can be characterised by the frequency of interaction and the reciprocity of the interaction (Barnes-Mauthe et al., 2015). If the different types of ties are, for example, characterised by ties of information, ties of trust and ties of common goals (as distinguished by Borg et al. (2015)), then we determine the strength of each of these ties by the frequency of interaction and reciprocity of interaction. Other categorizations of types of ties are, for example as explained by Lauber et al. (2008), divided in exchanging ideas, disseminating knowledge, providing funds, providing other tangible resources, and exerting influence (Table 2, Q7).
- Participation and empowerment: Another factor for the quality of the network involves the ability of network actors to participate in the network. This can be determined by the frequency of participation of an actor in the network, its access to decision making processes and its access to information in the network. An important factor to consider when discussing participation in the social network is that only offering the opportunity for participation may not lead to participation of actors in the network: they also need to actively take up this opportunity to participate in the network (Stringer et al., 2006). For this, empowerment of actors is needed. Empowerment is an important factor for the functioning of the social network, due to its potential to further enhance participation, ownership and effectiveness in collective action for landscape governance. When actors in the network feel empowered, they are more likely to actively engage in the network and in further collective action phases, contributing their knowledge and perspectives, and taking responsibility for the stewardship of their local landscapes. Empowerment encourages active participation in decision-making processes and it gives actors the courage and confidence to share their insights, which can lead to better informed decision-making (Table 2, Q8).
- Leadership: Moreover, the organization of leadership in the network also determines its quality. It is important that certain actors in the network possess leadership skills, have access to resources and have (political) influence to secure funds (Lauber et al., 2008). This means that the network needs (a) key figure(s) with a personal drive to connect network participants, internalise the shared goals, and further develop the network to prepare for collective action (Van Rooij et al., 2021). According to Bodin (2017), this should be a network actor that employs a central position in the network. Leadership carried out by a network actor who bridges otherwise disconnected actors positively impacts mutual trust. However, leadership and decision-making power concentrated in one central network actor can also have long-term negative effects, limiting individuals' access to sources of information and preventing diverse knowledge from being incorporated into the decision-making process (Crona et al., 2011). This thus links to the composition of the social network and its degree of hierarchy and centrality (Table 2, Q9).
- Capacity to learn and knowledge production: Learning capacity in a social network refers to the ability of individuals and groups within the network to acquire, share, and apply knowledge and information. This plays an essential role in facilitating collective action and informed decision-making. Social

networks, especially those targeting to work on complex environmental problems in landscape governance, should facilitate collective learning. This involves sharing experiences and engaging in collective deliberation. This requires a diversity of actors that can draw from a range of knowledge domains and expertise (Bodin, 2017). According to Crona et al. (2011), networks provide access to novel information and influence the ways in which information is being processed. Access to information relies on the communication with other network actors, and is thus influenced by the strength and types of network ties (Table 2, Q10).

3.2.4 Reflection

We reflected on the list of variables in Table 2, and came to three general conclusions. First, the variables can be used to assess and improve the functioning of an existing social network. Second, building on Bouwma et al. (2022), the variables can be used to efficiently and effectively help build a new social network. And third, we identify five key variables essential for a social network drive effective collective action in landscape governance. These key indicators include leadership, strength of ties (particularly trust), heterogeneity, diversity and inclusion, and participation and empowerment.

Table 2 Self-assessment questions in the LiLa framework to qualitatively evaluate the social network of a landscape, based on literature review in 3.2.1-3.2.3.

Element	Questions	Variable description	Criteria and/or reflection	Key references
Structure Composition	1. Who belongs to the social network?	Network participants: The stakeholders.	Describe who is part of the social network. Discuss the interests of various stakeholders and who can represent nature.	Feedback from workshops
	2. Is the group size of the network well suited for your goals?	Group size: the number of actors in the social network.	Larger groups means more resources can be mobilised but can also negatively affect frequency of interaction and trust. Larger groups can be split up into subgroups.	Hahn et al. (2008); Ostrom (2009); Ostrom (2019); Poteete & Ostrom (2004)
	3. Are different types of actors represented in the social network?	Heterogeneity, diversity and inclusion: the number and representation of different types of actors in the social network.	Make sure the network includes different types of knowledge and interests. A diversity of both producers and beneficiaries of landscape values and services should be included in, or at least have access to, the social network. In particular those that are currently not involved in the decision making.	Poteete & Ostrom (2004); Prager et al.; (2012) Westerink et al. (2017)
	4. How well are actors within the network connected to each other?	Centrality and network density: the degree to which a certain actor has a central role within the social network and the number of existing connections divided by the number of possible connections in a network.	Use centrality variables if you want to identify actors who are: well connected, able to connect to the wider network, able to influence (knowledge) flows in the network, best positioned to influence others in the network, and/or hold most information within the network. The higher the network density, the more potential for collective action. Increase network density for increased possibilities for communication, levels of reciprocity and mutual trust. Decrease network density to give space to different types of knowledge and capacity of single actors. A social network analysis provides further insights in the social structures of the network.	Prell (2022); Bodin & Crona (2009); Lauber et al. (2008)
Embeddedness	5. Do relationships trust, shared goals and information reach beyond the borders of the social network, or do they function in a closed circuit?	Open vs. closed network: the dichotomy between an open or closed circuit of all ties within the network	In most cases, open networks are preferred for collective action as this facilitates the assimilation of new thinking, people and diverse values. Closed networks are more efficient in establishing shared norms but restrict entry of new ideas or members with different values or beliefs.	Dale & Sparkes (2008)
	6. Does the network include actors whose ties bridge different social groups and actors whose ties link to different hierarchical levels?	Bridging and linking ties: the presence of bridging and linking ties with actors *outside* of the social network	Include actors with bridging and linking ties in your network, to gain access to diverse information and resources, (this increases opportunities for action) and provide access to a diversity of information and resources at different scales (this enables actors to gain influence in decision-making processes)	Barnes-Mauthe et al. (2015)
Quality	7. Does interaction between actors in the network generate trust, information exchange, resources, social support and productivity?	Strength of ties: The intensity of the relationship between two actors, possibly leading to stimulating the generation of social capital	Reflect on how current interaction between actors in the network. Increased and reciprocated interactions between actors can contribute to generation of social capital.	Barnes-Mauthe et al. (2015); Granovetter (1973)
	8. (How) are actors able and willing to actively participate in the social network and its decision making process?	Participation and empowerment: the ability and willingness of actors to participate in the social network	Empowered actors can lead to better informed decision-making. To stimulate participation and empowerment: increase frequency of participation, improve (equal) access to decision making processes and (equal) access to information in the network.	Stringer et al. (2006)
	9. Do certain actors in the social network possess leadership skills, have access to resources and have (political) influence to secure funds?	Leadership: the presence of (a) leader(s) within the social network	Reflect if your network is capable of connecting network participants, internalising the shared goals, and further developing the network to prepare for collective action	Bodin (2017); Crona et al. (2011); Lauber et al. (2008)
	10. Are actors able to acquire, share and apply knowledge and information within the social network?	Capacity to learn and knowledge production: the ability of individuals and groups within the social network to acquire, share, and apply knowledge and information	Facilitate social learning for example by sharing experiences and engaging in collective consultation.	Bodin (2017); Crona et al. (2011)

3.3 Collective action

3.3.1 Introduction

To optimise the delivery of landscape values and services, the social network may adapt the agricultural-ecological network through collective action. We define collective action as individuals from the social network coming together in a decentralied manner to coordinate actions towards a shared goal. It can emerge spontaneously as a community unites around shared interests without requiring a centralised authority to direct their actions. However, a theory of change approach can identify a shared goal and steps needed to achieve it, while allowing the social network to mobilise and self-organise around that goal in a way that is flexible, responsive and effective without the need for top-down direction (Ostrom, 2009). A theory of change approach entails mapping the steps required to achieve desired outcomes and identifying the assumptions and risks that support those steps. Such an approach has inspired the Lila framework regarding participatory processes where transformations in the ecological network are identified together with stakeholders in a landscape approach (Reed et al., 2022). Within this process, decision-making through self-organisation takes place. Self-organisation at landscape level is important to avoid the 'tragedy of the commons' (Hardin, 1968) in relation to landscape services, as well as to by-pass large-scale food chains and top-down governance. The key conditions to accomplish self-organisation are explained in 3.3.3.

The common goal or objective in the LiLa assessment framework is to improve the socio-ecological functioning of agricultural landscapes. A key factor of collective action in the LiLa assessment framework is that landscape patterns are inevitably tied to the complex structures and interactions between the agricultural-ecological network and the humans inhabiting them (Görg, 2007). Therefore, when jointly creating a theory of change around a shared goal, including effective and long-lasting actions to achieve this goal, the characteristics of the agricultural-ecological network must be explicitly taken into account (Bodin, 2017).

Collective action differs from the other elements in the LiLa assessment framework, as it revolves around the process of collective action instead of a quantification. It is essential that all elements of collective action occur; therefore, the extent to which they occur is not relevant. The following steps in the process and the decision making can be viewed as a checklist for action towards collective goals.

3.3.2 Process

For describing the process of collective action, we took inspiration from the integration of land use issues in a participatory process and co-production of a landscape design towards a shared vision with concrete goals performed by Baayen et al. (2022). Their performed methodology is unique since principles of landscape approaches, knowledge co-production and theory of change models were combined. The following steps describe the process of actions towards their theory of change model. These are translated into questions in Table 3, with the same numbering:

1. *Initiative*
    - Collective action begins with the recognition of a common problem within the landscape that cannot be solved by a single individual. As a result, the social network is brought together. The problem is identified as an underprovision of specific landscape values and services, which is acknowledged by the social network.
2. *Problem analysis*
    - The most pressing land-use issues are identified in relation to landscape values and services. Then, the issues are prioritised and linked to causes/drivers and results/impacts.
    - The varying interests of individuals within the collective are made explicit. It is clear who will be using the theory of change and for what purpose, and who utilises common goods (Field and Ostrom, 1992).
3. *Goal and vision*
    - Participants develop a desired future state (a vision) for the landscape as a whole (social and biophysical).
    - Goals are prioritised.

- The goals are SMARTIE (Specific, Measurable, Attainable, Relevant, Time-bound, Inclusive and Equitable).
- Some of the goals should be long-term, with a 50 – 100 years vision.
- Goals should not be limited to just one issue but should match the integrality of problems within the landscape.

4. *Goals into action*
    - This step integrates all previous steps to co-construct pathways for transition towards the future vision, consisting of concrete actions, interventions or policy options.
    - Activities with certain timeframes are linked to the goals. This will form a roadmap of actions towards the goals; the theory of change pathways.
    - The outputs of the previous steps are synthesised to produce a theory of change model. The model is shared with the collective for input and approval.
    - There is clarity on what is needed to implement the actions towards the future vision.
5. *Mutual understanding from the external stakeholders*
    - The approved model is shared with actors who did not join the collective meetings but are influenced by and interested in management of the landscape, and they validate the theory of change.
    - Input from these actors leads to adjustment to the theory of change if necessary.
6. *Learning*
    - The final theory of change is used for designing landscape monitoring and evaluation, with a co-produced action plan and roles clearly identified and agreed upon.
7. *Evaluation*
    - The theory of change model is not set in stone: constant evaluation and learning takes place during the process. Adaptability is key.

3.3.3 Decision making through self-organisation

During all steps of the process, decision making takes place in the social network. In order for collective action to succeed, decision making should take place through self-organisation (Ostrom, 2019). Field and Ostrom (1992), as mentioned in Morçöl (2014), counter the assumption that most governments are able to analyse social problems and produce desired outcomes and that people are not capable of managing themselves. Instead, Ostrom (2009) argues that not all social problems can be solved centrally by governments and that people are, sometimes even better, capable of organizing themselves to solve these problems; self-organisation. Here, we define self-organisation as coming together in a group in a decentralised way to achieve a common goal. It can emerge spontaneously as a community comes together around shared interests without the need for a centralised authority to direct their actions. There are however certain conditions that must be met in order for self-organisation to succeed, which are explained below. These conditions of self-organisation will be assessed in this study using the frameworks developed by Ostrom (2009) and Field and Ostrom (1992). Many of these conditions concern rule making within the self-organising group. This can be informal 'rules of the game' as well as more formalised statutes and bylaws. The conditions of self-organisation are described in the following list and translated into assessment questions in Table 3, with the same numbering:

8. *Collective choice*
    - There are arrangements for collective decisions, so all people can participate and have an equal voice or vote in decision making. When actors involved in self-organising activities have full autonomy of the collective choice, they have lower transaction costs.
    - The same arrangement apply when it concerns decision making on the rules of the game and possible sanctions; these decisions must be made collectively.
9. *Rules of the game present*
    - There is congruence between the rules of the game and local conditions. Rules for distribution of costs and benefits of delivery and use of landscape services are fair.
    - The supervision of the rules and possible sanctioning is executed by the network itself; the actors of the network hold each other accountable. This mechanism rules out free riders.
10. *Supervision and sanctioning of rules*
    - For learning, it is important that the sanctions do not hinder taking action because of fear of repercussions.
11. *Conflict resolution*

- There is a mechanism in place for participants to resolve conflicts.

12. *Support by governments*
    - The government minimally recognises the right to self-organise: external authorities should not question the right of the social network's actors to self-organise.
    - Building on this principle, decisions made by collective choice are respected by authorities.
13. *Tools*
    - The necessary resources such as financial support, time and skills are present.
14. *Interaction, learning, exchanging knowledge and evaluation*
    - Knowledge is mobilised within the network and exchanged with other networks. Exchanging knowledge about the SES, including internal knowledge on relevant SES attributes and how their actions affect each other, as well as knowledge on SES from other SESs, will result in lower costs of organising.
    - Meetings are interactive and during meetings co-design must take place, meaning that participants should work together to create something, participants are actively involved and every voice is heard.

The information in 3.3.1-3.3.3 is compiled as questions, variable and reflection/criteria in Table 3.

Table 3. Self-assessment questions in the LiLa framework to qualitatively evaluate the approach to collective action, based on literature review in 3.3.1-3.3.3.

Element	Question	Criteria and/or reflection
Process of decision making How can the social network be organised around a central goal?	*Initiative* 1. Does the social network acknowledge and convene around a common problem?	Acknowledging and agreeing on a problem being present is an essential basis for cooperation. Try to find common connections in the landscape and work from there.
	Problem analysis 2. Are the most pressing land-use issues that cause the common problem identified?	In most cases, usage of the landscape that differs between common expectations and desires underlies the common problem. Land-use issues can be caused by indirect drivers (e.g. institutions, economy) and direct drivers (e.g. intensified agriculture, recreation).
	Goal and vision 3. Are the interests within and around the social network made explicit?	A stakeholder analysis can be used for this step to determine why actors are participating in the collective, what actors can impact the landscape and what actors are impacted by the actions. The analysis identifies the actors needs and expectations.
	Goals into action – forming a theory of change 4. What are visions for the landscape and the concrete actions to work towards them?	All the previous steps are integrated to form a theory of change model. A future vision for the landscape is developed and goals are prioritised Envisioning a desirable future is necessary to determine towards what state the landscape should be developed. Goals should be SMARTIE (Specific, Measurable, Attainable, Relevant, Time-bound, Inclusive and Equitable). This should include desirable (level of delivery of) landscape values and services to determine actions and to link to the next element of the framework. Activities form the concrete adaptations of the agricultural-ecological network and its management that are necessary to reach the desired future state of the landscape.
	Mutual understanding from external stakeholders 5. Is the approved model shared with actors outside of the collective?	For implementation of the theory of change, it is key that actors who are affected by the actions in the model but did not participate in the collective decision making, identified in the stakeholder analysis, are included.
	Learning and evaluation 6. Is the final theory of change used for acting on landscape goals? 7. Does evaluation of these goals take place?	Questions 6 and 7 are introduced to ensure that the theory of change model is iteratively adapted to fit the most pressing goals and actions and these goals are evaluated. This is done so that the model is flexible for developments in the landscape, and to make sure that actions are being performed. Lessons learned during the process and evaluation should be exchanged within the network and with other networks
Rules for decision making Is self-organization present in the collective decision making?	*Collective choice* 8. Are there arrangements for collective decision making? Are these arrangements made collectively?	Examples of arrangements can include who or which representatives should be present during decision making, and in what manner actors have a vote.
	Rules of the game 9. Are the rules of the game developed and concise? 10. Is supervision and sanctioning of the rules done by the network?	Rules for self-organization include the steps described in this paragraph and describe the way the social network wants to cooperate and how the landscape must be managed. This managing must include some kind of reciprocity for the provider of the landscape values and services. In order to validate the rules, the network should think of ways to supervise and sanction them. Supervision could be executed by every member, or a board, depending on the self-made structure of the network. Sanctioning mechanisms could for example be a fine, losing a vote in the decision making, or as a last resort be eliminated from the social network. It is important to create these mechanisms before a rule is broken, so there are no different interests in the outcome of the sanctions.
	Conflict resolution 11. Is there a mechanism in place for participants to resolve conflicts?	Sometimes conflicts arise during decision making and the collective should decide on how to deal with such situations. Multiple mechanisms for conflict resolution exist, such as negotiation rules to produce a solution that all parties can agree on, or a complaints committee that deals with unsatisfied actors.
	Supported by governments 12. Is there a (if minimal) recognition by the government of the right to self-organise?	Collectives still operate within a country, province or region that is governed, so their self-organization must be agreed upon. If self-organization is performed without any legal basis, there is a risk that envisioned landscape changes will be overruled by governing authorities. Governments do not necessarily have to be included in the collective to recognise a self-governing entity.
	Tools 13. Are necessary resources for organization present?	In order to implement the theory of change, time from the social network and a budget is necessary. When no budget is available, try to find solutions in governmental support, either in the municipality, provincial or national subsidies or welcome an external stakeholder that is equipped with the necessary tools in the social network. It is key this stakeholder is embedded in the social network.
	Nature-inclusiveness 14. Is nature included in the collective decision making process?	Reflect on whether nature is sufficiently considered when making goals and visions regarding the landscape. Nature's needs tend to be underrepresented since it is difficult to include expertise on needs and threats for nature. One approach to counter this could be to appoint an advocate for nature in discussions. Using this framework, nature can be included in landscape processes by considering threats for natural area quality (Table 5. Question 4) and looking through the lens of needs for certain species using ecoprofiles (Table 5. Question 5).

3.4 Agricultural-ecological network

3.4.1 Introduction

We define the agricultural-ecological network as the tangible landscape. We identified three key elements for the assessment of the agricultural-ecological network: 1. Structure; 2. Management and quality; and 3. Biodiversity. Structure refers to the structural characteristics of the landscape (composition and scale), see section 3.4.2, while management and quality refers to the (influence of) management of the elements within that structure, including the management and quality of both (semi-)natural (e.g. hedgerows, forests) and agricultural structures (e.g. cropland, pastures), see section 3.4.3. Biodiversity is identified as the third element as it is follows from the structure and quality of the landscape, see section 3.4.4. The entanglement of these three elements makes that the process of assessment must be iterative. We acknowledge that landscape structure, management and consequently biodiversity together result in the capacity of landscapes to deliver ecosystem and landscape values and services (Haan et al., 2021). This is further described in section 3.5.

3.4.2 Landscape structure

Landscape structure, or landscape heterogeneity is defined by two components: composition and configuration of land use types (Dunning et al., 1999). The composition of land use can be the variation of e.g. productive farm land or natural areas, while configuration refers to the spatial arrangement of these different land use types in the landscape (Dunning et al., 1999; Fahrig and Nuttle, 2005; Fahrig et al., 2011). One can consider both the composition and configuration of agricultural cover types (such as crops and different types of grasslands) on one hand, and natural cover types on the other (Fahrig et al., 2011).

Scientific literature as well as policy documents provide reference values for landscape structure. A recent study by Opdam and Vos (2023) concluded that proper functioning of biodiversity-related landscape services is achieved in landscapes with a coverage of at least 10 - 15% green-blue veining (composition). With the condition that there is a mix of woody and grassy elements with a high diversity of flowering species (configuration or *Biodiversity*). Moreover, the distribution must be fine-grained, where the plot size should be targeted at 2 to 3 ha (configuration and scale, see below).

Proportion agricultural area vs. natural area (composition)
To gain a basic insight in the landscape structure, the distribution between farmed land and (semi-) natural land cover types can be considered (Table 3, Q1). Farmed land is defined as annual cropland and as all land that is cultivated, harvested or grazed such that it can be considered harvested. The 'Index Natuur en Landschap' offers a useful typology of natural and semi-natural elements in the Dutch landscape (BIJ12). It is important to note here that the division between productive and non-productive is not definitive since extensive agriculture can also contribute to natural values. This indicator can be further refined by assessing e.g. the variation in crops or (semi-)natural elements in the landscape (Van Doorn et al., 2022).

Spatial scale of land use (configuration)
A second reflective question is on the spatial scale of land use in a landscape. This can be evaluated by looking at the size and distribution of landscape elements and at parcel size of land use types in the landscape or by the total length of the borders between them (the edge density). More complex and heterogeneous landscapes can harbour higher biodiversity (Martin et al., 2019), and have an increased supply of landscape services such as pest suppression (Bianchi et al., 2006; Fahrig, 2020). (Table 3, Q2).

Connectivity of natural elements

A third reflective question was formulated on the extent to which the natural elements are connected (both green (field margins, hedgerows) and blue elements (fens, ditches and streams); (Table 3, Q3)). In order to discuss this element, it is key that the collective has a printed map of the landscape. This allows for clear assessment of current connectivity and what might be barriers to increase connectivity.

The connectivity of landscape elements can be described in two main ways: through structural and functional connectivity. Structural connectivity deals with the physical connectivity or fragmentation of (semi-)natural landscape elements. Functional connectivity refers to the coherence of habitat through the eyes of a specific species or species group, depending on the mobility and dispersal capacity of this species. As these characteristics are species specific, the functional coherence of habitats is not equal for all species. Some species can, for example fly and bridge gaps in the natural elements, others cannot. section 3.4.4. 'Ecoprofiles' are discussed to evaluate the functional connectivity in a landscape.

It is possible to quantify connectivity in indices, but it is disputed how much use this approach has in landscape processes (Kupfer, 2012). Indices do not convey much meaning since there are no clear goals or benchmarks, and they are often complex and with that hard to interpret (Kupfer, 2012). However, indices can be used to monitor connectivity in a landscape over time and connectivity could be calculated for each separate natural area to display which areas have high and low connectedness. This could be done using graph theory indices displaying habitat patches and their links such as the Harary index (*H)* (Niculae et al., 2016; Ricotta et al., 2000), and the integral index of connectivity (IIC) using Conefor (Saura & Torné, 2009).

3.4.3 Quality and management

Qualitative aspects of the agricultural-ecological network are not fully covered by the *structure* element. *Quality* and *structure* interact: large natural areas that are well connected tend to have a major effect on biodiversity and its capacity to deliver landscape services. The quality of agricultural land as well as of (semi-) natural elements is partly determined by the management (e.g. fertilisation, mowing and pruning regime, crop/wood harvest intensity and type). Additionally, the management of (semi-)natural elements and agricultural land may influence the quality of the other. For example, plant species in natural areas can be affected by herbicides on neighbouring agricultural fields. Broadly speaking, quality has two dimensions: intrinsic quality for nature or biodiversity, derived from ecological requirements, and quality coloured by the lens of landscape inhabitants, derived from needs and wishes of stakeholders regarding landscape services. These two dimensions, also named paradigms (Lothian, 1999), or approaches (Daniel, 2001), have long been debated since they form fundamentally different entry points of quality assessment. In this study, we acknowledge the need for both forms of quality assessment. Therefore we encourage the social network to determine which quality assessment indicators are relevant in their specific landscape. Furthermore, the social network is challenged to include indicators that safeguard the intrinsic quality of nature. Indicators for intrinsic quality of nature are described in the next paragraph *Biodiversity* (section 3.4.3).

It is important to assess whether the management that is being done actually leads to the goals that have been set during the collective action. Criteria and indicators for quality and management related to human preferences are difficult to generalise for all landscapes, as they are dependent on the quality of the landscape, its associated capacity of the landscape to deliver certain services, and on the needs and wishes of stakeholders for landscape services (Table 3, Q4). Management indicators are therefore linked to landscape services and may be focused on agricultural land management or may concern the impacts on natural area.

Indicators for the quality of agricultural land management are often linked to their scale of assessment. Some examples here are:

- Soil quality could be derived from the Functional Land Management framework described in Schulte et al. (2014) who define five key soil-based ecosystem services and associated indicators.
- Farm level quality could be assessed using indicators from integral agroecological assessment tools such as TAPE (Mottet et al., 2020), or by applying the set of key performance indicators which have been developed for Dutch agriculture (Van Doorn et al., 2021).

- Landscape level quality is often assessed by scaling up aforementioned lower level indicators (Geck et al., 2023).

These frameworks however mainly focus on provisioning, supporting and regulatory services. Landscape quality for non-farmers is mainly driven by cultural services such as housing, recreation, heritage and landscape beauty (Plieninger et al., 2014; Van der Sluis et al., 2019). Indicators related to these services are therefore key to include in the quality assessment.

Management of the landscape should not have detrimental effects on landscape goals. Therefore, indicators for quality of (semi-)natural elements should be linked to the most pressing threats for nature/biodiversity and its functions: habitat change, overexploitation, climate change, pollution and biological invasion (Bellard et al., 2022; Isbell et al., 2023). These are only examples of services and indicators, other indicators could be connected to each of the mentioned services, and other services of interest could be chosen by the social network.

3.4.4 Biodiversity

We place *biodiversity* within the *agricultural-ecological network* element of the LiLa assessment framework. This is because we consider biodiversity as an emerging result of the structure and quality of the agricultural-ecological network. Biodiversity broadly refers to the diversity and abundance of genes, species and ecosystems of all life in the landscape. The position of biodiversity in the assessment framework can be argued. It is not to be seen as a similar component as *structure* and *quality and management* of the landscape but as a major quality indicator of the landscape as well as a prerequisite and producer for a secure level of delivery of landscape services (Borchardt et al., 2020). Still, *biodiversity, structure* and *quality and management* are very much interdependent since each follows from the other. The community of herbaceous and woody plants, forms of itself biodiversity but is also a determining factor for the biodiversity of fauna and is in itself a major producer of landscape values and services. Finally, with the LiLa assessment framework we want to emphasise the intrinsic value of biodiversity. Therefore it is not placed among the landscape values and services.

For evaluating the element biodiversity, we can either look at whether the prerequisites for certain species are present in the landscape by using Ecoprofiles, or we can measure the biodiversity directly as an 'outcome' of the landscape.

The intrinsic quality of a landscape for certain (groups of) species can be evaluated through the use of Ecoprofiles (Table 4, Q5), as developed by Opdam et al. (2008). An Ecoprofile represents a group of species with similar spatial habitat requirements, that require similar conditions to be able to sustain in a landscape: type of habitat, area requirements and coherence of habitat. Coherence concerns the functional connectivity of the landscape, as described above in *structure*. Ecoprofiles can be used to work towards a biodiversity goal determined by the *social network* and to design a landscape pattern that provides the appropriate ecological conditions for a group of species represented by the Ecoprofile.

Measuring biodiversity directly is generally associated with high resource input, in knowledge, time and other costs. The most straightforward and easy to interpret way to measure biodiversity is by direct observation by counting of abundances and number of species (Table 4, Q6). This is usually done for specific target species groups or individual species, dependent on the set goals. Due to a historical limited and scattered monitoring of biodiversity in agricultural areas, reference data and benchmarking is mostly missing. Instead comparisons of biodiversity levels between different locations in landscapes can be done or the change in biodiversity over time can be monitored.

Table 4. Self-assessment questions in the LiLa framework for the element agricultural-ecological network, based on literature review in 3.4.1.-3.4.4.

Element	Question	Variable description	Criteria and/or reflection	Key references and resources
Structure How are (semi-)natural components and agriculture distributed in the landscape?	1. What is the proportion in the landscape between different land use types: the area of production cover (farmed land) and (semi)natural cover?	Quantification of the proportion of farmed land and (semi)natural cover on landscape and/or farm level.	% of farmed land versus (semi-)natural cover. Consider what areas are natural and which agricultural. Extensive agricultural management may benefit nature as well. The output percentage can be referenced against the Dutch policy goal of 10% natural area or 10-15% from scientific literature. Possible to look at proportions of different crop and nature types. Discuss whether the landscape goals are in line with the policy goals.	Theory: Baayen et al. (2022) Practice: Vos and Opdam (2022), Van Doorn et al. (2022)
	2. What is the spatial scale of different land use types in the landscape?	Quantification of edge density on landscape and/or farm level. Edge density gives an estimate of the spread of different elements of the landscape and the size of the "patches" with different land use.	Edge density in km/ha. The output can be referenced to a minimum of 200 and optimum of 400 m/ha which is desirable for conserving ecological quality. This corresponds to plot sizes of 4 and 1 ha respectively. Alternatively, discuss the question are there many small or large "patches" (agricultural fields or nature areas) in the landscape?	Practice and theory: Van Doorn et al. (2022) Vos and Opdam (2022)
	3. To what extent is there connectivity between natural elements in the landscape?	Visualisation the connectivity of natural elements in the landscape (e.g., in line form), for instance, through the use of a map.	A map with an overview of connection between natural areas and natural elements (green and blue). Distance between natural areas can be displayed using GIS (Nearest Neighbour Distance). The map is used to discuss the distribution and connectivity of natural elements in the landscape.	
Quality and management What is the quality of the agricultural-ecological network?	4. Is the management sufficient for a good quality of the agricultural-ecological network?	Various variables could be used to evaluate this question, some of which are partly subjective as the view on quality is determined by the social network.	Criteria are dependent on the choices of the social network. The criteria should be linked to the most pressing land-use issues for agricultural land and (semi-) natural elements (see text 3.4.3).	
Biodiversity What is the biodiversity in the landscape and does the landscape sufficiently support prioritised species?	5. Does the structure and quality of the landscape fulfil the needs of prioritised species?	The current state of the connection and patch size in the landscape are referenced against the needs of the species as described in their Ecoprofiles.	The selected species can provide detailed guidance on what constitutes a qualitative landscape by utilising Ecoprofiles, which display the intrinsic quality of the natural components of a landscape. However, it is the social network that determines which species are prioritised for conservation in the landscape.	Theory: Opdam et al. (2008) Practice: Van Rooij et al. (2021)
	6. To what degree are the target species in the different types of ecosystems/land uses present?	Making an inventory of species richness and/or abundance. May be specified towards specific group or specific/prioritised species if desired.	The number of different species present at different locations in the landscape. Consider whether this biodiversity is in accordance with landscape goals.	Overview of methods: Allema et al., 2023

3.5 Landscape values and services

3.5.1 Introduction

Agricultural-ecological networks (section 3.4) have value in themselves. In addition, people can benefit from them. For participatory landscape planning, expressing and describing the relevance of those networks to (and by) society is needed (Termorshuizen and Opdam, 2009). For this, the concept of landscape values and services has been suggested as a specification of the concept of ecosystem services (ibid). Landscape services, or other forms of values derived from landscapes, are manifold (see Figure 2) and depend on the state and dynamics of the agricultural-ecological networks. A generally agreed classification of services is into provisioning, regulating, habitat or supporting, and cultural & amenity services. The European Environment Agency manages the widely used CICES classification (www.cices.eu), which has a four-level hierarchical structure. Indicators have been developed for the potential state and performance of such services (De Groot et al., 2010). For a review of methods and in particular policy instruments related to these services see Van Zanten et al. (2014). There are many interdependencies and interactions between services. The supporting services, along with biodiversity, form the backbone – or prerequisite – for the supply of the other services. Thus, supporting services and biodiversity have a special role and are particularly worthy of protection.

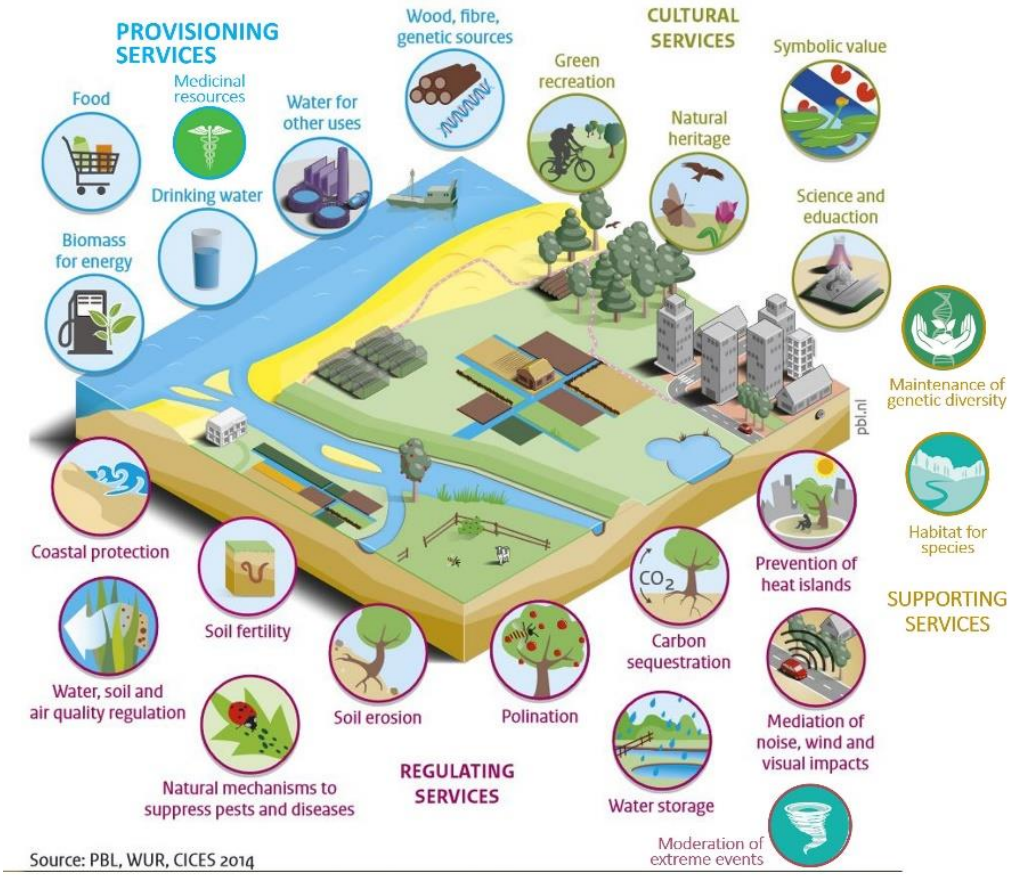

Figure 2: A set of landscape services that can be found in a landscape (source: adapted from PBL et al. 2014 as cited in Van Egmond and Ruijs (2016)*, with additional icons from https://www.fao.org/ecosystem-services-biodiversity/).*

The concept of ecosystem (landscape) services has been criticised for being anthropocentric, instrumental and utilitarian: focusing on the benefits of nature to people and ignoring intrinsic and relational values of nature (Pascual et al., 2021). Intrinsic values refer to the value of nature regardless of its benefits to people: the value of nature because of itself (Buijs, 2009). Relational values refer to the various relations that people can have with nature: these can include the more 'functional' relations of dependency of people on nature for their

subsistence, but they can also include values of responsibility (e.g. stewardship) and reverence (e.g. religious meanings of nature) (Muradian and Pascual, 2018). The various values relate to different world views. The IPBES Values Assessment provides an overview and classification of 'nature's benefits to people' (Pascual et al., 2023). Buijs (2009); Pascual et al. (2023) and many others make a plea for fostering plurality of values in processes of landscape management and policy making. In the LiLa assessment framework, we therefore not only consider landscape services, but also other values that may be a reason for the social network to engage in collective action to adapt the landscape.

3.5.2 Aggregated approach

The three most used approaches to describe the value of services or nature's benefits are 1) analysing information about properties, 2) asking people about their perceptions, and 3) observing people's behaviour. A fourth approach is the mixture of the previous (IPBES, 2022). There has been much scientific discussion about valuing landscape services monetarily. An important reasoning behind monetary valuation is to make a case for policy makers. A price tag would help taking landscape services into account in decision making. Since there is no functioning market for all services, alternative ways of assigning a price have been and are being developed and tested. However, this approach has also been criticised for its commodification of nature. While regulating and habitat services are also commonly valued qualitatively for their contributions within ecosystems, for example in terms of patterns (Bastian et al., 2014), a non-monetary valuation is equally required for cultural services, particularly in the form of a socio-cultural valuation (Mohtat and Khirfan, 2023). And, as argued above, also non-utilitarian values of nature must be considered, which by definition cannot be expressed in monetary value.

In any case, the usefulness of very detailed data about the services in planning processes has been challenged (Albert and Von Haaren, 2017). Planners in the same authors' sample did not trust the accuracy of such data and anyhow find the multitude of additional data to be processed in their planning processes far too overwhelming. The authors recommend first clearly capturing what landscape services data is required by planners and then tailoring it to provide that data. Following this line of reasoning, we propose here to start with an aggregated approach and therefore look into the diversity, quality and reliability of services as a whole and not disaggregated by single service. Diversity was used as an ecological principle to consider in living systems, quality as a measure of how well something is presented, while reliability takes into account temporal differences. The elaboration of this approach continues in paragraphs 3.5.3.

When our proposed aggregated approach is felt insufficient, because of a need for more details of trends per service, and still assuming that there is no need to quantify the monetary value per service, the CICES classification (cices.eu) or a descriptive matrix similar to Mooney (2014) could be used. For instance, Plieninger et al. (2010) classified services for their dynamics of supply and demand, the location where their benefits are primarily utilised, what user groups utilise the services to what extent and its impacts on service provision. Describing how services are maintained or enhanced is also the approach adopted by LandScale (2022) (compare section 'Goal 1.3' in the cited report). Several examples about assessing directions of development of service provision (and demand) were compiled by Van der Sluis (2021). Lange et al. (2022) reported several countries' pilot results of service accounting, which can help to detect relevant national databases[1]. In the Netherlands, a description of the state of services at national level is published (Knegt, 2014; Knegt et al., 2020). Such an analysis could serve as an entry point for a regional assessment. Thirteen landscape services were reported monetarily for Dutch sub-areas (Van Berkel et al., 2021). Identifying the national bodies (and regional if present) who deal with services and who publish assessments seems to be a good starting point for a local study about the status and trends of services.

A detailed approach would be to analyse how services relevant to the area and its specific users (such as farmers) are supported by structural elements in that landscape, and whether such structures are sufficiently present (Vos and Opdam, 2022). Vos and Opdam (2022, page 78) provide a practical overview of the structures that support farming related services. While many services are common pool resources or public goods, the structures or elements (compare section 3.4) to sustain them are often, but not only, on privately owned land.

[1] For further project materials and assessment routines put forward by the European Union see https://biodiversity.europa.eu/europes-biodiversity/ecosystems.

This underlines the importance of a multi-stakeholder approach in collective action (section 3.3) carried out by the social network (section 3.2).

3.5.3 Diversity of landscape values and services

A diversity of landscape services is important to meet society's needs. Many landscape services are common pool resources or public goods for which no functioning market exists. As a result, in many landscapes there is a focus on the production of food and fibre (provisioning services). Often, food and fibre are produced in large-scale crop production systems that rely heavily on pesticides to manage pest communities in order for their crops to thrive. In such landscapes, regulating services such as natural pest management are not functional well anymore. In addition, there is little room for cultural services in large-scale production landscapes. Cultural services include recreational activities, place identity, mental health and aesthetic experiences. Cultural services are among the most important reasons why people appreciate landscapes.

A very limited number of landscape services provided is often the result of promoting certain landscape services at the cost of other landscape services. Such trade-offs between landscape services are an important topic for discussion in landscape planning processes, because they reflect conflicting interests of stakeholders in the landscape (Cord et al., 2017; Plieninger et al., 2019).

It is not easy to get a clear overview of the societal needs for landscape services. Each landscape has multiple stakeholders with manifold and probably conflicting demands and needs. It does not stop here: one landscape is linked to other landscapes through the movement of species, interrelated resources such as water and air transcending borders, or type and state of vegetation influencing weather and climate processes. Therefore, assuming that we primarily focus on people living in the landscape who are members of the social network-part of the LiLa assessment framework (section 3.2), we need to consider how to engage or represent the interests and wellbeing of social and (agricultural-) ecological networks at nested levels, and thus further away and more easily overlooked. A diverse set of stakeholders is the starting point for appraising the state and prospects of the diversity of services. In addition to utilitarian values of the landscape (landscape services), also intrinsic and relational values must have a place in the appraisal. By discussing intrinsic and relational values of nature, nature itself becomes a stakeholder that must be represented in the collective action (cf. (Latour, 2004).

A simple evaluation of diversity is the presence-absence of landscape values and services (Table 5, Q1-Q2). One way to get clarity about presence-absence is figuring out who actually uses what types of services in a given landscape (Table 5, Q3). The rough assessment of users and presence-absence remains limited. Depending on the composition of the stakeholder group involved, there could be a bias towards a limited number of services. In addition, a presence-absence evaluation needs refinement through a more substantive assessment of the state of the services, which we further develop in the following sections.

3.5.4 Quality of services and values

Under quality of services we define here how well services are provided, and to what extent the provision of services satisfies their demand by potential users now and in the future (Table 5, Q4). Quality is here closely linked to a measure of quantity or intensity, including the spatial distribution of services in the landscape, which is already partly dealt with in the section agricultural-ecological network (3.4). The temporal availability of services is dealt with in the following section 'Reliability of services'.

The services concept implies that people benefit or can benefit from services. This socioeconomic lens has several dimensions. Biedenweg et al. (2016) identified "six domains of human wellbeing that are affected by the status of the environment: physical, psychological, cultural, social, economic, and governance". Thus, we can ask: to what extent do the services (or each identified service or value) contribute to the domains of human wellbeing? Also here, a diverse group of stakeholders is needed for an inclusive and balanced answer to this question. Finally, services do not simply contribute to wellbeing, people can be dependent on them. The two are not always easy to distinguish. Rau et al. (2020) differentiated between dependence on landscape services for the livelihood (e.g., food, shelter), for income, and for quality of life (e.g., public health,

recreation). Concluding, the specific framing and phrasing of question 4 matters and needs to be adjusted according to where the LiLa assessment framework will be applied.

3.5.5 Reliability of values and services

Reliability of landscape services refers to their availability over time (inspired by Müller et al. (2008)). As services can support livelihood, quality of life, and income (Rau et al., 2020), some landscape services require physical or economic access by individuals or communities (Müller et al., 2008). In addition, the level of service provision can be threatened by environmental stress or seasonal differences.

Recurring events of stress relate to seasonality, such as the seasonal flooding of rivers, causing a temporal obstruction to access land and related crop losses (Rau et al., 2020) (Table 5, Q5). Non-recurring form of stress may build up slowly via gradual changes (slow-onset changes), or cause sudden shocks (rapid-onset changes) (Rau et al., 2020). Gradual changes to the environment may cause (sometimes irreversible) effects such as climate change, eutrophication, biodiversity loss, landscape fragmentation, and overuse of natural resources such as water, vegetation, wildlife and fish stocks. Climate change enhances further gradual environmental degradation through e.g. rising sea levels, weather extremities (drought, floods), and the introduction of invasive species causing a threat to native species. In many cases, the reliability of services is threatened by human behaviour. For example, pollution may threaten the provision of drinking water. A high level of biodiversity is important for the reliability of some services. For example, a wide range of pollinating species supports reliable pollination, in spite of varying weather conditions, and throughout the season (Garibaldi et al., 2011).

Table 5. Self-assessment questions in the LiLa framework for the element landscape values and services, based on literature review in 3.5.1-3.5.5.

Element	Question	Variable description	Criteria and/or reflection	Key references
Diversity How diverse are landscape values and services landscape?	1. What landscape values and services are present in the current landscape?	List of current values and services in the landscape. See figure 2 for inspiration.	Presence of values and services in the current landscape.	Mooney (2014) CINEA (n.d.) GuideToES (n.d.)
	2. What landscape values and services do you miss in the current landscape and why?	List of missing values or services and qualitatively describe your wishes or vision for the landscape (to address what is currently missing). Could reveal adverse effects from missing values or services.	Absence of missing values and services. Opportunity to cross-check with first question about what is there.	
How diverse is the group of users who benefit from or even depend on the values or services?	3. When and how often do you and others use/enjoy which values or services or goods?	For each present and absent value or service listed in question 1 and 2, indicate the users (e.g. farmers, water boards, citisens, tourists, nature organizations), and indicate when (seasonality) and how frequently the service is used. Also consider indirect users (those who are not living in the landscape under study).	• Simple or complex user/actor group. • Complementarities or contradictions in usage.	
Quality What is the quality of the provided services in the landscape?	4. To what extent are the values and services adequate to address the needs of the users/actors in the landscape, today and in the future?[1]	The gap (or adequacy) in landscape values and services perceived by actors (*social network*) today and in the future. As a participating actor, also think along for other people/groups currently not present.	Depending on envisioned future[1], an estimate (%) or score (low, moderate, high) of the performance of key landscape values and services (current functioning) compared to desired.	Pickard et al. (2015) Liao et al. (2021)
Reliability Can the services be accessed when needed?	5. Which are times of a shortage of services caused by recurring events?	Quantification of length and frequency of shortage of services caused by recurring events.	Frequency or duration of a shortage of service due to recurring events	
	6. Which kind of gradual changes or shocks cause a shortage of services, and under what conditions are services more resistant to shocks?	List of gradual changes or shocks that massively impact services, and description of factors that create resilience to the shock.	% of decline of service by gradual changes or shocks, and risk level (low, medium, high) that service is not resilient to shocks	
	7. If there is a shortage of services, who will mainly experience this?	Assessment of supply of the service on the one hand, and demand by group(s) of actors on the other. Or: is there structural exclusion of people (in times of shortage)?	The ratio between supply and demand per stakeholder group at a given time, and the extent to which a stakeholder group is affected (through their quality of life, income or livelihood). Tipping point/threshold, updated information	

[1] Depends on desired future outlined in the collective action, Table 4, questions 3 and 4 and desired services outlined in questions 1-3 of this table.

3.6 External factors

Improving the functioning of landscapes does not happen in a vacuum, but is influenced by contextual factors and developments (Ostrom, 2009) that are not targeted at the well-functioning of the other elements of the LiLa framework, but might have an influence on it. This (external) context may therefore enable or constrain the desired developments. Context needs to be considered in the 'external factors' element of the LiLa assessment framework. The external factors cannot be influenced in the short term by the landscape stakeholders (e.g. geopolitical developments), and are also embedded in the current dominant 'ways of doing things' (e.g. conventional agricultural practices) (Geels, 2011). Multiple factors may be of influence here, including those of a social, economic, political (e.g., societal discourse, incentives, institutions) or technological nature (e.g. breeding, robotics, AI, remote sensing). These external factors can present both barriers and opportunities for improving the functioning of agricultural landscapes in terms of mutually supportive co-evolution of humans and nature. It is important to envision pathways and strategies on how the barriers can be removed and how the opportunities can be capitalised on.

A systematic way to analyse external factors is the assessment or analysis of Political, Economic, Social and Technological developments, the so-called PEST-analysis (Perera, 2017). Legal, environmental and demographic factors can also be added if relevant. After assessing these external factors, each factor can be identified as a threat or an opportunity for the goal of the network (i.e. improving the functioning of the landscape), as is done in a SWOT-analysis looking into the strengths, weaknesses, opportunities and threats. The PEST analysis focusses on external factors (O and T) of the SWOT. When external threats and opportunities are clear, the network can formulate actions to minimise threats and capitalise on opportunities. The exploration of barriers and opportunities in Appendix 1 illustrate some of these aspects for the Dutch context and these aspects can be placed within the PEST framework. The PEST analysis has been integrated in the assessment framework (see Table 6).

Table 6. Self-reflection questions to assess political, economic, social and technological developments in the external environment of the landscape (Perera, 2017).

Element	Question	Criteria and or reflection
Political	1. Which political developments, policies and regulations influence the development of the agricultural landscape?	Think about e.g. political (in)stability, changes in policies, laws and regulations, etc. Reflect on the threats or opportunities to improving the functioning of the landscape
Economic	2. Which economic factors influence the development of the agricultural landscape?	Think about e.g. labour availability, income levels, available subsidies, available funding, etc. Reflect on the threats or opportunities to improving the functioning of the landscape
Social	3. What social and cultural aspects influence the development of the agricultural landscape?	Think about e.g. cultural norms, dominant attitudes, traditions, etc. Reflect on the threats or opportunities to improving the functioning of the landscape
Technological	4. Which current technologies and innovations influence the development of the agricultural landscape?	Think about e.g. role of digitisation, adoption rate of innovation, extent of knowledge dissemination, dominant technologies used, etc. Reflect on the threats or opportunities to improving the functioning of the landscape

3.7 Practice tool to use the LiLa assessment framework

To facilitate stakeholders in actually assessing and improving the ecological and social functioning of their landscape in real life, we developed the framework into a more simple practice tool that can be used to apply the LiLa assessment framework in a participatory setting. This practice tool includes all materials that is necessary to organise stakeholder workshops with the aim of assessing and improving the social-ecological functioning of agricultural landscapes.

The materials include:

1. A folder that informs potential users in an easily accessible and concise manner about the framework: https://edepot.wur.nl/676949

2. A manual on how to use the LiLa assessment framework practice tool in a workshops with stakeholders:
   https://edepot.wur.nl/676947
3. A PowerPoint presentation with an introduction to the methodology and main definitions. This presentation can be used during workshops: https://edepot.wur.nl/676948
4. A set of self-reflection cards that guides stakeholders through the series of questions included in the framework (sections 3.2 – 3.6). This set of cards is the core of the stakeholder workshops.
   Available as appendix in: https://edepot.wur.nl/676947
5. A 'game' board that provides workshop participants an overview of where they are in the process
   Available as an appendix in: https://edepot.wur.nl/676947
6. The format of a to-do-list where planned actions that follow from playing the game can be noted.
   Available as an appendix in: https://edepot.wur.nl/676947
7. A webpage with complete information about the framework. From this website the practice tool can also be downloaded: Website link

The same materials are available in Dutch by changing the language of the website in the top menu bar.

4 Discussion

The objective of our study was to contribute to socially and ecologically well-functioning landscapes by developing a framework that stakeholders can use to identify and assess how the functioning of social and ecological components of their landscape can be improved. Our study resulted in the Living Landscape (LiLa) assessment framework. This chapter discusses the development of the LiLa assessment framework (4.1), the assessment framework itself (4.2), and concludes with key takeaways and implications (4.3).

4.1 Reflection on framework development

The LiLa assessment framework was designed to enhance landscape values and services by improving biodiversity conditions. However, other starting points for evaluating landscape functioning are equally viable. For instance, during one of our workshops, a landscape professional prioritised the regional water system as the guiding principle. From our experience, the LiLa framework is adaptable enough to incorporate such themes into its workshop structure.

We developed the framework with a multidisciplinary team of scientists specializing in transition studies, economics, sociology, ecology, agronomy, and animal sciences. This diverse expertise enabled us to efficiently gather 14 existing approaches spanning social-ecological networks, participatory change, and landscape assessment. While reviewing these approaches, we identified numerous indicators but found a lack of practical, integrated sets of indicators specifically tailored for the landscape level. This gap underscores the relevance and importance of our study.

During development, disciplinary differences in terminology emerged as a challenge. To address this, we provided clear definitions where necessary. Furthermore, to bridge the gap between academic language and the practical needs of target users, we tested the framework in case study workshops, using non-scientific language.

4.2 Reflection on LiLa assessment framework

The LiLa assessment framework builds on an existing framework for social-ecological networks (Opdam et al., 2015), focusing on four core elements: social network, collective action, ecological network, and ecosystem services. We adapted this foundation to refine its scope, terminology, and visualization.

To guide stakeholders in assessing their landscapes, we developed non-judgmental reflection and evaluation questions. These questions facilitate discussions about critical issues in participatory processes aimed at enhancing landscape values and services. Given the framework's broad coverage of social and agricultural-ecological domains, it necessitates an inclusive group of stakeholders. This approach not only enables a detailed understanding of the current situation but also helps anticipate potential side effects of proposed measures.

The framework's flexibility is one of its strengths. Stakeholders can choose to focus on specific questions or elements and even explore particular questions in depth. This makes the framework applicable to subgroups, provided that discussions remain connected to the broader context. To avoid blind spots, it is crucial to report subgroup findings to the entire stakeholder group.

Additionally, the framework can be applied at various stages of a landscape process. Early application helps design key steps, while later use aids in monitoring progress and evaluating outcomes. The LiLa assessment framework also helps participants assess whether all relevant providers and beneficiaries are represented in the social network, and if not, whether expansion of the network is desirable. However, the assessment

framework does not include the explicit question whether the network fully represents the whole social network of a landscape. Thus, the process in which the LiLa assessment framework is applied, determines whether an integrated participatory approach is in place.

The LiLa assessment framework meets most of the requirements for assessment frameworks outlines by Pearce et al. (2015). Specifically, it:

1. Provides a structured conceptual map of what needs to be assessed, including five main elements and their links.
2. Defines the concepts being assessed and their connections.
3. Offers guidelines and criteria for operationalization.

For the social network and collective action elements, the framework allows stakeholders to define their own goals and translate them into context-specific criteria. While it does not include data collection instruments, this aligns with Pearce et al.'s (2015) definition of assessment frameworks, which need not provide such tools.

While the framework focuses on both landscape values and services, it moves beyond an economic, anthropocentric view. Although assessing landscape services aligns well with the economic reality of farming, we wanted the assessment framework to move beyond this anthropocentric approach and also emphasise the intrinsic and relational values of nature. Therefore, the LiLa assessment framework is able to facilitate discussions among stakeholders on whether the focus should be solely on landscape services or also on various values of nature. In light of this, a prerequisite of the framework is that involved stakeholders all have the intention and willingness to contribute to improving landscapes and biodiversity. This implies that the framework is not well suited in situations where the need for improved landscapes and biodiversity is contested. The outcomes of application of the framework and tools will be strengthened when supportive policy is in place. The impact of action plans, stemming from stakeholder workshops, will be affected by the presence or absence or supporting policies, but are not dependent on it. Since the framework is to be used in a transdisciplinary way with all relevant stakeholders involved, impact can be reached even without supportive policies in place.

Finally, the LiLa assessment framework is primarily intended for regional processes and is therefore less suited for national approaches. Although the framework was developed and applied in a Dutch context, it is also applicable to foreign contexts, since the specifics of objective, species, landscape features and values and services etc. are to be determined within the collective action.

4.3 Concluding remarks

Agricultural landscapes are under increasing pressure to deliver multiple values and services due to mounting environmental and policy challenges. The LiLa assessment framework provides stakeholders with a tool to evaluate and enhance the socio-ecological functioning of their landscapes. It helps stakeholders assess:

1. The social network, which engages in
2. Collective action to influence
3. The agricultural-ecological network, which provides
4. Landscape values and services, all within the
5. context of External factors.

By integrating these elements, the framework contributes to the realization of well-functioning landscapes. Its adaptability and participatory design make it a valuable tool for diverse contexts, offering a pathway to sustainable landscape management and fostering a shared commitment to biodiversity and ecological health. Future research could explore its application in other regions, further enhancing its scalability and impact.

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6 Appendix 1 - Review of existing frameworks, tools and concepts

6.1 Context of review

As described in the report we initiated our study with an inventory of existing approaches (assessment frameworks, evaluation tools, and concepts) that share a link to assessing the social and/or ecological outcomes of agricultural systems or landscapes. Based on expert knowledge from all study team members and following a snowball methodology, a total of 14 existing approaches were collected. The study team included experts from multiple science domains being: transition studies, economy, sociology, ecology, agronomy, and animal sciences. Each approach was reviewed by individual team members answering a set of questions regarding the approach, its context, use, user group, limitations, assessment use, scale, the role of biodiversity and ecosystem services and relevance for our framework. In 6.2-2.14 the approaches are described based on these criteria.

6.2 Review results

6.2.1 Social-ecological networks

Social-ecological networks (SENs) is a very flexible concept to represent the complex relationships between ecological and social systems. This concept is motivated by that the biophysical aspects of a landscape and social networks within the landscape are interrelated. The SENs approach has mainly been used by scientists, however SENs have been used by real case stakeholders in landscape planning for collaborative transformation. The approach for applying SENs has been described as first finding a common vision for the future within a group of stakeholders, then to find the supply (i.e. through ecosystem services) and demand (i.e. through workshops) of the landscape, to ultimately have local actors work together towards that vision (Opdam, 2014). Thereby, SENs create a common language to facilitate communication of the results within the networks and

to other communities (scientists and local actors). The challenge in the SENs approach is how to determine what the value of the landscape is for different local actors. More specifically, Felipe-Lucia et al. (2022) show that there is a great difficulty in linking research questions to ecosystem services in SENs. They give four main ways in which this can be done (Figure 1), for example allowing to assess the underlying ecological processes (ES as links) and how they connect to actors (ES as node attribute).

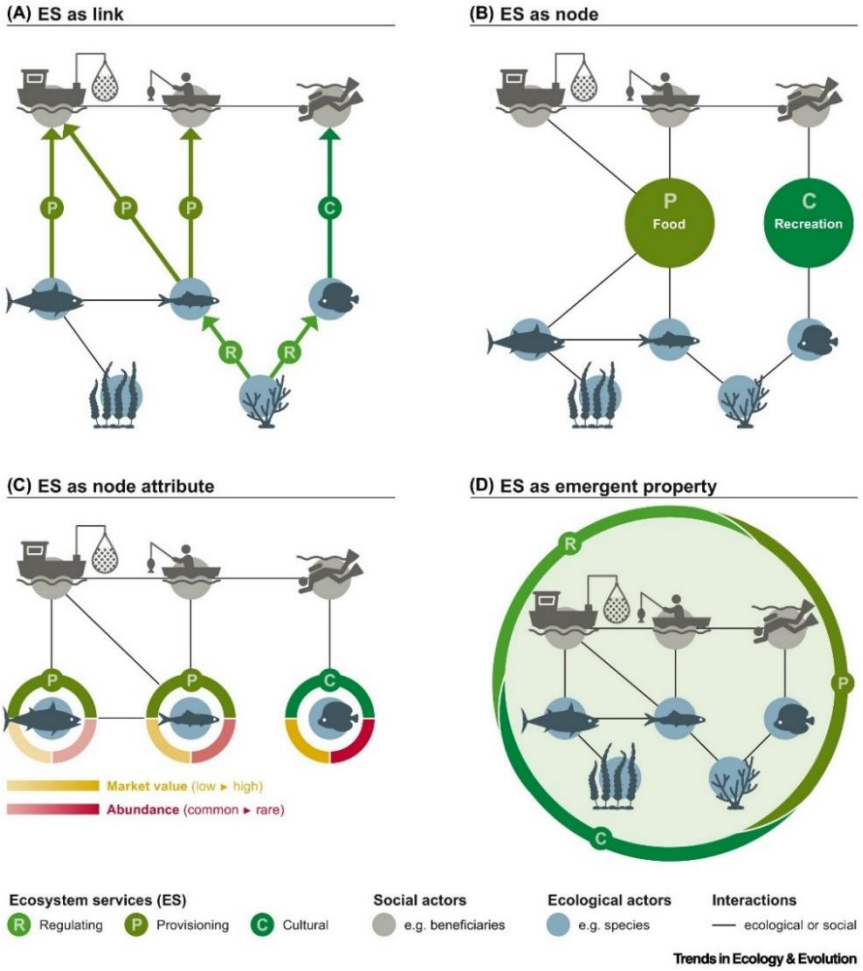

Figure 1. The four main different ways in which ecosystem services (ES) can be conceptualizsd in social-ecological networks (Felipe-Lucia et al., 2022) concerning social actors (gray), ecological entities (blue) and ecosystem services (green).

Another limitation of SENs is the assumption that actors have a certain agency to alter the outcomes of an SEN, which may not always be correct (McGinnis and Ostrom, 2014). SENs do not give a method to assess the ecological and social aspects of the landscape. Therefore, in the current project, SENs could be used to integrate different methodologies into one coherent framework. There is great diversity in how SENs are conceptualised, which is visualised in Figure 2. Fully articulated SENs will not only help the users to find the relevant ecosystem services, but also how they influence each other and how the interactions within the network shape the social and ecological network. We should consider to what degree we should articulate the SEN to fit the research question best, and how ecosystem services will be conceptualised in the framework.

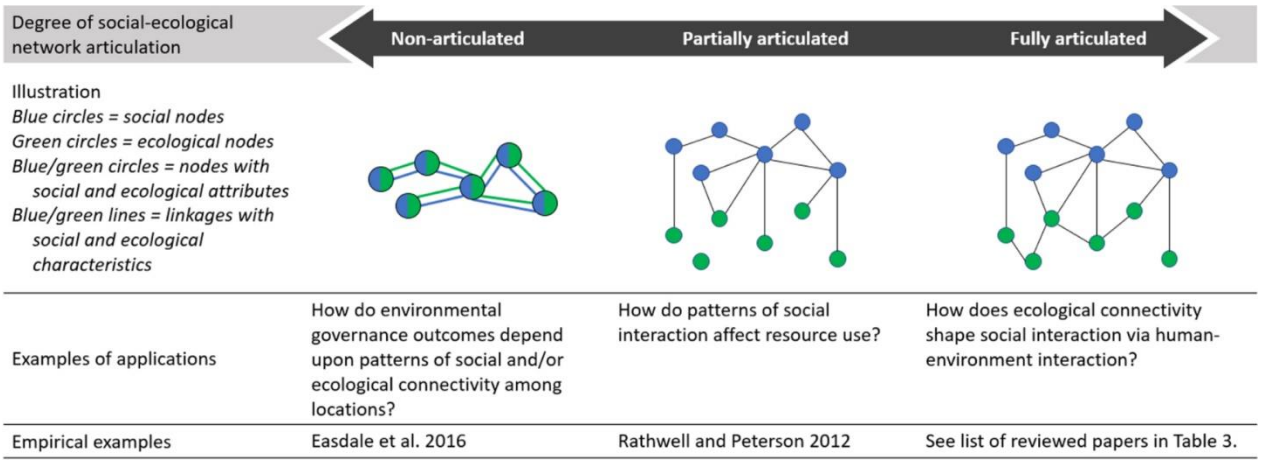

Figure 2. Different social-ecological networks along a gradient of explicitly related to the network components (Sayles et al., 2019).

6.2.2 Social-ecological systems

The social-ecological systems (SES) framework has been developed to help bridge the gap between researchers of social and ecological sciences and can be seen as a diagnostic approach (Ostrom and Cox, 2010). The creators aim at providing guidance to integrate knowledge and by this "to overcome overly simplified responses to serious environmental problems". The Figure 3 below outlines the framework's structure.

The SES framework is being developed and applied by a wide community of scholars. The framework is aimed at both, being generic and sufficiently specific. This leads to continuous suggestions to adjust the framework, respectively expanding the lists of variables, to better cover new situations. In their review, McGinnis and Ostrom (2014) found that environmental variables were less numerous than those from the social sciences, where to framework originates. Dwyer et al. (2020) applied an SES-based analysis to local initiatives which promote public goods and the provision of ecosystem services. The resulting diagrammatic presentations revealed the nature of the interactions between system elements and whether these were promoting or weakening the provision of public goods and ecosystem services. Understanding how the system works allowed bringing strategic stakeholders into contact to advance the system. By this, the SES analysis was feeding a transition process. Somewhat similar to the food system approach (not referenced), the SES framework is not explicit about methods and standards to be applied. Since interpretations of the framework vary substantially (hampering the comparison across applications), a guide was established, based on a review of cases that used quantitative data to some extent (Nagel and Partelow, 2022).

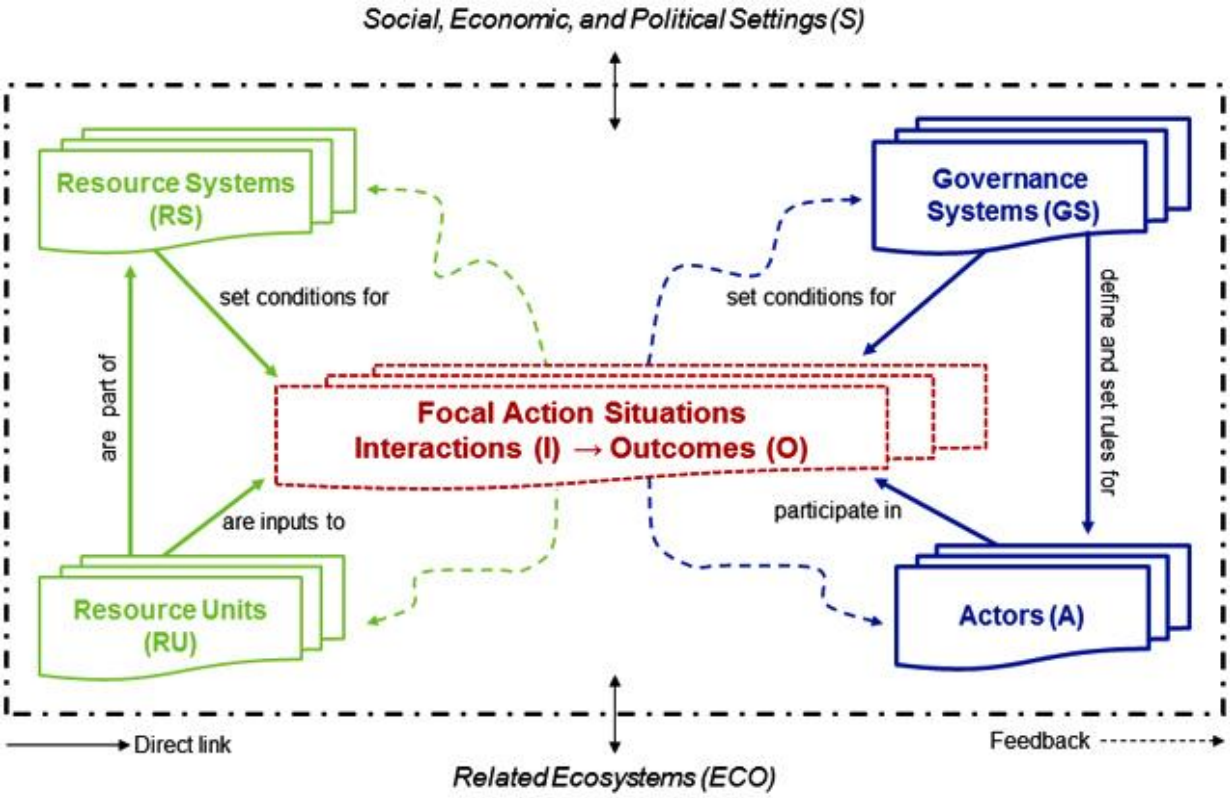

Figure 3. *Revised social-ecological system (SES) framework with multiple first-tier components (McGinnis and Ostrom, 2014). "Solid boxes denote first-tier categories. Resource Systems, Resource Units, Governance Systems, and Actors are the highest-tier variables that contain multiple variables at the second tier as well as lower tiers (…). Action Situations are where all the action takes place as inputs are transformed by the actions of multiple actors into outcomes. Dashed arrows denote feedback from action situations to each of the top-tier categories. The dotted-and-dashed line that surrounds the interior elements of the figure indicates that the focal SES can be considered as a logical whole, but that exogenous influences from related ecological systems or social-economic-political settings can affect any component of the SES. These exogenous influences might emerge from the dynamic operation of processes at larger or smaller scales than that of the focal SES." From McGinnis and Ostrom (2014)*

Similar to the landscape approaches, the SES framework can help us to structure our framework. It is not specific regarding biodiversity and ecosystem services. Though, may help to understand how to advance those. Any scale can be addressed by the framework.

Ostrom (2009) presents a multilevel, nested and diagnostic framework to analyse outcomes achieved by social-ecological systems. The framework in is an update of an earlier presented framework (Ostrom, 2007). Figure 4 is an overview of the framework and includes four so-called sub-systems including i) resource systems, ii) resource units, iii) governance systems and iv) users and furthermore studies their interactions (I) and outcomes (O). Each sub-system includes multiple second-level variables. The aim of the framework by Ostrom (2009) is to identify relevant variables for studying social-ecological systems (SES). Authors state how isolated knowledge acquired by biophysical and social scientists is not easily cumulated without a proper framework to identify and organise relevant variables. Each subsystem is divided in subcomponents which can be used in the design of data collection, fieldwork, and the analysis of sustainability of SESs.

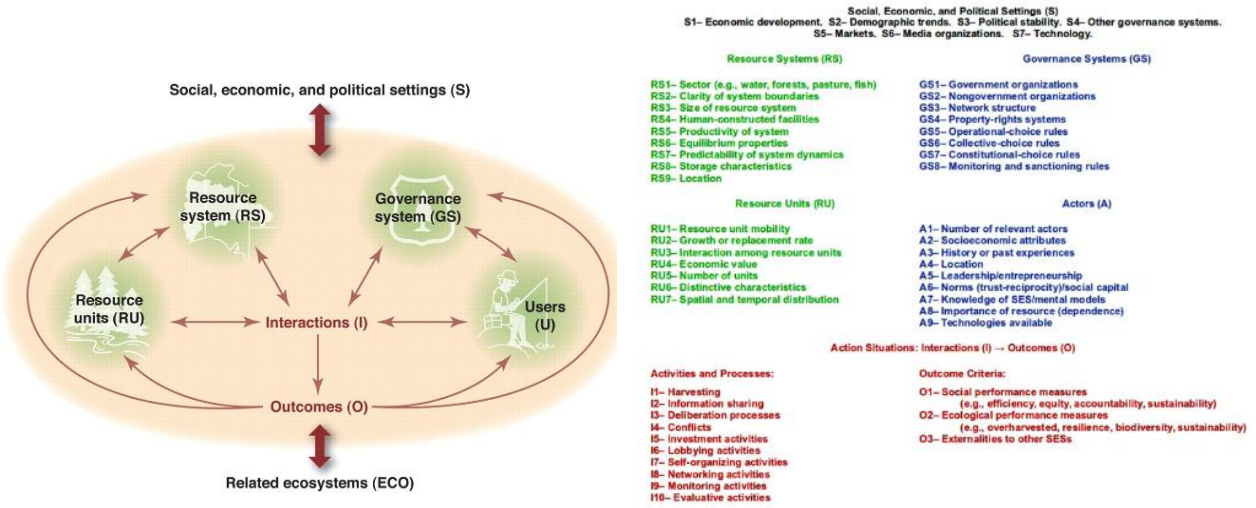

Figure 4. Left: the core subsystems (i – iv, I, O) in a framework for analysing social-ecological systems. From: Ostrom 2009. Right: the four core sub-systems, interactions and outcomes and their second-level variables From: Hinkel et al. (2014) adapted from Ostrom, 2009.

In work by Hinkel et al. (2014) several issues are raised regarding the SES framework developed by Ostrom (2009) including: the exact meaning of the sub-systems and where new variables and concepts should fit in, analyses of nested levels of ecological and social aggregation, how do variables listed under outcomes link with the other variables, and how can interactions between variables be represented?

The words '*biodiversity'* and '*ecosystem services*' do not occur frequently in Ostrom (2009). Originally, the study on SESs has largely focussed on if and how SES are able to sustain themselves, including studied concepts such as adaptive capacity, resilience, robustness, stability and transformability (Ostrom and Cox, 2010). In the subcomponents of sub-systems i) resource systems and ii) resource units several indicators could apply to the study of biodiversity or ecosystem services. Furthermore, in the study of the interactions and outcomes one of the indicators is Ecological performance measures (O2).

6.2.3 Landscape Approaches

This section is purely based on "Landscape Approaches: A State-of-the-Art Review" (Arts et al., 2017). All parts marked as direct citations come from this paper. Making such a summary appears useful to better understand the field of landscape approaches to which we can relate and place our decisions in the project in an informed way.

In short, biodiversity and ecosystem values and services (our project focus) are among the manifold sectors the landscape approaches look at. Landscape approaches indeed seek transition processes, though probably broader and more comprehensively than we have in mind. Landscape approaches, particularly through the views from the different disciplinary schools, show and make us aware of the different priorities that shape our studies and respective approaches. It can help us to pose relevant questions, even though we will not all work out in detail.

"landscape (…) refers to an area or spatial unit shaped by both natural and sociopolitical processes, and it reflects a high multifunctionality, as it harbors both biodiversity and biocultural functions"

Landscape approaches have several aims or selection of the following aims:

1. Look at different sectors and disciplines together (in planning, policy, management, governance)
2. Deal with scale issues, and external effects at different spatial and temporal scales
3. Account for the linkages of people and their environment (social-ecological systems)

The integrative ambition is central in landscape approaches (in opposition to reductionist science). Though, in how far is scientific integration useful? Often, "knowledge is combined, but not integrated". Criticisms of landscape approaches address their assumptions of being able to attain win-win solutions for competing interests and cross-sectoral integration, while sometimes taking conflicts and injustices not serious enough.

In the following, we look into development and state of the art of landscape approaches from different disciplinary backgrounds.

Landscape ecology/ecological dimension of landscape
Landscape services science has two strands: standardisation of assessment (to serve policy arenas) versus plurality of valuation due to context-dependency (to serve community/actor groups).

- ➔ One approach is to conceptualise social-ecological systems as networks

Economic and developmental dimension
Bring nature and people-focused goals together – do not exclude people from nature but aim at benefits for both – protective versus productive. Integrated management or community-based management are examples here. In the productive perspective, local communities and private sector elsewhere may have stakes, where initiatives such as payment for ecosystem services, striving for zero deforestation and responsible sourcing are attempts to secure the resource base over time. The voluntary landscape interest of corporations can also entail greenwashing and influence power relations to their favour.

- ➔ Costs and benefits to different stakeholders in the landscape need more attention
- ➔ Social and environmental externalities of businesses need more attention

Social-cultural dimension
Functional space versus meaningful place. Landscape identity and sense of place are terms used here. Character, perception, and bonding to place may again differ by people. Storytelling aims at combining narratives to mold collective action, where potential exclusion effects need attention. Social capital can be understood here as both, promoting settings that bring people together and as unevenly distributed resource leading to inequalities and power disparities. Cultural heritage and practices – "the notion of territorialization was introduced to capture the process through which culture and nature interact and coproduce landscapes" through objects (opportunities for action), symbols and institutions.

- ➔ The "production of landscapes" emphasises the strong interrelationships that people and nature have

Political dimension
Political science is about how politics shape space and how space shapes politics. Watershed management can link different administrative units and its manifold stakeholders with their various interests and power relations. Landscape governance (discourse, institutions, nature) is to make explicit the role played by space, place and scale, to debate local to global ambitions, and to link "social (…) processes to their biophysical and material conditions". Any landscape approach is highly political – is global or local leading?, what mechanisms of inclusion and exclusion exist?, what is the role of expert knowledge?, what social injustices and power inequalities exist?, how/by whom are (formal) decisions taken?. These issues have the potential to massively challenge the integrative character of landscape approaches.

- ➔ Make the political environment explicit

Example 1. Landscape Governance Framework
Buizer M, Arts B, Westerink J. 2015. Landscape governance as policy integration "from below": a case of displaced and contained political conflict in the Netherlands. Environ. Plann. C: Government Policy 34(3):448–62

Example 2. Landscape Capability Framework
WCDI together with partners developed a framework of what capabilities are required for landscape governance. It is:
1 think and act from a landscape perspective
2 achieve coherence in landscape diversity
3 make institutions work for the landscape
4 create landscape market value

6.2.4 Landscape sustainability science

A landscape perspective is required to capture the "biodiversity-ecosystem function-ecosystem services-human wellbeing relationship" (Wu, 2021). According to the author "biodiversity usually increases ecosystem function, stability, and resilience, which in turn leads to more diverse and sustained ecosystem services that support human wellbeing". And further: "landscape sustainability science is meant to help us achieve the goals of moderation, synergy, and cooperation in our landscapes by balancing development and environment, and by properly adjusting the distance between society and nature and the degree of connections between landscapes near and afar". See also Wu (2013) and Liao et al. (2020) and Figure 5 and Figure 6.

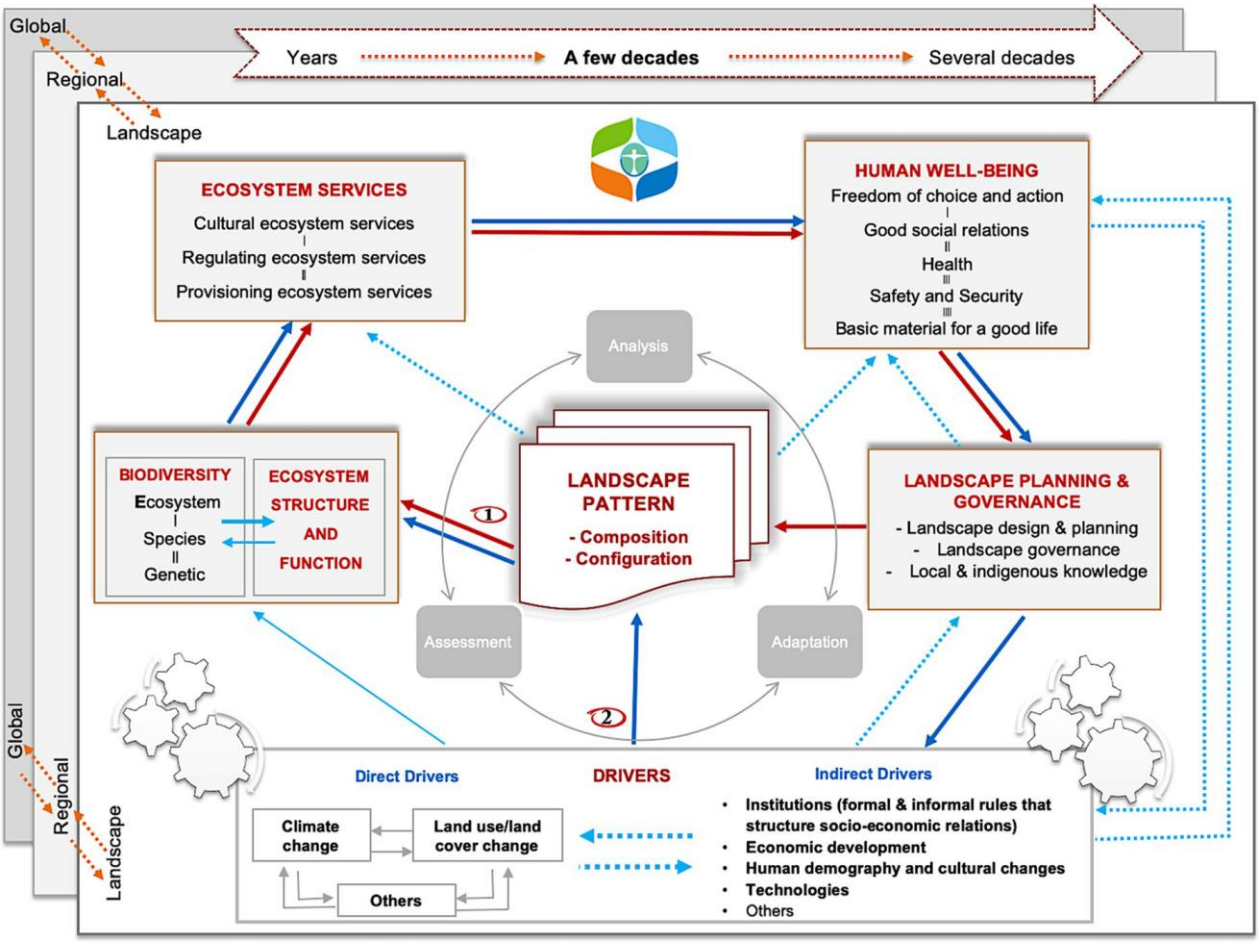

Figure 5. Visualisation of framework concept (Wu, 2021).

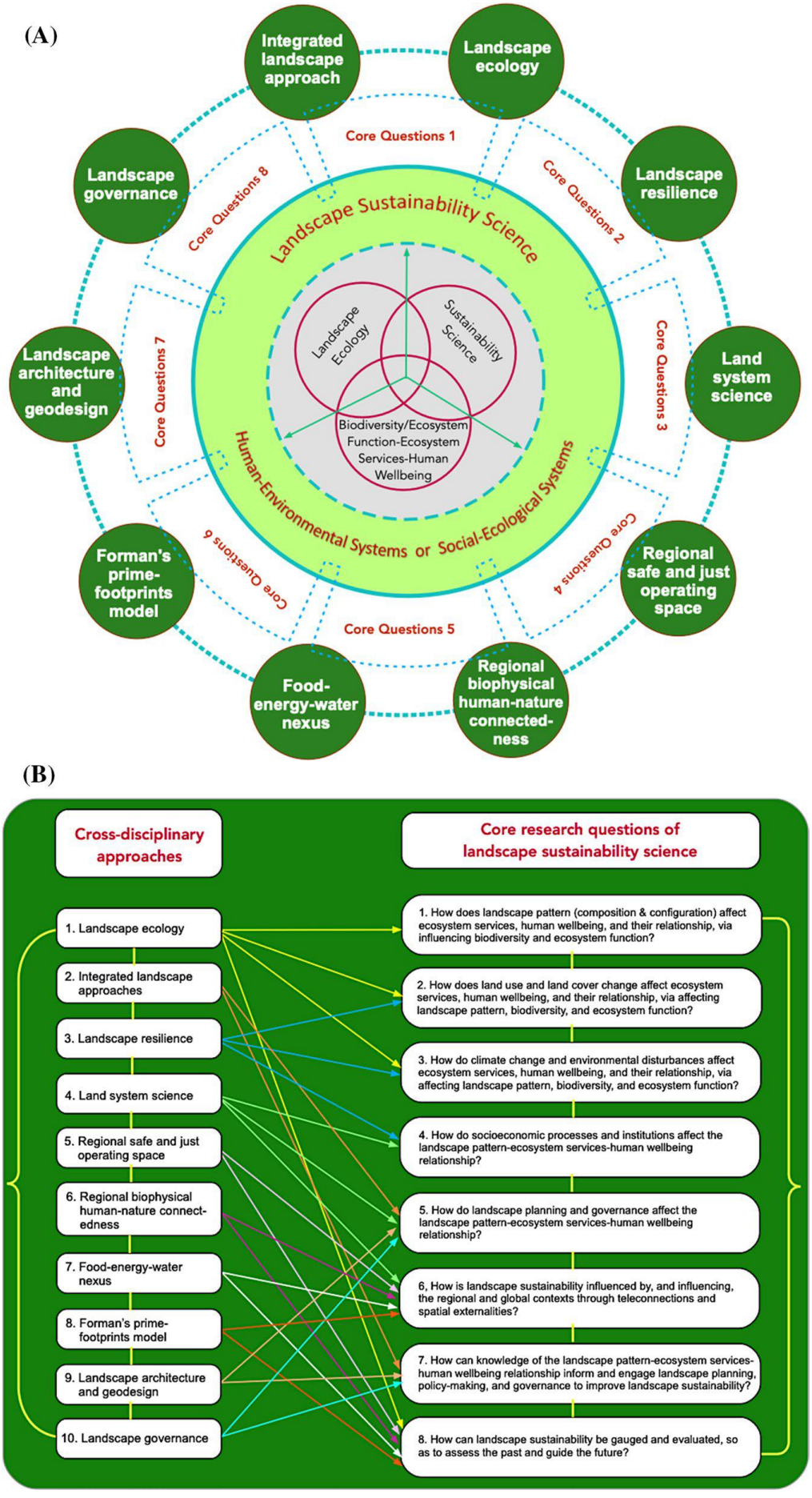

Figure 6. Visualisation of framework concept (Wu, 2021).

6.2.5 Co-producing theory of change to operationalise integrated landscape approaches

In this approach, many different methodologies are combined: the principles of landscape approaches, knowledge co-production and theory of change models. This combination is new and therefore only described in Reed et al. (2022). The key goal is to integrate land use issues in a participatory process and co-produce a landscape design towards a shared vision with concrete goals. It can build trust among stakeholders, establish shared visions and barriers towards them, and with that inform landscape management.

The nine steps guiding this approach are visualised in Figure 7. First, participants define the most pressing land-use issues in the landscape. Randomly selected groups then identified the most concerning issues that most hinder sustainable and integrated landscape management, which are classified in themes. In step three, these issues were linked to causes/drivers and results/impacts. Step four has participants develop a desired future state (vision) for the landscape. In step five, activities are linked to that vision with timeframes. Step six integrates all previous steps to co-construct pathways for transition towards the future vision, consisting of concrete actions, interventions or policy options. These form the theory of change pathways.

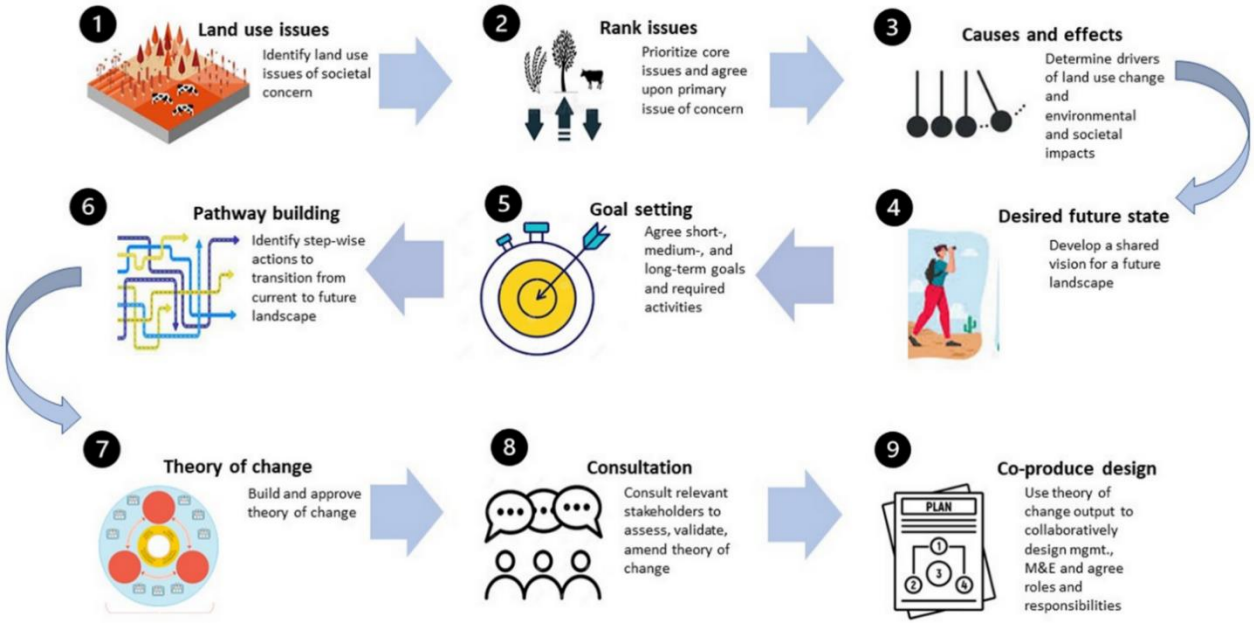

Figure 7. The nine steps of the participatory theory of change development (Reed et al., 2022).

After step two, three and six groups discuss the progress. Researchers synthesise the output of these steps to produce a theory of change model that is shared with the group for input and approval in step seven. The approved model is shared with actors who did not join the workshop but are interested in management of the landscape, and they validate the theory of change (step eight). The final theory of change is used for designing landscape monitoring and evaluation, with a co-produced action plan and roles clearly identified and agreed upon (step nine).

The approach has only been applied in the Kalomo District of Zambia, but has shown promising results: trust was built and necessary actions towards a sustainable future were identified. Identifying barriers and transition pathways are essential elements within the approach, and therefore make it relevant to the project. However, the approach does not necessarily involve biodiversity and ecosystem services, only if those are most endangered in the landscape. Furthermore, it does not quantify drivers and impacts in any way, and is not suitable as an assessment framework in and of itself. Other methods should be applied with the approach in order to evaluate the theory of change model.

Limitations given by the authors are that broad stakeholder engagement is required for this approach, and care should be taken to foster stakeholder involvement and to ensure representation of actors. Independent facilitation of the process is needed. Furthermore, consultation and long-term support is necessary for developing the action plan into future management (step eight and nine). Since theory of change models are

co-produced on a landscape level, the framework is relevant for the project. The participatory approach ensures that landscape actors are involved with developments towards a sustainable transition. If the theory of change model becomes complex however, many different methods might be required to monitor this development. Within the current project emphasis is placed on biodiversity and ecosystem values and services, while that could be a minor part of the theory of change model, which includes among others institutional, communal, political, economic and judicial drivers. This complete and integrated approach is a unique strength.

6.2.6 Ecoprofiles

Ecoprofiles are first introduced by Opdam et al. (2008). The concept of ecoprofiles reduces the complexity of ecological tools for incorporating biodiversity in regional landscape planning while maintaining the flexibility required in the planning and design process. It is a tool for sustainable landscape planning, taking into account how decisions are made. It can be used to set a clear biodiversity goal and to design a landscape pattern that provides the appropriate ecological conditions.
The ecoprofile approach builds on the insight that, at the landscape level, the distribution of species is determined by ecosystem type, quality, area, and connectivity. The term "ecoprofile" refers to groups of species with rather similar (spatial) habitat requirements. These species demand similar dimensions of an ecosystem network in order to persist at a regional scale. "Similar" in choice of ecosystem type, area requirements, and dispersal capacity of the species encompassed by a single ecoprofile, relative to the differences between species classified in other ecoprofiles. Together, ecoprofiles fill the theoretical space encompassed by the spatial variation of network size and network configuration. We can visualise this by arranging a suite of ecoprofiles in a multidimensional matrix (Figure 8).

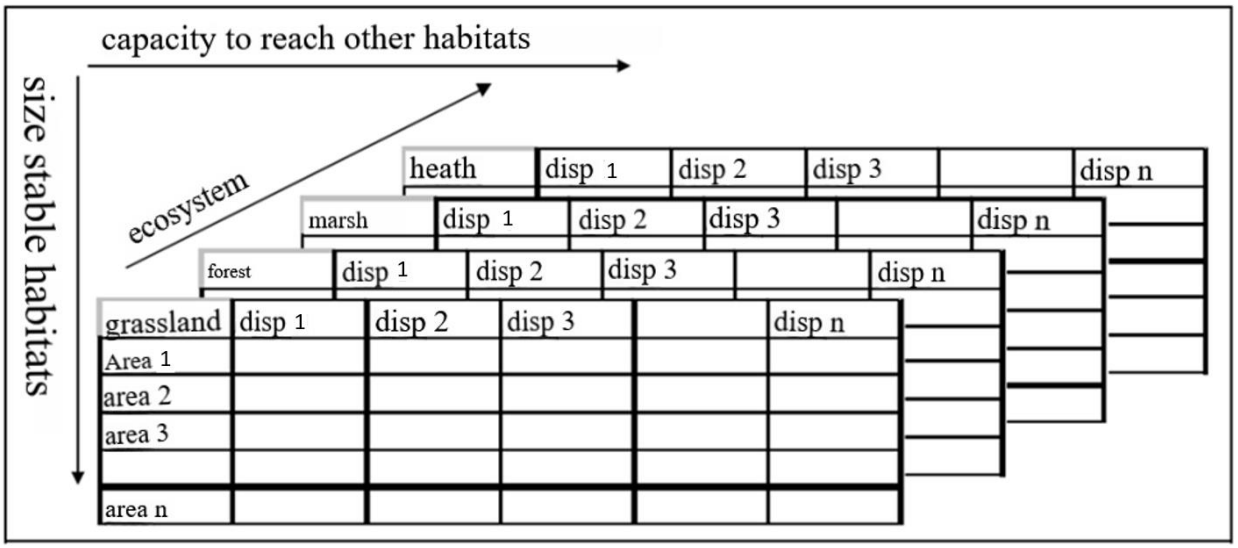

Figure 8: Schematic representation of linking species to an ecoprofile. (adapted from: Van der Grift et al., 2003)

The first dimension is the ecosystem type because, in planning, ecosystem types are often treated separately. The ecosystem type contains the habitat(s) of a variety of species. Although these species may differ in habitat demands at the micro level, at the landscape planning level they can often be regarded as inhabiting the same ecosystem type. It is assumed that, if there is enough area, the habitat of any species living in the ecosystem type can be found there.
The second dimension defines the ecosystem area requirements for each ecoprofile and corresponds to the carrying capacity of the ecosystem network. This axis can be scaled with a variety of measures of the area requirements of species, e.g., minimum key patch area (Verboom et al., 2001), or the minimum habitat network area (Opdam et al., 2003). These indicators, expressed as carrying capacity, can also incorporate variation in habitat quality. For example, low ecosystem quality can be compensated for by enlarging the minimum required area (Verboom and Pouwels, 2004; Van der Grift and Pouwels, 2006).

The third dimension encapsulates ecoprofile-specific requirements related to the configuration of ecosystems. This axis can be scaled by various measures related to connectivity, e.g., maximum distance between the

patches of an ecosystem, based on the dispersal distance encompassed by an ecoprofile. Also, a distinction can be made between barrier-sensitive ecoprofiles, including those for ground-dwelling species, and ecoprofiles that are not barrier sensitive.

The matrix is an open structure that can be adapted to the regional setting, as local experts can link target species in conservation programs to the cells of the matrix. Thus, by classifying the diversity of species into a nested set of ecoprofiles, based on generalis
ed ecological traits of species, we obtain a set of surrogates for biodiversity levels directly linked to the most important spatial characteristics per ecosystem type: total area and its configuration across the planning area. It shows how the number of ecoprofiles with sustainable conditions in the region increases with total area, enabling stakeholders to negotiate a feasible aspiration level for biodiversity.

6.2.7 Multi-level perspective on transitions

Sustainability transition studies (Köhler et al., 2019) take a long-term system perspective, aiming to shed light on different policy options and what their impacts and implications could be. Transition studies tend to focus on the interaction between actors, institutions, and technologies, emphasizing co-evolution and multi-dimensionality. Transitions involve many kinds of agency (e.g., sense-making, strategic calculation, learning, making investments, conflict, alliance building, power struggles), and the timing and direction in technology development is difficult to foresee. Transitions research addresses the drivers, barriers and opportunities arising from these processes and aims to understand patterns and possible pathways towards increased sustainability.

The multi-level perspective (MLP) is a middle-range theory that conceptualises overall dynamic patterns in socio-technical transitions (Geels, 2011). The MLP views transitions as non-linear processes resulting from the interplay of developments at three analytical levels: niches (the locus for radical innovations), socio-technical regimes (established practices and rules that stabilise existing systems), and an exogenous socio-technical landscape (Geels, 2004; Geels, 2011) (Figure 9).

Each level refers to a heterogeneous configuration of elements, and 'higher' levels are more stable than 'lower'. The regime level is of primary interest, because transitions are defined as shifts from one regime to another (Geels, 2011). The socio-technical regime refers to the semi-coherent set of rules that orient the activities of the social groups and form the "deep structure" of an existing socio-technical system (Geels, 2004). Because existing regimes are characterised by lock-in, innovation tends to occur incrementally, with small adjustments accumulating into stable trajectories. These trajectories occur not only in technology, but also in cultural, political, scientific, market and industrial dimensions, which co-evolve and interpenetrate each other (Geels, 2011).

Niches are "protected spaces" with actors (such as entrepreneurs, start-ups, spinoffs) working on radical innovations. Niches gain momentum if expectations become more precise and more broadly accepted, if the alignment of various learning processes results in a stable configuration ('dominant design'), and if networks become larger. The wider socio-technical landscape includes the established technical and material backdrop that sustains society, as well as demographical trends, political ideologies, societal values, and macroeconomic patterns. Although the MLP sometimes is summarised as 'micro-meso-macro', the levels refer to different degrees of structuration of local practices and are not necessarily hierarchical (Geels, 2011). Each transition is unique, but the general dynamic may be illustrated as in Figure 9: (a) niche-innovations build up internal momentum, (b) changes at the landscape level create pressure on the regime, and (c) destabilisation of the regime creates windows of opportunity for niche innovations.

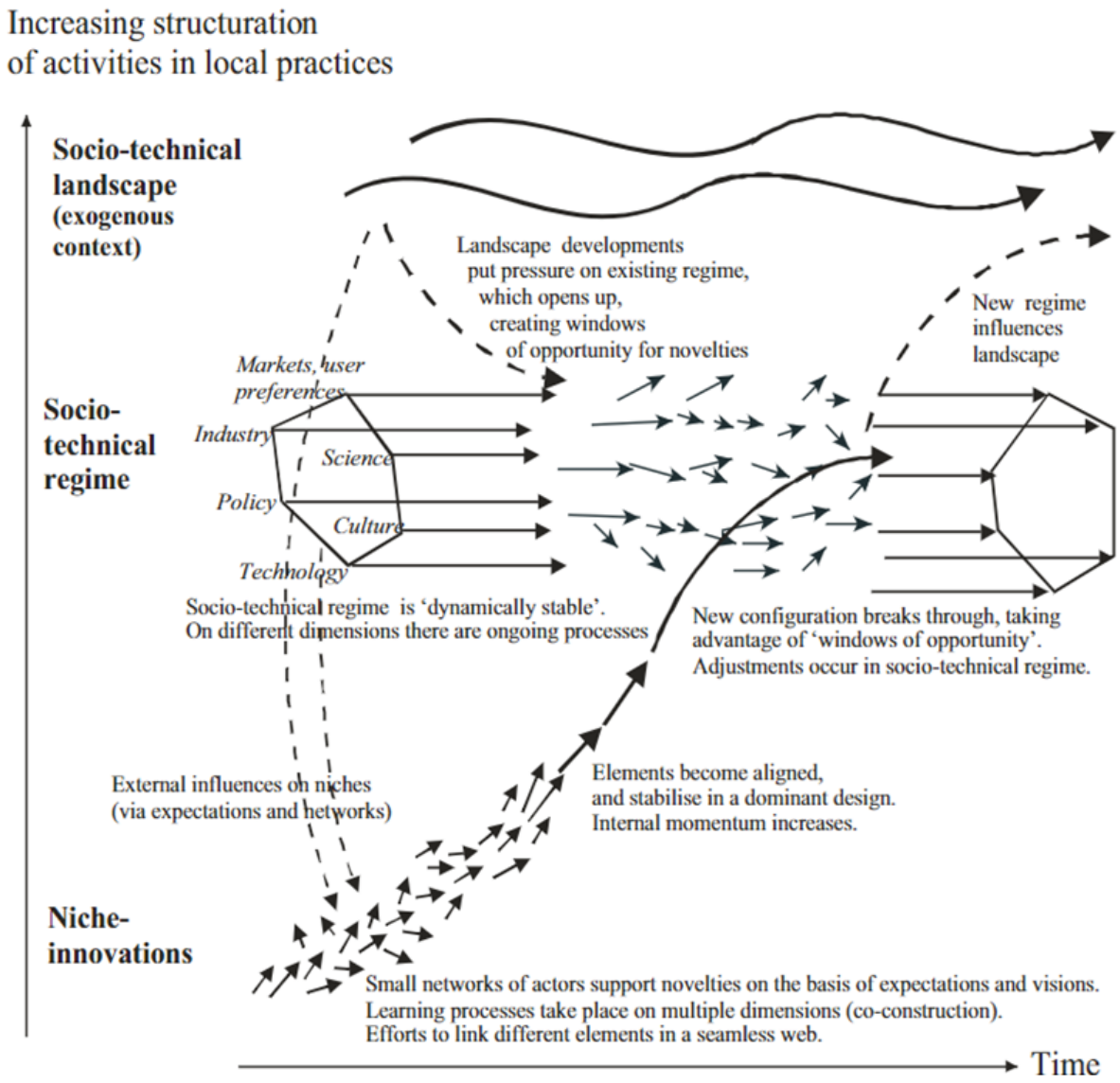

Figure 9. A multi-level perspective on transitions (Geels, 2011).

The notion of transition pathways refers to different trajectories or forms these processes may take. Several different typologies have been developed (e.g., Geels and Schot (2007); De Haan and Rotmans (2011)).

What is the aim of the development of this framework?
Underlying motivation of research on sustainability transitions is that systemic change ('socio-technical transitions') are needed to address urgent environmental problems such as climate change, loss of biodiversity and resource depletion (clean water, oil, forests, fish stocks, etc.)

What are the limitations of the framework?

- Academic debate on whether MLP lacks attention to power and politics/ role of agency in transition
- Bottom-up niche bias; more attention needed to ongoing processes at the regime and landscape level

Does the framework work on a landscape scale? How and what does it evaluate?
Yes, sustainability transitions refer to multi-actor and multiple scales. The MLP is a successful framework for analyzing so-called socio-technical transitions.
What does it evaluate?

- Trajectories, regimes, niches, path dependence, routines
- Sense making social networks, innovation as a social process shaped by broader societal contexts
- Rules and institutions / 'rules of the game'

How does the framework look at biodiversity and ecosystem services?
MLP does not specifically look at biodiversity and ecosystem services; but become apparent in case studies of transitions (e.g., biogas development; organic food and sustainable housing)

Is it possible to use the framework for a transition process?
Yes! It is helpful to get a better understanding of the barriers and opportunities in relation to the functioning of landscapes through for example studying bottom-up niche development trajectories.

From the answers above, how is the framework relevant for this research?

- Transition/ transformation: barriers and leverage from the perspective of social networks
- Explaining the ups and downs of "green" niche-innovations by analysing the learning processes, network dynamics, and struggles against existing regimes on multiple dimensions
- Case study research:
  - Niche development perspective (experimental projects, pilot projects and demonstration projects).
    - Multi-level actor interactions and interactions between expectations
    - Network building
    - Learning processes & articulations of expectations and visions
    - Importance of external regime developments: characterised by lock-in and path dependence
  - Examples from the ”Frisian Veenweiden (Aldeboarn-De Deelen)": pilots and experiments with higher water levels in combination with other measures such as underwater drainage for agriculture, meadow bird management, nature development and flood zones for vulnerable foundations.

6.2.8 Tool for Agroecology Performance Evaluation

The *Tool for Agroecology Performance Evaluation* (TAPE) (Mottet et al., 2020) is a participatory tool that assesses performance of agroecology across five dimensions of sustainability: environment, social and cultural, economic, health and nutrition, and governance. The 10 elements of agroecology are used for this assessment as criteria (Figure 10), each with different indicators. Performance on the elements is assessed by scores on each of these indicators, and is reviewed by the community to define opportunities for agroecological transition. It was developed by the Food and Agriculture Organisation of the United Nations (FAO) to provide a framework that could evaluate a wide range of agroecological farming systems globally and with that inform policymakers, but also farmers, scientists and staff from NGO’s. Because of its participatory approach, TAPE was designed to be simple and easy to understand for any user. It provides results at farm level but also provides results on a regional scale. Farms in the same region and national policies are used as input, but the assessment and performance is mainly focused on the farm scale. Limitations that are given by the developers are that the assessment may be more applicable to small- than large-scale farming, and that the assessment questions need to be adapted to the local context.

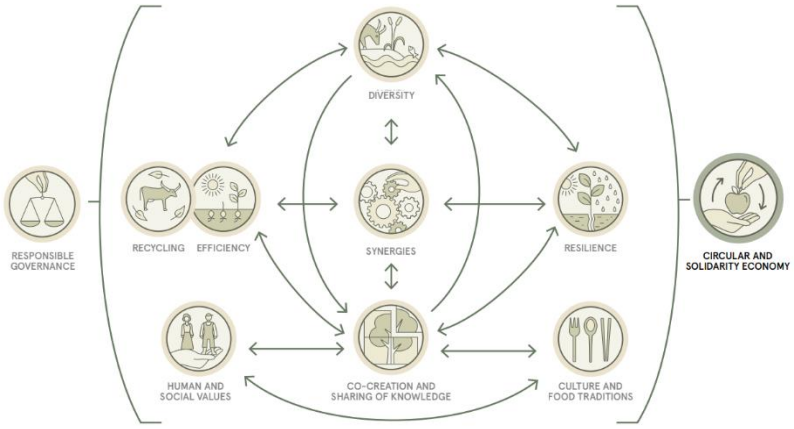

Figure 10. The FAO’s 10 elements of agroecology which are used in TAPE (FAO, 2018).

Biodiversity and ecosystem services are encompassed by the elements diversity and efficiency. The former uses agricultural biodiversity in terms of variety in crop and animal species and breed/variety, beekeeping and cover of natural vegetation as indicator. Efficiency refers to indicators for management of soil fertility and pests as indicators for biodiversity. A concrete step in the framework is to identify opportunities to foster transition by reviewing current performance and linking that to the transition level of agroecology (see next paragraph) and by doing this finding the strengths and weaknesses. Aside from the focus on farm scale, TAPE is very much in line with the focus of our study as it includes social, ecological and economic factors to identify barriers and opportunities for agroecological transition. There could be a more detailed assessment of biodiversity and ecosystem services in the framework as it is currently mainly assessed through simple indicators derived from farm management instead of, for example, monitoring the pollinator or natural enemies present.

6.2.9 Agroecology Criteria Tool

The 10 Elements of Agroecology Framework was developed between 2015 and 2019 in a multi-stakeholder process, and finalised by international and FAO experts (Barrios et al., 2020). The goal was to develop a system re-design framework which was flexible enough to be optimised and adapted to local context. In a formal document describing the 10 elements of the framework, it is furthermore indicated as being an analytical tool which can help countries operationalise agroecology (FAO, 2018). In the report, the tool is described as a guide for policymakers, practitioners and stakeholders in planning, managing and evaluating agroecological transitions. Barrios et al. (2020) describes it furthermore as mental model which can help policymakers in agroecological transitions.

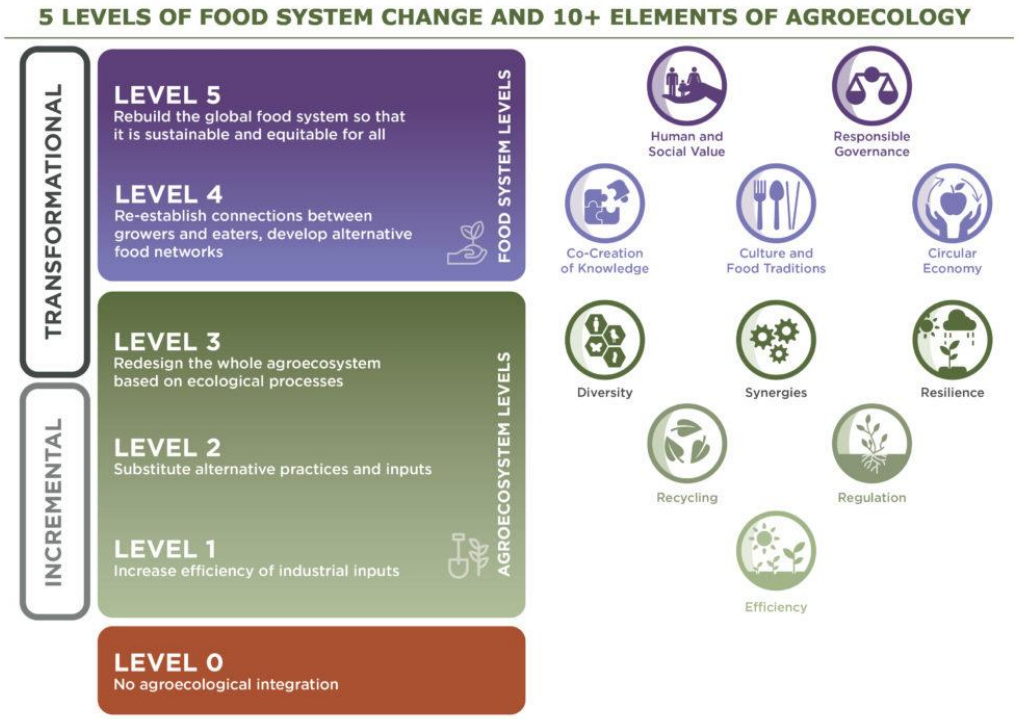

Figure 11. The 5 levels of food system change aligned with the 10 elements of agroecology (Gliessman, 2016).

The farm level agroecology criteria tool (F-ACT) is a digital decision-making tool that suggests alternative management to farmers for agroecological development. There is an on-farm participatory assessment done with an external facilitator, which consists of a series of questions which reflect the thirteen principles of agroecology. The tool assesses biodiversity and ecosystem services within the elements regulation and balance, synergies and diversity by finding which indicators or measures are present or taken on the farm (i.e. biological pest management, agroforestry, landscape elements, crop rotations and diversified production). Each question has predetermined graded answers to score for improvements and strengths. The final scores are discussed with the farmer in order to inspire them towards transformation. Therefore, identifying barriers and transformation are key elements of this tool.

The developers give three main limitations to F-ACT: it does not measure outcomes related to farm performance, so it's not suited for assessing impact of management or comparisons, F-ACT is prone to bias from self-reporting farm data and that the tool simplifies reality while agroecological practices are usually complex and interconnected. Furthermore, it might not be applicable to the project because the results are given on farm level. The tool is easily adaptable for the current project as it is open-source and adaptation to the local context is welcomed. The questions and scoring could very well be used in the project.

6.2.10 Key performance indicators

Key Performance Indicators (KPI's) are currently being selected and developed to form a KPI-set which measures farm performance, in many cases in relation to Dutch policy goals. The KPI-set is being developed for use by policy makers, commercial parties and farmers, to improve various sustainability goals simultaneously and monitor possible trade-offs. KPI's are goal oriented, hence, farmers are free to decide what management to implement in order to improve their KPI performance. The framework underlines that different farm management is required per farm to reach the same goal. KPI's apply to the farm level, and are calculated using already existing databases as much as possible to allow for calculation of KPI's on a large scale. Regional governments, NGO's and market parties have already started using KPI's to reward farmers for their performance towards certain goals. Because the KPI framework applies to the farm level, it allows farmers to measure the sustainability performance of their own farm production, and take measures to improve that performance.

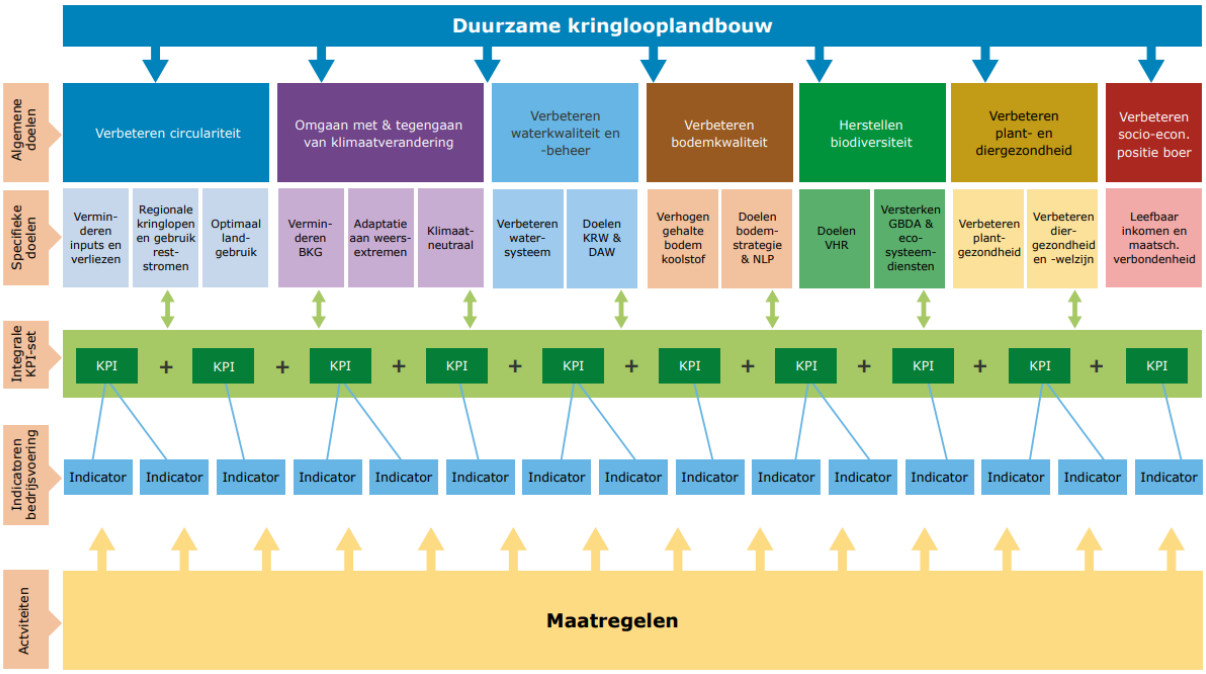

Figure 12. Conceptual framework of KPI-K, the connection between farm management, policy goals and KPI's as displayed in Van Doorn et al. (2021).

Biodiversity and ecosystem services are addressed within the policy goal of restoring biodiversity, to which the EU goals within the Bird- and Habitats Directive, and the Dutch goals of restoring landscape connectivity and ecosystem services are linked. To quantify the performance in relation to these goals, two KPI's have been developed: the KPI's crop diversity and nature & landscape. The KPI Crop diversity assesses biodiversity on the productive agricultural fields, whereas nature & landscape assesses the biodiversity on non-productive areas on the farm. The KPI Crop diversity is measured differently for arable farms and livestock farms: for arable farms, the Hill-Shannon diversity index and the edgy density (km/ha) of fields is used. For livestock farms, crop diversity is expressed as the percentage of herb-rich grassland. The KPI nature & landscape is expressed as the percentage of (semi-)natural area present on the farm.
Our goal is to assess biodiversity and ecosystem services on the landscape level. The KPI's on crop diversity and nature & landscape could mathematically be upscaled to include the performance of multiple farms within a landscape. In addition to the above mentioned KPI's for crop diversity and nature & landscape, a new way

for assessing connectivity of landscape elements between farms is currently being developed. This provides opportunities for measuring farm biodiversity performance on landscape level, and how nature areas on different farms are linked. Moreover, to use the KPI-set as a policy instrument, KPI's should be clearly defined, should have a biophysical relation with the goal, and the quality of data and data use should be managed by an independent party. An alternative for this data-intensive approach is peer review by colleague farmers, as is done in biodynamic agriculture.

6.2.11 Landscape services

The concept of landscape services (LS) is first defined in Termorshuizen and Opdam (2009) with the purpose of being a common ground where people from different disciplines can collaborate to produce a common knowledge base that can be integrated into multifunctional, collaborative landscape development. The concept is elaborated into a knowledge framework which is called the-structure-function-value chain which is an addition of the social system(value) to the pattern(structure)-process(function) paradigm coming from the field of landscape ecology (Figure 13). As such, in this framework a landscape is seen as the result between natural and human processes.

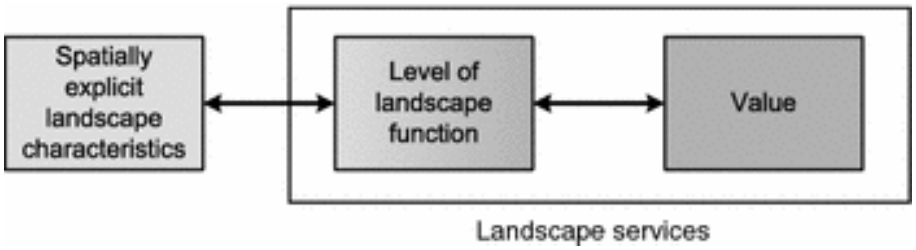

Figure 13. The structure–function–value chain as a framework for landscape ecological knowledge, which gives meaning to the term "landscape services" for collaborative landscape development.

The framework is intended to be used by scientists as well as practitioners and has been applied in real-life case studies such as in Westerink et al. (2017). The structure-function-value chain helps to study relations within SENs and to identify stakeholders as either providers or beneficiaries of services (Westerink et al., 2017). Arguments to make use of the landscape services concept include its spatial aspects, the context it provides and the applicability in human-influenced areas and for participatory landscape planning (Bastian et al., 2014). In participatory landscape planning, it can also serve as a boundary concept for facilitating communication and cooperation (Westerink et al., 2017).

Landscape services is not suggested as a replacement to the concept of ES. Instead, depending on the situation one or both of the concepts can be applied. Landscape services refers to the ecological services of landscape elements and emergent properties of landscapes pattern and configuration rather than those services produced by the isolated ecosystems in the landscape (Bastian et al., 2014). A list of landscape services is suggested, which is an extension of previous ES classifications (Vallés-Planells et al., 2014). Additions regard cultural ES, regulating services related to spatial structure and place-related provisioning services. Nevertheless, the assessment methods for ES and LS can be similar or identical. There is some work done in relating landscape services to landscape patterns (Bastian et al., 2014; Duarte et al., 2018). Effects of landscape patterns on landscape services can be analysed using mathematical landscape metrics as predictors (Duarte et al., 2018). Biodiversity is not explicitly mentioned in the presentation of the framework but is optional to include in the set of LS or ES.

There are no limitations of the framework listed in the most cited papers on landscape services. The framework is applied at the local level with local stakeholders and does hence not assess across spatial scales. It is therefore important that the choice of definition of landscape is suitable for the landscape development process that one has in mind.

Because landscape services have shown to be a useful concept in this field it may be interesting to see how we can apply it next to the concept of ecosystem services. As is stated by Bastian et al. (2014) it will differ per

case study which of the concepts are useful. We can compare the simple pattern-process-value framework with frameworks dealing with similar aspects and also investigate how it fits into larger transition frameworks.

6.2.12 Circularity and food systems approach

Circularity has been proposed as a framework to transform economies to stay within the biophysical boundaries of our planet (Jurgilevich et al., 2016; De Boer and van Ittersum, 2018; Van Kernebeek, 2020). In essence, the framework of circularity means producing with minimum needs, preventing waste along the life cycle of the products, and recycling unavoidable waste optimally. When recycling is required, it is attempted to make most efficient use of bio-materials by cascading of minerals and biomass.
In relation to food production, circularity aims to reduce the use of land on the one hand and of resources (e.g. phosphorus) on the other, while providing sufficient and healthy food for humans. These principles have been modelled by Van Kernebeek (2020) and are practically described in some other publications. The conceptual model entails (see Figure 14).:

- crops are grown for direct consumption by humans
- food and feed waste is prevented
- human inedible co-products and unavoidable waste streams are used for growing livestock
- human excreta are recycled
- manure and animal meal are used as fertiliser on crop land
- marginal grassland produces additional animal protein in case required to feed a human population

In a circular food system, all subsystems (i.e. plant and animal production, human consumption, waste recycling) interact. For example: if humans waste less food, less wasted biomass is available as feed for livestock, and, hence, less livestock can be raised. To include these kind of interaction effects between subsystems in a food system, a food system approach is required. In this approach, the resources used by agriculture is considered to be the total sum of resources in the subsystems in an area, not of only one subsystem or of a single product.

The principles described above result in optimal use of resources for food production. This can be contrary to optimal use of resources within one sector (e.g. pig production).

A limitation of this framework is that it is not a pre-defined what a food system includes. Furthermore, it does not entail biodiversity aspects. It implies the delivery of a set of ecosystem services as e.g. reducing pollution/ leaching to the groundwater, not overusing available soil and surface water resources, healthy soils, clean air etc.

The concept can be used to explore barriers and opportunities for socially and ecologically functioning landscapes.

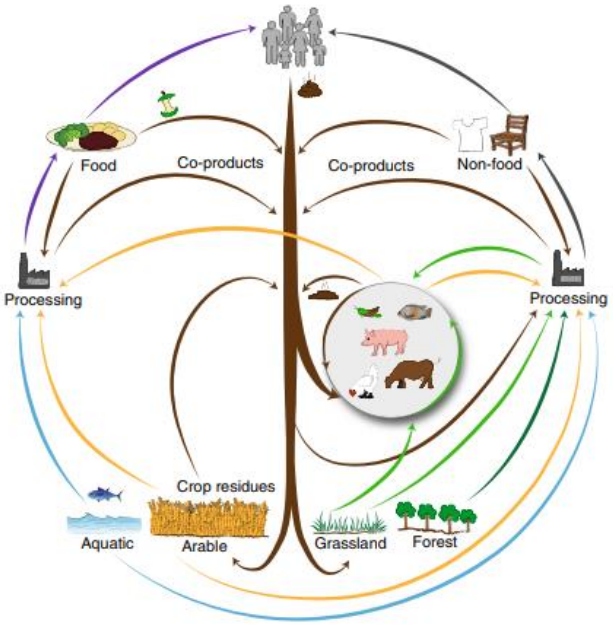

Figure 14. The flows of biomass in a circular bioeconomy. From: Muscat et al. (2021)

6.2.13 Nature-based solutions

Nature based solutions (NBS) are solutions for environmental and societal challenges based on processes and functions of nature. The concept of NBS was introduced to promote nature as a source of inspiration or as a means to provide solutions to climate challenges. The role of NBS has been studied in the context of disaster risk management, water security, and landscape conservation (Keesstra et al., 2023). NBS are accepted in the water sector as measures to reduce disaster risk and improve water security (De Vriend et al., 2015; Sonneveld et al., 2018). Other studies looked at NBS addressing multiple societal issues such as biodiversity decline and sustainable development, in addition to issues of food security (Maes and Jacobs, 2017; Seddon et al., 2019). Although some practices that are now seen as NBS have been used for centuries, there is no consensus on the definition of the concept of NBS. Different descriptions are used by organisations and communities in diverse contexts (Nesshöver et al., 2017).

NBS can not only contribute to biodiversity, but also can strengthen the resilience of an area or a landscape, CO2 sequestration, sustainable food supply and a healthier and greener living environment. However, practice shows that this is still mainly done on a small scale and in pilots. NBS are the product of a way of thinking or acting in which the above principle of making effective use of ecosystem processes and ecosystem services is reflected, and whether or not consciously inserted as NBS. An NBS can therefore be a longer existing solution, or a new approach where a new solution has been found. As a result, the term NBS does not resonate equally with everyone, but can nevertheless be present to a greater or lesser extent in the practice of decision-makers for a longer period.

Keesstra et al. (2023) hypothesise in a study on the potential of NBS to support a transition towards more climate-resilient food systems that nature-based solutions can overcome system challenges related to the functioning of the biosphere, society, or economy (including governance arrangements), and support a transition to sustainable climate-resilient food systems. They developed a conceptual framework to assess NBS contributions to such transitions. Three types of NBS are evaluated: intrinsic NBS which make use of existing ecosystems; hybrid NBS which manage and adapt ecosystems; and inspired NBS which consist of newly constructed ecosystems. The study shows that inspired NBS will increase opportunities to achieve sustainable development in food systems.

6.2.14 Nature-inclusive agriculture

Nature-inclusive agriculture is perceived as a possible route to more sustainable agriculture, as it is meant to produce food within the boundaries of nature and a living environment with a positive effect on biodiversity. There are various interpretations of this concept, and there have been plenty of initiatives to define nature-inclusive agriculture.

Van Doorn et al. (2016) define nature-inclusive agriculture on the basis of three dimensions, later also used by Smits et al. (2020). These dimensions include verrijken (to enrich), benutten (to utilise), and sparen (to safeguard) (Figure 15 and 16). These three dimensions can be operationalised by indicators and practices, that can be measured and used to monitor for effort and effect. Smits et al. (2020) emphasise that focussing on either of these three dimensions on a farm level can lead to different practices which may create synergies or trade-offs.

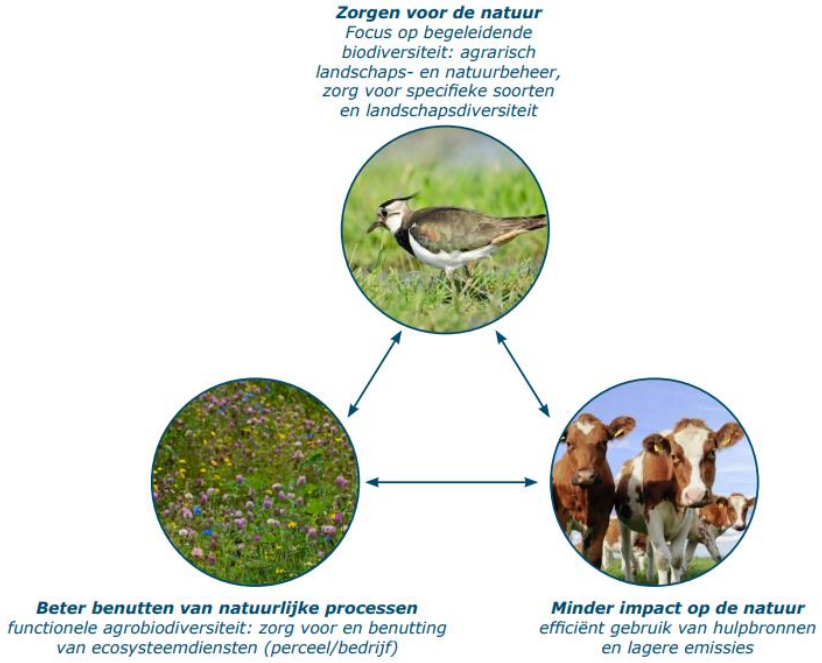

Figure 15. Three dimensions of nature-inclusive agriculture (Van Doorn et al., 2016)

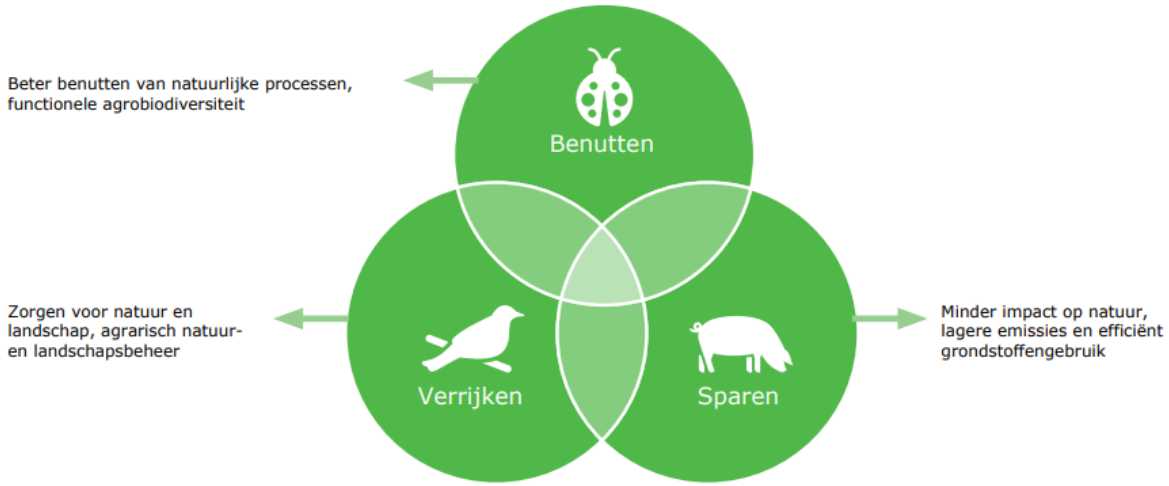

Figure 16. To enrich, to utilise and to safeguard nature. Based on Van Doorn et al. (2016) and Smits et al. (2020).

The framework is used to define nature-inclusive agriculture in the context of many different concepts that are related to sustainable agriculture (circular agriculture, regenerative agriculture, organic agriculture, etc.), while also making sense of the various interpretations of nature-inclusive agriculture that exist. The aim is thus to avoid miscommunication and confusion, and to provide clarification in the definition of nature-inclusive agriculture. However, it is also important to leave space for development of the concept and new insights in defining nature-inclusive agriculture.

Smits et al. (2020) acknowledge that there are many questions that follow from the framework of enriching, utilizing and safeguarding nature in nature-inclusive agriculture. Examples are whether all dimensions equally contribute to nature-inclusivity, whether nature-inclusive agriculture is always a form of extensive agriculture, or what should be the relation between nature-inclusive agriculture and land sparing (where agriculture and nature conservation are separate). These are not necessarily limitations, but these questions do illustrate that there is still some discussion regarding this definition of nature-inclusive agriculture.

The framework does not work on a landscape scale and is solely focussed on the farm level. The framework acknowledges the different practices that can be implemented on farm level based on the three dimensions of nature-inclusive agriculture. There is thus a large focus on nature-inclusive food production and decisions made on the level of the farm business, and less focus on other landscape services.

The concepts of ecosystem services and nature-inclusive agriculture are very compatible. Ecosystem services are important in nature-inclusive agriculture, while nature-inclusive agriculture also plays a significant role in maintaining ecosystem services, by delivering production services, regulating services, cultural services and supporting services.

Nature-inclusive agriculture is defined to have a positive effect on biodiversity. It is thus an outcome of nature-inclusive agriculture. However, nature-inclusive agriculture also uses natural processes through functional agrobiodiversity. It is therefore also a component of nature-inclusive agriculture.

There are multiple resources that focus on the transition to nature-inclusive agriculture. Van Doorn et al. (2016) envision a transition process to nature-inclusive agriculture with attention to process, profit, planet and people as a way to integrate ecological, economic and social-cultural aspects of sustainability transitions. Smits et al. (2019) acknowledge the importance of creating a vision/future scenario that serves as a baseline for the desired transition towards nature-inclusive agriculture. Smits et al. (2020) have built a route planner with a variety of points of attention that are essential in the transition process to nature-inclusive agriculture. The route planner consists of: (1) vision and agenda, (2) stakeholder engagement, (3) means, (4) concrete practices and (5) iterative learning (Figure 17).

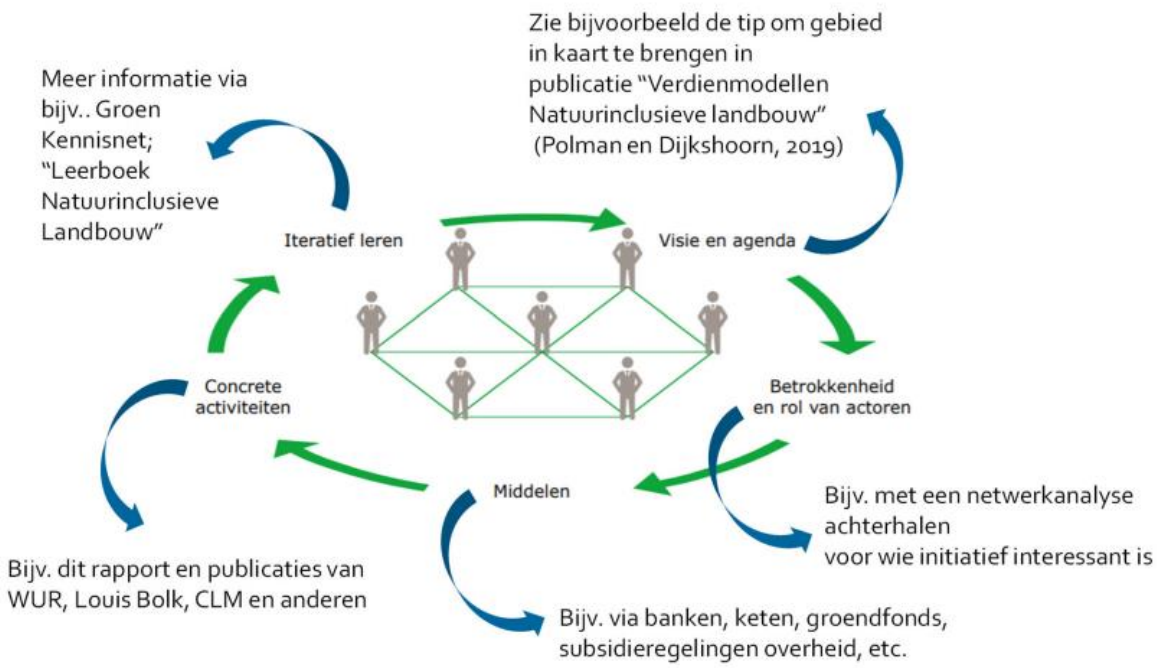

Figure 17. Route planner for transition to nature-inclusive agriculture. From: Smits et al. (2020).

It is important to consider the role of (nature-inclusive) agriculture within our landscape scale. It would be interesting to see how the concepts of verrijken, benutten and sparen would fit in a wider landscape framework or whether they are only relevant on the level of the farm.

7 Appendix 2 - Exploration of external factors, with the Netherlands as example

In this section we present how external factors can be assessed, with the Netherlands as example. We present a brief summary of the environmental status of Dutch agricultural landscapes and the policy context, and explore existing barriers and opportunities for improved landscapes. With this we provide exemplary context and embeddedness for the framework. However, in each individual case study in which the framework will be applied, the relevant context, barriers and opportunities will differ. The focus of the exploration of barriers and opportunities is on nature-inclusive agriculture.

7.1 Dutch agricultural landscapes

Agricultural land covers 66% of the Dutch terrestrial area (CBS, 2020). Over the last decades, biodiversity and the quality of related landscape values and services in agricultural landscapes substantially decreased. Agricultural practices contribute substantially to terrestrial eutrophication (excessive nitrogen deposition), desiccation (e.g. water table lowering in peat meadows), disappearance and fragmentation of semi-natural areas (disappearance of field boundaries, landscape elements, overhangs and the like), monoculture farming and pollution of natural habitat by chemical plant protection products (Berkhout et al., 2021). As a result of decreasing landscape quality, farmland biodiversity indicators such as the Dutch farmland bird index, butterfly index and habitat conservation status show negative trends (CBS; CLO, 2023a, 2023b). Furthermore, the quality of habitats and landscapes as a whole is under pressure. For 80% of the water bodies, including farm ditches, the biological water quality of surface water is insufficient (Van Halsema & Teurlincx, 2022). According to the 2018 national status assessment for the Water Framework Directive (WFD), the percentage of water bodies that meet the good ecological water quality criteria for algae is approximately 60%. For fish, 45% of the water bodies comply, while for macrofauna and aquatic plants, 40% and 30% of the water bodies respectively meet the standards for good ecological water quality (Gaalen & Osté, 2020; Gaalen et al., 2020).

7.2 Policy context

In the current context, there are policies at different institutional levels influencing rural areas and setting environmental policy goals. At a European level the Common Agricultural Policy (CAP) supports farmers in achieving more sustainable and environmentally friendly practices, and promoting rural development and innovation. Moreover, directives on nitrate, water, and birds and habitats are part of the broader framework of European environmental regulations and policies that aim to promote sustainable land use and protect the natural environment. Both the Nitrates Directive and the Water Framework Directive are important tools for protecting and restoring water quality and reducing pollution from agriculture, thus aiming to secure landscape services. The Bird- and Habitats Directive intends to protect and conserve certain habitats that are considered to be of special importance for biodiversity.

There are new trends in policy where the importance of a regional approach for reaching goals regarding these challenges is acknowledged. Such a regional approach may increase interest in a landscape-level framework. The National program for rural areas (Nationaal Programma Landelijk Gebied - NPLG) was developed to reach the targets that are set in these directives (Rijksoverheid, 2022c). Although the Dutch government abolished the NPLG in September 2024, we believe that our framework is still valuable in supporting landscape development. Two policies can be highlighted in relation to a landscape-level framework. First, as the integration of agriculture and nature is considered vital for rural transition, the concept of 'landschapsgronden' aims to bring land use for agriculture and nature together, beyond the existing dichotomy between land registered either as nature or as agricultural land (Rijksoverheid, 2022b). Secondly, there is an ambition to

increase the connectedness between natural elements, which also has synergies with regard to measures from Agrarisch Natuur- en Landschapsbeheer (ANLb) as part of the CAP (pillar 2). The goal is to realise 10% of natural elements in rural areas by 2050 (Rijksoverheid, 2022a).

7.3 Barriers

From the negative biodiversity and environmental trends in agricultural areas as mentioned in the previous section it follows that a more sustainable form of agriculture is necessary, one that produces food within the boundaries of nature and the environment and in line with the needs of the local community. One approach hereto is nature-inclusive agriculture (Erisman et al., 2017). Nature-inclusive agriculture makes optimal use of the natural environment and integrates it into its business operations. In addition, nature-inclusive agriculture actively contributes to the quality of that natural environment (Smits et al., 2020). On Dutch agricultural farms, however, natural processes and biodiversity are not sufficiently part of business operations, partly because efforts to strengthen these are often insufficiently rewarded. This does not only involve subsidies for meadow birds, but also rewards for strengthening the wider diversity of (functional) agro-biodiversity and landscape diversity (Berkhout et al., 2021). Payment for contributions to biodiversity and landscape by consumers still only happens occasionally in the Netherlands, while there are substantial costs associated with the transition from high-yielding agriculture to primary agriculture that produces in a more nature-inclusive manner (Berkhout et al., 2021). As a result, it is difficult for farmers to build a good business model around nature inclusive agriculture (Berkhout and Galema, 2022). Options for stacking public and private rewards for nature-inclusive agriculture (Silvis et al., 2022) and the potential of extensive business models (Schrijver et al., 2022) have recently been explored. The idea is that farms using such practices contribute to biodiversity within nature reserves and on farmland. The challenge is to come up with business models that will hold when scaled up (Schrijver et al., 2022). Another challenge is that agricultural land in the Netherlands is relatively expensive, making measures less attractive if they are not sufficiently financially rewarded (Berkhout et al., 2021; Jellema et al., 2023).

Furthermore, Vermunt et al. (2022) observed that the number of on-the-ground knowledge networks for nature-inclusive agriculture is growing in the Netherlands. Nevertheless, the knowledge development and dissemination is currently hindered by a couple of barriers. The first one is that knowledge often is too focused on details, abstract and difficult to apply by farmers. Secondly, there is little knowledge dissemination to others outside the current knowledge networks, and knowledge is often too scattered. While there is a lot of knowledge available for conventional dairy farming, both in agricultural universities and in the value chain, knowledge about nature-inclusive agriculture is rather scarce. A third barrier is farmers dependency on commercial actors (usually suppliers and other value chain parties) for knowledge acquisition, which means they will mainly receive information that is in accordance with the status quo and the interests of current regime actors, who often lack knowledge on alternative ways of farming (Vermunt et al., 2022).

Moreover, agricultural subsidies may have negative or adverse effects on nature and biodiversity. In the Netherlands, 12 out of 34 existing subsidy schemes available to Dutch farmers are potentially harmful to nature and biodiversity, according to research by the Netherlands Enterprise Agency, see Zanen and Cobben (2023). The subsidy schemes range from income support to farmers to subsidies for innovative greenhouse or livestock housing techniques and grassland conservation. Most of these subsidies have in common that they encourage increasing production levels and intensification of conventional farming practices. The main reason that the subsidy schemes provide perverse incentives, is because they were mainly designed with the objectives to secure food and economic development of the sector (Zanen and Cobben, 2023). As long as instruments that are not directed at improving nature and biodiversity, are not adapted or abolished, the trends in agricultural landscapes is unlikely to change. Moreover, subsidies that are promoting biodiversity and nature conservation do currently not provide a long-term perspective.

Finally, the lack of integrated policies for soil, water, manure, climate, biodiversity and landscape does not contribute to the restoration of nature and biodiversity. In recent decades, for instance, the manure policy has mainly focused on techniques to reduce ammonia emissions from agriculture, for example by manure injection. A side effect of this technique is that it can come at the expense of (soil) biodiversity (Onrust et al., 2019).

Integrated policies that simultaneously manage the important tasks for climate, biodiversity, soil and landscape and thereby gives unambiguous signals and incentives to farmers is of great importance to maintain biodiversity in the rural area in the long term (Berkhout et al., 2021).

7.4 Opportunities

The current social and political focus on nature and biodiversity is an important opportunity for biodiversity and landscape services. The Ministry of LNV and many provinces are more and more committed to nature-inclusive agriculture and circular agriculture, forms of agriculture in which natural processes and biodiversity are increasingly used in business operations. The government also aims to create zones of extensive agriculture around Natura 2000 areas to reduce the environmental impact on those natural areas. Also, more and more farmers are interested in other ways of farming, such as nature-inclusive agriculture (Berkhout et al., 2021).

Since 2016, the Netherlands has a system for collective agricultural nature and landscape management. In this system, groups of farmers (collectives) take care of the conservation of certain species and habitats. By working together as a group in promising areas for the conservation of certain species, the aim is to make agricultural nature management more effective as well as more efficient. Whether this collective approach is really more effective and efficient, in terms of restoring biodiversity, remains to be seen, but at least it seems to offer good opportunities. For example, collectives can play an important role in tackling area-specific tasks in an integrated way. The contribution of farmers' organisations to the Delta Plan for Biodiversity Restoration, a movement initiated by several civil society groups, is an example of this. Another one is the biodiversity monitor Dairy Farming scheme, launched by Rabobank, Friesland Campina and WWF (Berkhout et al., 2021).

The ongoing development of payments for green and blue services, in various forms of public-private partnerships, offers opportunities to pay farmers for the public services they provide, such as care for the landscape. The aforementioned system for collective agricultural nature and landscape management has laid the organisation and infrastructure for a joint area-based approach to species protection. This offers opportunities to use collectives for integrated area tasks related to water, biodiversity and landscape. Collectives not only commit themselves for certain target species, but also for general biodiversity, landscape and water management (Berkhout et al., 2021).

Furthermore, there is a lot of knowledge and expertise in the Netherlands on the agri-food sector, but also on the field of ecology and biodiversity. Bringing together this expertise is an opportunity to develop innovative ways to combine food production with restoration and utilisation of biodiversity. For example, the development of innovative cultivation systems offers opportunities for biodiversity, such as strip or mixed cultivation, the application of green crop protection and arable farming combined with woody crops (agroforestry) (Berkhout et al., 2021).

At last, the growing number of on-the-ground knowledge networks for nature-inclusive agriculture that is observed by Vermunt et al. (2022) in the Netherlands can be seen as an opportunity for learning, sharing of knowledge and effective collective action on landscape level.

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